Community-based Coastal Environmental Monitoring, Toledo District, Belize

(Project ATN/CP-6110-BL)

Toledo Institute for Development and Environment (TIDE)
and
Inter-american Development Bank (IDB)

Third (Final) Report

Training and Full Implementation of the Coastal Monitoring Programme

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Submitted to:

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TIDE - Punta Gorda, Belize

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1. Introduction

The purpose of the TIDE/IDB project in Toledo District, southern Belize is to establish a community-based coastal monitoring programme. This programme is intended to document the coastal zone impacts of construction activities and land use changes associated with the upgrading of the Southern Highway. The coastal monitoring project is being undertaken by MARIDEV International Limited, in collaboration with the Toledo Institute for Development and Environment (TIDE). The project is funded by the Inter-American Development Bank (IDB).

The main components of the project are:

1. review and assessment of past and current coastal zone monitoring initiatives in Belize (specifically in Toledo District);
2. examination of the institutional capacity for coastal monitoring;
3. determination of the possible impactors of the highway project which may be observed in the coastal zone of Toledo District;
4. definition of the data gaps which need to be addressed by the coastal monitoring programme;
5. through consultation with local stakeholders, development of the framework for the coastal monitoring programme (definition of the main monitoring parameters);
6. initiation of training of the local TIDE consultant;
7. implementation of some basic monitoring activities to obtain feedback to inform detailed monitoring programme design;
8. initiation of the GIS management of the coastal monitoring data;
9. detailed monitoring programme design;
10. local training in and evaluation of coastal monitoring implementation (including some training-of-trainers sessions);
11. development of recommendations for programme sustainability; and,
12. post-project technical support (via the internet).

Project activities related to the first nine components have been documented in two previous reports (#1: Scoping of the Coastal Monitoring Programme and Initial Training - July 23, 1999; #2: Coastal Monitoring Programme Design - September 14, 1999). The purpose of this third report is to document the training and implementation activities undertaken in Belize between September 19 and October 9, 1999.

More specifically, the main purpose of the recent trip was to deliver and install the remaining coastal monitoring and analytical equipment; to carry out training in the monitoring approach and use of the field and lab equipment, to ensure that all elements of the monitoring programme are implemented or at least primed for later implementation (for a few items scheduled for later in the programme), to ensure that quality data are consistent with the capabilities at TIDE and within the specifications of the equipment and approaches used; to provide manuals and written procedures for quality management, field sampling, and laboratory analyses; and, to assess the sustainability of the coastal monitoring initiative. In addition to these main activities, additional sediment samples were collected

from the Rio Grande and Monkey River to further define whether there is a problem with arsenic and mercury contamination in the area.

This report includes:

- a brief description of activities completed over the three-week training and implementation phase;
- minor revisions to the detailed monitoring programme design and the status of each component;
- additional details on the methodologies for each of the coastal monitoring parameters (based on the field and laboratory experience);
- presentation and initial interpretation of the data generated to date;
- an evaluation of the training and extension aspects of the project; and,
- comments on the future sustainability of the coastal monitoring programme.

2. Activity Report for the Last Trip

The following is a brief summary of the daily training and coastal monitoring implementation activities carried out during the last trip.

September 18: MacGegor - equipment packing and travel to Miami.

September 19: MacGregor - travel to Belize; equipment processed through Customs.

September 20: MacGregor - acquisition of materials/equipment for laboratory in Belize City; travel with Lindsay Garbutt and Karl Castillo to Punta Gorda via Southern Highway; stream crossings checked for soil erosion; unpacking equipment and checking against packing list.

September 21: MacGregor - review upgrading of laboratory and provision of advice on lab use; lab equipment stored; balance checked with calibrated weights; review of Imhoff cones for sediment trap sample procedure; checking of field, lab, and reporting templates (Excel sheets); GPS initialized.

September 22: MacGregor - preparation of ammonia, nitrate, and phosphate standards; training Karl in HACH analysis (results within specifications); some templates upgraded; sediment trap data entered and directories set up; meeting with Omar Gale (Pesticides Control Board) regarding pesticides used (no Toledo-specific data); onsite training preparation for next day.

September 23: MacGregor - training with Karl and Marcel from ESTAP; presentation on components of a Quality Management System; test of sampling equipment (Kemmerer water sampler; secchi disk, SCT meter) from bridge on Joe Taylor Creek; analysis of ammonia, nitrate, phosphate, and suspended particulate matter; standards recalculated.

September 24: MacGregor - additional supplies acquired; beach profiling stakes made up; surface drifters prepared; templates upgraded; lab methods reviewed in detail with Karl and amendments made to written manuals; sediments sampled in Rio Grande (5 sets) for analysis of arsenic and

mercury.

September 25: MacGregor - general project administration (expense report and daily log).

September 26: MacGregor - field work with Karl and students; 32 water quality stations and 12 samples for discrete water samples; extra sampling at Station 13 (Monkey River); 50 surface drifter cards released at Monkey River; two beach profiles completed at West Snake Cay; sediment traps inspected; demobilization and water samples checked; review lab structural needs; coastal sensitivities discussed with TIDE tourism consultant;
Carter - travel Halifax to Miami.

September 27: MacGregor - equipment needs reviewed; water analysis underway (nutrients), including blanks and standards; additional supplies acquired;
Carter - travel to Punta Gorda and aerial photographs of Monkey River, mangrove cays in Port Honduras, and Rio Grande; update with TIDE and Clive MacGregor; revisions to monitoring programme design.

September 28: meeting with TIDE on project budget and expenses to date; review of analytical laboratory; annotation of duplicate set of photographs for TIDE; meeting with ESTAP (Darlene Middleton); meeting with Eugene Ariola and Beverly Wade (CZMU); development of training/activity plan for the biological components of the programme; observations of first set of recruitment plates; cost recovery analysis for the laboratory; analyses for SPM; data entered on spreadsheets; quality assurance on data.

September 29: revisions to project budget; completion of training schedule for biological components; procurement of materials for biological components; development of protocol for aerial photographs to be taken by Maya Island Air; examination of potential role of TIDE in Mesoamerica Coral Reef Project; radio show with local Punta Gorda station - update on the coastal monitoring project, description of initial results, and discussion of the drifter card component; data entry for chemical data completed; surface driftter cards prepared for Rio Grande; review of laboratory protocol (Clive and Karl).

September 30: first data set sent to technical committee and others (e-mail listing); discussion of website requirements; water level gauge installed at the bridge on Joe Taylor Creek; two more sets of recruitment plates made up; discussion with Beverly Wade on Snake Cay observations; financial administration; meeting with Rachel Graham on circulation studies;
MacGregor - travel Punta Gorda to Miami.

October 1: field work Moho River to Monkey River; sediment traps serviced (samples collected and traps cleaned); recruitment plates serviced (plates collected and new plates installed); all gear marked with new tags; surface drifter cards released at Rio Grande; bottom drifter cards released at Monkey River; water level recording;
MacGregor - travel Miami to Halifax and demobilization.

October 2: review of project files and accounts; preparation of materials for Monkey River training; processing of all recruitment plates (visual observations and digital images).

October 3: Monkey River training (use of the Secchi disk, the water sampler, the refractometer and dipping thermometer; water level readings; beach profiling); installation of the water level gauge; completion of four beach profiles at Monkey River; collection of sediment samples upriver for pesticide analysis; completion of two mangrove plots at Black Creek.

October 4: preparation of materials for photoquadrats; update meeting with TIDE; drying and processing the recruitment plates; Imhoff cone processing of the sediment trap samples; one surface drifter card return; drying of surficial sediment samples; data logging.

October 5: processing of the sediment trap samples; drying of the surficial sediment samples; processing of the recruitment plates (tissue dry weights); preparation for field work; entering beach profile data to spreadsheets; digital images of the first set of recruitment plates.

October 6: field work; setting and completion of 18 seagrass and coral photoquadrats at West Snake Cay, Inside Sheepshead, and Bob Stuart Lagoon; completion of four mangrove plots at Inside Sheepshead and Bob Stuart Lagoon.

October 7: processing the first set of recruitment plates (tissue dry weights); visual observations of the 50 surficial sediment samples; data entry to spreadsheets; printing of GIS sampling station maps; confirmation of the aerial photograph protocol with Carlos Zablah (pilot) and permission from Fernando Trejo; newsletter article on the coastal monitoring programme.

October 8: entering data to spreadsheets; printing all data sets; report writing.

October 9: Carter - travel Punta Gorda to Belize City; observations of plumes from Deep River and Monkey River; report writing.

October 10: travel to Canada; demobilization and report writing.

3. Revised Coastal Monitoring Programme Design

The following matrix was presented in the second project report. Minor revisions to the coastal monitoring programme design and some additional details on methodology are provided below, based on the implementation experience over the last three weeks. The matrix also includes a summary of the status of implementation of each monitoring component at October 9, 1999.

Process Being Examined and Specific Parameter	Sampling Locations	Frequency of Sampling	Methodology	Protocol for Sample Handling, Data Recording;QC/QA Considerations	Linkages to Other Parameters	Management Cues Based on Data
1. Meteorological conditions 1.1 Air temperature, cloud cover, precipitation, wind, and waves **Status:** these observations have been made during all field trips since June; observations from TIDE office to be initiated	at the TIDE office for all observations at the beginning and end of each day; at sea while sampling	daily, and whenever sampling at sea	thermometer for air temperature; gauge and compass observations of wind speed and direction; wave height, period, and direction; cloud cover and precipitation	manual recording in a weather logbook at the TIDE office and in the field notebook while sampling; these are general observations which do not have to be exact; however, air temperature should be recorded carefully with the probe out of direct sunlight; the most common problem is that these observations tend not to be recorded daily	these observations help explain causative factors influencing freshwater discharge and sediment transport and re-working processes	there are no specific management responses to weather and oceanographic conditions; however, these observations can be used for safety considerations, such as stopping sampling at a given wind speed or wave height, based on previous experience

2. **Water level fluctuation** 2.1 River discharge, tidal variation and storm surge **Status:** gauge installed at Joe Taylor Creek on Sept. 30; Monkey River gauge installed Oct. 3; daily observations being made	in the creek near the TIDE office; at Monkey River	daily: at the beginning and end of each workday	visual observations on a permanently installed vertical board with marks at 1/4" intervals	manual recording in a water level logbook; this is a straightforward observation, but it requires that someone is designated to do this on a regular basis; daily time advancement of the tide makes routine water level observations difficult	these observations help explain the linkage between river discharge/coastal water height and weather phenomena; they also help track changes in river discharge due to water diversion or altered river morphology	unusual changes in water level fluctuation (such as those observed in Monkey River) can be early cues to water diversion problems upstream and provoke a management intervention

3. Discharge of freshwater to coastal areas and local circulation 3.1 Temperature and salinity (and associated water depth) **Status:** all stations have been recorded at regular intervals since July; twice weekly salinity and temperature observations by Monkey River Group initiated on Oct. 3; S/T data also being collected during other sampling	12 stations at the mouth of Rio Grande; 12 stations at the mouth of the Monkey River; 2 stations at the mouth of the Moho River (a spatial control); 2 stations at Inner Sheepshead; 2 stations at Bob Stuart Lagoon; 2 stations at West Snake Cay; all recordings at near-surface; mid-water level, and near-bottom	these *in situ* recordings should be made every two weeks at the 32 routine stations and twice per week at the Monkey River wharf station	use a YSI 30 (SCT) salinity meter with a probe lowered to the appropriate water depth; water depth to be determined before salinity and temperature measured - a depth line should be used for this, but the Eagle depth sounder can be used in conjunction with the GPS to find stations; temperature should be measured before salinity at each depth interval; a refractometer will be used at Monkey River	the instrument needs to be kept dry and not bumped around; the probe should be kept clean and rinsed of saltwater; calibrations can be made with a handheld thermometer and the refractometer	salinity and temperature measurements define the basic structure of the water column, whether river-dominated, marine-dominated, layered, or vertically mixed; these data can be tied to the meteorological observations and help with interpretation of sediment, nutrient, and contaminant transport to coastal areas	significant changes in the salinity-temperature structure of coastal waters may reflect pervasive global trends, or local changes in river discharge; comparison of coastal water structure at the different clusters of stations will help separate the global influences from local influences; increases in salinity at river mouths will reflect reduced river discharge

3.2 Surface and bottom circulation **Status:** all available surface and bottom drifters (100) released by the end of September; one card return so far; future releases to be made from these locations again and from West Snake Cay; visual observations of surface circulation during other sampling only casual so far	at the mouth of the Rio Grande and Monkey River; near West Snake Cay; releases of flat drifters with small floats at surface; release of cylindrical drifters at the seabed	50 surface and 50 bottom drifters should be released once in the dry season and once in the wet season (low and high river discharge events); number at each release to be evaluated based on percentage return (may require larger sample size); visual observations of surface current direction and velocity should be made at each sampling location during normal field work	drifter cards have been prepared and laminated in Canada; these are clearly marked for return and reward; date of release and return to be recorded, with location on each date noted; in addition to cards, visual observations of surface currents during routine sampling should be noted; a compass should be used to determine current direction	a logbook should be maintained for the drifter cards; some experimentation will be required to determine proper weighting for the bottom drifters (this now done); rate of return on drifter cards is generally 3-20% for local circulation scenarios; the location of each drifter card which is returned needs to be properly documented by the person finding the card, and verified by TIDE; a reward is to be paid as an incentive to return the cards to TIDE; cards will have to include Spanish in future	the local circulation observations should corroborate the salinity and temperature data; note also that the tannin discharge from some creeks serves as a tracer of freshwater distribution and circulation in coastal areas (especially at Monkey River)	there are no specific management responses to circulation observations; however, the location of dirfter card returns can indicate areas that are subject to river-based pollution

4. **Fate of sediments in coastal areas (river input, deposition, resuspension, and beach processes)** 4.1 Light penetration; water clarity **Status:** all stations have been recorded at regular intervals since July; twice weekly secchi disk observations by Monkey River Group initiated on Oct. 3; secchi disk data also being collected during other sampling	12 stations at the mouth of Rio Grande; 12 stations at the mouth of the Monkey River; 2 stations at the mouth of the Moho River (a spatial control); 2 stations at Inner Sheepshead; 2 stations at Bob Stuart Lagoon; 2 stations at West Snake Cay; Monkey River wharf station	32 stations routinely every two weeks; Monkey River station twice per week	secchi disk	the secchi disk should be kept clean and painted ar regular intervals; a small weight can be attached to the secchi disk if it is difficult to maintain a vertical line in the water; the disk must be lowered past the point at which it can no longer be seen, then raised back to the point of deepest observation	the secchi disk is an excellent and robust indicator of suspended matter in the water column, although it does not provide a direct measurement; the extensive data set for secchi readings will help with interpretation of the suspended particulate matter data; the secchi depth can be equated with the bottom limit of the photosynthetic layer	there are no specific management responses to secchi disk data

4.2 Suspended particulate matter **Status:** water sampling for SPM was initiated on Sept. 26; first data set has been produced; sediment traps have been sampled and processed four times since full installation in July	2 stations at the mouth of Rio Grande (and one additional one further upriver); 2 stations at the mouth of the Monkey River (one further upriver as well); 2 stations at the mouth of the Moho River (a spatial control) and one further upriver; 2 stations at Inner Sheepshead; 2 stations at Bob Stuart Lagoon; 2 stations at West Snake Cay; sediment traps located about a metre above the seabed; water samples for suspended particluate matter collected about a metre below surface	sediment traps should be sampled every two weeks; water samples for SPM should be collected at the same stations every two weeks	moored sediment traps; sediments collected, decanted, dried, and measured in an Imhoff cone (volume to weight conversion); discrete water samples for SPM collected with a Kemmerer water sampler, filtered, dried, and weighed	the sediment traps need to be moored vertically in the water column and sediments collected very carefully without losing any of the sample; biofouling inside the traps should be cleaned out each time the trap is sampled; calibration curves have been prepared for the use of the Imhoff cones (for the sediment trap data), based on different kinds of sediments; the curve for predominantly silt and clay should be used	these samples are direct measures of sediment input and resuspension in coastal waters; the water samples are discrete measurements at one point in time, whereas the sediment trap data are integrators of sedimentation and resuspension over two-week periods; the data reflect soil loss in the watershed, river discharge fluctuations, and prevailing weather and oceanographic conditions in coastal waters	the SPM levels and sedimentation rates indicated by the data can be related to coral and seagrass health; nearshore sediment conditions already exceed limits which are stressful to coral; if these levels increase, or the area of high SPM increases, then management interventions may be required to address soil loss in the watershed

4.3 Surficial sediments **Status:** 50 stations have been sampled; sediments have been dried and are currently being sieved; cores nay be collected later in the programme	50 stations in the nearshore area ranging from the Moho River in the south to Monkey River in the north	grab sampling once in the dry season and once in the wet season; selected cores near river mouths should be taken once per year	grab samples for particle size analysis (using sieves); selected cores at some stations for sediment deposition history	the grab sampler must hit the seabed vertically and penetrate enough to collect a good volume of sediments and close properly; surface water should be decanted carefully, and the sample stored in bags for later drying and particle size analysis (sun drying on the roof of the TIDE office and then breaking up clumps - approximately 1-2 days required for drying); visual observations of surficial sediments should be recorded at the time of sampling; cores should be analyzed visually; some samples may be used for contaminant analysis and will need special handling	the surficial sediments are the ultimate integrator of the sediment regime in coastal areas, since they reflect prevailing conditions and extreme events over the last several years; surficial sediments are also a repository for contaminants	significant changes in the surficial sediments in a particular area may reflect changing sediment inputs to the coast, changes in river discharge, or extreme weather conditions, which may require management interventions

4.4 Coastal bathymetry **Status:** water depth has been determined at all sampling stations to date; continuous profiles may be determined later in the programme	water depth is measured at each routine sampling station; depth profiles can be completed along lines running from the coast where grab samples are taken; profiles can also be completed at the mouths of the Rio Grande and Monkey River	water depth is measured at each station every two weeks; depth profiles for coastal bathymetry can be completed annually (or once in the dry season and once in the wet season in dynamic areas)	station water depths are determined with a depth sounding line; depth profiling is undertaken with the Eagle depth sounder	it is important to accurately record the position of each individual water depth measurement, using the GPS; the state of the tide should also be recorded, since this will significantly affect water depth; running profiles with the depth sounder requires maintaining a stable compass bearing, with the GPS position recorded at the time of each sounder record; the depth sounder should be calibrated occasionally with the sounding line	significant changes in coastal bathymetry may be explained by changing river discharge and sedimentation patterns, and by extreme weather events	evident deposition or erosion areas may require a management response (dredging or erosion prevention)

4.5 Beach profiles (erosion and deposition on shore) **Status:** 4 profiles at Monkey River and 2 at West Snake Cay have been measured and plotted; Punta Negra profiles to be completed over the next few weeks	4 profiles at Monkey River, 2 at West Snake Cay, and 3 profiles at Punta Negra	once every three months at Punta Negra and West Snake Cay; every month at Monkey River	stake and level profiling	beach profiling requires that a benchmark is in place for each profile and that each profile can be accurately repeated (the same starting point and compass bearing) at each observation period; a photograph of each profile helps with relocation; two people are required to undertake these observations and they need to be trained in how to make the measurements and record the data correctly (completed for TIDE and Monkey River Group)	changes in beach profiles indicate changes in sediment supply to coastal areas, sandmining problems, changes in river discharge, and alteration of nearshore oceanographic processes which influence sand supply to the beach	rapid changes in beach profiles (especially accelerated beach erosion) will require management interventions

5. Nutrient inputs to coastal areas 5.1 Ammonia, phosphates, and nitrates **Status:** First set of nutrient data generated for all stations on Sept. 26	2 stations at the mouth of Rio Grande; 2 stations at the mouth of the Monkey River; 2 stations at the mouth of the Moho River (a spatial control); 2 stations at Inner Sheepshead; 2 stations at Bob Stuart Lagoon; 2 stations at West Snake Cay; one additional station has been added about one kilomtere upriver on each river; water samples for nutrients collected about a metre below surface	water samples for nutrients should be collected every two weeks	discrete water samples for nutrients collected with a Kemmerer water sampler, chemically treated in the lab for colour, and then analyzed with a visible range spectrophotometer	water samples will follow the HACH specifications for nutrient analysis (detailed manuals have been left at TIDE); running of blanks, spikes, and duplicates for one in ten samples will maintain quality control/quality assurance standards	elevated nutrient levels can indicate the presence of fertilizer, human sewage, animal waste, or runoff from shrimp ponds; these inputs to coastal areas can in turn produce changes in coastal habitats	time-series tracking of nutrient levels (changes over time) or between areas may indicate local contamination problems (from altered land use); individual watersheds or specific coastal areas may be isolated for management intervention

6. Contaminant inputs to coastal areas 6.1 Pesticides **Status:** sediment samples were first analyzed in June; additional samples from Rio Grande and Monkey River being analyzed now	additional sediment samples should be taken from the mouths of the Moho River, Rio Grande, and Monkey River (done in September/99)	at least one more suite of samples for chlorinated pesticides (currently being analyzed); depending on results, additional samples may be required	grab sampling, proper handling and storage of samples, and analysis by gas chromatography - electron capture detection (in Halifax)	standard lab QC/QA to be applied	elevated pesticide levels would indicate contamination of coastal sediments caused by farm or plantation inputs	pesticide contamination of coastal sediments would be a cause for concern (coastal habitats and human health); better pesticide management would be required
6.2 Metals **Status:** sediment samples were first analyzed in June; additional samples from Rio Grande being analyzed now	sediments from the mouths of the Rio Grande, the Monkey River, and the Moho River	at least one more suite of samples for analysis of arsenic and mercury (which are elevated in the Rio Grande sediments); currently being analyzed	grab sampling, proper handling and storage of samples, and analysis by metal scan in the Seatech lab in Halifax	standard lab QC/QA to be applied	arsenic and mercury contamination can be caused by fungicides, wood preservatives, and processing of gold in small-scale and commercial mines	confirmation of the elevated levels of arsenic and mercury in the sediments of the Rio Grande would raise serious concerns about human health in this area, and would necessitate further analysis to isolate the source of metal contamination

7. **Solid waste inputs to coastal areas** 7.1 Solid waste washed onto beaches **Status:** to be set up as a student and community activity in the next few months	beach at Monkey River, Punta Negra, West Snake Cay, and Punta Gorda (north of TIDE office)	once at the end of the dry season and once at the end of the rainy season	community collection of all solid waste within a 20-metre swath of the beach (depending on the size of the beach)	a protocol will have to be established for collection and identification of solid waste	type, volume, and weight of solid waste may indicate whether contamination is occurring from local sources, boats, or more remote areas	time-series analysis of the solid waste collected from the beaches should indicate whether the waste problem is stable or increasing; waste management should be encouraged

8. Shoreline and coastal habitat evolution 8.1 Shoreline configuration and macrohabitat characteristics **Status:** two sets have been completed (June and Sept.); Maya Island Air has formally agreed to arrangement and Punta Gorda pilot briefed for routine photography every two weeks, starting Oct. 10	fixed photo areas at the mouth of Monkey River, the mouth of the Rio Grande, and selected mangrove cays in Port Honduras (depending on the flight path of Maya Island Air); Inside Sheepshead and Bob Stuart Lagoon confirmed with Carlos Zablah (pilot)	once every two weeks	pilots at Maya Island Air have agreed to take photographs of selected sites from a fixed altitude during routine flights between Punta Gorda and Belize City	there may be some initial difficulty in establishing pilot recognition of each of the photo plots and getting consistent photographs at the same altitude; some trial and error may be required; a protocol for provision, collection, and processing of film will has been established	these aerial photographs probably cannot be used for any exact area or density analysis, but basic changes in shoreline configuration, the nature of the mangrove fringe, and nearshore bedforms, seagrass beds, and patch reefs can be detected	changes in shoreline configuration and features of coastal macrohabitats may indicate changes in river discharge, sediment inputs, or deterioration of habitats due to overexploitation of resources or contaminant input, and should be used to cue a management response

8.2 Mangrove habitat **Status:** plots at Monkey River, Inside Sheepshead, and Bob Stuart Lagoon have been set up and measured; remaining plots at Rio Grande and Moho River to be set up over next two weeks	selected plots up to 25 square metres at the creek north of Monkey River, at Inside Sheepshead, Bob Stuart Lagoon, at the Rio Grande, and Moho River; plots selected on the basis of ongoing recruitment (presence of seedlings); 2 plots at each site	observations every four months	the plots should be roped off (clearly marked and easily found); photographed from the same position at each observation period (horizontal and into the canopy); species identification and all seedlings counted (absolute density in the plot); nine seedlings selected and tagged for measurement of total height and diameter at tag level (just above the propagule); ancillary observations of sediment type, degree of inundation, and canopy cover	the exact size of the plots will be checked against what can feasibly be counted and measured at the first sampling period (plots established to date range from 11 to 29 square metres - some plots are very difficult to access and have reduced size); absolute differences between sites will be less important than the rate of change of the individual plots over time	mangrove habitat characteristics depend greatly on the salinity regime, sediment type, and degree of exposure to waves (for example, storm-induced); changes in physical/chemical parameters in the study area may be reflected in the observations of mangrove habitats; resource use in mangrove swamps can obviously impact on the habitat as well	rapid and significant changes in mangrove habitat would be a cause for concern, but it would be difficult to isolate specific causes of habitat changes

8.3 Coral reef habitat **Status:** all photoquadrats were set up and photographed on October 6	selected photo plots at West Snake Cay and at selected patch reefs near the mangrove cays in Port Honduras; set up on Oct. 6 included 3 coral quadrats at each of West Snake Cay, Inside Sheepshead, and Bob Stuart Lagoon	recommend every 4 months or minimum once towards the end of the dry season and once at the end of the rainy season, depending on observed rate of change	white frame quadrat (113 x 68.5 cm) fixed on opposite corner re-bar pins; photo plots should be selected on the basis of dominant live coral cover; clearly marked for photo purpose (with a numbered subsurface buoy), and position recorded so that the site can be re-visited; the plot should be shallow enough that it can be photographed while snorkelling (using the disposable, submersible camera); 2-3 metres is optimal; photographs will be analyzed for changes in live coral cover, presence of algae, and other invertebrates; 3 photographs of each quadrat each time, at least 2 vertical and 1 oblique	it is important that the plots are photographed in the same manner and at the same height above bottom each time and that light and sea conditions are optimal; some groundtruthing may be necessary to verify objects in the photographs; photos can be scanned to make JPEGs - the quality of these will have to be checked to ensure that area analysis can be undertaken; for shallow quadrats, two photographs are required (top half of the quadrat and bottom half, to be joined for analysis)	quality of coral habitat depends very much on water quality (low levels of SPM and low levels of nutrients); changes in coral reef habitat within the photo plots may be linked to the data on nutrients, SPM, and water temperature and salinity	the coral reefs in the study area are already very stressed; the area data from the photographs may indicate continued recruitment failure, algal overgrowth or, possibly, improved live coral cover, depending on the influences of global or western Caribbean factors and water quality changes induced by land use change in Toledo District

8.4 Seagrass beds **Status:** all photoquadrats were set up and photographed on October 6	selected photo plots at West Snake Cay; Inside Sheepshead, and Bob Stuart Lagoon (3 at each location)	recommend every 4 months or minimum once towards the end of the dry season and once at the end of the rainy season, depending on observed rate of change	white frame quadrat (113 x 68.5 cm) fixed on opposite corner re-bar pins; photo plots should be selected on the basis of dominant seagrass cover; clearly marked for photo purposes, and position recorded so that the site can be re-visited; the plot should be shallow enough that it can be photographed while snorkelling (using the disposable, submersible camera); 2-3 metres is optimal; photographs will be analyzed for changes in seagrass cover, evidence of blowouts, presence of algae and other epiphytes, and invertebrates 3 photographs of each quadrat each time, at least 2 vertical and 1 oblique	it is important that the plots are photographed in the same manner and at the same height above bottom each time and that light and sea conditions are optimal; some groundtruthing may be necessary to verify objects in the photographs; photos can be scanned to make JPEGs - the quality of these will have to be checked to ensure that area analysis can be undertaken; for shallow quadrats, two photographs are required (top half of the quadrat and bottom half, to be joined for analysis)	quality of seagrass beds is influenced by water quality (high levels of SPM inhibits growth and high levels of nutrients encourage growth of algae); changes in seagrass beds within the photo plots may be linked to the data on nutrients, SPM, and water temperature and salinity	the seagrass beds in the Port Honduras area appear to be in reasonably good condition; any perceived deterioration might be traced back to water quality changes and these to land use changes

9. **Dispersal and settlement of biota in coastal areas** 9.1 Recruitment on artificial substrates **Status:** all recruitment plates have been sampled and processed twice since full implementation at the end of July; missing plates at Monkey River and West Snake Cay have been replaced; seabed-facing plates have been added to new sets; set missing at Moho River Station #12 to be replaced within next two weeks	2 stations at the mouth of Rio Grande; 2 stations at the mouth of the Monkey River; 2 stations at the mouth of the Moho River (a spatial control); 2 stations at Inside Sheepshead; 2 stations at Bob Stuart Lagoon; 2 stations at West Snake Cay; each set of four recruitment plates to be moored about one metre above the seabed	all plates to be examined and one plate retrieved for analysis every four weeks	ceramic tiles (15 x 15 cm), with rough side exposed to seawater attached to a plywood board to be moored facing up (some tiles should be tried facing down to bias more to coral attachment); the dry weight of the tile and date of set-out should be indelibly marked on each tile and recorded in the logbook; basic observations should be recorded and one photograph of the set of plates taken before the targeted plate is retrieved; the retrieved plate should be stored wet in a ziploc bag; detailed visual observations and counts should be made on the wet tile; a Conectix digital camera is used to record each plate(while it is damp, but not immersed in seawater) in the office and create a JPEG file; this file can then be analyzed digitally; however, basic observations on percentage cover of the plate by coral, algae, and various invertebrates should also be noted; after all observations have been made and the plate photographed, the plate should be sun-dried to a stable weight (avoid areas where ants can consume the tissue), then the dry weight with tissue determined to two decimal places (grams); dry weight with tissue minus dry weight of tile before set-out = dry weight of tissue	the plates that are being retrieved should be placed in individual ziploc bags with some seawater and kept wet until observations are completed; observations need to be made as soon as possible, to avoid degeneration of the sample	recruitment of algae, coral, and other invertebrates on ceramic tiles should reflect the standing stock of these communities in the local area (recruitment potential) and the prevailing water quality (such as nutrient concentrations and levels of SPM); these observations are to be made at the same locations as those used for water quality analysis; direct correlations between the two sets of parameters should be possible	significant differences in recruitment between areas may indicate local areas of stress or recruitment failure; dominance of algae may indicate a nutrient-rich environment, which might be traced back to specific sources to be better managed

9.2 Characteristics of soft sediment macrobenthos **Status:** protocol has been discussed; samples to be collected in about 4-6 months; some test sampling to be done in the meantime	at the 50 stations specified for grab samples of sediments	once per year at the end of the dry season	duplicate grab samples should be sieved through 1 mm mesh and samples of biota retained in 30% isopropyl alcohol; biota should be identified only to a higher taxonomic level, wet weight and density of each taxon then recorded	benthic biota can be very difficult to identify; identification only to higher taxonomic levels should help with this, while still retaining enough information to make the analysis useful	the composition of the benthic community is highly dependent on sediment type and salinity; changes in these parameters might be reflected in the benthos	the benthic community, acting as a long-term integrator of changes in physical and chemical conditions in sediments, might be used as a sentinel by coastal zone managers, especially in the Port Honduras area, where soft sediments appear to prevail
10. Coastal resource use 10.1 Fisheries landings data **Status:** discussions to be held with fisheries officers	fisheries landings data for Punta Gorda	annual data to be examined	there appear to be some problems at the moment with collecting and recording fisheries landings data, because of the absence of a cooperative in this area; a system of representative recording of data for 5-10 fishers could be instituted with the two fisheries officers in Punta Gorda	fisheries landings data are notorious for being inaccurate and difficult to interpret; perhaps some sentinel species could be recorded to give more focus to the data collection programme	fisheries landings generally reflect exploitation rates more than environmental factors; however, there might be some correlations between landings data and coastal habitat quality	this data collection programme would have to be instituted by the Fisheries Division, in consultation with TIDE; significant changes in landings data for sentinel species might cue fisheries or environment management interventions

4. Data Sets Generated to Date and Initial Interpretation

The maintenenace of quality by using documented methods for reporting field and analytical data (through controlled pre-established templates) was stressed throughout the latest trip and was formally installed in a specific training session on Quality Assurance and the ISO 9000 system. The Coastal Monitoring Project, in particular chemical and physical data, is very amenable to a simplified ISO 9000 system, and such a system was set up. The documentation for this system includes a Quality Manual, Procedures Manual, Work Instructions, and Report Forms. To maintain quality assured data, it is essential that the Quality System be maintained . This should be achievable, since all templates were used well by the local consultant for the project (Mr. Karl Castillo). Additional quality assurance has been and will continue to be provided by review of spreadsheets submitted by TIDE for quality review via e mail to Maridev (and Seatech).

Quality of data can be assured by following the Quality Assurance Manual (which is noted in the Appendix). The quality of the data is relative to the capability (training, equipment, procedures) used to produce the data. Thus, for physical and chemical parameters, limits of detection have been established that, although not as low as is technically possible (with more sophisticated techniques), are both useful in providing early warning of negative environmental impacts in the coastal zone, and within the capability of TIDE.

The major chemical analytical procedures are based on HACH methods (in turn, these are based on Standard Methods), adapted for seawater (which can cause high blanks, some interferences, and variability) and other standard methods for seawater. The limits of detection and expected accuracy developed during the training at TIDE are noted below:

Water level	1/4 inch
Salinity	0.5 ppt
Temperature	0.5 degrees C
Secchi	0.25 metre
Depth	0.25 metre
Ammonia	0.1 mg/l as N
Nitrate	0.4 mg/l as N
Phosphate	0.1 mg/l as P
Suspended Solids	4 mg/l (also called Suspended Particulate Matter, SPM)
Sedimentation Rates	10 g/m2/day (sediment trap data)
Beach profiles	2 cm vertical (for every 100 cm change) and 1 metre horizontal over 100 m distance

The instruments provided to TIDE (field and analytical) can read to a higher degree of precision than the detection limits noted above and may be reported more precisely, but conservative limits of detection are considered best for purposes of interpretation.

The appendix includes examples of all the data sets generated to date. These are briefly itemized

below, along with an initial interpretation of the data.

Water level:

- nine days of data were collected at the Joe Taylor Creek water level gauge up to the time of reporting; maximum water level variation during that period was 33 cm;
- water level gauging was also set up at Monkey River; observations during the first day indicated very little water level variation (minimal tidal influence, unlike Joe Taylor Creek).

Temperature, salinity, and secchi disk readings:

- the lowest surface temperatures (25.5 degrees) observed during the last set of observations on September 26 were found in the rivers (Rio Grande and Moho River); the highest surface temperatures (30.7 degrees) were observed at West Snake Cay;
- the Moho River and Rio Grande have typical salt wedges (higher salinity water under the fresh outflow); the Monkey River is predominantly freshwater until the mouth of the river, but there is an extensive surface plume of low salinity water extending away from Monkey River;
- the lowest secchi readings are in the Rio Grande and the Monkey River plumes; the highest secchi readings (clearest water) are found at Inside Sheepshead and Bob Stuart Lagoon, followed by West Snake Cay.

Circulation (drift):

- only one surface drifter has been returned to date, indicating a net south-southwest drift at 0.63 km/hr from the mouth of the Monkey River (impacting the beach north of Punta Negra).

Suspended particulate matter and trapped sediments:

- the highest values of suspended particulate matter (in discrete water samples in September) were observed near the mouth of Rio Grande, in the Monkey River, and at Inside Sheepshead;
- four sets of sediment traps have been processed; the average sedimentation rate for the whole set of twelve stations has increased at each interval, such that measured sedimentation rate at the end of September was about 3.5 x higher than the rate measured at the middle of August; rainfall increases may have contributed to this trend, but data still need to be checked;
- during the first three sampling periods, the sedimentation rate at West Snake Cay was usually the lowest, along with Bob Stuart Lagoon; this trend was skewed during the last sampling, with the lowest sedimentation rate recorded at Monkey River, and higher than usual rates at West Snake Cay, which suggests some diversion of the Monkey River plume away from the coast (which would be picked up in the coastal sediment traps) and further offshore (near the Snake Cays); this pattern in the plume was in fact seen from the air on October 9 (with the Monkey River plume clearly visible within one kilometre north of Middle and West Snake Cay);
- in general, the highest sedimentation rates are observed off the Rio Grande, with the exception of the last sampling period (Oct. 1) when sedimentation off the Moho River was extremely high.

Surficial sediments:

- 50 surficial sediment samples have been collected from Moho River in the south to Monkey River in the north; these samples are presently being sieved; however, visual observations indicate a higher incidence of silt and clay in the samples from deeper water, as expected, which

implies that there are several sediment sinks in Port Honduras.

Beach profiles:

- six beach profiles have been completed (4 at Monkey River; 2 at West Snake Cay); West Snake Cay has undergone significant beach erosion and reformation in the last three months; the Monkey River beach profiles require a time-series for interpretation of erosion.

Nutrients:

- nutrient analysis was initiated on Sept. 26; ammonia was not detected in the samples; phosphates above the detection limit were observed up the Monkey River and in Bob Stuart Lagoon; fairly high levels of nitrates were also observed in the Monkey River; the latter observations are consistent with fertilizer inputs to the Monkey River; the phosphates in Bob Stuart Lagoon are not readily explained.

Pesticides and metals:

- these were reported previously; sediment samples are being analyzed again for chlorinated pesticides and arsenic and mercury.

Aerial photographs:

- there are two series of aerial photographs which cover the Monkey River, some of the mangrove cays, and Rio Grande; the spit on the south side of the mouth of Monkey River has been significantly eroded since June, 1999.

Mangrove plots:

- two mangrove plots at each of Black Creek (just north of Monkey River), Inside Sheepshead, and Bob Stuart Lagoon have been surveyed; the mangrove plots near Monkey River are in a mature mangrove forest and have extensive seedling recruitment (mixed red, black, and white mangroves); the plots at Inside Sheepshead and Bob Stuart Lagoon are representative of red mangrove shore habitat, and the seedlings are therefore dominated by red mangroves (but much less dense than the plots near Monkey River); most plots show recruitment of seedlings from propagules apparently dropping in the last three months.

Coral and seagrass habitat:

- 18 photoquadrats were established covering seagrass and coral habitat at West Snake Cay, Inside Sheepshead, and Bob Stuart Lagoon; the coral habitat at West Snake Cay was very stressed, with only small patch of boulder coral being evident; the seagrass habitat at West Snake Cay comprosed *Thalassia* and *Syringodium*, whereas the seagrass habitat near the mangrove cays was dominated by *Thalassia*; coral habitat at the mangrove cays comprised small patches of boulder coral in a predominant seagrass habitat.

Recruitment plates:

- where recruitment of algae and invertebrates is naturally high, the rate of settlement and growth on the plates was very high; the greatest production of biological tissue was evident at Rio Grande, followed by the Moho River, and the mangrove cays in Port Honduras; settlement and production was very low on the plates at Monkey River and West Snake Cay (the northernmost

stations); no obvious coral settlement was observed; there was extensive settlement and growth of barnacles near the Moho River and the Rio Grande, and growth of algae.

An initial review of the data confirms, we believe, that the appropriate parameters are being monitored in the correct locations and that the detection limits are adequate to serve as "sentinels" of coastal environmental condition. This is discussed further below.

Since one of the past concerns in the Port Honduras area has been coral die-off, which may be due to elevated seawater temperatures, temperatures above 31 degrees, or frequent extreme fluctuations in temperature, could be considered a trigger for concern in this area. Similarly, prolonged low salinity conditions offshore, or expanded areas of low salinity, would be cause for concern. Low secchi readings in areas that are normally clear would also indicate unusual turbid conditions.

Levels of concern for nutrients are initially recommended at 0.5 mg/L (ammonia, nitrate, or phosphate) and suspended particulate matter (SPM) at greater than 50 mg/l. Values higher than these levels would indicate unusual inputs (such as fertilizers) or exceptionally turbid conditions (perhaps caused by land clearing). Sedimentation rates (from trap data) of greater than 150 g/m2/day (15 mg/cm2/day) should be considered injurious to corals and may affect seagrass beds (based on data in the literature). However, this is a generalized statement and Port Honduras corals and seagrass may possibly tolerate different levels of sedimentation (in this naturally turbid area). It is expected that after about five or six more sample sets (i.e., in about 3 months), a further assessment could be made of the collected data and a more specific recommendation made as to the levels that should be used as management triggers in the Port Honduras area.

The data for contaminants can be addressed more specifically. Just the presence of chlorinated pesticides in river sediments would be a cause for concern. Similarly, the presence of arsenic and mercury above the analytical detection limits would be a concern (the high levels found in one sample from the Rio Grande in June are being further investigated).

The biological parameters can be used as management cues as well. For example, with the mangrove plots, the loss of exisiting recruits in the plots, or the absence of new recruits during a normal propagule season, or reduced growth rates of tagged seedlings, would all indicate stress on the plot. With the photoquadrat observations, a reduction in seagrass cover, or further loss of coral cover (or no significant increase in coral cover) would also indicate stresses in these habitats. With the recruitment plates, reduced production of biological tissue, or a significant change in the community settling and growing on the plates, would indicate a change in the water quality or reduced stock producing spores, larvae, etc.

As noted above for the physical and chemical data, it will be important to examine the time-series data for the biological parameters in about 3-4 months and determine trends that may inform what changes should be set as management cues.

5. Training and Extension Aspects of the Project

Training was carried out by using "on-the-job" training techniques, in which the procedure is first reviewed with the trainees, equipment is explained, and then a test run is undertaken at a nearby location (e.g., bridge or wharf). For physical/chemical parameters, samples produced at this stage are analyzed along with quality control samples (standards, blanks and duplicates) and compared to the quality of data deemed acceptable for this project. For any non-conformances that may occur, the cause is discussed and samples are re-taken for repeat analysis. Once these samples are within conformance, then sampling of the actual field stations is undertaken. During this work, all collection, holding, analysis, and reporting are done by the trainees, with observation and supporting instruction by the training consultant. The consultant acts as an "auditor" and provides a final QA/QC check.

For the biological parameters, the training involved team implementation of the mangrove plots and photoquadrats, as well as collection and processing of recruitment plates. Karl Castillo and assistants were responsible for all field notes and data entry, which was then checked and entered to spreadsheets by the consultant (John Carter).

Due to the existing high level of training of the local consultant (Karl Castillo) and his existing experience as a teacher, there were no significant problems experienced with the training elements of the programme. Karl was also responsible for extending his training experience to others (this was monitored through training-the-trainer techniques and watching him in action as a trainer). Training was extended to the Monkey River Group during the trip and has been provided to university students on a regular basis (they are involved with each of the field trips). The people who have been exposed to training within the coastal monitoring project over the last few months are listed below:

Monkey River Group:
- Barry Young;
- Derwin Weatherburne;
- Clive Garbutt;
- Doyle Garbutt; and,
- Hudney Garbutt.

