NATIONAL UNDERSEA RESEARCH CENTER
NORTH ATLANTIC AND GREAT LAKES REGION
AT THE
UNIVERSITY OF CONNECTICUT AT AVERY POINT

REMOTELY OPERATED VEHICLE FACILITIES: TECHNICAL SPECIFICATIONS AND CRUISE PLANNING MANUAL

Revised By:
Nick Worobey

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1.0 INTRODUCTION

The National Undersea Research Program (NURP) is NOAA's underwater presence in the oceans and large lakes. NURP supports research that requires the direct placement of researchers underwater, either physically through the use of submersibles, underwater laboratories, and diving; or virtually through the use of remotely operated vehicles and observatories to collect otherwise unobtainable samples and observations. These technologies serve as important complementary additions to traditional oceanographic techniques and often go beyond the frontiers established by conventional methods.

The National Undersea Research Center for the North Atlantic and Great Lakes at the University of Connecticut at Avery Point (NURC-NA&GL) was established in 1983. A major technological goal of NURC-NA&GL is to increase the sampling capabilities and develop techniques for utilizing Remotely Operated Vehicles (ROVs) for scientific sampling. The Center operates four ROVs and two drop camera systems, each with unique capabilities. These diverse systems provide flexibility in addressing the objectives of various research projects. The Center continually strives to increase the sampling capabilities of each system, in response to the sampling needs of the research community and the ever improving state-of-the-art of undersea vehicle technology.

The Kraken, a light work class ROV (Deep Sea Systems International's Max Rover Mk I, Figure 1), is the largest in the Center's suite of vehicles and requires substantial lift capability and a large area for support facilities on the surface vessel. It also can carry the most sampling systems on a single dive and has the greatest payload capacity. The Phantom P3S2 (Fig. 1) is one of three low-cost ROV systems operated by the Center. While retaining many of the same sampling capabilities as the Max Rover, the payload capacity is much smaller and manipulative capabilities are limited. The Mini Rover MK-II and the Phantom 300 are the smallest vehicles in the ROV suite but can be operated from smaller surface support vessels. As do the other vehicles, these smaller systems carry high resolution color video cameras for conducting a variety of imaging tasks. The relatively small size and portability of several Center operated ROVs and support equipment makes them ideal for use from vessels of opportunity and for operations in remote areas. The two camera drop camera systems ISIS and DC2 are quite adaptable for different video, 35 mm and sensor packages but only allow manoverability by ships movement.

For additional information regarding vehicle capabilities, cruise planning, and sampling systems, please contact: Peter Auster, Science Director: voice 860-405-9119, fax 860-445-2969, auster@uconnvm.uconn.edu or Nick Worobey, Technical Director: voice 860-405-9135, fax 860-445-2969, worobey@uconn.edu

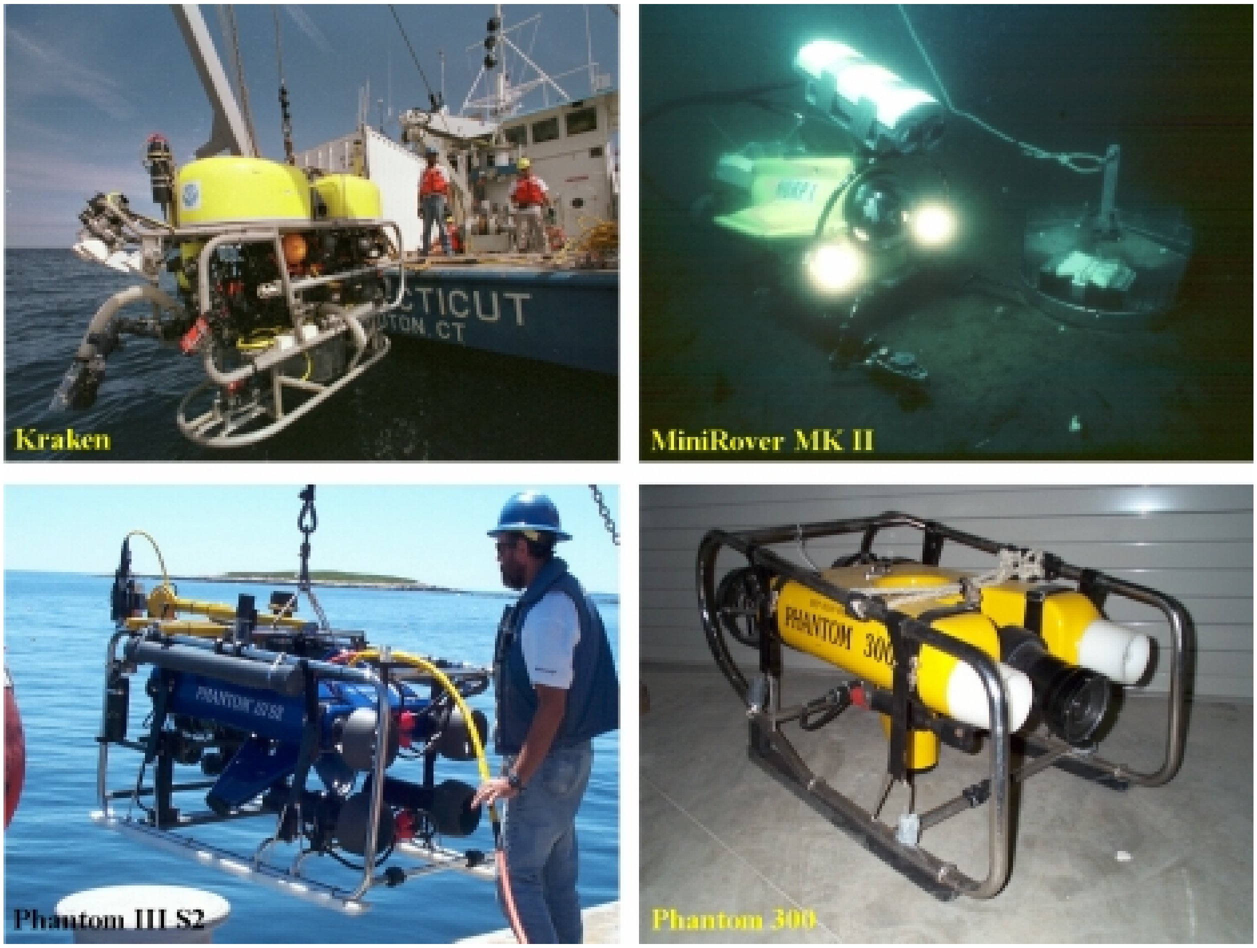


Figure 1. ROV systems operated by the National Undersea Research Center at The University of Connecticut.

