The University of Michigan

ENVIRONMENT, HEALTH & SAFETY

Safe Diving Practices

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Preface

This manual has been prepared as a guide to safer diving for University of Michigan employees and students. It has been promulgated to fulfill requirements of

- The American Academy of Underwater Sciences
- Department of Labor & Public Health for the State of Michigan
- The University National Ocean Laboratory System

This is not an instructional text for recreational or scientific diving classes or programs. This manual is intended for diving supervisors conducting diving operations under the auspices of the University of Michigan.

This document builds upon the 1991 Manual prepared by Lee Somers, Ph.D.

This manual is available from the Diving Safety Coordinator, Department of Occupational Safety and Environmental Health for the University of Michigan.

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INTRODUCTION

1.1 Purpose

This manual has been prepared as a guide to safe practices for University of Michigan diving operations in order to provide for the health and safety of divers and their support personnel. It is designed to meet the requirements of the

- American Academy of Underwater Sciences,
- the Departments of Public Health and Labor, State of Michigan, and the
- University National Ocean Laboratory System.

Since most University diving is primarily conducted using the scuba mode, this manual will focus on practices and procedures for scuba diving. Supplemental manuals for tethered scuba and surface-supplied diving are available from the Office of the Diving Safety Coordinator.

1.2 Resource Material for University of Michigan Divers

This manual is not an instructional manual. It is designed for use by University authorized and qualified divers and diving supervisors. In addition to this manual the following reference documents are available from the Office of the Diving Safety Coordinator:

- A Standard for Diving Operations issued by the State of Michigan Departments of Public Health and Labor (1979)
- Standards for Scientific Diving Certification and Operation of Scientific Diving Programs by the American Academy of Underwater Sciences (1987)
- The Diver Education Series by Lee Somers is available at Michigan Sea Grant
- Selected articles published by university divers available from the OSEH web site
- Selected Bibliographic materials on specific specialty areas of diving

1.3 Diver Training for University Employees and Students

1.3.1 Basic University Diver Training

At this time, the university does not offer basic scuba training. Divers wishing to dive on university projects must get their basic training off-campus. Once they have completed their basic training, then mission-specific training can be done to bridge the gap between recreational certification and the more stringent requirements of those diving for a scientific diving program. The transition between recreational and scientific diving is facilitated by the university diving safety coordinator.

1.3.2 Advanced and Specialty Training

Training in the use of specialized diving equipment and working under environmental conditions other that open water is contracted on an individual "as needed" basis. University approved instructors are available to provide the following additional training:

- Advanced Scuba Diving

- DAN Oxygen Provider
- Deep Diving (60 - 130 ffw)
- Dry Suit Diving
- Equipment Maintenance
- Oxygen Enriched Diving
- Rescue Diver
- River Diving
- Search & Recovery
- Tethered Scuba Diving
- Underwater Navigation
- Using a DPV
- Using multiple tank configurations

The individual trainee and/or employment unit shall be responsible for all cost associated with training. The costs for the DAN Oxygen Provider class are covered by OSEH.

1.3.3 Persons Trained in Non-University Courses

People trained in courses other than those offered and/or approved by the University of Michigan Diving Control Board shall be subject to evaluation upon application for University of Michigan Diving Authorization. This evaluation shall include, but not necessarily be limited to, the following at the discretion of the Diving Safety Coordinator:

- Written examination
- Water fitness (swimming and physical fitness) evaluation
- Confined water skills evaluation
- Open water evaluation dives

The Diving Safety Coordinator shall recommend that authorization be awarded or denied. The Diving Safety Coordinator may recommend approval with restrictions or additional training requirements.

1.3.4 AAUS Member Institution Divers

Persons who have been trained and authorized for diving by Member Institutions of the American Academy of Underwater Science and who hold current authorizations may, at the discretion of the Diving Safety Coordinator and Diving Control Board, be authorized to diver under University of Michigan auspices without additional training or evaluation. However, all individuals are to receive a program and environmental orientation if they have not previously participated in diving activities controlled by the University of Michigan or in the specific environment.

1.4 University of Michigan Diver Authorization

All persons, whether University of Michigan employees, students, visiting scientist/technicians, or guest of University of Michigan employees diving in conjunction with projects or programs conducted under the auspices of the University of Michigan must be authorized to dive by the University of Michigan Diving Safety Coordinator and Diving

Control Board in accord with the requirements specified in The University of Michigan Occupational Safety and Health Standard for Scientific Diving Operations.

These requirements are summarized by category below:

1.4.1 University of Michigan Employee or Student

In order to receive University of Michigan Diver Authorization an employee or student must demonstrate to the Diving Safety Coordinator completion of the following:

- Be 18 years of age or older
- Submit a copy of all diving related certifications or certificates of training
- Provide a copy of current training in:
  American Red Cross Standard First Aid
  American Red Cross/ American Heart Association CPR (or equivalent)
  (Because of variability, recreational scuba first aid cards are not sufficient)
  Diver's Alert Network (DAN) Oxygen Provider
- Provide a copy of a logbook to demonstrate participation in diving activities
- Provide medical approval to dive from a university approved medical practitioner
- Discuss diving background and goals with the Diving Safety Coordinator
- Complete the following University Forms:
  Application for Active Diving Status
  Release, Waiver, and Indemnity Agreement
  Acknowledgment of Risk
- Complete (at the discretion of the Diving Safety Coordinator)a written examination on diving-related first aid, planning, tables, safety, equipment, and procedures.
- Demonstrate water fitness, diving skills, and rescue skills in a pool (at discretion of the Diving Safety Coordinator)
- Demonstrate ability to plan and execute one or more open water dives under the direction of the Diving Safety Coordinator or a designated representative.

Upon review of documents and evaluation results, the Diving Safety Coordinator will recommend to the Diving Control Board that an authorization be issued or denied. The following limitations/conditions/specialties may apply:

- Depth limit
- Special equipment designations (dry suit, EANx, full-face mask, etc.)
- Environmental considerations (confined water, river, ice, cave, etc.)

1.4.2 Visiting Scientist or Guest Authorization

A temporary Diving Authorization may be issued at the discretion of the Diving Safety Coordinator to authorized visitors or guests. The following conditions/requirements apply:

- Be 18 years of age or older
- Submit a copy of all diving related certifications or certificates of training
- Provide a copy of current training in:
  American Red Cross Standard First Aid

American Red Cross CPR (or equivalent)
(Because of variability, recreational scuba first aid cards are not sufficient)
Diver's Alert Network DAN Oxygen Provider

- Provide a copy of a logbook to demonstrate participation in diving activities
- Discuss diving background and goals with the Diving Safety Coordinator
- Complete the following University Forms
  Application for Active Diving Status
  Release, Waiver, and Indemnity Agreement
  Acknowledgment of Risk
  Medical History
- Demonstrate ability to plan and execute one or more open water dives under the direction of the Diving Safety Coordinator or a designated representative.
- Additional mission-specific evaluation requirements shall be at the discretion of the Diving Safety Coordinator.

Upon review of documents and evaluation results, the Diving Safety Coordinator will recommend to the Diving Control Board that a temporary authorization be issued or denied.

1.4.3 Authorization to Use Personal Diving Equipment

All persons diving under the auspice of the University of Michigan may use personal diving equipment provided that the following conditions have been addressed:

- Equipment is inspected and approved by the Diving Safety Coordinator
- All scuba cylinders have current:
  visual inspection stickers
  valid hydrostatic testing date
- All regulators have been professionally inspected within past 6 months
  (certificate of inspection must include date & regulator serial number)
- Buoyancy control device is operational
  (holds inflation for minimum of 30 minutes)
- Depth gauge accuracy within 3% of full scale at maximum intended use depth

The Diving Safety Coordinator shall include a list of personal equipment to be used along with copies of inspection records in the diver's file.

1.5 Authority and Control of Diving Operations

1.5.1 General

Diving operations conducted under the auspices of the University of Michigan shall be in accord with the University of Michigan Occupational Safety and Environmental Health Standards for Scientific/Educational Diving Operations. University of Michigan auspices applies to any diving activity:

- Conducted from a University of Michigan vessel.
- Conducted with in the scope of a University employee's employment duties.
- Supported by research funds awarded to the University of Michigan.
- Related to University of Michigan research or scholarly activities involving University faculty, staff, or students supervised by University faculty or staff.

- Conducted utilizing equipment that is owned, leased, or controlled by the University of Michigan.
- Conducted on property or in waters owned, leased, or controlled by the University of Michigan.

The Diving Control Board of the University of Michigan has the authority to designate procedures, rules, and regulations governing said diving operations.

1.5.2 Delegating Diving Operation Control to Another Institution

In the event that a University vessel is contracted/designated to service another institution, the University of Michigan Diving Control Board may, by special agreement and approval of it's membership, delegate diving operations control to another institution's Control Board, provided that the visiting institution operates within the accepted standard of the scientific diving community, appoints a qualified cruise diving supervisor, and assumes all responsibility for equipment and other diving support requirements. However, if the home institution of the visiting investigators does not have a Diving Control Board operating in accord with the accepted standard of the scientific community, the University of Michigan Diving Control Board shall assume responsibility for diving operation control

1.5.3 Ultimate Responsibility and Authority in the Field

Ultimately, the Master of the vessel has responsibility for, and authority over, diving operations conducted from the vessel or smaller craft launched from the primary vessel. The Master of the vessel has the right to suspend any diving operation or activity that, in the Master's opinion, places any individual or the vessel at an unacceptable risk. The University Diving Coordinator, Diving Control Board, and/or cruise Diving Supervisor has the authority to suspended diving operations in which it is concluded that the actions of the Master or the crew of the vessel endanger the health and safety of the divers.

1.6 Requirements for Planning Diving Operations

1.6.1 General

The Principle Investigator (PI) shall notify the University of Michigan Diving Safety Coordinator of their intention to conduct diving operations no less than 30 days prior to the planned cruise and provide the following information:

- A list of all diver and support persons to be actively involved in diving operations.
- A detailed description of the diving activity planned including, but not necessarily limited to, dive locations, depths, underwater work to be accomplished, diving mode, special equipment to be used, and special request or requirements.
- A list of all items of diving equipment to be used on this operation.

The University of Michigan Diving Safety Coordinator shall, in turn, review diver qualifications, dive plan, and equipment requirements to assure that:

- All divers are qualified for:
- anticipated depth and environmental conditions
- use of the mission-specific specific equipment.

- The dive plan is realistic and minimizes risk to divers and support persons.

1.6.2 Designated Person-in-Charge

1.6.2.1 Designation and Responsibilities

A Designate Person-in-Charge, hereafter referred to as the Diving Supervisor, will be proposed by the Principal Investigator and approved/appointed by the University of Michigan Diving Safety Coordinator and/or Diving Control Board.

The Diving Supervisor shall:

- Assume responsibility for overseeing the diving operation.
- Be in charge of diving during field operations.
- Assure that all diving equipment to be used on the diving operation (University owned, leased, or personal) is operational and current.
- Brief the Master on details of the diving project (if diving from a vessel).
- Provide the University's Marine Office with a list of diving emergency medical supplies that will be on board. This must include a first aid kit and DAN oxygen unit (or equivalent.)
- Provide a copy of the University of Michigan Occupational Safety and Health Standard for Scientific Diving Operations and The University of Michigan Manual of Safe Diving Practices (for the specific mode of diving being used) are available to the scientist and crew.
- Prepare, with the assistance of the Diving Safety Coordinator, emergency plans that are appropriate for the diving activity, support vessel, and geographic location.

1.6.2.2 Qualification Requirements

The designated person-in-charge (diving supervisor or dive master) is assigned primary responsibility for control of a diving operation in the field. The individual assigned to this duty shall meet the following requirements:

- Meet all requirements for current University Diver Authorization
- Have at least three years of diving experience.
- Have training and experience necessary to safely conduct the diving operation.
- Qualified for the depth and environmental conditions of the dive site
- Qualified in the use of all diving-related equipment required for a given operation.
- Has demonstrated by past performance that he/she is knowledgeable of diving safety requirements and the University's diving program.
- Has demonstrated by past performance that he/she will uphold the University's Occupational Safety and Health Standard for Scientific Diving Operations.
- Has demonstrated by past performance leadership ability.
- Shall be approved by the Diving Safety Coordinator.

- The project's chief scientist or director may not serve designated person-in-change unless he/she has meant all of the above requirements. Since past experience in academic diving operations has shown that desire to meet scientific objectives has often taken precedence over personnel safety, the designated person-in-charge for diving should not, if at all possible, be the chief scientist or project director.

1.6.2.3 Trip Dive Plan Responsibility

The designated person-in-charge of diving shall meet with the chief scientist or projector and prepare a dive plan which must be filed with the Diving Safety Coordinator at least 5 working days prior to leaving campus. The dive plan shall include the following:

- Anticipated date(s) of dive(s).
- Location of dive(s).
- Anticipated diving depth(s) and environmental conditions.
- Diving activity
- Mode of diving (breath-hold, scuba, tethered scuba, or surface-supplied), breathing gas (air, nitrox, or other) and special equipment to be used (transit lines, life bags, underwater cutting devices, etc).
- Names of divers and surface support personnel
- Anticipated hazards and special precautions, procedures, or equipment to be used to minimize risk to divers and support personnel.
- Location of nearest medical services (clinic, hospital, ambulance).
- Means of calling for assistance from dive location
- Special generalized dive plans may be submitted for field projects which require persons to be away from campus for extended periods of time and/or involving diving activities that may not be completely identifiable in advance.

The Diving Safety Coordinator shall review this plan with the project director and designated person-in-charge of diving. Significant changes in the dive plan may be addressed by telephone, radio, e-mail, and/or FAX communication. The greatest concern is with changes in diving personnel or the designated person-in-charge of diving. The Diving Safety Coordinator must approve these changes.

1.6.3 Required Safety and Support Equipment for Diving Operations

The designated person-in-charge is responsible for assuring that the following items are available at the dive location for all scuba diving operations:

- First aid kit and American Red Cross Standard First Aid Manual.
- DAN Oxygen system (or equivalent) with a minutes minimum gas supply
- Approved dive tables.
- Dive Operations Record Forms.
- The University of Michigan Manual of Safe Diving Practices.
- The First Responder and/or The DAN Emergency Handbook.
- Marker float with line and weight.
- Search line.
- Surface rescue line.
- Personal flotation devices (or persons tending and supporting divers)
- Other equipment and support materials designated by the Diving Safety Coordinator for specific diving operations.

1.7 Planning Cruises Involving Diving Operations

1.7.1 University of Michigan Scientists and Divers

The Principle Investigator (PI) shall notify the Diving Safety Coordinator of their intention to conduct diving operations utilizing University of Michigan vessels no less than 30 days prior to the planned cruise and provide the following information:

- A list of all diver and support persons to be actively involved in diving operations.
- A detailed description of the diving activity planned including, but not necessarily limited to, dive locations, depths, underwater work to be accomplished, diving mode, special equipment to be used, and any special requests for personal or diving platform requirements.

1.7.2 Visiting Scientists and Other Users of UM Vessels

The Principal Investigator (PI) shall supply the Diving Control Boards of the University of Michigan and their institution with the following no less that 30 days prior to the cruise:

- Verification of approved diving credentials for all divers
- The name and credentials of the proposed diving supervisor
- A copy of the institution's Diving Standards.
- The name, address, e-mail address, and telephone number of the institution's Diving Officer and/or Diving Control Board Chairperson.
- A detailed description of the planned diving activity including, but not necessarily limited to, dive locations, depths, underwater work, diving mode, special equipment to be used, and any requests to the University of Michigan such as mooring requirements, etc.

The University of Michigan Diving Safety Coordinator or designated lead of the Diving Control Board shall, in turn, supply the University of Michigan Marine Office with a summary of the dive operation plans and requirements.

1.7.3 Cruise Diving Supervisor

A Diving Supervisor will be proposed by the Principal Investigator and approved by the Diving Control Board and will assume responsibility for overseeing the diving operation. The Diving Safety Officer shall:

- Be in charge of diving during the cruise.
- Brief the Master on details of diving planned.
- Inform the University's Marine Office of what diving emergency medical supplies shall be on board. Under UNOLS requirements these are to be supplied by the University of Michigan and verified by the Diving Supervisor.
- Assure that both the University of Michigan and visiting institutions Diving Standards Manuals are on board and available to the scientist and crew.
- Prepare, with the assistance of the controlling institution's Diving Officer, emergency plans that are acceptable to the University of Michigan's Marine Office.

1.7.4 High-Pressure Cylinders and Air Compressors

Prior to the cruise the controlling Diving Control Board and the University of Michigan Marine Office shall receive verification/certification that all high pressure cylinders to be placed onboard the vessel are within hydrostatic test date and internally inspected within the past 12 months (of the end of the cruise date). All cylinders shall be secured aboard the vessel in a secure and appropriate manner.

Prior to the cruise, certification of the air quality of all breathing compressors shall be supplied to the controlling Diving Control Board. All compressors shall be installed and operated in accordance with manufacturers specifications. Compressors should meet the minimum standards designated by the American Academy of Underwater Sciences.

Chapter 2

PLANNING SCUBA DIVING OPERATIONS

2.1 Selecting the Proper Mode of Diving

The key to diving safety is careful and detailed planning and preparation. First, all aspects of the diving operation must be evaluated to determine if conventional scuba diving techniques are acceptable or if tethered scuba or surface-supplied diving technique should be used. Open circuit, demand type scuba is the simplest and most frequently used type of diving apparatus employed by the modern scientific diver. The apparatus does have certain advantages and limitations that must be taken into consideration when planning diving operations. Open-circuit has the following advantages:

- Underwater mobility
- Portability
- Adaptability to small boat operations (requires minimum support equipment)
- Readily available training for civilian divers
- Relatively low cost
- Maintenance generally available

- On the other hand, open-circuit scuba has a number of limitations or disadvantages:

- Limited depth;
- Limited dive duration (air supply);
- Limited to low or moderate exertion level diving;
- Inefficient utilization of gas supply;
- Inefficient utilization of personnel (2 divers are required for safety)
- Limited communication capability
- Limited to self-contained thermal protection systems
- Relatively unsafe for limited visibility diving conditions

Environmental conditions that may prove to be unfavorable for self-contained diving include:

- Extremely poor underwater visibility
- Strong currents (at sites where divers must maintain position on the bottom)
- Exceptionally cold water:
- Ice cover
- Contaminated water

Self-contained diving is also somewhat limiting in operations requiring heavy underwater work. Under the above conditions, surface-supplied diving is considered more desirable. In addition the self-contained diver should avoid dives requiring decompression: surface supplied diving is preferable for decompression dives.

Dive planning and procedures, especially risk management considerations are topics that are frequently ignored in sport diving manuals. Since risk management is a critical element in proper dive planning, this topic will require additional discussion with new-to-scientific-diving personnel. Since diving operations must be conducted at the highest possible level of efficiency and safety, it is necessary that all personnel have a know ledge of a standard operational procedure.

2.2 Preliminary Dive Planning

2.2.1 Overview

Preliminary planning is vital for the success of any diving operation. Without adequate Preparation, the entire diving operation may fail and; even more seriously, the safety and well-being of the divers may be jeopardized. The diver must be placed in water under optimum conditions, including sufficient knowledge of the dive plan with the appropriate level of training, experience, and equipment to successfully fulfill the requirements for the diving operation. Surface support must be capable and well organized. The diving team and ship's crew must be available and capable of rendering all possible assistance. A Diving Supervisor's Checklist is included in the appendices of the handbook.

The preliminary planning phase of a diving operation is divided into the following steps:

- Survey of activity or task:
- Evaluation of environmental conditions:
- Selection of diving techniques:
- Selection of diver teams and assignment of task:
- Selection of equipment:
- Fulfillment of safety precautions and emergency assistance plan
- Establishment of procedures and briefing of all personnel

2.2.2 Survey of Activity or Task

The first step in planning a diving operation is to assess the activity or task and to formulate a general approach. In a working dive, it must be determined if the job is feasible and if proper equipment and personnel are available to undertake the job. All factors that might constitute a specific hazard must be noted.

2.2.3 Evaluation of Environmental Conditions

2.2.3.1 General

Diver safety, especially for self-contained divers, is influenced considerably by environmental conditions. Careful consideration must be give to both surface and underwater conditions and appropriate arrangements made for diving under these conditions. Surface conditions to be considered include sea state, weather (present and predicted), tides, currents, ship traffic, etc. Underwater conditions include depth, bottom type or condition, visibility, and temperature.

A physically fit, properly trained, and experienced diver can dive safety under most environmental conditions. However, being in top physical shape is not an excuse for using poor judgment in selecting and evaluating dive sites. A Diving Supervisor will exercise considerable common sense and judgment in selecting dive sites and evaluating environmental conditions so as to minimize risks to divers. A Diving Supervisor will never hesitate to cancel or abort a dive that in their opinion involves unacceptable risks to the safety of the divers. Prior to committing to a dive a the Diving Supervisor shall determine the following:

- Are the environmental conditions acceptable for scuba diving?
- Do I have training, experience, and equipment to dive safely under these conditions?
- Do the other divers in this group and/or my dive buddy have the necessary training, experience, and equipment to dive safely under these conditions?
- Are there specific environments that constitute significant risks?
- Are the anticipated rewards worth the potential risks associated with diving in this environment and under these conditions?
- Am I qualified to make this dive?