(The equipment for the Monkey River Group was left with Barry Young, and includes the secchi disk, the refractometer, thermometer, compass, beach profile stakes, measuring line, water sampler, water level gauge, field notebooks. Training at Monkey River involved the use of all this equipment.)

University College of Belize Students (Field Ecology Class):
- Omar Arzu;
- Felicia Mes;
- Disraeli Bol;
- Rosita Mes;
- Arelec Chawarria;

- Oren Nunez;
- Elizabeth Garbutt;
- Sonia Juarez;
- Carla Paulino;
- Miriam Muschamp; and,
- Godwin Humes.

In addition to the students listed above, who have been involved in several field trips each, another student, Derek O'Brian, has been involved in most field trips.

A technical person from ESTAP (Marcel) also participated in the physical/chemical training.

TIDE now has the capabilities, including personnel (Mr. Karl Castillo, support staff, student volunteers, and the Monkey River Group), training, equipment (provided by the project), and documented written procedures (provided by the project), to effectively monitor changes in the Port Honduras area that may be caused directly by the highway construction or by subsequent expansion of other activities (plantations and aquaculture).

6. Summary of Remaining Tasks for Monitoring Implementation

The following is a summary of remaining tasks, following directly from the implementation activities over the last three weeks. This list should serve as a workplan for Karl Castillo and TIDE in the near-term, to ensure that all elements of the coastal monitoring programme are put in place properly. The activities below should be addressed in addition to the routine activities already established.

- create a template (spreadsheet) for the weather observations and collect weather data on a daily basis at the TIDE office;
- continue daily water level measurements at the bridge at Joe Taylor Creek and collect the Monkey River water level data from the group there every week;
- collect the salinity, temperature, and secchi data from the Monkey River Group every week;
- release more surface drifters (include Spanish on the cards) in about 2-3 months;
- add three more stations about 1 km upriver, on each of the Moho, Rio Grande, and Monkey River, for water sampling;
- dry sieve the surficial sediment samples over the next 2 weeks;
- complete 3 beach profiles at Punta Negra within the next 2 weeks, and collect the beach profile data from the Monkey River Group every month;
- organize a public campaign for solid waste clean-up on the specified beaches in about 2 months;
- maintain the photo protocol with Maya Island Air, with provision of film and processing of photos every two weeks;
- set up two mangrove plots at Rio Grande and two plots at Moho River within the next two weeks;
- check that the photoquadrats are still marked with subsurface buoys (about a month from now);
- replace the missing set of recruitment plates at Moho River Station #12 within the next two

weeks;
- test the grab and the sieve box (to be made up according to discussions) for collection of benthos (animals in the marine sediments); then implement collection of benthos in January;
- discuss specific fisheries data collection with the Fisheries Officers;
- secure the lab, to ensure that it is watertight, and protected from wind;
- keep sending completed data sets (after quality assurance) to the list of e-mail addresses;
- convert the wordperfect tables (with the biological data) to Excel spreadsheets;
- follow-up on TIDE website hosting in Nova Scotia;
- facsimile machine, computer, and modem to be shipped and picked up at the airport in Belize City (end of October);
- ongoing assistance via the internet regarding data interpretation, and taxonomy of biota; and,
- follow-up with the Fisheries Department regarding the formal permit for the coastal monitoring programme.

7. Sustainability of the Initiative

The main ingredients of sustainability of the coastal monitoring initiative in Toledo District are equipment and required infrastructure, staff with suitable capability to continue the monitoring, financial resources for the immediate term, government and public support of the initiative, and the existence of related service requirements which can be provided by TIDE to permit future cost recovery. These are discussed below.

Equipment and Infrastructure:

All equipment provided by the project has been confirmed to be working properly. Karl Castillo has been trained in all aspects of the use of the equipment and ongoing cleaning and maintenance have been emphasized. There has been only a very low level of loss of moored gear in the water, and in fact this has stabilized over the last two months (there is only one set of recruitment plates missing at the moment). With ongoing maintenance, the analytical and sampling equipment should last at least five years. Gear that is in the water constantly (sediment traps and recruitment plates, water level gauges) may require replacement at more frequent intervals.

The facility chosen for staging field trips and analysis, adjacent to the boat launch area and across the road from the TIDE office, is well located for ease of loading gear and delivery of samples. The location has adequate space and has been plumbed and powered to sufficient level for an analytical laboratory. This location is actually superior to the previously chosen location (in the washroom facilities adjacent to TIDE).

However, as a long term facility, there are two major drawbacks that should be addressed.

1. The lab roof has leaked once already (however, the equipment was covered and no damage occurred). The roof is currently being replaced.

2. The facility is open to the air and ingress of insects, dust, high temperatures, and humidity. Although the temperature and humidity are within specifications for the electronic equipment present in the lab, the operation of this equipment is compromised by the open nature of the laboratory (e.g., wind drafts affecting the balance; humidity forming condensation on electronics, ants eating the tissue on the drying recruitment plates, etc).

If TIDE eventually moves offices (further north on the coastal road), the constraints in the laboratory arrangements can probably be addressed.

In addition to the sampling and analytical equipment already provided by the project, a facsimile machine and new computer and modem are also to be provided, to relieve the pressure on office equipment which the project has been imposing. A cover for the sampling boat will also be provided, since at the moment no shade is provided while working the gear.

Staff Capability:

Staff capability has already been discussed (see section on training and extension aspects). With Karl Castillo as principal investigator and a cadre of community members (students and the Monkey River Group) to help with sampling on a regular basis, TIDE is fully capable of continuing with the coastal monitoring programme as designed. Ongoing technical support will be provided by the project via e-mail. This may be required for identification of biota and interpretation of data generated by the programme.

Financial Resources for the Immediate Term:

With the remaining project budget and using the current unit costs for labour dedicated to the project (as reported by TIDE), it is estimated that there are sufficient project funds (for local fees, gas for the boat, processing of photos, etc.) to maintain the coastal monitoring programme at the specified level of effort for about another 7-8 months. Enough chemicals and other lab expendables have been provided to keep the lab operating for a year. This means that the coastal monitoring programme will eventually have been supported for a year within the project budget (this does not include consultant technical support after the end of October, 1999).

However, it is important to sustain the coastal monitoring initiative for an indefinite period. This can be achieved if there is cost recovery on the laboratory, and services can be provided by TIDE to other clients. This is discussed further below.

Cost Recovery of Laboratory and Field Services:

Sustainability ultimately means the ability to maintain quality of services and data, while being financially viable and marketing the services effectively.

For any facility, financial viability can be estimated based on general business principles. The market

viability is much harder to estimate, especially in areas where there is not a history of a market for laboratory services.

With regard to market potential, three related organizations appear to have requirements for laboratory and field services in Toledo District. They are:

- ESTAP: responsible for sampling streams and aquaculture facilities in the area of the Southern Highway. The sample and analytical requirement may be in the order of several hundred per year.

- CZMU: responsible for monthly monitoring at 12 monitoring stations in Port Honduras, generating in the order of 150 samples per year. These may have specialized analytical requirements not amenable to TIDE's capabilities, but perhaps partial services can be provided (e.g. sample collection, some analyses such as SPM).

- DOE (Department of Environment): has requirements to monitor in southern Belize (Toledo District), but at this time has no presence in the area. Analytical requirement estimated at approximately one hundred samples per year for analysis of effluents.

In addition to these organizations, the operators of plantations and aquaculture facilities (private sector) should have a requirement to monitor their effluents or inputs (or processes) for environmental impact assesment, or just for optimization of the operation (i.e., no plantation would want to over-fertilize, if the excess is just getting washed away). It is probable that in order to get these private sector organizations to send samples to TIDE or retain their services in some way would require an educational marketing effort. In total, the private sector may require 100 to several hundred samples per year to be analyzed.

In addition to these immediately obvious sampling and analytical requirements, there may be more remote clients (Guatemala and Honduras) or specific projects (such as the Mesoamerica Coral Reef Project or a proposed Tri-National coastal monitoring project), which have sampling and analytical components, which could in turn create an additional demand for TIDE services.

If TIDE is to start receiving samples from other organizations, their Quality Management system must be adapted to handle Customer Supplied Samples (Product). This project has only addressed sampling, analysis, and Quality Management for the Coastal Monitoring Programme in the Port Honduras area. However, the existing Quality Management System could be adapted to handle sustomer supplied samples.

Financial sustainability can best be estimated by taking salary rates and using an appropriate multiplier (to cover general overheads, lab supplies, equipment, etc). The multiplier must be chosen with some care. If this number is too low, the organization will not be sustainable because it cannot make enough to cover overheads. If the multiplier is too high, then the resulting cost of analyses is uncompetitive. Once the multiplier has been determined, then the actual revenue cost per sample can

be estimated and compared to what the market value is expected to be. The cost of analysis as determined by this calculation can be higher or lower than the market accepted value (representing an uncompetitive or competitive position, respectively). The next step is a back calculation based on costs of the facility (equipment amortization, contribution to overhead, cost of supplies, and labour costs). This total cost is divided by revenue per test (or sample, if there are multiple tests) to determine the total number of tests and labour required for cost recovery. If the labour required exceeds a work year (allowing for statutory holidays, vacation, sick time and administrative time), then the facility will have a hard time supporting itself (i.e., there is not enough work time to generate the revenue).

For the TIDE coastal monitoring facility, these calculations have been made with the assumptions noted below (all $ are Belize 1999 dollars):

Assumed Local Consultant		
hourly rate:	$12.50/hr	
Multiplier:	3	(allows for overheads, etc.)
Time to do ten tests:	2.5 hours	(includes set up, cleanup, analysis, QC samples, report)

Cost per test = ($12.50 x 3 x 2.5)/10 = $9.38/test (test = ammonia, or SPM, or nitrate, etc.)

Based on costs in other parts of the world and costs considered reasonable for Belize (conversations with Eugene Ariola, Sept. 1999), the range of acceptable costs per sample appears to be $10- $11; thus it appears that TIDE should be able to provide the service at market rates.

The annual cost of the facility (for the laboratory portion) is calculated as follows. The lab has major capital and support capital costs of an estimated $13,000 Belize (approximately $9,500 Canadian). Amortized over five years at 10%, this is $3,300/year.

The labour cost is the salary of the single employee at this time ($25,000/year). The contribution to overhead is perhaps the most difficult number to estimate., It has been assumed that 50% or $12,500/year is suitable. Numbers up to 100% are sometimes common where there is more expensive space and more management services to support. 50% has been assumed, due to the low space costs and small management structure at TIDE. This assumption may have to be revisited in the future.

The supplies, or variable cost, ranges from 80 cents to $1.80 for chemicals/test, including control sample chemicals (i.e., 20% of all samples). It is assumed for simplicity of calculation that $1/test represents the cost of supplies. It appears that the purchase of supplies in-country carries a high cost, relative to importing from Canada. If supplies are purchased in-country, then a variable cost of $2/test would represent supplies.

Annual costs are then summarized as follows:

Equipment amortization	$ 3,300
Salaries	25,000
Overhead contribution	12,500
Total	$40,800

Gross revenue per test is estimated at $10/test; thus, net revenue is $9/test (i.e., subtract $1 supplies cost).

To support the $40,800 annual operating cost, 4,533 tests ($40,800/$9) must be undertaken. The amount of time to undertake 4,533 tests is 1,133 hours (4,533/10 x 2.5). The work year is 2,080 hours (52 x 40). Allowance for statutory holiday (15 days), vacation (10 days), and sick time (6 days) reduces this by 248 hours. Allowance also has to be made for administrative time (e.g., upgrade training, administration tasks, etc). This is generally allowed at 15-20% of total time. When using 15%, the administration time is 312 hours. Thus, net work time available equals:

Work year	2080 hrs
Vac/stat/sick	-248 hrs
Admin time	-312 hrs
Available work time	1520 hrs
Required breakeven	1133 hrs

Thus, for laboratory work, there is sufficient time and revenue (based on $10/test and 4,533 tests) to support the lab. There is even some time left over (approximately 400 hours).

However, time must be budgeted for other activities, such as sampling and retrieval of traps and recruitment plates (50 days/year = 400 hrs). Thus, the local consultant would be fully booked to meet all these requirements. The revenue from fifty days of collecting samples has not been estimated at this point, but assuming that this is paid activity, with a blend of analysis (paid) and sampling (paid), the TIDE facility should be able to support itself, assuming marginal increases in labour (i.e., to help with sampling) and no increase in contribution to overheads. Rental of equipment has also not been factored in (it should perhaps be rented at 1% of replacement cost per day or 3% of replacement cost per week).

The number of tests at 4,533 per year would represent 1,134 samples (at 4 tests per sample, and thus $40 gross revenue or $36 net revenue). At present, the Coastal Monitoring Programme will generate 390 samples (15 stations 26 times a year), or 34% of that required for sustainability. The number of samples from other sources (such as ESTAP) could add another 20% or more.

The key question is: "Are there enough samples in reasonable reach of TIDE, amenable to their levels

of detection (some may wish lower levels of detection) to support their lab?" The question cannot be answered with full confidence; however, with three government agencies with a monitoring mandate in Toledo District, and other possible clients or projects, it should be possible to achieve cost recovery on the TIDE lab.

In this regard, efforts should be made to rationalize sampling, field testing and analysis in southern Belize (possibly also adjacent areas in Guatemala) to direct (if appropriate) as much work as possible to TIDE (this might generate savings to the people of Belize, in reducing the cost of government agencies working in Toledo District from Belmopan or Belize City). TIDE could also get directed work to use its boats and field equipment on a reasonable rental basis. Reasonable rental is generally 1% of item replacement cost per day (e.g., if the boat = $20,000, then daily rental should be $200; if the YSI 30 = $1,600, then rental = $16/day, and so on). Equipment should only be rented to qualified users or provided by TIDE technicians.

Although two basic premises emerge from this analysis (the coastal monitoring can continue with existing project funds for another 7-8 months; and there is a reasonable chance of cost recovery on the lab facilities, with a reasonable marketing effort), a few other points which would support the initiative should be made.

After the end of October, there are no project funds to support further technical assistance (through the consultants). However, regardless of funding, the consultants have committed to providing ongoing technical support via e-mail. A better arrangement would be to support 2-4 days per month of technical assistance for the next 6-8 months. A brief return visit about 3 months from now would also be beneficial in terms of checking the quality management system in place at TIDE. The technical support described above should include a review of the project data and data from other regions to better define the management trigger levels for each parameter in the coastal monitoring programme.

Although it is believed that the TIDE capability in coastal environmental monitoring has been established and it has a known life-span of at least another 7-8 months and possible cost recovery after that time, the possibility of donor funding for TIDE's coastal monitoring initiative should still be pursued. Some donor support for a further two years, while TIDE is developing its lab services and marketing, would be beneficial. Such donor support might be catalyzed by future project requirements, such as technical contributions to the Mesoamerica Coral Reef Project and a possible Tri-National Coastal Monitoring Project, in which TIDE could play a pivotal role in training emerging coastal monitoring agencies on the Caribbean side of Guatemala and Honduras, and help with development of small laboratories in those countries.

These future possibilities should be discussed by the Project Technical Committee. Regardless of such discussions, it is clear from the activities to date that TIDE is now in a position to carry on with coastal monitoring in Toledo District with a high level of self-sufficiency, and with the support of the local community.

APPENDIX

1. Table of Contents of the Lab and Field Manuals
2. Quality Management System for Coastal Monitoring in Toledo District
3. Instructions for Maya Island Air Pilots
4. Station Locations
5. Individual Data Sets
   Water level
   Temperature, salinity, and secchi disk readings
   Key station trip report
   Circulation (drift)
   Sediment trap data
   Surficial sediments
   Beach profiles
   Aerial photographs
   Mangrove plots
   Coral and seagrass habitat
   Recruitment plates
6. Photodocumentation of Project Methodologies

1.Table of Contents of the Lab and Field Manuals

Toledo Institute for Development and the Environment

Lab Manual

Prepared By:
Ms. Michelle L. Morrsion, B.Sc
Mr. Clive D. MacGregor, M.Sc.
SEATECH LTD.
Halifax, Nova Scotia
CANADA

October 8, 1999

Our File: P99-47

LAB MANUAL
Table of Contents

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Field Manual

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P:\1999\P99-47\fieldmanualfillers-mlm.wpd
Date Printed: October 8, 1999

seatech website address
www.seatech.ns.ca

FIELD MANUAL
Table of Contents

2.Quality Management System for Coastal Monitoring in Toledo District

SEATECH LTD.
Chemists & Environmental Scientists
958 Barrington Street, 2nd Floor
Halifax, Nova Scotia, Canada
B3H 2P7
email: seatech@seatech.ns.ca
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Toll Free: (877) 343-8090
24 HOUR EMERGENCY SERVICE (902) 422-2763

ISO 9002 QMI REGISTERED QUALITY SYSTEM
Certificate No. 008725

Our File: P99-47

RECOMMENDED POLICY AND PROCEDURES

QUALITY MANAGEMENT SYSTEM

COASTAL MONITORING PROGRAM

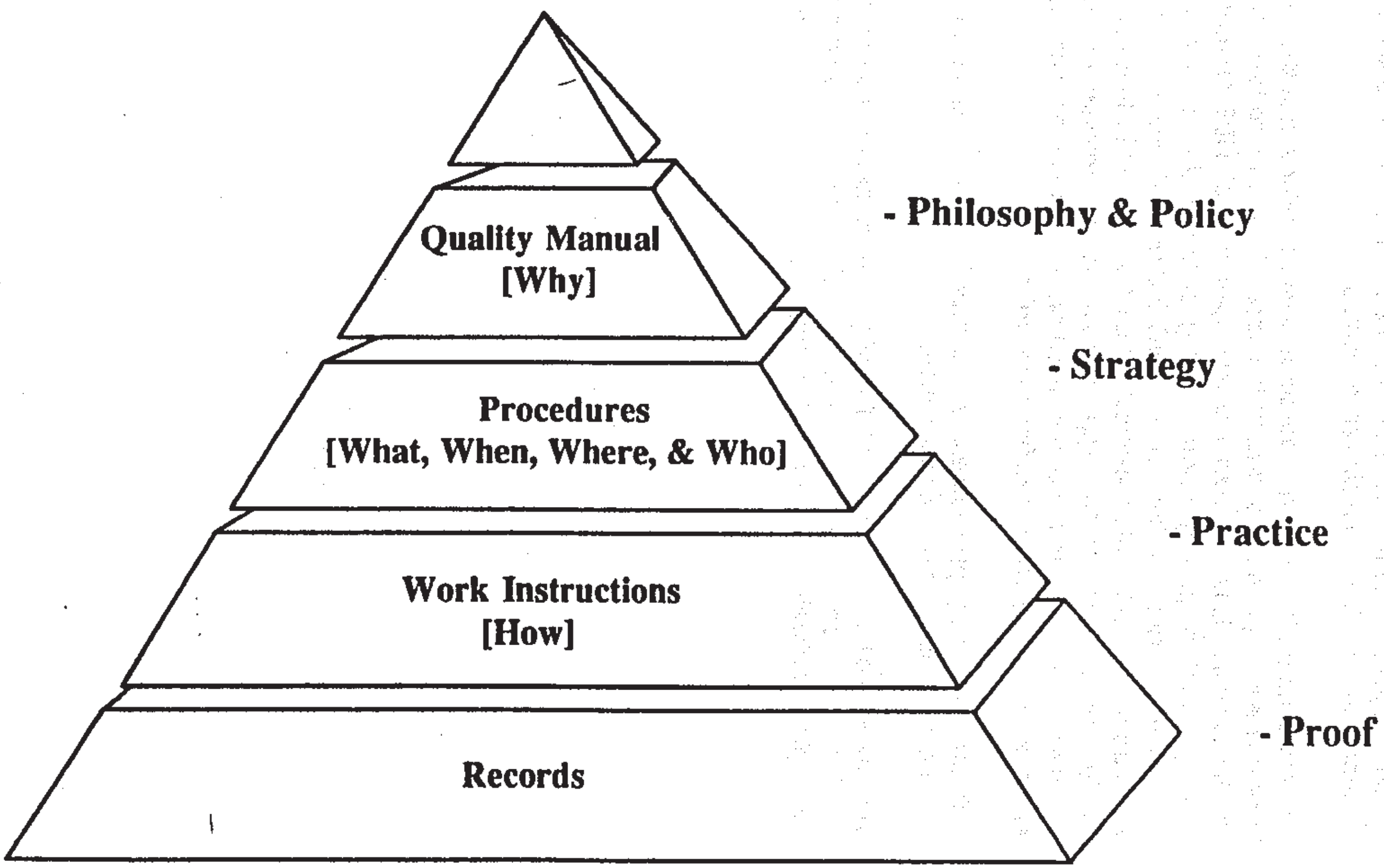
T.I.D.E., Punta Gorda, Belize

1.0 Introduction

A quality management system is similar to a pyramid (Figure 1.1) where policy developed by the management is set in place with operations and administrative procedures and detailed work instructions (with forms or records) provided for task in the organization. In reverse the quality policy is supported by well controlled written work instructions and procedures. These work instructions and procedures form the core for production of quality data for the Coastal Monitoring Program.

Developed below are some recommended policy and procedures for the Toledo Institute for Development and the Environment (TIDE) as discussed among participants in the September field trip to Belize. This proposed Quality Management System follows the ISO 9002 Quality Management System but is much less detailed than that system. It is not our intention for Quality Management within this project to install an ISO 9000 system, but without some Quality Management System in place any project will eventually begin to produce errors in their data in a random uncontrolled and potentially unrecognized manner, thus making the data invalid and unusable for management decisions.

Documentation Pyramid



2.0 Quality Management System Policy

Below is a policy statement for TIDE that we feel is reasonable and would be in general used by many organizations with similar mandates.

For the Coastal Monitoring Program and like services, it is the Quality Policy of TIDE to produce water quality data within it's capabilities and to levels of detection developed in the project. It is the management approach of TIDE to undertake work (eg water quality monitoring) only where training, equipment and written procedures with work instructions exist that have been validated by the review of an independent qualified professional. TIDE policy supports the efforts of all individuals to maintain trackable quality documentation to support analyses undertaken for the Coastal Monitoring Program. Once initiated in part or in whole, management is committed to reduction and elimination of any variances from the policy.

This manual (policy, procedures, work instructions, forms) is a controlled document and can only be amended under review as above.

The responsibility and authority for quality management rests with the executive director of TIDE and is delegated by him for the Coastal Monitoring Program to the senior consultant (principle investigator) hired to run this project (at time of this manual Mr Karl Castillo).

3.0 Quality Management System Procedures

These procedures are simplified from the ISO 9000 series of quality management documents. There are 20 sections, some which do not apply to all organizations. This outline is used as it is a standard throughout the world and any early introduction to it's format would be useful for quality management in any organization.

3.1 Management Responsibility

The executive director shall through regular meetings with management and staff ensure that the quality policy of TIDE is implemented and maintained.

The senior consultant (principal investigator) on the Coastal Monitoring Program shall ensure all staff working on this project understand the quality policy of TIDE.

All staff shall work within the documented and written procedures, ensure all quality-related issues are promptly brought to the attention of supervisory staff, and aid in the resolution of such issues. In cases of variance the written instruction shall supercede any verbal instructions.

3.2 Quality System

As covered in this manual. In a larger organization the control of the Quality System would be documented here.

3.3 Contract Review

All work requests regarding the Coastal Monitoring Program submitted to TIDE will be reviewed by the senior consultant to ensure the work requested is within TIDE's capability (eg limit of detection, environmental matrix, etc). The request and results of the contract review will be kept in both electronic and hard copy in the correspondence section of the Coastal Monitoring Project.

3.4 Design Control

This section does not apply to TIDE's operation.

3.5 Document and Data Control

The senior consultant to the Coastal Monitoring Project shall as a minimum maintain concurrent electronic and hard copy files for:

- Laboratory Data
- Field Data
- Sediment Trap Data
- Beach Profile Data
- Biological Data
- Reports

All electronic copies will be held in Excel for data sheets and in Wordperfect for text information.

All data will be recorded at the time of collection or analysis in a hardbound book, and

subsequently entered in the appropriate spreadsheet (record form) as found in:
Master Templates

The electronic data will be saved as: "namedaymonthyearinitials.file extension" in the appropriate file. For example ammonia analyses by Karl Castillo for samples collected September 26, 1999 would be given the following electronic identifier for its spreadsheet : "ammonia26sep99kc.xls" and saved in lab data, or a beach profile taken at Snake Cays along 280 degrees magnetic on 26 September , 1999 by Karl Castillo would be electronically identified : "snake28026sep99kc.xls" and saved in beach profile data.

Master template spreadsheets will not be amended without independent qualified professional. An amended template spreadsheet will have it's template date (numerical, day/month/year eg 26/09/99) changed to the date of the change to indicate a more recent template.

Examples of completed templates for the above are found in the appendix of this procedures manual. Since these templates may change refer to the Master Template list for current templates.

3.6 Purchasing

Purchasing will be preferred from companies with quality management systems. Supplies will only be purchased from a list of recommended suppliers for the equipment maintained under the Coastal Monitoring Project.

A list of recommended suppliers will be developed by the purchasing department of TIDE in consultation with the senior consultant for the Coastal Monitoring Project.

Quality will not be sacrificed for lower price.

3.7 Control of Customer Supplied Product

For a laboratory this means customer supplied samples. For the Coastal Monitoring Project this will not occur as all samples are collected by TIDE.

This may occur if TIDE accepts samples from other agencies and a quality management system will have to be put in place to control the receipt, analysis, reporting and invoicing of these samples.

3.8 Identification and Traceability

The senior consultant shall ensure that all samples and field data are traceable to their location and date of collection. All samples shall be collected in clearly numbered bottles or other suitable containers and these numbers traceable to location in the Port Honduras area. These numbers shall be recorded in the log book, subsequent field sheets, lab book and lab sheets as appropriate.

3.9 Process Control and Verification

All process control for sample collection, holding, analysis and reporting shall be controlled by the senior consultant for the Coastal Monitoring Project at TIDE. He shall verify that all samples collected have been returned and properly stored and that on days of subsequent

analysis that the samples analyzed are for the correct parameters and the correct locations.

He shall ensure collection is by the proper technique to eliminate as much as possible loss or modification to the sample, and is carried out in a safe manner following Safety Policy of TIDE. He shall ensure appropriate holding (temperature, length of time) prior to analysis. He shall ensure proper analysis following documented methods in this quality manual. Finally he shall ensure reporting is accurate and timely. Process control is maintained by rigorous maintenance of the use of templates and control of these templates (ie modification).

3.10 Inspection and Testing

This section refers to inspection and testing of the process and has been covered under Process Control and Verification.

3.11 Control of Measuring and Test Equipment

The senior consultant to the Coastal Monitoring Program at TIDE shall oversee the scheduling of all calibrations of test equipment and ensure proper records are maintained.

The equipment referred to in this section includes:

YSI 30 and 33 Salinity, Conductivity and Temperature field equipment
HACH DRL 2010 Spectrophotometer
Denver 3 place balance (0.001 gr)
Magellan GPS
Salinity Refractometer

The equipment is calibrated on a minimum as noted below:

YSI 30 or 33 every six months at three salinities and two temperatures.
Salinity refractometer every six months at three salinities.
Denver balance with a 100 mg weight every time it is moved or every thirty days.

HACH DRL 2010 during each set of analysis by running concurrent standards, blanks and duplicates
Magellan GPS by comparison at TIDE office to previous readings.

Any other equipment will be calibrated according to the manufacturers specifications, or as recommended in writing by a knowledgeable qualified professional.

3.12 Inspection and Test Status

The senior consultant at TIDE to the Coastal Monitoring Program shall be responsible for detecting non-conforming data. All such data detected shall be clearly marked "NOT VALID DATA" and this data shall not be released as a report, or in any other form except as necessary for resolution of the non-conformance.

The rest of this section is not required for the Coastal Monitoring Program for TIDE, but does become relevant when samples are to be processed from outside agencies.

3.13 Control of Nonconformity

Definition: A nonconformity is where a procedure, work instruction, or template is found to not

be the same as the written instruction (eg an analytical procedure used one day is not exactly as written, equipment does not operate as specified by the manufacturer, etc). In general it is when the action does not match the written procedure, that is it does not conform.

All staff shall endeavor to conform to written procedures and work instructions of TIDE.

Non-conformances shall be reported verbally as well as written (electronic preferred) to the senior consultant to TIDE on the Coastal Monitoring Program. These reports shall be kept and a preventative or corrective action undertaken according to procedures in this Quality Manual. For example if a work instruction is to be changed then the whole procedure must be rewritten, tested and submitted for independent review.

3.14 Preventative and Corrective Actions

The aim of undertaking any action is to prevent the occurrence of any non-conformances. The appropriate technical persons shall be consulted by the senior consultant to the Coastal Monitoring Project and their written input received prior to undertaking any preventative or corrective action. Prior to any action tests of the proposed action are recommended to confirm the desired result will be achieved.

3.15 Handling, Storage, Packaging Preservation and Delivery

This section has not been applied to a project the size of the Coastal Monitoring Project and is covered in other sections of this Quality Manual. However, this section is relevant when samples will be received from others for paid analyses.

3.16 Quality Records

Quality records means the documentation and maintenance of written documents for:

Personnel: basic qualifications and any upgrade or specialized training

Equipment: records of purchase, maintenance and calibration

Procedures, Work Instructions and Forms

All correspondence including non-conformances, corrective actions, customer inputs, qualified person's inputs, etc.

3.17 Internal Quality Audits

An audit is simply the regular checking of actual work versus the written work instruction or procedure. The audit is generally carried out by someone not involved in the work but competent enough determine whether the procedure or instruction is being followed as written.

It is recommended that TIDE undertake internal audits on a regular basis.

3.18 Training

The senior consultant to the Coastal Monitoring Program shall be responsible for arranging adequate training of staff working for him. He shall ensure that the persons are qualified to perform the tasks assigned, are familiar with Safety Procedures and understand the Quality

System as it applies to the task to be performed.

Training may be performed internally or externally as long it is consistent with the Quality Policy of TIDE.

All staff are required to read the policy and procedures manual within the first thirty days of joining TIDE for the Coastal Monitoring Project, and to understand by reading the work instructions they have been assigned.

3.19 Servicing

This refers to product produced that may be serviced and does not apply to TIDE (ie TIDE does not manufacture anything).

3.20 Statistical Techniques

For TIDES operations this section is not necessary. For larger labs it refers to control tables and statistical verification of analytical techniques. Since standard techniques are being used and were verified during project start up it is not required as long as control techniques (ie standards, blanks, and duplicates) are maintained.

This policy and procedures were produced by:

[signature] Date Oct 11/99
Clive MacGregor, M.Sc. Chemical Oceanographer, Seatech Ltd, Halifax, Canada

and reviewed by

[signature] Date Oct. 13/99
John Carter, M.Sc., Project Manager, Maridev, Halifax, Canada

and accepted by:

______________________________ Date ________________
Will Maheia, Executive Director, TIDE, Punta Gorda, Belize

Quality Control Check

3.Instructions for Maya Island Air Pilots

TIDE/IDB Coastal Monitoring Project

Instructions for Maya Island Air: Photographs of Coastal Areas in Port Honduras

Purpose:

TIDE is undertaking a community-based coastal monitoring project sponsored by IDB, which is intended to detect changes in the coastal zone of the Port Honduras area due to land use change, which in turn may be stimulated by upgrading of the Southern Highway.

This coastal monitoring includes detection of changes in water quality, as well as changes in the habitats in the coastal area. A very effective means of detecting significant changes in coastal habitats is to take photographs from the air.

During travel in June and again in September, 1999, the feasibility of taking useful photographs from the Maya Island planes was tested during travel between Punta Gorda and Belize City. The photographs from these flights were very clear and showed coastal features at the macro-level. On both occasions, pilots were consulted. They felt that it would be feasible to take photographs themselves.

The following details indicate a protocol for taking photographs, which can then be provided on a regular basis to TIDE.

Materials:

1. A 35 mm camera loaded with film, provided by TIDE, with a date imprint.
2. A map of the target areas for photographs.
3. This instruction sheet.

Methodology:

1. A camera, loaded with film and ready to use, will be provided to the Maya Island pilot who lives in Punta Gorda once every two weeks.
2. The target areas are noted on the map. There are four: the mouth of Monkey River, Inside Sheepshead (a mangrove Cay), Bob Stuart Lagoon (also a mangrove cay), and the mouth of the Rio Grande. Each of these areas can be covered from the normal flight altitude with several photographs at each target area.
3. Before takeoff from Punta Gorda, or just before taking photographs on the flight from Belize City to PG, the camera lens should be opened. However, before takeoff, the camera strap should be tied off to some part of the window or the door, so the camera cannot be dropped from the plane, is easy to access by the pilot, but does not get in the way.
3. Either prior to landing, or after takeoff and stabilized on the flight path, the pilot should open the window hatch just prior to the target areas, and hold the camera outside the window with the left hand (or right hand if more comfortable for the pilot) and the camera pointed down at the

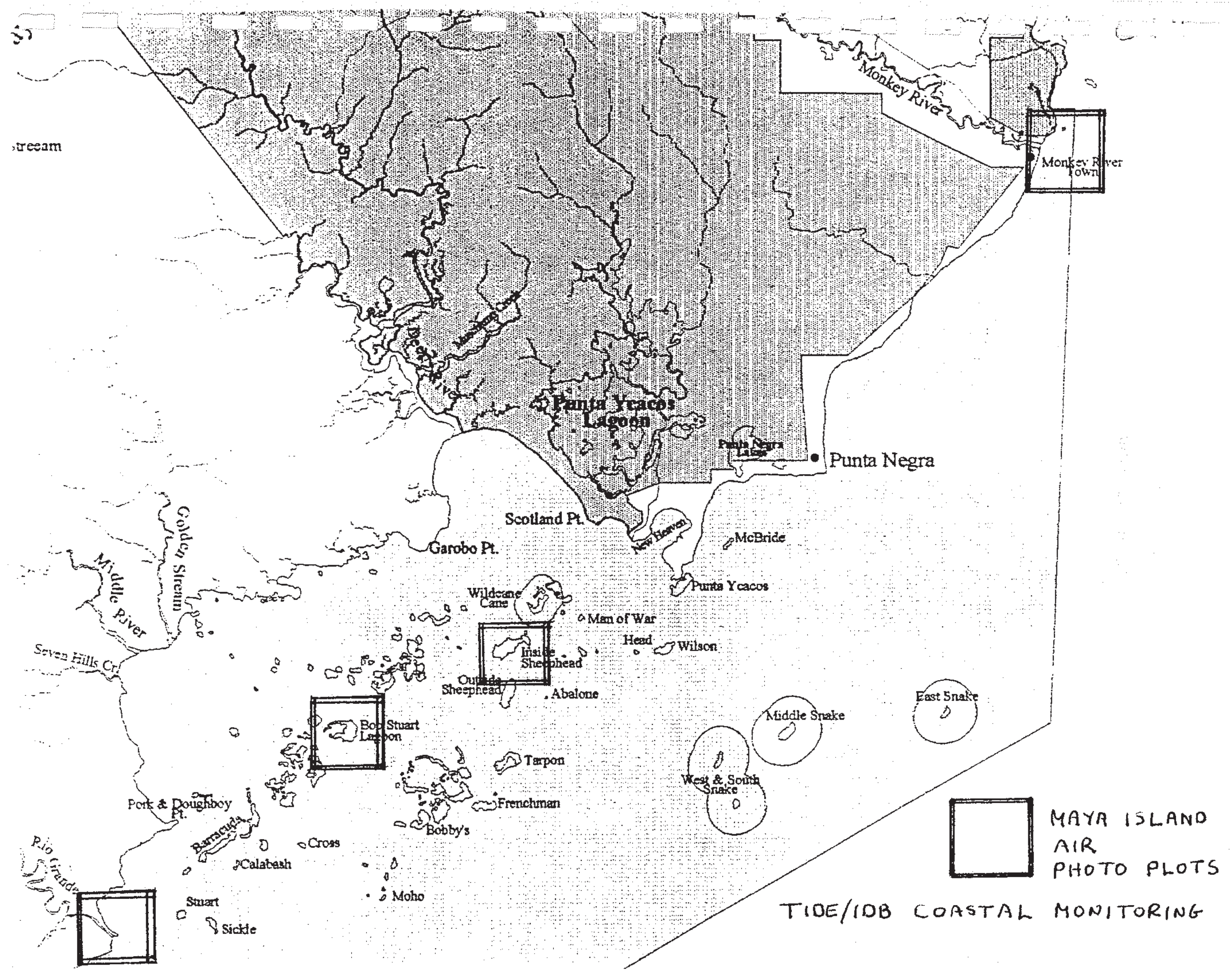
target. At each target area, the shutter release should be depressed very gently, without releasing it and taking a picture (this sets the correct focus for the coastal feature in the photograph). Immediately following setting the focus, photographs can be taken of the target area. At least two should be taken of each of the four target areas. The camera will automatically wind on to the next frame, so apart from releasing the shutter, nothing else needs to be done.

4. When the targets have been photographed, the lens should be closed.
5. The camera can be left with the Maya Island Air office at the strip in Punta Gorda when the film is finished. It will be picked up by TIDE and the film processed. The camera then will be brought back to the pilot at the time of the next set of photographs. The sequence above then applies again.

Some copies of the photographs can be provided to Maya Island Air for their own purposes. Maya Island Air's contribution to the coastal monitoring project will also be mentioned in TIDE's public awareness materials.

The main contact for the Coastal Monitoring Project is Karl Castillo. He can be contacted at the TIDE office - phone 22274.

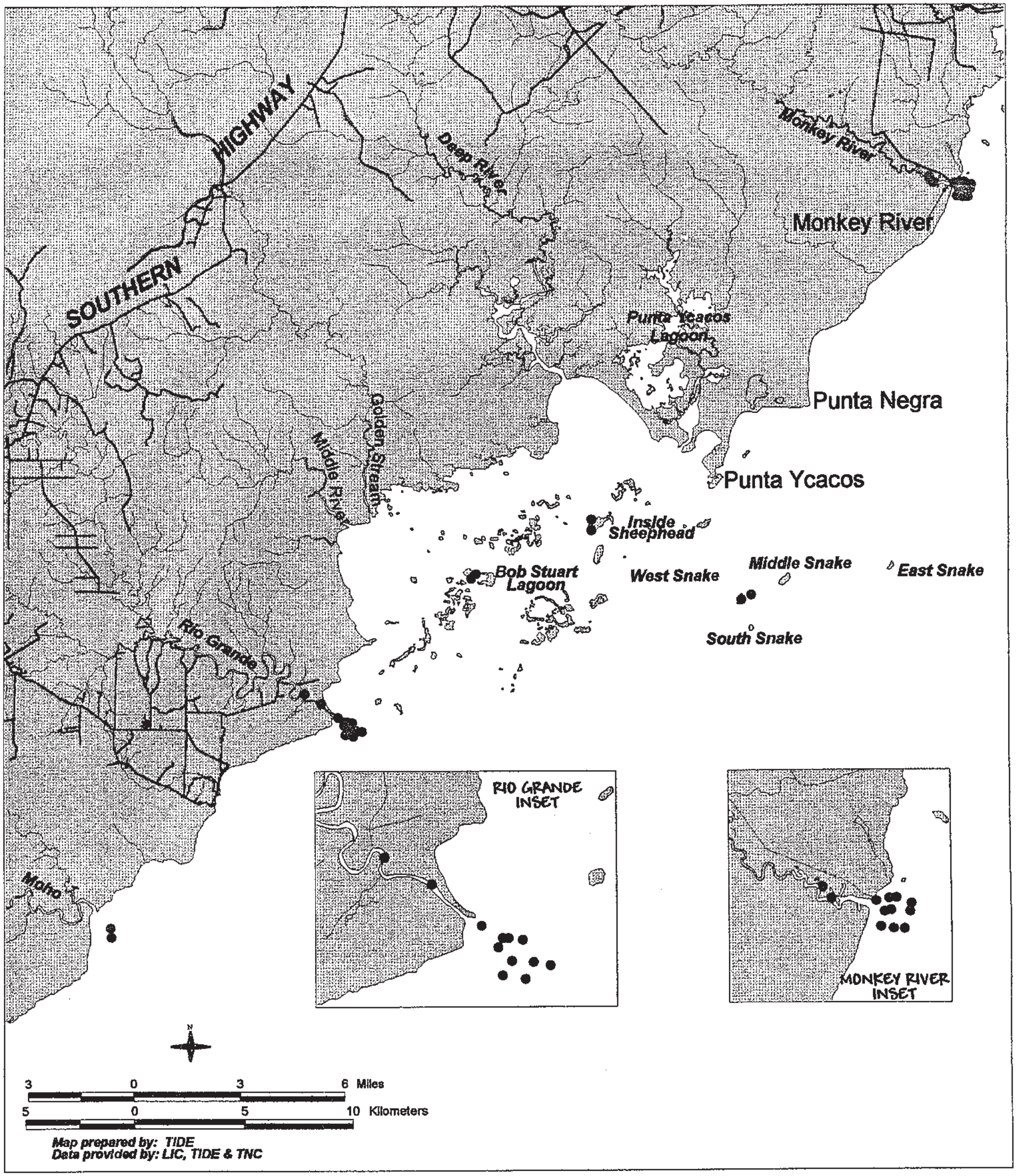
We appreciate very much Maya Island Air's contribution to this important initiative.