2.0 CRUISE PLANNING

Cruise planning and coordination requires that a range of factors be considered prior to commencing operations. The following outlines the major items to be considered. Please refer to sections 3.0 through 8.0 for more detailed information.

2.1 Surface Support Vessel:

2.1.1. Deck area - Each vehicle has an estimated footprint for required deck space. The vessel should have a retractable A-frame, crane or davit to launch and recover vehicles. A moon pool or rail space is required to mount the transducer and staff for an ultra-short baseline tracking system when vehicle navigation is required.

2.1.2. Lab size - Vehicle electronics and data recording systems require a sheltered, dry, and air conditioned space (depending on local conditions). Space for the pilot, navigator, and science party to sit comfortably for long periods is required, when a system van is not used.

2.1.3. Electrical power requirements - Ideally the vessel should provide a dedicated power supply (i.e., does not run refrigeration, hydraulic or other high usage systems). The power supply should match or exceed vehicle requirements.

2.1.4. Anchoring and retrieval capabilities - Criteria for selecting a support vessel should include the ability to anchor in the maximum depth planned for ROV dives. Speed of anchor deployment and retrieval is a factor which constrains actual dive time for periods when multiple sites must be visited each day. Vessels with a bow thruster or other low velocity propulsion system will allow live-boat operations.

2.1.5. Berthing requirements - For multiple day cruises away from port, plan on providing three berths for ROV operations personnel.

2.2 ROV Sampling Capabilities

2.2.1. Video imaging requirements - Each ROV is equipped with single or multiple video camera systems, which produce composite video signals. Video imaging is accomplished using color cameras with either zoom or fixed focal length wide angle and telephoto (=close-up) lenses. A monochrome SIT camera is able to produce images in low-light situations where vehicle lighting is not wanted or distance from a target attenuates vehicle lights, hence ambient light is used for illumination. A three chip CCD camera is available with the Kraken and P3S2 systems for high resolution video. Camera tilt angle can be fixed based on survey requirements. Paired parallel lasers and dual paired lasers can provide a size reference for measuring objects, calibrating path width for transects, or calculating altitude.

2.2.2. Still photographic capabilities - Area of coverage can be altered by changing camera positions on the vehicle. Number of exposures required per dive dictates which camera system is required for a particular cruise. Thirty-five millimeter film cameras are available with 28 mm and 15 mm lenses. Film capacity varies with camera model, from 28 to 250 exposures per loading. Area-of-coverage can be determined for each camera.

2.2.3 Acoustic imaging capabilities - A Kongsberg MS 1000 sector scanning sonar operating at 675 kHz can be used to search for underwater structures and aggregations of organisms. The system can also be used in a side-scan configuration. Continuous digital data files can be recorded for replay. Software for replay can be provided to the Principal Investigator.

2.2.4 Manipulative capabilities - Tasks such as tube and box coring, collecting organisms, and placing equipment on the bottom require prior planning to match manipulator and payload requirements to a specific vehicle.

2.2.5. Sampling system capabilities - A number of sampling systems for collecting sediments, water, and organisms are available. User supplied sampling equipment can be accommodated but must conform to available power, mounting, and payload capabilities of specific vehicles. Discussions regarding use of such systems must occur well in advance of any cruise.

2.2.6. Sample retrieval - Consideration should be given to timing of samples and processing requirements. Samples can be stored in the vehicle or in an elevator for retrieval after each dive, or the vehicle can be retrieved after each sample is acquired.

2.3 Data Products

2.3.1. Videotape format - Video is normally recorded on Hi-Band 8 mm tape. DVCAM, Standard 8 mm or VHS tape can be provided if arrangements are made at least 3 months in advance of a cruise. Other formats require user supplied recording decks and tape.

2.3.2. Film - Ektachrome 200 Professional (EPD404) is normally used in bulk loaded cameras while Kodachrome 200 (PKL200) is used in standard 36 exposure cassettes with the Benthos 3782 camera. Deviations from these standard film types must be arranged at least 3 months in advance of a cruise. While NURC-UCAP provides film for each cruise, the Principal Investigator is responsible for film processing.

2.3.3. Sensor data - A variety of sensors can be installed on the Phantom P3S2 and Kraken (Max Rover Mk I) vehicles. Oxygen and pH sensors are available but calibrations must be conducted by the science party. See Section 4.0 regarding types of sensors.

2.3.4. Navigation data - ROV positioning and position fixing is accomplished using differential global positioning system data and an ultra-short baseline acoustic tracking system (Trackpoint II). Positions can be recorded throughout each dive and fixes for specific positions, such as sample locations and start/stop of transects, can be recorded in a separate file. Special file configurations must be arranged in advance. Integrated Navagation is accomplished using Winfrog and data is supplied as a spreadsheet on CD.

2.3.5. Operations logs - Paper records of selected dive and navigation data are recorded by operations personnel and copies are provided to the science party at the end of each cruise leg. Any additional data needs should be discussed in advance of the cruise.

If NURC-NA&GL is providing a surface support vessel, then the science party does not need to deal directly with this part of the cruise planning process. If the scientist is arranging for a support vessel, then coordination directly with the Center is required.