Some of the answers to the above questions are objective; others are subjective. A Diver Elite will often have to make decisions based on observations, discussions, and prior knowledge. However, in some situations such as assessment by unfamiliar divers, the opinions may be truly subjective "gut" opinions. In the final analysis, all divers must accept full responsibility for their decisions and actions. Furthermore, divers must never place themselves in a situation that may, in turn, place others at risk either through encouraging an unqualified person to make a specific dive or by "getting into trouble" and requiring others to assist.

Unfortunately, environmental factors and our personal response to those factors are often addressed only casually in dive planning and preparation. Keep in mind that decisions relative to diving or not diving, entry/exit locations and techniques, navigation techniques, general diving procedures, equipment, and safety depend on the diver's ability to properly assess and understand environmental conditions. The following environmental factors are identified with brief comments on items that should be considered by every diver:

2.2.3.2 Sun

Many divers travel to the tropics with visions of returning home with a golden-brown tan. The prudent diver will take measures minimize exposure to sun and prevent sunburn. Sunburn can result in extreme discomfort, serious injury to the skin, and, in extreme cases, require hospitalization. Wear a wide-brim hat or a desert hat fitted with a neck cover, long sleeved shirts, and long pants to fully protect the skin. If wearing clothing that exposes skin, use a high SF factor sun block lotion. Keep in mind that tops of exposed feet can burn in minutes. Take advantage of shaded beach and boat areas. Surface-swimmers (skin divers or snorkelers) should wear full neoprene or nylon body suits. Furthermore, the possibility of heat exhaustion and sunstroke can not be dismissed under extreme circumstances. A suited diver exposed to intense pre-dive sun may experience significantly elevated temperature inside the suit (possibly exceeding 120 ^{0}F) and subsequent hyperthermia. If long surface exposure in hot sun is anticipated or arises, divers should cool themselves by injecting water into the wet suit, wrapping their head in a wet towel, and seeking shade. Do not hesitate to abort the dive, remove the diving suit, and cool the overheated body.

Keep in mind that overheating can also lead to severe dehydration. Dehydration may very well be the major predisposing factor in the development of decompression sickness in tropical divers.

2.2.3.3 Cold

A cold diver is a compromised diver. The Diving Supervisor must assess both atmospheric and water temperatures as well as wind chill factors to determine if the diver's thermal protection is satisfactory and if the dive can be made within the realm of acceptable risk. Keep in mind that cold stress rapidly leads to degradation in both physical and mental performance. In addition to reduction in manual dexterity, touch sensation, coordination, and muscular strength, the diver many experience mental confusion, slowing of thought and reasoning processes, and forgetfulness. A cold diver often exercises poor judgment. Do not deploy if divers or support personnel are already compromised by atmospheric temperatures. A cold environment dive plan includes consideration of surface clothing, transportation to the dive site, protected dressing facilities, and post-dive re-warming. Be alert for signs of frostbite and hypothermia in surface personnel. If a diver becomes exceptionally cold during a dive they must adhere to a more conservative dive schedule (add 10 feet to the actual depth for purposes of reading dive tables) and terminate the dive as soon as possible. Thermal discomfort and shivering are good indicators for termination. Uncontrolled shivering indicates a seriously compromised diver.

2.2.3.4 Ice Cover

Diving under ice is particularly hazardous and should only be undertaken when absolutely necessary. The diver is subjected to severe cold stress, emergency procedures are complicated, and the scuba may be adversely affected by severe cold. All University divers intending to work under ice cover must be specifically trained in an approved ice diving training course and authorized for ice diving by the Diving Control Board. In addition to previously discussed procedures, the following should be considered when working under ice:

- Use ample protective clothing
- Do not commit a chilled diver to an under-ice mission
- Always have a standby diver ready to enter the water immediately.
- Cut a hole large enough to accommodate 2 or 3 divers even though one diver is under the ice at a time. (Be sure to mark the hole clearly following ice diving to warn fisherman and snowmobile riders of the hazardous opening.)
- Limit dive duration and provide sufficient facilities for immediate warming.
- Never rely on a compass; the safety line is the only way to navigate back to the hole.
- The safety line must be secured to the diver using a locking carabineer.
- A trained tender must handle the safety line or umbilical hose.
- Secure the line to a fixed object on the surface.
- Avoid long (both time and distance) excursions under the ice.
- If it is necessary to cover large areas when under the ice, cut several holes and make a series of dives.

- Avoid having more than one scuba team in the water at a time
- Divers must have considerable open-water experience and special training prior to diving under the ice
- Carry an auxiliary breathing unit
- Do not inhale from regulators above water

Detailed information on cold water and under ice diving is included in The Cold Water Diver's Handbook.

2.2.3.5 Waves, Surf, and Currents

The Diving Supervisor must consider wave, surf, and current conditions when selecting a dive site. Entering and exiting the water on a surf beach requires special planning, specific site selection, and coordination of movements with breaking waves. The size of breaking waves is influenced by the near shore topography (steep, gentle, canyon, etc.), shoreline configuration (point of land, straight beach, or cove), and beach exposure. Ideally, a diver should select a location with minimal surf. In addition, entry technique will be will depend on the type of shoreline - rocky or sandy beach. The diver must then observe breaking wave patterns to determine the time of least wave activity.
Rip currents must be identified and the diver must determine if the current will useful in facilitating movement to an offshore location or if the current constitutes a hazard that must be avoided. Rip and long shore current patterns must be analyzed in planning the entry point, swimming course, and exit point(s). Generally, a diver will select primary and secondary exits points.

Generally, rough seas can be expected during storms and high winds. Weather forecasts must be reviewed to determine if proper weather conditions will last for a sufficient amount of time to complete the mission. Critical weather changes and a wind shift can jeopardize safety of personnel and vessels. Conditions must be such that adequate mooring may be maintained for the duration of the operation. Do not attempt self-contained or surface supplied diving in rough seas (Sea State 4: 5 to 8 ft waves; 1.5 to 2.4 meters), and when possible, avoid or limit diving in moderate seas (Sea State 3: 3 to 5 ft waves; .9 to 1.5 meters). Naturally, sea-state limitations will be dependent to a large degree on the type and size of diving vessel.

When diving from a boat, divers must evaluate wave conditions in order to properly deploy the anchor. Under severe wave conditions, it is often wise to abort the dive rather than risking damage to vessels or personnel injury. If the anchor line breaks or the anchor drags, the divers safety could be seriously compromised. Ideally, a boat operator always remains with the boat. Diving operations may be more safely conducted in rougher seas from properly moored larger vessels or fixed structures.

Current and tidal conditions must be considered before commencing with diving operations. Current direction and magnitude are important considerations when mooring a diving vessel. When diving in a current one must determine if the divers can move against the current (from an anchored boat) or if it is more appropriate to drift with the current (with a buoy) and have the boat follow at a safe distance. Anchored vessels are generally rigged with trail and lead lines in current. When diving in current divers should carry appropriate signal devices such as inflatable markers and smoke flares.

When currents exceed 1 knot, self-contained diving operations from anchored vessels should be avoided unless absolutely necessary and adequate provisions are made for diver control and safety. If divers are deployed from an anchored vessel or fixed structure, a pickup or safety boat is a more desirable factor. Drift diving techniques are more appropriate for higher speed current situations. Divers are deployed to drift with the current. Surface personnel track divers via a large brightly colored surface float carried by the lead diver. Upon completion of the dive the divers surface beside the float and are picked up by the boat.

Tidal currents may prohibit diving at some locations except during periods of tidal current direction change. Consult tide tables when necessary and determine magnitude of tidal currents prior to diving.

2.2.3.6 Underwater Visibility

Generally, the most pleasurable diving is in areas of good underwater visibility. Unfortunately, some geographic locations offer only limited visibility water throughout most of the year. The diver must first determine if the underwater visibility is sufficient enough for a safe and enjoyable diving experience. In some cases it is best to simply not dive rather than swim aimlessly in water where visibility is only a few inches or feet. Divers electing to dive in limited visibility water must be skilled navigators (compass swimming).

Underwater visibility depends in time of day, locality, water conditions, season, bottom type, weather, and currents. Dark or murky water is a disadvantage in all underwater operations. Self-contained diving should be avoided under zero to limited visibility conditions when possible and a tethered scuba or surface-supplied diver used.

Self-contained divers are at a considerable disadvantage especially if decompression is required. In addition to a descent (shot) line, a distance line carried on a reel is required. This enables the divers to return to the shot line for controlled ascent. Short distance lines are also desirable for surface-supplied divers in limited visibility. An alternate method of controlling ascent and decompression is by the use of an inflatable float with a line marked at 10 ft (3 m) intervals below the float and which is twice as long as the diving depth. At the end of the dive, the diver releases the float and secures the line to an object on the bottom with a releasable knot. He may then ascend to the appropriate decompression level, unreeling the remaining line below him. When the diver surfaces, the diver simply tugs on the free end of the line to release the knot and to retrieve the line. This technique is not recommended for diving in currents or high wave activity. Caution must be observed to avoid becoming tangled in the line. Do not leave lines and floats attached to submerged structures. Self-contained divers should avoid decompression dives

Self-contained divers must establish a procedure for reunion of separated divers. Generally, if separated, the best procedure for separation is to surface or return to a predetermined bottom location (“rally spot”). Striking the scuba cylinder with a rock or knife has only limited value in reuniting separated divers. The use of a buddy line or common float line is encouraged.

2.2.3.7 Night

Novice scuba divers are discouraged from participating in open ocean/lake night dives. Only through considerable daytime diving experience can the diver gain the necessary ability to maintain underwater orientation. It is vital for the diver to return to a designated point.

Orientation underwater and on the surface must be considered. Diving at night in areas of high current and/or wave activity and limited surface or underwater visibility presents added risks that may be quite unacceptable and diving operations should be suspended.

Diving at night is a popular activity among recreational divers, especially in clear tropical waters. With proper environmental assessment, planning, and diving procedures diving at night can be quite pleasurable and safe. Ideally, night dives should be planned and executed at locations offering calm water conditions and good underwater visibility. Divers should be familiar with the location from previous daytime diving. Ideally, the boat should be securely anchored and divers deployed just before dark. Each diver should carry a primary and a secondary light as well as a signaling device (strobe or flare). The boat or staging area must be properly lit for easy identification and the diver activity radius should be limited (depending on location, diver experience, environmental conditions, etc.).

Night diving sites must be considered on an individual basis and the dives planned accordingly. Dives may be conducted from both boats and shore stations. The following is a list of considerations that the supervisor and diver should take into account when planning and executing a night dive:

- Do not dive at an unfamiliar site. Daytime underwater reconnaissance is necessary to gain familiarity with the local underwater terrain. Such familiarity is vital to maintaining night-time orientation.
- Prepare and study sketch maps of the dive site.
- Be certain to avoid ship traffic routes.
- A diver is difficult to spot on the surface at night, especially if his light has failed. If it is necessary to anchor and work at night in a ship's channel, use a large vessel, display proper night anchoring and work signals, and execute radio security calls to warn ship traffic. When possible, surface-supplied divers should be used instead of scuba divers
- Any boat, whether large or small, must be securely moored. This is especially significant when working near reefs and in even slight currents. If the mooring breaks, the boat could drift a considerable distance before the divers surface. The vessel could be destroyed if it drifts onto a reef.
- Anchor precisely over the underwater site and work as close to the boat as possible
- Long underwater swims are both unsafe and unnecessary at night
- Use a weighted descent line with a large light colored, reflective marker or light suspended several feet above the bottom
- Secure an underwater light pointing downward several feet below the surface on the descent line. Some divers use flashing strobe lights: however, a constant light is a better reference point than a flashing light
- The divers should descend and ascend on the line and use the light and bottom marker as the primary orientation point
- Unless the underwater task requires that the divers move some distance from the boat, work close to the descent line with the operational range determined by the distance at which the underwater marker light is visible
- The surface vessel should never be left unattended. At least one person must be assigned as surface tender/boat operator. This person must have a high intensity light and a whistle or loud-hailer. In the event that divers become disoriented and surface away from the boat, the

surface tender can direct them back to the boat with both light and noise signals. Ideally, there should be a standby diver and a boat operator stationed in the surface craft

- A prominently displayed white anchor light should be used as both a warning to other vessels and an orientation point if divers accidentally surface away from the boat
- Avoid night scuba dives when surface visibility is limited
- Each diver must be equipped with at least one underwater light and a compass.
- Divers should also carry a compact light as a spare.
- Special effort may be required to maintain the buddy system
- In cold weather or when diving in cold water, surface personnel in small boats should wear a protective type diver's suit (wet or dry suit) or have a cold water survival suit available.

2.2.3.8 Atmospheric Conditions

A Navy SEAL may take advantage of adverse weather conditions to conduct a clandestine operation. However, the Scientific Diver is seldom called on for clandestine activities. Cold environmental factor have already been addressed. Free swimming scuba divers must consider limitation of surface visibility associate with fog, snow, and rain. Significant visibility limitations are a basis for delaying or canceling a dive. The use of tethered scuba diving techniques are more appropriate under low visibility conditions.

Some geographic regions experience rapidly developing storm and fog conditions. The diver must be completely familiar with local climates and take such factor in consideration. Underwater orientation and good navigation practices are major factors in returning to a boat or predetermined shore position at the end of a dive.

The selection of diving dress and equipment will depend on the activity, weather conditions, and type of vessel. For example, even though water temperatures may permit the use of wet-type suits, cold air temperatures and wind would dictate a variable-volume dry suit (or equivalent) when diving from an open or unheated vessel.

2.2.3.9 Toxic Environments

There is absolutely no reason for a diver to be intentionally exposed to a recognized toxic chemical or biological hazard. Since. unfortunately, an increasing number of potential dive sites are reaching levels of unacceptable toxic risks, divers need to be aware of local risk areas. The traveling diver will consult with divers and authorities in unfamiliar areas to determine locations that should be avoided. In the event that a diver must enter a toxic or polluted environment, special equipment and operational procedures are currently available that affords complete diver protection.

2.2.3.10 Depth

Deep diving is not a means of proving superior skill; it merely suggests just those who routinely dive to deep depths are willing to accept higher levels of risks. Depth limits depend on training, experience, equipment, and environment.

2.2.3.11 Ship Traffic

Ship traffic may constitute a hazard to divers, particularly self-contained divers. It is necessary to display proper visual signals in a prominent location on the diving vessel during operations in order to notify approaching vessels that divers are in the water. The following signals are appropriate:

- U.S. Diver's Flag: This is a red flag 4 units wide by 5 units long with a one-unit wide white diagonal from the upper-left to lower-right corners. Sizes are not standardized and will vary with the size of the vessel.
- United Nations Maritime Group International Divers Flag: The single-letter signal "A" or alfa flag (blue and white) is recommended for international waters and is currently used by the U.S. Navy and the major nations of the world. The proper interpretation of this flag is that the vessel (not divers towing a float) flying the flag (in international, not local, waters) is engaged in underwater operations and, as such, is restricted in its ability to move.
- International Code of Signals: The two-letter signal "HD" has the meaning, "I am engaged in submarine survey; please keep clear."
- Underwater Task Shapes: A "red ball - white diamond - red ball" shape vertically displayed spaced 6 ft (1.8 meters) apart may denote diving operations.

Self-contained divers must tow a float on which a diver's flag is displayed or be accompanied by a chase boat with a diver's flag if they operate out of the immediate vicinity of the support vessel. The flag must be 3 ft (0.9 meters) above the water. Divers must consult local authorities for regulations on diver's flags since these regulations are designated on a state-by-state basis. In Michigan waters, divers must remain within 100 feet of the diver’s flag and vessels must stay at least 200 feet away from the displayed flag. However, this flag does not give “right-of-way” to divers if displayed in commercial shipping channels.

2.2.3.12 Type of Bottom

The type of bottom affects the diver's ability to work and is a factor in determining visibility. Consequently, this must be considered in the preliminary dive plan and certain precautionary measures may be necessary to ensure the diver's safety and efficiency. Mud (silt and clay) bottoms are generally the most restrictive for divers. The slightest movement will stir sediment into suspension and restrict the diver's visibility. The diver must orient himself so that the current, if any, will carry the suspended sediment away from the work area. In severely restricted visibility, a “distance line” (line connected to an anchor … either on the bottom or from a support vessel) is highly recommended. Since the self-contained diver is more hampered by the limited visibility, surface-supplied diving techniques should be considered for this activity. For general survey work, self-contained diving techniques have the advantage of the diver hovering at a survey depth above the bottom and swimming with minimal disturbance of the bottom.

Sand bottoms present little problem for divers. Visibility restrictions from suspended sediment are less and footing is firm. In marine areas the diver must be alert for sting rays in the sand.

Coral reefs are solid with many sharp protrusions. The diver should wear gloves and coveralls or a wet suit for protection if the mission requires considerable contact with the coral.

Proper buoyancy control is extremely important. Survey divers and photographers have to be cautious to avoid injury. Learn to identify and avoid corals and any marine organisms that might inflict injury.

2.2.4 Selection of Diving Techniques

The proper diving technique, scuba or surface-supplied, is based on the activity requirements, environmental conditions, and available personnel. It is the responsibility of the diving supervisor and divers to review the situation and determine which technique to use. The advantages and limitations of various techniques have been summarized previously.

2.2.5 Selection of Divers and Assignment of Jobs

The diver must be qualified and designated in accordance with the depth, equipment and environmental rating required for the activity or underwater task. The diving supervisor is responsible for determining the qualifications of a diver before assigning him to an activity. In addition to the diver, the diving supervisor must designate qualified tenders or aides, timers, and stand-by divers.

2.2.6 Selection of Equipment

The diving supervisor and divers will determine whether to use scuba, tethered scuba, or surface-supplied diving equipment for a particular activity based on a review of the activity requirements, personnel available, and environmental conditions. The diver must be outfitted with the proper equipment to complete the activity or task assigned. When selecting equipment, the diver should not overburdened with unnecessary equipment. Use only the equipment required for safety and completion of the activity or task. When the diver is encumbered with excess equipment, the possibility of entanglement and fatigue increases.

2.2.6.1 Individual Diver Equipment

A scuba diver shall have the following items of equipment appropriate for the environment(s) of their choice:

- Mask, fins, snorkel, foot protection, knife, weight belt, swimsuit, and personal flotation device (PFD)
- Complete scuba including primary regulator, secondary breathing unit, pressure gauge, buoyancy control device with inflator, cylinder(s), and backpack (may be integral with BCD)
- Timer, depth gauge, and compass (may be integrated console unit or dive computer)
- Compass board (for operations requiring extensive underwater navigation)
- Environmental protection garment appropriate for the designated geographic region
- Underwater lights (primary and secondary)
- Emergency signal devices including whistle (“storm whistle” preferred) and smoke flare for daytime diving and flare and strobe light for night activities. For those diving with full-face masks, an air-driven (hooks into b.c. hose) horn is preferred since this can be activated without removing the full-face mask.

- Waterproof decompression tables (to be carried by at least one member of buddy team for all scuba dives: generally carried in BCD pocket: a slate with appropriate dive schedule data is an acceptable substitute)
- Slate/pencil (small slate and attached pencil in BCD pocket: larger slate or clipboard system if extensive data recording)
- Surface float/diver's flag (required in navigable waters: include tow line and line reel or retainer: float anchoring device optional: minimum 14 x 16 inch flag elevated three feet above water)
- Buddy line (for limited visibility diving)
- Tool and spare parts kit (mask strap, fin strap, CO2 cylinders (2), port plugs for regulators, bulbs and batteries for underwater light, "0" rings (4), adjustable wrench (6iflCh), Allen wrench, extra pencils)
- Equipment bags/containers appropriate for air transport and field operations ("Action Packers" make superb alternatives to a traditional dive bag)
- Other items of equipment including photographic equipment, special lights, special surface floats, underwater propulsion devices, signal flares, coral/beach shoes, lines, pry tools, collecting equipment/containers, thermometers, and so on will depend upon the underwater task, diving conditions, and diving procedures.
- All divers must have adequate equipment containers or bags to transport and stow equipment. Also, include a hanger for drying wet suits.

All equipment is subject to the approval of the Diving Safety Coordinator. The equipment must be in satisfactory operating condition and not show evidence of abuse or neglect.

Each diver must provide a personal swim suit, towel(s), and adequate protective clothing to wear on the surface. In tropical areas this will include lightweight sun blocking garments: deck, beach, or coral shoes: and a hat. In colder climates this will include wool, down, or fiber filled garments, wind/rain protection outer clothes, gloves, and cold weather boots. Divers are also expected to have in their possession, at or near the dive location, a certificate of scuba diver training (C-card): a copy of their most recent medical diver exanimation results: a personal log/record book: and an information card specifying medications currently being taken, medication allergies, and relative(s) to contact in the event of an emergency.