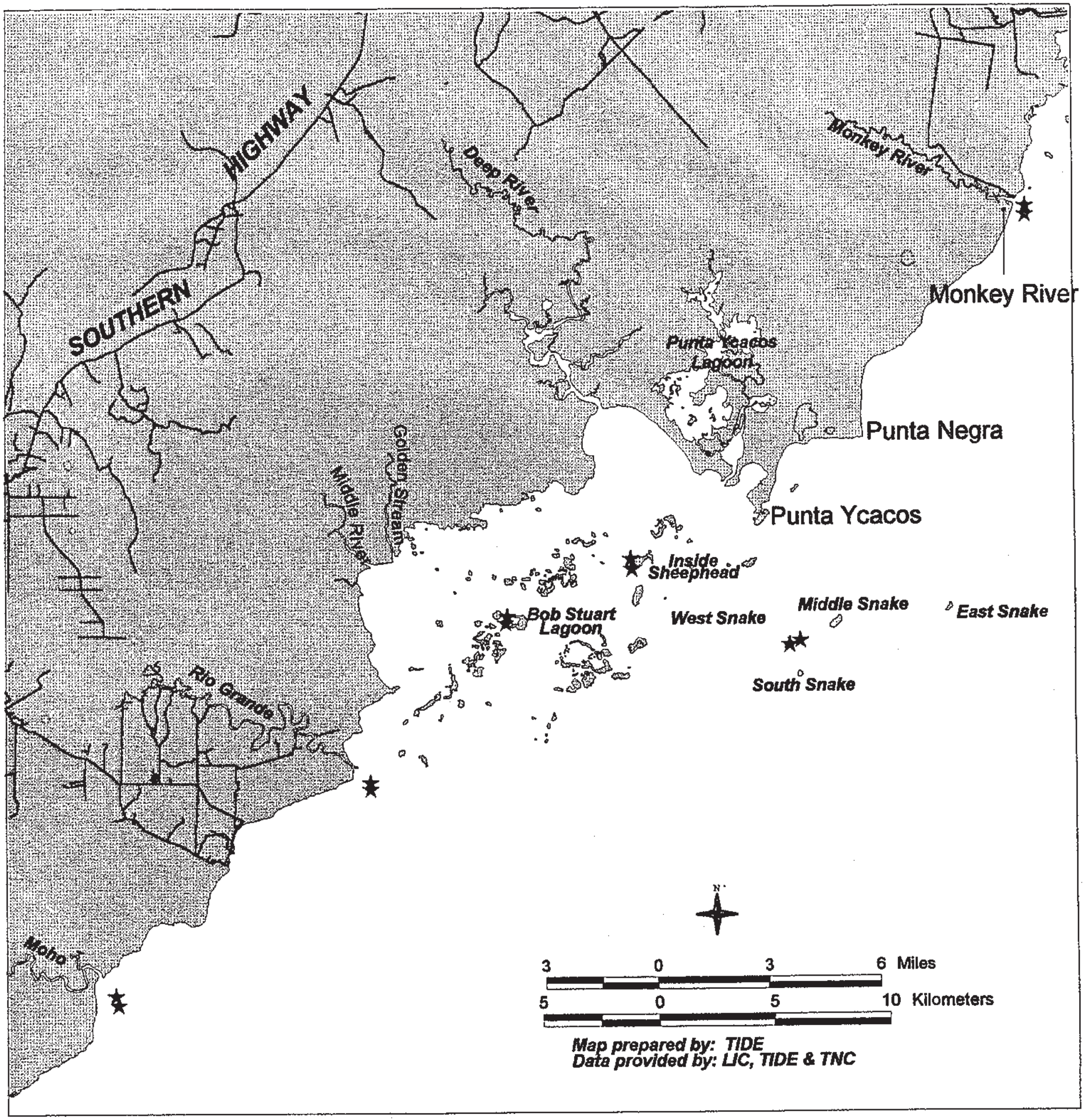
Monkey River
Monkey River Town
Punta Negra
Punta Negra Lagoon
Punta Ycacos Lagoon
Scotland Pt.
New Haven
McBride
Garobo Pt.
Punta Ycacos
Golden Stream
Middle River
Wildcane Caye
Man of War
Head
Wilson
Inside Sheephead
Outside Sheephead
Abalone
Seven Hills Cr.
East Snake
Middle Snake
Tarpon
West & South Snake
Frenchman
Bobby's
Cross
Calabash
Moho
Stuart
Sickle
Barracuda
Pork & Doughboy Pt.
Rio Grande
MAYA ISLAND AIR PHOTO PLOTS
TIDE/IDB COASTAL MONITORING

4.Station Locations

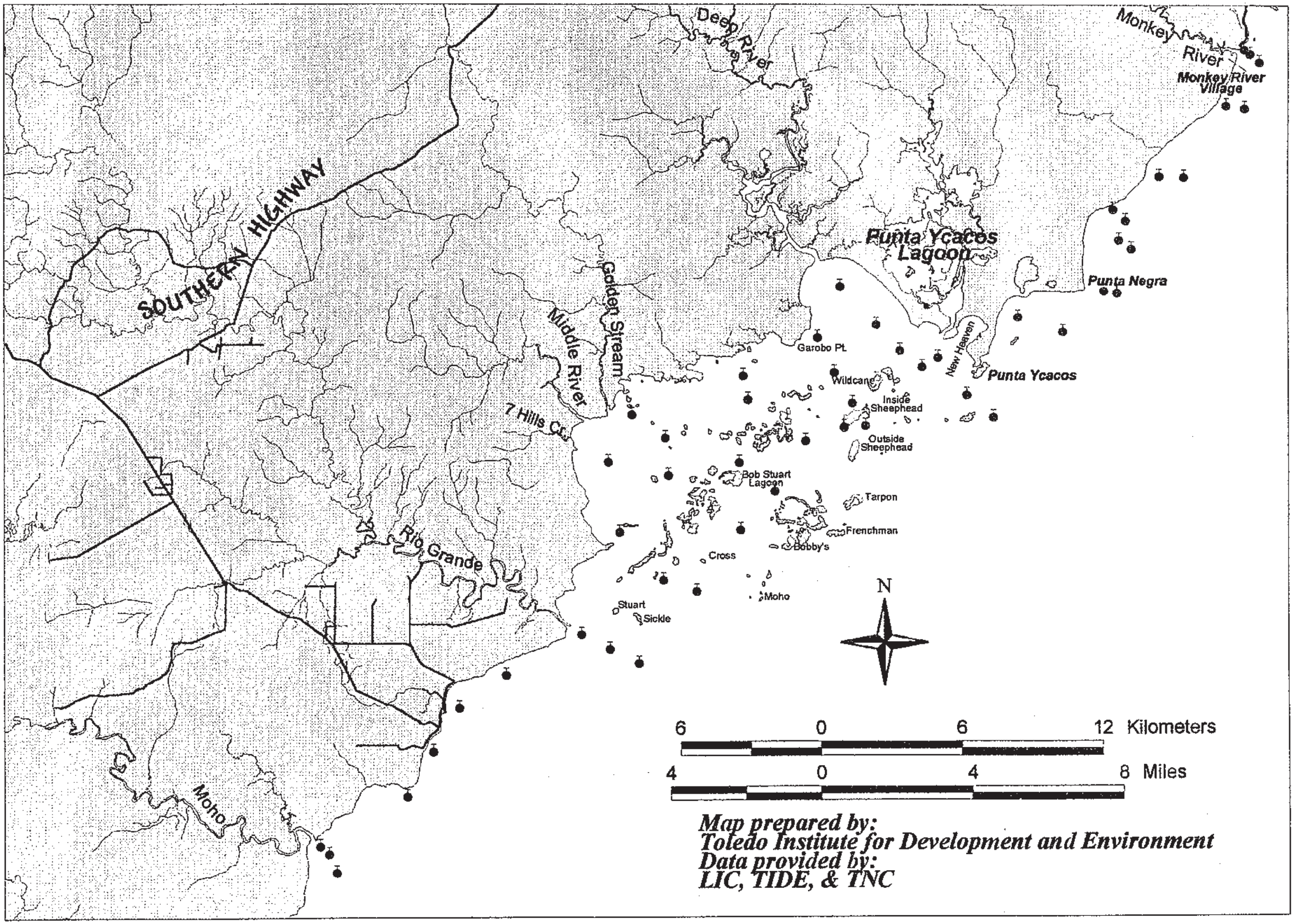
WATER QUALITY STATIONS



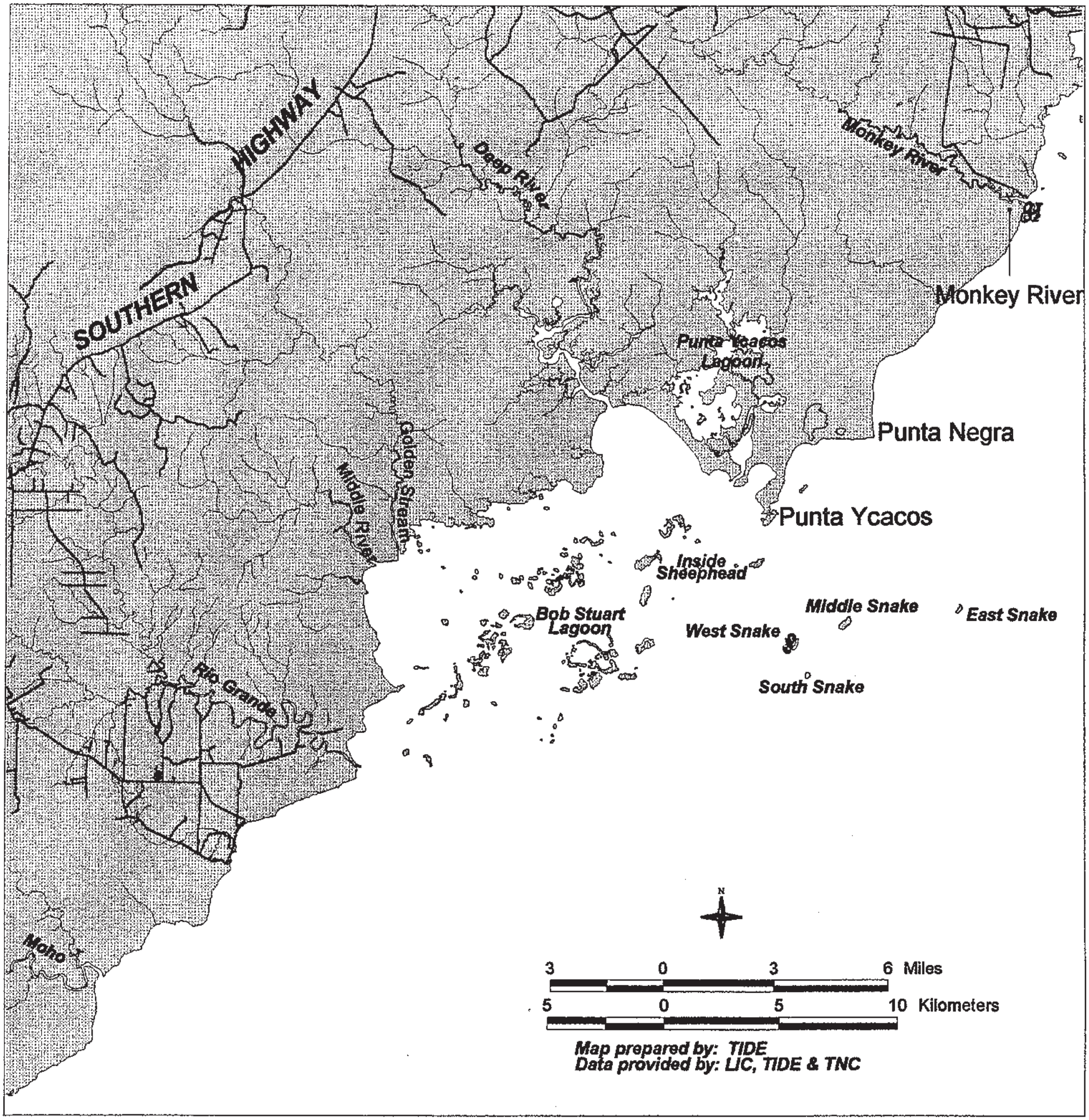
LOCATIONS OF SEDIMENT TRAPS AND RECRUITMENT PLATES



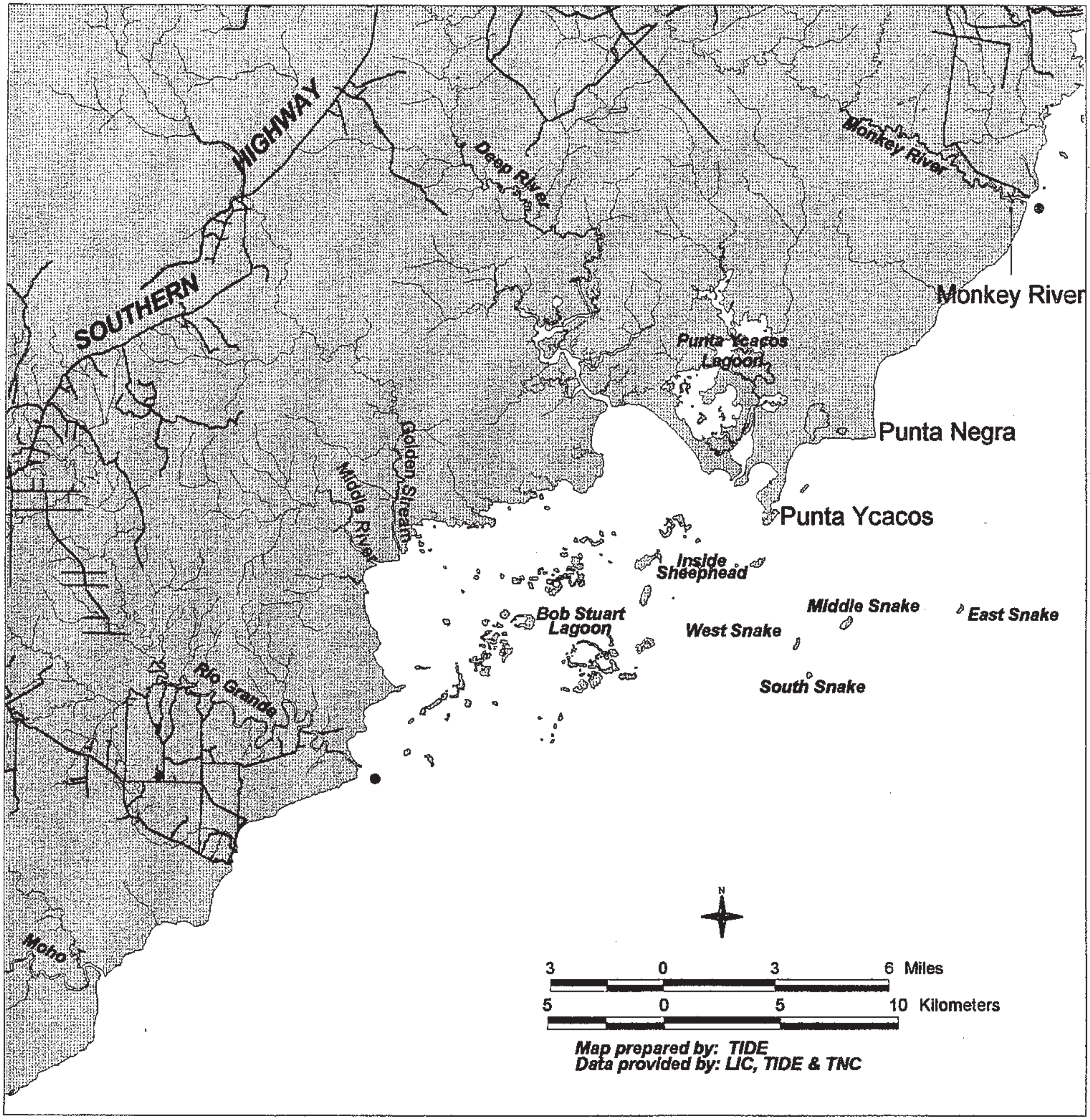
SURFICIAL SEDIMENT SITES



BEACH PROFILE LOCATIONS



SURFACE AND BOTTOM DRIFTERS



MANGROVE PLOTS

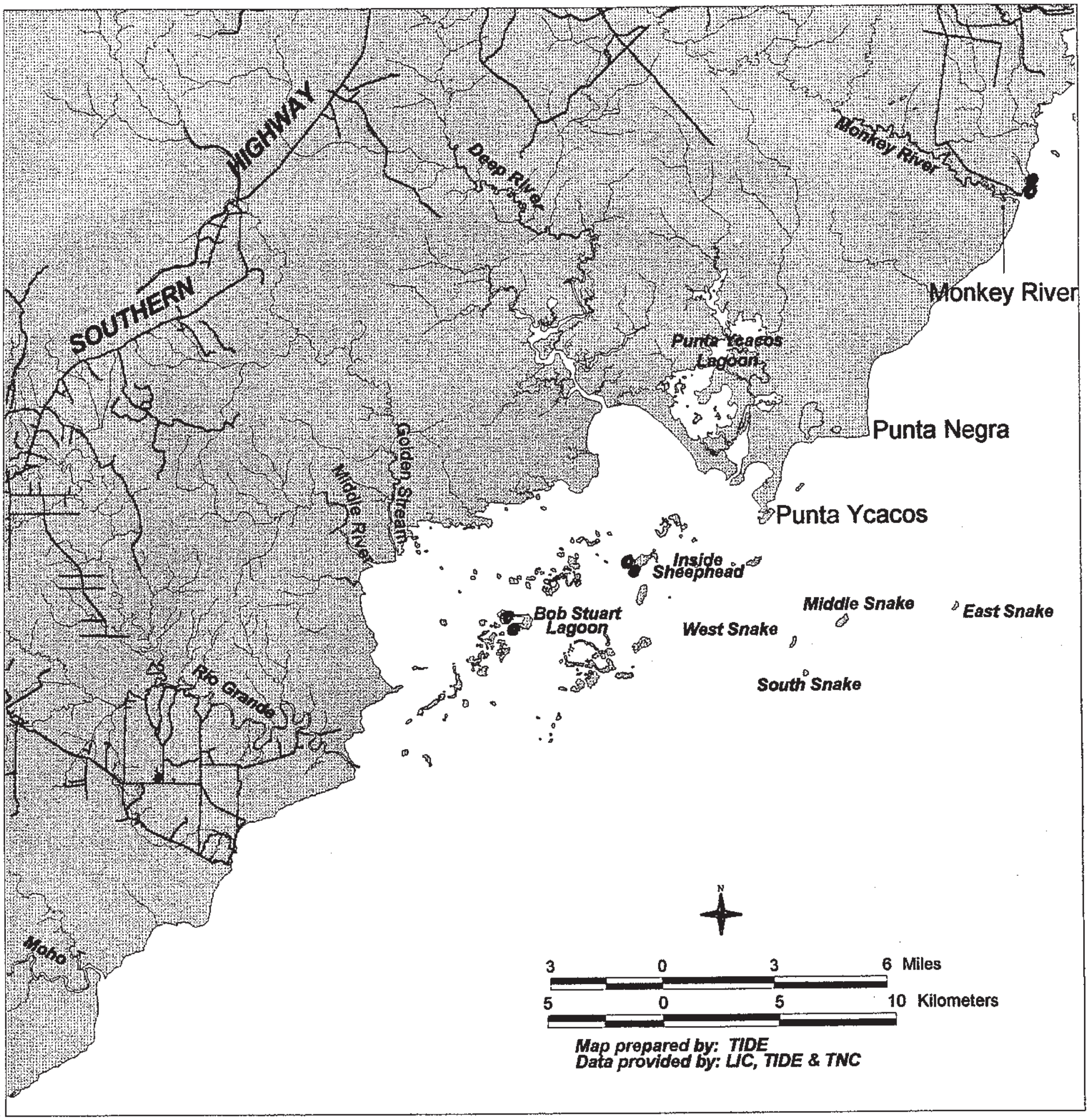
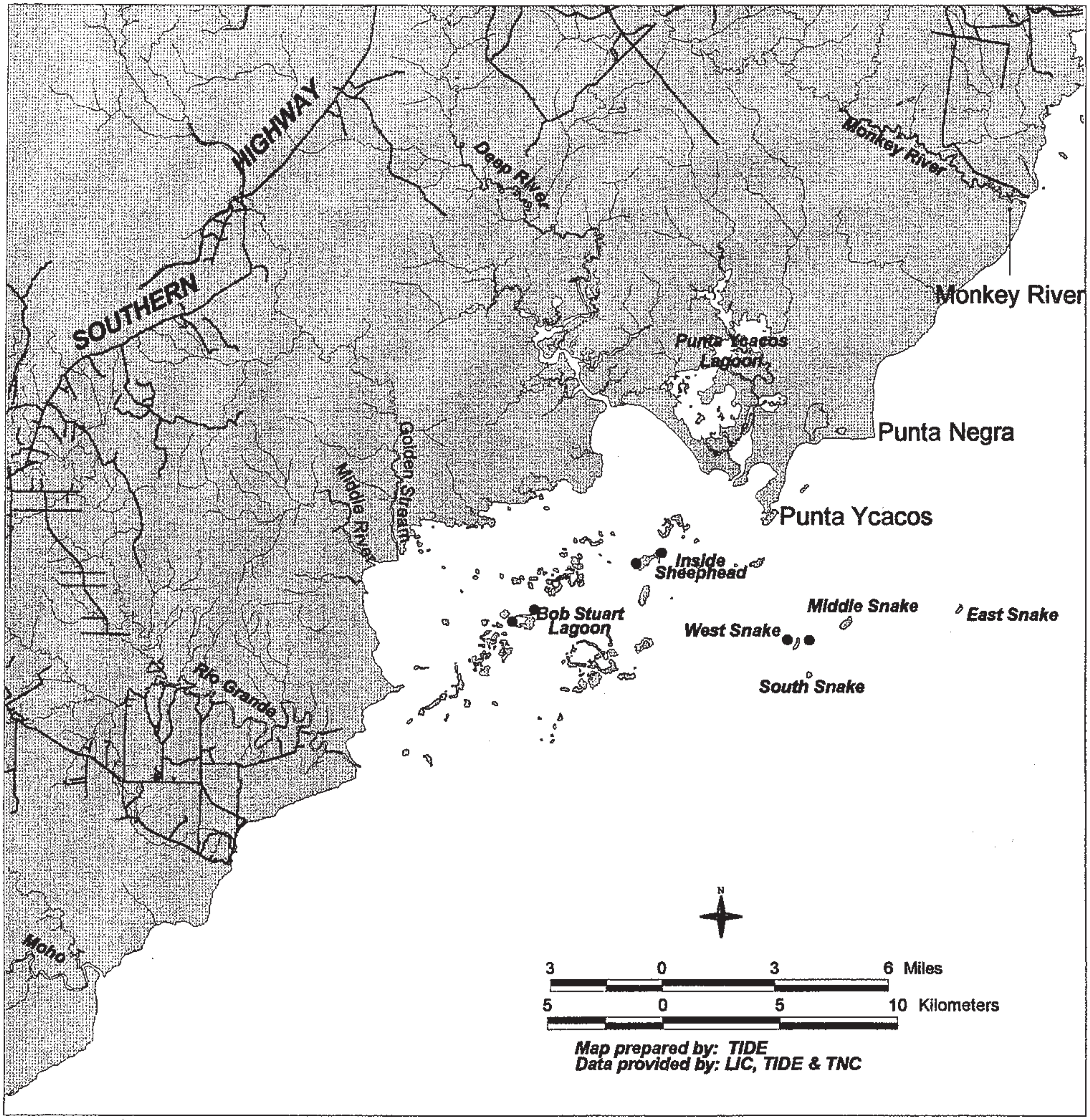


PHOTO QUADRATS



5.Individual Data Sets

Water Level at Joe Taylor Creek Bridge:

Date	**Time**	**Water Level** (inches above creek bottom at location of gauge)
Sept. 30/99	2:00 p.m. 4:45 p.m.	29.75 28.50
Oct. 1/99	8:00 a.m. 5:30 p.m.	22.50 29.00
Oct. 2/99	1:30 p.m. 5:00 p.m.	29.00 34.50
Oct. 3/99	8:00 a.m. 4:20 p.m.	27.00 33.00
Oct. 4/99	8:30 a.m. 11:15 a.m. 11:30 a.m. 5:45 p.m.	26.00 23.00 22.25 34.00
Oct. 5/99	8:30 a.m. 11:30 a.m. 1:30 p.m.	28.50 23.00 21.50
Oct. 6/99	4:30 p.m.	26.50
Oct. 7/99	9:00 a.m. 11:00 a.m. 12:45 p.m. 1:00 p.m. 5:00 p.m.	26.00 25.75 23.00 21.50 26.50
Oct. 8/99	8:40 a.m. 12:00 p.m. 1:30 p.m. 5:40 p.m.	32.00 27.00 26.50 29.00

Notes:

1. Datum for the Joe Taylor Creek water level gauge is 0" at the bottom of the creek; maximum range in water level variation recorded to date is 13" or 33 cm.
2. A separate gauge was installed at Monkey River Wharf on October 3, 1999. 0" or datum is at the riverbed. Observations on October 3 indicated a narrow water level range between 15.5" and 17". This gauge is being monitored by the Monkey River Group and schoolchildren twice daily. This data set will be collected every week by Karl Castillo when he is sampling at the Monkey River stations.

Temperature, salinity, and secchi readings

Date: 26 Sept. 99 | **Location:** Port Honduras

Sheet 1 **of** 3

TIDE FIELD SHEET

Start Time: 07:45

Weather Conditions:
Wind Direction/Speed: 5.8 Km/hr 300 mag.
Wave Height/Direction: ripples
Cloud Cover: cloudy
Precipitation:none

STATION	Sample Depth (m)	Secchi (m)	Temp. (°C)	Salinity (ppt)	Samples Collected								Remarks
					SPM	Sed. Trap	Rec. Plate	NO3	NH3	PO4			
(1.) Moho Mouth	0.2	3.0	29.3	25	11			11	11	11			
	1		30.9	32.9									
	3	D=4.5	30.6	33.2									
(2.) Moho Southwest	0.2	2.8	29.1	22.6	12			12	12	12			
	1		30.2	31.8									
	3	D=4.5	30.5	33.1									
(3.) Rio Grande	0.2	0.5	25.5	1.6									
	1		25.5	1.4									
	3	D=7	25.8	3.2									
(4.) Rio Grande	0.2	0.5	25.6	2									
	1		25.7	2.6									
	3	D=5.25	28	16.1									
(5.) Rio Grande	0.2	0.8	26	5.5									
	1		28.3	26.6									
	3	D=3.5	30.1	32.1									
(6.) Rio Grande	0.2	1.8	29.5	26									
	1		30	31.9									
	3	D=2.75											
(7.) Rio Grande	0.2	1.8	28.3	19.5									
	1		29.9	30.3									
	3	D=2											
(8.) Rio Grande	0.2	2.5	29.7	27									
	1		30.1	31.7									
	3	D=5	30.1	32.2									
(9.) Rio Grande	0.2	4.0	29.6	29.9									
	1		29.8	30.8									
	3	D=5	30	31.6									
(10.) Rio Grande Mouth	0.2	3.8	28.5	18.8	1			1	1	1			
	1		29.5	30									
	3	D=5.25	30	31.7									
(11.) Rio Grande Southwest	0.2	3.0	29.6	29.7	2			2	2	2			
	1		29.6	29.9									
	3	D= 3	30.1	32									

In situ measurements use YSI Model 30 Temperature and Salinity meter. Cal date 08/99. Secchi 20 cm disk.

End Time: 09:40

Collected By: Karl D. Castillo

Template Date: 27/09/99

Weather Conditions:
Wind Direction/Speed: 3.4 Km/hr 20 mag.
Wave Height/Direction: Calm
Cloud Cover: Cloudy
Precipitation: none

Date: 26 Sept. 99

Location: Port Honduras

Weather Conditions:
Wind Direction/Speed: 7.7 Km/hr
Wave Height/Direction:Calm
Cloud Cover: Cloudy
Precipitation:drizzling

Sheet 2 of 3

TIDE FIELD SHEET

Start Time: 9:45

STATION	Sample Depth (m)	Secchi (m)	Temp. (°C)	Salinity (ppt)	Samples Collected SPM	Sed. Trap	Rec. Plate	NO3	NH3	PO4				Remarks
	0.2	4.5	29.1	25.5										
	1.0		29.5	29.7										
(12.) Rio Grande	3.0	D=6.75	29.8	31.5										
	0.2	3.0	28.4	18.2										
	1.0		29.2	29.7										
(13.) Rio Grande	3.0	D=6.50	29.7	31.2										
	0.2	3.3	29.1	22.3										
	1.0		29.5	29.7										
(14.) Rio Grande	3.0	D=5	30.2	31.9										
	0.2	3.3	29.1	22.3										
	1.0		29.5	29.7										
(15.) Rio Grande	3.0	D=5	30.2	31.9										
	0.2	5.0	29.4	27.2	9			9	9	9				
(16.) Bob Stuart	1.0		29.6	30.7										
Lagoon East	3.0	D=8.5	30.3	31.5										
	0.2	6.5	29.6	28.2	10			10	10	10				
(17.) Bob Stuart	1.0		29.6	28.2										
Lagoon West	3.0	D=7	29.9	31.0										
	0.2	5.5	29.8	31.0	7			7	7	7				
(18.) Inside	1.0		29.8	31.1										
Sheephead East	3.0	D=5.5	29.8	31.5										
	0.2	3.3	29.8	23.6	8			8	8	8				
(19.) Inside	1.0		29.7	30.9										
Sheephead West	3.0	D=5.0	30.0	32.0										
	0.2	0.5	26.0	0.1	13			13	13	13				
	1.0		25.9	0.1										
(20.) Monkey River	3.0	D=3.0	25.9	0.1										
	0.2	0.8	26.0	0.1										
	1.0		26.0	0.1										
(21.) Monkey River	3.0	D=4.00	25.9	0.1										
	0.2	0.5	26.1	0.1										
	1.0		26.0	0.1										
(22.) Monkey River	3.0	D=1.5												
	0.2	0.5	28.6	1.8										
	1.0		30.1	32.4										
(23.) Monkey River	3.0	D=5	30.1	32.4										

In situ measurements use YSI Model 30 Temperature and Salinity meter. Cal date 08/99. Secchi 20 cm disk.

Weather Conditions:
Wind Direction/Speed: 8.6 Km/hr 60 mag
Wave Height/Direction:
Cloud Cover:
Precipitation:

End Time: 11:59

Collected By: Karl D. Castillo

Template Date: 28/09/99

Date: 26th Sept. 99 | Location: Port Honduras

Sheet 3 of 3 | TIDE FIELD SHEET

Start Time: 12:02

Weather Conditions:
Wind Direction/Speed: 6.6 km/hr 120 mag.
Wave Height/Direction: Partially Choppy
Cloud Cover: Partially Cloudy
Precipitation: None

STATION	Sample Depth (m)	Secchi (m)	Temp. (°C)	Salinity (ppt)	Samples Collected									Remarks
					SPM	Sed. Trap	Rec. Plate	NO3	NH3	PO4				
	0.2	1.8	28.2	13.3										
	1.0		30.2	32.2										
(24.) Monkey River	3.0	D=2.25												
	0.2	1.0	29.5	10.8	4			4	4	4				
(25.) Monkey River	1.0		29.9	32.1										
Southwest	3.0	D=5.5	30.0	32.2										Dropped 50 surface drifter cards
	0.2	1.3	27.8	7.6	5			5	5	5				
(26.) Monkey River	1.0		30.8	32.2										
Mouth	3.0	D=6.5	30.1	32.3										
	0.2	0.5	27.9	11.0										
	1.0		30.1	32.2										
(27.) Monkey River	3.0	D=6	30.1	32.2										
	0.2	0.5	3.0	31.5										
	1.0		30.1	32.1										
(28.) Monkey River	3.0	D=12	30.0	32.2										
	0.2	0.5	30.1	30.7										
	1.0		30.1	32.1										
(29.) Monkey River	3.0	D=12	29.9	32.1										
	0.2	0.5	28.2	19.2										
	1.0		29.8	32.1										
(30.) Monkey River	3.0	D=12.75	30.0	32.2										
	0.2	4.0	30.7	29.9	3			3	3	3				
(31.) Snake Caye	1.0		30.3	29.9										
East	3.0	D=4.0	30.1	30.7										
	0.2	4.5	30.2	29.6	6			6	6	6				
(32.) Snake Caye	1.0		30.1	29.6										
West	3.0	D=4.5	30.1	29.6										

In situ measurements use YSI Model 30 Temperature and Salinity meter. Cal date 08/99. Secchi 20 cm disk.

End Time: 13:07

Collected By: Karl D. Castillo

Template Date: 28/09/99

Weather Conditions:
Wind Direction/Speed: 1.5 Km/hr 120 mag
Wave Height/Direction: calm
Cloud Cover: Partially Cloudy
Precipitation: None

Key Station Trip Report

TIDE KEY STATION TRIP REPORT

LOCATION: **PORT HONDURAS, BELIZE, CENTRAL AMERICA**
DATE COLLECTED: **Sept. 26th, 99**
ANALYSIS DATE(S): **Sept 27th, 28th 99**

Sample ID	Salinity (ppt)	Temp. (C)	Secchi (m)	SPM (mg/L)	NO_3-N (mg/L)	PO_4^{3-} P (mg/L)	NH_3-N (mg/L)	Sedimentation Rate (g/m2/day)	Remarks
Moho River (15)	NS	NS	NS	NS	NS	NS	NS	NS	Sediment traps on Sept. 9th, 99
Moho Mouth (11)	25	29.3	3	4	<0.4	<0.1	<0.1	281	
Moho Southwest (12)	22.6	29.1	2.8	4	<0.4	<0.1	<0.1	281	
Rio Grande River (14)	NS	NS	NS	NS	NS	NS	NS	NS	
Rio Grande Mouth (1)	18.8	28.5	3.8	4	<0.4	<0.1	<0.1	958	
Rio Grande SW (2)	29.7	29.6	3	11	<0.4	<0.1	<0.1	894	
Monkey River (13)	0.1	26	0.5	17	0.9	0.2	<0.1	NS	phosphate value corrected 8/10
Monkey River Mouth (3)	7.6	27.8	1.3	<4	<0.4	<0.1	<0.1	230	
Monkey River SW (4)	10.8	29.5	1	<4	<0.4	<0.1	<0.1	249	
Snake Caye East (5)	29.9	30.7	4B	<4	<0.4	<0.1	<0.1	58	
Snake Caye West (6)	29.6	30.2	4.5B	<4	<0.4	<0.1	<0.1	26	
Bob Stuart Lagoon E (9)	27.2	29.4	5	<4	<0.4	0.5	<0.1	160	
Bob Stuart Lagn. W (10)	28.2	29.6	6.5	4	<0.4	<0.1	<0.1	89	
Inside Sheephead E (7)	31	29.8	5.5B	4	<0.4	<0.1	<0.1	128	
Inside Sheephead W (8)	23.6	29.8	3.25	12	<0.4	<0.1	<0.1	121	
Method Detection Limit	0.5	0.5	0.25	4	0.4	0.1	0.1	10	n/a

Complete data are available from TIDE in Punta Gorda, Belize, Central America   These results for surface waters at key locations.   Sediment traps 1 meter from bottom.

NS = Not sampled

Note: Dates of sampling for water quality and sediment traps will differ, see remarks column.

Analyst Karl D. Castillo

Template Date: 28/09/99

Checked: Clive MacGregor

Drifter Cards:

Location	Date and Time of Release	Type and Number of Drifter Cards	Location and Time of Retrieval	Direction and Velocity of Drift
Mouth of Monkey River (S/T water station #19) GPS: 1809303N 16Q342027E	Sept. 26/99; 12:20 p.m.	50 surface drifters	1 retrieved on the beach about 1.2 km north of Punta Negra at 7:30 a.m. on Sept. 27/99	net south-southwest drift at 0.632 km/hr
Mouth of Rio Grande (sediment trap station #1) GPS: 1784691N 16Q313582E	Oct. 1/99; 11:11 a.m.	40 surface drifters	-	-
Mouth of Monkey River (sediment trap station #3) GPS 1794510N 16Q324861E	Oct. 1/99; 2:09 p.m.	7 bottom drifters	-	-

Notes:

1. - indicates no returns as yet.
2. Additional cards will be made and released in the near future. The number of releases should probably be increased to 200 per release. Future cards will also be marked in English and Spanish.

Sediment Trap Data

Lab No.:

TIDE SEDIMENT TRAP CALCULATION SHEET
Sediment Trap Data

Client Name: TIDE, PUNTA GORDA BELIZE
Date Collected: Aug. 20th, 1999
Collected By: Karl D. Castillo
Date Received: Aug. 20th, 1999

Station ID	Mass Retained By Trap (g)	Sedimentation (mg/cm2/day)	Sedimentation (g/m2/day)	Number of Days Sampled
Moho River Mouth	6	3.3	32.8	21
Moho River Southwest	11.5	6.3	62.9	21
Rio Grande Mouth	50	27.4	273.7	21
Rio Grande Southwest	31	17.0	169.7	21
Monkey River Mouth	35	19.2	191.6	21
Monkey River Southwest	31	17.0	169.7	21
Snake Caye East	1.25	0.7	6.8	21
Snake Caye West	14	7.7	76.6	21
Bob Stuart Lagoon E	8	4.4	43.8	21
Bob Stuart Lagoon W	6	3.3	32.8	21
Inside Sheephead E	17	9.3	93.0	21
Inside Sheephead W	7.5	4.1	41.1	21

Notes: Snake Caye west was mostly algae, not sediment

Area of bottom of sediment trap = 87cm2

Traps are 10.5 cm diameter by 47 cm long

,Analyst Chemist — Karl Castillo

Quality Control Check

Lab No.:

TIDE SEDIMENT TRAP CALCULATION SHEET
Sediment Trap Data

Client Name: TIDE, PUNTA GORDA BELIZE
Date Collected: Aug. 31, 1999
Collected By: Karl D. Castillo
Date Received: Aug. 31, 1999

Station ID	Mass Retained By Trap (g)	Sedimentation (mg/cm2/day)	Sedimentation (g/m2/day)	Number of Days Sampled
Moho River Mouth	16	16.7	167.2	11
Moho River Southwest	15	15.7	156.7	11
Rio Grande Mouth	43	44.9	449.3	11
Rio Grande Southwest	62.5	65.3	653.1	11
Monkey River Mouth	11.5	12.0	120.2	11
Monkey River Southwest	12.5	13.1	130.6	11
Snake Caye East	5	5.2	52.2	11
Snake Caye West	6	6.3	62.7	11
Bob Stuart Lagoon E	7.5	7.8	78.4	11
Bob Stuart Lagoon W	1	1.0	10.4	11
Inside Sheephead E	10	10.4	104.5	11
Inside Sheephead W	12.5	13.1	130.6	11

Notes:

Area of bottom of sediment trap = 87cm2

Traps are 10.5 cm diameter by 47 cm long

,Analyst Chemist — Karl Castillo

Quality Control Check

Lab No.:

TIDE SEDIMENT TRAP CALCULATION SHEET

Sediment Trap Data

Client Name: TIDE, PUNTA GORDA BELIZE
Date Collected: Sept 09th, 1999
Collected By: Kari D. Castillo
Date Received: Sept 09th, 1999

Station ID	Mass Retained By Trap (g)	Sedimentation (mg/cm2/day)	Sedimentation (g/m2/day)	Number of Days Sampled
Moho River Mouth	22	28.1	281.0	9
Moho River Southwest	22	28.1	281.0	9
Rio Grande Mouth	75	95.8	957.9	9
Rio Grande Southwest	70	89.4	894.0	9
Monkey River Mouth	18	23.0	229.9	9
Monkey River Southwest	19.5	24.9	249.0	9
Snake Caye East	4.5	5.7	57.5	9
Snake Caye West	2	2.6	25.5	9
Bob Stuart Lagoon E	12.5	16.0	159.6	9
Bob Stuart Lagoon W	7	8.9	89.4	9
Inside Sheephead E	10	12.8	127.7	9
Inside Sheephead W	9.5	12.1	121.3	9

Notes: Snake Caye west was mostly algae, not sediment

Area of bottom of sediment trap = 87cm2

Traps are 10.5 cm diameter by 47 cm long

,Analyst Chemist   Kari Castillo   Quality Control Check

Lab No.:

TIDE SEDIMENT TRAP CALCULATION SHEET
Sediment Trap Data

Client Name: TIDE, PUNTA GORDA BELIZE
Date Collected: Oct. 1st, 1999
Collected By: Karl D. Castillo
Date Received: Oct. 1st, 1999

Station ID	Mass Retained By Trap (g)	Sedimentation (mg/cm2/day)	Sedimentation (g/m2/day)	Number of Days Sampled
Moho River Mouth	237.5	124.1	1241	22
Moho River Southwest	200	104.5	1045	22
Rio Grande Mouth	100	52.2	522	22
Rio GrandeSouthwest	70	36.6	366	22
Monkey River Mouth	12.5	6.5	65	22
Monkey River Southwest	7.5	3.9	39	22
Snake Caye East	30	15.7	157	22
Snake Caye West	24	12.5	125	22
Bob Stuart Lagoon E	29	15.2	152	22
Bob Stuart Lagoon W	17.5	9.1	91	22
Inside Sheephead E	42	21.9	219	22
Inside Sheephead W	47	24.6	246	22
	MDL	0.1	10	

Area of bottom of sediment trap = 87cm2

Traps are 10.5 cm diameter by 47 cm long. Suspended vertically 1 meter off bottom with subsurface float. Recovered by manual hauling, decanting and placement of sample in jar. Jar sample poured to Imhoff cone and volume measured converted to mass

,Analyst Chemist

Karl D. Castillo

Quality Control Check

Template Date: 28/09/99

	Sediment Trap Data			
	Sedimentation Rate - g/m2/day			
Station ID	**Aug.20/99**	**Aug.31/99**	**Sept.9/99**	**Oct.1/99**
Moho River Mouth	32.8	167.2	281	1241
Moho River Southwest	62.9	156.7	281	1045
Rio Grande Mouth	273.7	449.3	957.9	522
Rio grande Southwest	169.7	653.1	894	366
Monkey River Mouth	191.6	120.2	229.9	65
Monkey River Southwest	169.7	130.6	249	39
Snake Caye East	6.8	52.2	57.5	157
Snake Caye West	76.6	62.7	25.5	125
Bob Stuart Lagoon E	43.8	78.4	159.6	152
Bob Stuart Lagoon W	32.8	10.4	89.4	91
Inside Sheephead E	93	104.5	127.7	219
Inside Sheephead W	41.1	130.6	121.3	246

Surficial Sediments Collected on Sept. 7/99:

Station	Location	Water Depth	Visual Observations Prior to Sieving	Sieve Analysis
1	1809652N 16Q0341772E	2.25 m	light brown granitic sand	currently underway
2	1809472N 16Q0342022E	7.25 m	brown silt	"
3	1809116N 16Q0342418E	13 m	brown silt and clay	"
4	1807155N 16Q0341786E	12 m	fine sand and silt	"
5	1807286N 16Q0340997E	3 m	medium grain sand and shell debris	"
6	1804065N 16Q0339180E	11.75 m	fine sand and silt	"
7	1804298N 16Q0338135E	8.5 m	fine sand, silt, and shell debris	"
8	1802886N 16Q0336156E	4.5 m	brown silt	"
9	1802410N 16Q0336686E	7.25 m	fine sand, silt, and shell debris	"
10	1801580N 16Q0336406E	10 m	brown silt	"
11	18011017N 16Q0336930E	11.75 m	brown silt	"
12	1799284N 16Q0336324E	16.25 m	brown silt and clay	"
13	1799359N 16Q0335760E	13.75 m	silt and clay	"
14	1797599N 16Q0333990E	13.25 m	silt and clay	"

15	1798226N 16Q0332096E	8 m	clay	"
16	1793988N 16Q0331048E	17 m	clay	"
17	1794920N 16Q0329920E	12.75 m	clay	"
18	1796501N 16Q0328689E	6 m	clay	"
19	1796107N 16Q0328013E	6 m	silt and some shell debris	"
20	1796792N 16Q0327063E	7.5 m	silt and clay with some shell debris	"
21	1797915N 16Q0326045E	6.25 m	silt	"
22	1799569N 16Q0324510E	3.25 m	silt and clay	"
23	1797351N 16Q0323550E	2.75 m	fine sand, silt, and shell debris	"
24	1795860N 16Q0324253E	7.5 m	clay	"
25	1794593N 16Q0325028E	8.5 m	clay	"
26	1793583N 16Q0324669E	10 m	fine sand, silt, and shell debris	"
27	1793647N 16Q0325595E	13.5 m	silt and clay	"
28	1793021N 16Q0323033E	10.2 m	clay	"
29	1794736N 16Q0320559E	7 m	clay	"
30	1795739N 16Q0320359E	4.25 m	clay	"
31	1794125N 16Q0315597E	5 m	silt and clay	"

32	1793153N 16Q0317031E	6.75 m	clay	"
33	1792097N 16Q0320203E	11 m	clay	"
34	1790888N 16Q0321716E	13 m	clay	"
35	1789240N 16Q0320261E	14 m	clay	"
36	1791563N 16Q0317168E	5.2 m	silt and clay	"
37	1792142N 16Q0314596E	3.5 m	clay	"
38	1789152N 16Q0315095E	3 m	silt and clay	"
39	1787697N 16Q0316969E	8 m	clay	"
40	1786617N 16Q0318393E	14 m	clay	"
41	1783530N 16Q0315911E	11 m	clay	"
42	1784146N 16Q0314677E	8.75 m	silt and clay	"
43	1784766N 16Q0313445E	3 m	silt and clay	"
44	1783010N 16Q0310209E	2.25 m	silt and clay	"
45	1781613N 16Q0308202E	3.5 m	fine sand, silt, and shell debris	"
46	1779753N 16Q0307081E	3.5 m	silt and shell debris	"
47	1777877N 16Q0305966E	3 m	fine sand, silt, and shell debris	"
48	1775783N 16Q0302217E	3 m	fine sand, silt, and shell debris	"

49	1775450N 16Q0302599E	3.25 m	silt and shell debris	"
50	1774647N 16Q0302923E	5 m	silt and shell debris	"

Notes:

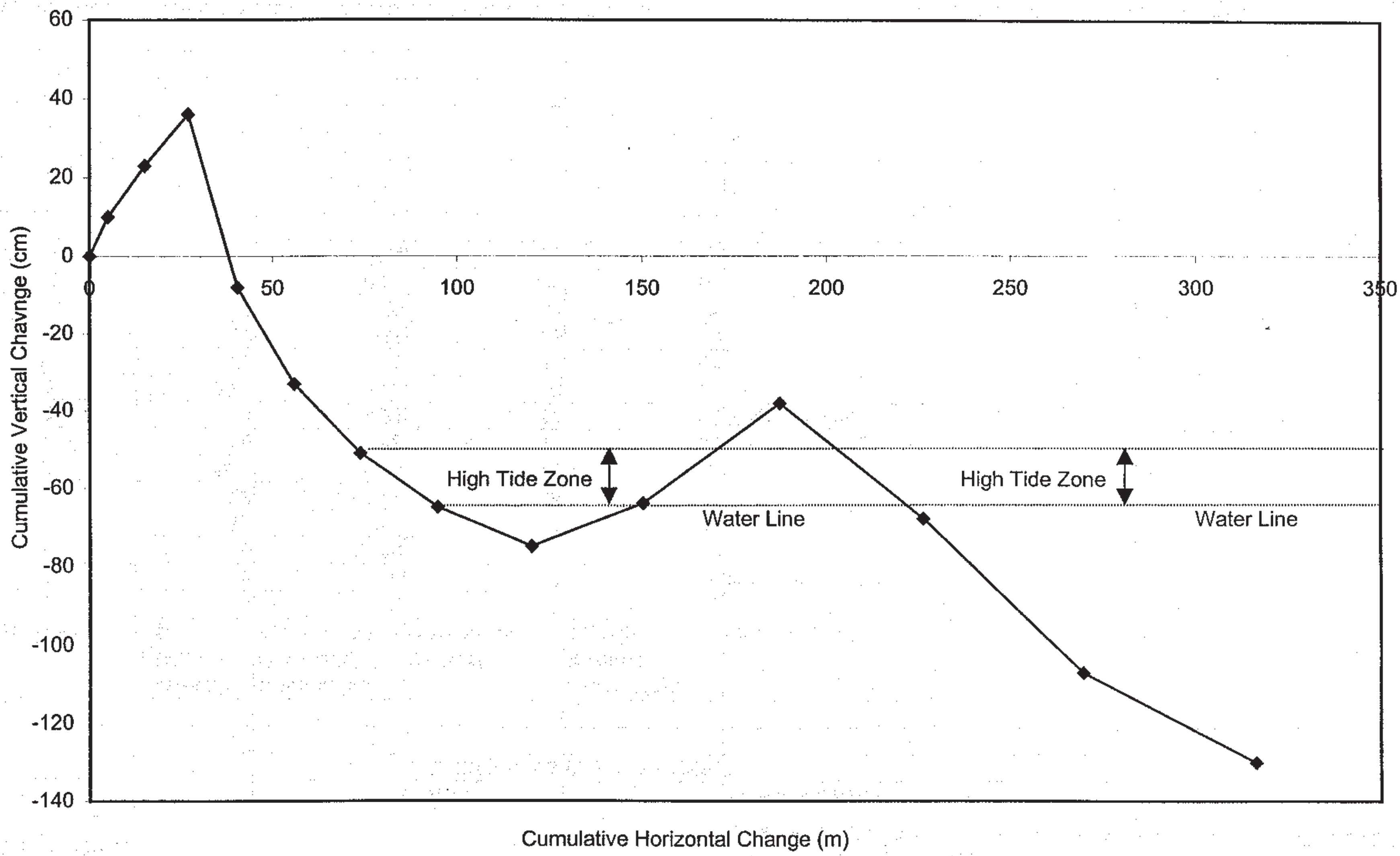
1. Visual observations may be corrected after sieve analysis. Samples were dried on October 5-6, 1999 and should be sieved over the next two weeks.