3.0 VEHICLE DESCRIPTIONS AND SUPPORT REQUIREMENTS

Center ROVs utilize ships of opportunity as support platforms and basic requirements must be met in order to conduct safe and productive diving operations. All ships used **must** be able to anchor in the depths of proposed work. Each of the ROV systems requires deck space for launch/recovery operations and an area that is dry and void of sea spray and mist for surface control systems. Note that laboratory bench space requirements include estimates for accommodating a video tape recorder and video monitor (i.e., 1 m L x 0.5 m W x 0.5 m H). The vehicle tracking systems requires an additional 2 m L x 0.75 m W x 1 m H. Each vehicle also has specific power and handling system requirements. The following vehicle descriptions outline these requirements as well sampling capabilities.

3.1 Phantom 300

The Phantom 300 is the smallest and lightest ROV available through the Center. Power requirements are minimal. These characteristics make it ideal for operations from small vessels in relatively shallow water (i.e., less than 90 m).

Vehicle size: length 1 m, width 0.5 m, height 0.5 m, weight 32 kgs
Maximum operational depth: 90 m

Cable: length 120 m, weight 9 kg/90 m in seawater, 25.2 kg/90 m in air, diameter 1.27 cm, minimum bend radius 12.7 cm
Power requirements: 120 VAC 50/60 Hz, 1.2 KVA

Laboratory bench space requirements: ROV control system, video and tracking
3.75 m L x 0.75 m W x 1 m H.
Video camera: Photosea TV 5000
Resolution: 430 lines horizontal, 350 lines vertical
Sensitivity: 20 lux minimum illumination at 1/60 sec shutter speed
Lens: 4.2 mm, ½ inch CCD sensor
Auto iris control: F 1.6 to 360
Angle of view: diagonal 143^o air/100^o water, horizontal 115^o air/80^o water
vertical 82^o air/60^o water
Focus: fixed from 30.5 cm to infinity

The Phantom 300 is propelled by three thrusters that produce forward, reverse, left, right, up, and down motions. The Phantom 300 can maneuver in currents of 25 cm s^{-1} or less. The video camera is mounted on a tilt platform and the field-of-view is illuminated by two fixed mounted 150 watt quartz-halogen lights. The entire system is protected by a sealed tubular crash frame.

Ship requirements are minimal. A small deck space of approximately 2.3 m^2 (1.5 x 1.5 m) is required. The vehicle has minimal handling requirements. If the freeboard of the vessel is more than 0.5 m, a davit and block are needed for launch and recovery. If the freeboard is 0.5 m or less, the ROV can be deployed and recovered by hand. A 10 cm diameter "mouse hole" is needed to pass cables from the laboratory to the deck. The vessel must be able to anchor in water depths of the proposed scientific work. Portable generators can be used to provide power to the ROV system. This requires additional dry deck space for securing the generators. The deck space must also be located away from combustibles and in such a way as to minimize fumes entering the laboratory space.

3.2 MiniRover Mk II

The MiniRover Mk-II can operate to depths of 300 m and in currents up to 50 cm s^{-1}. Dual remote-head video cameras or single CCD camera, with fixed focus wide angle and telephoto lenses, provide flexible imaging capabilities. The custom skid and framework around the vehicle can accommodate a variety of sampling systems.

Vehicle size: length 1 m, width 0.56 m, height 0.66 m, weight 35 kg
Operational depth: 300 m
Cable: length 330m, weight is neutral in seawater, 25.2 kg/100 m in air, dia. 1.04 cm
Power Requirements: 120 VAC 50/60 Hz 1000 Watts
Laboratory bench space requirements: ROV control system, video and tracking

3.75 m L x 0.75 m W x 1 m H.

Video Cameras:

Wide angle (3 mm) and telephoto (8 mm) on an A/B switch
Iris control: Auto (wide angle), user adjustable (telephoto)
Focus: fixed 30.5 cm to infinity (wide angle), user adjustable (telephoto)
Single camera: 4.8mm/f 1.6 340 TV lines minimum

The MiniRover M II is propelled by three thrusters, that allow forward, reverse, left, right, up, and down motions. The video cameras are mounted on a tilt platform behind an optically corrected dome port and field of view is illuminated by two fix mounted 150 watt quartz-halogen lights.

Ship requirements are minimal. A small deck space of approximately 2.3 m^2 (1.5 x 1.5 m) is required. The vehicle has minimal handling requirements. If the freeboard of the vessel is more than 0.5 m, a davit and block are needed for launch and recovery. If the freeboard is 0.5 m or less, the ROV can be deployed and recovered by hand. A 10 cm diameter "mouse hole" is needed to pass cables from the laboratory to the deck. The vessel must be able to anchor in water depths of the proposed scientific work. Portable generators can be used to provide power to the ROV system. This requires additional dry deck space for securing the generators. The deck space must also be located away from combustibles and in such a way as to minimize fumes entering the laboratory space.

3.3 Phantom P3S2

The Phantom P3S2 is the largest low cost ROV operated by the Center. The Phantom P3S-2 is very adaptable due to its open frame design and high output thrusters, has an operating depth of 330 m, and can maneuver in currents up to 100 cm s^{-1}.

Vehicle size: length 1.75 m, width 1.2 m, height 0.7 m, weight 145 kg
Operational depth: 300 m
Cable: length 450 m, weight is neutral in seawater, diameter 1.9 cm
Power Requirements: 120 VAC 50/60 Hz 4.5 KVA.
Laboratory bench space requirements: ROV control system, video and tracking 4.0 m L x 0.75 m W x 1 m H.
Video Cameras:

3-Chip CCD 14X Zoom 5.5 mm TO 77mm F 1.9-16 750 Horiz. TV Lines
Single chip and rear looking camera switchable

The Phantom P3S2 is capable of operating to a depth of 330 m and is propelled by six thrusters. Four ½ HP horizontal thrusters propel the ROV forward, reverse, turn left and turn right, while two 1/2 HP vertical thrusters maneuver the ROV up, down, laterally left and laterally right. The primary video camera is mounted on a tilt platform along with paired parallel red 10 mW lasers and two 250 watt quartz-halogen lights. A video overlay containing information on vehicle attitude and time/date is standard.