2.2.6.2 Team Equipment

The diving supervisor or other designated person is responsible for providing dive team equipment. Naturally, the team equipment requirements will depend upon the dive location, environmental condition, underwater task, and diving technique/procedures. The following items are considered as minimum for all organized diving operations:

- First aid kit approved for diving (OSHA requires approval by a physician)
- DAN oxygen unit (30 minute minimum supply) or equivalent
- First aid manual (OSHA requirement)
- Diving manuals/handbooks
- Decompression/repetitive dive tables
- Dive record sheets/repetitive dive worksheets
- Emergency information and procedures sheet (Emergency Action Plan)

- Pencils/pens/note paper
- Clipboard (Posse Box)
- Cylinder "0" rings
- Cylinder pressure gauge
- Wet/Dry suit repair kit
- Stopwatch or watch for dive timing
- Whistle and/or other appropriate audio signaling equipment
- Lights (for use at surface during night operations; include extra bulbs and batteries)
- Communications unit (if no ship or land communications system is available at dive location; CB radio may be used; OSHA requirement)

The Diving Supervisor may also wish to include a stretcher/backboard and a blanket. All items should be stowed in substantial weatherproof containers and be available at the dive location for routine emergency use. The Diving Supervisor may also include a Carbon Monoxide Test Kit.

2.2.7 Fulfillment of Safety Precautions

All personnel associated with the diving operation are responsible for maintaining proper safety standards. Ultimately, the diving supervisor (or team leader) must assume responsibility for the safety of the divers. He must evaluate each and every aspect of the operation. Safety must be considered in all aspects of preliminary planning. Divers must not be committed to a task or activity which is unreasonably hazardous or for which they are not sufficiently trained or equipped. In evaluating environmental conditions and the dive site, the diving supervisor must train himself to anticipate potential hazards and take appropriate measures to protect the divers from these conditions. Naturally, all hazards cannot be eliminated from any diving operation; however, they can be minimized. If a particular hazard is foreseeable, it can usually be eliminated. The diving supervisor may wish to prepare a list of potential hazards, including precautionary measures to use when setting up the operation and briefing the personnel.

The diving supervisor must verify that there are appropriate emergency first aid supplies (including oxygen inhalation equipment) available. He must establish an emergency protocol for diver and/or aid injuries that includes emergency transportation, communications, medical attention (personnel and source), and recompression facilities (location and availability).

2.2.8 Establish Procedures and Brief Personnel

The diving supervisor, dive master, or team leader, after careful evaluation of the above factors, will establish the operational procedure and brief all personnel. The procedure and briefing should include:

- Objectives and scope of the operation
- Conditions in the diving area
- Dive plans and schedules
- Assignment of personnel: buddy teams, divers, aides, tenders
- Assignment of specific tasks for each team member
- Safety precautions and any special considerations

2.3 The Underwater Team

A scuba diving underwater team must consist of no less than two divers and a surface support person. Diving alone should not be permitted, and all team members must hold a valid diving certificate. A leader will be designated for each diving team prior to entering the water, and it will be the responsibility of the other divers to stay in visual or physical contact with the leader. If a diver becomes separated, he should promptly surface or return to a previously designated location.

The maximum size of a diving team depends on the diving activity and environmental conditions. Generally, two-person teams are more desirable in poor visibility waters. More than two divers seem to become easily separated. (Studies of fatalities in Ontario suggest that diving in open water with threesomes is particularly hazardous … it is often been described in Corner's Inquests as a proximate cause of recreational diver deaths.)

For specialized activities such as cave diving, many persons prefer to use three to five person teams. It is assumed that two divers can better handle a third victim diver in an emergency situation. Large teams of four to ten divers can work under good visibility conditions.

The diving supervisor will stipulate the dive area boundaries or require that all members of the team stay within visibility range of a given central bottom feature, descent line (with a highly visible submerged marker) or lead person (designated by a specific feature such as a special color cylinder, a colored hood, etc.). Under these conditions the large team generally subdivides into two-person swimming groups. For underwater tours, a guide system has proven quite successful. Ideally, this system utilizes a team leader and an assistant. The leader (or assistant) enters the water first followed immediately by various team members. The assistant (or leader) enters last. The team assembles on the bottom at the anchor or shot line and the leader then leads the diving team or party on an underwater swim. The assistant (and one other team member) swims at the end of the line of divers to keep them from dispersing or falling behind. The team maintains a close but comfortable spacing between divers. In this case, the buddy pairing of divers mayor may not be required.

Any person in the team may respond to the needs of another member. However, generally the leader or the assistant is the focus for emergency assistance. These persons are generally the most skilled and are to be equipped with auxiliary breathing equipment. The leader judges the dive/air supply duration and makes every effort to return the team to the starting point (under the boat) before any member has depleted the air supply. As the members deplete their air supply, they are escorted to the surface by the assistant or sent to the surface in buddy pairs. Water conditions must be such that the leader and assistant can maintain good visual contact. This technique works well in clear tropical waters; however, its use is discouraged in poor visibility water.

A diving supervisor will be designated for each diving operation. Diving supervisor qualifications and responsibilities are in accordance with those previously described.

A scuba diver's aide or tender must also be used on scuba diving operations. The support person must be qualified to independently aid divers and operate all surface-support equipment. From a standpoint of efficient human resource utilization, the aide may be a qualified diver and used in a diver-aide rotation system. Although there is no specific requirement that the aide must be a qualified diver, the support person must have a working knowledge of diving equipment, procedures, first aid, and safety. The support person must hold current certification in ARC Standard First Aid/CPR (or equivalent).

Frequently, scuba diving operations will involve only two divers and a surface crewman. It is unwise to conduct any operation without at least one person remaining on the surface to aid divers before and after the dive and to tend the surface vessel.

2.4 Preparation Prior to Diving Trip

In preparing for any diving project or trip it is necessary to complete certain portions of the dive plan and equipment inspection before leaving for the dive location. Generally, the Diving Supervisor will prepare a specific checklist for each trip. The following items must be considered:

- Personnel availability and qualifications
- Emergency procedures and contact numbers for specific dive location
- Air source in field or portable compressor requirements
- Scuba cylinders/regulators required (many divers are issued a regulator or use their own; some divers prefer to use their personal backpack; cylinders are often furnished by laboratory or sponsoring agency)
- Team/equipment transportation

The individual diver must consider the following:

- Diving equipment and personal items checklist (equipment requirements previously stated; special request by Diving Supervisor; environmental conditions; living conditions)
- Personal fitness and qualifications for specific diving operations (discuss with Diving Supervisor; abort the dive if physically unfit or not qualified)
- All equipment operational
- All equipment properly packed
- Travel funds/advances

Packing individual diving equipment and personal items is generally a matter of personal preference. However, the diver must consider transportation arrangements, space, weight (especially on overseas flights) and so on. Most divers prefer a roomy, heavy-duty soft vinyl, nylon or canvas equipment bag instead of hard cases or containers. Soft, lightweight bags for both diving equipment and personal items save space and weight in vehicles, aircraft and diving vessels. In addition, a net bag ("goody bag") is desirable for stowing fins, mask, snorkel, buoyancy vest, regulator, gauges, and other small items on boats. Naturally, delicate instruments such as depth gauges, compasses, watches, and masks should be placed in a padded protective case and/or carried in a camera bag. Regulators may be wrapped in a wet suit for protection.

One exception to this is the diver who has ample transportation space (pickup or van) and dives from a large vessel. In this case the large plastic heavy-duty trash container with a cover (“Action-Packer”) has gained significant popularity. This container serves for transport, stowing on board vessel, and washing equipment. These also have the advantage that water draining from equipment post-dive is contained within the container as opposed to leaking out of the gear bag.

Chapter 3

EMERGENCY PROCEDURES

3.1 Equipment and Underwater Emergencies

Equipment failure is an uncommon cause of scuba diving accidents. However, all divers must be adequately trained in the management of equipment malfunctions as well as other emergency situations that they might encounter. All scuba divers are instructed in management of the following emergency situations:

- Loss or exhaustion of air supply
- Loss or flooding of face mask
- Flooding of breathing system
- Loss of mouthpiece
- Entanglement
- Breathing apparatus failure
- Buddy rescue (possible failure of flotation equipment)

3.2 Adverse Environmental Conditions

Obviously, environmental conditions can have profound influence of the safety of a diving operation. Supervisors and divers must evaluate environmental conditions and determine if it is safe to conduct a diving operation. Environmental aspects of dive planning were addressed in Chapter 2 of this manual. The following is a summary of general factors to consider in operational diving:

- Review weather forecast prior to committing divers to the water. Postpone scuba diving if high winds/seas decreasing surface visibility, or storm conditions are predicted
- Do not start diving operations during storm or high sea/wind conditions
- Do not allow scuba diving under low surface visibility conditions (fog, snow, etc.)
- If divers are in the water and surface visibility is decreasing, sound recall and terminate the dive
- If divers are lost in poor surface visibility conditions, they should inflate buoyancy
- systems and periodically give three blasts on their whistles (all scuba divers are to carry whistles ("Storm Whistles" are preferred) or inflator air horns (preferred for divers using a full face mask).
- The support vessel will display all appropriate lights and sound fog horn at appropriate intervals. A security call should be given to alert other vessels in the area to the fact that divers are lost, possibly on the surface awaiting rescue. Commit radio-equipped search boat at the discretion of the ship's officers.

3.3 Diver Illness or Injury

3.3.1 First Aid Manuals and Supplies

The Michigan Department of Public Health requires that the American Red Cross Standard First Aid Manual (Workbook) be available at the dive location. In addition, University of

Michigan divers are to have The First Responder and/or The DAN Emergency Handbook available at the dive location.

In addition to standard first aid supplies commonly maintained on University of Michigan vessels, the following two items shall be available where diving operations are being conducted:

- Oxygen delivery equipment with sufficient oxygen to maintain a continuous supply to a patient until the vessel reaches port or the injured dive is evacuated
- Sufficient mix to prepare 6 liters of balanced-electrolyte drink for consumption by an injured diver.

3.3.2 General Response

The nature and location of University diving operations in the Great Lakes is such that medical facilities are generally within a few minutes to a few hours from the operations area. An ill diver can be readily transported by the vessel to shore and from there by ambulance to the nearest hospital or clinic. Although there will be some variation depending upon exact location, the following is recommended:

- Terminate diving operations and secure equipment for getting underway
- Immediately provide aid and comfort to the ill diver.
- Advise the Master of the vessel to contact the U.S. Coast Guard or other appropriate
- agency and arrange for an ambulance (and physician, if deemed necessary) to meet the
- vessel at the nearest dock facility.
- If the condition is serious, request U.S. Coast Guard helicopter evacuation (especially if surface travel involves a considerable time delay)
- Beach based diving parties will acquire medical services by CB radio or nearest telephone

3.3.3 Accident Management Procedure

All supervisors and dive team members must be prepared to respond properly in the event of an accident. Regardless of the nature of the accident, prompt emergency procedures can reduce the residual effects on the victim and possibly save a life. Emergency drills are encouraged! Development of a standardized accident management protocol is difficult since the procedures will depend upon diving location, available personnel, available medical/chamber facilities, nature of the injury, available transportation and so on. Proper management procedures are extremely difficult to formulate for diving in remote locations. Consequently, the Diving Supervisor (and Diving Safety Coordinator) will have to assess each location on an individual basis. An Emergency Assistance Plan (EAP) should be prepared for each dive location. The following list is intended to aid Diving Supervisors in the field in formulating specific procedural guidelines:

- The person(s) nearest to the accident victim will initiate rescue/recovery procedures. In scuba diving this is usually the diving buddy
- The rescuer will signal for assistance (voice, whistle, flare, etc.)
- If the victim is not breathing, the rescuer will immediately determine whether to tow the victim to the nearest stable location (boat or beach) or start resuscitation in the water. If a

tow of more than two or three minutes of delay is anticipated, in-water resuscitation is required

- The Diving Supervisor will immediately take charge of the scene and dispatch the standby diver and/or other divers to assist in rescue procedures. The Diving Supervisor will delegate tasks to various responsible individuals
- Upon return to shore/boat, resuscitation will be continued (including CPR, if indicated) with a minimum of interruption time
- If air embolism is suspected and the victim is breathing, immediately begin prescribed first aid procedures (supine position, prevent shock, oxygen administration, and constant monitoring)
- Account for all other dive team members
- Recall all divers in the water, terminate diving operations and secure equipment (while rescue personnel are proceeding to handle the emergency)
- Advice the vessel's Master of the situation and request what assistance is needed
- If shore based, immediately call or dispatch someone to call a Rescue Unit
- Designate dive team members to control crowds/bystanders. Keep nonessential personnel away from the accident victim and first aid personnel. This is especially necessary in a beach operation
- Non-involved dive team members are to standby and not interfere with emergency efforts. Instruct dive team members to NOT mingle with bystanders and NOT to discuss the accident with anyone except designated law enforcement officials who are responsible for official documentation only
- If the accident occurs in a training class, have an assistant isolate all students away from the scene. Do not let anyone leave until the Diving Instructor/Supervisor authorizes dismissal. Have an accurate record of all persons involved in the class. In serious accidents/fatal accidents, authorization from local law enforcement authorities will generally be required for dismissal of witnesses
- Contact local law enforcement officials if this is a fatal accident
- Contact designated Diving Physician for advise on management/transportation
- Transport accident victim to nearest medical facility (or approved diving accident treatment facility if the travel time is not too great). Local medical attention is necessary prior to subsequent transportation to a chamber. Designated Diving Physician will advise. This applies to air embolism/decompression sickness. Non-pressure related injuries will be handled at local hospital
- Arrange for communications with Diving Physician during transport
- Alert chamber
- Instructor/Supervisor (or designated representative) remains with victim during transport/emergency treatment (if possible)
- Advise University Security
- Have University Security notify appropriate University authorities and contact victim's family
- If the emergency is managed at the scene and hospitalization or professional medical attention is not required (emergency ascent, water accident where resuscitation is not required, etc.), provide victim with emergency identification, telephone numbers for diving physician. local medical facility, etc.

- Do not let the victim be alone for next 6 hours
- Do not let the victim drive
- Any person resuscitated at the dive location must be transported to a medical facility for follow-up examination/treatment
- Contact Diving Safety Coordinator and Department/Division Head

3.4 Fatal Diving Accident

If a fatality occurs or it is suspected that an injured diver may die, also observe the following:

- Do not discontinue resuscitation procedures until the victim is pronounced dead by a
- physician or emergency medical services personnel
- Transport to the nearest medical facility if there is no physician at the scene.
- Make every effort to avoid contact with newspaper reporters and general public. This includes all dive team members
- Be polite but firm regarding interviews and questions. If approached, simply indicate that information will be made available to the press through the University Information Services Office. Remember that any misquotation or undesirable statement made under stress can be printed and later cause considerable problems for any or all members of the dive team, the University and the victim's survivors
- Only one individual should serve as an official spokesperson for the group. The spokesperson will generally be the Master of the Vessel, the Diving Supervisor, or a person delegated by one of these individuals
- Give only facts to law enforcement officials. If the authorities attempt to interview any members of the dive team in public (in the presence of unidentified strangers, bystanders, reporters, etc.), politely request that such interviews be conducted in private
- Give only facts such as name, address, University affiliation, authorities to contact at the University, the exact location of the accident, a brief factual description of the occurrence (only if required), the name of the victim, who to notify in the victim's family, etc. If the interviewer attempts to force anyone beyond the basic facts, request that University legal counsel be present. Avoid expressing opinions or conclusions. Under stress it is easy to make irrational or undesirable statements. Simply think before speaking. Law enforcement reports are public information
- Immediately prepare a complete and detailed written report for the University legal office, insurance office, Diving Safety Coordinator, and other authorized persons who will be involved. This is a confidential report, not for public release. If the situation is bad, do not give the report to anyone except the legal office. Use the accident report included in this manual as a guide. The report should include photographs of the scene, sketch maps (accurate), weather conditions, water conditions, a detailed description of the activity being performed, role of all persons involved, safety precautions, and anything, regardless of how minor it may seem that relates to the scene, activity, diver, and the actions of everyone on the scene
- Have each dive team member prepare detailed statements of facts. Do it the day of the accident, not a week later. These statements should be given only to the legal office

- Record information on each dive team member, ship crew member, scientist, technicians, and bystanders that were in present at the time the accident occurred and observed any aspect of the event including name, address, their involvement (if any).
- Inform everyone on the accident site that they may be asked for facts as they recall them only. Do not attempt to put words in their mouths! Ask them not to discuss opinions with bystanders, etc.
- Prepare a complete file on the diving operation/course for the legal office including outlines, memos on procedures, records of all personnel, etc. These will be valuable for future reference in the event of legal actions
- Complete the official University Accident Report form and submit it to the Department/Division chairperson
- Complete the Accident Report form for the Duke University Divers Alert Network, but do not mail until approved by the University attorney
- Assist Information Services in preparing a statement for public release.

The above procedures may appear quite demanding and restrictive. However, everyone associated with the scene may be seen by the public as a representative of the University. As such, everyone on the site has a serious responsibility to the University and themselves. Serious accidents and fatalities often lead to legal actions.

3.4 Fire on University Vessel

In the event of a fire on the large research vessels the diving team must consider the following:

- Do not interfere with the emergency activities of the trained crew.
- Be prepared to assist in fire control as directed by the captain of the vessel or crewmembers.
- Be prepared to assist in lifesaving and survival procedures if it is necessary to abandon ship

Naturally, each vessel will have its own fire drill procedures. On larger vessels the appropriate lifeboat stations are designated for each person on the vessel including scientists and technical persons, which generally includes the diving teams. If a general alarm (or fire alarm/abandon ship alarm) sounds, the divers should quickly assemble their exposure suits along with fins, mask snorkel, and inflatable vest, and a ship's lifejacket and proceed immediately to their designated lifeboat station. If time permits, don exposure suit and have other equipment ready for use. Divers have a distinct advantage over non-diving crewmembers. The exposure suit may ensure hours of survival in cold water. In addition the divers are very capable of performing lifesaving tasks if a general abandon ship is necessary.

A fire on board the vessel while divers are underwater or under pressure in a deck chamber is an extremely serious situation. The following procedure should be followed:

- Immediately terminate in-water diving operations. Recall scuba divers using underwater sound device. Surface-supplied divers are recalled, decompressed, and removed from the water. If extensive in-water decompression is required, place a communicator, air cylinder and regulator in a lifeboat or chase boat and transfer the diver's umbilical assembly to that unit. At the discretion of the Ship's Master cast off and decompress away from the distressed vessel.

- The scuba divers will ascend to the chase boat or tending boat, remove scuba, and stand by the staging location of the distressed vessel to render assistance or perform lifesaving tasks
- If a chase boat is not being used, the scuba divers will ascend to the support vessel, remove and secure scuba on the diving ladder (or descent line), and stand by in the water with inflated vest (BCD) to render assistance or lifesaving tasks as required (adjacent to staging location)
- Divers will board the support vessel at the direction of the Captain or the Diving Supervisor
- If persons are under pressure in a deck chamber, the supervisor should immediately inform the Captain and request permission to continue decompression as long as permitted. Secure oxygen. If the fire is threatening and it is necessary to abandon the vessel or the chamber area, bring the divers to surface pressure, transfer to a lifeboat, and resume oxygen breathing on portable inhalation units as soon as possible at surface pressure. Be prepared to manage decompression sickness.
- Retain only the personnel required to handle the divers at the dive staging area. Others should proceed directly to their designated lifeboat/assembly station. If no specific assembly station has been designated by the ship's officers, the divers will assemble at the diving station unless it is threatened by fire or other immediate hazard. If so, they will assemble as a group at a location designated by the Diving Supervisor away from fire and await further orders from the ship's officers.

Chapter 4

THE SCUBA DIVE

This chapter is intended to provide divers and diving supervisors with a brief and non-comprehensive review of basic scuba diving practices in order that they might better plan and execute operational dives.

4.1 Limitations of a Scuba Diver

The diver, the diving equipment, and the surface support determine the limitations of any scuba diving operation. The physiological limitations associated with pressure changes and breathing compressed air are discussed in scuba diving manuals. Keep in mind that while there are individuals who challenge physiological limits in any activity, academic diving operations are not the place to exceed reasonable and prudent activities.

Dive duration and, ultimately, dive depth is limited by the amount of air that can be contained in the mission scuba cylinder(s). Today most divers enter the water with 70 to 100 cubic feet of air contained in a single cylinder. The duration of this air supply is controlled by the individual diver's physiology, emotional status, thermal condition, and work level, and depth. A rule of thumb is that the “average” diver consumes:

- one cubic foot of gas per minute on the surface
- two cubic feet of gas per minute at 33 fsw
- three cubic feet of gas per minute at 66 fsw
- four cubic feet of per minute at 99 fsw
- five cubic feet of gas per minute at 132 fsw

Keep in mind that individual factors for every diver may change considerably between 30 and 100 feet, as well as varying with different diving conditions. Also, air consumption at 100 feet in clear tropical waters may be quite different (typically much less) than at the same depth in the cold, dark water of the Great Lakes.

Although equipment failures are rare in modern day diving, a reasonable and prudent individual will limit dives to a depth from which they may safely ascend in the event that they lose their air supply. Emergency ascents may be made independently or with the assistance of another diver. Thus the ability of a "buddy" to assist in an emergency also becomes a limiting factor.