Beach Profiles

Weather: Sunny					Date/Time Start: 26 th Sept. 99
					Location/Bearing (Mag):Snake Caye Profile 1 Western End 280 degrees
			TIDE		Personnel: Karl D. Castillo
			BEACH PROFILING DATA SHEET		
Measurement #	**Horizontal Distance (M)**	**Cumulative Horizontal Distance (M)**	**Vertical Change (cm)**	**Cumulative Vertical Change (cm)**	**Observations**
1	0	0	0	0	
2	5	5	10	10	from base of tree
3	10	10	13	23	
4	12	12	13	36	
5	13.4	13.4	-44	-8	
6	15.5	15.5	-25	-33	
7	18	18	-18	-51	High Tide Zone
8	21	21	-14	-65	Edge of water
9	25.5	25.5	-10	-75	
10	30	30	11	-64	
11	37	37	26	-38	
12	39	39	-30	-68	
13	43.4	43.4	-39	-107	
14	46.4	46.4	-23	-130	
Profiling technique:	!.5 meter stakes (2 cm vertical markings), ground meter line, line of sight horizon leveling, bearing by magnetic compass.				
		Template date: 28/09/99			

Toledo Institute for Development and the Environment
Punta Gorda, Toldeo District
Belize

Snake Caye 280° Mag Beach Profile (September 26, 1999)



Date Printed : 11/10/1999

Weather: Sunny

Date/Time Start: Sept. 26th, 99

Location/Bearing (Mag): Snake Caye Profile 2 South of P-1 0 degrees

Personnel: Karl D. Castillo

TIDE

BEACH PROFILING DATA SHEET

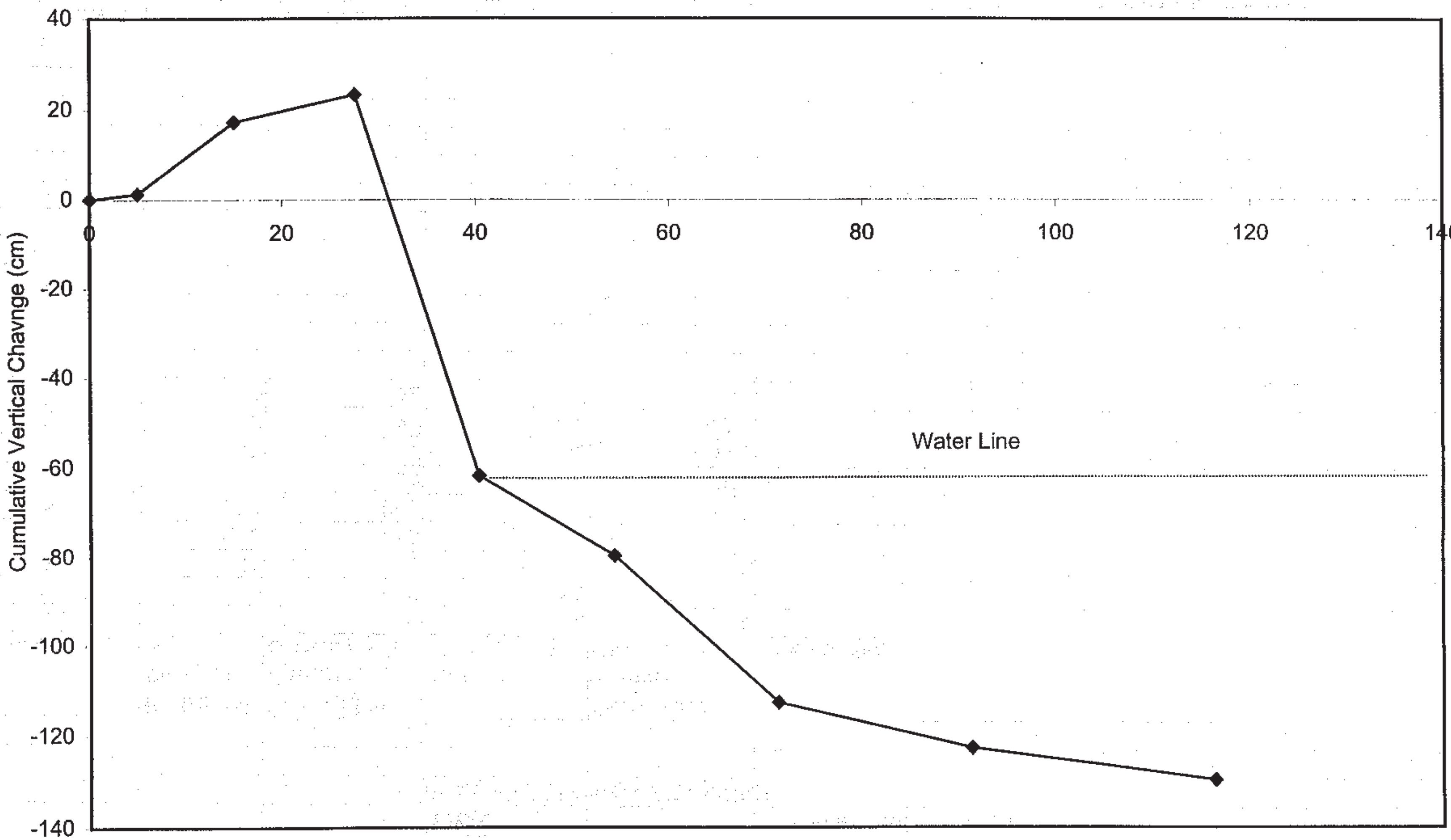
Measurement #	Horizontal Distance (M)	Cumulative Horizontal Distance (M)	Vertical Change (cm)	Cumulative Vertical Change (cm)	Observations
1	0	0	0	0	
2	5	5	1.3	1.3	
3	10	10	16	17.3	
4	12.5	12.5	6	23.3	
5	12.9	12.9	-85	-61.7	Cliff
6	14	14	-18	-79.7	Water edge
7	17	17	-33	-112.7	
8	20	20	-10	-122.7	
9	25	25	-7	-129.7	

Profiling technique: !.5 meter stakes (2 cm vertical markings), ground meter line, line of sight horizon leveling, bearing by magnetic compass.

Template date: 28/09/99

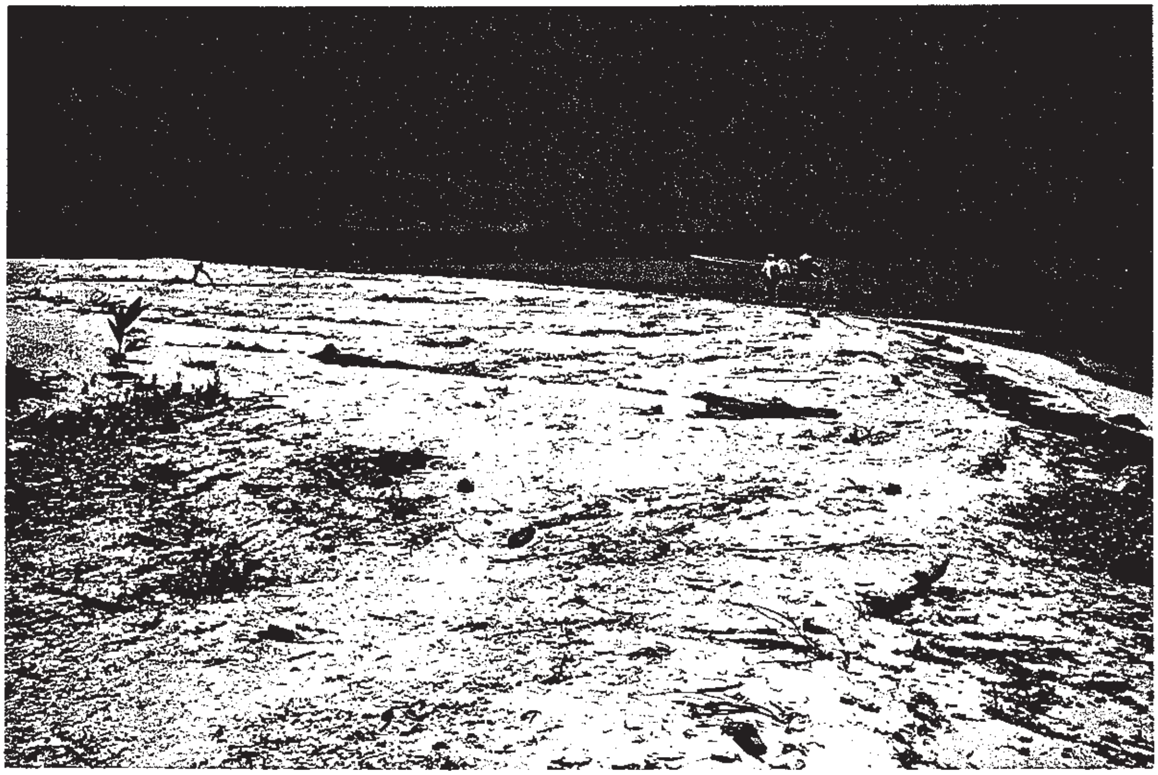
Toledo Institute for Development and the Environment
Punta Gorda, Toldeo District
Belize

Snake Caye 0° Mag Beach Profile (September 26, 1999)

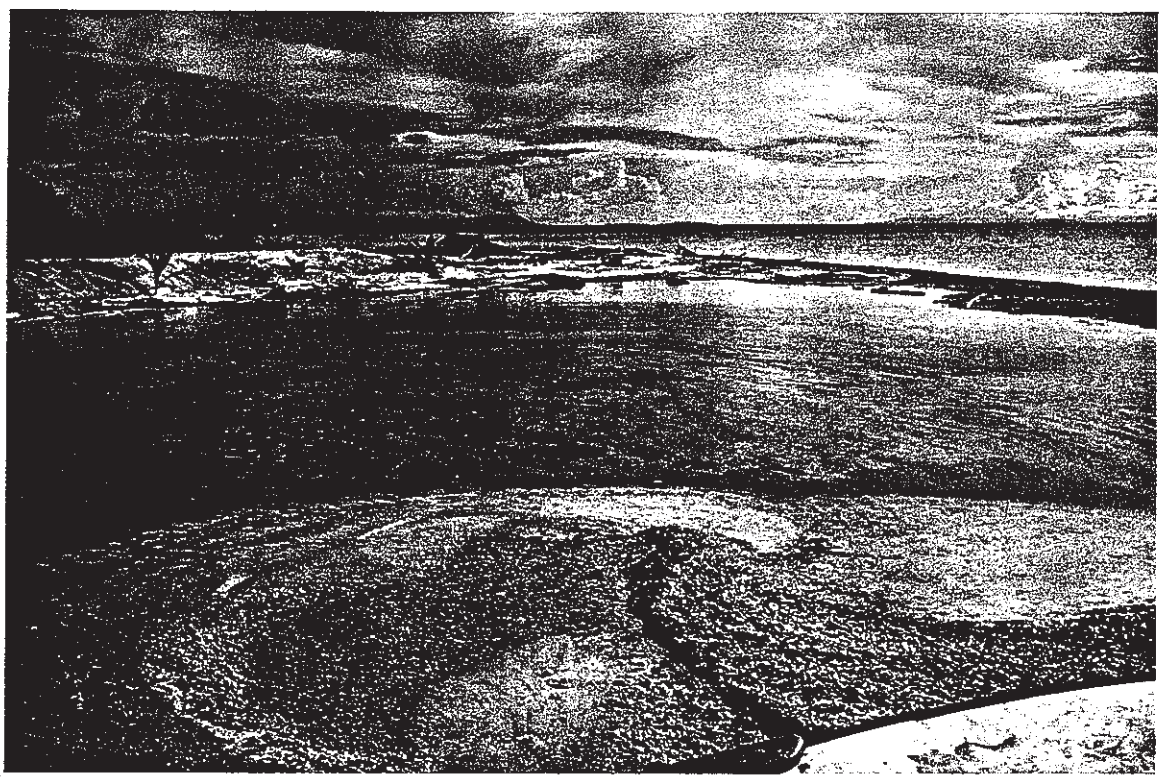


Date Printed: 11/10/1999

Beach at West Snake Cay in June, 1999, with significant build-up of sand.



Same beach in September, 1999, with significant erosion and development of a lagoon.



Weather: Sunny, Slighly Cloudy

Date/Time Start: October 3, 1999

Location/Bearing (Mag): Monkey River Profile 1 Northern End-58 degree

Personnel: Karl D. Castillo

TIDE

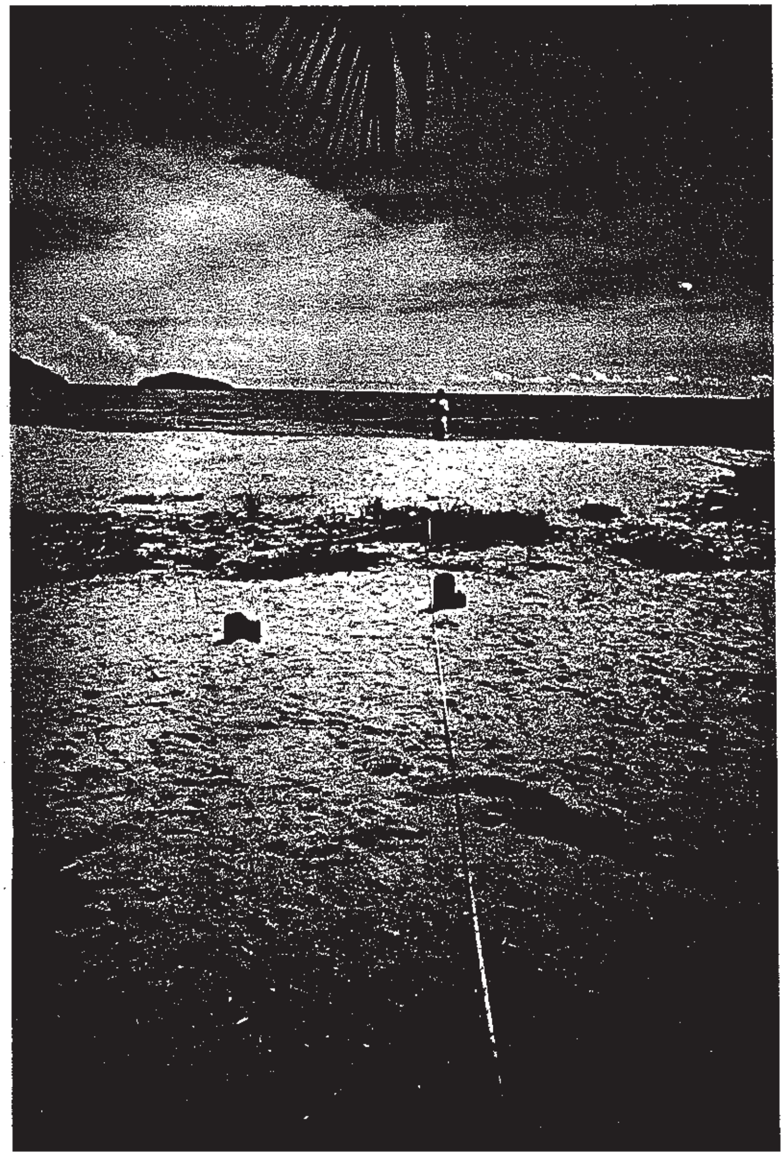
BEACH PROFILING DATA SHEET

Measurement #	Horizontal Distance (M)	Cumulative Horizontal Distance (M)	Vertical Change (cm)	Cumulative Vertical Change (cm)	Observations
1	5	5	-12.5	-12.5	
2	10	10	-8	-20.5	
3	12.7	12.7	0.5	-20	
4	15	15	0.5	-19.5	
5	20	20	28	8.5	
6	25.5	25.5	32	40.5	
7	26.8	26.8	-28	12.5	
8	28.2	28.2	-18	7	
9	32.1	32.1	-66	-51	
10	37.1	37.1	-46	-117.5	

Profiling technique: !.5 meter stakes (2 cm vertical markings), ground meter line, line of sight horizon leveling, bearing by magnetic compass.

Template date: 28/09/99

Beach profile #1 at Monkey River.



Weather: Sunny, Partially Cloudy

Date/Time Start: October 3rd, 99

Location/Bearing (Mag): Monkey River Profile 2 South of P-1 90

Personnel: Karl David Castillo

TIDE

BEACH PROFILING DATA SHEET

Measurement #	Horizontal Distance (M)	Cumulative Horizontal Distance (M)	Vertical Change (cm)	Cumulative Vertical Change (cm)	Observations
1	5	5	10	10	
2	10	10	29.5	39.5	
3	12.6	12.6	8	47.5	
4	14.8	14.8	-22	25.5	
5	18.2	18.2	-17	8.5	
6	19	19	-43	-34.5	eroding berm
7	22.6	22.6	-42	-76.5	
8	25.8	25.8	-36	-112.5	

Profiling technique: !.5 meter stakes (2 cm vertical markings), ground meter line, line of sight horizon leveling, bearing by magnetic compass.

Template date: 28/09/99

Beach profile #2 at Monkey River.

Weather: Sunny, Partially Cloudy

Date/Time Start: October 3rd, 99

Location/Bearing (Mag):Monkey River Profile 3 South of P2 108 deg.

TIDE

Personnel: Karl David Castillo

BEACH PROFILING DATA SHEET

Measurement #	Horizontal Distance (M)	Cumulative Horizontal Distance (M)	Vertical Change (cm)	Cumulative Vertical Change (cm)	Observations
1	5	5	-38	-38	
2	7.2	7.2	4	-34	
3	8.8	8.8	13	-21	
4	15.3	15.3	-88	-109	
5	15.38	15.38	-19	-128	beyond is rough and palmeto sticks

Profiling technique: !.5 meter stakes (2 cm vertical markings), ground meter line, line of sight horizon leveling, bearing by magnetic compass.

Template date: 28/09/99

Beach profile #3 at Monkey River.

Weather: Sunny

Date/Time Start: October 03rd, 99

Location/Bearing (Mag): Monkey River profile 4 South of P-3   120 deg.

TIDE

Personnel: Karl D. Castillo

BEACH PROFILING DATA SHEET

Measurement #	Horizontal Distance (M)	Cumulative Horizontal Distance (M)	Vertical Change (cm)	Cumulative Vertical Change (cm)	Observations
1	3.5	3.5	-26	-26	
2	5	5	1	-25	
3	7.5	7.5	-35	-60	
4	12.3	12.3	-68	-128	
5	13	13	-20	-148	

Profiling technique: !.5 meter stakes (2 cm vertical markings), ground meter line, line of sight horizon leveling, bearing by magnetic compass.

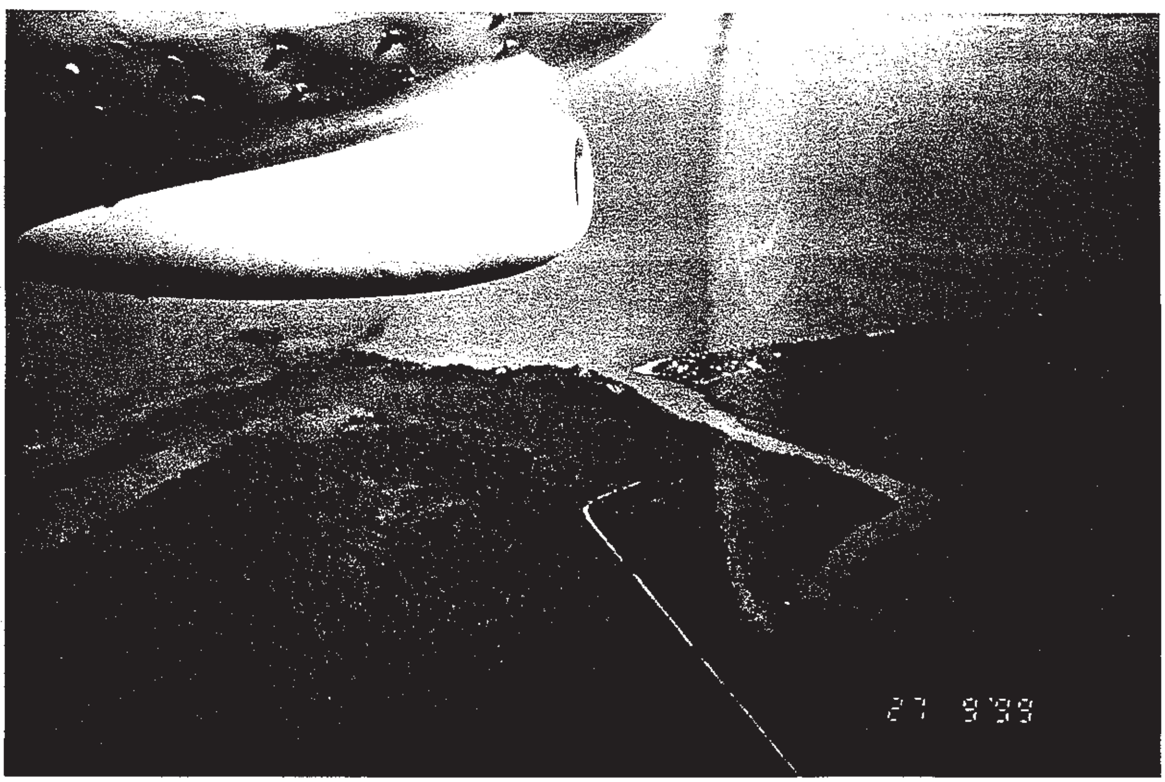
Template date: 28/09/99

Beach profile #4 at Monkey River.

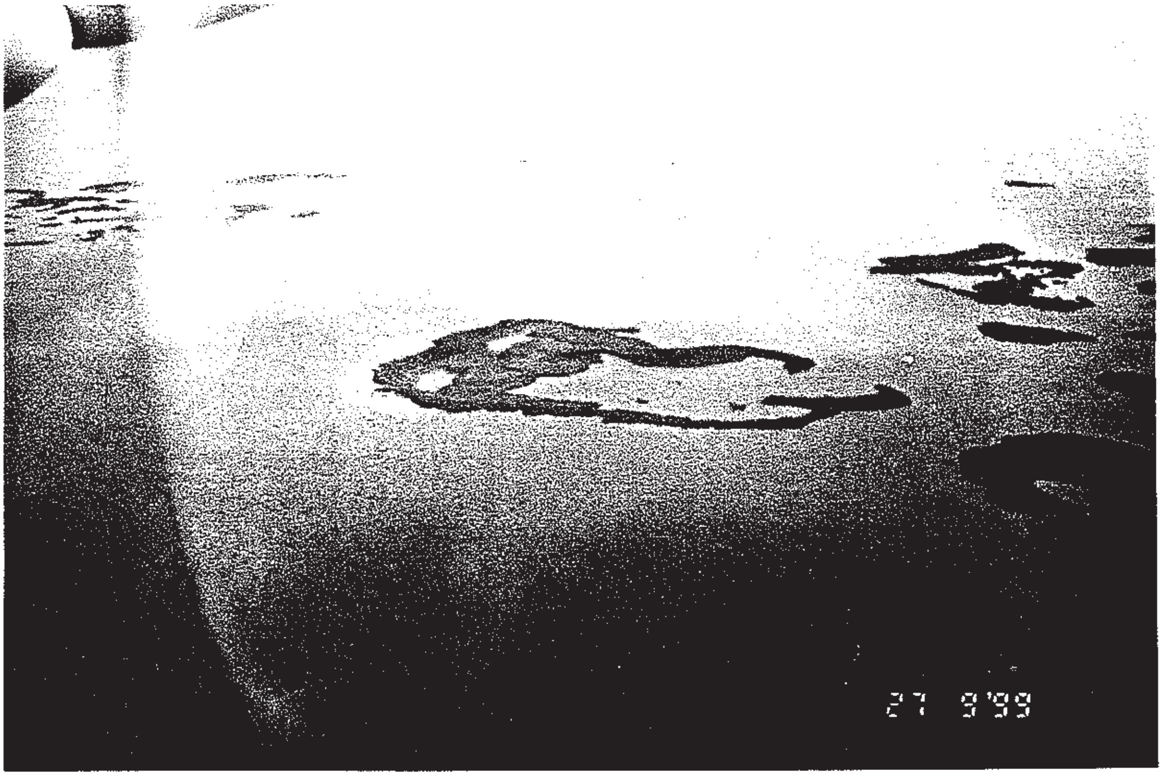
Aerial Photographs

Extensive freshwater plume from Monkey River, running south - September, 1999.

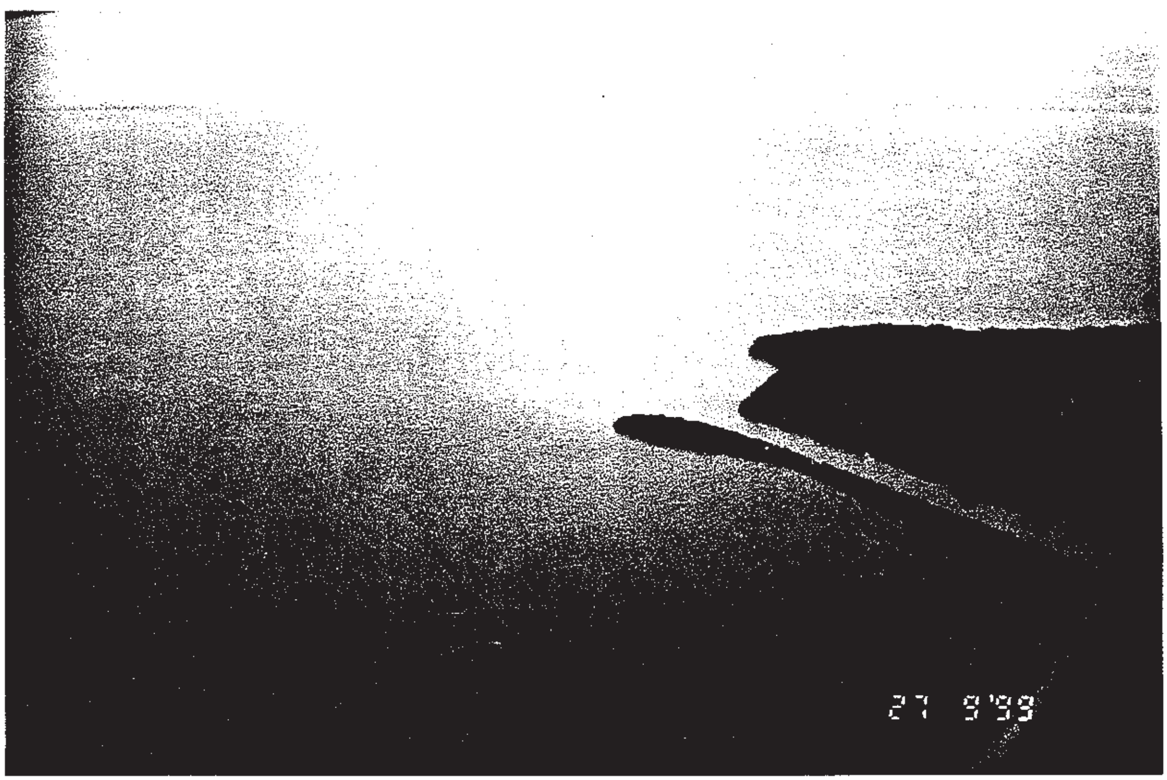
The sandspit on the south side of Monkey River has been reduced in size since June, 1999.



Bob Stuart Lagoon - September, 1999.



The mouth of Rio Grande - September, 1999.



Mangrove Plots:

Location	Date	Plot Size	Density of Seedlings (in plot)	Growth Data (tagged seedlings)	General Observations
Monkey River Plot #1 GPS: 1810331N 16Q340268E (mouth of Black Creek)	3/10/99	5.4 x 5.7 x 5.0 x 5.6 metres (= 29.39 square metres)	red: 22 black: 29 white: 21	red #1: height: 54 cm diam.: 8 mm red #2: h: 48 cm d: 6 mm red #3: h: 100 cm d: 11 mm black #1: h: 76 cm d: 6 mm black #2: h: 55 cm d: 8 mm black #3: h: 38 cm d: 5 mm white #1: h: 97 cm d: 14 mm white #2: h: 96 cm d: 10 mm white #3: h: 68 cm d: 7 mm	near mouth of Black Creek, about 10 metres in from the riverbank; sandy mud sediments; half the plot is under 4-5 cm of water; plot surrounded by mature red and black mangroves, but canopy fairly open; no mature trees in plot; black mangrove roots throughout; vines growing through plot, and some grass (see photographs).

Monkey River Plot #2 GPS: 1810331N 16Q340268E (south of mouth of Black Creek)	3/10/99	3.8 x 3.6 x 5.5 x 4.1 metres (= 18.12 square metres)	red: 2 black: 131 white: 0	red #1: height: 44 cm diam.: 10 mm red #2: h: 44 cm d: 7 mm black #1: h: 28 cm d: 4 mm black #2: h: 27 cm d: 4 mm black #3: h: 42 cm d: 4 mm black #4: h: 39 cm d: 4 mm black #5: h: 41 cm d: 5 mm black #6: h: 21 cm d: 3 mm black #7: h: 26 cm d: 3 mm	south of the mouth of Black Creek, 5 metres back from the shore; muddy sand substrate; lots of coral rubble in the plot; red mangrove roots throughout the plot; heavy canopy, so shaded area; substrate wet, but not covered in water; mature red, black, and white mangroves in surrounding area (see photographs).

Inside Sheepshead Plot #1 GPS: 1793950N 16Q324833E (east side of small beach)	6/10/99	4.25 x 4.5 x 4.0 x 4.7 metres (= 18.96 square metres)	red: 14 black: 0 white: 1	red #1: height: 19 cm diam.: 3 mm red #2: h: 18 cm d: 4 mm red #3: h: 18 cm d: 4 mm red #4: h: 18 cm d: 4 mm red #5: h: 15.5 cm d: 4 mm red #6: h: 12.5 cm d: 3 mm red #7: h: 10 cm d: 3 mm red #8: h: 16 cm d: 3 mm white #1: h: 12 cm d: 3 mm	dominant red mangrove community with mature trees; a quarter of the plot is under water and at least half is wet at high tide; 80% cover by the canopy (shaded); dense red mangrove roots in quadrat; grass intrusion on west side; sand and coral rubble substrate; all seedlings are on the northern, drier side of the plot (see photographs).
Inside Sheepshead Plot #2 GPS: 1794031N 16Q324878E (west side of small beach)	6/10/99	3.9 x 4.9 x 3.0 x 3.0 metres (= 14.06 square metres)	red: 1 black: 2 white: 0	red #1: height: 36 cm diam.: 4 mm black #1: h: 13 cm d: 2 mm black #2: h: 10 cm d: 2 mm	mixed mangrove and seagrape community; 2/3 of the plot is under water; lots of coral rubble in substrate; canopy provides 50-60% cover; red mangrove roots dominate the plot (see photographs).

Bob Stuart Lagoon Plot #1 GPS: 1791747N 16Q319367E (west side of mouth of lagoon)	6/10/99	5.0 x 3.5 x 4.7 x 3.0 metres (= 15.80 square metres)	red: 15 black: 0 white: 0	red #1: height: 60 cm diam.: 8 mm red #2: h: 56 cm d: 9 mm red #3: h: 57 cm d: 9 mm red #4: h: 53 cm d: 10 mm red #5: h: 40.5 cm d: 6 mm red #6: h: 78 cm d: 18 mm red #7: h: 50 cm d: 10 mm red #8: h: 61 cm d: 11 mm red #9: h: 70 cm d: 17 mm	whole plot is flooded; coral sand and mud substrate; very open canopy (only about 15% shade); red mangrove habitat (there are 5 larger trees in the plot); roots dominate the plot (see photographs).
Bob Stuart Lagoon Plot #2 GPS: 1791575N 16Q319557E (east side of mouth of lagoon)	6/10/99	5.2 x 2.3 x 4.7 x 2.25 metres (= 11.27 square metres)	red: 3 black: 0 white: 1	red #1: height: 45 cm diam.: 7 mm red #2: h: 39.5 cm d: 5 mm red #3: h: 32 cm d: 4 mm white #1: h: 14 cm d: 6 mm	very open canopy with only 15% shade; dominant red mangrove habitat, with one red mangrove tree in plot and also one white mangrove tree; lots of coral rubble in substrate; 100% of plot under water at time of survey (see photographs).

Notes:
1. 2 additional plots at Rio Grande and 2 plots at Moho River to be set within the next week.
2. All plots to be re-sampled and photographed every four months.

Mangrove Plot #1 near Monkey River.

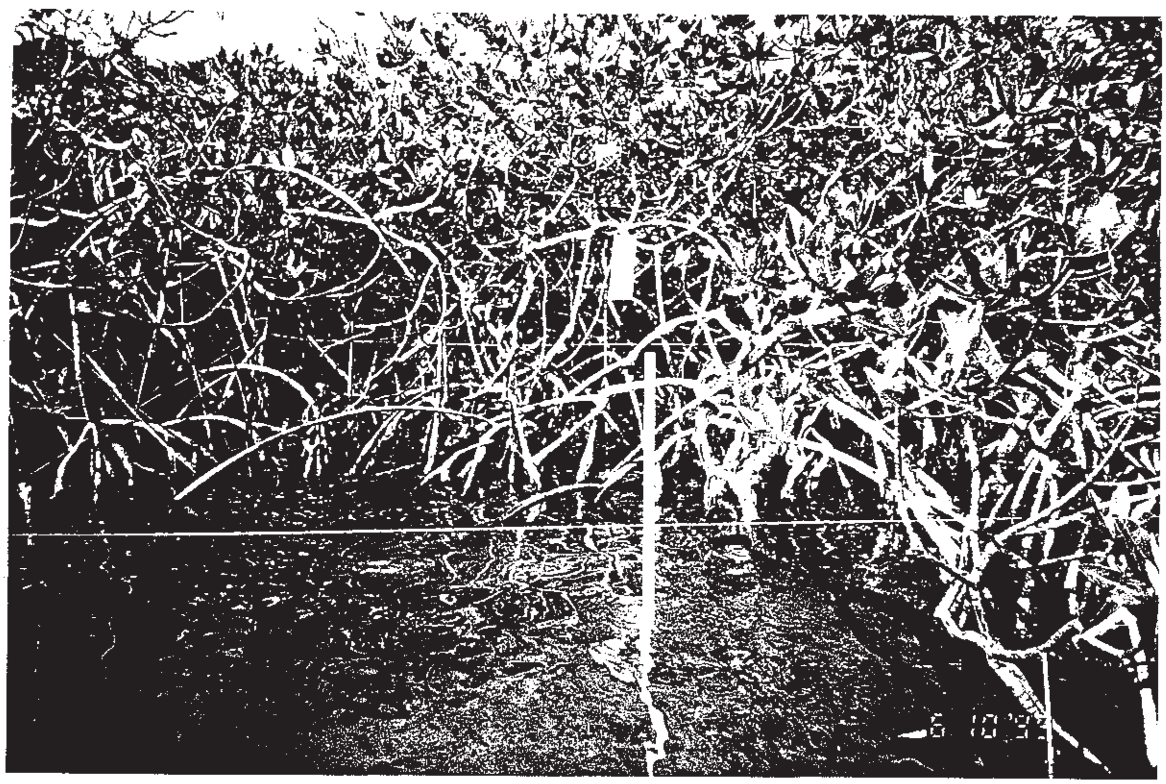
Mangrove Plot #2 near Monkey River.

Mangrove Plot #1 at Inside Sheepshead.

Mangrove Plot #2 at Inside Sheepshead.

Mangrove Plot #1 at Bob Stuart Lagoon.

Mangrove Plot #2 at Bob Stuart Lagoon.