The Phantom P3S2 requires deck space at least 1 m x 1.5 m and 2.0 m x 2.0 m, located relatively close together. The 2.0 m x 2.0 m space must be located close to the launching area and must have a 1.5 m wide clear pathway to the launching area. The Phantom P3S2 requires the use of a winch on a boom, crane or A-frame for launch and recovery. A winch operator will be required. Lifting capacity of the system being used must have a 600 kg minimum safe working load. If an A-frame is used, it must be at least 1.4 m wide. If a boom is being used there must be at least 1.25 m clearance from the lifting block to the top of the rail and 0.75 m clearance from the boom stand pipe to the lifting wire. An enclosed dry space for the top side electronics is needed with a 10cm diameter "mouse hole" to the deck for running the tethers. The dry lab/work area must have an outlet on a dedicated 30 amp breaker for running the ROV console. Additional electronics can be run from other available power supplies on 15 amp breakers. The support vessel must be able to anchor in water depths of the proposed scientific work or have dynamic positioning capabilities.

3.4 Kraken (MaxROVER Mk I)

The Max ROVER Mk-I is a light-work class ROV. It has an open frame design providing ample mounting spaces for additional science equipment. The large payload capacity of this vehicle permits multiple types of sampling on a single dive. The depth limit for the vehicle is currently restricted, due to tether length, to 600 m. We expect that with the acquisition of a new tether and winch, projected for 2002 that the vehicle will operate to its design depth of 1000 m. This vehicle can maneuver in currents up to 100 cm s^{-1}.

Vehicle size: length 2 m, width 1 m, height 2 m, weight 820 kg
Operational depth: 600 m (1000 m future)
Cable: length 600 m, weight 27 kg/100 m in seawater, 89 kg/100 m in air, dia. 3.3 cm
Power Requirements: 220/240 VAC single phase, 70 amps
System Van: 6.1 m L x 2.5 m W x2.5 m H
Laboratory bench space requirements: ROV control system, video and tracking 7.0 m L x 1.5 m W x 1 m H. If used without system van)
Video Cameras:

- 3 chip color video 14X Zoom 5.5 mm-77mm, F 1.9-16, 750 Horiz. TV Lines, 2/3 chip.
- Wide-angle fixed focal length camera: 3.8 mm lens, 450 lines of resolution, ½ inch sensor
- Rear looking fixed focal length camera: 450 lines of resolution, ½ inch sensor
- Iris control on all cameras: Auto (wide angle and rear looking)
- Focus: fixed 30.5 cm to infinity (wide angle), user adjustable (close up)
- SIT camera with 5.5 mm lens, 5 x 10^{-4} lux minimum faceplate illumination, auto iris

The Kraken is propelled by six thrusters. The vehicle is equipped with six THL-404 series 1.5 HP brushless DC thrusters. Four horizontally mounted thrusters propel the ROV forward, reverse, turn left and turn right. Two thrusters mounted as vertrans maneuver the ROV up, down, lateral left and lateral right. The video cameras are mounted on an inverted T pan and tilt unit along with two sets of paired parallel 1 mW red lasers set at 10 cm vertical separation and 20 cm lateral separation. A low light SIT camera, one 150 watt quartz-halogen flood light, and one 150 watt quartz-halogen spot light are also mounted on the pan and tilt. A video overlay containing information from an oceanographic sensor (see Section 4.2), vehicle attitude, and time/date is standard.

The Max ROVER Mk-I system requires deck space at least 2 m x 3 m for the vehicle, an adjacent 3 m x 3 m for the tether/winch and a 1 m x 1 m for the hpu. The tether areas must be located close to the launching area and must have a 1.5 m wide clear pathway to the vehicle. An electric tether handling system will be mounted within 1 m of the deployment area. The space required will be approximately 1 m x 1 m. The vehicle requires a crane or A-Frame for launch and recovery. A winch operator will be required. The minimum safe working load for the handling system must be 910 kg. If an A-Frame is used it must be at least 1.5 m wide. An enclosed dry space for the top side electronics is needed with access (13 cm) to the outside for running the tethers. The support vessel must be able to anchor in water depths of the proposed scientific work or have dynamic positioning capabilities.

3.5 Integrated Seafloor Imaging System (ISIS)

ISIS has a standard package consisting of a forward looking video camera, forward looking 35 mm (250 exposure) camera, two 150 watt lights, two lasers for scaling, a downward looking video camera, two downward facing 150 watt lights, and scaling lasers mounted in a 1m H x 1m W x 2m L SS frame.

3.6 Drop Camera System (DC2)

DC2 is available with a video camera, two 50 watt lights and 3 uncommitted conductors, which can be shipped in a single 1m x 1 m x 2m shipper case.

4.0 SAMPLING SYSTEMS

Table 1 summarizes the sampling equipment that can be accommodated on each ROV. Following the table is a description of each sampling system, and an example of the data products where applicable.

Table 1. Summary of ROV that can support a range of sampling systems.

Sampling System/ROV	Phantom 300	MiniRover Mk II	Phantom P3S2	Max Rover Mk I
Benthos 3782	X	X	X	X
Photosea 1000A			X	X
Intervalometer			X	X
CTD and additional Sensors			X	X
Collimated Light		X	X	X
Suction sampler			X	X
Detritus/Water Sampler			X	X
Plankton Nets		X	X	X
Tube Core		X	X	X
Box Core				X

4.1 Still photography

Film has a greater resolution than video, although still photography cannot capture motion or provide continuous images. Still photography does provide high-resolution records for species identification, documenting behavior or associations, and recording aspects of the underwater environment. Each of the cameras described below has an accompanying electronic flash unit that provides daylight illumination of short duration. Recharge time between flashes can range from 5 to 15 seconds.

Benthos 3782 Mini Camera: The Benthos 3782 Mini Camera is light weight (1.1 kg in air, 0.2 kg in water) and can be mounted on all Center ROV systems. The camera uses a standard 35 mm film cassette. However, approximately 6 exposures are used during the loading and unloading process (so there will be 30 useable exposures per loading). A Nikkor 28 mm underwater corrected lens is used with focus variable from 0.6 meters to infinity and an adjustable aperture from f/3.4-f/22 (standard settings are 1 meter distance at an aperture setting of f/11.5). The optical viewing angle is 60^0 diagonal x 35^0 vertical x 50^0 horizontal in water and the camera has a shutter speed of 1/70 second. The camera is triggered manually from the surface. However, once underwater, camera settings are fixed and cannot be changed remotely during the dive. A single or dual head electronic flash unit provides illumination. The depth rating for this system is 600 ft.