The national recreational diving training agencies have established reasonable and prudent limits for recreational scuba diving. Based on diver training, skill retention, diver physiology, equipment performance, air supply duration, emergency response capability, and a number of other factor a maximum depth of 130 feet has become the standard of the recreational diving community. Most agencies and instructors encourage scuba divers to not exceed 100 feet and any dive beyond 60 feet is considered as a deep dive.

The recreational standard focuses on *no-decompression dives.* Statistically, individuals diving in excess of 80 feet and exceeding the no decompression limits are at higher risk of decompression injury. Beginning divers should limit their first 10 to 15 dives to depths less than 30 feet and the next 15 dives to a maximum depth of 60 feet. One deep diving instructor told me that no more than 2% of trained recreational divers have the physical and emotional constitution to advance to diving *safely* beyond 130 feet.

The standards of the American Academy of Underwater Sciences allow scuba dives to a depth of 190 feet and engage in decompression diving provided that the diver has meant specific training requirements, completed a proper experience progression, and been approved for diving beyond 130 feet by their Diving Control Board. The State of Michigan limits occupational scuba diving to depths of 100 feet and within no-decompression limits unless a hyperbaric chamber is operational at the dive location. Even with a chamber on-site, the depth limit is 130 feet.

4.2 Trip Planning

The amount and degree of trip planning depend on the proposed dive location, distance from home base, and mode of transportation. Obviously, traveling thousands of miles to dive in the tropics takes more planning and arrangements than diving at the local quarry. However, every dive trip, regardless of location, has common elements of planning.

First, every diver must be assured that the diving operation is approved and that all personnel are qualified for the tasks and environment. Second, the dive team must be aware of environmental conditions and dive support facilities when selecting equipment. Ideally, the diving supervisor should review descriptions of underwater dive sites, if available.

One of the primary objectives of this pre-trip research is to eliminate as many surprises as possible. The dive supervisor and each diver should consider:

- Where are the best site entry points
- Where is the nearest telephone/radio for use in the event of an emergency?
- Is there a 911 emergency response system?
  Where is the nearest medical facility?
  Best means of transportation to nearest medical facility?
- What first aid supplies are available at the dive site
- What first aid supplies must be provided?

Prior to departure:

- Carefully select, inspect, test, and pack all necessary dive equipment
- Prepare a complete checklist right down to extra o-rings for scuba cylinders and silicone lubricant for the cameras.
- Carefully inspect and test rental equipment before leaving the dive shop.

All of this must be done well in advance of the planned travel. It is generally too late to make repairs if equipment flaws or failures are not discovered until after arrival at the dive site. Diving with inadequate or malfunctioning equipment could predispose everyone on site to serious injury or a fatal accident.

Finally, plan to arrive at the dive location in the best possible physical condition. Get plenty of sleep and maintain a healthy diet and life style prior to the trip or dive day. Avoid alcohol while traveling and prior to diving.

Trip planning can range from very simple to quite complex. The above is just an overview of major considerations. Through research, personal experience, and the experiences of others, divers will ultimately develop their own planning scheme. Keep in mind that the quality and safety of the diving experience is directly related to the degree of planning.

4.3 Dive Buddy Selection

How does anyone select a proper diving buddy? There is no easy answer to this question. Frankly, most recreational divers pay little attention to training, experience, equipment, and physique when selecting a person that they may have to assist (even rescue) during a dive or rely on for similar services. In some cases, bedroom prowess or fantasy takes precedent over diving expertise.

Diving buddies must be compatible! Ideally, they should have received training in similar courses. Even better, they should have been trained by the same instructor. Even though training agencies have established strict standards for course content and skill methodology, we still find considerable variability in diving instruction.

Scientific dives have the advantages of Dive Control Board authorization and annual re-qualification requirements. These procedures help assure that all divers are qualified to dive.

Divers should consider the following questions when diving with an individual with whom they are unfamiliar:

- Is the diver authorized (certified) to dive by the University?
- When did this individual last dive? Where? How many dives?
- How experienced is this individual?
- Does the individual have a cold or other physical ailments that might compromise the dive or my safety?
- Is the diver properly equipped?
- Does the equipment appear to be well maintained?
- How does the individual handle equipment?
- Did I observe the individual drinking last night? Excessively? Intoxicated? Hung over?
- Does the individual smoke?
- Have I heard any good or bad comments about the individual from other divers?
- Could I rescue this individual? Could this individual rescue me?
- Mr. Macho or Ms. Machette?

Naturally, there are many other questions that might be asked. Simple observation and casual conversation with the prospective buddy may provide the best clues. Often, a single, simple dive in confined water dive with the individual can demonstrate skill or lack of skill with respect to lack buoyancy control, excessive swimming speed underwater, air consumption rate, buddy diving techniques, and so on. If divers are incompatible, then it is best to avoid diving together.

If divers are paired with a diver that makes them feel uncomfortable? Consider these options:

- Dive with a different person

- Swim with the dive guide
- Elect to not make the dive. This may seem extreme, however, avoiding a dive that is unsuitable to personal comfort level of all involved is preferred to having anyone placed in a situation where their risk-benefit assessment is unacceptable.

Divers may sometimes find themselves in a peer-pressure controlled environment where electing to dive may be perceived as cowardly or socially inappropriate. In this case, an acceptable solution is to indicate an ability to equalize ear pressures. Since this is an event that happens to all divers at some point in time, it is a socially acceptable (and self-ego non-threatening) reason for not diving.

4.4 Dive Site Selection

Divers must be assigned to dive in environmental conditions that are consistent with their level of training and experience. Beginning divers have no business in swift currents, deep water, extremely limited visibility, adverse surf conditions, caves, and so on. Keep in mind previous statements regarding progressive acquisition of experience. Do not let another individual (including a diving supervisor or project director) lead divers into conditions for which they are not prepared!

Divers should be completely aware of the environment conditions to be expected at the dive site prior to arrival. If divers arrive at the site and find unfavorable conditions or are unsure about their ability to dive under the conditions, do not dive!

The decision not to dive is always correct.

4.5 Equipment Selection

Equipment selection has been discussed in detail in other sections of this manual. Naturally, specific dive location and underwater activities will determine specific equipment requirements. However, certain items of equipment are common to most scuba diving activities. A list of basic required equipment with some comments is presented below:

- Mask, fins, and snorkel (check straps prior to leaving; include extra straps for remote dive locations)
- Environmental protection garment (range from thin wet suit in tropics to dry suit with heavy undergarments in the north; 1/4-inch (5-6 mm) neoprene wet suit is common in the Great Lakes region; include boots for foot protection in tropics)
- Buoyancy control device or BCD (inspect prior to trip; whistle attached; octopus attachment option; includes scuba backpack)
- Regulator (includes pressure gauge, auxiliary breathing unit, BCD inflation hose, and dry suit inflation hose; inspected/serviced; extra o-ring for scuba cylinder)
- Cylinder (s) (current internal inspection and hydrostatic test; traveling divers seldom transport cylinders on air craft; more than one cylinder needed for some boat trips)
- Instruments (include depth indicator, dive timer, and compass; console unit including cylinder pressure gauge; batteries for electronic units replaced as needed; dive computer options; protection for transport)
- Knife (compact low profile model)

- Weight belt (belt only when traveling to resorts by air; small weights for adjustment; quick release buckle design; excess length trimmed)
- Slates and pencils (for dive planning and records; generally carried in BCD pocket; extra small slates in dive bag)
- Plastic dive tables (for dive planning; carry in BCD pocket)
- Equipment bag (net bag for boat; duffel bag or suitcase for travel)
- Tool kit/spare parts (as needed; personal preference; location dependent)

Be certain that all equipment is functioning properly prior to leaving home. Use a checklist!

4.6 Environmental Analysis

Upon arrival at the dive site, one of the first responsibilities of every diver is to evaluate environmental conditions of the dive site(s). Check visibility, wave conditions, current, temperature, and other factors that may influence dive quality and safety. Select a comfortable and secure staging area for shore-based operations. Determine entry and exit points as well as emergency exit points. Keep in mind that divers should refrain from diving if the environmental conditions exceed the scope of their experience/training.

4.7 Risk-Benefit Analysis

Every activity that we engage in has an element of risk. Driving an automobile or crossing a street has inherent risks Today, casual relationships and dating can easily lead to fatal disease. Although most people do not formally recognize the concept of risk evaluation, reasonable and prudent individuals are continuously making risk-benefit assessments in everyday life. In diving, diving must constantly assess the environment, the equipment, fellow divers and other related factors and weigh them against personal training, experience, and dive supervision. Ultimately, a diver must ask, "Are the potential benefits of this experience worth the risks that I might encounter while engaging in the activity?" and "What level of risk am I willing to accept?"

4.8 Personal Space

Generally, a buddy team will select a location to stow and assemble their equipment whether operating from a shore base or a boat. On many boats there are seats with areas beneath for equipment. Scuba cylinders may be standing upright in a rack position in the center of the boat. This is characteristic of many smaller boats used in the Caribbean. Larger dive boats may have different arrangements. Immediately upon arrival at the boat it is desirable to "claim" a seat and cylinder. On some boats number cylinders and seats are assigned to each diver

4.9 Briefing by the Diving Supervisor

At some point prior to diver deployment the person-in-charge will call for the divers to assemble and pay attention to a site and activity briefing. The briefing generally includes location-specific information on environmental conditions, diving procedures, current direction, swim direction, underwater features, return cylinder pressure, depth limit, time limit, special precautions, task assignments, and so on. During briefing, divers should not be assembling equipment, working out dive schedules, talking to their buddies, or daydreaming.

The dive master should have everyone’s undivided attention. This is also the time to ask/answer questions. If something is unclear, ask for a clarification.

4.10 Finalizing The Dive Plan

Once the briefing has been completed divers (as buddy team) must review and finalize their dive plan. This includes, but is not necessarily limited to, maximum depth, maximum dive time, underwater swim path, special precautions, buddy separation procedures, who will lead the dive, and hand signals. If this is a repetitive dive, both divers should compute maximum allowable dive time independently and compare results. The following is a summary of a hypothetical survey dive plan:

- Maximum depth is 60 feet for maximum dive time of 40 minutes
- Must be back on deck with 300 psi of air remaining
- Following entry we will descend down the anchor line to the bottom and do a brief buddy and equipment check
- We will then swim down the slope to a depth not exceeding 60 feet and swim south into the current (slight current) until the first diver's air supply reaches 1,800 psi (start with 3,000) or 18 minute have elapsed
- We will then ascend to 40 feet and swim back north along the slope (return trip with current is generally faster and uses less air at shallower depth)
- Upon arrival at the anchored boat we will explore the area around the boat until the first individual's air reaches 600 psig or about 38 minutes
- Proceed to decompression bar (suspended 15 feet under boat) and stop for approximately 5 minutes
- If we get separated and do not reunite in 1 minutes, surface
- I will lead on this dive and we will use this signal [give signal] for [mission-specific] object

4.11 Pre-Dive Equipment Assembly and Buddy Check

Many recreational diving instructors and agencies have a prescribe buddy check procedure and nice little memorized acronyms to assist the diver in remembering this procedure. Basically, the pre-dive buddy check begins long before the dive. First determine verify all divers are physically and emotionally qualified for the dive. Are they properly trained and equipped for the dive? It is too late for all of this once everyone is dressed and standing on the dive platform.

Ideally, a buddy team should assemble their equipment together. This allows for such pre-dive considerations such as verifying air supply, security of the scuba cylinder, connection of the BCD hose, and scuba/BCD operation. This allows corrections to be made more easily before final dressing and deployment. Once the equipment has been donned, each diver must make a final systematic check of themselves and their buddy. Just before entering the water divers should do the following quick head-to-toe check:

- Mask and snorkel in place; Regulator on and operational
- BCD secure and inflator hose attached
- Scuba cylinder secure

- Octopus attached to retainer in visible, accessible position
- Cylinder pressure; depth indicator and timer visible
- Suit zipped and inflator hose attached (dry suit)
- Weight belt on, securely positioned, and buckle visible
- Knife accessible
- Fins secure

4.12 The Dive

Each dive is unique and it is difficult to describe a generic dive. Below is a hypothetical dive based on the above dive plan.

Don equipment: The divers assist each other in donning scuba and proceed to the deployment area with their mask and fins in hand. They do a quick final buddy check and put on their fins and mask.

Report to Diving Supervisor: Before deployment divers report names to the diving supervisor who maintains a record of entry and exit times.

Entry: Divers use stride entry from the stern platform and snorkel to the anchor line together. At the anchor line divers note environmental conditions and dive site features. The current is very slight and visibility is only about 50 feet. They see the bottom below. The boat is anchored near the edge of a shelf in about 35 to 40 feet of water. The shelf break and slope are visible from the surface.

Descent: After a brief check of each other and an "OK" signal, the divers descend. During descent they adjust buoyancy to limit descent rate. Upon arrival at the bottom they do a quick check of their equipment and a visual check of their buddy.

Orientation: The top of the slope is visible from the anchor line. Divers swim to the slope and observe a very large assembly of tube sponges at exactly 40 feet. The sponges are the most prominent feature in the area adjacent to the boat and will serve as a reference marker (rally point) upon return.

Swim: Divers swim down the slope to a depth of about 55 feet and begin a slow swim south into a slight current. They are very careful to maintain proper buoyancy throughout the swim. Occasionally, they stop to observe marine life. Every few minutes they check their depth gauge, cylinder pressure, and timer. At about 15 minutes into the dive a diver signals 1800 psig.

The divers begin a slow ascent to 40 feet, turn and swim slowly back along the slope at 35 to 45 feet. They see the large tube sponges (the rally point) about 15 minutes later. As they approach the sponges they look upward and see two divers on the decompression bar under the boat. One diver’s pressure gauge reads 1000 psig and another's gauge reads 800 psig. They decide to explore for a few minutes below the boat.

Ascent: At 37 minutes the divers slowly ascend together to the decompression bar where they will remain for 5 minutes. As they near the 5 minutes mark they look toward the ladder to see if it is clear for exit. The exit is clear, so the divers swim to the ladder and exit.

Report to Diving Supervisor: As soon as the divers are onboard they report their names, maximum depth, and dive time to the diving supervisor.

Remove, Disassemble, and Stow Equipment: Divers immediately proceed to their allocated "space" and assist each other with equipment. The scuba is disassembled, all personal equipment is placed in dive bags or other storage, and the dive gear is stowed beneath the seat.

Record Dive Information: As soon as the divers have taken care of their equipment they should record all pertinent dive information on a slate or dive log.

Return to Port: During the return trip divers will re-warm themselves, talk with other divers, and/or relax. Divers should respect the sun, especially when reflected from the water's surface. Thirty minutes of post-dive tropical sun exposure can do considerable damage to already over-exposed skin.

Washing and Stowing Equipment: Divers close to home base will simply take their equipment home to wash and dry. Procedures differ from one location or boat to another. In most cases, fresh water tanks or water hose can be found for washing diving equipment. Allow equipment to drain and dry as much as possible before final packing. Place equipment in appropriate containers for transport.

Post-Dive Activity: If possible, divers should relax for a hour or so following a dive before driving home. Avoid heavy exertions such as jogging or tennis for several hours. Drink plenty of water and nonalcoholic beverages such as fruit juice. Be careful of excessive sun exposures. It is best to allow at least one hour between dives.

4.13 Critical Analysis

Following each dive, divers should critically review the dive and discuss it with their buddy (and the diving supervisor, if necessary). This is especially important for beginning divers. If any diver had even the slightest problem, the incident should be discussed to figure out the nature of the problem and, more importantly, what can be done to avoid such problems in the future. Experience is a great teacher.

4.14 Records

All divers must maintain an accurate dive log and document scientific observations and tasks. Unfortunately, far too many do not. If divers intend to retain a University diver authorization and advance to higher ratings, this record becomes mandatory. Details of dive record keeping are covered in Record-Keeping chapter.

4.15 Conclusion

Each dive will be unique and present different rewards, challenges, and problems. Divers are constantly learning and acquiring the new experiences to progress to more exciting and rewarding diving. Observe and analyze the actions of other divers. The only way to become a good diver is to dive!

Chapter 5

DIVING IN LIMITED VISIBILITY

Most beginning scuba divers envision diving in the warm pristine waters of the Caribbean where underwater visibility often exceeds 100 feet. Divers working far offshore or under the ice shelf in Antarctica boast of virtually unlimited water clarity. On the other hand, a diver may enter a zone of total darkness when diving in lakes, bays, and rivers where the suspended material in the water is so profuse that all light penetration is blocked. Great Lakes divers and commonly dive in water with visibility of 5 to 20 feet.

5.1 Risk-Benefit Assessment

Most divers will agree that given equivalent circumstances, a dive in clear water has less potential risk than a dive in limited visibility water. The obvious concerns are in maintaining a proper buddy system, determining a reasonable idea of location with respect to entry/exit point, and lack of vision in performing useful work/observation on the dive site.

In some lakes, bays, and rivers the bottom is cluttered with debris from both human and natural sources. The risk of entanglement in lines and nets is often quite significant. Many inland lakes were formed by flooding large areas of land after rivers were dammed. Buildings, trees, barbed wire fences, and other debris of pre-flooding remain in dark waters. Many inland rivers and lakes have been historical (or more current) garbage dumps or land-fills and, as such, may contain a variety of entanglements. Some rivers in our western states have large accumulations of submerged tumbleweed that can literally consume a diver. In ocean waters divers may encounter unseen marine life that can cause injury.

All of the above would not represent as high of risk if the diver could easily see potential hazards and thus, avoid potential hazards. Consequently, divers electing to dive in limited visibility must be prepared to accept a higher level of risk, take special precautions, use special equipment (in some cases), and obtain special training. For some individuals the emotional stress associated with perceived confinement, disorientation, unseen marine life, and surprise encounters place them at an exceptionally high level of risk, and limited visibility diving is definitely contraindicated.

5.2 Factors Determining Underwater Visibility

Pure water is transparent. The range of underwater visibility is controlled primarily by particles of organic and inorganic material suspended in the water. Fine-grained sediment particles (clay and silt) eroded from land by running water and weathering processes are carried into lakes and ocean waters where they remain suspended in the water column for days, even years. For example, clay size particles have a settling velocity of 0.00025 cm/sec in still water. This means that in the open ocean it would take approximately 50 years for the particle to settle to the bottom at a depth of 4 kilometers. What does this mean to the average diver? If a clay size particle is introduced into a calm body of water, theoretically it will settle toward the bottom at a rate of slightly over three feet in 4.56 days. A silt size particle (10 times larger) will settle 100 times faster. Vertical water movements can both slow and increase settling time.

Water clarity is often directly related to weather conditions. During the rainy season rivers and streams continuously supply lakes and bays with large quantities of sediment-laden water. However, during the dry season clearer water can be expected due to less influx of river water containing sediment. Many otherwise clear lakes and quarries will have severely limited visibility following a spring rainstorm and several days may be required for the sediment to settle and visibility improve.

The type of bottom sediment is also a principal factor influencing underwater visibility. Coarse-grain sand is heavy and settles rapidly back to the bottom when disturbed. Consequently, rock and sand bottom bodies of water often make the best diving locations. On the other hand, divers commonly disturb silt or muck bottom sediments with their fins and raise clouds of sediment into the water column. In an otherwise clear quarry, careless and unskilled divers can reduce the bottom water to zero visibility in a short time. The excessive hand movements of poorly trained divers can create convective currents that will pull sediments off the bottom and rapidly create clouds of low visibility. In these waters diver, must use great care in controlling buoyancy and swimming as far above the bottom as possible. The fins need not make contact with the sediment to disturb it; current produced by fin movement near the bottom is sufficient. Cave divers use an unorthodox high fin knee kick to minimize silting.

Thermal structure of the water column may also be a significant factor. During spring and fall months, temperate zone lakes and quarries are isothermal (same temperature from top to bottom) and suspended sediments are carried throughout the water column by natural wind induced circulation. As the surface waters warm, the water column develops a thermal stratification and a thermocline (a narrow zone of rapid temperature change with less dense warm on top and denser cold water below) is established. Following mild rains and subsequent sediment influx, the upper layer of water will have very limited visibility and the cold deep water will be clear. A diver may go from 3 feet visibility in surface water to more than 20 feet visibility after passing through the thermocline.

Plankton (tiny plants and animals) remains suspended in the water column for many days or even weeks. The quantity of plankton in the water depends on the season, sunlight, nutrients, suspended sediment (blocks light penetration), water movements, and thermal structure. Phytoplankton (drifting plants) reproduce rapidly in well-mixed nutrient rich water during spring months due to increased sunlight exposure. This is the spring bloom. Zooplankton (drifting animals) reproduction soon follows due to the increased food supply. In some locations the water literally turns into a organic soup with plankton so concentrated that visibility is obscured. Prolific blooms of dinoflagellates, a minute planktonic organism that possesses characteristic of both plants and animals, causes the classic red tides. These organisms become so concentrated that the water appears reddish-brown. During red tides, filter-feeding marine organisms such as clams and mussels concentrate a toxic by-product in their flesh and are unfit for human consumption.

In some coastal ocean areas underwater visibility will change significantly with tidal movement. During flood (rising) tide clear ocean water moves into coastal embayments and during ebb (receding) tide dirty river or back bay moves seaward to obscure visibility. Wind and wave conditions also influence coastal currents and sediment erosion and transport.