Photoquadrats:

Location	Date	Photographs	General Observations
West Snake Cay Q1 (coral) GPS: 1810331N 16Q340268E north side of West Snake Cay; between Station 5 and the shore	Oct. 6/99; 8:56 a.m.	2 (1 lost in processed film)	one dead *Acropora* colony; one small live boulder coral colony; some calcareous algae; algal tufts on the dead coral; water depth 2 m
West Snake Cay Q2 (coral) GPS: 1810331N 16Q340268E north side of West Snake Cay; between Station 5 and the shore, several metres further offshore than Q1	Oct. 6/99; 9:17 a.m.	3	dead *Acropora*; green calcareous algae; water depth 2 m
West Snake Cay Q3 (coral) GPS: 1810331N 16Q340268E north side of West Snake Cay; between Station 5 and the shore	Oct. 6/99; 9:23 a.m.	3	lots of dead *Acropora* with algal tufts; red algae on coral; green calcareous algae, sea urchins present; water depth 2 m
West Snake Cay Q4 (seagrass) GPS: 1790736N 16Q331780E west side of West Snake Cay; between Station 6 and shore; white buoy numbered	Oct. 6/99; 9:46 a.m.	3	100% seagrass cover, but moderate density; *Thalassia* and *Syringodium*; water depth 3 m

West Snake Cay Q5 (seagrass) GPS: 1790716N 16Q331775E west side of West Snake Cay, between Station 6 and shore; gray buoy numbered	Oct. 6/99; 10:00 a.m.	3	on edge of seagrass - 50% seagrass and 50% sand; *Thalassia* and *Syringodium;* water depth 2.5 m
West Snake Cay Q6 (seagrass) GPS: 1790708N 16Q331776E west side of West Snake Cay, between Station 6 and shore; orange buoy numbered	Oct. 6/99; 10:20 a.m.	3	100 % seagrass moderate density near edge of bed; *Thalassia* and *Syringodium*; water depth 2.5 m
Inside Sheepshead Q7 (coral) GPS: 1794480N 16Q325864E northern end of the cay, about 80 m offshore, with a bearing of 262 degrees to the tallest tree; numbered buoy	Oct. 6/99; 10:56 a.m.	3	Live boulder coral; 2 dead *Acropora* colonies with algal tufts; also *Thalassia* throughout the quadrat; green calcareous algae; red algae throughout, water depth of 2.5 m
Inside Sheepshead Q8 (coral) GPS: 1794472N 16Q325866E northern end of the cay, about 80 m offshore, near other quadrats; numbered buoy	Oct. 6/99; 11:19 a.m.	3	Same habitat as quadrat above; water depth of 2 m
Inside Sheepshead Q9 (coral) GPS: 1794472N 16Q325866E near quadrats above; numbered buoy	Oct. 6/99; 11:40 a.m.	3	2 live boulder coral colonies; *Thalassia* throughout the quadrat; some red algae on coral; water depth of 2 m

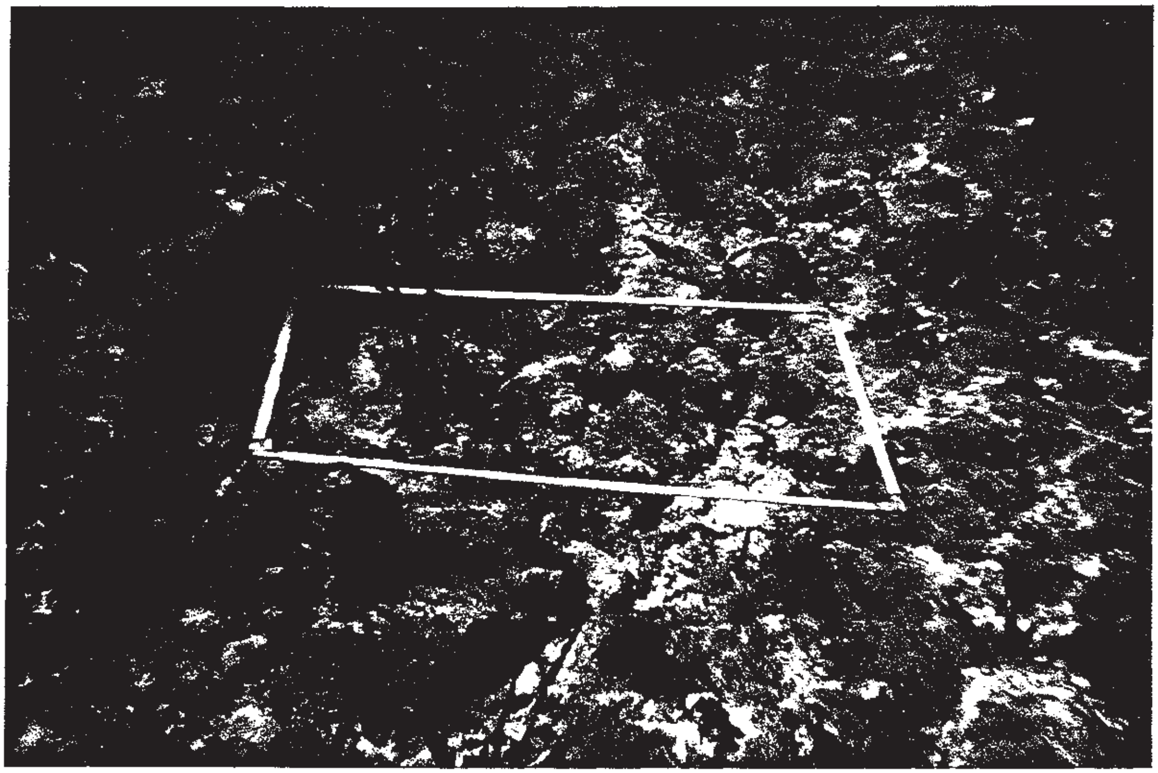
Inside Sheepshead Q10 (seagrass) GPS: 1794036N 16Q324766E between the buoys at Station 7 and the shore; numbered buoy	Oct. 6/99; 11:31 a.m.	3	Thick *Thalassia* here; 100% coverage; lots of suspended mud here; water depth of 2.5 m
Inside Sheepshead Q11 (seagrass) GPS: 1794036N 16Q324766E near quadrat above; numbered buoy	Oct. 6/99; 11:50 a.m.	3	50 with *Thalassia* and 50% sand; lots of mud on seagrass blades; water depth of 2.5 m
Inside Sheepshead Q12 (seagrass) GPS: 1794036N 16Q324766E near quadrat above; numbered buoy	Oct. 6/99; 12:10 p.m.	3	Very similar to Q10; water depth of 2.5 m
Bob Stuart Lagoon Q13 (coral) GPS: 1792028N 16Q320346E northeast end of Bob Stuart Lagoon, about 60 m from shore, bearing of 210 degress to the tallest tree; numbered buoy	Oct. 6/99; 1:23 p.m.	3	2 dead *Acropora*; one small boulder coral colony regrowing; *Thalassia* seagrass throughout; water depth of 2.5 m
Bob Stuart Lagoon Q14 (coral) GPS: 1792028N 16Q320346E near quadrat above; numbered buoy	Oct. 6/99; 1:45 p.m.	3	Dead coral overgrown with green algae; some red algae; a few small boulder coral colonies; *Thalassia* in this quadrat; water depth less than 2 m

Bob Stuart Lagoon Q15 (coral) GPS: 1792028N 16Q320346E near quadrat above; numbered buoy	Oct. 6/99; 2:05 p.m.	3	One small boulder coral growing; dead coral rubble; sand and seagrass in the quadrat; water depth of 2.5 m
Bob Stuart Lagoon Q16 (seagrass) GPS: 1792035N 16Q320375E between the buoys at Station 9 and the shore; numbered buoy	Oct. 6/99; 2:20 p.m.	3	*Thalassia* on sand and coral rubble; lots of algal epiphytes; suspended sediments in the water; seagrass is sparse; water depth 2 m
Bob Stuart Lagoon Q17 (seagrass) GPS: 1792035N 16Q320375E between the buoys at Station 9 and the shore; numbered buoy	Oct. 6/99; 2:40 p.m.	3	Very similar to quadrat above; water depth 2.5 m
Bob Stuart Lagoon Q18 (seagrass) GPS: 1792035N 16Q320375E between the buoys at Station 9 and the shore; numbered buoy	Oct. 6/99; 3 p.m.	3	On a slope - water depth of 1.8 m; fairly dense *Thalassia* seagrass; lots of brown algae in quadrat; some calcareous green algae

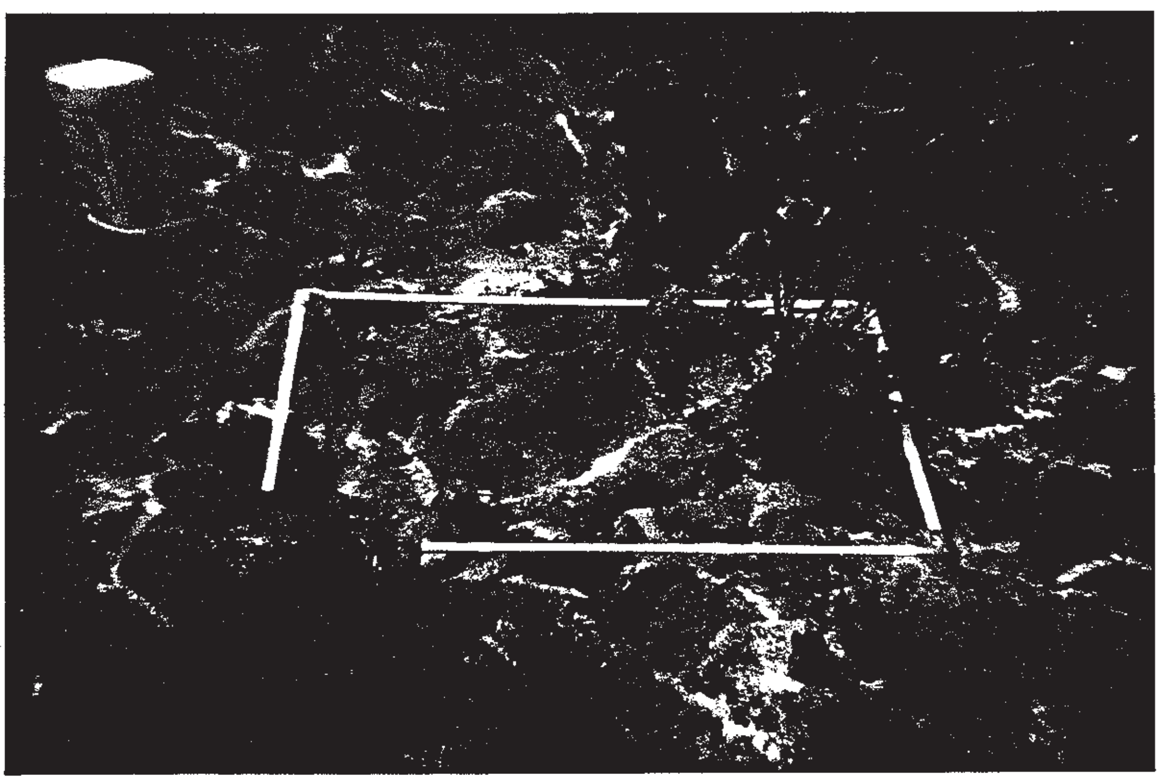
Notes:

1. Quadrat size is 113 cm x 68.5 cm.
2. Shallow quadrats (generally less than 2.5 metres water depth) were photographed in two halves, with photographs subsequently to be overlapped. Deeper quadrats could be covered by one film frame.
3. Quadrats to be photographed 2 or 3 times per year, depending on the observed rate of change within the quadrats.

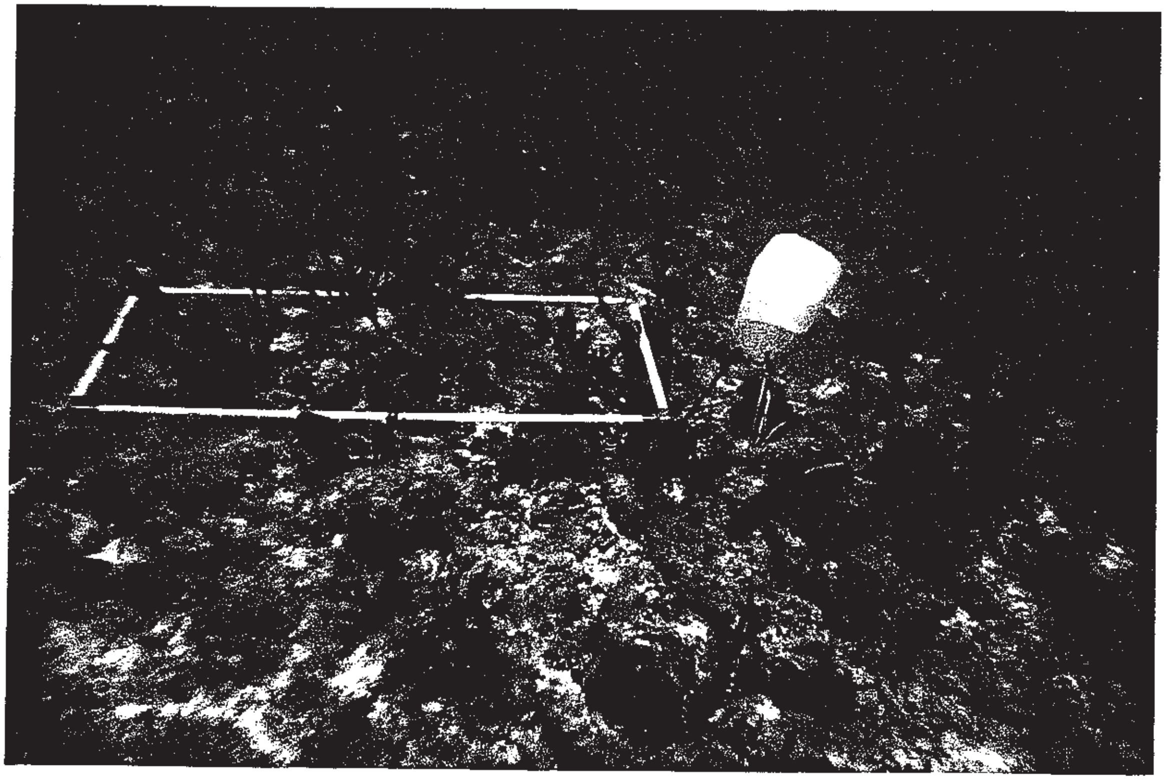
Quadrat 1: coral at West Snake Cay.



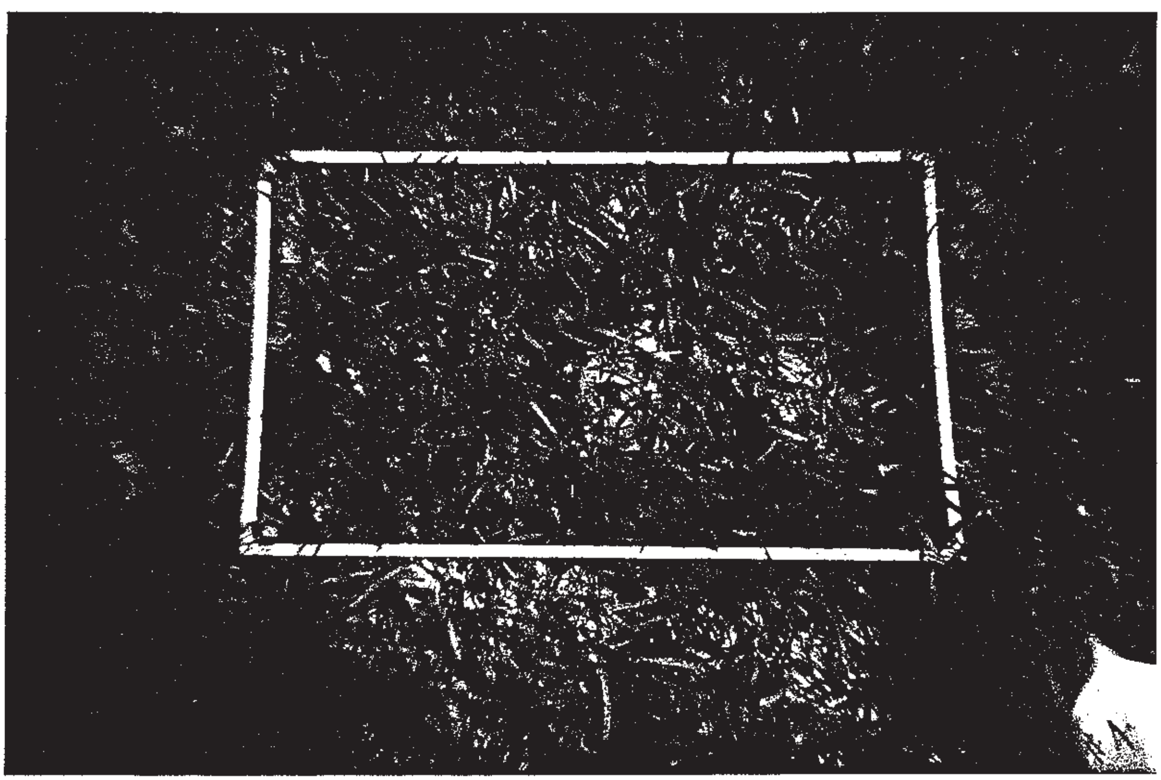
Quadrat 2: coral at West Snake Cay.



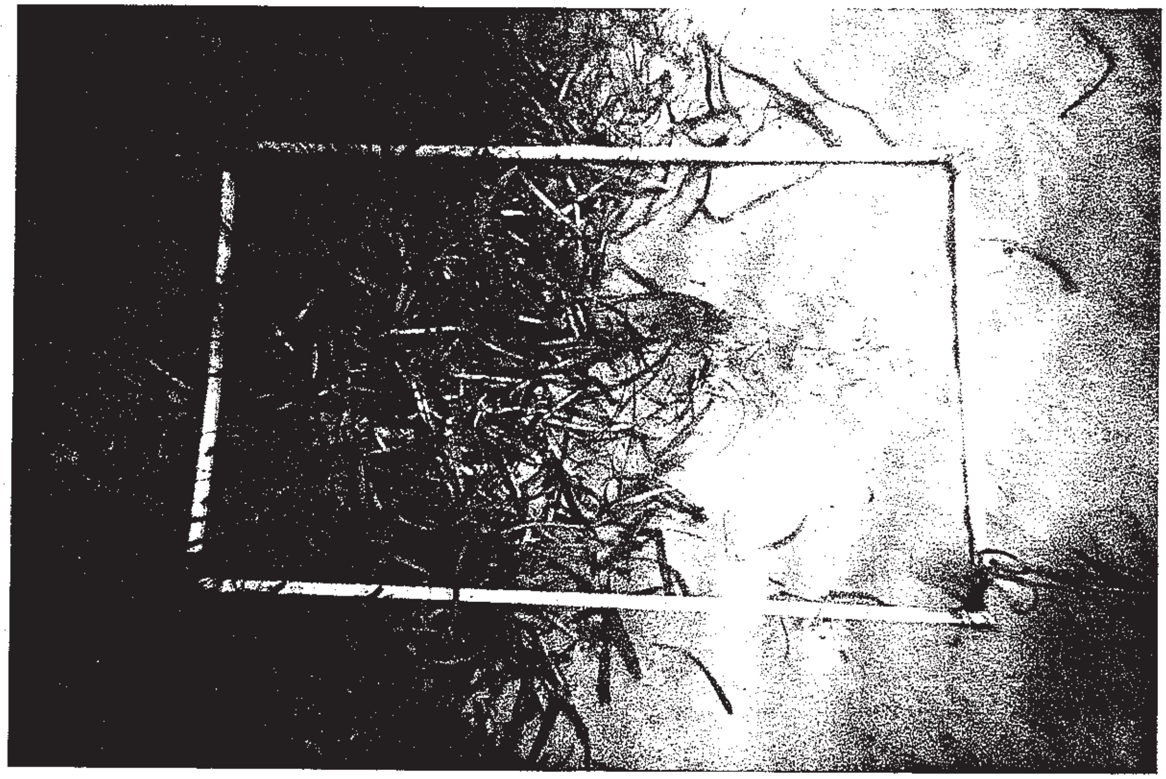
Quadrat 3: coral at West Snake Cay.



Quadrat 4: seagrass at West Snake Cay.

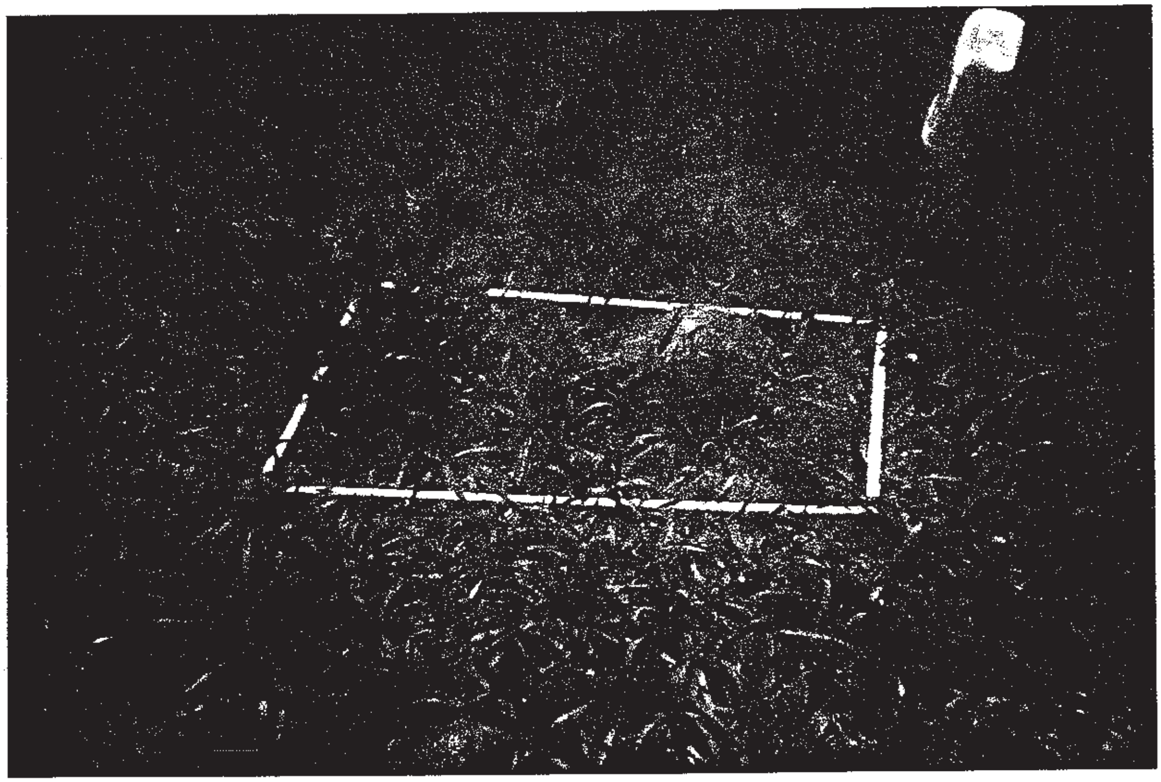


Quadrat 5: seagrass at West Snake Cay.

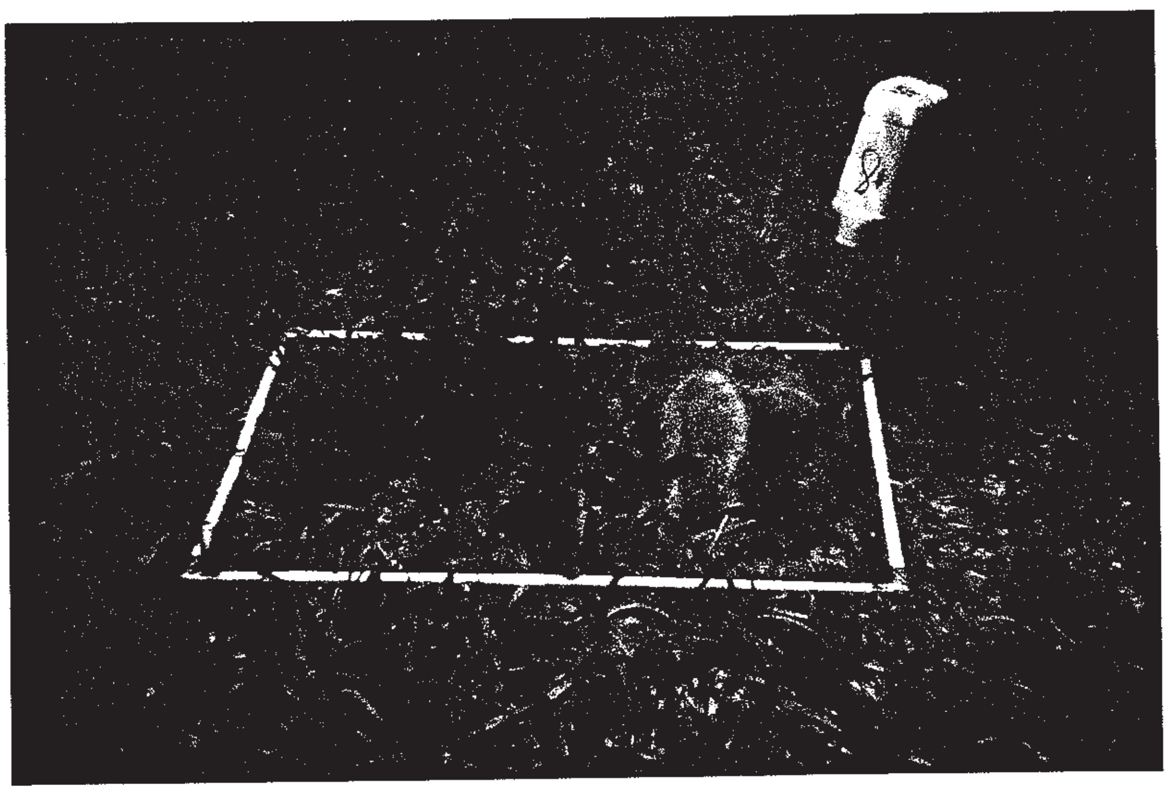


Quadrat 6: seagrass at West Snake Cay.

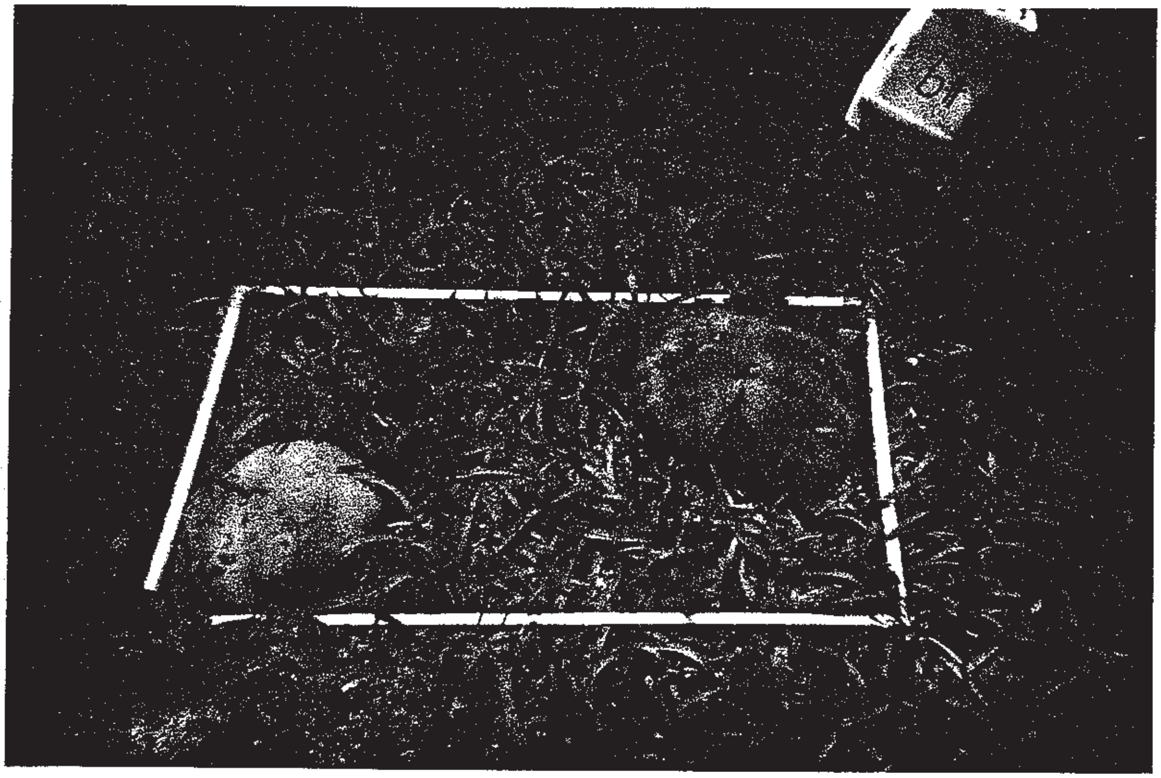
Quadrat 7: coral at Inside Sheepshead.



Quadrat 8: coral at Inside Sheepshead.

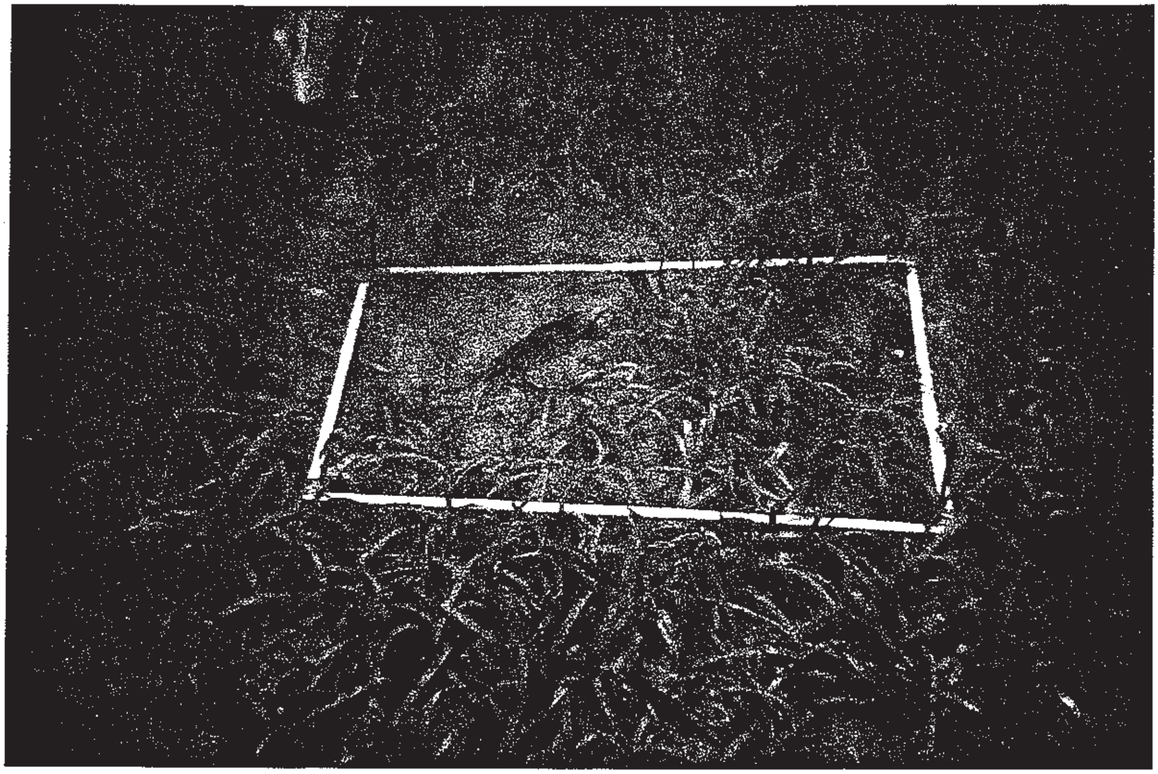


Quadrat 9: coral at Inside Sheepshead.

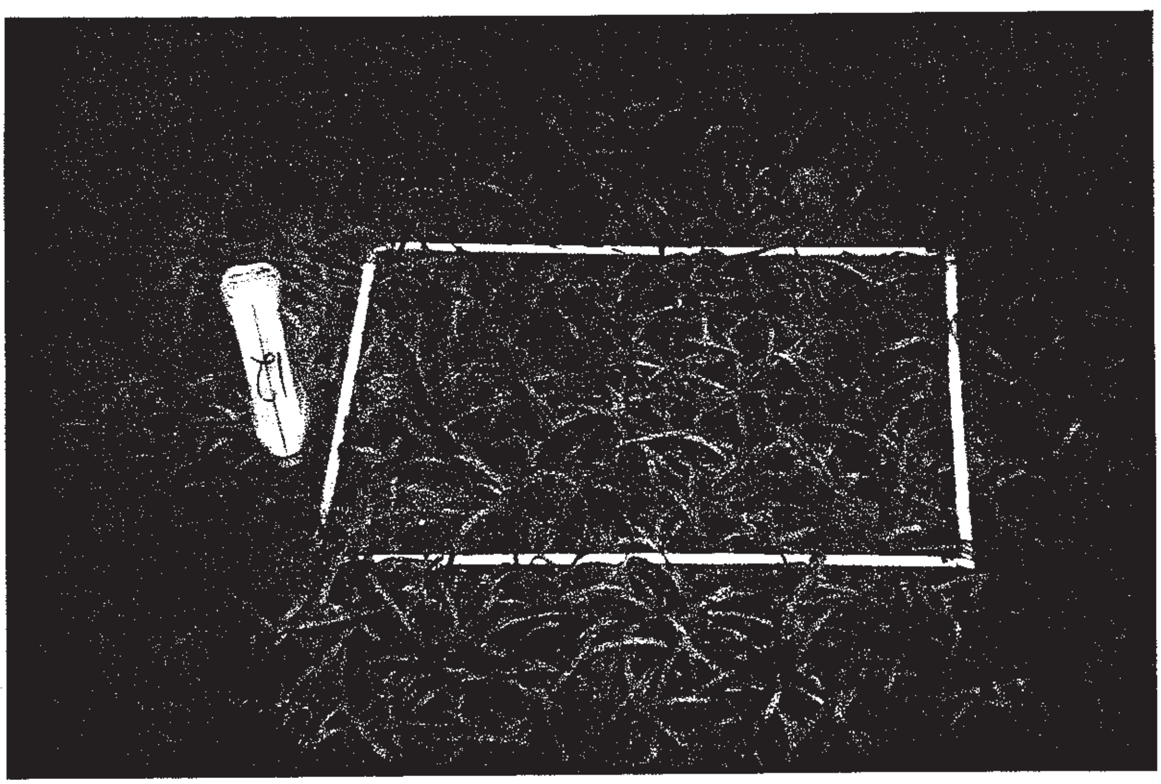


Quadrat 10: seagrass at Inside Sheepshead.

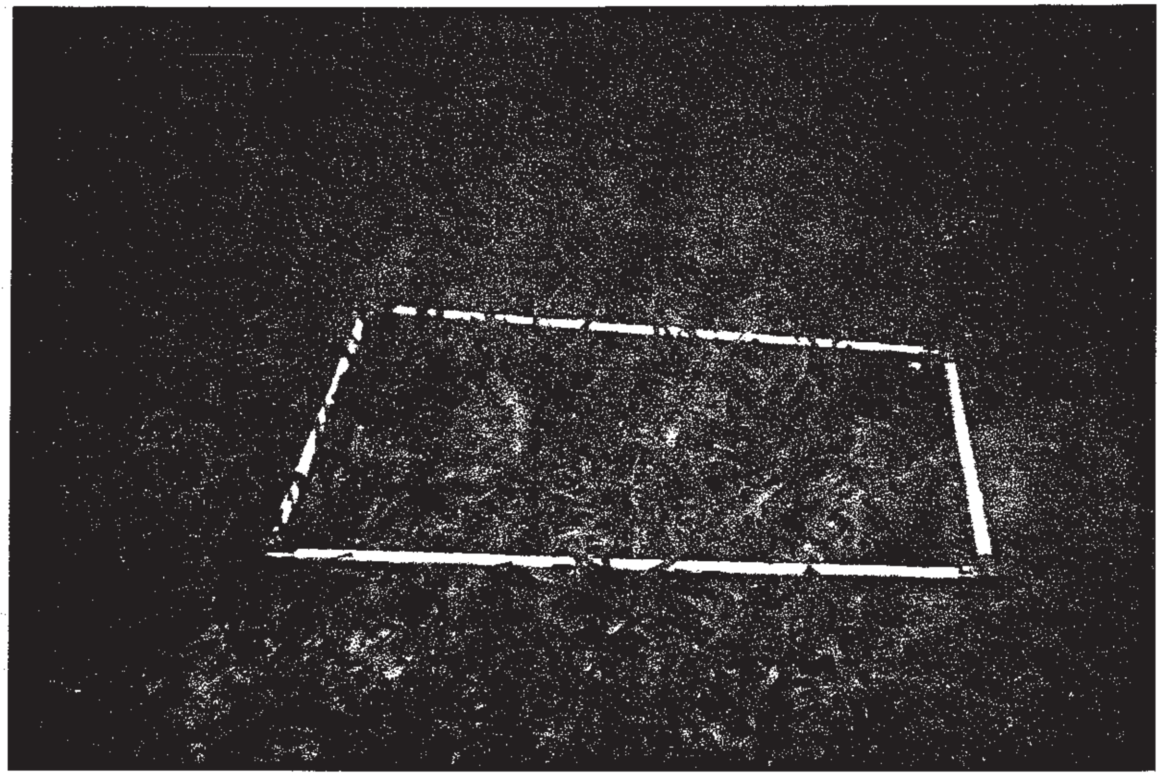
Quadrat 11: seagrass at Inside Sheepshead.



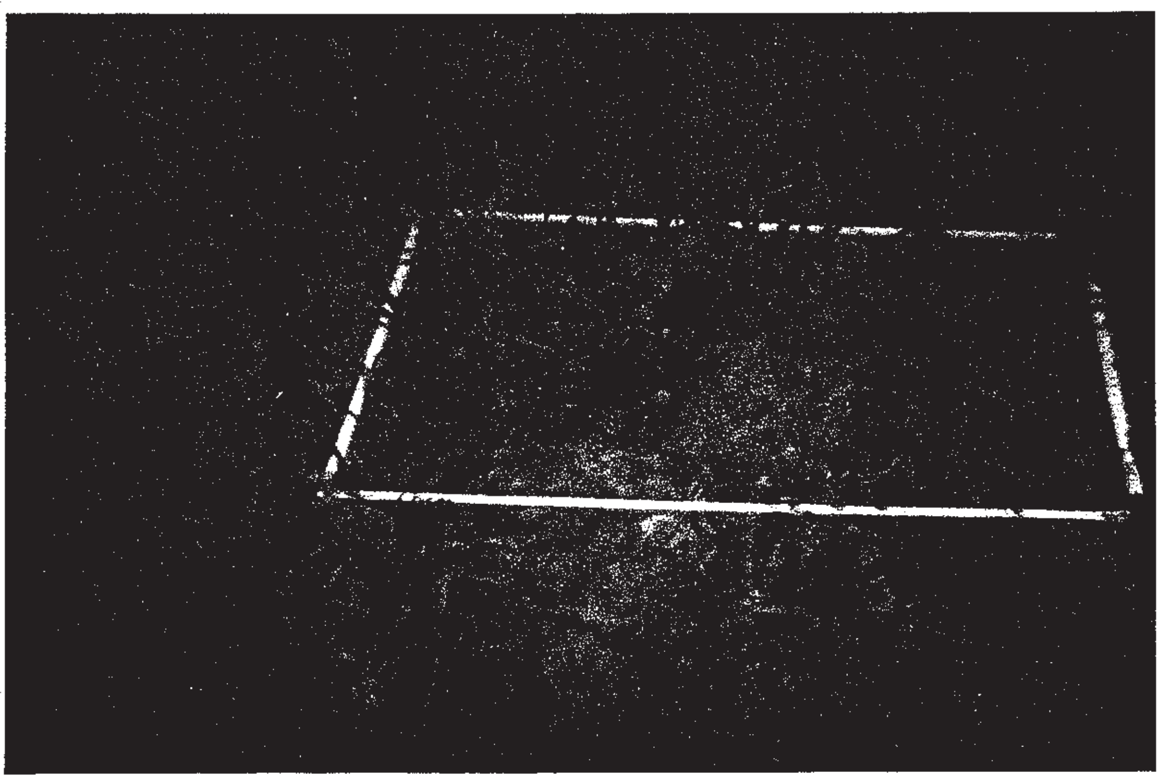
Quadrat 12: seagrass at Inside Sheepshead.



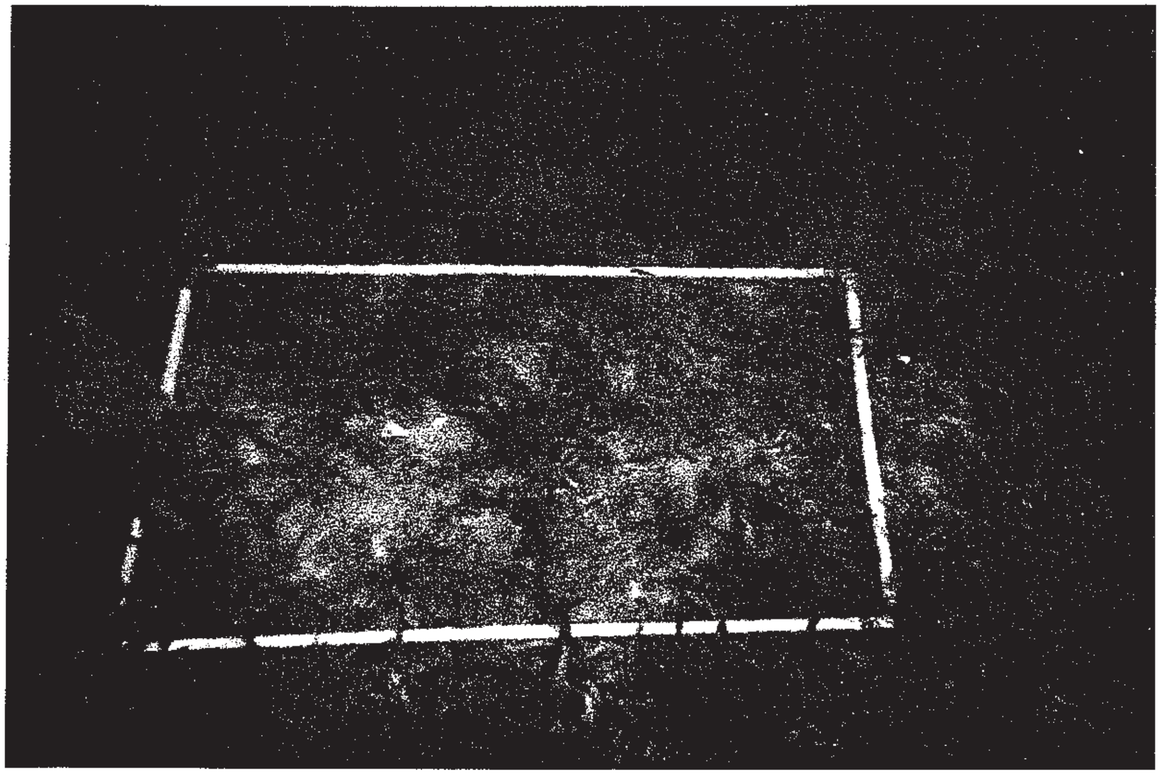
Quadrat 13: coral at Bob Stuart Lagoon.



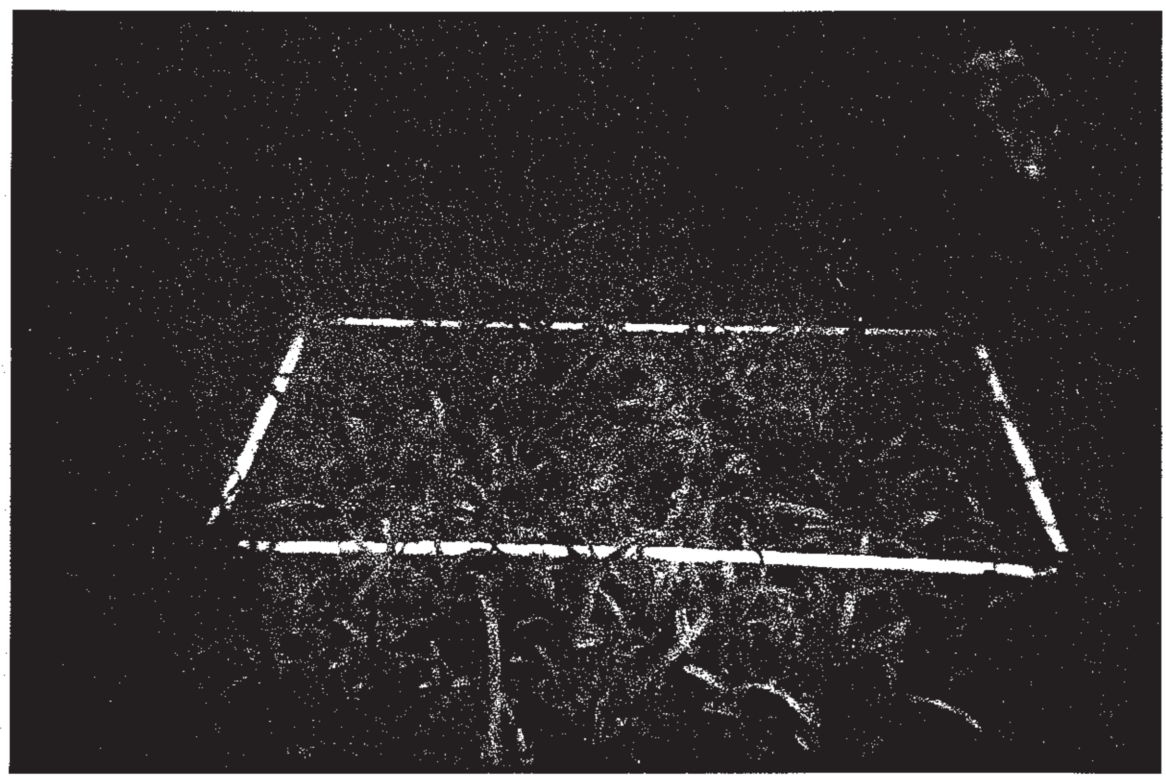
Quadrat 14: coral at Bob Stuart Lagoon.