Photosea 1000A: The PS 1000A is a bulk loaded camera with a depth rating of 1000 m and can carry a standard 35 mm film cassette or a 250 bulk film load. A Nikkor 28 mm underwater corrected lens is used with focus variable from 0.6 m to infinity and an adjustable aperture from f/3.4-f/22 (standard settings are 1 meter focal distance at an aperture setting of f/11.5). Lens viewing angle is 60^0 diagonal x 35^0 vertical x 50^0 horizontal in the water and the camera has a shutter speed of 1/100 second. The camera is triggered from the surface, either manually or with an intervalometer. However, once underwater, camera settings are fixed and cannot be changed remotely during the dive. The PS 1000A has a display window which is recorded on each image. The data display includes the photo number (first three digits); a two digit alphanumeric code which can be used to signify location, dive number, day number, etc.; and time of day or elapsed time (last four digits). A single flash unit provides illumination.

Intervalometer: The PS 1000A camera can be used with an intervalometer. Photographs can be taken automatically at intervals of 15, 30, 60, 120, or 240 seconds.

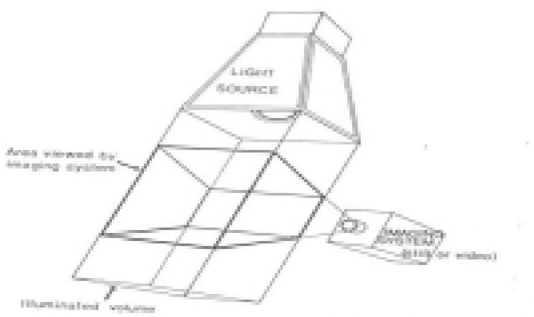
4.2 Sensor Systems

Presently, a Sea Bird SBE19 conductivity, temperature and depth probe can be mounted to the Kraken or P3S2 for water parameters. Data will be recorded internal to the CTD and downloaded to disk/CD after each dive.

4.3 STRUCTURED LIGHTING

Collimated Light: The collimated light is a continuous structured illumination system allowing known volumes of water to be censused for large zooplankters using video (Fig. 4). Utilizing a 150 watt high-intensity tungsten-halogen lamp and a series of Fresnel lenses, a rectangular volume of water is illuminated. The 6000 lux light beam is 12.7 cm x 25.4 cm with 1.4^0 beam divergence. For example, the wide angle video camera on the Phantom S2 instantaneously images a water volume of approximately 8906 cm^3 while 2276 cm^3 is viewed with the telephoto lens. A flow meter can be used to calculate volume censused over time. (NOTE: The illuminated volume should be calibrated for each cruise to account for slight differences in mounting configuration.)

Figure 2. The collimated light source illuminates a known volume of water in front of a video camera.



4.4 SAMPLE COLLECTION SYSTEMS

Center ROVs can carry a variety of systems to obtain samples of organisms, sediments, and water. Depending upon the vehicle, only a single sampling system can be carried at one time, requiring multiple divers to collect different types of samples. The Phantom 300 and P3S2 do

not have any manipulative capabilities while the MiniRover MkII carries a single function manipulator. Only the Max ROVER Mk I carries a six-function manipulator that allows a greater degree of dexterity for implementing complex manipulative tasks. Several of the systems described below do not require a manipulator (e.g., plankton nets, detritus/water sampler) and are self contained units, requiring only power from the vehicle.
Plankton Nets: Dual opening and closing 0.333 micron plankton nets are attached to an acrylic tube (14.1 cm ID) which holds the net open. An acrylic door can be opened and closed using a pull motor. A flow meter mounted in the mouth of each net allows the volume of water sampled to be calculated. Larger or smaller mesh sizes can be supplied by the scientist and fitted to the collars.

Tube Cores: ROVs with manipulator capabilities are able to take tube cores of varying sizes. Tubes are made from acrylic or plexiglass. Depending on conditions, one to five cores may be taken per dive. The Center currently has two core tube sizes available; 29 mm diameter and 60 mm diameter. Coring works best in soft cohesive sediments.

Box Cores: Box cores are rectangular (10 cm x 10 cm) sediment samplers with have flexible doors which close at the bottom of the box. Inserts can used to subsample the core. A T-handle is grasped by the manipulator and turned to close the doors. These samplers are used in areas of uncohesive sediments (i.e., where tube cores will not function), as well as for large volume samples. The sample box is made from stainless steel.

Detritus sampler: Detritus, zooplankton, and water can be collected with these samplers. The top and bottom of each sampler slides into place over the openings of a 15 cm diameter tube. This type of sampler allows the ROV to rise or fall through the water column to "capture" undisturbed samples. Sample volume is 3.0 l. Up to three samples can be taken on a single dive.

Water sampler: A series of Van Dorn "like" bottles can acquire samples of approximately 900 ml. Up to 8 samples can be taken per dive.

Suction sampler: A high-volume, selectable flow rate, suction sampler can collect two samples (P3S2) or eight samples (MaxROVER) in 7 liter Plexiglas and acrylic containers depending on the vehicle. Samples are collected by selecting one of two input ports and using one of two input nozzles mounted to the front of the ROV. Three-inch diameter hoses are used to facilitate collection of large animals or objects. Flow direction can be reversed to flush samples or material from buckets as well as remove material from surfaces at a study site. Use of this sampler to distribute chemicals, such as quinaldine, requires the investigator to purchase special purpose containers, lids, and hoses to avoid contamination of the basic system.

Rotary sediment sampler: A "ferris wheel" surficial sediment sampler can obtain three samples per deployment. Sample volume is 180 cc. Samples are stored in aluminum containers with Lexan tops sealed with rubber o-rings. Sediments are collected by rotating the wheel through the sediment, partially homogenizing the sample.