5.3 Diving Techniques

5.3.1. Navigation By Natural Features

The fixed reference point on the surface may be a boat, shoreline feature, or man-made structure. Underwater, the reference point may be a prominent natural feature such as the channels between reefs; a man-made structure such as pipeline, cables, or an anchor; the general ripple mark trend; the bottom slope; a cliff or drop off; the current; or a combination of these factors. For example, if the ripple marks are orientated parallel to shore, the diver may determine his orientation with respect to shore by observing the ripple marks and relative depth. It should be emphasized, however, that ripple marks are not always orientated parallel to shore and that their orientation should be checked with a compass.

In clear water most divers navigate by bottom features. For example, many excellent dive sites are located on ledges or steeply sloping bottoms. The diver can simply use these natural features as a guide and swim parallel to the feature. For example, a boat may be anchored in 50 feet of water. The Dive Master may instruct the divers to swim in a given direction at a depth not to exceed 70 feet until they have consumed about one-third of their air supply. At this point they are instructed to move up slope to a depth of 50 feet and swim in the opposite direction. In most cases the divers will arrive back at the anchor point with one-third of their air supply remaining and complete the dive in the vicinity of the boat.

Many coral reefs form a spur and groove topography. In such areas fingers of coral and rock separated by sand channels protrude seaward. The boat is anchored in a sand channel in order to prevent damage to coral. Upon entering the water the divers are instructed to observe the general underwater topography. The divers may descend to the anchor, take a depth reading, and swim to the coral area on either side of the sand channel. The divers can then move in either direction parallel to the coral. Eventually, the divers may elect to cross the sand channel and return to anchor depth along the opposite side of the channel.

5.3.2 Navigation by Compass

Self-contained divers commonly use a liquid-filled magnetic compass for underwater direction finding and navigation. Generally, the compass is part of the instrument console that is attached to the scuba regulator. However, some divers will secure the compass to their wrist, use a compass attached to a clip line, or a compass board.

A diver's compass should have the following features:

- correct dampening action
- liquid filled
- the compass rose marked in degrees
- lubber's line showing direction over the face
- course setting line or reference markers
- movable bezel.
- high degree of luminescence for use in dark water

When using a compass, the diver will first obtain a bearing in degrees to the target relative to magnetic north. While sighting on the target, rotate movable bezel until the parallel lines on the compass face (movable) are aligned with the North-seeking needle. The bearings, in degrees, will be indicated at the end of the North-seeking needle. To navigate a straight line, the dive must point the lubber line in the direction of intended travel and keep it perfectly aligned with the longitudinal axis of the body. Be certain to hold the compass level so that the needle can swing freely and not lock in place. To maintain proper direction while swimming, the diver must keep the North-seeking needle aligned with the parallel lines on the compass face and maintain the lubber line parallel to the longitudinal axis of the body.

If visibility and bottom characteristics permit, sight over the compass (or use a “side-reader”) to an object or feature that lies in the path of travel. Swim toward that object and look ahead for another sight point. It is easier to navigate using the point-to-point method than by constantly monitoring the compass. Unfortunately, on featureless bottoms and in very poor visibility the diver will have to navigate solely by compass observation.

A compass may be strapped to the diver's wrist (right for right-handed and left for left handed persons). Metallic objects that might cause deviation should be worn on the opposite wrist. When swimming underwater, the compass-lock position is recommended. In this position the arm without the compass is extended straight in front of the diver, the diver bends his compass arm 90 degrees at the elbow, and then grasps the extended arm near the elbow. This places the compass directly in front of the diver's eyes and aids in keeping the diver's body on a straight line.

The two most serious mistakes when using a compass are failure to keep the lubber line parallel to the longitudinal axis of the body, and the diver looking down at the compass instead of sighting over the compass. The diver must keep his body straight and swim in a straight line to accurately navigate.

5.3.2.1 Compass Boards

The use of a compass board will greatly improve accuracy on long underwater swims. U.S. Navy Underwater Demolition and SEAL Team swimmers generally operate well within a 1-3 percent margin of error relative to target; good wrist compass accuracy is about a 5 percent error factor. Compass boards are not generally sold in United States dive shops or used by recreational divers. However, they may be easily constructed of 1/4-inch sheet plastic (Plexiglas) with dimensions of approximately 8 x 10 in. One end may be rounded to give a more hydrodynamically efficient shape. The compass may be mounted permanently or the board can be slotted in order to utilize the wrist strap and facilitate easy removal for conventional use. The compass is mounted at the middle of the board directly on the center line. A depth indicator, timer, and/or small waterproof light may be included in various configurations at the diver's discretion. A lanyard or snap-hook may be added to minimize the possibility of loss. Hand slots may be cut on each side to facilitate handling.

While swimming, the compass board is held firmly in both hands parallel to the intended direction of travel. The elbows are pressed against the sides of the body for stabilization and the compass board is held about one foot in front of the mask. When using a luminous dial compass at night, the compass board may have to be held closer to the face. Prior to submerging, a visual sighting on the target is made and the compass is set. Underwater the compass is observed throughout the swim. If the compass board also includes a depth indicator and timer, these instruments are scanned systematically along with the compass.

5.3.2.2 Basic Navigation

Assuming that the diver swims a straight course, the diver can return to the original point of entry by following a reciprocal course (180^o opposite his original course bearing) with an accuracy of +/- 5 degrees.

Divers can use simple navigation skills. The simplest method of navigation involves simply starting at a known point and moving along an intended track (determined by chart or on-site bearing). This involves establishing a position in relation to known features and plotting a course toward a destination from a known position. The diver simply determines the bearing and swims on course to a specific point or area.

Dead reckoning, however, requires following a compass bearing in a specific direction and taking into account speed and time. An estimated time of arrival (ETA) may be computed. Approximated distance or time required to swim between two points may be determined by the simple formula: Speed x time = distance. Thus, an ETA can be determined. Distance traveled underwater can be determined by time or counting the number of kick-cycles. On the average, at normal swimming level, a diver wearing a wet suit will travel 2.5 ft/sec or 3.25 ft per kick cycle. The same diver without a wet suit will travel 3.6 ft/sec or 4 ft per kick cycle. The individual can measure his own underwater swimming rate by swimming a given course and recording the time and number of kicks. An average of several course swims should be used.

5.3.3 Maintaining the Buddy System

The most obvious concern in limited visibility diving is buddy separation. Consequently, dives must be planned and executed to minimize this possibility. For purposes of this discussion I will define limited visibility as a condition where the diver's lateral range of vision is less than 20 feet.

Safe and effective group diving in limited visibility is difficult if not impossible. When the visibility drops much below 20 feet, it is difficult for more than two divers to maintain effective visual contact. Further reduction in visibility to less than 10 feet can significantly compromise even two-person team operations.

Divers must maintain continuous visual contact throughout the dive. When entering areas of silt and completely obscured visibility, divers will have to establish physical contact by holding hands or using a buddy line. Special care must be exercised during descent and ascent to avoid separation. Ascents/descents are best done with divers facing each other as they move through the water column. Even then emergency responses such as sharing air will be seriously compromised.

Divers who routinely operate in limited visibility must, in my opinion, be far more self-sufficient than clear water divers. Since buddy separation is more likely to occur and air sharing is extremely difficult, the use of an auxiliary scuba emergency air source is far more attractive that relying on someone else's octopus or safe-second.

5.3.3.1 Use of a Buddy Line

A 4- to 6-foot piece of 3/8-inch synthetic polyolefin braided or 3-strand twisted line with hand loops at each end makes an excellent buddy line. Polylefin line has the advantage in that it floats and thus reduces the possibility of snagging on bottom objects. Hand loops may be fashioned by placing an eye splice in each end of the rope. The rope may be looped into a small coil and carried in a BCD pocket when not in use.

Long buddy lines allow divers to separate far out of visual range and easily catch on submerged objects, especially if the rope sinks and drags along the bottom. When using a buddy line it is best that one diver be designated as leader and the other as "wingman" (maintains a position always on one side). The lead diver should not jerk and drag the other diver around the bottom nor should the divers compete for directional control.

5.3.3.2 Diver Separation

Even the best of divers can become separated underwater. The pre-dive plan must include procedures that is to be followed in the event that the divers become separated. Diver separation can be especially stressful for some individuals. Suddenly a diver may find themselves alone and disoriented. The diver may simply be fearful of being alone or that something has happened to his buddy.

Whenever divers are separated, they should simply stop swimming, take a deep breath, relax, and listen. If distance is small, perhaps bubble noises can be heard. Often bottom visibility is very poor, but improves significantly a few feet above the bottom. Divers should carefully rise upward in the water column until several feet above the bottom and scan the surrounding area for the separated buddy, bubbles, or a silt trail (fin disturbed sediment). If both divers have responded properly they should see each other at this point. If there is no evidence of a buddy, spend a few seconds systematically searching the immediate area. In open water, a single box search pattern may be productive. (First, using a compass, swim 4 or 5 kick cycles north, turn 90' and swim the same number of kicks east. This is repeated until all four sides of the box pattern are completed.

As a general rule if buddies do not reunite in one minute, both divers are to make a controlled ascent to the surface. At the surface the divers reunite, discuss ways to improve diving procedures, and may then descend and continue the dive. Hopefully, the divers will now use a buddy line or take greater care in maintaining visual contact. At this point (on the surface) some dive teams will elect to terminate the dive and return to shore (or the boat).

In deeper situations, or on wrecks, where ascent would definitely terminate the dive, some divers will use "rally-points." As the dive progresses, various large, easily recognizable objects are selected as "rally-points." If separated, divers return to the last "rally-point" and wait one minute before ascending.

If only one diver surfaces, they should scan the surrounding area for bubbles. If there are two or more bursts of bubbles surfacing side by side, it may be another group or divers (assuming others are operating in the area). A single burst of bubbles may be the dive buddy. Remain over the bubbles and await ascent. If a steady stream of bubbles (unlike breathing burst) is coming to the surface, this could be a free-flowing regulator and means a dive buddy might be in serious trouble. If so, descend along the bubble trail to investigate.

If bubbles are not visible and the "lost" buddy does not ascend to the surface, divers must, unfortunately, assume the worst. The next response will depend on the site, personal experience, availability of other divers, and so on. If alone in a lake or quarry, have sufficient air, and are an experienced diver, a diver may elect to return to the bottom to conduct a brief systematic search.

On the other hand, the diver on the surface may lack the air and experience to conduct a solo diver search. In this case, the diver should remain calm and take a series of compass bearings on several different shore objects. These bearings will be needed to assist search and rescue personnel in establishing the last known point of contact. The diver should swim to shore and seek professional assistance as soon as possible.

If other divers are in the vicinity, the diver on the surface should signal for assistance, and try to establish point of last contact.

5.4 Tethered Scuba Diving

Modern tethered scuba diving techniques are virtually unknown in the recreational diving community and are in only limited use by scientific divers. Tethered scuba diving is probably one of the must under-rated and misunderstood of all modern diving techniques. Deployment of a single scuba diver is currently inconsistent with recreational training policies.

The modern tethered scuba diver is outfitted with an independent redundant breathing system, a full-face mask, a safety harness, and a combination safety-communications line. This line leads to a surface tender and communications unit. Throughout the dive the diver and tender are in constant voice communication. In addition, a second tethered scuba diver remains on standby to assist if needed.

This technique has been used with great success by scientific divers operating in cold, dark waters where the underwater task can be easily accomplished by a single diver and attempting to maintain the buddy system is both inefficient and in effective. For selected diving activities deployment of a properly equipped and trained single tethered scuba diver may be much safer than placing two free swimming scuba divers in an environment where visual contact is limited to impossible. A detailed discussion of this diving technique is presented in Tethered Scuba Diving by Somers (available from the Michigan Sea Grant College Program in Ann Arbor).

5.5 Summary

Diving in limited visibility is a higher risk activity than diving under otherwise similar circumstances in clear water. Divers may use special precautions and techniques to reduce bottom disturbance and maintain contact. A proper dive plan will include a specific procedure to follow in event of diver separation.

Keep in mind that every dive site has its own unique bottom characteristics. Consequently, each dive must be planned accordingly. The prudent Diving Supervisor will use a chart or sketch or the dive site when briefing divers. Using common sense, natural features, and a compass, divers should always know their underwater position relative to their entry and exit points.

Chapter 6

BOAT DIVING

Frequently, divers will be required to use a boat as a diving platform. Diving vessels range in size from small, inflatable rubber boats to large research vessels or charter boats. The type and magnitude of diving operation, environmental conditions, distance offshore, number of personnel, amount of support equipment, etc., will dictate the type and size of vessel. For near shore, scuba diving in relatively calm water, a small 14 to 18 ft (4.2 to 5.4 m) outboard motorboat is commonly used. More extensive offshore diving operations must be undertaken from a larger vessel with adequate deck space and seaworthiness. The following factors must be considered:

- Adequate size to accommodate divers, surface personnel, and equipment
- Sufficient stability and seaworthiness to function as a platform for diving operations
- Equipped with proper safety equipment as required by state and/or federal laws (Certificate of Inspection. if applicable)
- Large, open work/staging area
- Mooring capability (3- or 4-point moorings may be required for working dives)
- Adequate protection from rain, sun or cold
- Sufficient storage space to accommodate diving equipment when not in use
- An adequate ladder and staging area to facilitate entering and leaving the water
- Diving personnel and/or professional crew trained in boat handling, seamanship. etc. (licensed crew when applicable)
- Ship-to-shore communications (marine radio with Federal Communications Commission Station license posted; CB may be used in some small boat operations)

A satisfactory diving ladder/exit platform is an extremely important safety consideration. Most boats, unless specifically designed and equipped for diving, will not have a ladder that is safe for use by divers. Serious injuries have resulted from the use of inadequate ladders. The ladder should include the following features:

- Solid construction;
- Rungs wide enough to allow comfortable use with bare feet and stability with fins;
- Sufficient handrail extending the full length of the ladder
- Inclined relative to the side of the vessel
- Secure enough to avoid movement when the diver is on it

The information contained in this chapter is intended to provide divers with a general overview of boat operations. It is not intended as an instruction manual for boating and must not be used as a guide for boat operation. Persons intending to operate boats must receive proper instruction from authorized agencies and instructors.

6.1 Small Boat Diving

6.1.1 Choice of Craft

Features to consider in selecting a small boat for diving include seaworthiness, stability, space, and carrying capacity. The boat may be of rigid construction or an inflatable design. Good quality inflatable boats are excellent diving crafts if protection from surface exposure is not required.

6.1.2 Propulsion

Outboard engines power most small boats. The engines must be serviced and in good working order. A rigid, comprehensive service/maintenance program should be established. Engine operation must be verified prior to leaving for the dive area. Avoid outdated, poorly maintained outboards.

Be certain to secure the engine to the vessel with a safety chain. Generally, a gasoline-oil mix will be required. Use appropriate mix proportions and oil. Be certain that sufficient fuel for all requirements plus reserve fuel for an emergency is on board.

A spare parts/tool kit must be included as standard boat equipment. The kit must include spare plugs, shear pins, and a starter rope plus the appropriate tools to replace them. Ideally, an engine trouble-shooting chart with correction procedures should be included in the kit. The kit should be fully waterproof and stowed in a secure location. At least one member of the dive team must know the function of the engine and how to make field repairs.

Always carry an auxiliary pair of paddles or oars; they could be the only means of propulsion in an emergency. Many divers prefer the use of twin-outboards. This means propulsion is available if one engine fails. Others use a small auxiliary engine that is exclusively for emergency use.

6.1.3 Safety Equipment

In addition to the spare parts/tool kit standard boat equipment must include a bailing device or container, a flashlight, emergency flares, and approved lifejackets. The diver's inflatable vest is not an approved flotation unit for boating. Ideally, a rescue lifeline/float should also be available. A first aid kit is standard equipment. Ship-to-shore communications is required for all diving operations covered by federal/state occupational safety and health regulations and are recommended for all offshore diving operations. A diver's flag and adequate support must be available. All boats must be equipped with a fire extinguisher. A megaphone is useful for warning approaching boaters or recalling divers on the surface. An underwater diver recall/signaling device is also desirable.

6.1.4 Navigation Equipment

The amount and type of navigation equipment will depend upon the diving location, distance offshore, landmarks, and so on. Ideally, a waterproofed chart, or chart in a waterproof case, of the area should be on board. Even if within sight of distinctive landmarks and buoys, a compass must be available. Fog, forming after departure, can necessitate the use of a compass for safe return to port. Modern electronic navigation systems are highly portable and may be used on small outboard motor boats. A sextant, pencils, and plotting instruments should be included as required.

6.1.5 Knots for Line Handling and Attachment

All boat divers should be able to tie the following knots: bowline, square knot, clove hitch, two half hitches, and sheet bend. Lines must be coiled in a fashion to prevent snagging when being deployed. Coiling the anchor line into a locker or container is a good practice. The line may also be stored as a figure-eight on the deck or in a "stuff bag" to minimize snagging during rapid deployment.

6.1.6 Preparation of Boat

Pre-launching preparation procedures will depend upon the boat itself. In general, inspect the boat to assure that no damage has occurred during transport, secure drain plugs, secure engine, ready mooring and anchor lines, and stow safety equipment. Do not bury the anchor and anchor line under diving gear. Do not load heavy equipment into the boat until it is afloat. Be certain that inflatable boats are assembled in accordance with the manufacturer's instructions.

6.1.7 Launching

When launching from a trailer, make sure that someone is holding onto the mooring lines while the boat is being pushed off the trailer. Be certain that the trailer is parked in a proper location so as not to interfere with the launching of other boats. Load heavy equipment while the boat is moored. Be assured that the water depth is adequate to prevent damage to the engine. Install or lower engine, connect and prime fuel system, start engine, check for cooling water coming from engine, and allow sufficient time for the engine to warm up before proceeding to sea. Be cautious to avoid engine damage in shallow water.

6.1.8 Handling Under Way

All boat operators, regardless of the size of the boat must be familiar with boating rules- of-the-road, local ordinances, speed regulations, and so on. Pamphlets and manuals relating to these subjects are available from the U.S. Coast Guard, U.S. Power Squadron, state agencies such as the Department of Natural Resources, and some sheriffs' departments. A variety of boating manuals are available in bookstores. Each operator should be provided with appropriate information.

Speed is one of the greatest hazards. Avoid unnecessary speed, particularly in confined water. Avoid sudden bursts of speed and tight turns under full power. The latter can cause a capsizing and, if not expected by those in the boat, can pitch people overboard. In addition, equipment may move around causing damage or injury.

The operator must be in total control of the vessel at all times. This requires, among other things, constant and uninterrupted attention to the boat and surrounding water. Always be alert for other craft or persons in the water (swimmers, water-skiers, etc.) . Do not allow a person under the influence of alcohol or drugs or a person suffering from motion sickness to operate a boat.

Hopefully, a diving team will not put to sea in adverse rough water conditions. However, such conditions can develop quickly and a team in a small boat can be caught out by bad weather conditions. The general rule is, "Keep the boat headed into the sea and proceed at slow speed." When it is necessary to go with the sea, allow the waves to overtake the vessel; to travel faster than the sea means that the boat is more likely to suddenly swing off course and be hit broadside by the waves.

Watch waves approaching from the stern and control speed in order to minimize water flood over the stern. If the course is across the direction of the seas, it may be necessary to alternately almost head into the sea for some distance and then change course so that the sea is almost astern. If the distance between wave crests is large, it may be possible to run at speed along the trough and turn the bow into the crest at the last minute. In rough seas all persons in small boats must wear lifejackets, or at least the diver's inflatable vest. Ideally, all persons, both tenders/operators and divers, should wear diving suits or waterproof exposure suits, especially if the water is cold. Not only does this allow for greater thermal comfort and reduce the discomfort of wetting spray, but greatly enhances survival if the boat capsizes.

When going alongside a dock or object or picking up a diver in the water, approach against the wind or tide, whichever has the greatest effect on the boat, and on the sheltered side if possible. Use reverse gear to brake, if necessary. The idea is to come to a halt within reaching distance of the dock, object, or diver. The most common fault when going alongside or picking up is to approach too fast. Do not hurry! When moving off from alongside a pier or boat, back off first if possible.

6.1.9 Anchoring and Mooring

The anchor must be of adequate size for the boat. A Danforth or grapnel (wrecks/rock bottom) with approximately 12 ft (3.6 m) of chain is recommended. The heavy-duty anchor line should be at least three times the maximum water depth. Many divers secure a buoy near the upper end of the anchor line. In the event that the boat must be moved quickly (such as picking up a distressed diver), the anchor line can simply be thrown off and later retrieved. Mooring lines, twice the length of the boat, should be available at the bow and stern.

Always anchor clear of other craft, and not in an area designated as prohibited or restricted on a chart. Be sure that the anchor line is clear. Stop the boat into the wind or current and let the anchor go, allowing the boat to drop astern. Make sure the anchor is holding before stopping the engine.

Always make sure the anchor line is secured in the boat. When retrieving the anchor, start the engine first. The engine can be engaged in slow ahead to assist in breaking out the anchor. Immediately prepare the anchor line so that the anchor is always ready for use. It should always be available in the event of engine failure or other emergency.