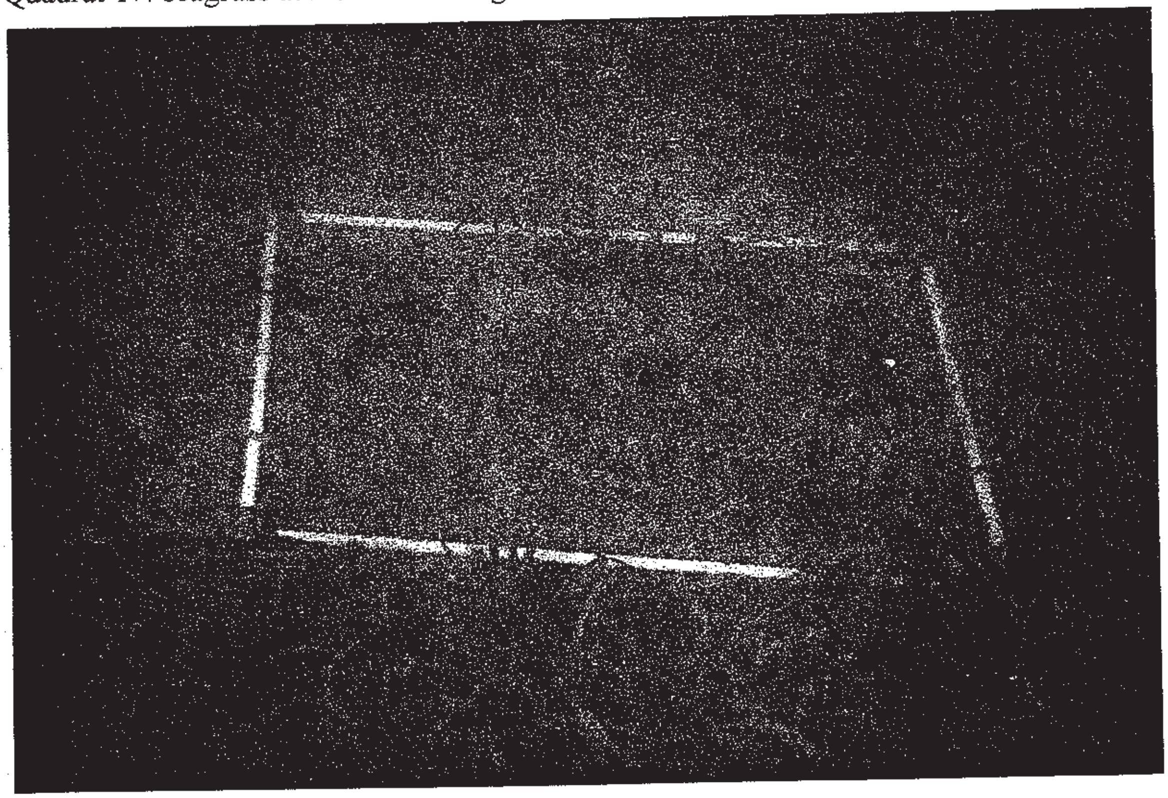
Quadrat 15: coral at Bob Stuart Lagoon.



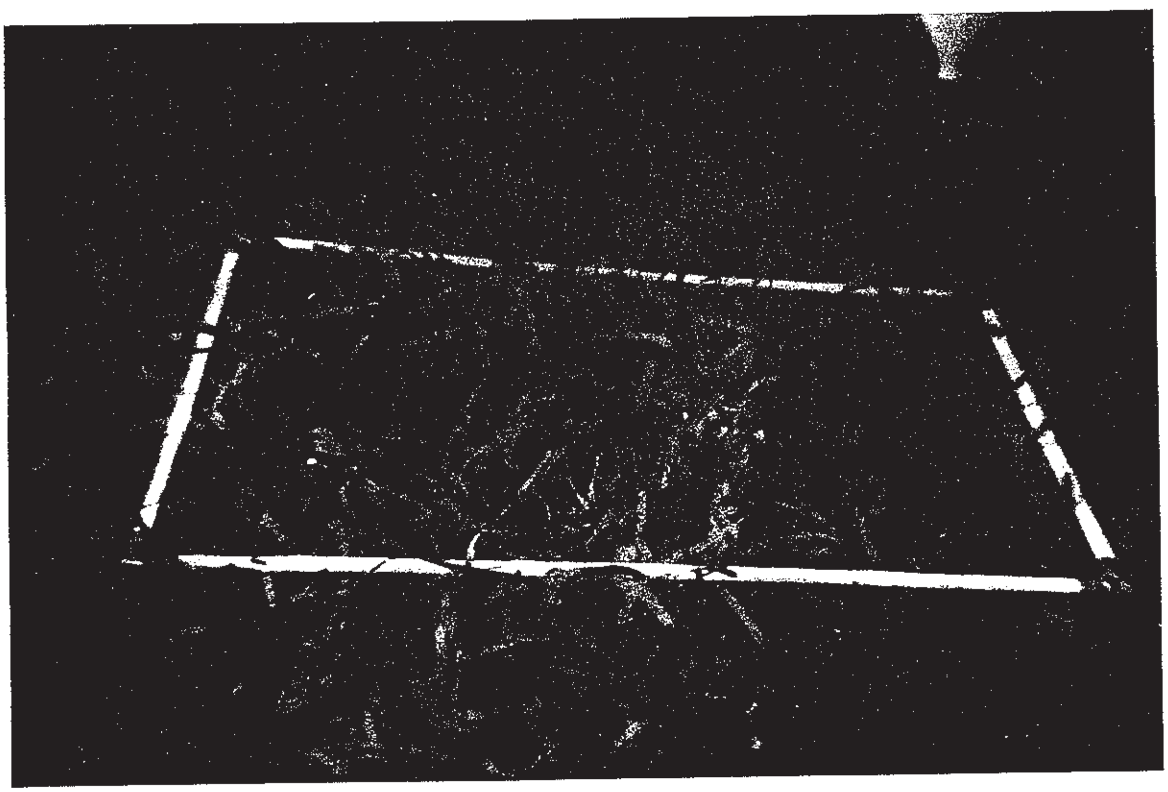
Quadrat 16: seagrass at Bob Stuart Lagoon.



Quadrat 17: seagrass at Bob Stuart Lagoon.



Quadrat 18: seagrass at Bob Stuart Lagoon.



Recruitment Plates:

Station	Set Date	Retrieval Date	Dry Weight Tissue (g)	General Observations	Digital Image
1 Rio Grande	July 30/99	Aug. 31/99	1.39	Heavy sedimentation on tile; lots of barnacles; algal growth on edges of tiles; 25 barnacles; 10 other barnacle scars 1 tuft of red algae 6 serpulid polychaete 1 patch of bryozoans	rp01aug31kc
1 Rio Grande	July 30/99	Oct. 1/99	16.70	66 barnacles and some scars 1 red alga - 8-9 cm high 5 tunicates 1 sea anemone 1 polychaete 9 serpulid (calcareous) polychaetes 1 seapen lots of filamentous algae 1 small crab	rp01oct1kc
2 Rio Grande	July 30/99	Aug. 31/99	1.00	Heavy sedimentation on tile and growth of algae algal turf on tile 15 barnacles and 14 scars	rp02aug31kc
2 Rio Grande	July 30/99	Oct. 1/99	10.42	40 barnacles 5 large red algae (8-10 cm high) with hydroids moderate amount of filamentous algae	rp02oct1kc

3 Monkey River	July 30/99	Aug. 31/99	0.03	Some sedimentation on tile and light algal turf a few filamentous algae 2 large bryozoan patches some smaller bryozoan patches just getting established	rp03aug31kc
3 Monkey River	July 30/99	plates lost	-		-
4 Monkey River	July 30/99	Aug. 31/99	0.03	Little sedimentation; light algal turf a few algal tufts on the tile 4 bryozoan patches 1 clump of small algal filaments	rp04aug31kc
4 Monkey River	July 30/99	Oct. 1/99	0.18	3 red algae one of which is 4 cm high red algal patches on the tile 3 brown algae	rp04oct1kc
5 West Snake Cay	July 30/99	plates lost	-		-
5 West Snake Cay	July 30/99	plates lost	-		-
6 West Snake Cay	July 30/99	Aug. 31/99	0.05	Light algal turf on tile 14 barnacle scars 2 bryozoan patches	rp06aug31kc
6 West Snake Cay	July 30/99	Oct. 1/99	0.44	Just some diatomaceous or algal slime on tile	rp06oct1kc
7 Inside Sheepshead	June 23/99	Aug. 31/99	0.03	Tunicates and algal turf on tile (fairly thick) scars of three tunicates (lost during tile storage) scattered patches of calcareous algae	rp07aug31kc

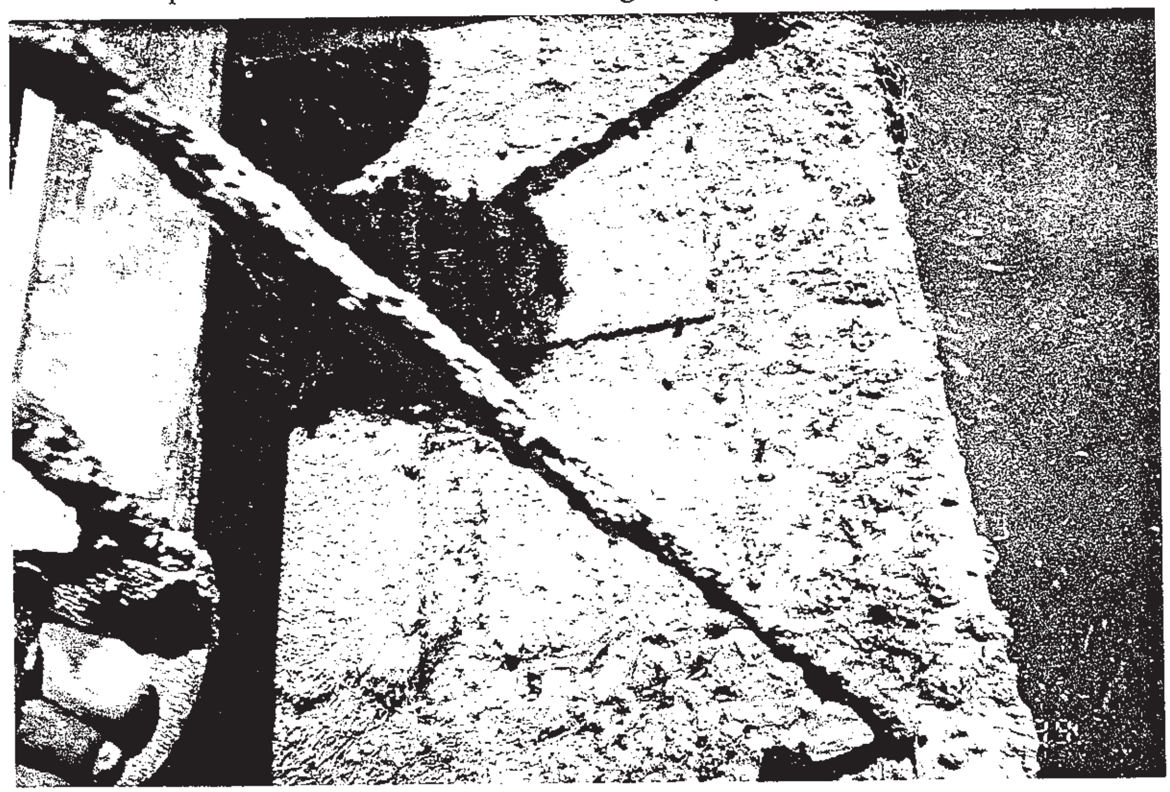
7 Inside Sheepshead	June 23/99	Oct. 1/99	1.10	3 large tunicates 1 polychaete (fanworm) some algal turf 2 small green algae filaments algal or diatomaceous slime on tile	rp07oct1kc
8 Inside Sheepshead	July 30/99	Aug. 31/99	0.04	Very little sedimentation on tile light algal growth 7 bryozoan patches 11 small barnacle scars	rp08aug31kc
8 Inside Sheepshead	July 30/99	Oct. 1/99	0.43	1 large tunicate about 3 cm high 5 brown algae about 2 cm high 2 serpulid polychaetes 1 bivalve small amounts of filamentous algae 5 clumps of green algae 1 red alga about 2 cm high	rp08oct1kc
9 Bob Stuart Lagoon	July 30/99	Aug. 31/99	0.02	Very light algal growth a few small patches of calcareous algae forming	rp09aug31kc
9 Bob Stuart Lagoon	July 30/99	Oct. 1/99	1.10	65 green algae filaments about 5 cm high 9 brown algae 1 red algae 1 serpulid polychaete 1 seapen about 3 cm long lots of filamentous green algal turf	rp09oct1kc
10 Bob Stuart Lagoon	July 30/99	Aug. 31/99	0.01	Some sedimentation on tile algal mat evident a few very small patches of calcareous algae forming	rp10aug31kc

10 Bob Stuart Lagoon	July 30/99	Oct. 1/99	1.38	19 green algae filaments about 6 cm high 1 large red alga about 5 cm high 1 bivalve 3 cm long 2 smaller bivalves about 3 mm long 4 brown algae 1 polychaete in a mud tube moderate amount of filamentous algae	rp10oct1kc
11 Moho River	Aug. 6/99	Aug. 31/99	0.07	Sedimentation and heavy algal truf evident some algal filaments	rp11aug31kc
11 Moho River	Aug. 6/99	Oct. 1/99	1.93	24 barnacles and some scars 2 red algae about 2 cm high 7 green algae about 2 cm high 2 small tunicates about 7 mm wide some hydroids 7 serpulid polychaetes moderate amount of filamentous algal turf	rp11oct1kc
12 Moho River	Aug. 6/99	Aug. 31/99	0.03	Sedimentation and algal turf evident many small bryozoan patches 2 large bryozoan patches two small calcareous patches (possible coral polyps?)	rp12aug31kc
12 Moho River	Aug. 6/99	plates lost	-		-

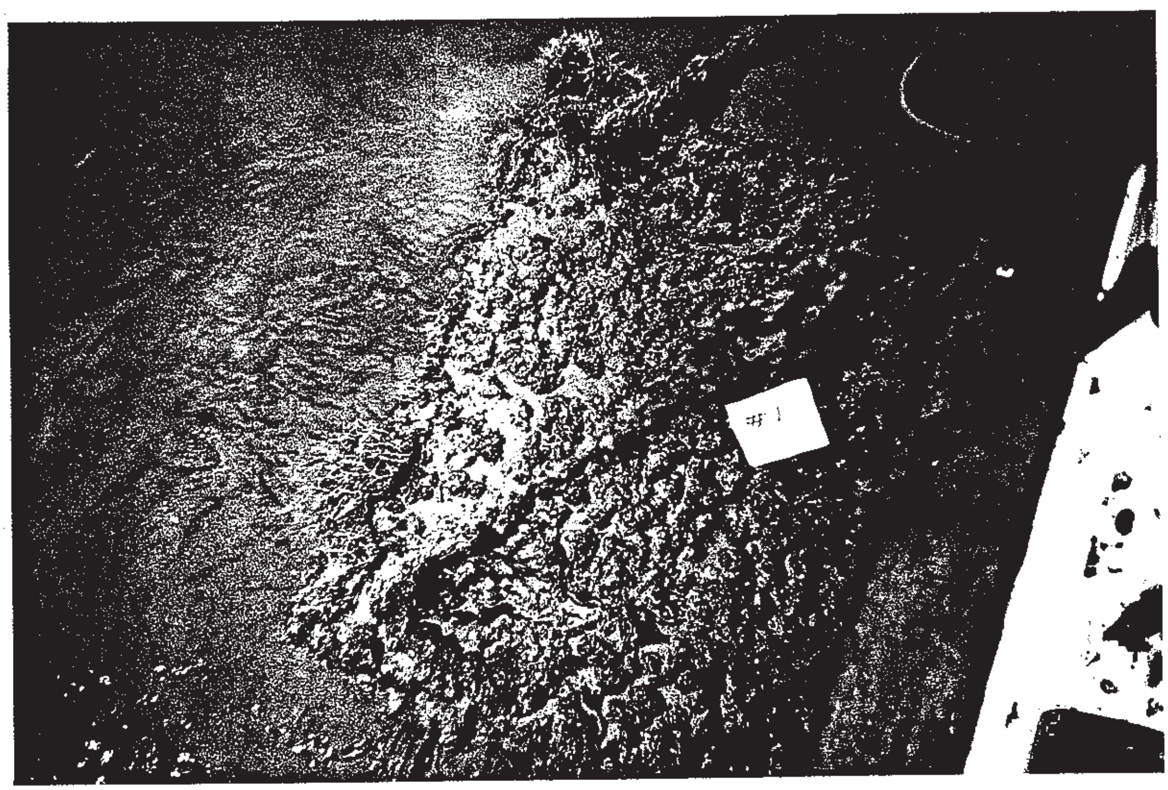
Notes:

1. With the exception of Station 12 at Moho River, the lost plates were replaced on October 1, 1999. These new sets of plates also included four plates facing the seabed, as well as the surface-facing plates. A new set of recruitment plates will be set out at Station 12 - Moho River within the next week. 2. The dry weights of tissue for the first set of plates may be low, since there was apparent tissue loss during storage of the plates, before weighing. 3. Tissue dry weight was calculated for all tissue scraped off the plates and weighed to three decimal places. In future, the dry weight of each recruitment plate will be determined before the plate is set out, and then the plate and biological tissue weighed intact after drying, which should be more accurate (no loss of tissue in the process).

Recruitment plates at Station 1 Rio Grande - August 31, 1999.

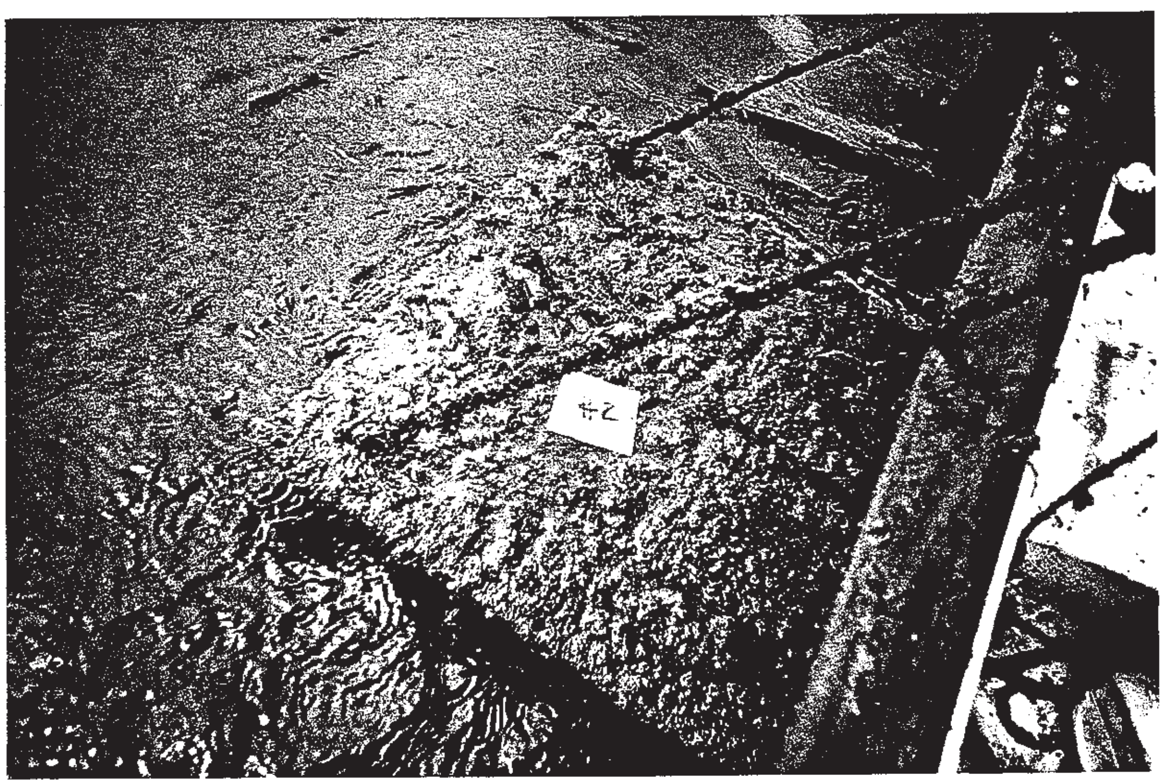


Recruitment plates at Station 1 Rio Grande - October 1, 1999.



Recruitment plates at Station 2 Rio Grande - August 31, 1999.

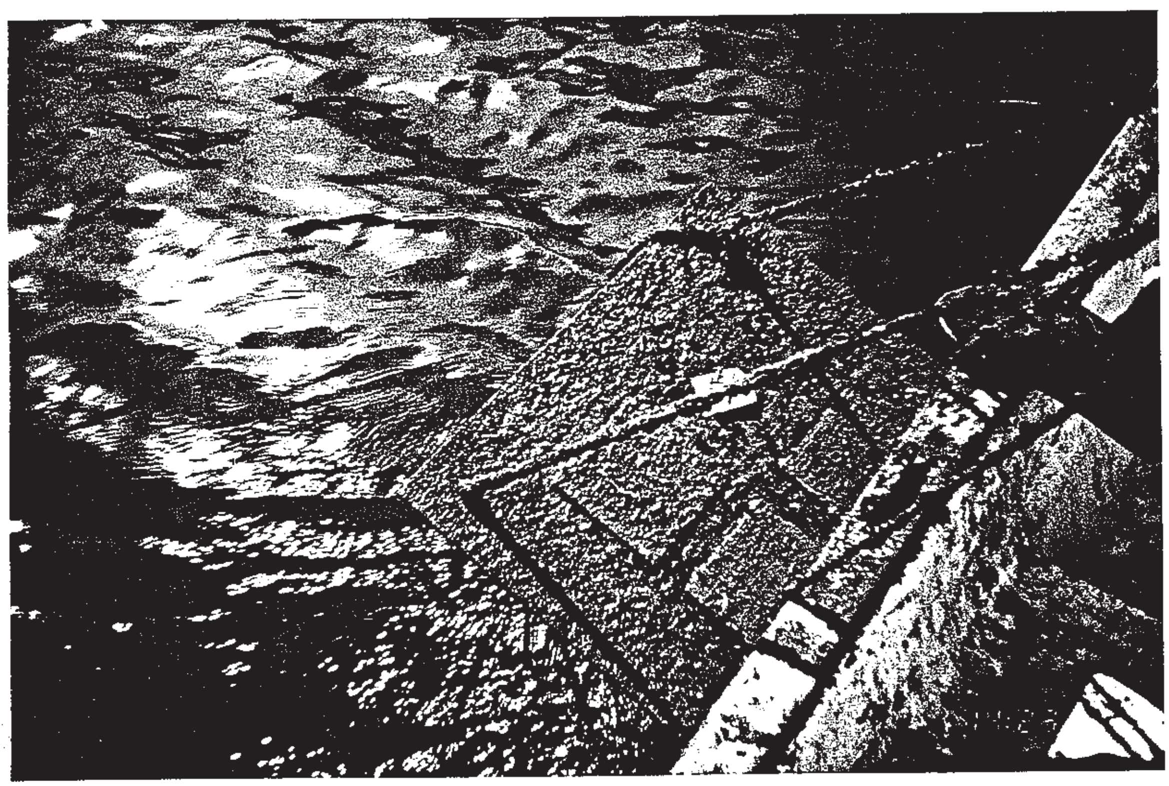
Recruitment plates at Station 2 Rio Grande - October 1, 1999.



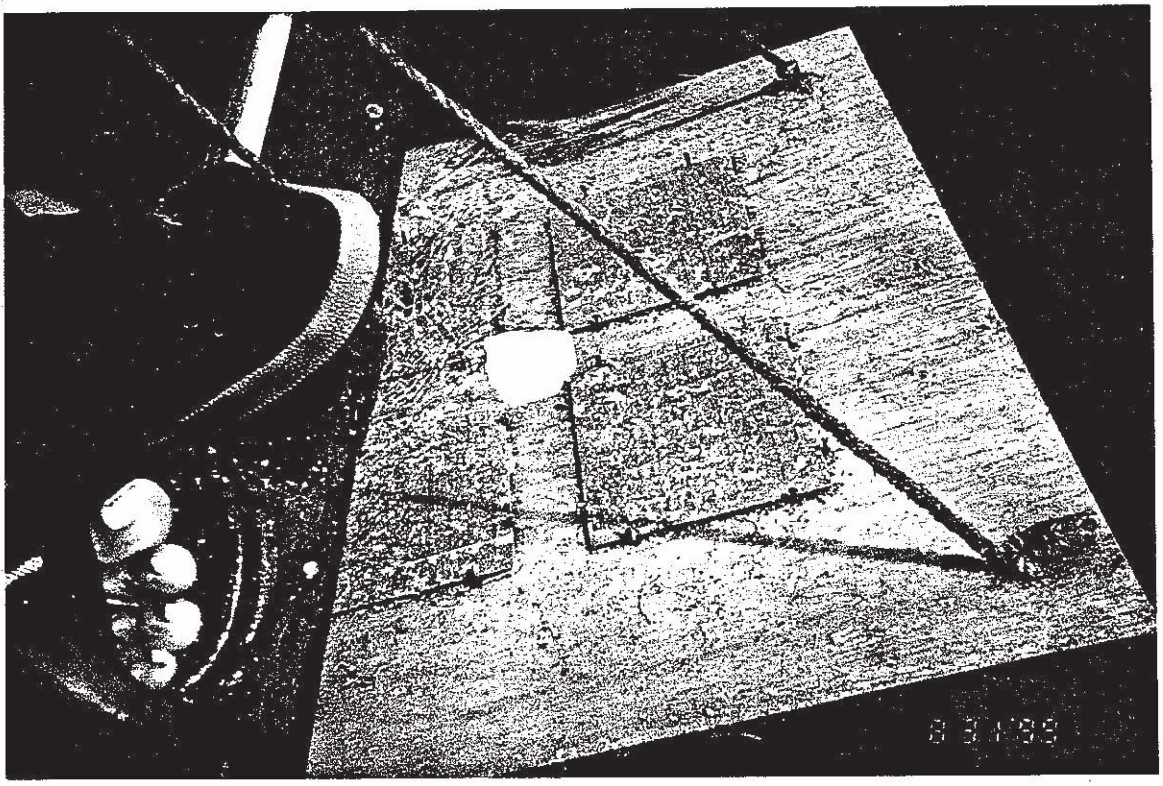
Recruitment plates at Station 3 Monkey River - August 31, 1999.

Recruitment plates at Station 4 Monkey River - August 31, 1999.

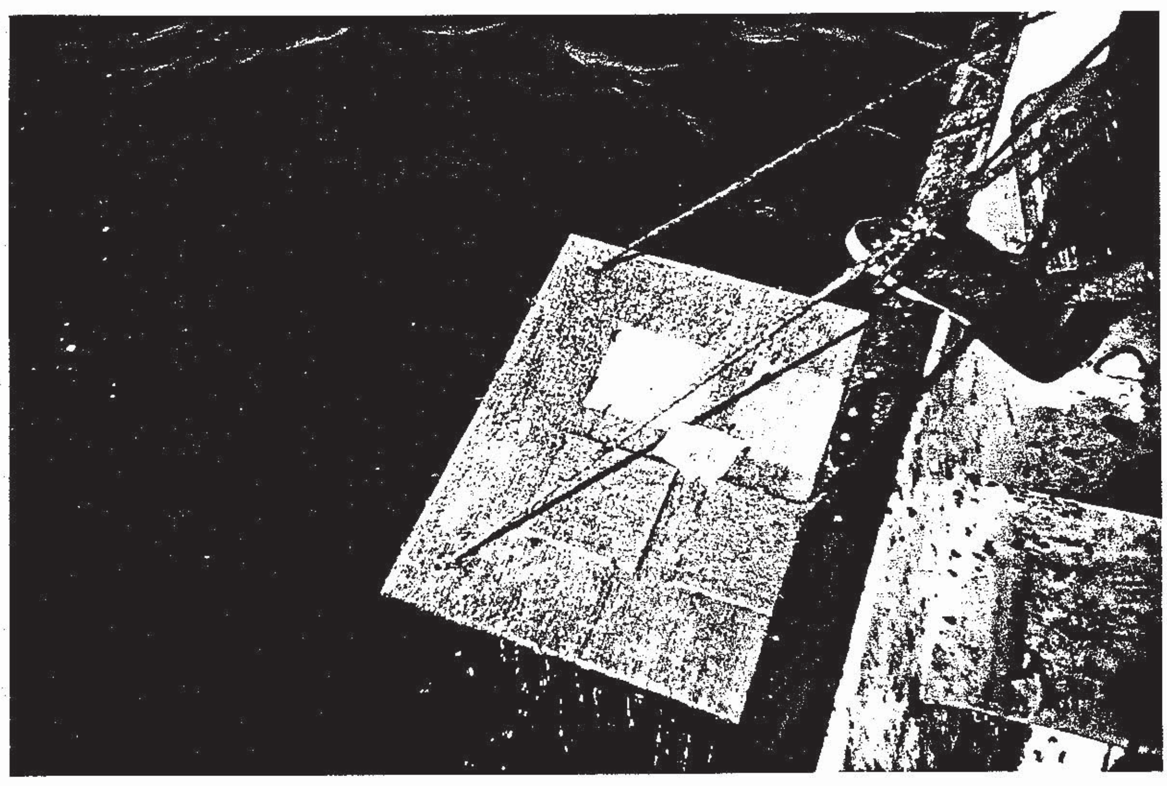
Recruitment plates at Station 4 Monkey River - October 1, 1999.



Recruitment plates at Station 6 West Snake Cay - August 31, 1999.

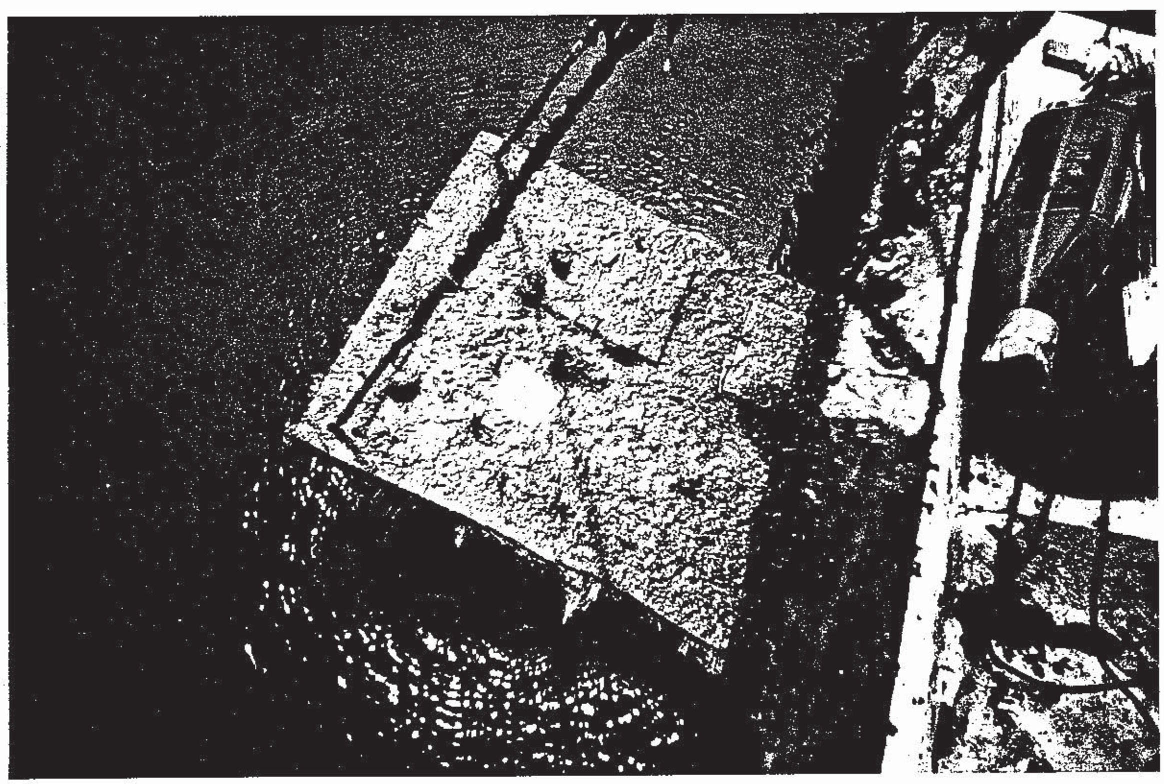


Recruitment plates at Station 6 West Snake Cay - October 1, 1999.

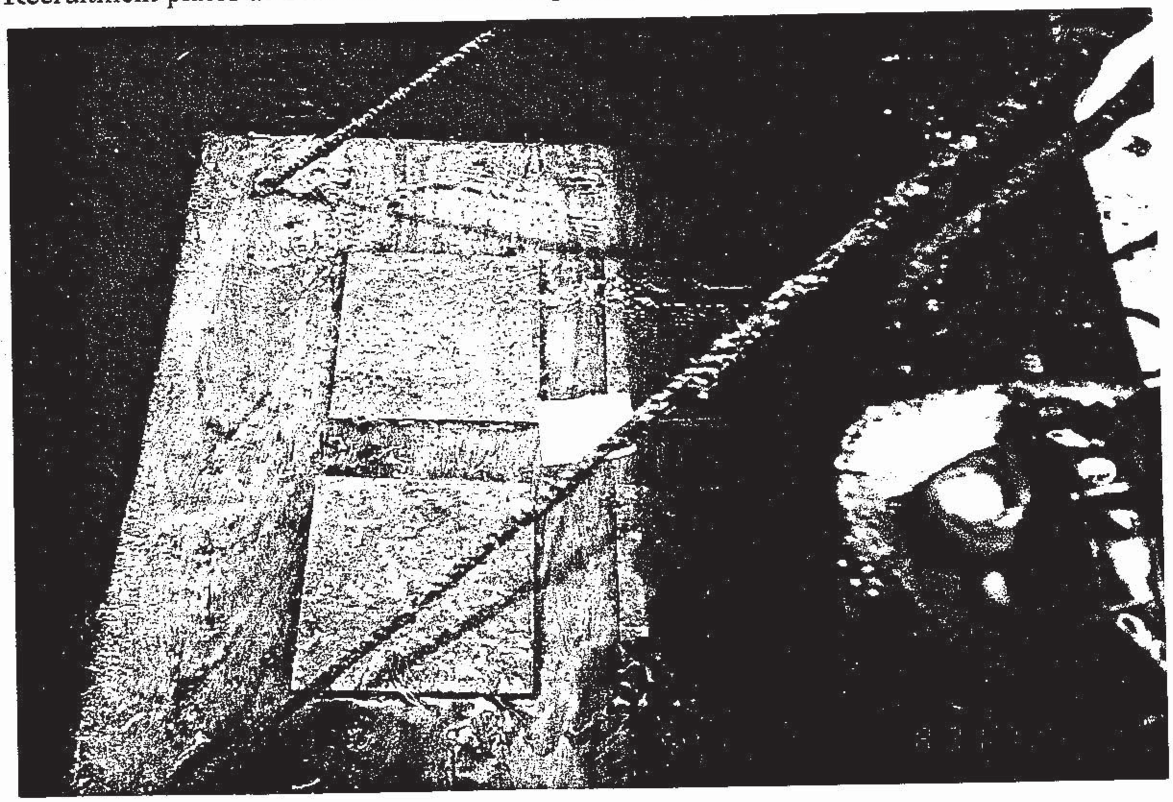


Recruitment plates at Station 7 Inside Sheepshead - August 31, 1999.

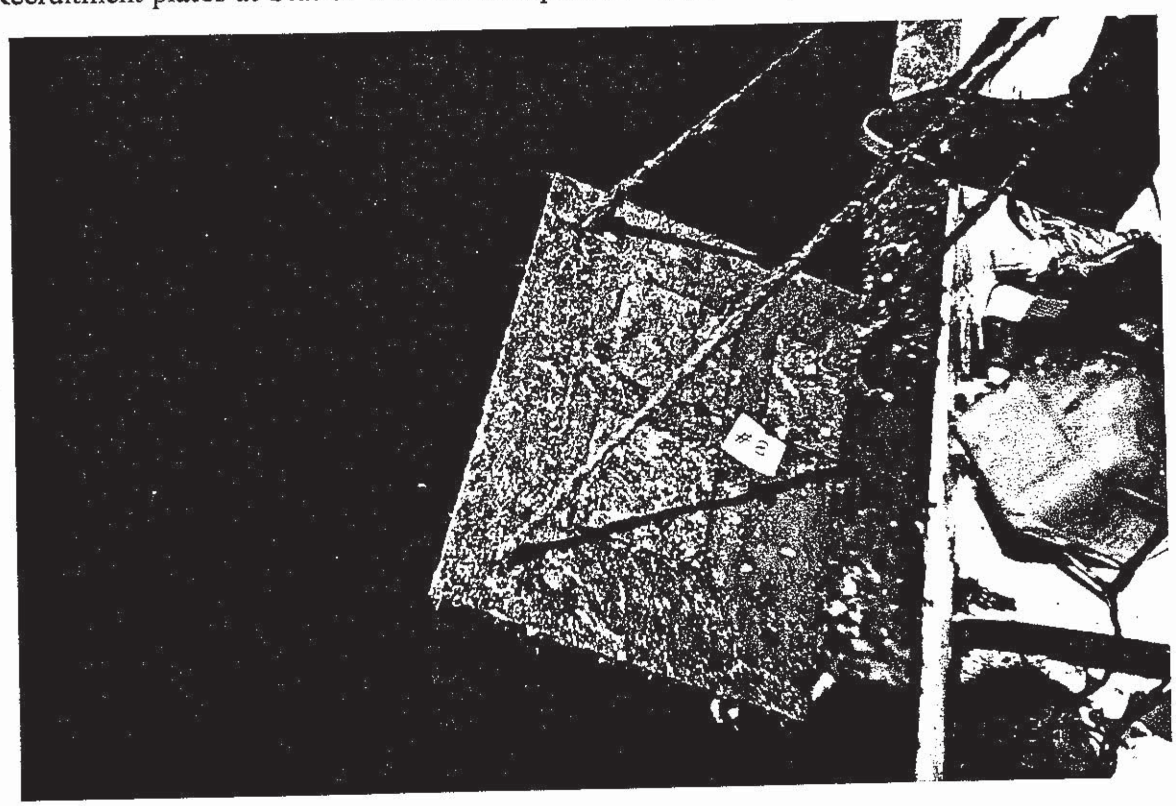
Recruitment plates at Station 7 Inside Sheepshead - October 1, 1999.



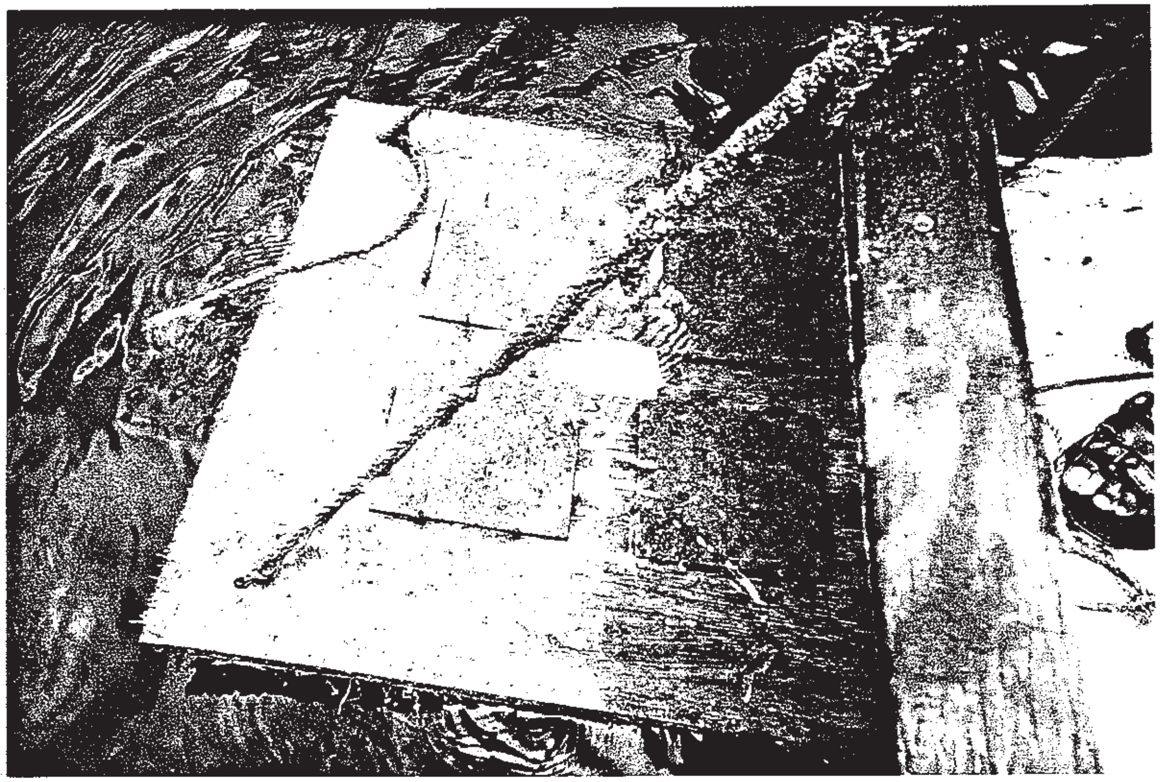
Recruitment plates at Station 8 Inside Sheepshead - August 31, 1999.



Recruitment plates at Station 8 Inside Sheepshead - October 1, 1999.