5.0 NAVIGATION AND TRACKING

Vehicle tracking and navigation is accomplished using an integrated navigation system (INS) with Differential Global Positioning System (DGPS) and an ultra-short baseline (USBL) tracking system. DGPS is used to determine the vessel position; a USBL determines depth, slant range and bearing to the underwater vehicle; and the INS computes a latitude and longitude for the vehicle. If a differential station is not operating or the signal cannot be acquired, Loran C is used to determine vessel position. Uncorrected GPS can be utilized as a last resort but is the least accurate.

The Center currently uses a Magnavox 200 GPS receiver, Magnavox MX50R Differential Receiver, 4410C Trackpoint II USBL system, and a Winfrog INS. Positions can be entered in the INS, in advance of any dives, and can be used as waypoints, for vectoring, or running track lines. While acquiring a running position log for the ship and ROV, positions for sites of special interest can be tagged, and comments entered, to correspond with that unique position. For example, positions can be logged where samples are collected, start and end of transects, changes in seafloor features, etc. Data from the system is saved to a file in ASCII format which can be imported to a spreadsheet program such as Excel. A paper record can also printed as a list of positions (Table 2), as well as an x-y plot (Fig. 5 and 6).

If a Track Point II system is required, a hydrophone mounting bracket must be attached to the vessel. If the integrated navigation system is required, an antenna bracket must be mounted to the highest point on the ship as practical.

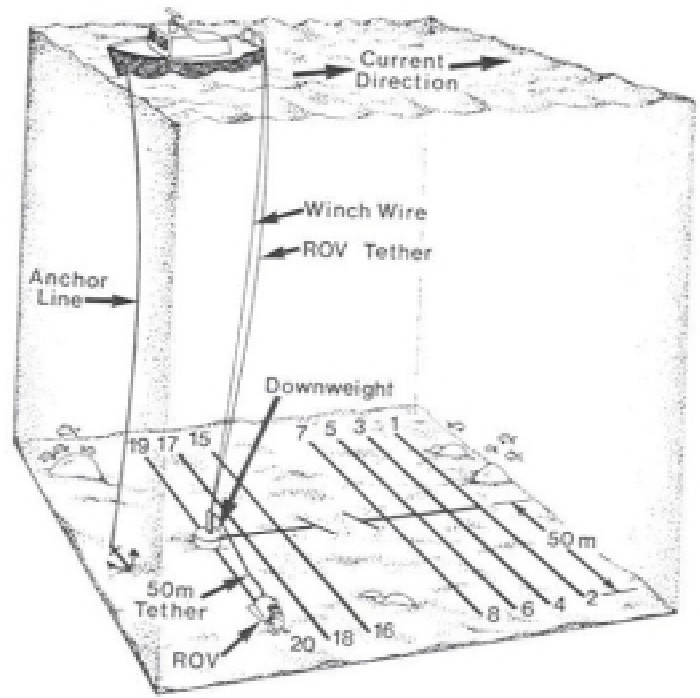
6.0 OPERATING SCENARIOS

The support vessel must be anchored prior to performing any ROV operations unless approval for live-boat operations has been confirmed during the cruise planning process. An anchored vessel greatly reduces two major logistical concerns; ship motion in relation to the vehicle and entanglement of the tether in the ship's propeller or on bottom obstructions. Using one anchor, all but major swings of the ship can be handled through tether management. Two or three point moorings may be needed to operate around areas of high topographic relief.

The tether cable is clearly the limiting factor for conducting ROV operations. For certain procedures, the tether can be helpful as a locating tool (e.g. standardizing video transect length, returning samples to an elevator). In others instances, the tether may constrain the movement of the vehicle or disturb the bottom. The following scenarios may aid in developing an understanding of ROV capabilities.

Scenario 1: Conducting video transects along a known path length.

The downweight acts as a transect starting point. The vehicle flies on the seafloor away from the downweight on a constant compass heading. When the vehicle can no longer proceed forward, the path length has been traversed. The vehicle follows the tether back to the downweight to start another transect on a different compass heading. The downweight position can be changed by adjusting the length of anchor line. In this way, multiple transects can be completed at a single anchorage. The error in length associated with this method is well within the error associated with various electronic navigation systems.



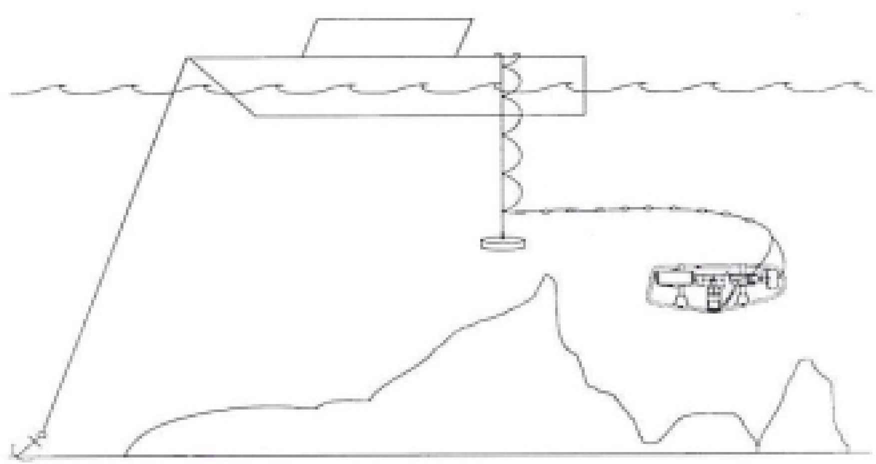
Variations:

As with the example above, an anchorage can be considered a station. If current velocities are low, the ROV can be operated without a downweight. Approximately, 10 transects, of 50-60 m length, can be conducted around the vessel. Longer transects are possible but longer transects may require a smaller number of replicates due to overlap problems. Transect length is computed using the INS (i.e., using DGPS and USBL inputs).