The anchor line is often used as a descent-ascent line. Often this practice encourages divers to use less scope or adequate length of line for anchoring. Such practices can lead to dragging the anchor or place unusual stress on the line or boat hardware, especially in rough seas. Use of a specific weighted ascent-descent line secured to the stern is more acceptable. Some divers use a separate ascent-descent system. Once the vessel stabilizes after anchoring, a heavy weighted line with a surface float is placed directly off the stern of the vessel. The line is generally equal to the water depth so it remains taut.

The size buoy will depend upon the bottom weight; however, both should be of adequate size to allow the divers to pull down or up on the line without affecting the position of either. A short length of line generally leads from the boat to the ascent-descent line.

When the anchor line is used for descent and ascent and a current is running, a length of line is secured from the stern to the anchor line. The diver holds this line, enters the water, and pulls hand over hand to the anchor line. In all current diving a brightly colored floating line with a float or floats must be trained behind the boat. If a diver enters and is carried away by the current, they can grab the trail line and pull hand over hand back to the boat. Typically, these lines are 100 to 300 ft (30 to 90 m) long.

6.1.10 Boat Maintenance

Following a dive, completely clean and inspect the boat. When working in salt water, wash the boat down with fresh water, particularly the engine. Make minor repairs (tighten screws, hardware, etc.) and carefully/correctly stow all gear. Dry out lifejackets and other moisture absorbing equipment. Carefully inspect for damage, especially after operating in a rough sea or hitting an object. Routine professional maintenance schedules must be developed.

6.2 Safety Precautions

Common sense and good judgment are the keys to diving and boating safety. Safety considerations are dictated by the personnel, environment, and type of boat. For example, John Dorr, University of Michigan, Great Lakes Research Division, developed the following guidelines for small boat operations (16 to 21 ft outboards) and research diving in the Great Lakes:

- Loads will be anticipated so as to avoid exceeding the capacity of the boat.
- Operations will not be conducted during marginal weather conditions
- Boats will be anchored or moored from the bow only
- The anchor line will be attached to the boat and retained in a ready position.
- In rough sea an anchor will be set in addition to securing mooring lines to fix anchorage buoys, especially for night operations
- Two buckets or bailing devices will be carried in the boat
- Emergency equipment (including flares, horn, whistle, and first aid kit) will be placed in a floatable container and secured to the boat
- Paddles will be secured to the boat
- Ideally, a radio telephone (marine band radio) should be carried if the boat cannot be visually monitored from shore
- If extended offshore operations are anticipated, a means of receiving continuous weather advisories should be available
- Do not overpower small boats or place too heavy of a engine on the stern
- No more than 6 scuba cylinders will be carried at any time (4 for diving, one for standby diver, and I extra; assume single diving operations)
- Equipment is carried for a maximum of 3 divers (2 divers and one standby diver)
- All dives will be conducted with a minimum of 4 persons (2 divers, 1 standby diver, and 1 boat handler/tender)

- During January to May and September to December all personnel will wear full diver type exposure suits (Great Lakes diving operations)
- Standby equipment and the standby diver will be in a ready status
- A strobe light will be displayed from the boat mast during night diving operations.
- Arrangements will be made to have all dives, especially night dives, monitored by onshore personnel. Specific emergency procedures will be provided in writing in accordance with location and situation. A beach master should be designated
- A contingency plan will be established in the event that the divers are separated from the boat. This plan will be established prior to the divers leaving the boat for every dive.
- Flare/smoke distress signals will be carried by divers
- Only the equipment and personnel necessary to complete the given task should be carried on the boat.
- After each dive, the boat should return to shore to drop off unneeded equipment and samples and to exchange personnel as required

6.3 Conclusion: Lessons Learned

The above guidelines were developed following an incident involving the capsizing of a dive boat at night during early spring in cold Lake Michigan water. Fortunately this incident did not result in loss of life or serious injury. The boat was heavily loaded with dive equipment and equipped with a large engine. The boat was secured to a mooring buoy about 8oo yards offshore when it began to take water over the stern. The boat rapidly filled and capsized. The individuals in the boat were not wearing exposure suits. However, they were able to climb onto the capsized boat and paddle it toward shore with their hands. Upon entering the broad surf zone they were thrown from the boat and swam to shore.

Meanwhile, the divers surfaced offshore. The night was dark and there was no boat in sight. They called to attract attention and waited to be picked up by the boat. Eventually, they realized that something must have happened to the boat. As they began to chill, even in dry suits, they discarded their scuba and began the long swim to shore. The severely damaged boat was found the next day some distance down the beach. All dive equipment was lost.

Chapter 7

DIVING AT NIGHT

Scuba diving at night, especially in tropical waters, has become a popular activity at recreational dive resorts and on live-aboard dive boats. These adventurous divers observe and photograph animals not normally seen during daytime dives. Also, being in the sea at night fulfills some fundamental human psychological needs for adventure and perceived risk-taking. In addition, marine biologists have discovered new assemblage of coral reef animals actively feed at night and this has opened new avenues of research.

This chapter is an overview of fundamental factors that a beginning diver should consider when planning and executing a night dive. Keep in mind that all divers are encouraged to acquire advanced and specialty course training which includes instructor supervised night dives.

7.1 Risk-Benefit Assessment

Most divers will agree that otherwise given equivalent circumstances, a dive during daylight hours has less potential risk than a dive at night. One obvious concern is with maintaining a proper buddy system. Although in clear water this is generally not a problem, limited visibility water may seriously reduce diver safety factors. Navigation is also more difficult and many divers become easily disoriented. Consequently, they may have to make long surface swims following depletion of their air supply in order to return to the boat or designated exit point.

Night diving in limited visibility is certainly more demanding and often carries a higher risk factor than diving in the same water during the day. Suspended particles in the water column reflect the beam of an underwater light in much the same fashion as automobile headlights reflect in a dense fog. In extremely poor visibility, the light becomes virtually useless.

All of the above would not represent as high of risk if the diver could easily see and avoid encountering hazards. Consequently, divers electing to dive at night must be prepared to accept a higher level of risk, take special precautions, use special equipment (in some cases), and obtain advanced training. For some individuals, the emotional stresses associated with perceived confinement, disorientation, unseen marine life, and surprise encounters may place them at an exceptionally high level of risk, and, if so, limited visibility diving is definitely contraindicated.

7.2 Equipment for Night Scuba Diving

Divers who operate at night and in limited visibility must be far more self-sufficient than daytime-only and clear water divers. Since buddy separation can occur more easily and air sharing is much more difficult to coordinate at night, the use of an auxiliary scuba emergency air source is far more attractive that relying on using a buddy's octopus or safe-second. At least one knife for cutting potential entanglements is mandatory. Underwater lights and surface signal device are the only items that will be covered in significant detail here.

7.2.1 Dive Lights

There are probably at least 50 styles and models of dive lights available. In selecting a light for travel diving, priority of selection is placed on size, weight, application, cost, and versatility. For highly specialized activities such as cave diving, the special underwater light requirements are beyond the scope of this paper.

A prudent diver will select a light that can be used year-round for many diving or non-diving applications. A good dive light will cost $40 to $100 or more. Selecting an expensive light that may only be used three or four times per year is a bit frivolous. If a light is designed to withstand the crushing pressure of 2000 feet of seawater, it should withstand normal everyday use.

In selecting a travel light that is reasonably compact and lightweight, one will have to make some compromises. For example, lights intended to illuminate large areas of cave or wrecks would blind many night reef creatures. In addition, very bright underwater lights intended for cave or wreck diving may weigh as much as 10 pounds and have battery packs more than 18" long. Such lights are simply too large, heavy, and expensive for the average traveling diver.

Several flashlight-size models weighing 10 to 16 ounces are available. The consumer should compare beam intensity, beam angle, beam quality (i. e., even illumination versus dark zones and hot spots), burn time, recharge time, and cost). LED light sources are quite bright for the their size and are becoming the light of choice for many dive operations. The shopper must be reasonable and accept the fact that they cannot expect the same performance from a five-pound light and a 10-ounce light.

The diver may select either a rechargeable or a disposable battery. Disposable battery lights have a lower initial cost, require limited maintenance, do not require the availability of electrical outlets for recharging, and have burn times of 3 to 10 hours. If the light is accidentally flooded with seawater, a good freshwater rinse and a new set of batteries and/or bulb is usually all that is needed to put it back in service, especially if it is attended to immediately.

Most compact dive lights use either AA or C batteries. Divers should always load lights with fresh batteries prior to a trip and take extras in accordance with projected use; also, include spare bulbs. It is sometimes difficult, if not impossible, to find proper batteries or bulbs in tropical cities or at resorts. From a standpoint of weight, four alkaline C batteries weigh 9 ounces and four alkaline AA size batteries weigh 3 ounces. For the average diver making only a few dives per year, disposable alkaline batteries make a lot of sense.

Rechargeable gel-cell batteries generally have a burn time of about two hours with a recharge time of up to 15 hours. They are more expensive than alkaline; however, they do pay for themselves if used with moderate frequency. They also require a periodic recharge maintenance program even when not in use.

Rechargeable Ni-Cd (Ni-Cd or nickel-cadmium) batteries are the most expensive ones commonly used in dive lights. They generally last longer and accept more recharges that most other rechargeable types. Burn time is 1 to 2 hours with recharge requiring up to 9 or more hours. The consumer must be aware that Ni-Cds are manufactured in various grades and matched cells should be used in the construction of Ni-Cd battery packs. Be sure to avoid polarity reversal that can be caused by completely discharging the batteries; this can significantly reduce the life of a battery pack. Wattage output is relatively constant until burn time is completed, then it drops sharply. Turn the light off when the beam turns yellow. Ni-Cds will pay for themselves if used with moderate frequency. However, they do require a periodic recharge maintenance program even when not in use. Ideally, Ni-Cd batteries should be stored at a temperature of 50° to 60 °F; avoid temperatures in excess of 110 °F. Improper maintenance or neglect can result in reduced life and, ultimately, destruction of the battery pack. Be certain to follow manufacturer's instructions for recharging and care.

The final selection is dependent on personal requirements. Keep in mind that the light need only illuminate the portion of the underwater scene that being viewed, not the entire reef. In addition to the various factors discussed above, consider grip, buoyancy, corrosion resistant construction, ease of O-ring examination/replacement, bulb availability/cost, accessories, and warranty. Depth could also be a factor, however, most manufacturers claim operation depths between 300 and 2000 feet, well beyond the range of ordinary scuba diving.

As with any item of diving equipment, the prudent diver will carefully compare diving lights and select a model that best fits diving needs and pocketbook. Look for a light that can be used for other recreational and everyday activities. Divers can carry a good dive light in the glove compartment of their car or keep it in your nightstand 365 days per year for use as an emergency light.

By using reasonable care in handling the light and maintaining it in accord with the manufacturer's recommendations, it should provide years of satisfactory service. Be sure to include spare bulbs and batteries in a spare parts kit. Always read the manufacturer's instruction manual supplied with the light completely and assemble necessary tools, parts, replacement batteries and bulbs, and special instructions in a travel repair kit.

The primary cause of light flooding is an improperly seated o-ring. If possible, determine if the o-ring is making a solid contact between the two sealing surfaces prior to each dive. Many underwater lights are designed and manufactured with clear plastic that allow the o-ring to be inspected. Through the clear plastic the o-ring should appear as a solid black line. The o-ring should be periodically removed, gently cleaned, lightly coated with silicone grease, and carefully replaced. Be certain that there is no sand, towel fibers, or other foreign matter on the o-ring. Under pressure, a tiny cloth fiber can wick large amounts of water into the housing.

Following each dive the light should be rinsed in fresh water, dried, and stowed where scuba cylinders and weight belts will not damage it. Ideally, the light should be disassembled and inspected for moisture. Even a small amount of water can cause serious damage to batteries and internal components within a few hours. Corrosion of batteries in a partially flooded light produces a gas build up and a highly acidic solution. Take great care in opening a light if it is suspected that water has entered the light. It may literally explode and spray the area with an acid solution that can damage clothing and skin. If this solution enters the eyes, serious injury and vision impairment may occur.

If the light floods during the dive, immediately turn the light off. Return to the boat, carefully open and drain the light. Avoid contact with the water drained from the light. Do not reseal the case! Disassemble the light as soon as possible and rinse all components with liberal amounts of fresh water. Dry the components completely.

Properly dispose of damaged batteries. Replace damaged parts as required. The light may then be reassembled and tested. If damage is significant or the will not operate properly, promptly return to factory for repair. Keep in mind that all dive lights have an airtight seal that restricts the venting of hydrogen gas produced by the batteries. This gas could cause the light housing to explode. However, most lights manufactured in the United States and some imports contain a hydrogen-absorbing catalyst. This catalyst may be located on the battery pack (rechargeable units), on/behind the circuit board, or on the reflector assembly. If a light is flooded, this catalyst must be replaced before resealing.

Ni-Cd batteries require special care. New battery packs do not generally reach full capacity until they have been recharged 20 to 30 times; 2 or 3 charges will bring them to near full capacity. Following several months of storage, the battery pack may have to be recharged to reach full capacity. Keep in mind that if Ni-Cd batteries are discharged to the same point many times in a row, they will develop a "memory" and reduce the light's burn time. This memory can be erased by several training cycles of running the beam down to a yellow glow and then recharging. If the Ni-Cd batteries have not been used for many months, recharge before switching the light on.

Very few scientific and recreational scuba divers carry flares or signal devices for use at the surface. They rely on the beam of their primary light. Today open water night divers are encouraged to carry a compact backup or secondary light for emergency use.

Most guides require night scuba divers to attach a "glow" light to their scuba valve or regulator first-stage or other visible location. In the event of light failure, the highly visible glow light can still determine the diver’s location. The light tube contains two separated chemicals. When the tube is bent, one chemical discharges and mixes with the other resulting in a soft green glowing light emission that lasts for several hours. Although green is the most common color, other colors are available. By using different colors on divers, underwater identification is simplified. Glow light may also be attached to small, stable surface floats towed by the divers. This enables surface personnel to track dive teams. Furthermore, by using different colors specific dive teams can be identified.

A compact, high-intensity strobe light may be carried for emergency signaling on the surface. These lights may be seen for several miles, especially from the air. A flashing light at sea is also more likely to attract the attention of persons on shore. Divers operating at night in areas of high current are encouraged to consider special signaling devices. These strobes are compact enough to conveniently carry in a BCD pocket. White strobes should only be used as emergency location marker since a flashing white light strobe is perceived as an international distress signal.

Military divers and surface swimmers often carry a combination day/night distress flare. One end contains a dense orange or red smoke for daytime signaling; the other has a red flare. The flare is activated by means of a pull ring. After the ring has been pulled the flare must be held at arm's length at an angle of 45° down wind from the diver. If the flare does not ignite immediately, waving it will generally cause ignition after a few seconds. The flare will not ignite if pulled underwater. Do not look directly into the flare because it will destroy night vision for a short time. Although an excellent safety item, these flares are expensive and not generally available to recreational and scientific divers.

7.2.2 Environmental Protection Garment

Divers are encouraged to wear complete environmental protection at night regardless of the water temperature. In some locations thousands of tiny jellyfish congregate near the surface at night. Either a thin neoprene or lycra hood and gloves are advisable.

7.3 Night Dive Procedures

Diving at night requires consideration of all the factors associated with daytime dives. Since dive planning and basic diving procedures have been discussed in detail in other sections of this manual, this section only addresses the added requirements for night diving.

7.3.1 Personnel Considerations

It is somewhat difficult to conduct a guided group dive at night except under the most ideal conditions. In the Caribbean Sea some organizations will have a guide lead small groups on underwater tours and a safety diver will generally swim slightly above and behind the group. In some cases buddy teams simply orient on the team in front of them and hope that that team is following the guide.

It is important to place a beginning night diver with an experienced night diver, especially for their first few underwater excursions at night. This will generally significantly reduce anxiety and thus improve safety.

It is very important to maintain a proper surface crew during night operations. The vessel must never be left unattended! The boat operator must be prepared to pick up distressed divers at any time. Ideally, a surface rescue swimmer should be available to assist divers in the water. Many larger dive boats will maintain a small inflatable boat and operator on standby whenever divers are in the water.

7.3.2 Dive Site Selection

Most dive sites frequented in daylight hours will be acceptable for night operations. However, the prudent diver will use greater care in avoiding locations with strong surface currents, rugged shore line entry requirements, high surf, and night boat traffic. Furthermore, operations should be suspended when surface conditions such as fog, rain, or snow may hinder the diver's return to the staging area or vessel.

Dive sites with distinct topographic features such as slopes, ledges, sand channels, etc. are more acceptable because they provide the diver with natural navigation features. Ideally, divers should be familiar with shore (and/or surface conditions) and underwater features. The prudent diver will do a familiarization dive during the day on a new location prior to a night dive.

7.3.3 Defining Dive Parameters

The dive area boundaries must be well defined. Divers should be restricted to a specific radius of operation. The exact radius depends on the experience level of the divers, the site, environmental conditions, nature of the operation, etc. If the dive site is well selected and the vessel is properly anchored, prudent divers will operate within a radius of 100 yards or less.

Divers must strictly observe depth and time limitations. Decompression dives at night should be avoided. Since most dive instruments are not illuminated throughout the dive, some divers may become careless in instrument monitoring. Take special care! Furthermore, prudent diving supervisors will generally designate a specific time for dive termination. This means that all divers must be on board and accounted for at that time. Stories of dive vessels pulling anchor and returning to shore only to find that some one is missing are not without foundation.

7.3.4 The Night Dive

Every dive site is unique. Consequently, it is difficult to establish specific procedures to address the requirements of all geographic areas and water conditions. Also, divers participate in various geographic specific activities such as photography, collecting lobsters, and collecting shells. Most simply go sightseeing. Night diving interest has increased significantly for divers vacationing in tropics over the last decade. The following is a more or less generic approach to night diving that is slightly biased toward tropical oceans.

Leave shore for the dive site at a time that will assure arrival at the site and anchoring well before dark. In some clear tropical locations it is beneficial for the divers to make a short snorkel swim before dark to view the orientation underwater features. This could be significant in navigating and maintaining orientation at night.

Ideally, the vessel should be anchored in a sand channel or flat area adjacent to a reef or major bottom feature. Avoid anchoring the boat on delicate reefs or in a position so that it will swing over a reef. Beginning night divers need an opportunity to adjust buoyancy and equipment before venturing about. They generally descend to the bottom as part of this adjustment procedure.

Be certain that the anchor is secure, or if using a permanent mooring, the line is secured to the anchor unit. Ideally, a crewmember or local dive guide should be deployed to inspect and secure the anchor prior to deployment of other divers.

The exact procedure for preparing the vessel will depend on the type of vessel and the environmental conditions. If there is any hint of current, a floating trail line with a light marker at the end should be deployed. This is a line 100 to 200 feet in length with a series of small floats. Some will attach small lights to line floats to assist to make the line more visible.

A distinct surface light should be placed at a high point on the mast or other elevated feature in a position so that it is visible from any position in the water. This is to guide divers who might surface away from the vessel. Large boats are often visible because of deck lighting.

Some divers will use the anchor line of descent and others will deploy the preferred weighted descent-ascent line at the entry-exit point. Ideally, a light should be fixed to the line in mid-water and on the line weight which is usually several feet off the bottom. A similar light arrangement may be used on an anchor line. Some divers use chemical glow lights and others use flashing strobes. Still others prefer a standard underwater hand light. Regardless of the type used, it should have 360^0 visibility.

Divers should be briefed well in advance of deployment. Ideally, the briefing should take place before darkness so that the divers can get some visualization of underwater features. In calm, clear water reef areas will tend to appear dark and sand areas light. The briefing should include a sketch of the underwater area and a recommended course to follow. It is essential that the diving supervisor define depth and time limits as well as verifying that all divers have had sufficient surface intervals following prior dives. Avoid mandatory decompression dives.

The diving supervisor must also identify specific characteristics of the site, currents, and potential hazards. Also, the Diving supervisor must designate special procedures to be followed in the event of light failure, diver separation, and need for assistance at the surface. Other briefing factors specific to the site, vessel, and activity must be addressed. Dive teams must be allowed sufficient time after the briefing to discuss individual dive plans and ask questions. The diving supervisor shall designate a specific time that all divers must be back on deck for post-dive roll call. It is each diver's responsibility to adhere to this requirement.

Individual divers may prepare their equipment either before or after the briefing. Ideally, lights have been assembled and inspected prior to departure. Scuba assembly and pre-dive inspection is best accomplished in daylight. Attempting to do this in darkness and by hand light is difficult and may increase the likelihood of mistakes. Divers must take special care and the diving supervisor needs to verify that the divers enter with complete and properly assembled equipment. For example, many divers are careless with their safe-seconds (octopus regulators). They may be caught under straps, in a BCD pocket, or dangling behind the diver. In the event that the unit is needed, in an emergency, locating it can be quite difficult in daylight and next to impossible at night.

When diving from a large vessel it is desirable to deploy a small pickup boat. In the event that a diver is injured or surfaces far from the vessel, the diver can be more easily retrieved using the small boat. Generally, a response team remains on standby on the large vessel and scans the ocean surface for signals. In some cases the safety boat will be used to follow a group of divers. The divers may be tracked by the glow of their underwater lights or by a small-lighted surface float towed by one of the divers.