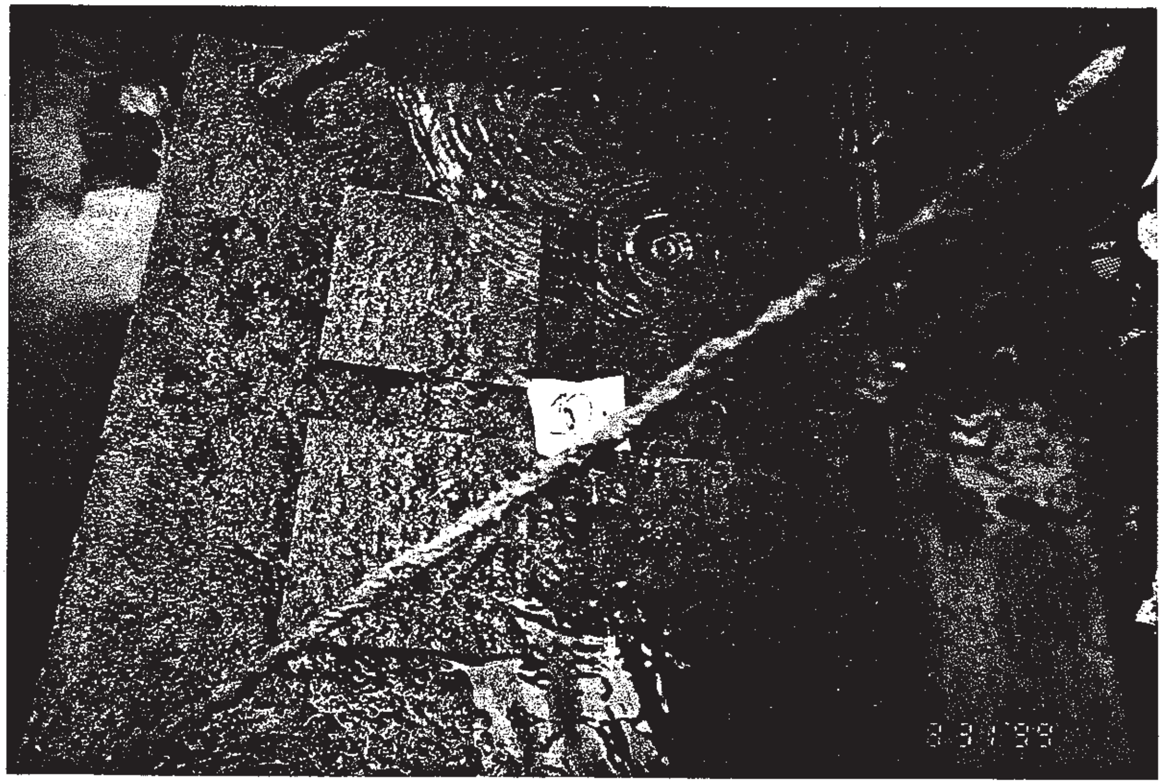


Recruitment plates at Station 9 Bob Stuart Lagoon - August 31, 1999.



Recruitment plates at Station 9 Bob Stuart Lagoon - October 1, 1999.

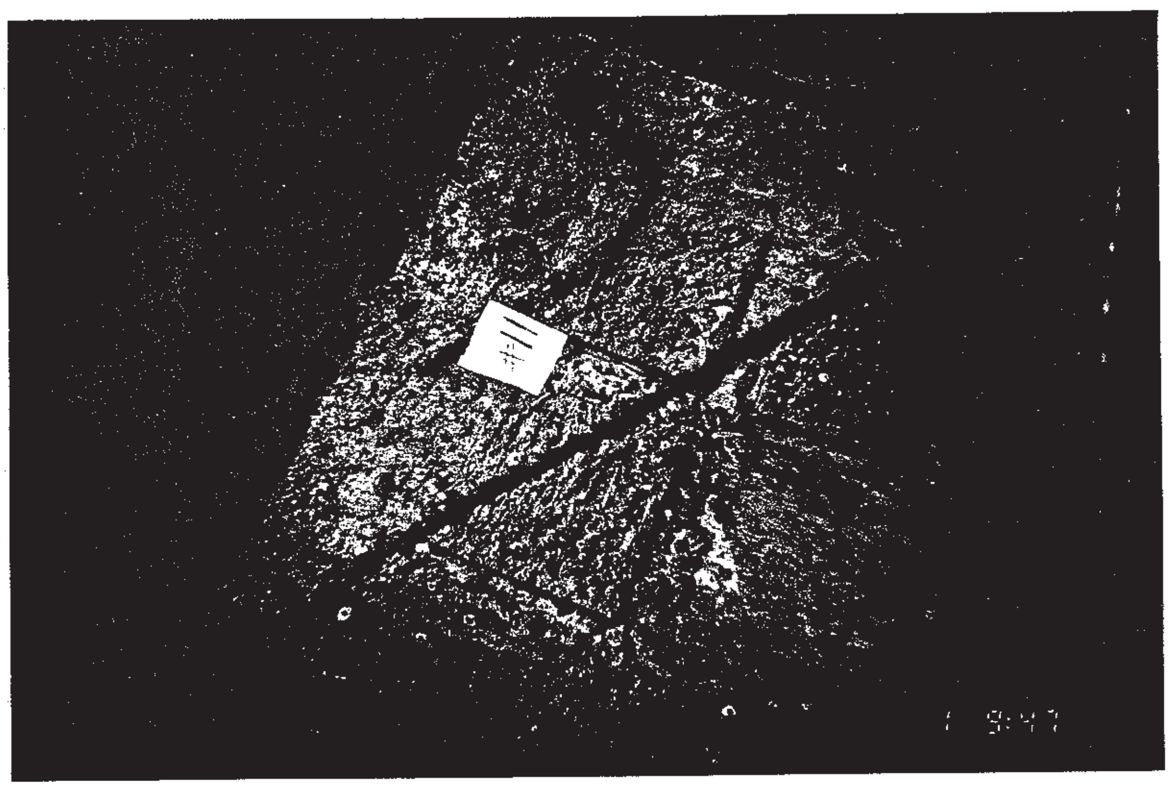
Recruitment plates at Station 10 Bob Stuart Lagoon - August 31, 1999.



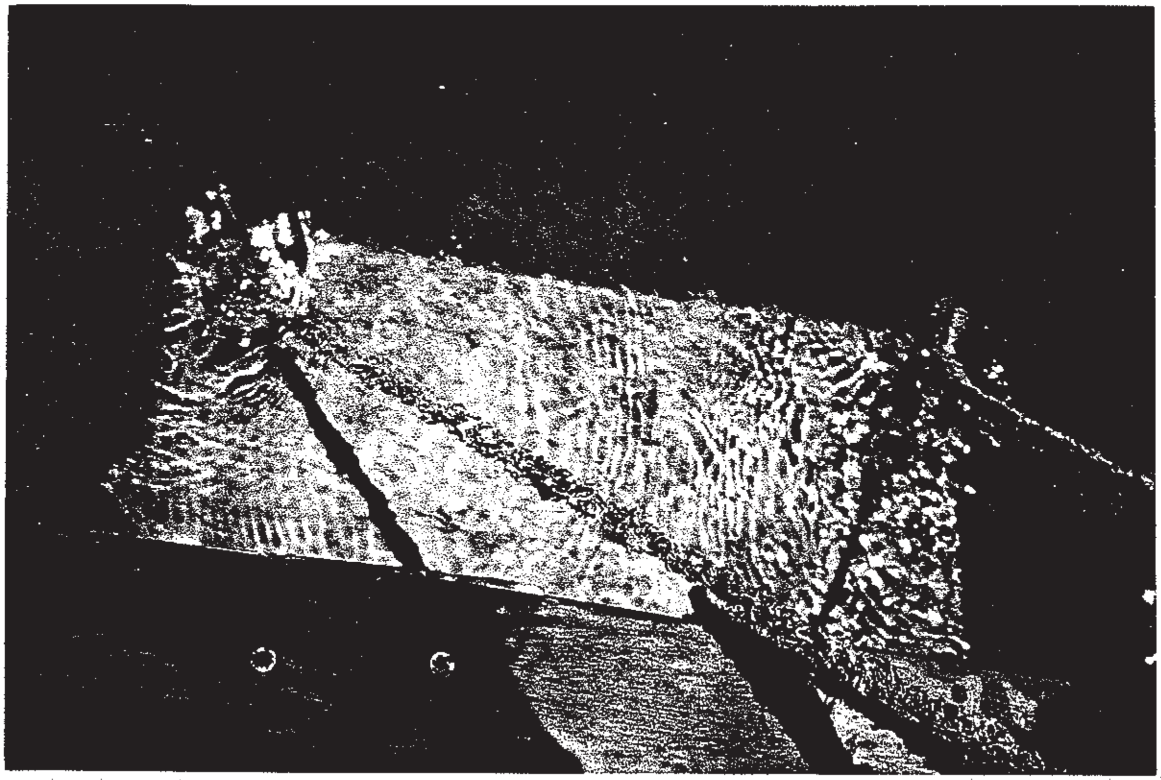
Recruitment plates at Station 10 Bob Stuart Lagoon - October 1, 1999.

Recruitment plates at Station 11 Moho River - August 31, 1999.

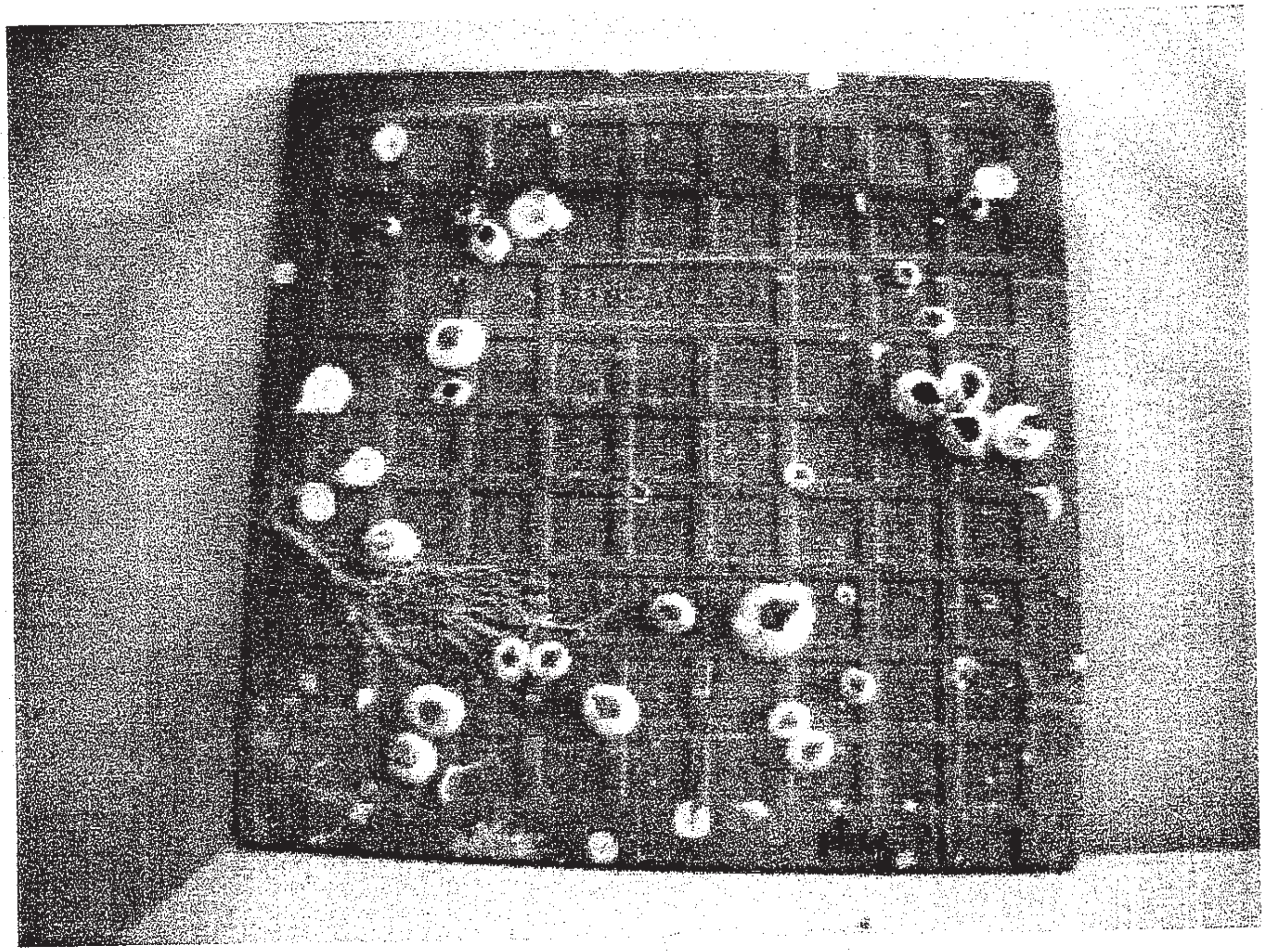
Recruitment plates at Station 11 Moho River - October 1, 1999.



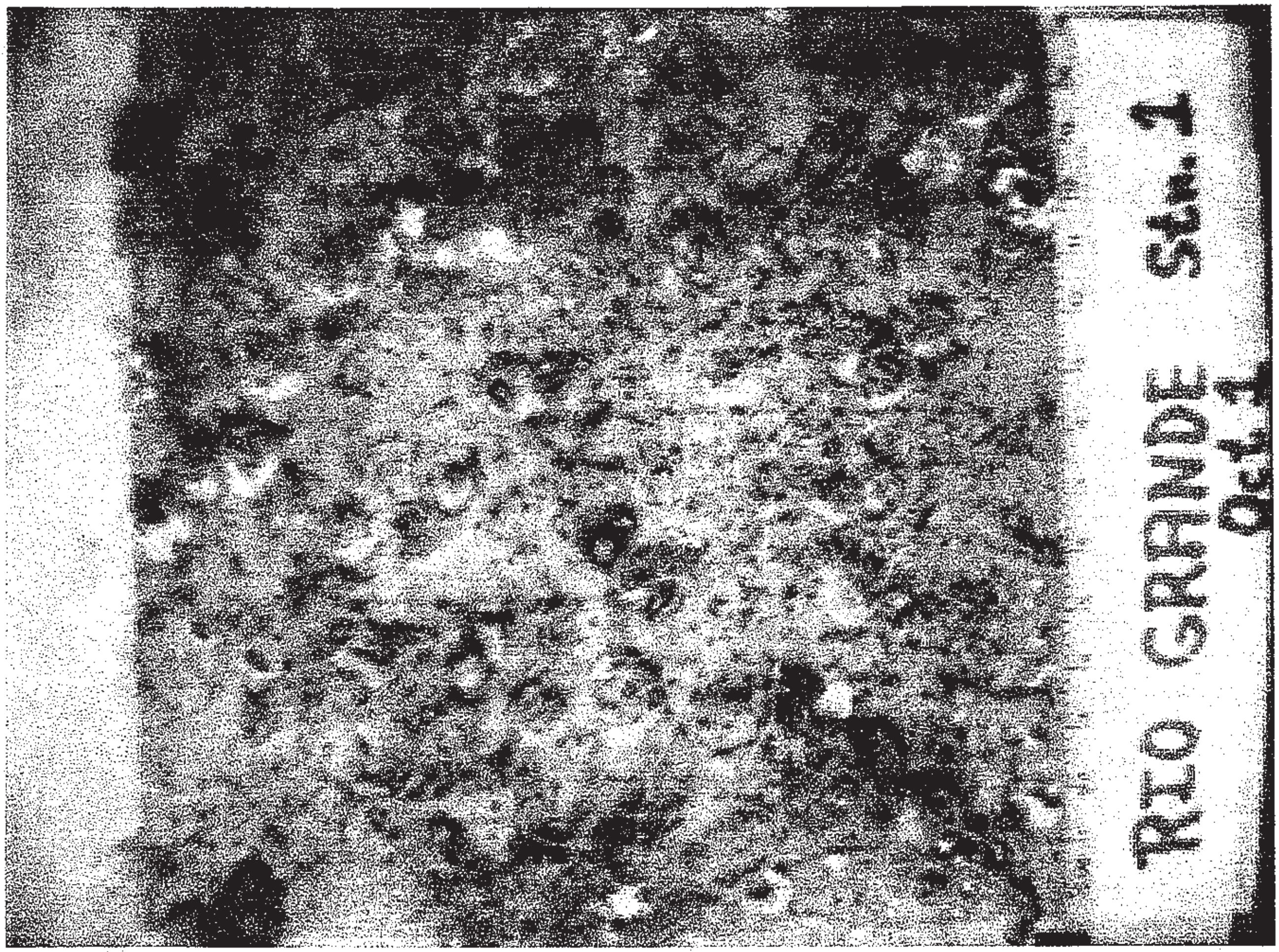
Recruitment plates at Station 12 Moho River - August 31, 1999.



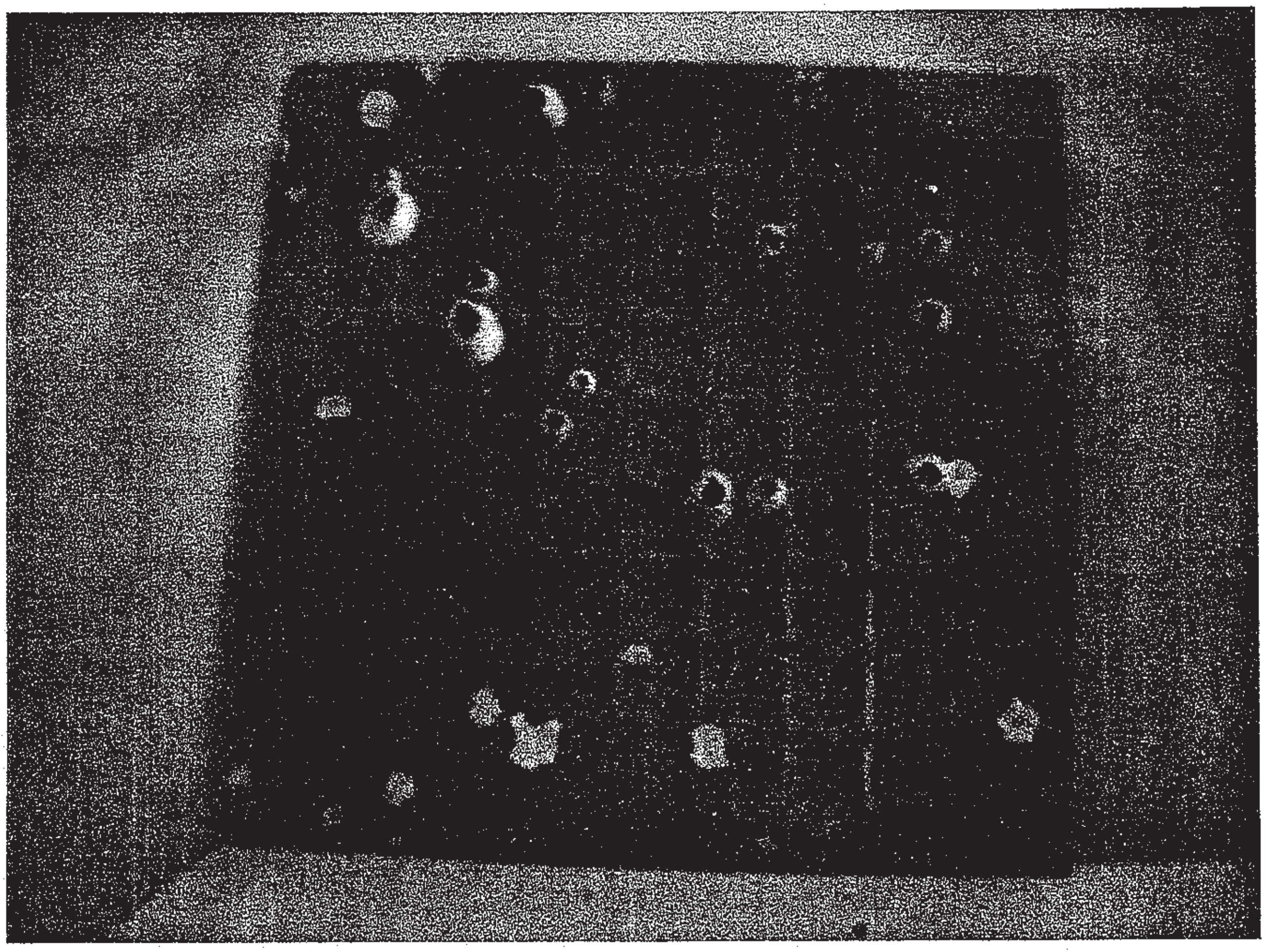
Digital image - recruitment plate at Station 1 Rio Grande - August 31, 1999.



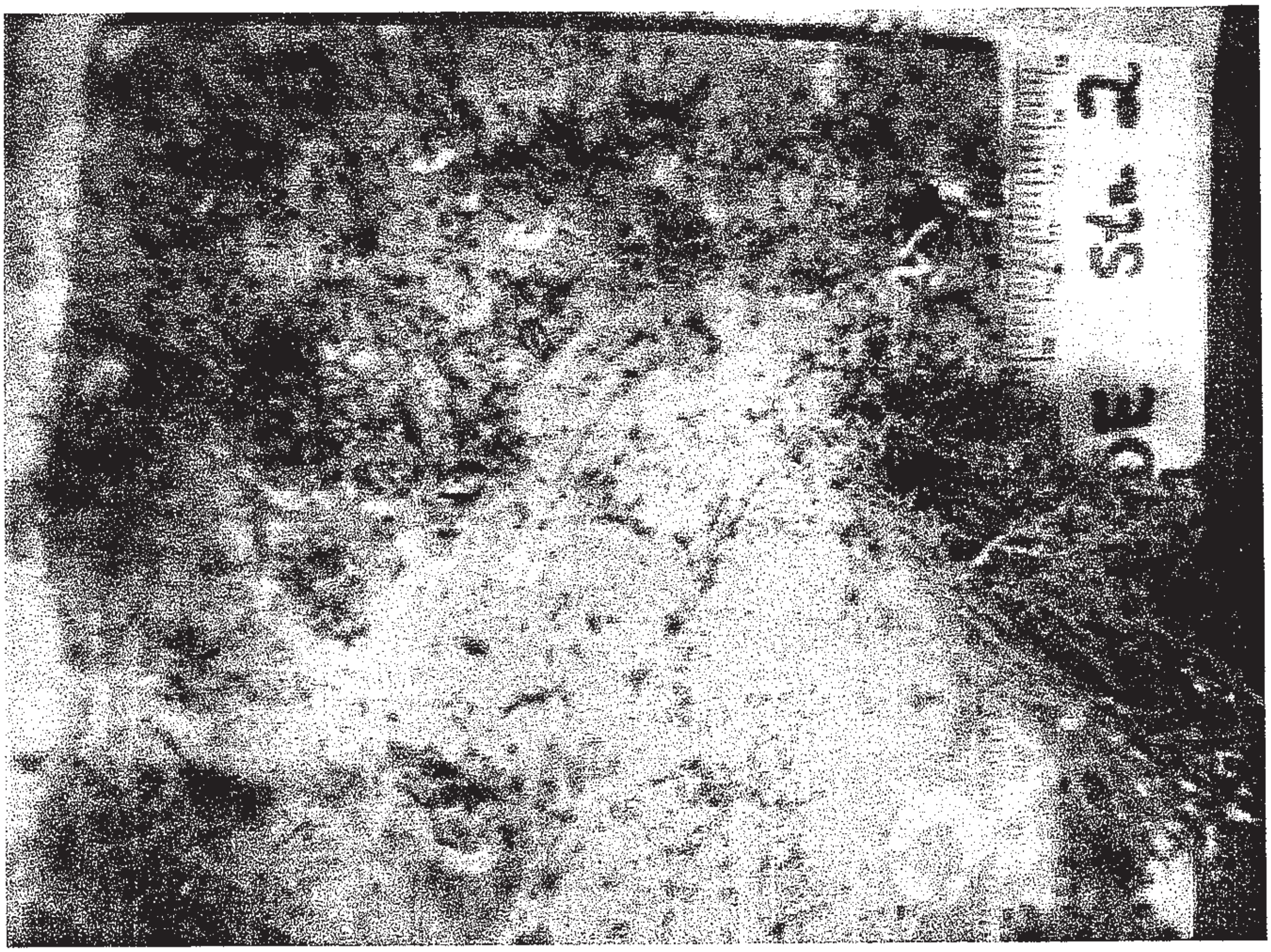
Digital image - recruitment plate at Station 1 Rio Grande - October 1, 1999.



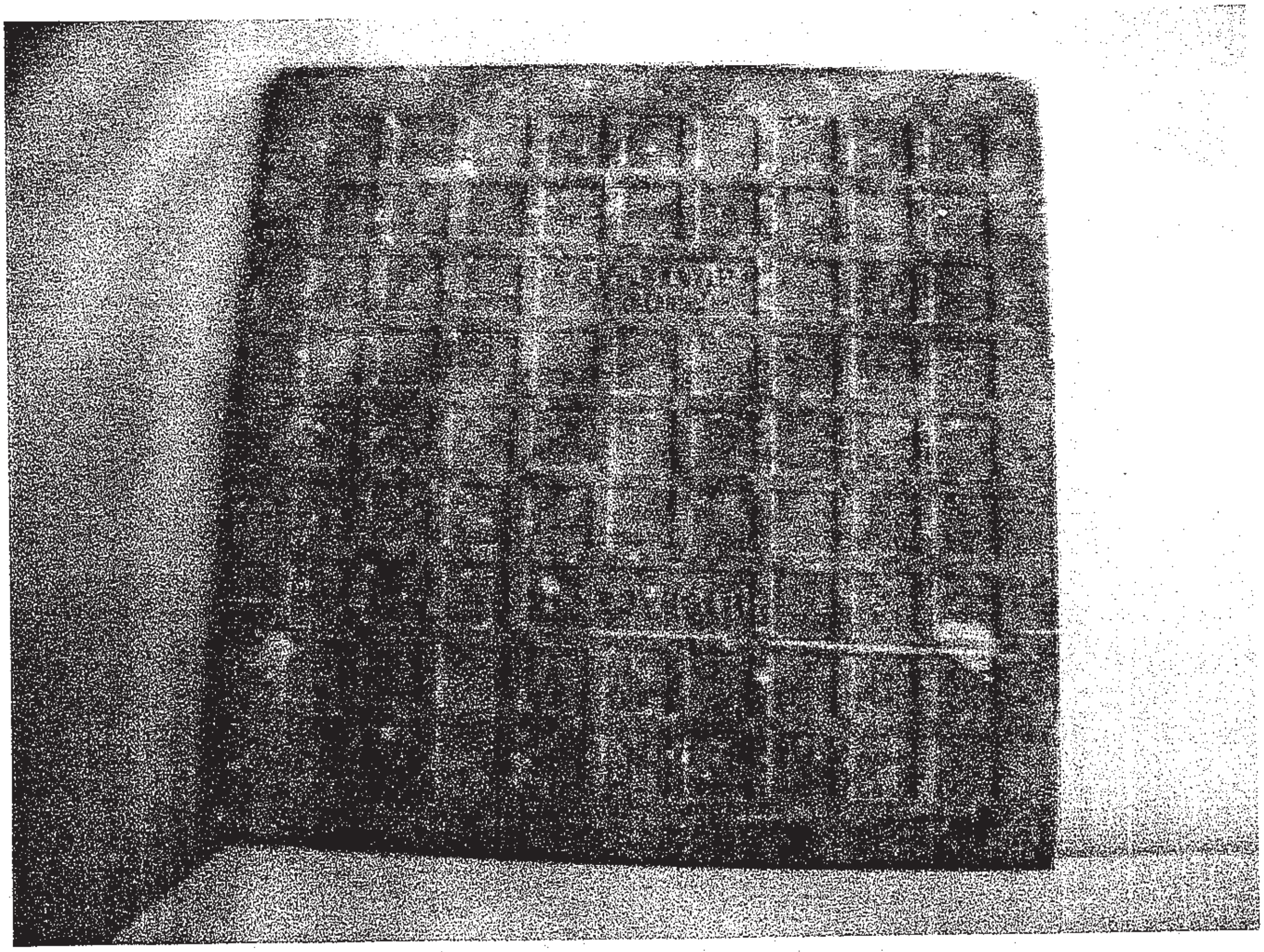
Digital image - recruitment plate at Station 2 Rio Grande - August 31, 1999.



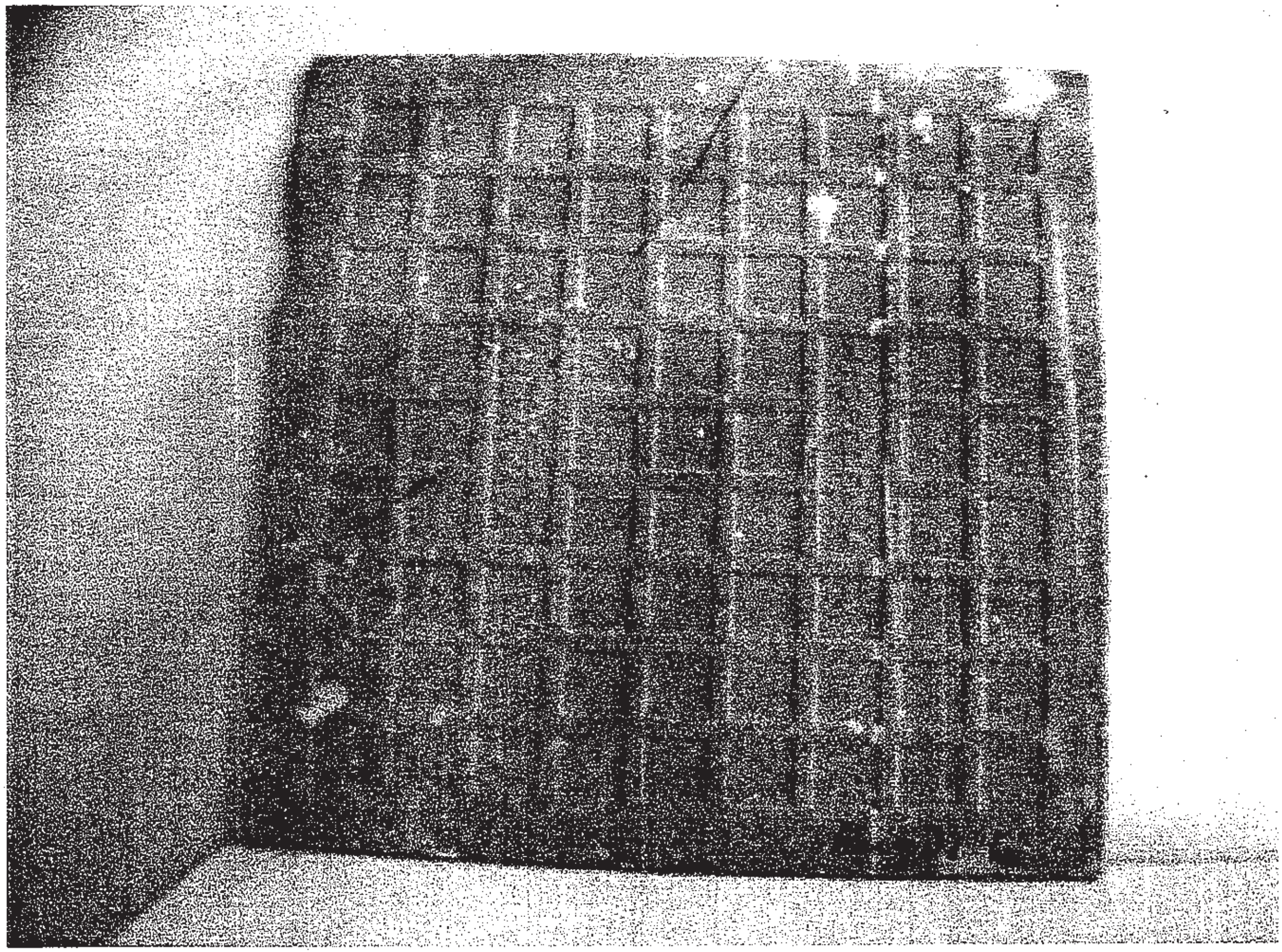
Digital image - recruitment plate at Station 2 Rio Grande - October 1, 1999.



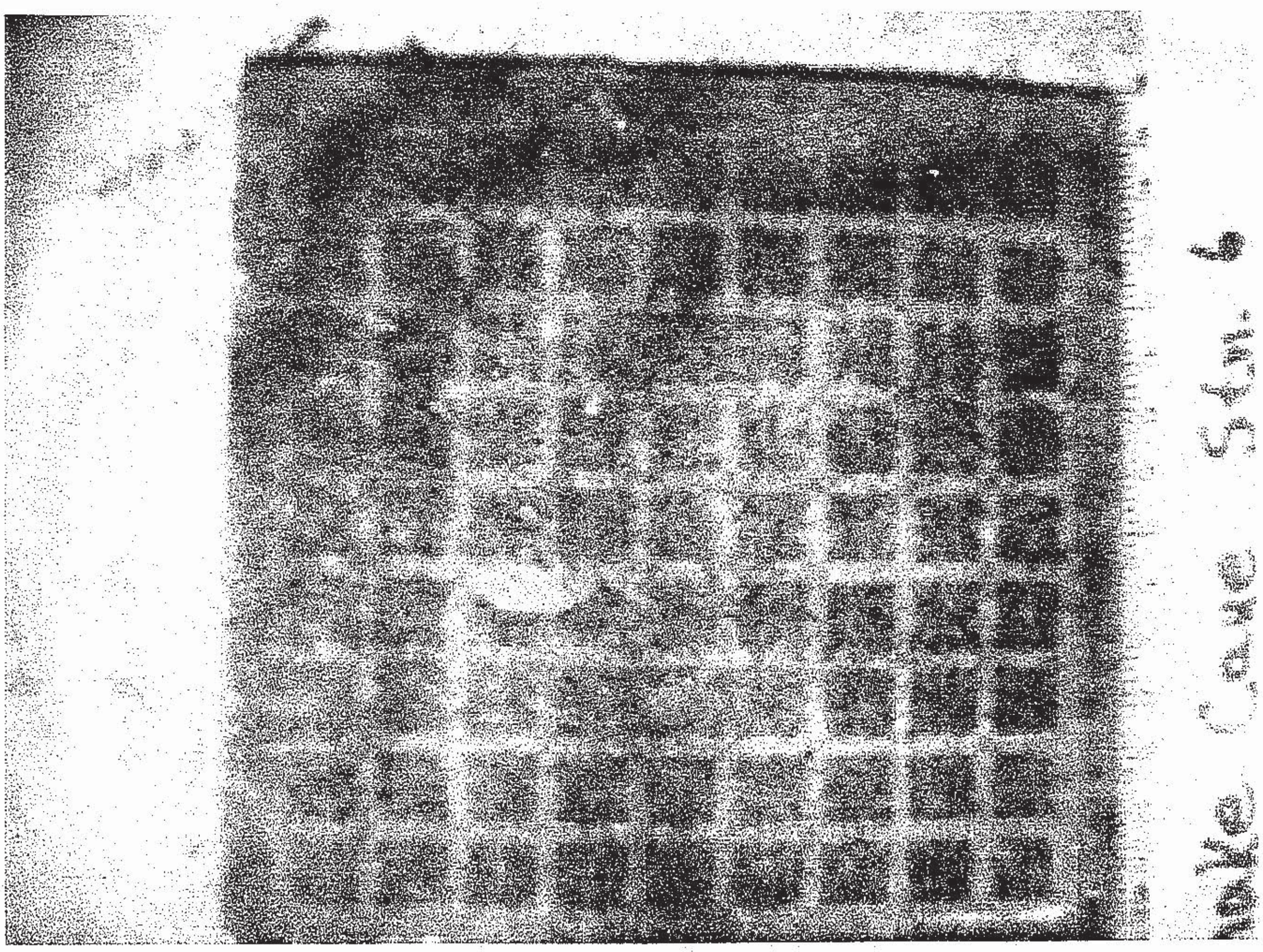
Digital image - recruitment plate at Station 3 Monkey River - August 31, 1999.



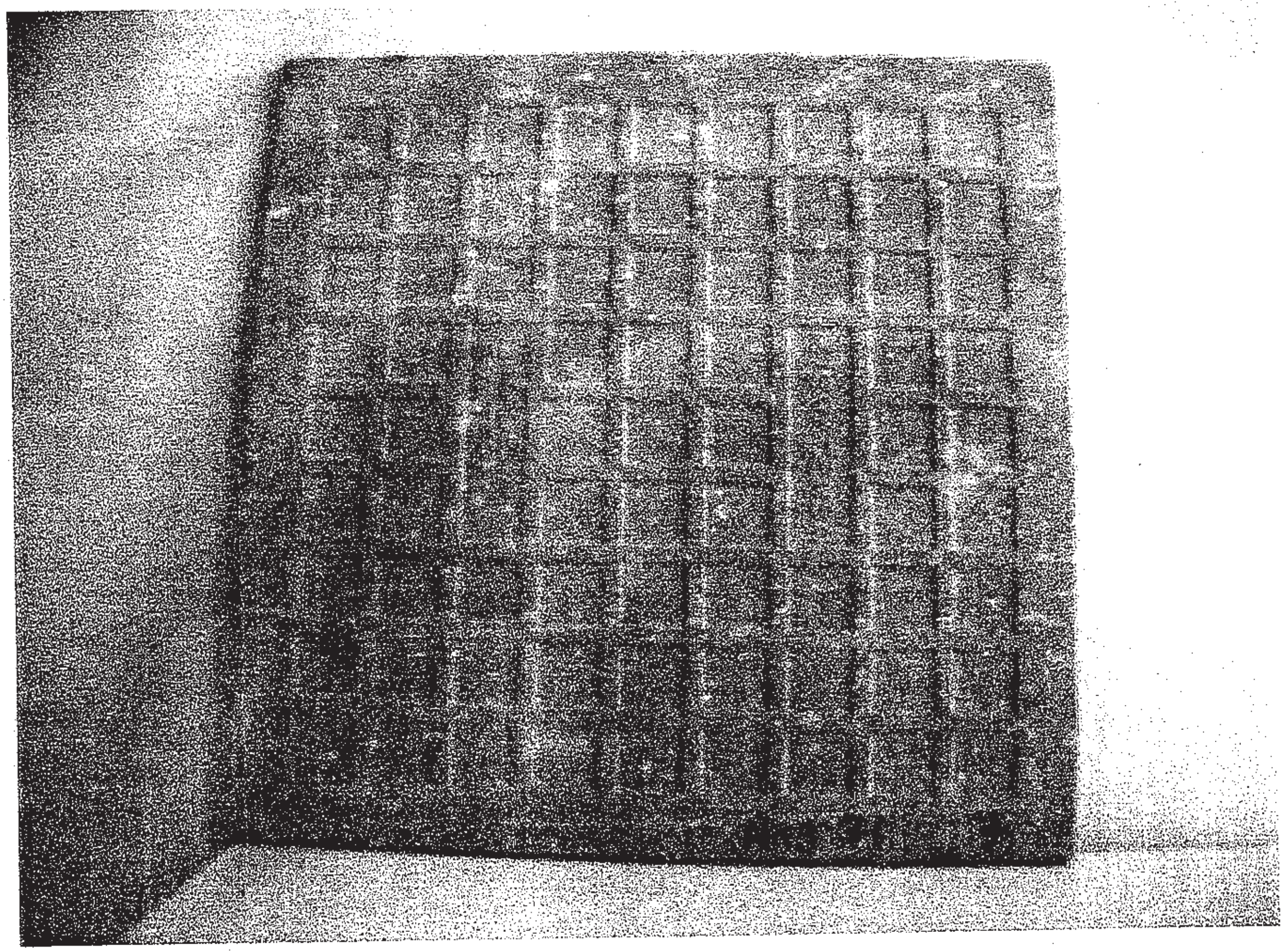
Digital image - recruitment plate at Station 4 Monkey River - August 31, 1999.



Digital image - recruitment plate at Station 6 West Snake Cay - October 1, 1999.

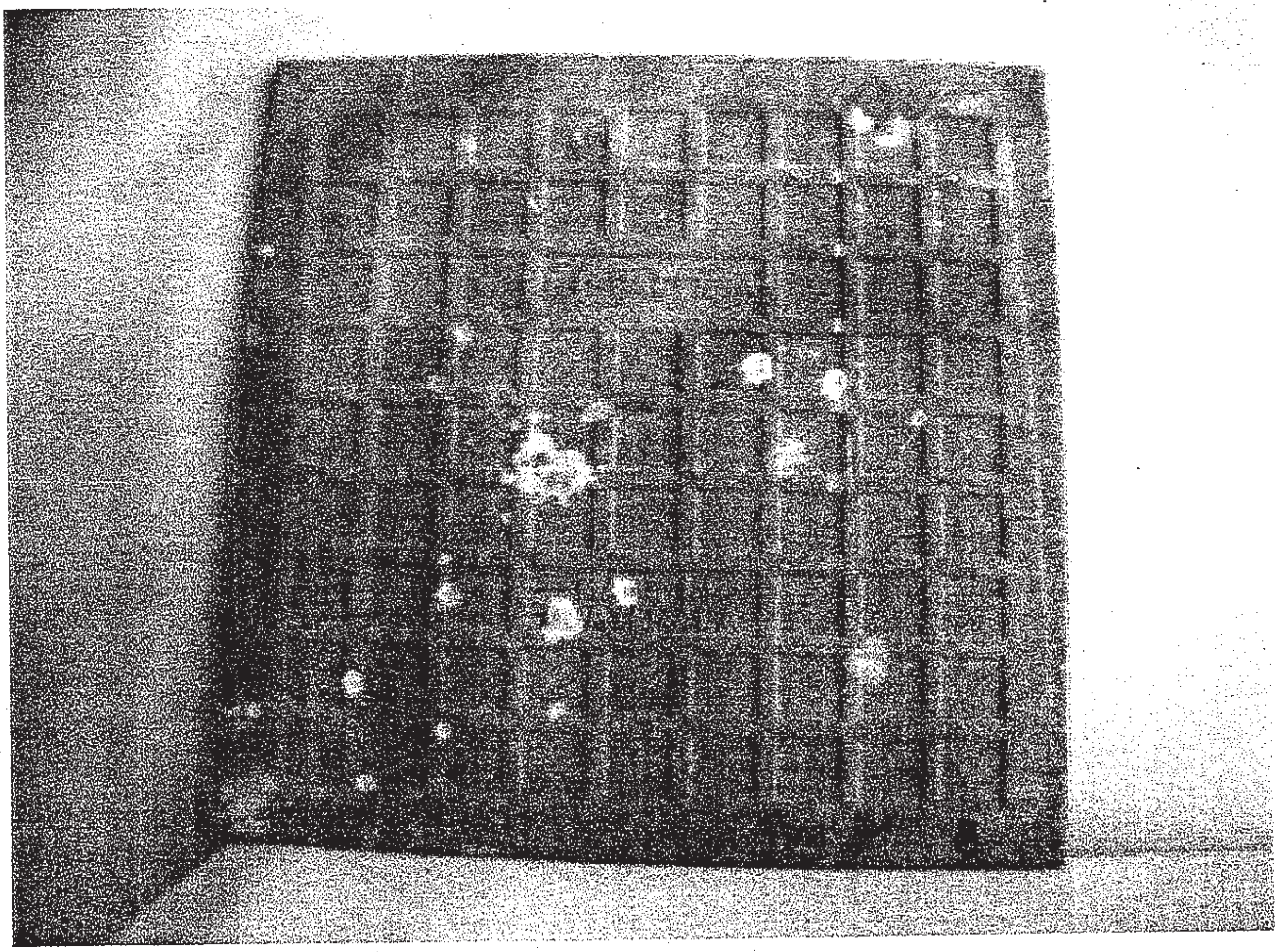


Digital image - recruitment plate at Station 7 Inside Sheepshead - August 31, 1999.