When operating at very high current velocities (>150 cm/s), the ROV can be attached to a down weight via a bridle. The downweight is lowered until the ROV contacts the bottom while the downweight remains suspended in the water column. To progress along a transect, anchor line is let out. As the ship drifts back the ROV moves along the bottom. Very long transects are possible; limited only by the length of anchor line available. Transect length can be quantified by knowing the area of a single video frame (or field) and summing these for all frames in the transect. This method is very time consuming however due to the recovery of the anchor after each set.

Scenario 2: Operating over high relief bottom

When operating in areas of high topographic relief (e.g. rock outcrops, coral reefs), a two or three point mooring may be necessary to safely operate the ROV. This mode of operation will greatly reduce chances of tether entanglement. A two or three point mooring is made over the site. The downweight is deployed to a depth less than the highest obstruction. Floats are placed on the tether to make it slightly positive. Time, rather than area, can be used as a variable to conduct survey transects.



Scenario 3: Collecting multiple samples.

Water or plankton samples will be limited to the number of containers, which can be attached to the ROV. However, tube core or box core samples require a receptacle to store used and unused cores. Generally, an elevator is required to hold multiple cores, as the payload capacities of most ROVs are low. An elevator is a sample receptacle, which has a buoy or acoustic release. It should be deployed as close to the sampling site as possible to reduce ROV transits back and forth to collect and deposit samples. Since thruster wash and the tether may impact the immediate surroundings of the elevator, sampling should occur at increasing distances from the elevator. In quiescent conditions, a silt cloud may persist around the elevator, which may necessitate bounce dives to collect samples.

7.0 SOME CONSIDERATIONS FOR CONDUCTING ROV OPERATIONS

Daily dive plan: Due to science objectives changing daily based on weather, accomplishments of that days work, etc., it is pertinent to have a meeting the night preceding the next days operation. It is during these meetings that prioritize the objectives, determining amount of time required for each dive, and time required between dives (due to types of samples taken, changing of sampling gear, changing anchor sites, etc.) will be established.

Hours of operation: ROV operations require the full concentration of the operator at all times. In order to maintain ROV operations at peak performance, pilots can perform a maximum of four continuous hours of dive time. Dive operations shall then be terminated or pilots must be rotated. After a one-hour break, the original operator can return for another four-hour period of vehicle operations. ROV operations can be performed during the day or night, but each operator shall be given the opportunity to acquire at least eight hours of continuous sleep per day. Normal work hours for personnel engaged in ROV operations should not exceed twelve hours during any twenty-four hour period.

Travel and set-up time: Travel time is dependent on the port of departure. In most cases one day for travel is required. Set up will require one full day. If only the ROV is needed, one full day may not be needed.

Berthing: Three berthing spaces will be required for the ROV operations personnel. Please discuss gender related issues of berthing assignments with the Center during the cruise planning process.

Night Operations: Night operations can greatly reduce visibility. Visibility will be reduced to the area illuminated by the vehicle lights. This is typically less than 2 m. When operating the ROV at night, deck lights must sufficiently illuminate an area of the deck and alongside the vessel to safely launch and recover the ROV.

8.0 DATA PRODUCTS

At the end of a mission the chief scientist will be given the following data products:

1. **Video tapes:** An original Hi-band 8 mm tape of all the dives will be provided. If a different format (i.e. DVCAM, VHS, 8 mm, 3/4 inch) is required, a request must be made to the Center at

least 3 months before the start of the cruise. Additional tape copies can be made during the cruise but only during time periods when the ROV is not in use. The science party must supply tapes for additional copies. NURC-NA&GL will retain copies of the primary video source tape in its archive.

2. **35 mm Film:** All original films will be given to the Chief Scientist, who is responsible for film development. Be sure all film containers are labeled with film type, whether it is in a cassette or dark bag, and the speed (i.e., ISO) of the film. The ROV crew will provide special instructions depending on film type. Kodachrome 200 Professional is used with the Benthos 3782. The film is wound into another cassette in this camera. Both the original and take-up cassettes are required by most processing laboratories.

3. **Samples:** The science party is responsible for processing all samples after each dive. The science party should bring all equipment required to process, preserve, and store any samples taken during the cruise.

4. **Navigation and sensor data:** A copy of the INS and oceanographic sensor data will be provided consisting of ship date, time, lat, lon, northing, easting,heading and vehicle lat, lon, northing, easting heading depth, as digital (disk) comma delineated lists. NURC-UCAP will retain a disk copy for our archival records.

5. **Cruise Logs:** Copies of the all logs will be given to the scientist at the end of a cruise. Appendix 1 contains copies of standard log forms.

9.0 REPORTING REQUIREMENTS

The Chief Scientist must complete a Mission Summary Form and Quick-Look Report prior to departing from a cruise. Copies of the report formats are contained in Appendix 2.

APPENDIX 1

Standard Cruise Log Forms

NURC-NA&GL OPERATIONS LOG FORM

Project Dive #: System Dive #: Date:

Principal Investigator: ________________ Project Number: ____________________________

Dive System: _______________________ Support Vessel/Platform: ____________________

Dive Location (site/station name): ____

Latitude (e.g. 42 14.7453 N): ____________ Longitude (e.g. 070 42.4573 W): _________________

Dive Start/End: _____ / _____ Total Dive Time (e.g. 2.85 hours): ____________________

Maximum Dive Depth (meters): _________ INS Folder: _______________________________

Bottom Type(s): Mud Sand Gravel Boulders Outcrop Other____________

Pilot: _______________ Scientific Observer(s): ___________________________________

Stills:

35 MM Camera #: _____ Flash #: _____ Roll #: _____ Frame #s: ____________

35 MM Camera #: _____ Flash #: _____ Roll #: _____ Frame #s: ____________

Video Tape Numbers (affix labels here):

Other Sample Types: ____

____

General Observations / Samples Taken: ____

____

____

____

____

____

NURC-NA&GL NITROX SCUBA DIVE LOG (sheet 1)

Date: ______/______/______ Site #: ________________ Page _____ of _____

Location: __________________________ Latitude: ______________ Longitude: _______________ P.I.: ______________________________

Dive Master: ________________________ Support Vessel/Platform: ___________________________ Project Number: _____________________

Bottom Type(s) (circle all that apply): Mud Sand Gravel Boulders Outcrop Other ______________________________

Dive No.	Diver's Name Last, First	Surf. Interv. (hr:min)	Rept. Grp RNT	N_2O_2 %	Planned Depth (ft)	Planned B.T. (min)	$PP0_2$ Cutoff Depth	Acknowledgment	Time Down	Time Up	Actual Depth (ft)	Actual B.T. (min)	Rept. Group Out
								PSI/In Out					
								PSI/In Out					
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Requires completion for each unique date or dive site. Use sheet 2 of the dive log form for documentation of video tapes, still photos, and other dive samples.