Ideally, divers should be deployed before darkness. As the sun sinks below the horizon there is unique underwater twilight that fades rapidly to darkness. I encourage beginning night divers to enter the water early in this twilight period. In the tropics the last of the daytime feeder (fish) are moving into the security of the reef for night. For a few moments there is a unique serenity. As darkness falls the night feeders emerge. In this twilight a diver can observe surrounding features, establish orientation, and adjust to the dimming light.

Swimming underwater at night is much like swimming in the daytime. Divers range of vision is generally limited to the illumination of their dive light. They are aware of divers around them from the glow of the hand lights and chemical lights. Divers should be briefed to never point their lights into another diver's face!

Some nights in shallow, clear tropical water divers can turn out their light and actually swim by moonlight. As eyes adjust, bottom features become quite distinguishable. The movement of fins leaves a trail of tiny sparkles - the cold light emitted by stimulation of bioluminescent plankton.

Night divers must have exceptional buoyancy control. Without visual references beginning divers tend to lose track of their position in the water column and must make a special effort to properly adjust buoyancy. Also, divers must take care when kicking close to the reef or bottom in order to avoid damage to marine life or injury to themselves.

Divers must pay more attention to navigation at night, especially if it is intended to exit at a predetermined location. Observing ripple marks, current direction, feature trends, and moonlight as well as the compass is necessary throughout the dive. Divers should monitor their instruments at frequent intervals. They should plan to be back at the boat with plenty of air remaining and well before the designated termination time

Divers may use normal hand signals that are illuminated by the lights. But, the light beam itself can be used as signal:

- Emergency: Swinging the light back and forth on the horizontal plane crossing other diver's light beams
- Attention: sweep the light beam up and down in a vertical motion.
- OK: a slow circle

If a primary light fails during the dive, the light should be secured and a backup light is then used. Stay close to other divers and rely on their light(s) for viewing underwater scenery. A backup light is generally only satisfactory for viewing small areas and instruments. Some diving supervisors require that the buddy team immediately return to the boat if one primary light fails. This is discretionary based on diver experience level, environmental conditions, and number of carried backup lights. Many divers now carry compact backup lights that have higher light output than primary lights used several years ago. Divers must observe policies established by the Diving supervisor.

If separated, look for diver's light beam or a chemical light. Turning a light off for a few seconds may assist in locating other divers. If a short visual search is unsuccessful, the diver should make a controlled ascent to the surface, inflate their BCD, and wait for other divers to surface. While on the surface, sweep the dive light below the surface and occasionally across to surface to facilitate being found. Diving supervisors are encouraged to review diver separation procedures in the pre-dive briefing.

In the event that a diver is injured, caught in a current, fatigued, or distressed at the surface some distance from the dive vessel, a small boat should be available for emergency deployment. In some cases where a small boat is not available, a rescue swimmer may have to be deployed or the dive boat moved. This can be very complicated if the injury is serious or if there are a number of divers in the water.

Divers may attract attention of the Diving supervisor or other persons by waving and/or flashing their dive lights and blowing their whistles. Ideally, each diver should be equipped with a strobe light to use as an emergency signal. Prior to the dive, the diving supervisor should identify signal methods.

The fear of an adverse marine life encounter is probably the most stressful aspect of night diving for some individuals. In fact, this fear can be so significant that some individuals should be discouraged from diving at night. For the most part such fears are without foundation. There are few, if any, actual documented reports of shark attacks on divers at night. In reality, a surface swimmer is probably at much greater risk than a scuba diver.

Most marine life injuries result from careless encounter with coral or sea urchins. Jellyfish stings are also common. However, at one time or another all night divers have a serious flash of anxiety when they think they see a large form move in the water outside of the range of their light beam.

Divers should return to the immediate vicinity of the support vessel well before the designated dive termination time. Ideally, the vessel will be anchored in relatively shallow water so that the dive may be completed at the 10 to 30 foot ascent control stop while casually viewing the underwater scene. In some cases a decompression bar will be suspended below the boat or the divers will simply stop on the ascent line.

After divers have completed any stop requirements, they should ascend slowly to the dive platform or ladder and immediately leave the water. One of the most unpleasant aspects of a tropical night dive may be encountered during surfacing and exiting the water. In some locations, thousands of tiny jellyfish congregate just below or at the surface at night. The stings are more annoying than painful. The diving supervisor will generally inform divers if this encounter is likely to occur and advise divers on exiting procedures.

Once on the boat, the divers should report to the Diving supervisor and then remove and stow their equipment.

One procedure that is often neglected by Diving supervisors is post-dive roll call. Too often I have heard a Diving supervisor say, "Is everyone on board?" Dive boats have returned to shore only to find that a quiet team of divers is missing.

Shore-based dives are conducted using basically the same procedures as stated above, except the dive is staged from a well-selected location on a beach or from a pier or dock. The staging area should be established well before dark. This location is marked with some sort of light or lights. Ideally, one light is located near the water and another farther up the beach slope. Aligning the two lights (which serve as a range marker) enables surface swimmers to return to shore on a straight course. In some cases permanent lights such as street and building lights may be used. However, do not rely on house lights that might be turned off during your dive. Be careful with regard to the position and type of shore light that you use to assure that it cannot be mistaken for a navigation light by boaters.

7.4 Summary

Night diving can be a very pleasurable and rewarding experience. However, by comparison, diving in restricted visibility, both surface and underwater, is potentially more hazardous that diving during daylight hours. Many of the same procedures associated with limited visibility diving in daytime also apply to night diving.

Night dives must be well planned and properly supervised. Special attention is given to beginning divers to assure that they enter the water under optimum conditions, establish orientation, and navigate properly. Buoyancy control is very important. Divers are encouraged to carry a backup light and display a chemical glow light. Although the basic principles of buddy diving apply, a higher degree of self-sufficiency is desirable in night divers.

Chapter 8

Dive Records

8.1 The Diver's Logbook

The diver's logbook is a permanent record of training, experience, and qualifications. A record of diving experience is essential for advancement in research diver classification at various universities and governmental agencies. Diving instructor applicants are required to provide a record of a minimum number of dives or hours underwater in order to qualify for acceptance into instructor training programs. Employed divers are required by both management and occupational safety and health regulatory agencies to maintain an accurate record of all dives.

Unfortunately, no standardized procedures or format for diver records exist at present in the civilian diving community. This is left to the discretion of the individual company, school, or agency. Most often the diver's individual logbook is a matter of personal preference. Several excellent formats most commonly used are listed below:

- Cumulative loose-leaf record sheets on which each dive is entered on a separate line are used most commonly. Vertical column headings generally include date, location, depth, time, environmental conditions, and buddy. Many universities use this format to facilitate submission of monthly records.
- Several diving logbooks are available to recreational divers that use a separate page for each dive entry. Some books provide headings and spaces for a fairly complete record of the dive.
- Research divers often combine the diving record with a comprehensive field observation or data book. These books are generally relatively large bound notebooks. A standard dive record format may be designed and placed on a rubber stamp.
- Some divers simply keep a diary-type record in a small notebook. There are no special forms or formats. This is the least expensive method of recording dives. However, it is the most difficult for others to review in terms of qualification advancement, employment records, or evaluation of experience.

8.2 Information to be Documented

Before one can design the "ideal" diver's record book, one must first determine what information must be included in the record, how this information may later be used, and who will use it. In general, employers, health and safety officials, and diving coordinators agree that the diver should record the following data for each underwater or pressure exposure:

- Date and time
- Geographical location
- Name of buddy
- Names of support crew directly associated with the dive
- Depth of dive
- Bottom time, decompression schedule (if required), and total dive time

- Environmental conditions (sea state, underwater visibility, water temperature, atmospheric temperature and conditions, and current)
- Type of equipment used
- Brief description of work performed or dive activity
- Unusual conditions and/or observations made during the dive
- Description of injuries (if any)
- In the case of a working dive, the employer should be designated

8.3 Official Document Requirement

The above data should be recorded in a hardbound book and, in the case of working dives, each dive must be verified by the supervisor or an employer representative. The recreational divers may not wish to go to such a comprehensive procedure for each dive. However, the above procedure has many excellent points.

Why use a hardbound record book instead of loose-leaf fillers in a ring binder? It seems that the loose-leaf method is more flexible, less expensive, and easier to use. True! However, the working diver's log book is a legal record of their activity in the event of a future court case that involved something that occurred during that dive or as a result of the work or observation accomplished on that dive. The hardbound book is more likely to be recognized as a legal document whereas the loose-leaf sheets from a notebook mayor may not be considered acceptable. This is an especially important factor for recreational diving instructors and dive masters.

Many divers will use a recreational dive log from their initial training, but keep a separate record of all dives in a bound account ledger type book. This provides a convenient on-site record with the legal acceptability of bound, numbered page entries.

Some divers transfer their dive logs to dive log software applications. Without date/time entry verification, these easily manipulated records are not legal documents and may not be useful in any legal situation.

8.4 Other Information

The "ideal" diver's record book should include much more than an entry for each individual dive. The most important additional data includes:

- Records of periodic medical examinations
- Records of training in diving
- Records of activities such as first aid, CPR, boating, etc., that relate to diving
- Records of diving-related employment
- Record of personal equipment including serial numbers or identification markings
- Annual dive summaries or re-qualification designations
- Record of equipment malfunctions/problems
- Records of equipment maintenance and inspection
- Notes on special related activities

8.5 Using the Logbook

The first entries in a diver's log book should be the pre training medical examination results and a verified record of completion of training. Some agencies prefer to include a cumulative training, experience, and qualification summary page. Instructors and supervisors can enter brief notations verifying special training or advancement.

The diver can briefly summarize each year of diving experience. fo example, the diver may enter the following summary, "1989 dive summary: 56 scuba dives, depth 20 to 110 fsw including 6 dives over 80 feet, 37.8 hours total cumulative dive time; 14 surf entries southern in California, 10 boat ocean dives in Caribbean."

The diver's log sheets may be reviewed and this entry verified by the agency diving officer, dive club safety officer, or other "official" persons. Divers not involved with agencies or clubs simply make the entry and personally attest to its accuracy. This is much simpler for people viewing the book than attempting to count or read each individual dive log sheet. In this fashion, several years of diving experience and training can be recorded on a single sheet for "quick-look" review.

Some diver record books include special sheets for periodic depth gauge calibration data, flotation unit (BCD) inspection, regulator inspection, and cylinder inspection. These records are vital to diving safety.

A cumulative medical record sheet should include entries of periodic medical examination (signed by a physician), illness or injury related to diving, and medical information that should be known by persons who might be treating a diving accident victim. The diver or his buddy should give the diver's logbook to the attending physician if it contains this information.

How is the information in a log book used?

For a commercial or scientific diver this data becomes vital for qualification or classification advancement. In research diving it is a common practice to limit the depth and/or environmental condition exposure for a diver until he has acquired sufficient experience and proficiency to advance to the next level. The diving supervisor, project director, and/or division representative must neither force nor permit a diver to exceed his level of qualification. In many cases the diver's logbook is consulted as a verification of the diver's qualification before assigning work tasks.

As previously stated, candidates for scuba instructor certification must provide the course or institute director with a complete record of diving experience. In order to qualify for certification the individual must have logged a given number of dives and/or hours underwater using scuba. In past years this requirement has often been waived since many recreational divers have not maintained records of their experience. In other cases, especially with loose-leaf logbook binders, it is probable that records have been falsified. In reality, hardbound record books should be considered mandatory if an individual anticipates eventually qualifying for scuba diving instructor certification.

A diver certification card generally does not indicate environmental condition exposure or training. A diver trained to dive in a calm, small, shallow quarry in the Midwest receives the

same plastic card as a diver trained to dive under rigorous surf and ocean conditions of northern California. What happens when a diver travels from the Midwest to northern California? How does the charter boat operator, the dive master, or the buddy determine the diver's qualifications? What about the average recreational diver who never intends to work underwater, take an advanced course, or become an instructor? Why should this individual maintain a log book? At the completion of basic training the diver generally receives a plastic certification card. This card simply indicates that the individual completed a training course in accord with a given minimum standard of knowledge and skill performance. Realistically, this card does little more than identify that the individual is qualified to scuba dive in a swimming pool and that the diver has
participated in a few supervised open water dives. Certainly, it does not indicate a level of proficiency in open water diving since many authorities recognize that it takes at least 10 to 12 open water diving exposures to gain acceptable proficiency for even shallow open water scuba diving.

In recreational diving as well as commercial and research diving there are now many levels of training or advancement following entry level certification. These may include advanced open water, medic first aid, rescue, dive master, assistant instructor, and instructor certifications for recreational scuba divers. In addition, a number of specialty certifications such as cave diving, ice diving, and underwater photography are available. Various prerequisites in terms of training and experience are necessary for acceptance into these courses. The log book is the diver's only record of experience.

In commercial diving, qualification advancement is based on field experience, diving proficiency, and technical proficiency. The diver must maintain and verify a specified number of dives or exposures each year in order to maintain a given qualification rating. These various ratings include tender/trainee, tender, diver/tender, air diver, rack/console operator, mixed gas diver, saturation diver, lead diver, air diving supervisor, and mixed gas diving supervisor. Advancement and designation depend upon number of field days diving and tending, specific number of dives (with minimum depth and bottom time requirements) at each designation, and technical training. The diver's record book with employer verification is his only personal record of experience. This record is vital to his advancement, work assignment, and pay-grade designation.

The log book is the primary cumulative record that divers use to verify experience and qualification. Charter boat operators, dive masters or tour guides, or even a potential dive buddy may ask to see some sort of verification of experience that indicates that a diver is qualified to participate in a given diving activity. The diver's log book has become the primary legal record to document diving training and experience.

Scores of diver's logbooks are available from instruction agencies and diving equipment supply stores. Some universities now maintain records on computers. In such cases divers complete a special single page form for each dive and submit it to the Diving Office. Divers are encouraged to select their personal record-keeping system to meet present and anticipated future requirements.

The diver's logbook is neither a private nor confidential document. As evident in the above discussion a number of persons including advanced course instructors, dive masters, instructor training directors, employers, charter boat operators, court officials, safety inspectors, supervisors, project directors, and diving buddies will at sometime or another review the content. As such, the entries must be neat, complete, and factual.

Appendices

Appendix A

Scuba Diving Equipment

SCUBA DIVING EQUIPMENT

The scientific diver has both a personal and team obligation to arrive at the dive site with a complete outfit of safe and functional diving equipment appropriate for the activity and environment. The equipment must be maintained in accord with standards designated below.

Individual Equipment

Mask, Fins, and Snorkel

These are the basic items of equipment for all divers. The primary factors in mask and fin selection are quality and comfortable fit. A low volume mask without a purge valve is recommended. Corrective lenses should be installed in the mask for individuals with impaired vision. Although soft contact lenses may be used with a mask, the diver must risk loosing the lenses if the mask is accidentally flooded. Divers working in remote locations should seriously consider including an extra corrective mask lens in their kit.

Fins should fit comfortably with boots or coral shoes. Some cold water divers will select two pair of fins - one for lightweight tropical boots and a larger pair for use with a dry suit. Adjustable, open-heal fins are recommended. A high-quality snorkel with a comfortable mouthpiece is necessary for surface swimming.

Boots or Coral Shoes

Boot selection depends upon the diver's environment. Low top boots of 3 mm foamed neoprene are quite adequate for tropical diving. High top 9 mm foamed neoprene boots may be use for both topical and temperate climate diving. Most boots are constructed with a firm sole to facilitate walking on decks or rougher surfaces. Divers who anticipate activities involving shore approaches from sea with considerable running or waking on sand and rock or in swampy areas should consider wearing coral shoes. Theses shoes are constructed of lightweight canvas with rubber soles and are similar to old-style high-top wrestler's shoes. The shoe may be worn without socks or over socks or a thin soft sole neoprene boot for added comfort and thermal protection. Coral shoes are less satisfactory than conventional neoprene boots for long distance swimming, however, the are superior for movement on shore and in wetlands. Navy swimmers have used coral shoes since the early years of UDT operations. However, these shoes have never entered the civilian diving equipment market. The L. L. Bean Maine Guide Shoe is an excellent substitute.

Surface Swimmer's Personal Flotation Device

Although scientific divers are to be skilled swimmers, the use of an inflatable collar-style buoyancy unit is considered mandatory for personal safety during surface swimming operations, especially when assisting another swimmer. Although the standard US Coast Guard Approved Personal Flotation Device (PFD) is required on some vessels and by some organizations, many diver support persons actually prefer using an inflatable unit. Conventional recreational skin diver units are poorly designed and fragile; most suppliers do not even stock reasonable quality collar-style buoyancy control units. The Navy's UDT Inflatable Life Jacket many be acquired through special arrangements and is to be used by scientific divers. This compact unit fits comfortably and offers minimal resistance to movement and swimming. It may be inflated orally or with a high-volume CO_2 inflation system.

Environmental Protection

The degree of environmental protection is determined by atmospheric conditions, water temperature, personal cold tolerance, activity, and exposure time. Thin fabric body suits have become popular in the recreational diving community. Although these suits offer excellent protection form sun and some protection against injury from contact with marine organisms, they offer little or no real thermal protection. It has been shown that divers working in warm tropical waters experience varying degrees of thermal stress and low-level hypothermia is a potential problem. Full body 1.5 to 3 mm thick foamed neoprene suits are recommended for tropical diving. Supplemented with a 3 mm hooded vest a 3 mm body suit provides adequate thermal protection for limited duration scuba diving in temperate latitudes (lower Michigan-northern Ohio) during months of July through September.

Some individuals dive year around in 9 mm foamed neoprene suits. Although these suits provide adequate protection in 50 to 60° F surface water with limited exposure to lower temperatures below the thermocline, they compromise the diver's thermal condition during exposures to cold atmospheric conditions. The use of a dry suit with appropriately layered undergarments is recommended for water temperatures below 55° F and atmospheric conditions with a temperature or wind chill factor below 45° F.

Weight Belt

A weight belt is required to offset natural buoyancy and environmental protection garment buoyancy. Although the traditional nylon web belt with lead weights is satisfactory, a compartmented nylon mesh belt with zippered closure is far more versatile and comfortable. Conventional lead weights or packets of lead shot may be easily inserted into these pockets. Beginning divers and persons who change equipment configurations frequently should avoid lead heavy "hip weights" and traditional single compartment pellet belts. Heavy hip weights limit weight/buoyancy adjustments. Ideally, the belt weight should be adjusted to the pound whenever there are equipment or environment (fresh vs. salt water) changes. Divers must avoid over-weighting themselves and must keep in mind that the weight belt is an expendable item of equipment that may be discarded to achieve flotation.

Knife

A small knife with a line cutter carried in a low-profile sheath is more desirable than a large, heavy knife for most diving activities. The sheath may be secured to the buoyancy control unit, arm, or leg. Some divers carry small EMT shears or skydiver's compact line cutter tools. Special tools may be carried for projects requiring cutting heavy materials, prying, and digging.

Scuba

Modern open-circuit scuba generally consists of a cylinder, regulator (fitted with an instrument unit, BCD inflator, and auxiliary second-stage), and combination backpack-buoyancy control unit. Each component is discussed separately in the following paragraphs:

Scuba cylinders are available in volumes (of free air) ranging from 15 to more than 100 cubic feet. Small cylinders (less than 50 cubic feet) are general limited to use in emergency scuba units (pony bottles). In selecting a cylinder, divers must consider diving duration, personal air consumption, cylinder weight, cylinder diameter, and cylinder length. Ideally, a scuba cylinder should be approximately neutral buoyant when empty, short enough to not interfere with upper leg movement while swimming, and have the smallest diameter for a given air volume. Heavy, large diameter cylinders may prove to be unstable and cause the diver to roll sideways when the body is tilted to the left or right. Although the initial cost is high and periodic maintenance (inspection) cost doubled or tripled, low profile multiple cylinder units offer excellent swimming characteristics.

A number of high-quality regulators with excellent performance characteristics are available today. Most regulators supplied by major manufacturers perform within an acceptable breathing standard for recreational and scientific diving (within accepted depth limits). Several of the "hi-tec" regulators provide an abundance of air with negligible breathing resistance. Divers should thoroughly research and evaluate a regulator and test dive the regulator prior to purchase. Some individuals find breathing characteristics of extremely high performance regulators to be uncomfortable and annoying. Since most retailers will not provide test dive opportunities, divers will probably have to rent or borrow the regulator. Information on sustained performance, problems, and maintenance cost can often be acquired from other divers. Also, divers are cautioned with regard to purchasing newly designed regulators (or any major item of equipment) within the first six months to one year of release. Keep in mind that the consumer is the alpha equipment tester of the diving industry. It takes about a year of use for divers to identify problems and manufacturers to make corrections.

Several emergency breathing unit options are available to the modern scuba diver. The auxiliary second-stage option (octopus or safe-second) dominates recreational and scientific scuba diving today. This axillary unit does not allow for independent resolution of a loss-of-air supply problem; an out-of-air diver must depend on sharing another diver's air. As such, some divers prefer to carry an independent system. Depending on the individual and the diving situation independent secondary systems can range in size from a compact 2 to 3 cu ft integrated cylinder-valve-regulator unit to a separate 100 cu ft scuba fitted beside the primary scuba in a dual backpack assembly; 30 to 40 cu ft units are most common.

A scuba divers instrument unit generally consists of a pressure activated timer, depth gauge, cylinder pressure gauge, and compass. These components are packaged into a single unit (console) that is attached to the regulator's high pressure hose. Both digital and analog instruments are currently in use, however, digital units are gaining significant popularity.

Instrument units are available as a single integrated system or as an assembly of individual components. Some dive computers provide all data (except compass direction) in a single digital and graphic display including gas absorption status and remaining air time. Unfortunately, if the unit malfunctions, the dive loses all critical information. Divers working in remote locations may wish to consider component instrument units since spare components may be included in the spare parts kit. If a single component malfunctions the remaining components are not compromised and the faulty component can be more easily replaced in the field.

Signal Devices

The type of signal device(s) carried by a diver depends on the environmental conditions and diving activity. Most divers routinely carry a whistle for attracting attention on the surface in an emergency. When diving in currents or offshore, divers are encourage to carry a long, slender plastic tube that can be inflated and held upright. This device can be seen for long distances if the diver is carried away from the boat by the current. Although not generally available to civilian divers, smoke flares are excellent for attracting attention and identifying position in an emergency. The US Navy uses the MK 13 Mod 0 Day-Night Distress Signal. These signal devices include both orange smoke (day) and red flare (night) signal capability. The MK 13 signal may be acquired for civilian use. Night divers should carry a high-intensity strobe light to attract attention in an emergency.

Underwater Light

A variety of underwater lights ranging from high-intensity cave diving units with large belt mounted battery packs to single AA cell penlights are available today. With the introduction of alkaline and lithium batteries, gas-filled bulbs, and improved reflectors, divers no longer need to carry massive lights to provide adequate underwater illumination. Naturally, the type of light used will depend on the requirements of a given diving operation. However, an increasing number of divers are using compact three to six C-cell models for routine night diving. Because of infrequent use, most divers find disposable batteries more economical and easier to use and maintain than rechargeable batteries.

Special Equipment

When diving in limited visibility water each diver should carry a compact marker float fitted with a small weight and thin line of a length appropriate for the depth. This float may be deployed in the event that an item of equipment is lost or divers are separated and one does not surface. A six-foot floating buddy line is also standard equipment for limited visibility diving. Each diver is encouraged to include a 100 foot rescue-search line as part of their dive kit.

Tool and Spare Parts Kit

Every diver should assemble a tool and spare parts kit. The components of the kit will depend upon the diving activity, geographic area, the availability of a well stocked team kit and availability of parts at the dive location. The diver should be capable of replacing select parts in the field. When working in remote areas divers are encourage to carry selected replacement components rather than a number of individual parts to repair disabled components. A list of recommended tools, components, and parts is included in the appendices.

First Aid Kit

Every diver should assemble a first aid kit, however, the contents of the kit will very with activity, geographic location, team kit contents, and availability of first aid supplies at the diver location. Most frequently divers will have to deal with minor abrasions, sunburn, insect bites (tropics), and dehydration. Selected first aid items should be carried in a waterproof container in the dive bag.

Transport Containers and Bags

Most divers transport equipment in fabric duffel bag. However, proper selection of a bag or container depends on the type of transport vehicle, staging area, and equipment protection required. For air transport a duffel bag is generally satisfactory, however, it affords minimal protection of the contents from physical abuse. Delicate items may be placed in rigid, padded containers prior to packing. Many divers use standard inexpensive suit cases (hard or soft models) in order to better conceal the fact that they are transporting expensive diving equipment. In any case, do not advertise the contents of your container with decals and diving equipment manufacturer markings. Upon arrival at the dive location equipment is assembled and transferred to a net bag for field operations. When traveling by vehicle some divers prefer to use rigid plastic containers. Equipment can be easily stowed on most boats in these containers and wet equipment may be conveniently placed in the container between dives.

Equipment Standardization

Scientific Dive Teams are encouraged to evaluate several regulators, buoyancy control units, computers, and select standardized equipment for all members. This simplifies equipment servicing and maintaining parts inventories as well as assuring that all team members are familiar with each diver's equipment.

Team Equipment

Team equipment will vary depending on the diving mission, the diving environment and the funds available. The team typically provides equipment too expensive for individuals to provide. At a minimum, team equipment typically includes:

- Oxygen Delivery Unit. Immediate administration of oxygen by demand valve is second only to CPR (if required) in caring for a diver with suspected air embolism or decompression sickness. Scientific diver teams are to include a demand-type oxygen delivery unit (ODU) as part of team equipment for all outings and expeditions. If dives are to be conducted from a commercially operated vessel or dive site, it is the Team Leaders responsibility to assure that a satisfactory and functional ODU is available as part of the boat/site equipment. All scientific divers are to be trained in the use of ODUs and administration of oxygen.
- First Aid Kit.
- Tool and Spare Parts Kit.
- Search and Rescue Equipment.

Equipment Maintenance

Divers are responsible for maintaining their personal diving equipment. Certain items of equipment require periodic professional inspection and service in addition to personal inspections and routine post-dive maintenance. Equipment exhibiting any signs of performance impairment or malfunction must be taken out of service and repaired. Do not continue to dive with malfunctioning equipment. Many of these individuals are not certified to service some regulators and cylinders. Always test regulators in a controlled environment after servicing. Also, use caution during the first few dives with new equipment.

Routine Post-Dive Procedures

Immediately upon returning to the staging area (boat or shore) equipment is consolidated into a container, bag, or compartment. This is not only good etiquette but also reduces the possibility of equipment loss or damage. Cylinders are secured in designated locations. Any item of equipment that malfunctioned during the dive must be repaired or replaced. Do not use questionable equipment on subsequent dives. Upon completion of daily diving activities equipment is rinsed in freshwater, dried, and properly stowed. A dry regulator dust cap must be securely positioned over the regulator inlet orifice immediately upon removal from the cylinder valve. Prior to storage equipment should be thoroughly dried, inspected, and repaired as needed.

Periodic Regulator Maintenance

Regulators are to be inspected and cleaned annually by a qualified technician. Selected parts may require lubrication and/or replacement. If you use a combination BCU inflator auxiliary second stage, that unit must also be submitted for annual inspection. If you regulator exhibits signs of substandard performance or malfunction, it must be professionally serviced immediately - do not continue use! If the regulator is taken to a diving equipment retailer, ask to see the certificate of training by the regulator manufacturer of the technician who will inspect or repair the regulator. Scuba equipment authorizations are by individual manufacturers, so be certain to inspect the credentials of the service technician. Unfortunately, some regulator repair persons have no formal training.

Periodic Cylinder Inspection

Annual inspection of the interior and exterior of scuba cylinders has become a standard of care in the diving community and most commercial air fill facilities will not charge a cylinder that lacks a current certificate of inspection. If the cylinder is taken to a diving equipment retailer for inspection, ask to see the technician's certificate of training for cylinder inspection. Unfortunately, may cylinder inspectors have no formal training.

Periodic Inflatable Lifejacket and Buoyancy Control Unit Inspection

All inflatable diver flotation units are to be inspected prior to each dive to assure that that the inflation-deflation system is functioning properly and that they will hold air. Diver injury and fatality has resulted from malfunction of BCU s. Every 30 dives or six months, whichever comes first, and prior to use after extended periods of storage, flotation units should be inflated to maximum capacity and leak tested. If the unit holds air for four hours without notable loss, it is considered acceptable. If the unit loses significant air, the leak must be identified and the component repaired or replaced. Units with CO_2 inflation devices are tested by activation of the CO_2 cylinder. Since there is no community standard for inspection, replacement, rather than repair, of malfunctioning components is often required. The same standard of inspection and care applies to dry suit valves.

Depth Gauges

Depth measurement devices should be tested annually for accuracy. Test may be performed in the water using a accurately marked and positioned chain. As the diver descends along the chain both actual depth and gauge depth readings are noted on a slate. A similar test by be performed using a pressure chamber and a precision test gauge. A correction tag may be secured to the gauge.

Dive Computers

Most computers are sealed units that require only limited maintenance. Post-dive washing/drying, periodic battery replacement, and reasonable care in handling and transporting are the primary maintenance considerations. The most critical consideration for most users is proper replacement of the battery and assuring that the battery compartment is properly sealed. Improper battery replacement is the cause of many in-field failures. An increasing number of computers are completely sealed and use long-life batteries. These units must be returned to the manufacturer or a designated service center for battery replacement. Computers go through an automatic systems check upon activation. If a malfunction is identified the computer will not advance to the dive mode. A malfunctioning computer must be returned to the manufacturer for repair. Some manufacturers encourage divers to return computers to the factory for annual inspection and servicing. as with any item of equipment, computers are to be maintained in accord with manufacturer instructions.

Knife

Dive knives are to be periodically inspected and lubricated. Corrosion can be removed with a very fine grit emery paper or polishing compound and cloth. Knives may be sharpened with a stone and oil or by a knife sharpening service (through businesses that sell and service cooking utensils).

Record of Inspection and Repair

A record of all periodic inspection and repairs is to be maintained in the Scientific Diver Training and Certification Record. This notation includes the date and name of the organization/technician performing the service. In addition, receipts and inspection documents/forms are to be maintained in the diver's files. A professional service organization will provide a form designating the test and inspection results, services performed, and parts replaced.

Long Term Storage

Equipment must be thoroughly cleaned and dried before storage. Store equipment in a cool, well-ventilated area away for water heaters and furnaces (to reduce rubber deterioration). Cylinders are best stored with 0 psig of air and valve closed. Regulators should be positioned so as to reduce or eliminate strain on hose-fitting connections. If planning a trip after long-term equipment storage, always inspect test the equipment at least two weeks prior to the trip to assure that all components are operations satisfactorily.

Appendix B

Diving Supervisor's Checklist

DIVING SUPERVISOR'S CHECKLIST

GENERAL PLANNING

___ Have you notified all appropriate individuals or offices that diving operations are in progress?

___ Is the type of equipment that you have chosen to use adequate and safe for the task/operation?

___ Is the boat or vessel being used for the operation adequate and properly equipped?

___ Have you made provisions to obtain medical assistance in case of an emergency?

___ Have you made provisions for emergency transportation?

___ Is an operational recompression chamber ready for use at the dive site or do you have the location, contact numbers, and operational verification for the nearest chamber facility?

___ Do you have a means of emergency communication (marine radio, telephone, or CB unit) at the dive site?

___ Has a timekeeper/record keeper been detailed and briefed on duties and responsibilities?

___ Is a copy of the decompression tables available?

___ Is an approved first aid kit, first aid manual, and oxygen demand inhalator available and ready for use at the dive site?

___ Has a measurement of water depth been made?

___ Have provisions been made to notify marine traffic in the area that diving operations are being conducted (security calls, visual displays, etc.)?

___ Is a copy of an appropriate/required diving regulations available at the dive site?

___ Is a copy of the U of Michigan Safe Practices Manual available at the dive site?

___ If diving around a ship's hull, have you informed the Captain not to operate sound heads or propellers?

___ Have you planned the dive to remain well within the no-decompression limits?

___ Have you filed a dive plan with a responsible person on shore indicating dive sites, estimated time of return, and procedures to follow if you do not return by the designated time?

PERSONNEL

___ Have you determined that all of the divers meet the medical standards for diving within the designated time period of the University?

___ Have all of your divers been trained to use the equipment you have selected?

___ Do all of your divers hold a current diving certification/authorization?

___ Have you determined that all of your divers are trained/qualified for the depth, environmental conditions and techniques unique to this diving operation?

___ Do you have reason to suspect the physical condition of any of your divers?
Consider the following:

- Do not dive a person suffering from a cold, sinusitis, or ear trouble.
- Do not dive or assign important surface responsibilities to a person who is fatigued from lack of sleep or previous physical or emotional stress.
- Do not dive or assign important surface responsibilities to a person who shows evidence of alcoholic/drug intoxication or their aftereffects.
- If you have questions about the physical condition of any person, have them contact a physician and be guided by medical advice; do not dive a physically or medically questionable person.
- Do not force or urge a person to dive if they honestly desire to be excused. If reason for desiring to be excused does not appear to be sufficient or appropriate, it is best to take administrative action.

EQUIPMENT

___ Has the equipment you intend to use been tested/maintained in accord with designated safety regulations and are the results of such tests available for your inspection?

___ Have you inspected the equipment to determine that it is in usable condition?

___ Do you have an adequate supply or source of compressed air?

___ Is each diver properly equipped with all required equipment?

___ Is the diver's personal buoyancy system operational?

___ Is the scuba properly worn with quick release operative?

___ Is the scuba fully charged, properly assembled, turned on?

___ Is the weight belt in proper position for unobstructed release and the quick release operative

SAFETY DURING DIVING OPERATIONS

___ Have all efforts been made to minimize the possibility of divers from becoming fouled on the surface or on the bottom?

___ Is the dive boat moored or shore staging area in the most advantageous position to minimize efforts by the divers to reach their underwater work site?

___ Are you displaying the proper diver down signal?

___ Has a standby/emergency assistance diver been designated and is he ready to enter the water in minimum of time?

___ Has boat traffic been cleared from the immediate area?

___ Is a chase boat available for emergency assistance to scuba divers when working from a large, moored vessel?

___ Have you taken into account that the depth of the water and the condition of the diver (especially in regards to fatigue and cold), rather than the amount of work to be done, shall determine the mount of time the diver is to spend on the bottom?

___ Have you made provisions for decompressing the divers should this be necessary?

POST -DIVE CONSIDERATIONS

___ Have provisions been made for post-dive warming of fatigued, cold divers?

___ Are sufficient personnel available so that divers will not have to engage in heavy work activities at the surface (such as hauling in the anchor)?

___ Have you inspected the record of the dive?

___ Have you evaluated the physical condition of each diver to insure that they are not exhibiting symptoms of decompression sickness, air embolism, physical injury or other diver related problems?

___ Have you instructed divers to report any physical abnormality or symptom to you?

___ Have you instructed the divers to remain in the vicinity of the chamber or personnel capable of managing a diving injury for at least one hour after surfacing?

___ Have you instructed the divers not to fly for at least 12 hours (24 hours following total dive time of more than 2 hours in the past 48 hours, mu1tiday diving, or decompression dives)?

___ Have all divers and support personnel been provided with a list of emergency facilities and procedures including the nearest location of medical assistance and a chamber?

Appendix C

General Safety Checklist

GENERAL SAFETY CHECKLIST

STEPS IN PLANNING DIVING OPERATIONS

Analyze the Mission for Safety (Detailed advanced planning is the greatest single safety precaution!)

___ Objectives defined

___ Environmental conditions

___ Emergency assistance

___ Relevant instructions

Identify Potential Hazards

Natural Hazards

Atmospheric:
___ Extreme exposure of personnel to elements

___ Adverse exposure of equipment and supplies to elements

___ Delays or disruption caused by weather

Surface:
___ Sea sickness

___ Water entry and exit

___ Handling of heavy equipment in rough seas

___ Maintaining location in tides and currents

___ Ice, flotsam, kelp, petroleum, etc. disrupting operations

___ Delays or disruption caused by sea state

Underwater and Bottom:
___ Depth exceeds diving limits of personnel or limits of available equipment

___ Exposure to cold temperatures

___ Dangerous marine life

___ Tides and currents

___ Limited visibility

___ Bottom obstructions

___ Dangerous bottom conditions (mud, drop-offs, sewer outfall, etc.)

On-Site Hazards

___ Local marine traffic

___ High powered, active sonar

___ Other conflicting scientific operations

___ Other conflicting commercial operations

___ Radiation contamination

___ Pollution

Mission Hazards

___ Decompression sickness

___ Communications problems
___ Drowning
___ Other trauma (injuries)

Object Hazards

___ Entrapment

___ Entanglement

___ Toxic substances or containers

___ Explosives or other ordnance

___ Shifting or movement of objects

Minimize Hazards and Plan for Emergencies

Diving Personnel

___ Assign a complete and properly qualified Diving Team

___ Assign the right man to the right task

___ Verify that each member of the Diving Team is properly trained and qualified for the equipment and depths involved

___ Determine that each person is physically fit to dive, paying attention to:

- ___ General condition
- ___Most recent of medical exam
- ___Ears and sinuses
- ___Respiratory infections (cold, flu, etc.)
- ___Use of depressants, stimulants, or intoxicants
- ___Fatigue

___ Determine each persons emotional fitness to dive (as far as possible) :

 ___Motivation (willingness)

 ___Stability

Diving Equipment

___ Verify that the type of diving gear chosen (and diving technique) is adequate for the particular task

___Verify that the type of equipment and diving technique is proper for the depth involved

___Verify that all equipment has been inspected and approved

___ Determine that all necessary support equipment and tools are readily available, and are the best for accomplishing the job efficiently and safely

___ Determine that all related support equipment such as winches, boats, cranes, floats, etc. are operable, safe, and under the control of trained personnel

___ Check that all diving equipment has been properly maintained with appropriate records, and is in full operating condition

Provide for Emergency Equipment

___ Obtain suitable communications equipment with sufficient capability to contact emergency assistance personnel/organizations.

___ Check all communications for proper functioning

___ Verify that a first aid kit is completely stocked and readily available

___ Verify emergency first aid oxygen equipment is available, that the oxygen cylinder(s) is (are) full properly pressurized, and that all masks, valves and other accessories are operable

___ Verify that emergency transportation is either on standby or on immediate call

___ Establish Emergency Procedures

___ Know how to obtain immediate medical assistance

___ Assign specific tasks to the Diving Team and support personnel for different emergencies

___ Have available an Emergency Action Plan, and ensure that all personnel are familiar with it

___ Verify that a copy of University approved dive tables are available

___ Brief all divers, boat crews, and other support personnel on diver hand signals

___ Predetermine distress signals and call-signs and assure with all members of the diving team, boat crews, and other support persons/groups know and understand these signals

___ Be sure that all divers have removed anything from their mouths which might choke them during a dive (gum, dentures, tobacco)

___Thoroughly drill and train all personnel in Emergency Procedures, with particular attention to cross-training. Drills should include, but not necessarily be limited to:

Standard First Aid
Management of Suspected Air Embolism
Emergency Recompression
Management of Uncontrolled Ascent Victims
Fire
Rapid Dressing/Undressing
Restoration of Breathing and Management of Near- Drowning Electric Shock
Entrapment

Establish Safe Diving Operational Procedures

___ Determine that all other means of accomplishing the task have been considered before deciding to use divers

___ Be sure that contingency planning has been conducted

___ Completely brief the Diving Team and support personnel

___ Designate a properly qualified Diving Supervisor to be in charge of the mission

___ Designate a timekeeper and verify duties and responsibilities

___ Determine the exact depth at the job-site through the use of a lead line or pneumofathometer

___ Verify the existence of an adequate supply of compressed air available for all planned diving operations plus an adequate reserve for emergencies

___Be sure that no operations or action on the part of the Diving Team, support personnel, boat crews, technicians, winch operators, etc. may take place without the knowledge and by the direct command of the Diving Supervisor

___All efforts must be made through proper planning, briefing, training, organization, and other preparations to reduce and minimize "bottom time." Remember in all cases, water depth and the condition of the diver (especially fatigue) rather than the amount of work to be done shall govern that diver's bottom time

___Decompression tables should be on hand, be up-to-date, and be used in all planning and scheduling of diving operations

___Instruct all divers and support personnel not to cut any lines until that action is approved by the Diving Supervisor

___ Be sure that the ship, boat, or diving craft is securely moored and in position to permit the safest and most efficient operations (except in the case of emergency and critical ship repairs)

___Verify that, when using surface-supplied techniques, that the ship, boat, or diving craft is in at least a two point mooring

___ Ensure that, when conducting Scuba operations, a boat can be quickly cast off and moved to a diver in distress

___ Ensure that each diver checks his own equipment in addition to checks made by tenders, technicians, or other support personnel

___ Designate a standby diver for all surface-supplied operations

___ Check that the standby diver is dressed and ready to enter the water if needed

___ Assign buddy divers for all Scuba operations

___All efforts should be made to prevent the divers from being fouled on the bottom. If work is to be conducted inside a wreck or similar underwater structure, designate a team of divers to accomplish the task. One diver will enter the wreck, the other shall tend his lines from the point of entry

___ Brief all divers and deck personnel on the planned decompression schedules for each particular dive.

___Check provisions made for decompressing the diver

___Verify that the ship, boat or diving craft is displaying the proper signals, flags, day shapes, or lights to indicate diving operations are in progress

___Ensure that proper protection against harmful marine life has been provided

___Check that the quality of diver's air supply is periodically and tested to ensure purity

___ Thoroughly brief the boat crew using the Diving Boat Operations Checklist

___ Verify that proper safety and operational equipment is aboard small diving boats or craft

Notify Proper Parties that Diving Operations Are Ready to Commence

___ Ship's Master
___ Master of ships alongside
___ Bridge (to ensure that ship's personnel will not):
Turn the propeller or thrusters Get underway
Activate active sonar or other electronics
Drop heavy items overboard
Shift the moor
Operate the rudder or steering mechanisms

___ Other interested parties

___ Harbor Master

___ U.S. Coast Guard (if broadcast warning to other vessels is required)