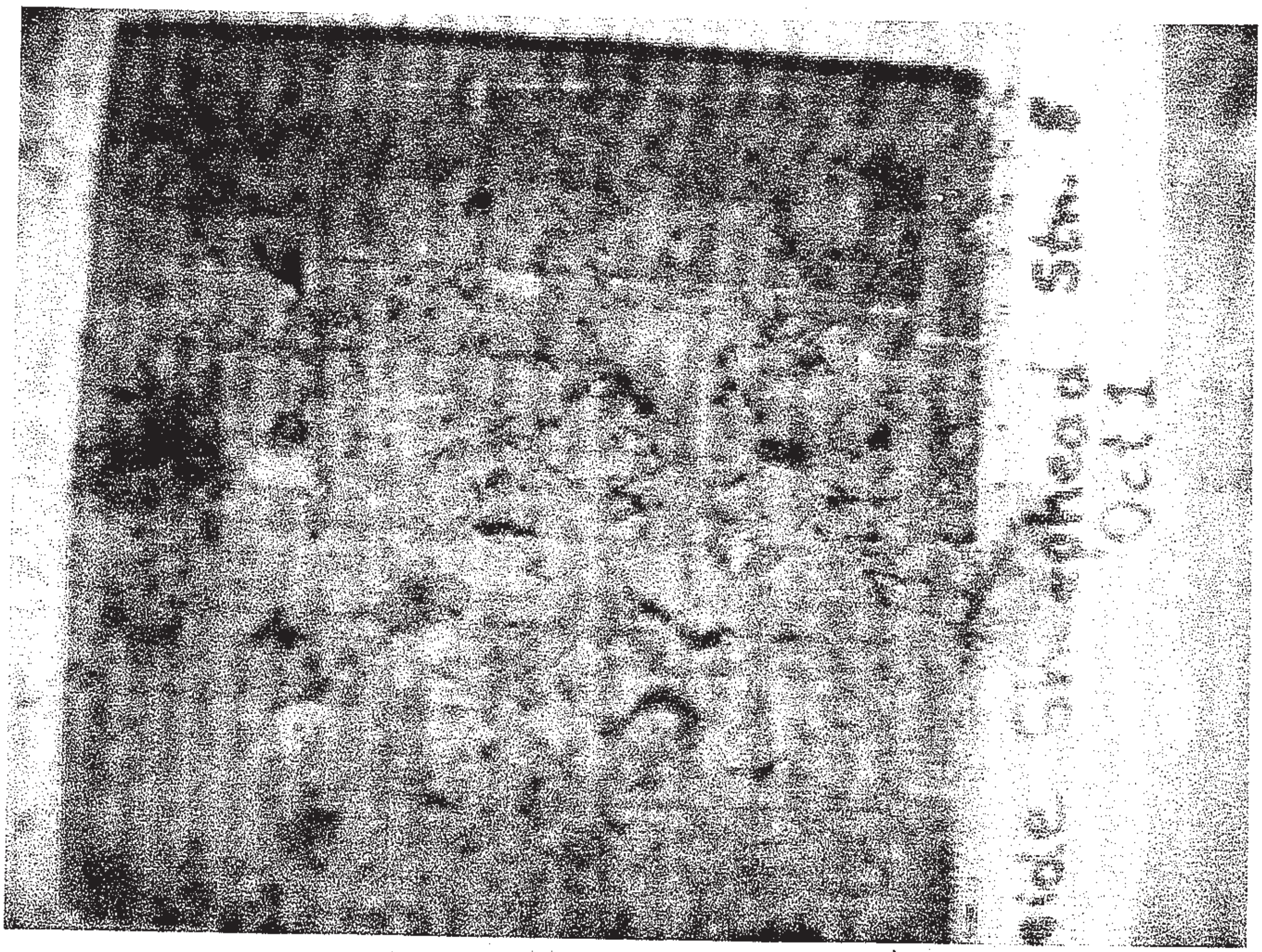


Digital image - recruitment plate at Station 7 Inside Sheepshead - October 1, 1999.

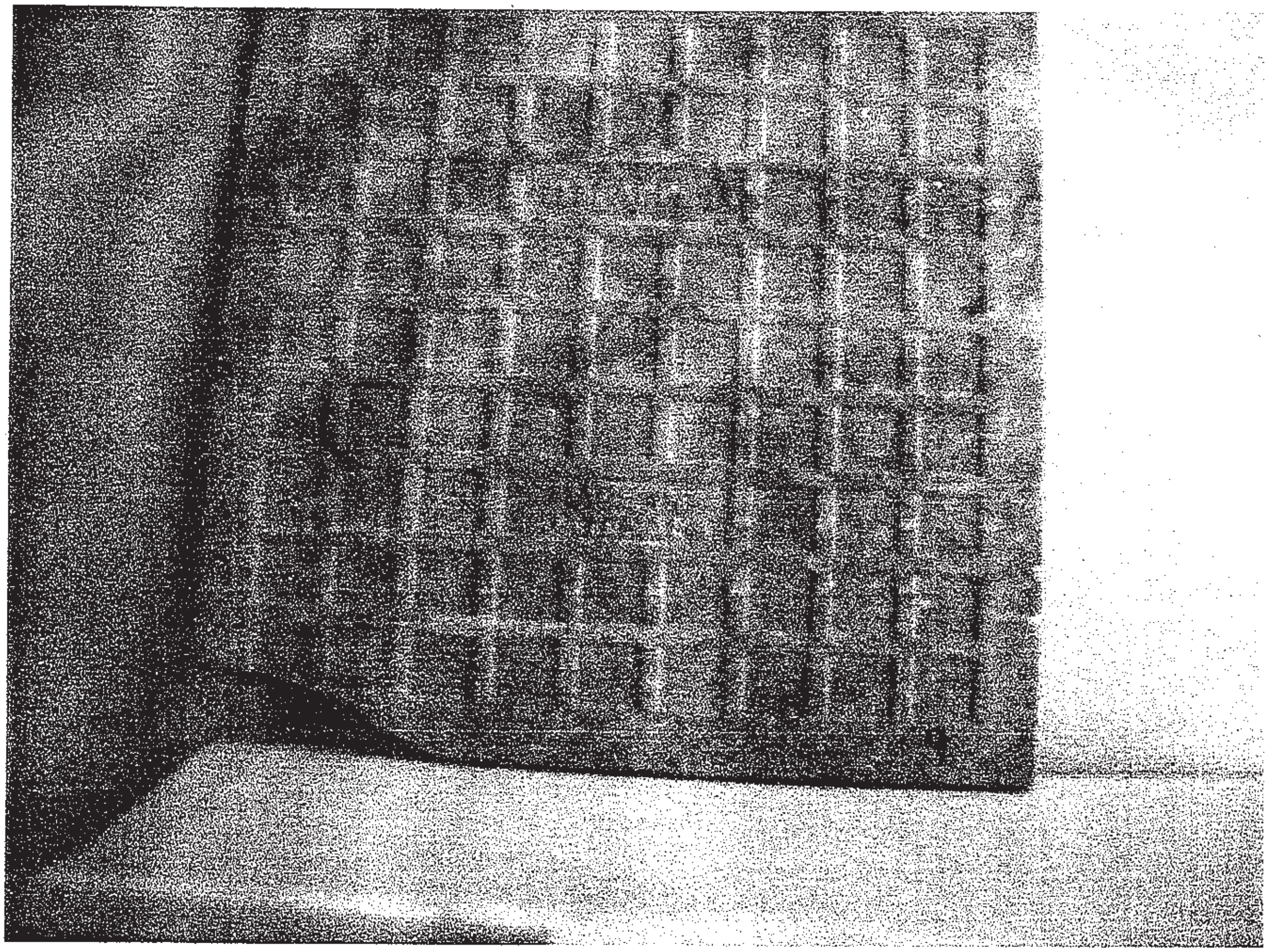
Digital image - recruitment plate at Station 8 Inside Sheepshead - August 31, 1999.



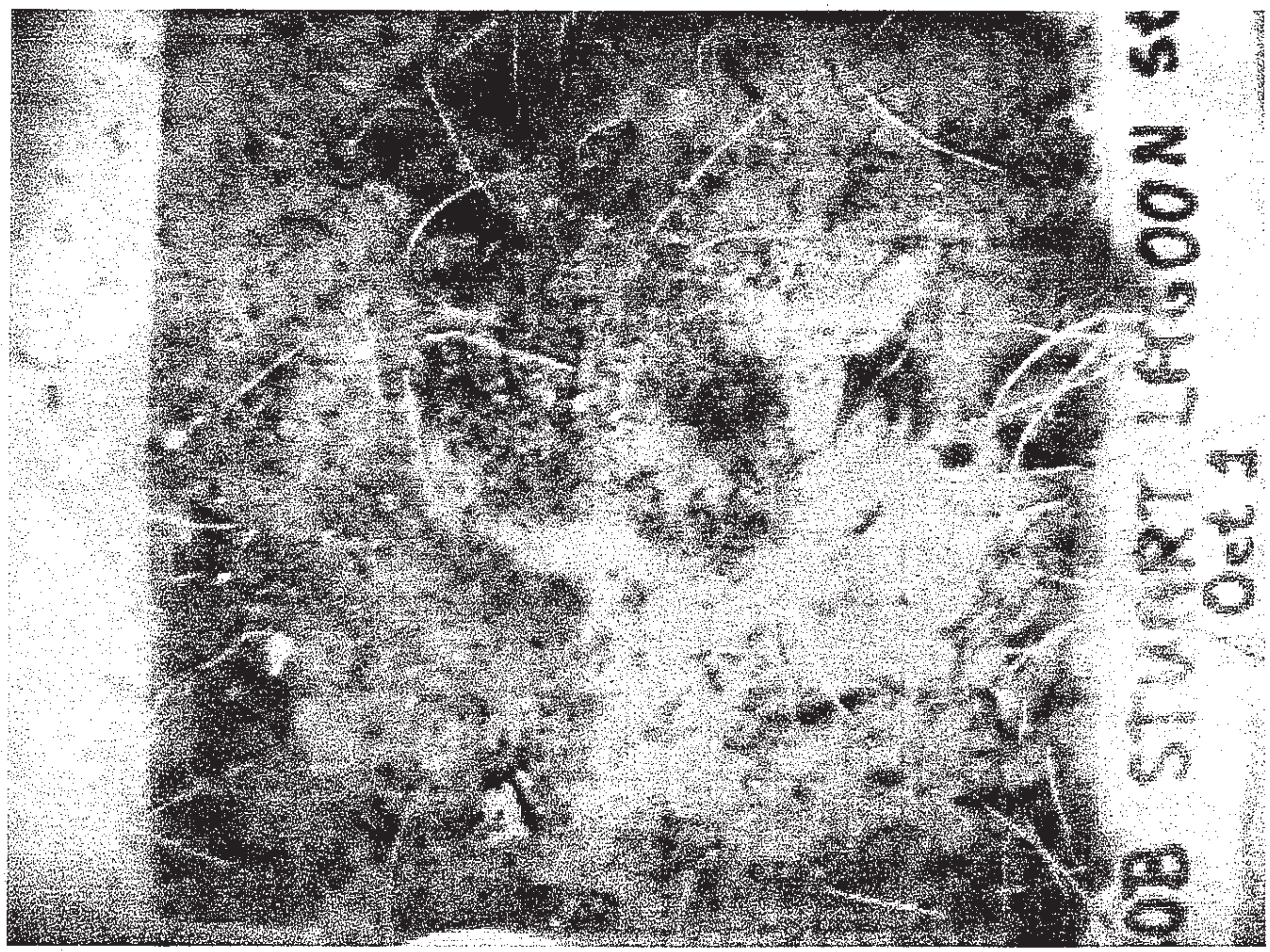
Digital image - recruitment plate at Station 8 Inside Sheepshead - October 1, 1999.



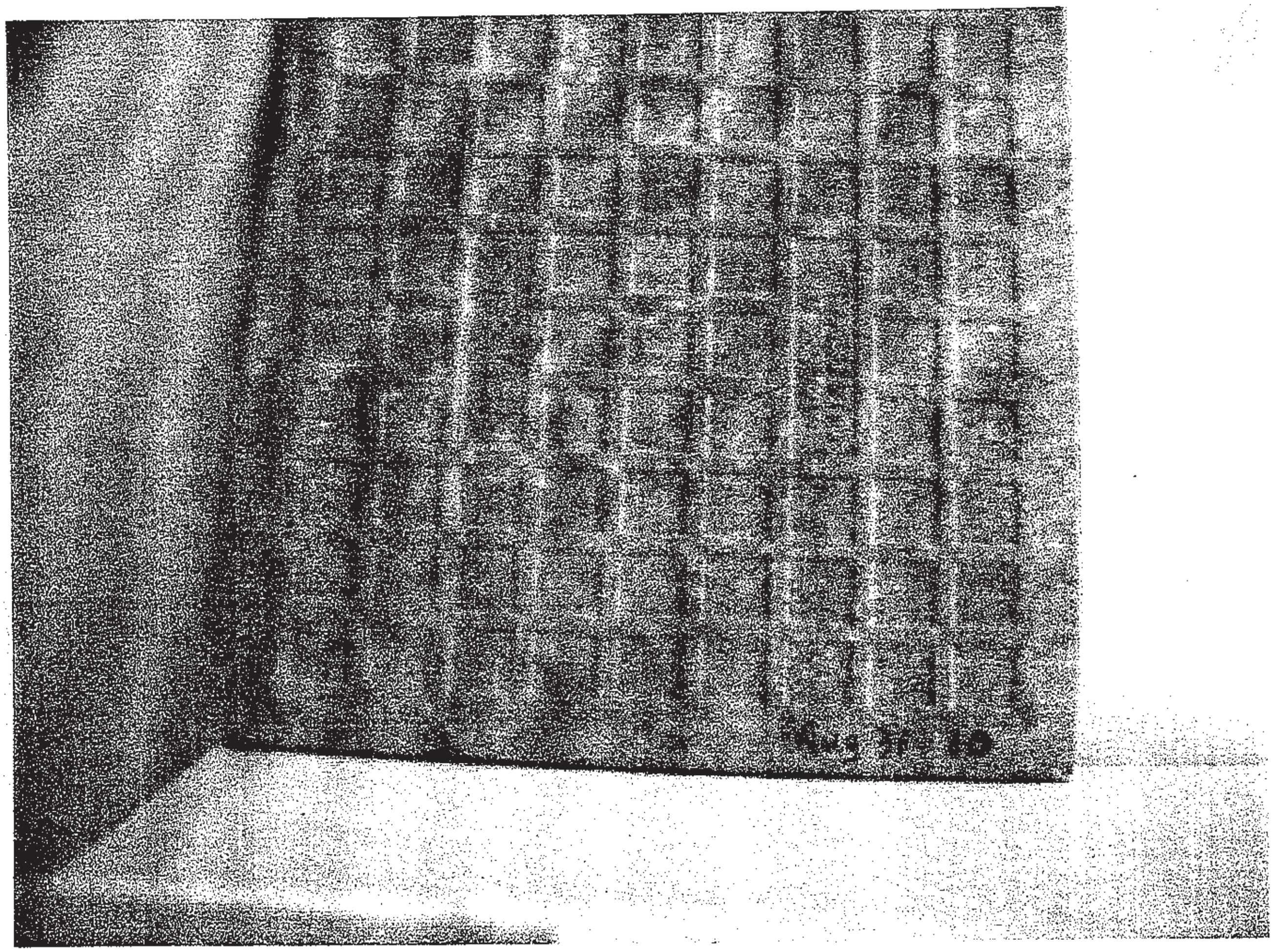
Digital image - recruitment plate at Station 9 Bob Stuart Lagoon - August 31, 1999.



Digital image - recruitment plate at Station 9 Bob Stuart Lagoon - October 1, 1999.

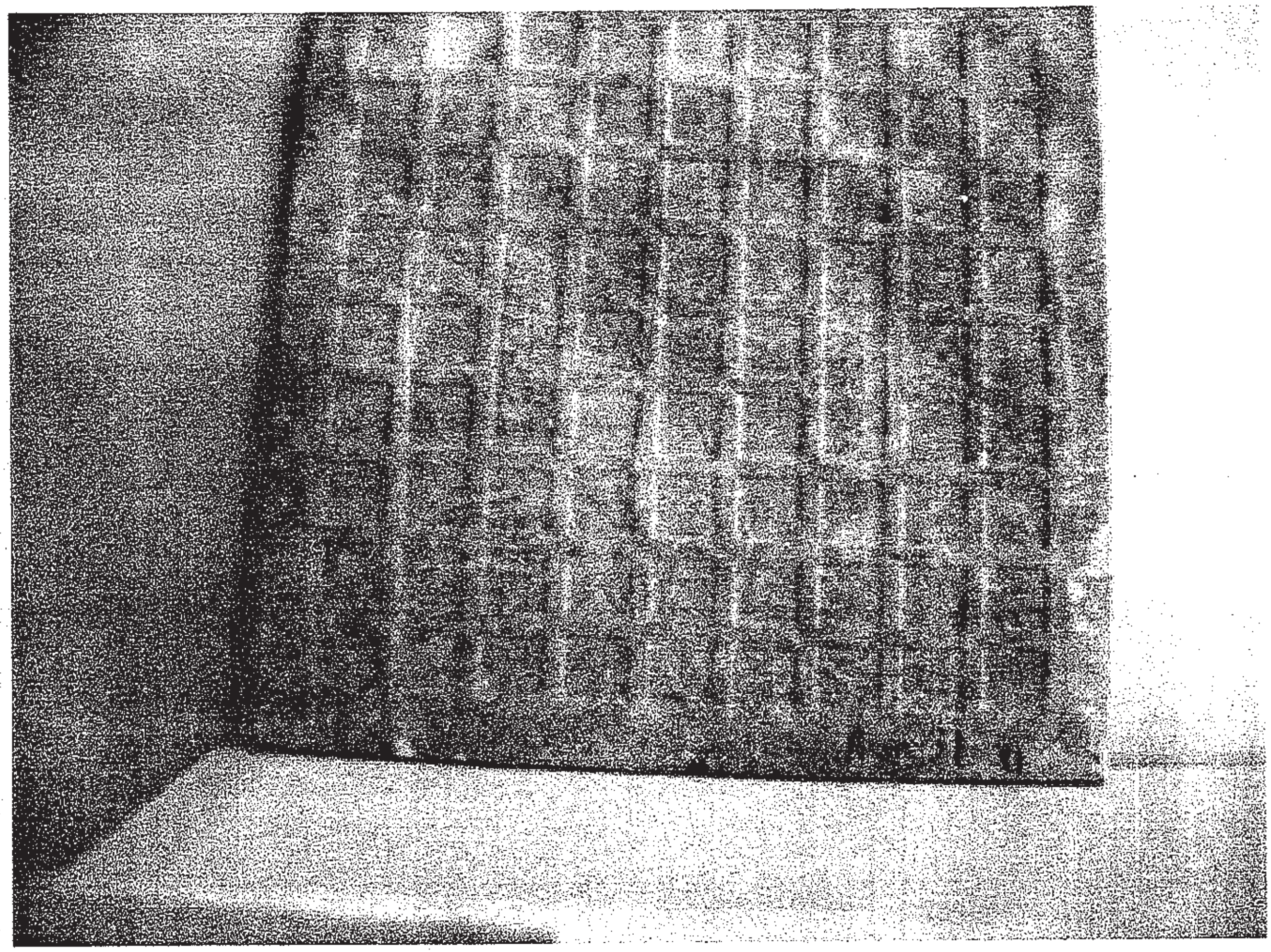


Digital image - recruitment plate at Station 10 Bob Stuart Lagoon - August 31, 1999.

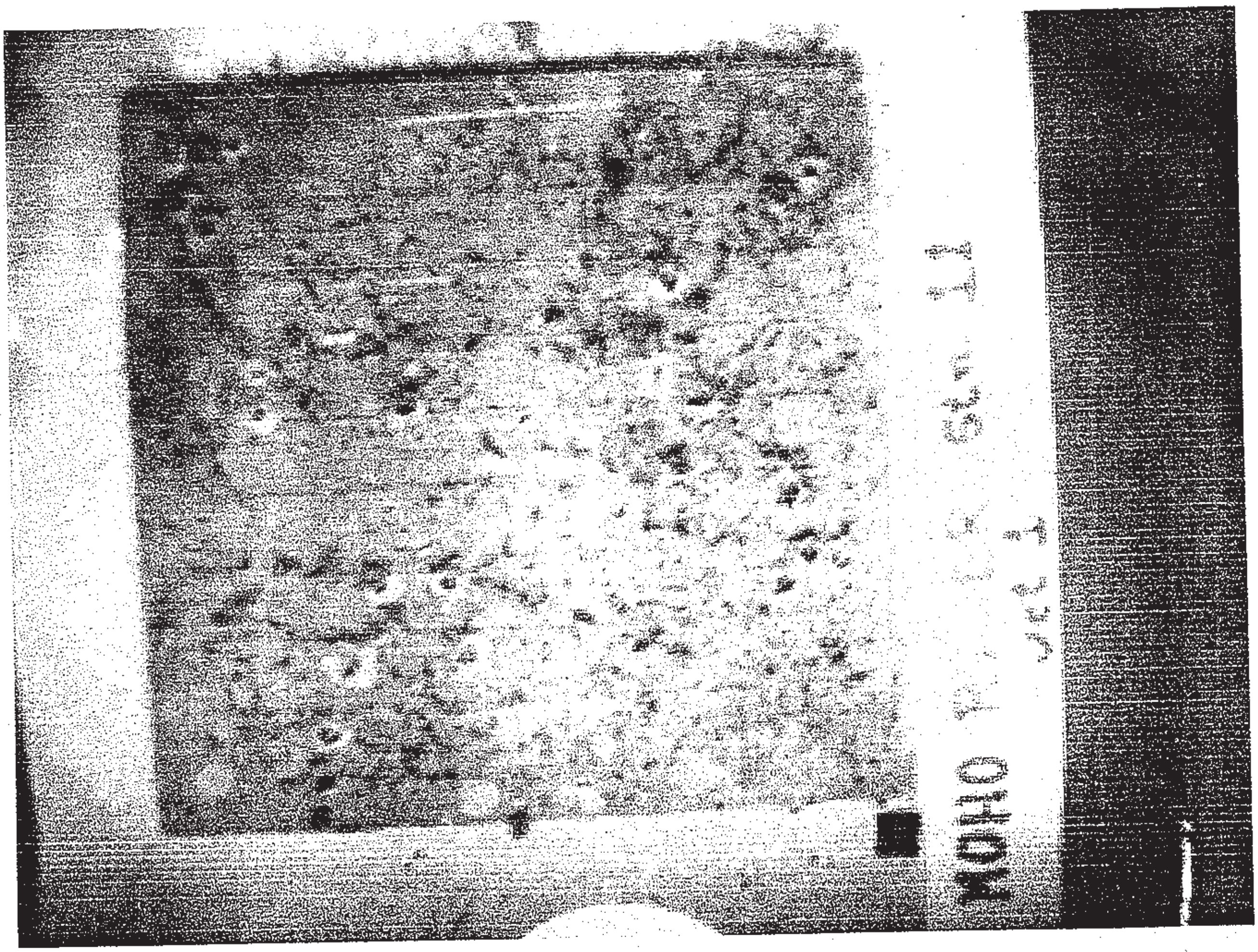


Digital image - recruitment plate at Station 10 Bob Stuart Lagoon - October 1, 1999.

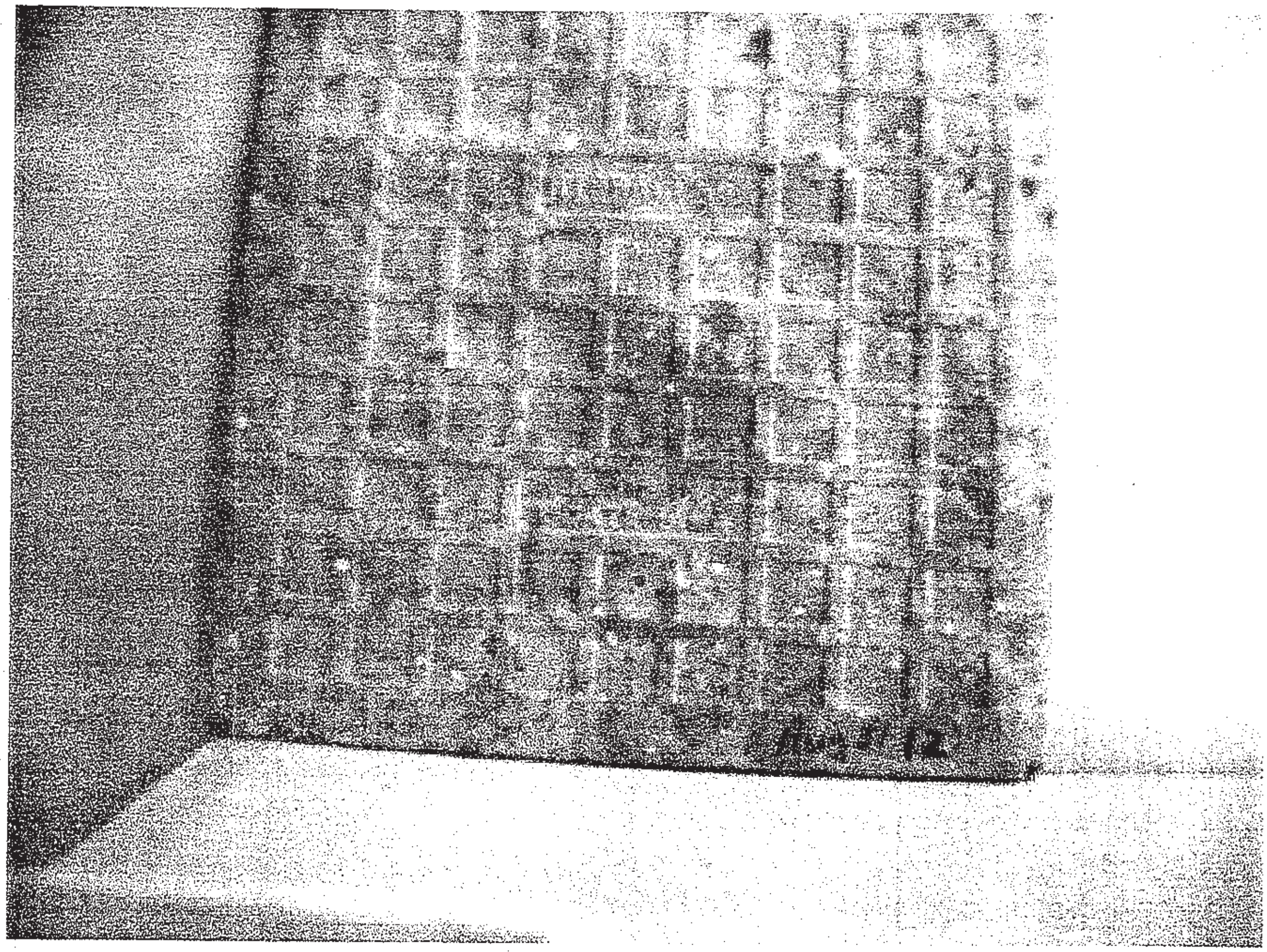
Digital image - recruitment plate at Station 11 Moho River - August 31, 1999.



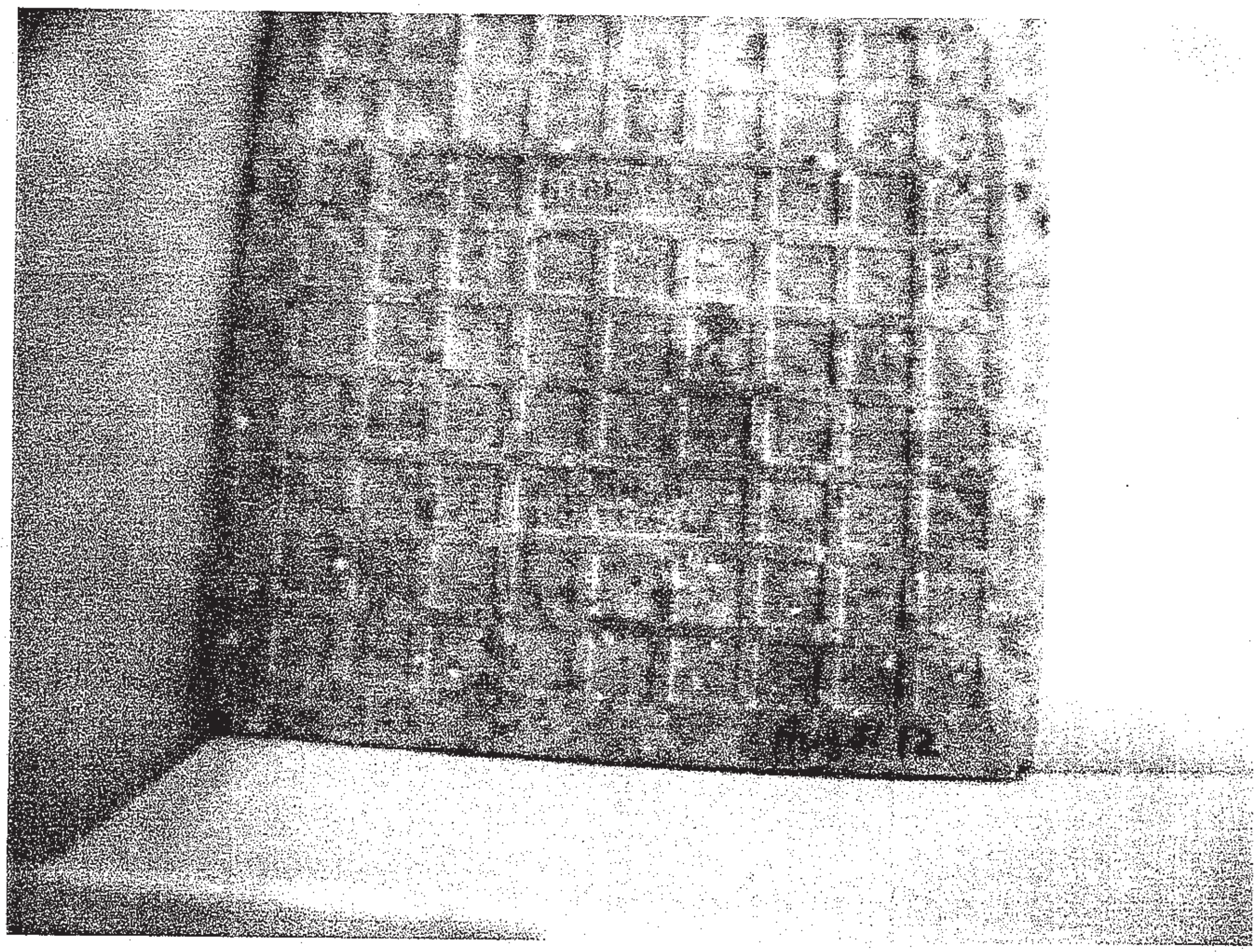
Digital image - recruitment plate at Station 11 Moho River - October 1, 1999.



Digital image - recruitment plate at Station 12 Moho River - August 31, 1999.



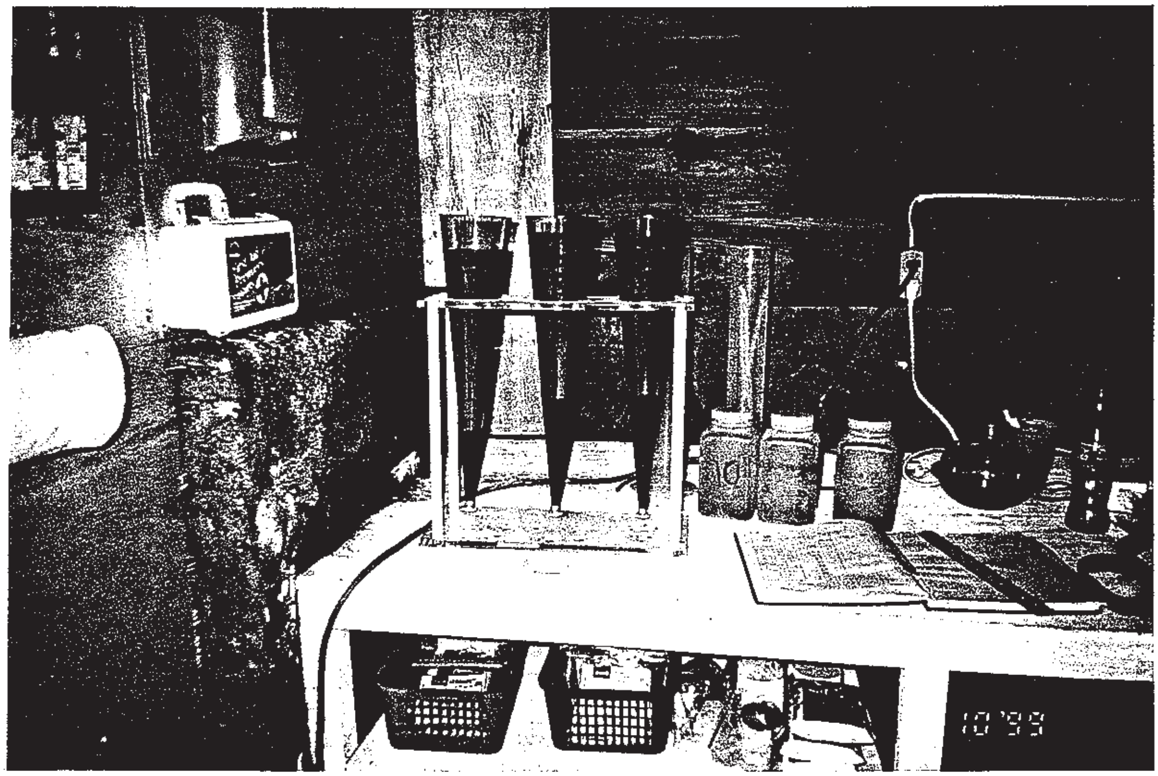
Digital image - recruitment plate at Station 12 Moho River - August 31, 1999.



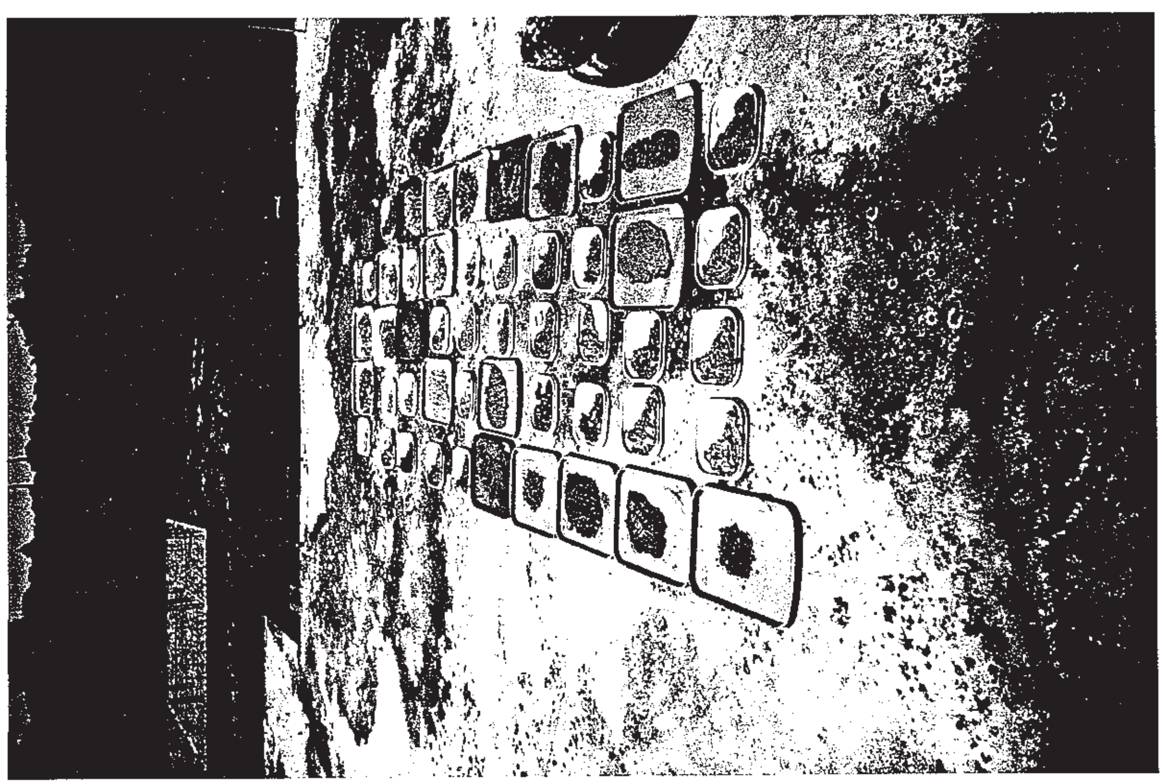
The TIDE laboratory near the boat launch.

Karl Castillo processing water samples in the laboratory.

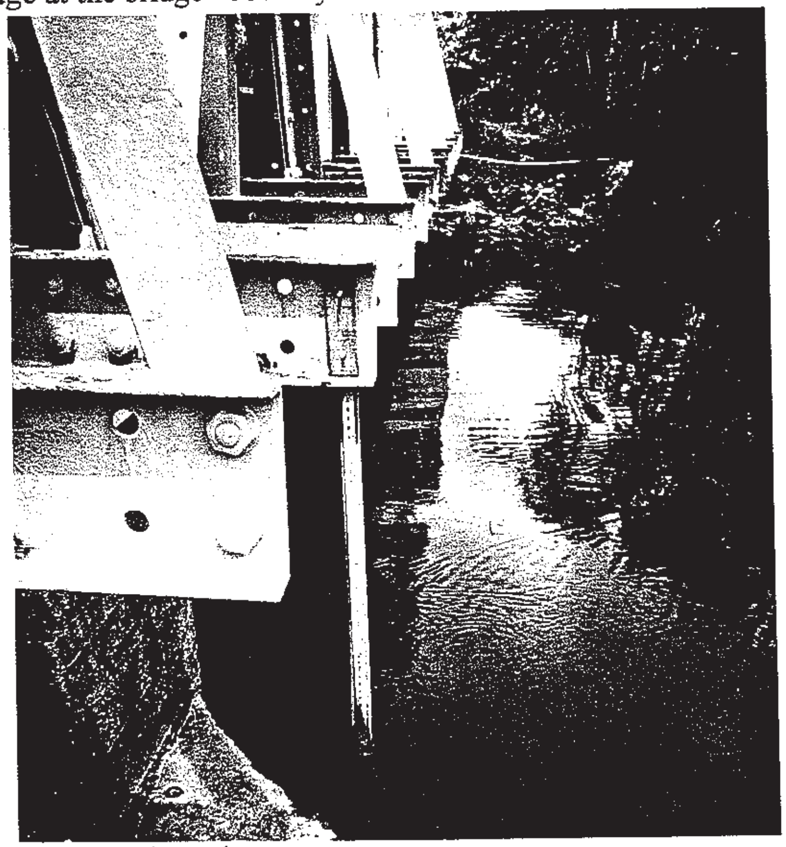
Use of the Imhoff cones for calculation of sedimentation rates.



Drying of surficial sediment samples on the TIDE roof.



The water level gauge at the bridge - Joe Taylor Creek.

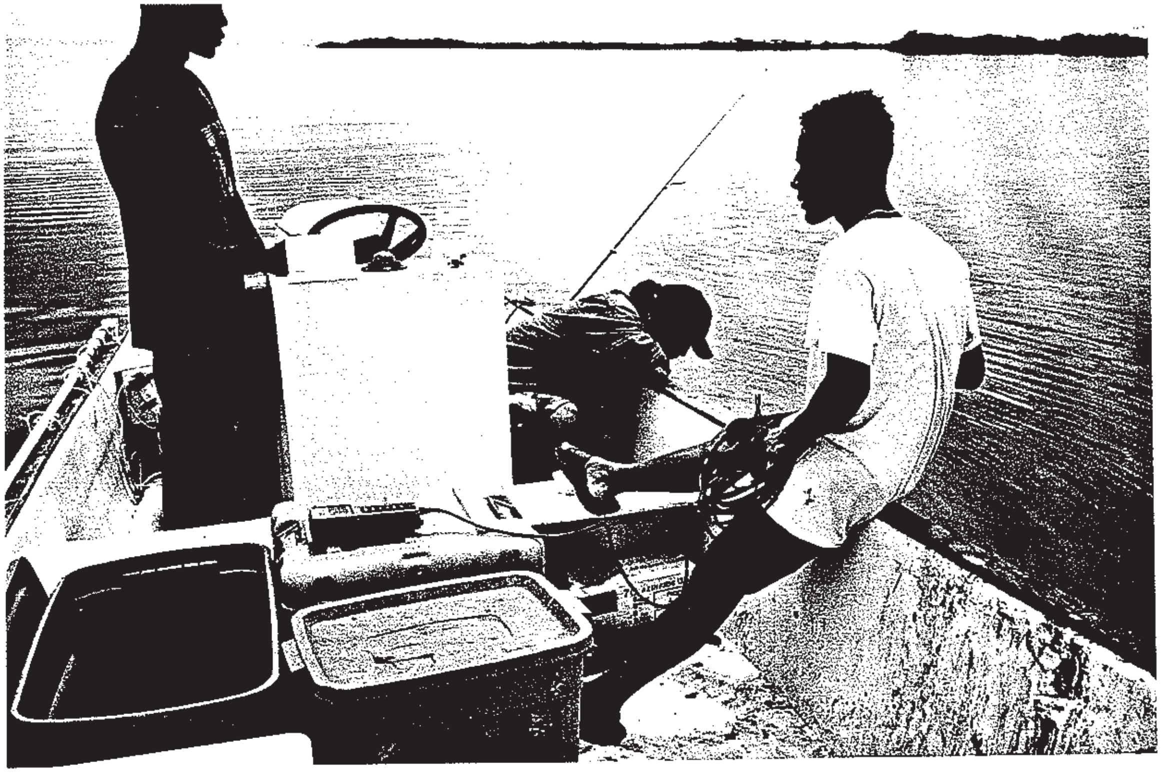


The water level gauge at Monkey River.

Marking of the moored equipment with tags.

The bottom drifter cards released at Monkey River.

Use of the YSI salinity/temperature meter during field work.



Servicing the sediment traps.

Marking of the mangrove plots and tagging of seedlings.

Training session at Monkey River October 3, 1999.

Training in the use of the refractometer at Monkey River.

Beach profile training at Monkey River.

The Connectix digital camera (on top of the computer monitor), used for recruitment plates.