NURC-NA&GL NITROX SCUBA DIVE LOG (sheet 2)

Page _____ of _____

Video Tapes: Insert the dive number, as listed on sheet 1, along with each unique video tape number or label. Tapes spanning multiple dives should be recorded separately for each dive.

Dive No.	Video Tape Number or Label	Dive No.	Video Tape Number or Label	Dive No.	Video Tape Number or Label	Dive No.	Video Tape Number or Label

Still Photos: Insert the dive number, as listed on sheet 1, along with the 35mm role number. Documentation of frames (e.g. 1 – 20) is only necessary for roles spanning multiple dives.

Dive No.	35mm Roll #	Frame #s	Dive No.	35mm Roll #	Frame #s	Dive No.	35mm Roll #	Frame #s	Dive No.	35mm Roll #	Frame #s

Other Dive Samples:

Dive No.	Sample Description	Dive No.	Sample Description	Dive No.	Sample Description	Dive No.	Sample Description

APPENDIX 2

Report Forms

Operations Data Reporting Check List

NURC-NA&GL is responsible for maintaining information in a database that is sent to the National Office at the end of each operations year. The reports and accompanying log forms included in this notebook contain fields for information that are collected and maintained in our center's relational database. In an effort to fulfill our data requirements, we have tried to develop intuitive forms that are applicable to both the scientist and NURC's reporting needs. The following checklist describes all items included in the operations notebook and highlights those documents requiring completion to fulfill our data reporting needs.

Post Cruise Reports

_____*1. Quick-Look Report (required)* – This report must be completed at the end of your cruise (preferably before you leave the vessel). Please keep this report in the notebook to be returned to NURC-NA&GL. A digital copy (Microsoft Word 6.0/95 format) can be found at the end of the Dive Logs & Reports section of the notebook.

_____*2. Cruise Assessment Form* - Please fill out this simple evaluation and mail it in the enclosed envelope at the end of your mission.

Log Forms

_____*3. Dive Log Form (required)* – The operations log form provides the necessary structure to fully document each dive of project operations. Please place one copy of all completed forms in the notebook to be returned to NURC-NA&GL.

_____*4. Fix Log Sheet* – Fix log sheets have been provided for use to assist in the documentation of samples or events requiring individual identification. Please store the blue sheets in the notebook to be returned to NURC-NA&GL.

_____*5. Observations and Comments* – The observation and comments NCR forms are provided to aid in the documentation of special events or observations taken during dive operations. Again, please place the blue sheet in the NURC notebook.

Labels

_____*6. Tape Labels* – Every tape used for your mission will have it's own coded label. This code is used in our database to link the video archive with any additional project information. Six copies of each tape label have been provided for use. (1) label for scientist's tape, (2) label for case of scientist's tape, (3) label for NURC-NA&GL archive tape, (4) label for case of archive tape, (5&6) labels for tape documentation on dive log forms.

The information you provide is extremely important to NURC-NA&GL, so please be as accurate and complete as you possibly can. If you have any questions, please call us at (860) 405-9121. Thanks in advance for your cooperation and good luck on your cruise!

QUICK-LOOK REPORT

Inclusive Dates of Operations:

Support Vessel:

Dive System(s):

Number of Dives:

Total Dive Time:

Maximum Working Depth (m):

Project Title:

Principal Investigator:

Co-Principal Investigator:

Preliminary Scientific Results:

Cruise Products (including number of videos, still photos or rolls of film, and summary of other samples collected; e.g. number of box cores):

Safety Problems and Concerns:

Dive System Management (e.g. adequacy of dive system to accomplish tasks):

Logistics and Support Activities (including pre-cruise planning):

Participants, Affiliations, and Roles (note: participants fully documented in the original cruise plan need only be listed by name and role. All other entries must include full participant name, affiliation, address, phone, fax, email and role in operations. Participant roles include Mission Coordinator, Chief Scientist, Other Scientist, Research Technician, Operations Technician, Post-Doctoral Student, Graduate Student, Undergraduate Student, Teacher/School Representative, or Other.):

Cruise Assessment Form

Ship: ____________________

PI/Chief Scientist: ____
PI/Chief Scientist Institution: ____
Project Name: ____
____

1. Length of the cruise, including transit
   ( ) Less than 7 days
   ( ) 7-14 days
   ( ) more than 14 days

2. Did the cruise meet scientific scientific objectives?
   No ( ) ( ) ( ) ( ) ( ) Exceeded objectives

3. How did each of the following impact the success of the cruise?

	greatly harmed -- greatly helped
a) Weather	( ) ( ) ( ) ( ) ( )
b) Precruise planning with ships	( ) ( ) ( ) ( ) ( )
c) Precruise planning with techs	( ) ( ) ( ) ( ) ( )
d) Ship equipment (generators, winches)	( ) ( ) ( ) ( ) ( )
e) Scientific equipment (CTD, computers)	( ) ( ) ( ) ( ) ( )
f) Performance of Captain	( ) ( ) ( ) ( ) ( )
g) Performance of crew	( ) ( ) ( ) ( ) ( )
h) Performance of techs	( ) ( ) ( ) ( ) ( )
i) Precruise coordination of scientific party	( ) ( ) ( ) ( ) ( )
j) Instrumentation brought by scientists	( ) ( ) ( ) ( ) ( )
k) Performance of scientific party	( ) ( ) ( ) ( ) ( )

4. List any safety related problems or concerns:

5. Additional comments: