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Logistics of Ecological Sampling on Large Rivers

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Section 1
Introduction

by
Bradley C. Autrey

The objectives of this document are to provide an overview of the logistical problems associated with the ecological sampling of boatable rivers and to suggest solutions to those problems. It is intended to be used as a resource for individuals preparing to collect biological data from large rivers. Its greatest benefit to project planners will be the knowledge and awareness necessary to provide a greater level of safety to the crew members who will be collecting ecological data on large rivers. A large river can be a hazardous work environment, but can be made relatively safe with adequate training and preparation. In addition to the safety benefit, this document will provide the means needed to ensure the accurate and complete collection of data. The execution of preparatory steps outlined in this document will minimize the collection of inaccurate or incomplete data, thereby decreasing wasted time and money. A third benefit that can be derived from this document is the more efficient collection of data in the field. There are many aspects of conducting ecological research on large rivers which can cause delayed or inefficient data ˇcollection. A well-designed study with adequate preparation, including thorough training of field crews, will minimize problems and maximize efficiency, which will increase the likelihood of successful field endeavors.

Prior to the sampling season, a Project Plan should be developed. The Project Plan should include a detailed outline of every aspect of the project. The development of the plan should include managers, field crews, laboratory personnel, statisticians and anyone else that has the experience necessary to provide constructive input. Involving all the individuals that will be involved in the project in the planning process will help ensure that the correct data are collected and that they are collected correctly.

This document addresses the specific steps needed to prepare for the collection of biological data from large rivers. Therefore, the information provided in this document is essential to, but not necessarily exclusive to, large river sampling.

Section 2
Equipment, Maintenance and Field Repairs

by

Joseph E. Flotemersch

2.1 Introduction

This section is largely constructed to be of assistance to those engaged in ecological research on boatable streams requiring the use of jon boats of 16 feet or less in length. Generally, the jon boat is a wide-bodied, flat-bottomed, shallow, square-ended utility boat particularly well-suited for rivers (Figure 2-1). A boat of 16 feet or less is frequently used because of a lack of access sites that were designed for boats and/or shallow waters, both of which may lead to situations which require portage of equipment in order to sample the stream. However, many of the topics discussed apply to larger boats and will prove worthy of consideration. Some of the comments are personal preferences attributable to the author. Where this occurs, there has been an effort to include justifications and/or reasoning. The overall goal of this section is to provide assistance to those tasked with making equipment purchasing decisions as well as those conducting the research on boatable streams.

Most items discussed in this discussion are included as a result of the author's experiences in the field. There are likely numerous additional items that other experienced personnel could contribute. These items will be added to this section as they make themselves evident or are brought to the attention of the author.

2.2 General Philosophy on Equipment

Most equipment purchased for research on boatable systems is not designed for the extreme wear and tear to which it is subjected once in the hands of biologists. However, purchasing heavy-duty equipment can limit where and how effectively one can sample. Consequently, a balance between the mobility and the durability of equipment must be found. Although some pieces of equipment are better viewed as consumable, there are several actions that can be taken to increase the life-expectancy of specific equipment. Most of these actions are maintenance opera-

Figure 2-1. An example of a jon boat, trailer and outboard motor.

tions, but others are field-proven modifications/fortifications. Both types of actions are included in the text where appropriate.

Essentially, the basic philosophy regarding field equipment is that it should be kept simple. There are three primary benefits to purchasing less complex equipment; 1) more complex equipment has more areas of potential problems, 2) more complex equipment is more difficult to repair in the field or have repaired and 3) readily available, off-the-shelf items are easier to find and purchase when on the road.

2.3 Boat Selection

The selection of a boat that best fits the needs of a study is difficult and is a topic of much debate among experienced field personnel. Often, there is no single "right boat" but rather one of a few options that, depending on the preferences of the personnel utilizing the equipment, may be the best choice.

2.3.1 Construction

2.3.1.1 Riveted Versus Welded Hulls

When purchasing an aluminum boat, an important issue related to the construction of the vessel is whether the hull is riveted or welded. This refers to how the individual components of the hull are attached to each other to produce the hull. Typically, the type of construction found in the boats that an individual boat dealer is selling is what is touted as the better choice. In truth, a riveted boat is stronger, flexes instead of cracks, and is easier to repair in the field when necessary (see Section 2.4.2). While welds themselves are relatively strong, the process of welding weakens the metal around the weld. As a result, when cracks occur, they usually occur adjacent to the weld and not on the weld itself. As evidence of the strength of riveted construction, fighter jets are riveted rather than welded.

A positive aspect of welds, however, is that they are more aesthetically pleasing than a rivet line.

2.3.1.2 Hull Gauge

Of the options available, a boat constructed of a lighter gauge of aluminum is usually preferred for conducting field work. A boat constructed of lighter-gauged aluminum allows the field crews greater flexibility in maneuvering the boat, on land and in the water. Figure 2-2 illustrates the type of difficult situation on a river that may require a high degree of maneuverability. Lighter-gauge aluminum also allows for more efficient motor performance. Because lighter-gauge aluminum boats are more susceptible to hull damage, one of their negative aspects is the decreased length of time that they are useful. However, the cost of a new jon boat every few years is offset by the ability to access a broader range of access sites, thereby being much more efficient in the field.

2.3.2 Size

Many factors can influence the selection of a suitable boat size for the field component of a research endeavor. Some of these factors are:

- The nature of the site to be sampled
- Who will be conducting the sampling
- The type of vehicle to be used to haul the boat
- Who will be available for loading and unloading the boat
- The type of access that will be available
- The amount of equipment that is required
- The number of people that the boat will need to transport

Some basic pros and cons related to boat size are listed in Table 2-1.

Figure 2-2. A jon boat in a sampling area that requires a great deal of maneuverability.

Table 2-1. Size Considerations for Selecting Research Boats.

Consideration	Bigger Boat	Smaller Boat
Cost of boat	increases	decreases
Vehicle towing capacity requirements	increases	decreases
Wear on towing vehicle	increases	decreases
Gas milage of towing vehicle	decreases	increases
Ability to hand-carry the boat[1]	decreases	increases
Outboard motor h.p. requirements	increases	decreases
Outboard motor gas requirements	increases	decreases
Water depth required to run	increases	decreases
Boat trailer capacity rating	increases	decreases
Wear on boat trailer	increases	decreases
Stability of boat	increases	decreases
Cargo space	increases	decreases

[1]Includes not only a crew's ability to carry a boat to a remote or primitive launching site, but a crew's ability to pull equipment over obstacles and through shallows.

Many additional factors may be worthy of consideration prior to the purchase of research vessel. If boats are selected carefully, transportation options may present themselves. As an example, if a wide 12-foot boat is selected rather than a narrow 14-foot boat, the option exists to transport the boat in the bed of a pickup truck. This is a useful option when access roads are especially tricky or when field personnel are not particularly skilled at towing a trailer.

Another potential benefit to careful selection of boat size is realized when multiple boats are required at a single site. If two boats are of compatible size, a smaller boat can be inverted and placed on top (within the perimeter) of a larger boat (Figure 2-3). This reduces the requirements from two tow vehicles and two trailers to one tow vehicle and one trailer. If the boats are locked together, it also provides an easy way to safely transport and protect equipment within the boats.

2.3.3 Shape

2.3.3.1 Width and Length

Among two boats of equal length and different widths, the wider of the two will be more stable. This is especially true of small jon boats (10-12 feet). However, this is not intended to be an endorsement for the purchase of the widest boat possible. Carried to an extreme, buying too wide of a boat will actually defeat the advantages of using a small boat.

An example of a width-versus-length choice would be whether to buy a wide 12-foot boat or a narrower 14-foot boat, each with the same square-footage. From a safety standpoint, in relatively calm water, the wide 12-foot boat provides more stability and also results in more of the equipment being within reaching distance of the crew, thus reducing the need for crew members to traverse the length of the boat. However, a longer boat of equal square-footage will perform better in rough water or when attempting to ascend rapids, both issues responding positively to the fulcrum point of a longer boat.

Figure 2-3. A smaller jon boat inverted and placed on top of a larger jon boat. This is an efficient method for transporting two boats to the same sampling site.

2.3.3.2 Side Depth

Because field biologists often have the need to load boats with a large amount of equipment (Figure 2-4), it seems wise to select boats of increased side depth. This issue is of increasing importance as the length of a boat decreases. The smaller the boat, the more susceptible it is to shifts in weight and listing during turns, but a greater side depth helps to counteract this effect. The added weight of increased side depth is usually minimal. However, it should be noted that some boats with an increased side depth may also have an increased transom height.

2.3.3.3 Squared Bow Versus Pointed Bow

A pointed bow excels at performance while a square bow excels at hard work. A pointed bow increases the overall performance of a boat and rides smoother, especially in rough water. But if one is working from the boat, a squared bow has some advantages. Equipment is much easier to retrieve over a squared bow than a pointed bow. This is especially true of gill, trammel, fyke, trap and hoop nets which can become snagged on the point. Reenforcing the bow of a boat is also much easier with a squared bow (see Section 2.4.1.5).

Another positive aspect of a squared bow is its usefulness as a pivot point. When working on boatable waters, a useful skill to master is the technique of maintaining location in the system by positioning the bow of the boat against an available structure and using the motor to hold the boat in position against the structure. This maneuver is much easier if the bow of the boat is squared instead of pointed.

2.3.3.4 Flat, Semi-Vee, and Vee-Bottoms

The advantages of a vee-bottom boat are largely performance based, although in rough

Figure 2-4. A jon boat heavily loaded with sampling equipment. This illustrates the need for boats with deep sides.

water, a strong argument could be made for safety. In rough water, vee-bottom boats cut through the water and run smoother than flat-bottom boats which have a tendency to skip and slap the water. Vee-bottom boats also have the ability to turn sharper than flat-bottom boats which have a tendency to slide out in turns. Another advantage of a vee-bottom boat is that the "V" shape of the bow will displace rough water at the bow and lead to a dryer bow and boat.

From a research perspective, a flat-bottom boat runs better in shallow water and also requires less horsepower to maintain planing speed. Because outboard motors with less horsepower are lighter and require less fuel than those with more horsepower, this further reduces the weight of the total outfit, and consequently, increases the flexibility of the field crew with respect to their maneuverability on the water.

2.3.4 Options

2.3.4.1 Steering Console or Tiller Drive

Steering consoles are a great luxury aboard a boat, but on smaller research boats, they are not practical. Steering consoles require the dedication of a motor to a specific boat. This means that if the motor should require service, the boat to which it is dedicated is also out of commission. Another negative aspect of a steering console is that it limits the ability to reduce the components of a research vessel to their individual elements in the event that they must be carried to the water's edge. Finally, a steering console is a disadvantage for field work because it has more complex parts and, therefore, requires a higher degree of skill and more time to repair in the field.

A tiller drive set-up has several advantages. These advantages include the ability to

store boats and motors in separate locations, the easy removal of a motor from a boat if it is necessary, and the lack of the additional choke, shift, and throttle linkages of a steering console.

2.3.4.2 Flooring

Flooring on a jon boat is also a luxury that comes at a cost. While it does improve the appearance of a boat and the ease with which the boat can be made to appear clean, it also adds weight to the boat, makes it difficult to thoroughly remove accumulated sediment from beneath the flooring, and makes it difficult to implement hull repairs. The combined added weight of the flooring and trapped sediments reduces the variety of sites where the gear can be utilized because it:

- increases the load on the trailer,
- limits the ability of a boat to be run in shallow water,
- limits the ability of a crew to carry the boat to the river,
- limits a crew's ability to pull a boat through shallow water,
- may increase motor requirements and
- is a barrier to retrieving items that are inadvertently dropped in the boat.

As an alternative to no flooring, 1/4 inch plywood can be cut to serve as removable flooring. This allows for easy cleaning under the flooring of the boat. The flooring will protect the inside-bottom of the boat from damage from hauled equipment, especially while on the road.

2.3.5 Color

When considering the color of a research vessel, there are a few factors to consider. If the vessel is to be used in the summer, darker colors absorb a great deal of heat, which can

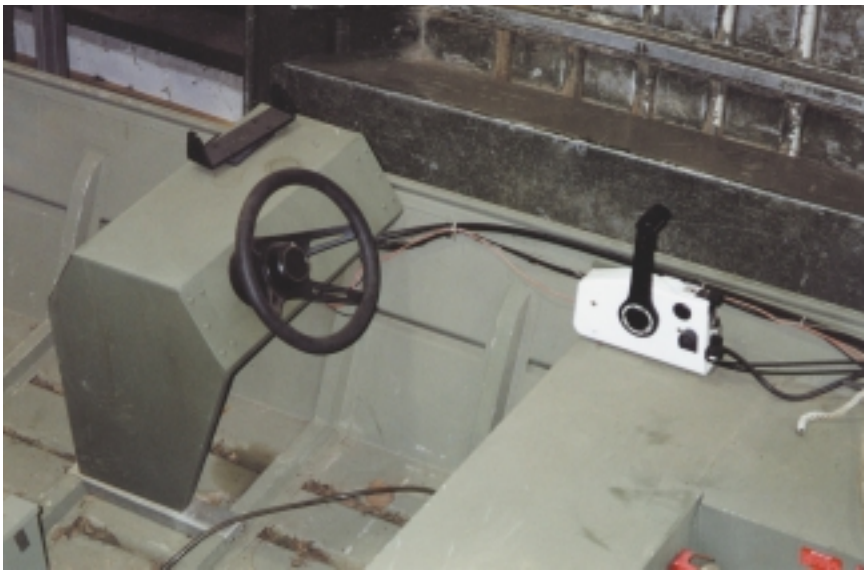

Figure 2-5. A jon boat with a steering console.

be uncomfortable for a crew and harmful for equipment. However, the amount of light reflected from excessively light or bright colors may be blinding.

From a safety standpoint, a unique color may help identify a boat as a research vessel. Having a well marked vessel can help to avoid the problems that can arise from people not recognizing that the crew is a team of researchers. This can be a problem especially when the crew is using sampling equipment that is illegal for anything except research. Color selection may also increase the ability of others to see the boat from a distance. Because research on flowing waters often requires anchoring, it is important to make the boat as visible to other water crafts as possible. This is especially important on larger rivers where large crafts (e.g., barges) are common. Some manufactures offer jon boats in various colors including orange and red.

2.3.6 Additional Notes

When purchasing a boat that is to be powered by a motor that is already owned, it is important to make sure that the motor can move the boat upstream and is compatible with the transom height of the new boat. It is important to avoid buying a boat that is too large or too small for the existing motor.

2.3.7 Standard Onboard Equipment

When considering the cost of purchasing a boat, additional equipment should be considered. These items include:

- life jackets (1 per crew member),
- throwable life preserver/seat cushion (1 per crew member),
- fire extinguisher,
- anchor with attached rope of ample length (See Section 3.2.1),
- two oars,
- first aid kit (kit should respect potential remoteness of field work),
- air horn,
- flashlight and spare batteries (1 or 2),
- flare gun,
- emergency communication equipment (e.g., cellular telephone) and
- tool box (to be discussed in greater detail in Section 2.7).

Some of these items may need to be kept in waterproof containers.

While the list of needed field equipment will be different for almost every field endeavor, it is useful to prepare a simple checklist of essential and safety related equipment necessary for every outing. This can help ensure that all equipment needed to operate the boat safely is onboard. Additionally, all the equipment on the list should be kept in good repair, replaced, or updated as needed.

2.4 Boat Maintenance, Care and Optional Modifications/ Fortifications

2.4.1 Modifications/ Fortifications

There are several modifications that can be applied to the boat that will aid the crew in the field by extending the life of the equipment and increasing the safety of field efforts.

Most of the suggested modifications are not necessary if equipment usage is infrequent, but if usage is heavy, the modifications may decrease the amount of time the equipment is in the shop and increase the amount of time the equipment is in the field.

2.4.1.1 Non-Skid Surfaces

Among the simplest of safety modifications is the addition of non-skid surfaces to walking areas on the boat. An especially advantageous area for this application is on the deck of the boat where personnel may be entering and exiting the boat or working with gear. A simple way to meet this objective is to apply a mixture of paint and sand (or a commercially available equivalent) to the surface. Other options are non-skid tape and non-skid strips made for showers and tubs.

2.4.1.2 Additional Handles

If research is expected to require a fair amount of portage of the boat, an advisable modification is the addition of user-friendly handles to the hull of the boat (Figure 2-6). Location, size and angle of these handles is critical. It is highly advised that handles be located where they will not interfere with gear (such as nets), hang on debris in the water, or be easily destroyed. Also, if the handles are to be utilized in cold weather, they should be big enough to be used by a gloved hand.

2.4.1.3 Carrying Capacity Enhancement

When field work necessitates the use of smaller jon boats, it is easy to approach and exceed the official carrying capacity of a vessel. If this is a reasonable possibility, it may be worthwhile to consider the incorporation of additional flotation to the hull of the boat. This does not necessarily require the permanent loss of space in the boat because removable floatation is an option. Possible locations for supplemental floatation are under front decking and in the rear of the boat behind the seat.

Figure 2-6. A jon boat that has had handles added to it. These handles allow field crews to more easily maneuver the boat when it is in shallow portions of a stream or river or when the boat is not on the water.

Important Note: While the addition of floatation to the hull of the boat may increase safety, it does not increase the carrying capacity of the vessel.

2.4.1.4 Bow Eye Fortification

A common weakness in stock jon boats used in ecological research is the bow eye. The bow eye is the loop located at the front of the boat. It is used as an attachment point for hauling the boat or retrieving it from the water. Recognition of this weakness is especially important when proposed field research is expected to include sites with poor access. Most stock bow eyes are made of aluminum and are not reinforced. This can result in damage to personnel, the towing vehicle, and the boat itself. A weak bow eye can easily fail or result in damage to the boat during winching of the boat onto the trailer. If the bow eye fails during winching, the tensioned winch cable can injure personnel or damage the tow vehicle to which the trailer is attached. The unexpected release of the jon boat can also endanger personnel.

This risk can be largely negated by replacing the bow eye with a stronger substitute and reinforcing it at its anchor point (Figure 2-7). A bow eye that is backed and faced with reinforcing plates will distribute the force exerted on the eye across the bow. It also increases the life of the boat by reducing the likelihood of hull damage at the bow eye anchor point.

2.4.1.5 Bow and Transom Fortification

If aluminum jon boats are likely to be subjected to excessively harsh conditions, an advisable modification is the addition of bow and transom plates at the time of the boat's purchase. While this may be a substantial cost, it will likely be offset by days lost in the field and the untimely need for replacement equipment. The bow plate will protect the boat while winching the vessel and also provides an ideal surface for anchoring a fortified bow eye. This modification is especially advised if the boat will be used in a manner which requires that the bow will be frequently docked or placed against hard surfaces.

Transom fortification is advisable if a boat and motor are going to be used in systems that are particularly deleterious to the motor. These situations are not only demanding for the motors, they also wear on the transom of the boat. To alleviate this, a plate can be welded across the entire area of the transom. The fortification should include a plate to protect the top of the transom where the weight of the motor will rest. If installed with care, the transom plate can also serve to reinforce the drain plug opening as well.

2.4.1.6 Railings

Some manufactures offer jon boats with railings attached to the outside hull of the boat. These could be used to assist with portage of the boat, but depending on the application, may only manifest themselves as additional places to snag debris.

2.4.2 Common Boat Field Repair/Patches

2.4.2.1 Hull Repairs

The rigors of boat-based field work will eventually take their toll on a boat. Damage to the boat may take the general form of cracks, punctures or rivets that have popped loose. Hull cracks and punctures should even-

Figure 2-7. A jon boat with a reinforced bow eye. The fortification of a bow eye can help protect the boat from damage and help prevent injuries and accidents.

tually be repaired by a qualified aluminum welder, but in the field, temporary repairs may be necessary. The majority of punctures and minor cracks can be easily field-repaired with either a marine-grade silicone sealant or a fusion bondage epoxy that is designed for such repairs. Major hull cracks may compromise the integrity of the hull and should be professionally repaired.

Rivets that have been severely loosened or completely detached as a result of an impact can be field repaired with a nut and a bolt. A proper-fitting washer and lock washer should also be used to ensure that the bolt does not pull through the hull or become loose. Eventually, field-repaired rivets should be replaced by a professional. Usually, it is possible to wait until a few welding needs accumulate before a visit to the welder. This is the most cost effective course of action since most welders charge a minimum fee.

2.4.2.2 Maintenance Items to Have Available

If field work involves extensive time away from a base station, some items which may be advisable to have for field repairs include:

- marine-grade silicone sealant for minor hull repairs,
- aluminum welding/brazing rods,
- torch for aluminum welding rods,
- fusion bondage epoxy aluminum boat repair sticks,
- a hammer and chisel to remove damaged rivets, and
- nuts and bolts to field-repair damaged rivets.

It is also strongly advised to have a few extra boat drain plugs on board the boat. A practical way to store one plug is tied to the transom of the boat. When tying the spare drain plug to the transom, it is important to not use too big of a piece of string so that the plug may be retrieved in a short amount of time. This maintenance equipment is included in the tools and hardware list of the Field Overview of Field Maintenance and Repair Section (2.7) of this chapter.

2.5 Boat Trailers

2.5.1 Trailer Selection

The selection, modification and outfitting of a well-suited trailer can be a tremendous asset to a field effort. Most importantly, a trailer used for field work must be of a capacity sufficient to support the boat, motor, gas for the motor, and any equipment that the boat may be required to carry. If given the option of tire size, a larger-sized tire offers a few advantages. The primary advantage is that it provides additional clearance under the trailer. This is especially important if the potential exists for poor site access points or primitive roads leading to the sites. Trailer axle hubs that are equipped with grease fittings which allow for the easy and convenient application of grease to the hubs of the trailer are also an asset.

Another desirable attribute of a field trailer is a long neck (Figure 2-8). It is easier to back a long-neck trailer. A long-neck trailer also permits the towing vehicle to make sharper turns in both forward and reverse. This is a result of the increased distance between the boat on the trailer and the rear of the vehicle. Common limiting factors for this clearance are the mounting location of the jack-stand on the trailer and the mounting location of both the tow vehicle and boat trailer spare tires. Long-neck trailers can also be a tremendous asset at poor access points.

If the neck of the boat trailer is short, it may be possible to make a modification which will make the trailer more suitable. If the tow vehicle is equipped with a receiver base for towing, an extended receiver hitch can be purchased. This will serve to increase the distance between the vehicle and trailer in the same manner as a trailer with a long neck. As a safety note, because the length of the hitch has been lengthened, it is highly recommended that the extended hitch be removed from the receiver hitch.

If an option exists for how and where the spare tire should be mounted, the best location for field work is horizontally on the tongue (Figure 2-8). This should be far enough back that it will not interfere with the turning clearance of the towing vehicle but not so far back that it will interfere with the trailered boat. It is highly advised to carry two spare tires.

At the time of the boat and trailer purchase or when preparing for a field endeavor, additional items which may need to be purchased include an additional spare tire, a four-way lug wrench, a tire plug kit, a spare set of bearings, races and seals for the trailer axle, grease for the axle hubs, and spare bulbs for the trailer lights.

2.5.2 Modifications/ Fortifications

The most frequently occurring problems with boat trailers are malfunctions in the lighting system. There are several simple modifications/fortifications that can greatly reduce the occurrence of malfunctions. Many problems are a result of damage to the wiring sys-

Figure 2-8. A long neck trailer (background) is contrasted with a short neck trailer (foreground). Note that the spare tires for the trailers are mounted horizontally on the trailers.

tem. One simple action which can limit damage to the wiring system is adequately protecting all exposed wires. If the wires hang down on the trailer or are excessively exposed in a vulnerable area, fasten them so that they are not exposed or re-wire the trailer in order to make the wires less susceptible to damage. This is especially important in the neck of the trailer because wires in this area are subjected to much abuse. These wires can be easily protected by wrapping them with electrical tape or by running the wire through a piece of hose.

The tail lights are another vulnerable area of the trailer's lighting system. From the factory, most tail lights are mounted unprotected on the rear corner of the trailer. When this is the case, a simple preventative measure is to relocate the lights more forward so that they are less exposed. To further protect the tail lights, tail light guards can be added to the frame of the trailer. If the entire tail light housing requires replacing, choose a housing that is commonly available. This makes field repairs more feasible. A uniform brand among tail lights also allows for efficient and convenient use of spare parts among trailers.

A simple modification to make a trailer more field worthy is to adjust, trim or remove any hardware that hangs excessively low beneath the trailer. This will help reduce the chances of dragging or snagging the trailer on debris at a launch point or when traveling on unimproved roads. If more clearance is desired and the axle is mounted above the springs, additional ground clearance can be provided by placing the axle below the springs.

Another simple modification that increases the safety of trailering a boat is the addition of heavy-duty eye-bolts along the length of the trailer frame (Figure 2-9). These permit the boat to be better secured to the trailer by providing logical anchor points for tie-down straps rather than available points which

may be less advantageous. It also makes securing the boat to the trailer more convenient.

2.5.3 Trailer Maintenance and Care

At least once every year, all bolts on the trailer and associated hardware should be checked and tightened as needed. All aspects of the trailer's running boards should be inspected. This includes each running board's anchor points to the trailer, the quality of the materials with which the running boards are constructed and the quality of the materials with which the running boards are covered. These materials should be replaced or repaired as needed. In addition, the running boards and rollers should be adjusted, as needed, in order to insure that when the boat to be trailered rests upon them, it is fully supported. If the boat does not properly rest on the trailer, stress fractures may occur and rivets may become loosened.

The winch strap or cable on the trailer should also be inspected. When doing so, it is important to check the full length of the winch strap or cable for strength and integrity and to make sure it is properly anchored to the winch. To minimize wear on the winch strap or cable, when winching a boat onto a trailer, the winch strap or cable should be protected from kinks, twist and knots. It is also important to properly lubricate the winch to ensure that it is functioning properly.

Ratchet straps are often used to secure the boat to the trailer (Figure 2-9). When using ratchet straps in this capacity, assuring that there is at least one twist in the strap per point-to-point section will eliminate strap vibration and reduce wear on the straps at all contact points.

The trailer's spare tire and its associated equipment should also be inspected. This includes assuring that the spare tire can be removed from its storage location. Common problems associated with removing and using the spare tire are; the keys to the lock on the trailer's spare tire have been lost, the lock is damaged or corroded, the threads on the spare tire bracket are damaged, the spare tire is flat, the spare tire has dry rot, the spare tire is not the correct size, the spare tire rim has the incorrect number of lug stud holes or the spare tire is not present.

The trailer's bearings should be inspected at least once per year and packed or replaced when necessary. The hubs themselves should be lubricated often, especially if the trailer has gone into the water and/or it has gone through mud or loose dirt. The grease seals on hubs can fail for many reasons or, occasionally, for no discernable reason. The ill effects of such an occurrence can largely be reduced by frequently checking the hubs. Freshly repacked hubs may often be warm to the touch for a while, but in general, hubs in proper working order should be no more than slightly warm to the touch. Check the temperature of axle hubs frequently. Every time the trailer is parked is an opportune time to inspect the trailer's hubs.

2.5.3.1 Common Trailer Field Repairs/Patches

The most common field repairs are associated with the trailer light system. This includes the replacement of trailer lightbulbs, the replacement of trailer light housings; and the re-soldering, replacement or repair of trailer wires.

The second most frequent category of field repairs are associated with the trailer

Figure 2-9. An eye bolt has been added to this trailer. This simple modification allows the boat to be securely fastened to the trailer with a ratchet strap so that the boat can be safely transported..

hubs. Problems can arise with the hubs even when they are well maintained. If a problem is detected with a hub (i.e., it is hot to the touch), the hub will likely need to be disassembled, cleaned, repacked and reassembled in the field. While this can be an untidy task, if the needed materials are available, it is not very difficult to execute.

However, if the bearings of the hub should overheat and seize, rebuilding of the hub in the field can become much more difficult and time consuming. The worst-case scenario is that the bearings (or what remains of the bearings) and the races will need to be cut off of the axle. This can be accomplished with the use of a chisel and possibly a hacksaw. If this is required, all burrs on the axle should be removed prior to reassembly of the hub with new bearings, races and grease seals. Failure to do so may result in premature failure of the new assembly.

2.5.3.2 Trailer Maintenance Items

In order to perform trailer maintenance and repair tasks in the field, a number of items should be made available to the field crew. These items are:

- trailer light plugs (spare set),
- spare set of wheel bearings, races and seals for the trailer,

- spare length of wire suitable for the trailer lights,
- supply of grease,
- grease gun,
- hammer,
- cutting chisel,
- hacksaw,
- soldering gun and solder,
- metal file,
- sandpaper and
- an extra set of winch straps and hooks.

As a safety precaution, a portable set of pre-wired trailer lights which can be temporarily attached to the trailer should be carried in the tow vehicle. The pre-wired lights should have ample wire to permit them to be directly plugged into the wiring harness of the towing vehicle. Numerous options exist for how these lights attach to the trailer or boat. One of the simplest options is to mount the lights on clamps which can be attached to the trailer or boat. Another option is to mount the lights on a length of a 2"X4" piece of lumber that will span the width of the boat. If the assembly is needed, it can quickly be placed over the width of the boat and secured to either the boat or trailer. This will permit safe passage to a suitable location where more permanent repairs can be made.

2.5.3.3 Trailering Notes

When towing a trailer, it is important that the lighting system of the trailer function properly. It is also important that the safety chains of the trailer not only be attached to the trailer, but that they be attached correctly. If an adequate length of safety chain is available, the chains should be crossed under the trailer tongue and then hooked to the vehicle's hitch or frame. If the tongue disengages while the vehicle is in transit, it will drop down on the cradle created by the crossed chains and that should keep the tongue from dipping to the roadway and keep the trailer attached to the vehicle.

2.6 Outboard Motors

2.6.1 Outboard Motor Selection

When buying an outboard motor for a new or used boat, one of the most important things to consider is the boat(s) on which it is to be used. Too big or too small of an engine can drastically impact the effectiveness and safety of the field crew. The weight of the motor should also be considered if field crews may be called upon to carry the engine to remote launch sites. The weights of motors do not always increase with horsepower. Some models may be more recently updated than others.

Outboard motor models may also differ in the length of the shaft. The shaft length of the motor should be checked to ensure that it is appropriate for the transom height of the boat with which it is to be used. If the shaft is too short, the efficiency of the engine will be severely hampered and if it is too long, it will limit the depth of the water in which the boat can be used. A long shaft will also increase the likelihood of encountering underwater debris which not only increases the likelihood of motor and boat damage, but also poses a serious safety concern. Entanglement of an outboard motor in underwater debris can trap or send a boat dangerously out of control, placing all involved in danger.

2.6.2 Outboard Motor Maintenance and Care

An ideal source for learning about the maintenance and care of outboard motors is the owner's manual. In case a manual is not available, however, this portion of the document deals with the outboard motor maintenance tasks that should be addressed before, during and after field season.

2.6.2.1 Lubrication

There are several points on a boat motor that should be greased on a regular basis. The frequency at which boat motor components should be greased is largely dependent upon how, when and where the boat motors are used. Motors used in salt or polluted waters require lubrication approximately twice as frequently as motors used in fresh or unpolluted waters. Areas where grease should be applied generally includes all grease fittings and parts that swing, swivel or roll (Figure 2-10). This includes all of the components that allow the motor to swivel and tilt, and linkages associated with the carburetor, throttle, and shifting systems. To ensure that enough grease is injected into the grease fittings, it should be pumped into the fitting until some grease is forced out of exit points. This also serves to replace the older grease. If the grease is excessively deteriorated, the decision may be made to pump enough grease into the fitting until some of the new grease is forced out of the exit points.

The lubricant in the gearcase (lower unit) should be checked after every 50 hours of use and replaced after every 100 hours of use. If motors have been operated under harsh conditions, the gearcase lubricant should be checked more frequently. When the lubricant is drained, the lubricant should not appear sig-

Figure 2-10. An outboard motor being lubricated.

nificantly different from when it was added. If the lubricant contains metal shavings, has a milky appearance, or is excessively black and smells burnt, the engine likely requires service.

The presence of metal shavings in the gearcase lubricant indicates problems with the gears and pending failure. Their occurrence necessitates service of the gearcase. Failure to have the unit serviced will likely result in complete failure of the gearcase and additional damage to the unit.

A milky appearance of the gearcase lubricant indicates that water is leaking into the gearcase. This is most frequently caused by a failure of the rear seal of the lower unit. It can also be caused by a loose fill screw or a cracked lower unit. The most common cause for a rear seal failure is harsh use conditions in which the propeller has been frequently impacted.

If the gearcase lubrication is an excessively black liquid with a burnt smell, this most frequently indicates that the gearcase lubricant is overdue to be changed. As a result, the oil no longer possesses the qualities that help protect the gearcase from overheating. If the fluid is not overdue to be changed, a burnt smell likely indicates a problem in the lower unit which has caused the assembly to overheat.

> Important Note: When servicing the gearcase, the rubber seal at the base of the drain/fill plugs should be inspected. If it appears worn or even questionable, it should be replaced. This is a relatively inexpensive piece of equipment compared to the expense of a failed seal.

> Important Note: When servicing the gearcase, care should be taken to not over tighten the drain/fill plugs. The screws are metal but they are threaded into an aluminum receptacle of the lower unit housing. If these screws are stripped, the gearcase lubrication can leak out of the unit, water can seep into the unit and metal shavings can get into the gears of the gearcase. All of these conditions will lead to major repairs.

> Important Note: When servicing the gearcase, the shift cradle screw(s) and the drain/fill plugs should not be confused. The shift cradle screw(s) are usually significantly smaller than the drain/fill plugs which are fairly broad and flat-headed.

2.6.2.2 Ignition System (Spark Plugs and Spark Plug Wires)

The spark plugs of an engine should be inspected periodically. The spark plugs should be removed in order to properly inspect them. To remove a spark plug, the lead to the spark plug is first removed. Once the plug wire is removed, then the spark plug can be removed from the cylinder head by using a spark plug tool or socket (Figure 2-11).

> Important Note: When removing spark plugs from an aluminum head of an engine, first pop the plug loose by smacking the wrench. This helps to break loose the aluminum threads from the steel threads of the spark plug which helps to prevent stripping the aluminum threads.

If upon inspection, the plugs appear worn or damaged in any way, they should be replaced. However, if the spark plug is in good condition, it can be reinstalled. To install or reinstall a spark plug, first, the spark plug seat

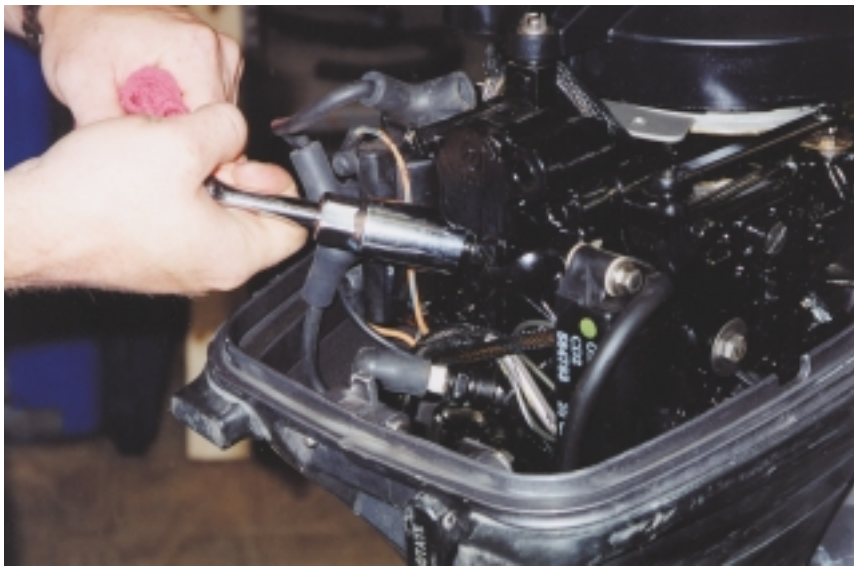

Figure 2-11. A spark plug being removed from an outboard motor.

should be cleaned with an unsoiled rag or paper towel. The spark plug should be tightened to the specified torque setting. If the torque setting or a torque wrench is unavailable, care should be taken to not over tighten the spark plug. While inspecting or replacing the spark plugs, it is important to inspect the plug wires. If there is any evidence of dry rot, vibration damage, or heat damage, the wires must be replaced immediately. Failure to replace damaged plug wires could result in damage to the motor or potentially ignite fuel within the engine cover.

Important Note: It is vital that the leads of different spark plugs are not confused. An easy way to avoid this is to only remove one plug wire at a time.

Important Note: During inspection, the plugs are to be handled with care in order to avoid damage. Damaged plugs may not only fail, they may also emit sparks outside of the ignition chamber which could ignite fuel within the engine cover.

Important Note: If possible, the spark plug should initially be installed without the aid of a tool in order to minimize the chances of cross-threading the spark-plug threads with those of the cylinder head. It is equally important not to over tighten the spark plug because this can also damage the threads of the cylinder head. If the threads of the cylinder head are damaged, the cylinder head itself will likely need to be replaced.

Important Note: When possible, it is preferred to install spark plugs into a cool cylinder head.

2.6.2.3 Fuel Pump Filter

The fuel pump filter should be inspected on a regular basis. An ideal time for this is when the gearcase lubricant is changed or whenever the filter is suspect. The fuel pump

filter on smaller engines varies greatly by year, make and model. Because of the great diversity of fuel pump filters, specific guidance for inspection has not been included in this document.

> Important Note: During the process of inspecting the fuel filter, the fuel hose should be disconnected from the motor in order to prevent excessive fuel spillage.

2.6.2.4 Propeller

The extent and frequency of propeller maintenance activities will vary greatly depending on how and where the motor is used. If the motor is used exclusively in deeper waters that are free of debris, maintenance activities will be minimal. However, if the motor is used in shallow waters or in waters that have a great deal of debris, propeller maintenance can be a daily activity.

If the propeller hits a solid object, the propeller may be damaged. Damage may occur to the blades or to the hub of the propeller. If the blades are excessively damaged, the propeller should be repaired or replaced. Beyond hampering the performance of the engine, running an engine with an excessively damaged propeller can damage the lower unit of the engine. If the hub is damaged, the propeller may slip on the shaft. When this occurs, the propeller usually cannot be repaired or rebuilt and must be replaced.

The engine can also be damaged by an excessively worn propeller (Figure 2-12). A worn propeller could permit the engine to be over-revved and eventually overheat. This may result in the motor seizing which would require that the power-head be replaced.

In waters that have extensive fishing activity, discarded fishing line may become entangled in the propeller. It is important that this line be entirely removed from the propeller and the shaft of the lower unit. This may require removal of the propeller. Failure to remove the line could lead to the rear seal of the gearcase being damaged.

2.6.2.5 Manual Start Pull Rope

If the motor being used is manual start, the pull rope attached to the manual start handle should be inspected for wear. If the rope displays excessive wear, it needs to be replaced the next time the outboard motor is serviced.

2.6.2.6 Emergency Kill Switch Modification

If the motor being used for field work is equipped with a emergency stop switch with a clip and lanyard assembly, check the length of the lanyard when fully extended. Depending on the application and type of work being done, it may be advisable to shorten the length of the lanyard. This will serve to decrease the possible distance an operator can be from the controls of an engine before the clip is disengaged from the emergency stop switch. While it may present itself as an occasional inconvenience, it will increase all around safety in the field.

2.6.2.7 Fuel/Oil Ratio (Two-Stroke Engines Only)

As a general rule, the fuel/oil ratio of all non-oil injected two-stroke engines, beyond the break-in period, is 50:1 (2% oil). The owner's manual on some older motors recommended a 100:1 fuel/oil ratio, but that recommendation has since been recalled by the manufacturer.

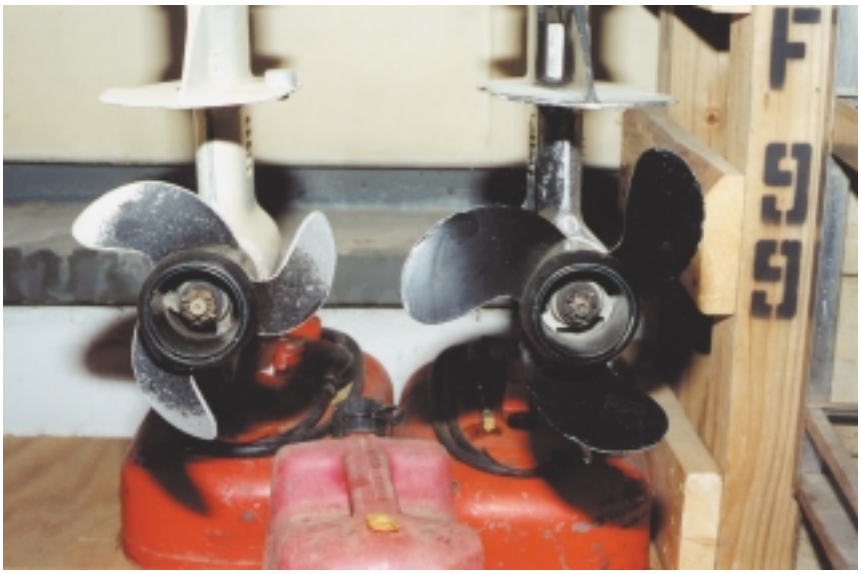

Figure 2-12. An excessively worn propellor (left) is contrasted with a relatively unworn propellor (right).

Many problems can result from improper gas/oil mixture. If the mixture is too lean (not enough oil) the motor can run hot resulting in excessive wear and damage to the engine. If the mixture is too rich (too much oil) the engine may be difficult to start, smoke excessively, or idle roughly. In most cases, the worst consequence of having too rich of a gas/oil mixture is poor performance or the premature fouling of plugs. In fact, if twice the required oil is accidentally added to the gas, it will only be at the mixture recommended for the break-in period of the engine. Therefore, if it is suspected that the mixture is lean, more oil should be added to be safe.

2.6.2.8 Gas Tank Storage

If motors are not going to be run for an extended period of time, the ideal situation is to have no gas left in the tanks. However, this is rarely the case. If the gas will be sitting for a considerable period of time (greater than 50 days), adding gas stabilizer to the fuel tank is advised.

2.6.3 Outboard Motor Trouble Shooting

Determining the cause of outboard motor problems and correcting those problems can be very challenging. This is often true because many problems are basic to outboard motor operation and, therefore, are easily overlooked. Usually, outboard motors are fairly reliable. If motor problems are encountered, the trouble shooting process should begin with the most basic possibilities. To assist in this effort, a basic trouble shooting check list (Table 2-2) has been compiled from various engine manuals and supplemented with field experiences.

2.6.4 Outboard Motor Storage (General Procedures for Motors £ 50 H.P.)

When outboard motors are to remain unused for an extended period of time, proper

Table 2-2. Basic Trouble Shooting Checklist for Outboard Motors.

Symptoms	Possible Cause
Engine will not start	Starting procedure not followed Fuel tank empty Fuel hose disconnected, kinked Fuel hose installed backward so that gas is pumped in the wrong direction Fuel system contaminated with water or dirt Fuel pump filter obstructed COLD ENGINE: Engine not choked WARM ENGINE: Engine flooded1 Spark plug incorrect Spark plugs improperly gapped, carboned, burned or wet Ignition system component failure Emergency stop switch clip not properly engaged Fuel tank not properly vented and starving engine of fuel If equipped, be sure the fuel valve is open
Engine will not idle properly	Motor angle excessive Carburetor mixture out of adjustment Spark plug damaged or incorrect Fuel system contaminated with water or dirt Fuel/oil mixture incorrect Fuel tank not properly vented and starving engine of fuel
Engine loses power	Spark plug damaged or incorrect Fuel pump filter obstructed Fuel system contaminated with water or dirt Water intakes obstructed Fuel tank not properly vented and starving engine of fuel
Engine vibrates excessively	Propeller shaft bent Propeller damaged or fouled and restricted Fuel system contaminated with water or dirt Carburetor mixture out of adjustment Engine mount(s) damaged
Engine propels boat weakly	Propeller hub loose, slipping Propeller shaft bent Propeller damaged or fouled and restricted

[1]If the engine is suspected of being flooded, disconnect the fuel hose at the engine, push in the choke, and crank the engine a few times. If the engine starts, let it continue to run until it clears. If it does not start, wait a few minutes and then try again to start the engine. If the engine will still not start, consider replacing the spark plugs with spare plugs that have been kept with the motor. Patience and persistence are key when working with a flooded engine. If all efforts to start an engine fail, let the engine sit for a few minutes. If engine still fails to start or floods frequently, check the vent on the fuel tank.

storage can minimize the occurrence of problems when they are used again. This section focuses on the procedures for preparing motors for storage.

2.6.4.1 Outboard Motors with External Tanks

The supplies needed to properly prepare outboard motors with external gas tanks for storage are listed below:

- Fuel Conditioner/Stabilizer
- Fogging Oil
- Gear-case Lube
- Grease gun
- Oil

Table 2-3 lists the protocol for properly storing outboard motors that are of 50 h.p. or less, are in operable condition and have external gas tanks.

In order to properly store non-operable motors, first the outboard motor is positioned horizontally with the propeller facing toward the ground (Figure 2-13). In order to prevent water from entering the cylinders, the engine unit should not be lower than the propeller. This position will help to drain residual gasoline from the carburetor. The motor should be left in this position for up to 1 week. After this process has been completed, continue with the storage protocols from step 5 of Table 2-3.

If the lack of supplies or time prevent the procedure in Table 2-3, then a few minimum steps will suffice. Those steps are given in Table 2-4. Storing an engine using these methods is better than doing nothing. However, the engine will likely need to be serviced prior to its next use.

2.6.4.2 Storage Procedures for Outboard Motors with Internal Tanks

The supplies needed to properly prepare outboard motors with internal gas tanks for storage are listed below:

- Fogging Oil
- Gear-case Lube
- Grease gun
- Oil

Table 2-5 lists the protocol for properly storing outboard motors that are operable and have internal gas tanks.

2.6.5 Common Outboard Motor Field Repairs/Patches

Listed below are some of the common repairs or patches made to outboard motors while in the field. It is important that all crews have the supplies to perform these tasks and at least one person on each crew has the knowledge to execute each task.

- Replacing the spark plugs on the boat motors
- Replacing the propeller on the boat motor
- Clearing debris from the water intakes of the cooling system on the outboard motor
- Clearing debris from the water pump operation indicator port
- Replacing or repairing the gas hose fittings on the gas tanks and occasionally on the outboard motor

Table 2-3. Protocol For Properly Storing Small Operable Motors With External Gas Tanks.

1) Stabilize the fuel remaining in the external tank(s) with an appropriate fuel stabilizer.

2) After the fuel in the tank has been stabilized, run the engine long enough (~ 5 minutes) to distribute the stabilized fuel through the fuel system. Be sure to have attached to the engine an appropriate flushing devise to provide circulating coolant water to the engine. Running the engine without supplying water to its cooling system will damage engine components.

3) Fog the engine by spraying fogging oil into the carburetor's air intake. See specific directions on brand of fogging oil used.

4) Stop the engine by stopping the fuel delivery (disconnect the fuel hose), letting the engine run the carburetor out of fuel.

5) Remove and examine the spark plugs. Clean or replace as needed.

6) Spray fogging oil into the spark plug holes in the engine. With the spark plugs still removed, slowly rotate the flywheel several revolutions to distribute the oil and to drain water from the water pump.

7) Re-install the spark plugs and tighten to specifications. (Note: Leave spark plug leads unattached during storage to prevent accidental start-up.)

8) Clean or change fuel filter as needed.

9) Check screws, bolts, and nuts and tighten any that are loose.

10) Check the electrical, ignition, and fuel systems for misplaced leads and damaged or deteriorated parts.

11) Remove and inspect the propeller (replace or have repairs made as needed).

12) With propeller removed, clean the propeller shaft and lubricate it.

13) Drain and fill the gear-case and lubricate the lube points on the engine.

14) Store the engine on the boat (or on a motor stand/rack) in a vertical, self-draining position.*

15) Cover the engine to protect it from dust, and stand the outboard vertically in a dry, well-ventilated area.

*Prior to storing an engine in a vertical position for an extended period of time, the engine should be run until it is out of fuel. When this is complete, the engine should lay, propeller down, for approximately 24 hours. This will permit all fuel in the carburetor to drain, helping to prevent the needle valve from sticking in the carburetor.

- Replacing the coil spring for starting the outboard motor
- Changing the lower-unit oil on the outboard motor
- Remove fishing line, rope, etc. from lower unit (may require removing propeller)
- Starting the motor with a pull rope if the spring is broken

Listed below are the spare motor parts that each crew should have when in the field. Having these parts as well as the ability to perform repair tasks may mean the difference between being able to complete the required work and being delayed for a day or more.

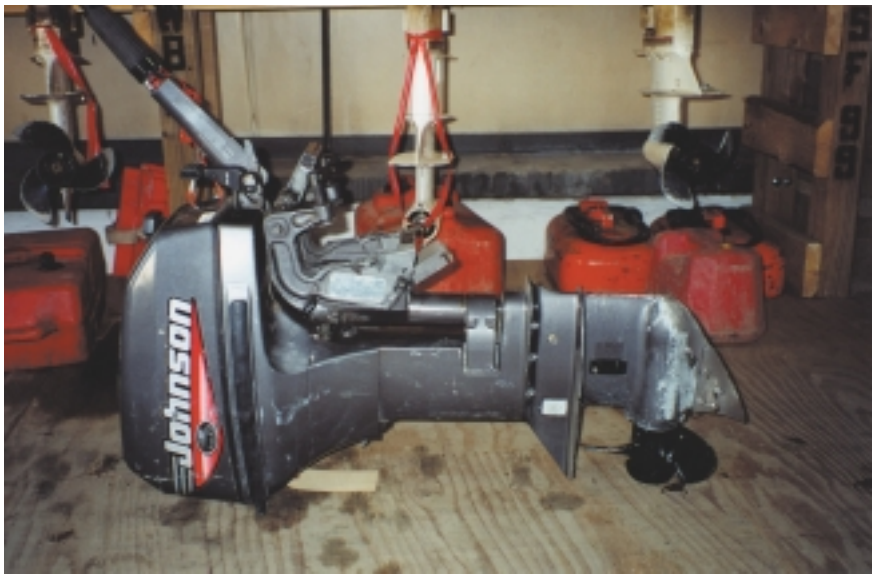

Figure 2-13. The proper positioning of an outboard motor when preparing it for storage.

Table 2-4. Protocol for the Minimum Steps to be taken in Motor Storage Preparation.

1) If the engine is not vertically oriented, reposition the engine to assure that the engine is drained of water.

2) Pull the spark plugs and spray a liberal amount of fogging oil into the spark plug holes. (Note: If fogging oil is unavailable, WD-40TM can be used as a substitute).

3) With the spark plugs still removed, slowly rotate the flywheel several revolutions to distribute the oil and to drain water from the water pump.

4) Re-install the spark plugs and tighten to specifications.

Table 2-5. Protocol For Properly Storing Small Motors With Internal Gas Tanks.

1) Drain fuel from the engine, fuel pipes, fuel cock and carburetor, and clean parts.

2) Optional: Disassemble the carburetor, remove any internal dust, and clean it using gasoline and air.

3) Remove the spark plug and feed engine oil (1 teaspoon) or storage fogging oil through the spark plug hole. Slowly pull the starting rope a few times to circulate the oil to the internal parts.

4) Remove the propeller, clean the shaft and apply grease to the propeller shaft.

5) Change the gear oil in the gear case.

6) Apply grease to all sliding parts, bolts and nuts.

7) Cover the engine to protect it from dust, and stand the outboard vertically in a dry, well-ventilated area.

- spare spark-plugs for the boat motors
- spare emergency motor kill-clip for outboard boat motor
- spare gas hose for outboard motor

2.7 Overview of Field Maintenance and Repair

Personnel conducting field research will eventually be confronted with the task of conducting field repairs. A crew's ability to successfully execute such repairs will depend on a combination of the nature of the repair job, a crew's combined experience, and available tools and hardware. Additionally, field crews engaged in research that requires extended periods of travel will need to conduct regular maintenance activities on equipment. Essential to both of these tasks is a well-equipped tool box and repair kit (Figure 2-14).

Two general approaches can be adopted when amassing tools and hardware for boatable river research. The first approach is to have a downsized kit (Table 2-6) which will be primarily kept in the boat and used while conducting the research and one larger tool kit (Table 2-7) which is kept in the vehicle used for towing the boat. The actual composition of the downsized tool kits will vary with the type of research being conducted by a boat crew. The advantages of this approach are: 1) more tools and hardware can be housed without adding to a boat's weight, 2) tools are better maintained because they are less frequently exposed to the elements and 3) a single large tool kit does not take up excessive space in the boat(s). The disadvantage of this approach is that fewer tools are available to affect repairs without returning to the vehicle.

Figure 2-14. A collection of tools that may be needed for field repairs of vehicles, boats, motors, trailers and/or sampling equipment.

Table 2-6. Tools Suggested for a Small Basic Tool Kit.

Basic Boat-Based Tool Kit	Basic Truck-Based Tool Kit
Hammer	Hacks Saw
Chisel	Vise-Grip Pliers
Channel-lock Pliers	Adjustable Wrench
Needle-nose Pliers	Soldering Iron/Solder/Flux
Regular Pliers	Propane Torch/Ignition Source
Wire Cutter	Socket Set
Utility Knife	Open/box-end Wrench Set
Spark-plug Socket/Tool	Trailer Jack
Screwdriver Set	Conductivity/voltage Meter (Spare Battery)
Flashlight (Spare Batteries)	

This approach is suggested when conducting research from smaller boats and access to research sites does not usually involve long boat trips.

The second approach is to compile one large all-encompassing tool kit which is carried on the boat(s) at all times. This kit would simply be a combination of the two tool kits presented in Tables 2-6 and 2-7. The advantage of this approach is that a crew is more likely to have what it needs to effectively conduct a repair without returning to the vehicle at the access point. The disadvantages are that the comprehensive kit will: 1) occupy an excessive amount of space, 2) be heavy and 3) take a great deal of time to dry after it gets wet. This approach is suggested when a long boat trip is required to reach a research site.

Table 2-7. Equipment to be Added to the Basic Tool Kit in Order to Create an Advanced Tool Kit.

Boat-Based Tool Kit	Truck-Based Tool Kit
Starting Fluid for Boat Motor	Scouring Pad
WD-40 or an Equivalent Penetrating/Lubricating Spray	Spare Sections of Electrical Wire (Various Gauges)
3-in-1 Oil or an Equivalent Penetrating Oil	Spare Rags
Electrical Tape	Spray Engine Cleaner to Clean Parts
Duct Tape	Hand Cleaner
Strapping or Bailing Wire	Wheel Bearing Grease
Wire Ties (Various Sizes)	Grease Gun for Grease Fittings on Boat
Assorted Bolts, Nuts, Screws, Washers, etc.	Trailer and Outboard Motors
Cable Clamps	Epoxy
Hose Clamps (Various Sizes)	Marine-Grade Silicone Sealant
Rope	Steel Wool
Trailer Light Plugs	Aluminum Welding/Brazing Rods
Spare Set of Wheel Bearings, Races, and Seals	Extra Bungee Cords for Securing Equipment
Spare Wire	Spare Winch Strap
Grease	Fusion Bondage Epoxy
Grease Gun	Extra Drain Plugs
Hammer	
Cutting Chisel	

2.8 The Towing Vehicle

2.8.1 Tools Specific to the Towing Vehicle

Before traveling, the crews should be supplied with the basic tools and equipment needed for any motorized vehicle. Jumper cables are one of the most important pieces of equipment to have in the vehicle. It is important to note that the vehicle's battery is more susceptible to being drained when the crew is using a portable freezer for the storage of certain samples. Another important piece of equipment to have in the vehicle is a winch strap. This can be used to free the vehicle if it becomes stuck in the mud. However, it is not necessary if the vehicle is equipped with an electric winch.

2.8.2 Towing Vehicle Maintenance Notes:

Above and beyond normal maintenance activities, there are a few items which should be monitored on vehicles used for boat-based field research.

- Check the oil level on the towing vehicle every time the vehicle is refueled.
- Check the tire pressure on the towing vehicle every time the vehicle is refueled.
- Check tires for punctures or cuts after each off road activity.

Section 3
Safety

by
Bradley C. Autrey and Gerilyn Ahlers

3.1 Introduction

There are many safety hazards associated with biological sampling on boatable rivers. These hazards are encountered when working in inclement weather (e.g., heat stroke, hypothermia), on bodies of water (e.g., drowning), or with sampling equipment (e.g., electrical shock). Therefore, it is important that stringent safety guidelines be established for every aspect of field sampling. These guidelines should be established before the beginning of field sampling and integrated into crew training. If safety is treated as an essential part of field work and crew training, the threat of hazards can be minimized and the safety of sampling crews maximized.

Many hazards can be avoided by making inexperienced crew members aware of possible hazards and emphasizing the importance of strictly adhering to established safety guidelines. It is the responsibility of the project's coordinator or planner to provide the safety training necessary to give crew members the knowledge needed to be safe during the field season (see Section 5.3.2). The American Red Cross (1989), the National Institute for Occupational Safety and Health (1981), U.S. Coast Guard (1987), Ohio EPA (1990), and Lazorchak et al. (1998) provide information useful for safety training. Once field work begins, the responsibility of providing the safest possible working conditions lies with the crew leader, but the responsibility of adhering to safety guidelines ultimately lies with each individual crew member.

It is important that crew members be aware of and take a common sense approach to safety hazards that are not closely associated with field work but may be encountered in the field. These safety hazards include, but are not limited to, venomous snakes, poison ivy, stray dogs, and illegal human activities. While these safety hazards can be serious in nature, they can all be avoided if the crews are aware of their presence.

3.2 General Field Safety

3.2.1 Heavy Equipment

Field work often includes tasks that require physical exertion. When river access is not convenient, crews may be required to carry

heavy equipment, including boats and motors to the river. It is important for crew members to recognize their individual limits for lifting and carrying equipment. Heavy equipment should be carried by two or more people. When lifting heavy objects, crew members should bend at the knees, not the waist, and lift with the legs, not the back. Back strain can easily occur and cause an individual to work in discomfort or be forced to not work at all. Most importantly, crew members must be aware of the effort they are exerting and the terrain they are traversing when carrying equipment. If a crew member falls while struggling with a piece of heavy equipment, such as a boat, serious injuries can be incurred.

In addition to lifting and carrying hazards, heavy equipment can present other hazards to crew members. When working with heavy objects in the boat (e.g., anchor, ponar grabs), crew members should be mindful of the other people in the boat. Careless handling of such an object can result in a serious injury. Also moving heavy equipment within the boat has the potential of unbalancing the boat. In order to avoid this hazard, crew members should alert the other crew members prior to the movement, remain low in the boat and be careful not to shift large amounts of weight quickly.

3.2.2 Field Attire

Usually, the most appropriate field attire will depend on the weather. If the temperature is high, then field crews should be most concerned with protecting themselves from the sun, dehydration, and heat exhaustion/ stroke. But when temperatures are low, hypothermia and frostbite should be the primary concern. However, there are a few principles of safe field attire which should always be followed.

Many injuries can be avoided by simply wearing appropriate attire. Open-toed shoes, while comfortable, leave toes vulnerable to injury from rocks, propellers, dropped equipment, or a myriad of other hazards. Likewise, long pants may not be as comfortable as short pants while sampling during the summer months, but will better protect the legs from injuries and irritants (e.g., poison ivy).

If research requires crew members to wade in the river, it may be advisable for them to wear waders. Because many pathogens may be present in the water, keeping the river water separated from the skin is the safest course of action. If crew members wear waders, they should make sure that they fit properly and do not restrict movement. If a crew member is wearing chest waders and inadvertently wades into water that is too deep, falls while wading in the river or falls out of the boat, water will go over the top of waders and fill them. If this occurs, the weight of the water in the waders may pull the crew member underwater, creating a serious danger. This hazard can be avoided by wearing a belt, at waist level, on the outside of waders. This will prevent the water from completely filling the waders and avert a potentially disastrous situation. Also, the suspenders on the waders should not be worn so tight so that the waders could not be quickly removed in the event of such an emergency.

If field sampling will be taking place in heavily wooded areas or areas with recreational activity, crew members should wear brightly-colored clothing. This will allow them to be more easily seen by the other people using the area. Also, long sleeves should be worn in wooded areas in order to provide protection from hazards such as poison ivy and ticks. After returning from working in wooded areas, field workers should

thoroughly inspect themselves for ticks. Any ticks found should be removed as soon as it is possible.

3.2.2.1 Eye Protection

There are many times when some eye protection should be worn. When working outside during daylight hours, it is advisable for crew members to wear sun glasses in order to protect their eyes from harmful UV rays (Figure 3-1). When working in heavily wooded areas, sun glasses or safety goggles should be worn in order to protect the eyes from abrasions. In addition, eye protection should be worn when crew members are working with substances that may be harmful if splashed into the eyes (e.g., formalin).

3.2.2.2 Hearing Protection

Under certain circumstances, hearing protection will be required for field workers. It may be advisable for the person operating the boat motor to wear hearing protection. When a generator is being used (i.e., during electroshocking) hearing protection is required for all personnel in the boat (Figure 3-1).

3.2.3 Electrical Shock

The use of certain sampling devices require a great deal of training and care. Electrofishing equipment, in particular, can be a danger to those using it. All crew members working with or around electrofishing equipment must be trained by personnel experienced in its proper use. Crew members should be specifically aware of the proper set up and maintenance of the electrofishing equipment, as well as the protective clothing and gloves to be worn while this equipment is in use (Figure 3-1). Section 3.4 contains more information about electrofishing equipment and electrical shock.

Figure 3-1. A member of a field crew removes fish from the river during a fish sampling effort in which electroshocking equipment is being used. Note that the crew member is wearing hearing protection, eye protection, a life jacket, an orange safety vest, protective gloves and protective waders. The gloves and waders help to protect the crew member from electric shock.

3.2.4 Communication

An important safety feature that should be built into the field sampling work plan is the establishment of strong communication lines. The telephone numbers of all personnel, especially those who work from the home base should be provided to all crew members. If crews are not returning to the home base daily, they should contact home-based personnel on a daily basis. If possible, each field crew should be supplied with a cellular telephone. In addition, field crews should be supplied with the telephone numbers of local law enforcement contacts and local emergency medical services. If these numbers are not readily available, "911" can be dialed in the event of an emergency.

3.2.5 Safety on the Road

While driving to and from sampling sites, it is important that the driver and passengers keep safety as the highest priority. Every person in the vehicle must wear seat belts. The driver and passengers should always be aware of and avoid the potential driving hazards around them. It may be helpful if the persons responsible for driving during the project take a course in defensive driving before the field season begins.

When sampling large rivers, it is usually necessary to tow a boat and a trailer, further increasing the potential for traffic hazards. In order to ensure safe trailering, the proper trailer and hitching equipment must be in proper working order and properly installed, the vehicle must be of the proper weight and power for the task, and the driver should be experienced in trailer towing.

Most trailers, hitches, and vehicles have capacity labels which indicate the maximum weight that each can safely negotiate. These weights should never be exceeded. In addition to the hitching mechanism on the trailer, safety chains should be crossed and attached to the vehicle in a location that is secure but separate from the bracket that secures the hitching ball. It is crucial that the driver conduct an inspection of the trailer before each trip. Table 3-1 is a suggested checklist of items that should be inspected and maintained on a daily basis. Items that should be inspected include the trailer's wheels, axle, frame, bearings, tires, brake lights, turn signals and spare tire. Crew members who are experienced at towing a trailer and boat should be the primary drivers. Inexperienced drivers should be particularly aware of the hazards associated with backing and trailering. It may be helpful for inexperienced crew members to practice

Table 3-1. Suggested Daily Checklist for Trailer Inspections.

Inspection Item	Action
Tail lights	Check that the lights for brakes, turn signals, hazards and tail lights are working.
Tires	Check air pressure, tread and lugnuts. Check for damage to the wheels, rims, or walls of the tires.
Spare tire	Make sure it is present, secured, properly inflated, sufficiently treaded, able to fit on the trailer, and that the crew's lug wrench will fit the lugnuts on the trailer.
Wheel bearings	Periodically lubricate.
Trailer connection	Check to make sure that the hitch, light connection and safety chain are all in proper working order and securely attached to the vehicle.

backing and other trailering skills in a low-risk area such as an empty parking lot. While towing a trailer, it is important to always remember that it is there and the hazards it presents. Driving speed should be reduced in order to compensate for the added hazard of a trailer and it is advisable to stop periodically in order to check the temperature of the wheel bearings and the security of the boat ties. Additional instructions for the proper care and maintenance of trailers can be found in Section 2, Equipment, Maintenance, and Field Repairs.

3.2.6 Chemical Safety

Field crews are routinely required to work with chemicals. Because improper exposure to some chemicals can present potential health risks to those individuals, all precautions must be observed.

3.2.6.1 Formalin

Formalin, which is often used to preserve biological samples, is a potentially hazardous chemical that members of a field crew may be required to use. It is a colorless liquid with a pungent odor that can be fatal if ingested and can irritate skin and eyes if contacted. If formalin vapors are inhaled, they can cause irritation, headache, unconsciousness, nausea or vomiting. Long term exposure to formalin is suspected to be carcinogenic. Crew members can circumvent the adverse effects of working with formalin by avoiding ingesting the chemical; wearing chemical resistant safety gloves, chemical safety goggles, and protective clothing; and by using the chemical in a well-ventilated area. If formalin comes in contact with the skin or eyes, the exposed areas should be flushed with water for 15 minutes. If a crew member is overexposed to formalin vapors, he/she should be moved to an area that is well-ventilated and medical assistance should be sought. If a crew member ingests formalin, medical treatment should be sought immediately.

3.2.6.2 Ethanol

Ethanol, like formalin, is used by the field crews to preserve some biological samples. It is a clear liquid that is a potentially hazardous chemical and the members of the field crew should be aware of these hazards. The primary concern when using ethanol is its flammable nature. It should be kept away from high temperatures, sparks and open flames. Ethanol vapors, which are also flammable, may be moved by air currents, and therefore, present a further fire hazard. Ethanol can cause irritation when contacting the skin and can cause irritation or blindness when contacting the eyes. Ingestion of ethanol or inhalation of ethanol vapors can cause headaches or nausea. Crew members can avoid the adverse effects of ethanol by using it in a well-ventilated areas; wearing chemical resistant gloves, chemical safety goggles and protective clothing, and by washing the hands thoroughly after ethanol has been handled. If ethanol contacts the eyes, they should be irrigated with water for 15 minutes and medical attention should be sought. If ethanol contacts the skin, it should be immediately flushed with water. If the vapors are inhaled to the point of overexposure, the crew member should be moved to a well-ventilated area, artificial respiration should be given, if needed, and medical attention should be sought. If ethanol is ingested, vomiting should be induced and medical attention should be sought. If ethanol ignites, a water spray, dry chemical, carbon dioxide, or alcohol foam extinguisher should be used. A direct water stream should not be used to extinguish an ethanol fire because it will only serve to further spread the fire.

3.2.6.3 Gasoline

Gasoline is a chemical compound that crews are required to use when working with outboard motors or generators such as those used for electroshocking. Like ethanol, the primary safety concern when working with gasoline is its flammable nature. It has the potential to be explosive and should, therefore, never be kept near extreme heat, open flames or sparks. Because gasoline is so volatile, it should never be kept in a container that was not specifically designed to store gasoline. Inhalation of gasoline vapors can irritate the mucous membranes, induce the onset of pneumonia and cause narcosis. Prolonged inhalation of gasoline vapors can affect the peripheral nervous system and blood alterations. Exposure of gasoline to skin or eyes can cause irritation and dermatitis. Ingestion of gasoline can cause a number of gastrointestinal disturbances and can be fatal. Long term exposure to gasoline is suspected to be carcinogenic. Crew members can avoid the adverse health effects of working with gasoline by keeping it in a proper storage container. If gasoline must be handled outside of the proper storage container, the crew member should work in a well-ventilated area; wear impermeable gloves, safety goggles, and protective clothing; and thoroughly wash any exposed areas prior to eating, drinking, or the use of toilet facilities. If gasoline contacts the eye, it should be flushed with water for 15 minutes. If the skin is contacted with gasoline, it should be thoroughly washed with soap and water. If the fumes are inhaled to the point of overexposure, the crew member should be removed to a well-ventilated area, artificial respiration should be given, if necessary, and medical attention should be sought. If gasoline is ingested, the crew member should be given a dose of vegetable oil to prevent absorption and medical attention should be sought immediately. Vomiting should not be induced. If gasoline ignites, it should be extinguished with a Class B medium such as foam, carbon dioxide or a dry chemical.

3.2.6.4 Material Safety Data Sheets (MSDS)

A Material Safety Data Sheet (MSDS) provides the crew members with the proper procedures for handling or working with a substance. It includes information such as the physical data, toxicity, health effects, first aid procedures, reactivity to other substances, storage and disposal procedures, needed protective equipment, and spill and leak procedures. The MSDS for substances that crew members are required to use must be made available to the crew members by the project planner. The MSDS for each substance can be obtained from the manufacturer of the substance.

3.3 Boating Safety

The U.S. Coast Guard or a state boating official can provide a copy of the rules and regulations for boat operation. These rules should be strictly followed because most of them were created in order to increase the level of safety enjoyed by boaters. Table 3-2 lists some of the general rules for safe boating. Each of these rules is vital to the assurance of crew safety.

In most states, boats with motors are required to have fire extinguishers, life jackets or floatation cushions, flares or communication devices, and boat horns. Section 2 of this document provides a more detailed list of the tools and safety equipment that should be on board boats.

Table 3-2. General Boating Safety.

Carry the proper equipment and know how to use it.
Keep the equipment in proper working order.
Be familiar with the laws concerning boat operations.
Operate boat with care, courtesy and common sense.
Maintain complete control of the boat at all times.
Life jackets must always be worn by everyone in the boat.
When the boat is in motion, all passengers must be seated.
Avoid overloading the boat.
Keep lifesaving and emergency equipment accessible.

3.3.1 General Boating Safety

Because the ecological sampling of large rivers is generally conducted from a boat, it is essential that field crews be prepared with the general knowledge of how to work in and around boats. This knowledge and its proper application will help prevent accidents from occurring in a relatively inhospitable environment. In order to ensure that someone can operate the boat during an emergency, at least two crew members should have sufficient training and knowledge to safely handle the boat.

Boats used to sample large rivers are often relatively small and this feature should be taken into consideration during operation. Because of the nature of large rivers, field crews may encounter boats which are considerably larger, faster and/or less maneuverable. Under normal circumstances, the safest action for the sampling boat would be to yield to other water crafts. Cargo ships, river tows, barges and other large vessels are very restricted in their ability to stop and turn, and will probably not be able to steer clear of a small boat. Therefore, when in restricted channels, these larger vessels should be kept at a maximum distance from the sampling boat. Some heavily-loaded ships pull in strong currents and leave large wakes. When encountering such a ship, it may be safer to take the sampling boat to shore and wait until the disturbance has settled.

Small boats, while easier to handle and maneuver, can be unsteady, especially if the crew is not accustomed to working in small boats. While a crew member is boarding the boat from the water, it is advisable for the other crew members to shift their weight to the opposite side. During operations, crews should be seated close to the centerline and should remain seated while the boat is in motion.

Care should be taken to ensure that a boat is never overloaded. The Coast Guard requires that boats be outfitted with a capacity plate which states the maximum safe number of people or carrying weight, and the maximum safe horsepower for the boat. In rougher water, the safe carrying capacity of the boat is decreased. An overloaded boat is generally off balance and has a higher risk of capsizing. Weight should be evenly distributed in the boat with special care taken to avoid placing heavy loads near the bow. When the boat is in motion, too much weight in the bow may cause it to dip thereby causing the boat to take on water. If a boat begins to take on water over the bow, slowly stop the boat and redistribute the weight.

If the boat begins to take on water from a loss of structural integrity, an attempt should be made to stop the leak and proceed to shore. Many objects on board, such as a bucket, an ice chest, or an emptied tool box, can be used to bail water from the boat and may make the difference between sinking and staying afloat.

There should not be unnecessary ropes tied to the side of the boat. If ropes tied to the side of the boat hang on the outside, they have the potential to become entangled in objects in the water and present a very real threat to the integrity of the boat and the safety of the crew.

When anchoring, slowly lower the anchor to the bottom, then allow the boat's drift to set the anchor. In order for the anchor to properly hold, approximately five meters of anchor rope are needed for every one meter of distance from the boat to the river bed. In windy or wavy conditions, a 7:1 ratio is recommended. Never tie a boat to buoys or other navigation aids. It is both dangerous and illegal.

When planning a trip or day on the water, the "1/3 Rule" for fuel consumption should be used. The "1/3 Rule" states that trips should be planned with enough fuel so that 1/3 will be used going and 1/3 will be used returning. This will leave another 1/3 in reserve for those times when wind, waves, or drift make the running time longer than expected. However, there should always be a pair of oars on board in case there is not enough gasoline.

All maneuvers in and around other boats, piers, and docks should be done slowly and skillfully. Dams, however, pose an extreme danger to boats in their vicinity. They are among the common hazards encountered on large rivers and should be avoided. The upstream side of low-head dams can be particularly hazardous because they can be difficult to see even from a close distance (Figure 3-2).

The operation of boats at night is much more hazardous than their operation during daylight. If boats are operated at night, they should be operated at reduced speeds and with greater caution. The operation of boats at night require that they be outfitted with not only the proper lights needed to see hazards in the water, but also with the proper lights needed to be seen by other water crafts.

3.3.2 Drowning

Each crew member must be assigned a properly-fitting life jacket. The straps should be secure and adjusted properly. When in the boat, all crew members should always wear their life jackets.

Crews should be familiar with the proper procedures in the event that a crew member falls out of the boat. It is generally recommended that the following four steps be followed in this order. First, reach for the person with a hand, life jacket, belt, oar, or thalweg pole. If reaching fails to retrieve the person, then throw a floating object, such as a seat cushion, life jacket, plastic bottle, water jug, or ice chest to the person. However, if the person is too far away to reach by throwing a floating object, then row toward the person. If oars are not available, use your hands or any other means necessary to row the boat. If exhausting the first three options does not retrieve the person from the water, the last option is for another crew member to go into the water. This is the most hazardous of the four options because it puts two people in danger and therefore, should only be used when all other options have proven to be unsuccessful. Because of thedangers associated with this life-saving option, the crew mem-

Figure 3-2. A low-head dam can be a hazard during a field effort. They are particularly hazardous because they are difficult to see from the water.

ber who goes into the water should be a strong swimmer and should have some training in retrieving a drowning person.

If the victim must be retrieved by boat, it is best to approach the person in the water from the upwind or up-current direction and the propeller should be disengaged. The person should be brought on board over the boat's stern. Care should be taken to make sure that the rescue boat does not become overloaded.

Crews should review and practice this drill before beginning the sampling season. See Section 3.4, Cardiopulmonary Resuscitation, to review the procedures for treating a drowning victim.

3.3.3 Storms (Nielson and Johnson 1992)

Because locally severe storms are not always predicted, crew members should know how to interpret the clouds. Cumulonimbus clouds are towering clouds with an anvil-shaped leading edge at the top and a churning, rolling bottom edge. A dark area between the clouds and the earth indicates approaching rain, hail, or lightning. Some time should be spent by crew members learning or reviewing the sky characteristics that may indicate potential weather problems.

Lightening is one dangerous feature of thunderstorms. The best course of action to avoid the dangers of lightening is to remain away from the water during thunderstorms.

Strong winds and rapidly-rising water are also dangerous features of thunderstorms. The typically-small boats used for sampling large rivers should avoid these conditions when possible. If there is a doubt of the safety of the crew during storm conditions, the crew should leave the river as soon as possible. If returning to the access point is not possible, then a sheltered location should be located. Making headway in rough water requires a

great deal of both experience and skill. The boat should approach waves slowly at a 45o angle. The approach angle can be varied to maximize progress and minimize roughness. When the boat is flooded, it will probably remain floating and crew members should usually stay with the boat. Remaining with the boat will enable the crew members to conserve body heat and will afford them more protection from drowning than being afloat in a rapidly-rising river.

3.3.4 Boat Rescues

If another boat is in distress, immediate action must be taken. If the sampling boat is unable to serve as a rescue vessel, then someone with a capable vessel should be contacted as soon as possible. When the emergency calls for people to be rescued from the water, follow the guidelines given in Section 3.2.2. Towing another boat can be an extremely dangerous operation and should, therefore, only be attempted when absolutely necessary and both boats are structurally ˇable to manage the strain. In calm waters, towing the boat by tightly securing it beside the rescue boat is the best route. However, in rough water, the disabled boat should be towed behind the tow boat. One end of a towline should be attached to the towing craft as far toward the bow as possible and the other end should be attached to the bow eye of the disabled boat. Before attaching either end of the towline, inspect the points of attachment to ensure that they will be able to withstand the strain. The length of the towline should be proportionate to the roughness of the water. The towing boat should proceed at a slow and controlled speed and remain constantly aware of the reactions of the disabled boat.

3.4 First Aid

It is important that some or all of the members of each sampling crew receive some formal first aid training. Below are some basic first aid instructions which may aid in refreshing the memory of a crew member who has already received some training. This section is not intended as, and should not be used as, a comprehensive training manual.

First aid is the initial care of the injured or sick. It is administered as soon as possible after an accident or illness. This prompt care may mean the difference between life and death, or between a full and partial recovery. If possible, it is best to bring first aid to the patient. Moving an injured person may cause additional injuries.

3.4.1 Cuts and Bleeding

In most cases, the application of pressure to a wound is sufficient to stop the flow of blood. However, in severe cases such as when major veins or arteries have been damaged, more vigorous steps may be required to stop the flow of blood. Table 3-3 lists the steps suggested to stop serious bleeding. Small cuts and scrapes usually don't require professional medical treatment, but proper care is necessary to keep infections or other complications from occurring. Infectious agents such as viruses, bacteria, rickettsia, fungi, or parasites may be present in the water that is being sampled. Special care should be taken when the portion of the river being sampled is known or suspected to be pollutedwith sewage or other biological waste. Table 3-4 contains the suggested steps for treating small cuts and scrapes.

3.4.2 Bruises

Bruises, caused by bleeding beneath the skin, usually occur after a blow or a fall. If the skin is not broken, a bandage is not necessary. However, the effects of the bruise can

Table 3-3. Treatment For Serious Bleeding.

The injured person should lay on a stable surface. If possible, blood flow to the brain is increased by positioning the person so that his/her head is slightly lower than the trunk of his/her body or his/her legs are elevated. The flow of blood from the wound should be reduced by elevating the site of bleeding.
Steady, firm pressure should be applied directly to the wound using a sterile bandage, a clean cloth, or a hand. Pressure should be maintained until the bleeding stops, then the wound is wrapped with a tight dressing and secured with adhesive tape. Most bleeding can be controlled this way. Professional medical treatment should be sought as soon as it is possible.
If the bleeding continues and seeps through the bandage, more absorbent material should be added without removing the first bandage.
For severe bleeding, pressure should be applied to the major artery that delivers blood to the area of the injury. The pressure points are illustrated in most first aid manuals and include the neck, armpits and groin.
When the bleeding has stopped, the injured portion of the body should be immobilized. Another part of the body, such as a leg or torso, can be used to immobilize the area. The bandages should be left in place and the injured person should be taken for professional medical treatment as soon as it is possible.

be diminished by elevating the injured area and applying ice or cold packs for 30 to 60 minutes each day for the first few days following the injury. Bruises accompanied by persistent pain or headache may indicate a more serious underlying illness and require professional medical attention.

3.4.3 Puncture Wounds

A puncture wound usually results in little blood flow and the surface of the wound, in most cases, closes almost instantly. However, puncture wounds are dangerous not because of the threat of blood loss, but because the object that punctured the skin may carry bacteria that can cause serious infections and the depth of the wound may prevent topical antibiotics from being effective. A puncture wound should be treated by first stopping any bleeding by applying pressure with a sterile gauze pad or clean cloth. Professional medical treatment should then be sought in order to prevent infections. A tetanus booster may be necessary.

3.4.4 Heat Emergencies

Field personnel working in excessive heat are potentially in danger of suffering a heat emergency. When working in hot weather, a larger portion of a person's circulation is directed to the blood vessels in the skin which enables heat to be radiated from the body. However, during times of excessively high temperatures or excessively long periods of exposure to heat, the ability to control body temperature is lost and the person can suffer from one of the following three types of heat emergencies: heat cramps, heat exhaustion, or heat stroke. Each of these heat emergencies has a different set of symptoms, a different set of treatments, and a different level of urgency. Individuals can avoid being victims of these heat emergencies by minimizing their direct exposure to the sun and by drinking plenty of fluids. Table 3-5 lists the symptoms and treatments for the three types of heat emergencies. usually in the legs and abdomen, extreme exhaustion, and possibly dizziness or periods of faintness.

Table 3-4. Treatment For Minor Cuts And Scrapes.

The bleeding should be stopped by applying pressure to the wound using a gauze pad or clean cloth.

The wound should be kept clean by washing the area with soap and water and removing any debris. The area should then be dried gently with a clean cloth, treated with an anti-bacterial agent (e.g. isopropyl alcohol) and covered with a protective bandage.

The bandage should be changed at least once a day. If the wound becomes tender and red or oozes fluid, seek professional medical treatment.

Treatments include cooling the patient, giving salted water or sports drinks to the patient, and easing the patient's cramps by massage. Although it is likely that the victim of heat cramps will resist taking fluids, it should be strongly encouraged by those administering the treatment.

3.4.4.1 Heat Cramps

After a long period of exposure to heat, an individual's loss of both water and salts due to sweating can bring on painful muscle cramps. Symptoms include cramps

3.4.4.2 Heat Exhaustion

Heat exhaustion occurs when the circulatory system begins to fail as blood collects near the skin in an effort to rid the body of excess heat. Symptoms include rapid and shallow breathing, a weak pulse, cold and clammy skin with heavy perspiration, weakness, and dizziness sometimes leading to unconsciousness.

Treatments include moving the patient to a cool place, making sure the patient rests,

Table 3-5. Symptoms And Treatments For Heat Emergencies.

Heat Emergency	Symptoms	Treatment
Heat Cramps	Cramps (usually in the legs and abdomen) Exhaustion Possibly dizziness or faintness	Cool the patient Administer fluids (salted water or sports drinks) Massage the cramped areas
Heat Exhaustion	Rapid and shallow breathing Weak pulse Cold and clammy skin Heavy Perspiration Weakness and dizziness (possible unconsciousness)	Move the patient to a cool place Cool the patient Rest the patient Administer fluids (salted water or sports drinks) Treat as a shock victim but do not cover
Heat Stroke	Deep breaths followed by shallow breaths Rapid strong pulse followed by a rapid weak pulse Hot, dry skin Dilated pupils Unconsciousness Convulsions	Immediate professional medical treatment Cool the patient as rapidly as possible (e.g. ice packs) Treat as a shock victim but do not cover

cooling the patient, giving the patient salted water or sports drinks. Although it is likely that the victim of heat exhaustion will resist taking fluids, it should be strongly encouraged by those administering the treatment. The patient should be treated as a shock victim with the exception that heat exhaustion patients should not be covered. If the field crew is in a remote area, an option for quickly cooling a victim of heat exhaustion is placing him/her in a shaded portion of the river. Cool water has the ability to quickly draw heat away from the body.

3.4.4.3 Heat Stroke

Heat stroke is a serious emergency. All cases of heat stroke require that the patient to be sent to a medical facility as quickly as possible. Symptoms include deep breaths followed by shallow breathing, a rapid strong pulse followed by a rapid weak pulse, skin that is hot and dry, dilated pupils, loss of consciousness, and convulsions. Treatments include cooling the patient as rapidly and in any manner possible including placing ice packs under the armpits, and at each wrist and ankle. As with heat exhaustion, the patient should be treated as a shock victim with the exception that heat stroke patients should not be covered.

3.4.5 Hypothermia

Hypothermia occurs when the core body temperature decreases to a level such that normal muscular and cerebral functions are impaired. Conditions which may lead to hypothermia include cold temperatures, improper clothing and equipment, wetness, fatigue, exhaustion, dehydration, poor nutrition, and alcohol intake.

While hypothermia normally occurs at below-freezing conditions, any ambient temperature below 37°C may lead to hypothermia. Cool water has the ability to quickly draw heat away from the body (25 times faster than air). Therefore, prolonged submersion in cool water can lead to hypothermia. The time required for hypothermia to occur shortens as the water temperature decreases. Table 3-6 lists the symptoms and treatments for the three levels of hypothermia.

3.4.5.1 Mild Hypothermia

Mild hypothermia occurs when the core body temperature is between 35 and 37°C. Symptoms of mild hypothermia include involuntary shivering and the inability to perform complex motor functions. A person suffering from mild hypothermia can still walk and talk.

3.4.5.2 Moderate Hypothermia

Moderate hypothermia occurs when the core body temperature is between 33.9 and 35°C. Symptoms of moderate hypothermia include dazed consciousness, loss of fine motor coordination, slurred speech, violent shivering, and irrational behavior.

3.4.5.3 Severe Hypothermia

Severe hypothermia occurs when the core body temperature is between 30 and 33.9°C. Core body temperatures below 30°C are immediately life threatening. Symptoms of severe hypothermia include violent shivering that occurs in waves, the inability to walk, muscle rigidity, pale skin, dilated pupils, and decreased pulse rate.

3.4.5.4 Treating Hypothermia

The basic principles of rewarming a hypothermic victim are to conserve the heat they

Table 3-6. Symptoms and Treatments for the Three Levels of Hypothermia.

Level of Hypothermia and Respective Core Body Temperature	Symptoms	Treatments
Mild Hypothermia (35-37°C)	Involuntary shivering Inability to perform complex motor functions	Reduce heat loss Provide additional clothing Replace wet clothing with dry clothes
Moderate Hypothermia (33.9-35°C)	Dazed consciousness activity Loss of fine motor coordination Slurred speech Violent shivering Irrational behavior	Increase victim's physical Provide shelter from cold and wind Administer food and liquids
Severe Hypothermia (30-33.9°C)[1]	Violent shivering in waves Inability to walk Muscle rigidity Pale skin Dilated pupils Decreased pulse rate	Place patient in a hypothermia wrap Administer warm, sugared liquids (e.g., dilute gelatin mixture) Add heat to areas near major arteries

[1]A core body temperature of less than 30°C is immediately life threatening.

have and to replace the body fuel they are burning to generate that heat. If a person is shivering, they have the ability to rewarm themselves at a rate of 2°C per hour.

Treatment for a person suffering from mild or moderate hypothermia is to reduce heat loss by providing additional clothing, replacing wet clothing with dry clothing, increasing the victim's physical activity, and providing shelter from the temperature and wind conditions. In addition to preventing additional heat loss, it is important to provide food and liquids to a hypothermic person. Foods high in carbohydrates are good for nourishing a hypothermic person because they are rapidly released into the blood stream and provide a quick surge of heat. Foods high in protein or fat are also desirable because even though the heat gained from these foods is released slowly, it is released over a longer period of time.

A person suffering from severe hypothermia should be placed in a hypothermia wrap. The principal of a hypothermia wrap is to provide a shell of total insulation for the patient. A patient's ability to internally warm his/herself is much more efficient than any external rewarming. The patient should be dry and have a polypropylene layer to minimize sweating on the skin. Multiple sleeping bags, wool blankets, and wool clothing can be used and a minimum of 4" of insulation should be formed around the patient, especially between the patient and the ground. An aluminum blanket can be used to help prevent radiant heat loss. The entire insulation blanket should then be wrapped in plastic to protect the patient from wind and water.

When administering hydration to a hypothermic person, hot liquids are preferred because they provide calories in addition to being a source of heat. Warm sugar water should

be given to people in severe hypothermia. In severe hypothermia victims, the stomach has probably shut down and will not digest solid food but can absorb water and sugars. A dilute mixture of warm water and sugar should be administered every 15 minutes. Dilute gelatin mix works well to treat severe hypothermia because it is part sugar and part protein. A person suffering from hypothermia should not be given liquids that contain alcohol or caffeine. Alcohol promotes heat loss and caffeine increases dehydration.

Tobacco or other products containing nicotine should not be given to a hypothermia victim because nicotine is a vasoconstrictor which increases the risk of frostbite.

An additional treatment for hypothermia victims is adding heat. This can be accomplished by building a fire or exposing the victim to another external heat source such as an electric heater, chemical heat packs, hot water bottles, warm rocks, towels, compresses, or the body heat of a normothermic person. For victims suffering from severe hypothermia, added heat should be applied specifically to areas where the transfer of heat to major arteries (e.g., neck, armpits, groin, palms of the hands) can be transferred.

Hypothermic people will need to urinate due to cold diereses. Because a full bladder is a place for additional heat loss, urinating will help conserve heat.

3.4.6 Frost Bite

Frost bite is the damage to skin and underlying tissues caused by extreme cold. Frostbite occurs when the skin and body tissues are exposed to cold temperatures for a prolonged period of time. If only the skin and underlying tissues are damaged, recovery may be complete. However, if blood vessels are affected, the damage is permanent and gangrene can follow which may necessitate amputation of the affected part.

A person with frostbite on the extremities may also be subject to hypothermia. Because hypothermia is a more threatening condition, it should be treated first.

3.4.6.1 Symptoms of Frostbite

The first symptom is a pins-and-needles sensation which is followed by numbness. Frostbite is distinguishable by the hard, pale and cold quality of the skin that has been exposed to the cold for a length of time. The area is likely to lack sensitivity to touch, but may have a sharp, aching pain. With more severe frostbite, the skin may appear white and is numb. The severest cases of frostbite may cause blister; gangrene; or hard, frozen skin.

Although any part of the body may be affected by frostbite, hands, feet, nose and ears are the most vulnerable.

3.4.6.2 Treatment of Frostbite

Frostbite can be an extremely threatening ailment and should be treated as soon as possible. Table 3-7 lists the suggested steps for treating frostbite. This list is meant to be used as a quick reference guide and should not be used as a substitute for formal medical training.

Upon warming, it is common to experience pain and tingling or burning in the affected area. In addition, blisters (in severe cases), shivering, slurred speech, and some memory loss may occur.

Professional medical assistance should be obtained if there has been severe frostbite and feeling and color do not return after field treatment; or if frostbite has occurred recently and new symptoms develop, such as fever, malaise, discoloration or drainage from the affected body part.

When treating frost bite, there are several actions which could further damage the patient. These actions include thawing a frostbitten area that cannot be kept thawed, using direct heat on the frostbitten area, rubbing or massaging the affected area, disturbing blisters on frostbitten skin and allowing the patient to smoke tobacco or drink alcoholic beverages during recovery. All of these actions should be avoided when treating a frostbite victim.

Table 3-7. Treatment For Frostbite.

The victim should be sheltered from the cold.
Any constricting jewelry or wet clothing should be removed.
The affected areas should be immersed in warm water or warm cloths can be applied to affected ears, nose, or cheeks. These treatments should last 20 to 30 minutes and hot water or hot cloths should never be used.
Warming is complete when the skin is soft and sensation returns.
Dry, sterile dressing should be applied to the thawed areas.
Thawed areas should be moved as little as possible.
The thawed areas should be insulated to prevent refreezing.
If the frostbite is extensive, warm fluids should be given to the patient to replace lost fluids.

3.4.6.3 Prevention of Frostbite

Several factors contribute to the occurrence of frostbite. These factors include extreme cold, wet clothes, high winds, and poor circulation. Poor circulation can be caused by tight clothing or boots, cramped positions, fatigue, certain medications, smoking, alcohol use or diseases that affect the blood vessels (e.g., diabetes). Therefore, it is advisable for crew members to wear suitable clothing in cold temperatures and protect susceptible areas. The most effective clothing includes mittens; wind-proof, water-resistant, many-layered clothing; a pair of wool socks on top of a pair of cotton socks; and a scarf and a hat that cover the ears. Before anticipated prolonged exposure to cold, crew members should not drink alcoholic beverages or use tobacco and they should be properly nourished and well rested.

3.5 Cardiopulmonary Resuscitation (CPR)

Crew members engaged in large river research are at risk to several kinds of injuries. Two of these injuries, drowning and electrical shock, are particularly dangerous because they can cause the victim to stop breathing. When this happens, it is vital that breathing resume within 4-6 minutes. However, resuscitation should be aggressively pursued for anyone who has been submerged for up to an hour. The best first aid treatment for victims who have stopped breathing is cardiopulmonary resuscitation (CPR). CPR is a rescue and basic life-support technique for someone whose heart or breathing has stopped and can keep a person alive until an ambulance and medical treatment is available. Before anyone attempts to resuscitate a victim using CPR, they should be formally trained. There

should be at least one person on each crew that has had CPR training. The steps given in Table 3-6 quickly summarize suggested CPR procedures to be used for adults. This summary should not be used as a substitute for the proper CPR training. It should also be noted that the technique is often modified in order to be more effective and/or safer. Therefore, the protocol given in Table 3-8 should be checked annually for current accuracy. Improper CPR or CPR performed on a person whose heart is still beating can cause serious injury. This table is meant to serve as a quick reference or refresher information. Training in CPR techniques is available from the Red Cross, American Heart Association, universities, local hospitals, fire departments, and other companies and agencies.

3.6 The Heimlich Maneuver

The Heimlich maneuver is a simple life-saving technique consisting of a series of under-the-diaphragm abdominal thrusts intended to dislodge a foreign object from a choking victim's throat. It is a widely recommended technique that may help save the life of a choking victim.

Table 3-8. Summary of CPR Protocol.

First, the individual should be tested for responsiveness by touching, tapping and questioning.
If the individual fails to respond, then medical assistance should be summoned.
The victim should be turned while his/her head and neck are supported and he/she should be positioned on his/her back on a hard surface.
The victim's airway is opened by pushing down on the forehead while lifting chin.
Three to five seconds should be spent determining if the victim is breathing by looking at the chest for movement, listening for breathing sounds, and feeling for breath.
If the victim is not breathing, the nostrils are pinched, a tight seal is formed around the victim's mouth and the rescuer breathes two quick breaths into the victim's mouth while watching for the victim's chest to rise.
If the air way is obstructed, then the victim's head is repositioned and a second attempt to give the victim two quick breaths is made.
If the airway is still obstructed, then six to ten abdominal thrusts are given to the victim in order to dislodge any obstructions.
The victim's mouth is cleared of dislodged items.
If the victim's airway is still obstructed, the above steps are repeated.
After two unobstructed breaths are given, 5 to 10 seconds are spent determining the victim's pulse. The pulse should be checked at the carotid artery (in the neck).
If no pulse is detected, then the rescuer begins chest compressions.

(continued)

Table 3-8. Continued.

Chest compressions are 1.5 to 2 inches deep for adults, 1 to 1.5 inches deep for children, and 0.5 to 1 inch deep for infants.

For adults, 15 chest compressions are followed by two breaths. For children and infants, 5 chest compressions are followed by 1 breath.

The sequence of chest compressions and breaths is repeated for 4 (adults) to 10 (children and infants) cycles, then the victim's pulse is determined.

If no pulse is detected, the CPR cycle of breaths and chest compressions is begun starting with two breaths.

If pulse returns but no breathing, one breath is given every 5 seconds.

These procedures should be continued until professional medical assistance arrives.

The basic steps for performing the Heimlich maneuver are given in Table 3-9. However, this brief overview should not be used as a substitute for proper training administered by licensed personnel. The Heimlich maneuver is not to be used if the victim is coughing, speaking or breathing. If the person cannot cough, speak, or breathe, the steps listed in Table 3-9 are recommended. The protocol for treating an unconscious choking victim is given in Table 3-10. Although the overall technique remains the same, the specific steps are occasionally modified. Therefore, the protocols given in Tables 3-9 and 3-10 should be checked annually for updates.

Table 3-9. Summary of Heimlich Maneuver Protocol.

The rescuer should stand behind the victim and wrap his/her arms around the victim's waist.

The rescuer clasps his/her hands together in a doubled fist and places the fist (thumb side in) just below the victim's rib cage and above the navel.

The rescuer presses into the victim's abdomen (not the rib cage) with a quick, upward thrust.

The thrusts are repeated until the object is dislodged.

Table 3-10. Summary of Heimlich Maneuver Protocol Recommended for Unconscious Victims.

The awareness of the victim is determined.
The victim's airway is opened by pushing down on the forehead while lifting chin.
Three to five seconds should be spent determining if the victim is breathing by looking at the chest for movement, listening for breathing sounds, and feeling for breath.
If the victim is not breathing, the nostrils are pinched, a tight seal is formed around the victim's mouth and the rescuer breathes two quick breaths into the victim's mouth while watching for the victim's chest to rise.
If the victim's airway is still obstructed, then his/her head is repositioned and an additional attempt is made to breath into the victim's lungs.
If the second attempt fails, then the victim is given a series of abdominal thrusts.
In order to administer the abdominal thrusts, the rescuer straddles the victim's thighs.
Then the rescuer places the heel of one hand near the victim's navel.
The rescuer's other hand is placed on top of the first and together they are thrust toward the victim's nose.
Six to ten of these thrusts are given.
Then the rescuer attempts to clear any dislodged objects out of the mouth.
Next, the rescuer attempts to breath two quick breaths into the victim's lungs.
If the airway is still obstructed, the rescuer repeats the abdominal thrusts.
This procedure is repeated until the airway is cleared or until professional medical assistance arrives.

Section 4
Access and Legal Issues

by
Jennifer Everett and Bradley C. Autrey

4.1 Site Access

When rivers are assessed, a primary logistical concern is site access. Often the accessability of sites on a river will determine the degree to which that river can be surveyed. In order to evaluate the accessability of a river, reconnaissance should be conducted well in advance of the sampling season.

4.1.1 Public Land

It is often productive to determine the location of boat ramps that are available to the public. It is helpful to remember that not only are boat ramps available on public lands, but are also commercially available to the public on private lands. Initial reconnaissance should determine not only the location of these ramps but also the amount of any fees associated with their use.

4.1.2 Private Land

Once the avenue of public boat ramps has been exhausted, the ownership of privately-owned lands adjacent to the river should be researched. Because the riparian zones of large rivers are often the focus of conservation concerns, private conservation groups may own these lands. These organizations will often grant access to their land for the purpose of accessing the river. It is necessary to contact these organizations well in advance of the sampling season so that the proper permits can be procured and any keys that may be needed can be obtained. It is also necessary to gain access to the lands in advance of the sampling season so that further reconnaissance can be conducted to determine the location of access to the river, as well as the location of a suitable area for parking vehicles and boat trailers. It is important that the sampling crews be given a copy of the land use permit, any keys needed for gate access, the name and phone number of a contact from the organization and any pertinent instructions or restrictions.

Other resources for gaining access to private lands are government agencies that conduct biological sampling on large rivers. If any of these agencies have conducted biological sampling on the target river during previous years, they may be willing to share the locations of the sites they used for access. With this information, it is then necessary to

conduct reconnaissance to confirm the existence of adequate launch sites and, when needed, contact the land owners and attempt to gain permission for the use of the land.

The final course of action that can be used to gain site access is through direct land owner contact. It may be necessary to visit local county courthouses in order to determine land ownership. Once land ownership has been determined, it is then necessary to contact the land owner to gain permission to use the site for river access.

When contacting land owners, it is prudent to make available a written description of the study so that they can be fully informed of the project's objectives. If a land owner chooses to grant permission for river access, it is important to have the land owner complete and sign a form to verify that permission for the use of his/her land has been granted.

Figure 4-1. An example of a primitive access point.

4.1.3 Primitive Access

If the number of sites with boat ramps is not adequate for the sampling requirements, it may be necessary to access the river from more primitive launch sites (Figure 4-1). It is possible, and often necessary, to launch boats from a number of areas such as low banks or gravel bars. Some adequate launch sites may be found under highway bridges or areas used by the public for recreational fishing. If such an area is to be used on public land, it is important to contact the local authorities in order to gain permission to use these areas. It may be helpful to make sure that the sampling crews using these areas have the names and phone numbers of the local authorities so that they may be contacted in the event of an emergency. If the primitive launch sites are located on private lands, it is important to gain permission from the land owner to use these sites in this manner. When primitive access points are going to be used during field work, it is important that the equipment to be used be selected appropriately. See Section 2, Equipment, Maintenance and Field Repairs, for additional information.

4.1.4 Targeted Sites

When particular portions of the river are targeted for sampling and the river has frequent obstructions such as impoundments, it may be necessary to employ all of the above tactics to reach all of the targeted sites. When sampling in areas that are infrequently used for recreational purposes, the need for primi-

tive sites and permission from private land owners will increase. However, in areas that are heavily used for recreational activities, there may be an adequate number of boat ramps available.

4.1.5 Access Etiquette

When using land as access to a river, certain protocol should be followed to ensure the safety of the crew and to maintain favorable public relations with land owners and other persons using the land. One important safety measure is for a laminated information sheet to be placed in each vehicle that is used for field work. The information sheet should include the name of the agency conducting the research, the name of the research project, and the names and telephone numbers of home-based personnel that should be contacted in case of emergency. The information sheet should be displayed in a visible area of the vehicle such as inside the driver-side window.

An additional safety measure that should be taken when the field crew is using privately-owned land for site access is to make contact with any individuals that may be using the land while the field crew is present. This measure also serves as positive public relations for the sampling agency. Although the initial site reconnaissance should have provided the field crew with permission to use the land for site access, it is possible that the individuals using the land are unaware of the permission granted. Speaking with these individuals can help avoid misunderstandings. In addition, informing individuals present that the crew will be on the river gives the crew a contact on land. This contact may be able to inform the crew of hazards on the river, help protect the crew's vehicle and may be the first to call for help should the crew become stranded on the river.

4.2 Permits

When sampling rivers, it is important to make sure that all of the proper permits are obtained. It will be necessary to contact officials associated with the natural resource, wildlife, or fish and game agencies within the states where the sampling will occur. If any sampling activities are to take place within the boundaries of areas designated as a park or wildlife refuge, it is important to contact the officials associated with the areas before the sampling takes place. It may be necessary to obtain permits specific to these designated areas. Because the processing of permit requests can be time consuming, it is important that the process of obtaining permits be started as soon as possible. It is important to note that most permits require annual renewals and may require that a report of the study's results be submitted to the permitting agency.

Section 5
Crew Logistics

by
Joseph E. Flotemersch and Bradley C. Autrey

5.1 Introduction

As sampling crews gain more experience over the course of a field season, they will naturally become more efficient. Often, the most efficient work flow will evolve as crew members discover how to effectively and completely accomplish tasks in the safest and quickest time possible. This section is designed to speed the evolution of the most efficient work flow for an individual crew by offering solutions to problems that may potentially be encountered in the field (Figure 5-1).

5.2 Crew Size

The number of persons on each crew is an integral part of the crew's effectiveness. A crew with too many members is often inefficient and lacks the proper structure for maintaining personal responsibility, while a crew with too few members can be overworked, exhausted or unable to complete the assigned task. Therefore, a great deal of consideration should be given to the number of people assigned to each crew.

The best way of determining optimal crew size is through trial and error or experience. Therefore, an option for determining the best possible crew size is to consult with an individual who has coordinated a similar project or worked on a crew with similar tasks. If such a resource is not available, it may be advisable to conduct a preliminary trial run. In the trial run, the members of a mock crew will simulate the activities to be conducted by the actual crew at a later date. This activity will not only aid in determining the optimum crew size, but will also give an initial view of some logistical problems that may be encountered by the crews once the real work begins.

Among the factors that will affect the number of members needed on each crew are the tasks to be completed, the number of working days in which the tasks are to be completed and the number of hours per day the crew can spend on the river (see Section 5.4). Once all of these factors have been considered, it should then be possible to estimate the number of persons that will be required for each crew. If the exact number of crew

Figure 5-1. An example of a crew working together. Note that each member of this crew has his/her own responsibility. While one crew member identifies a fish species, another crew members weighs and measures each fish and a third crew member records the information on a field sheet.

members needed is uncertain, some experienced field personnel prefer to err toward a smaller crew. A smaller crew is challenged to work as a team and excel at efficiently accomplishing tasks. These efforts are more likely to lead to a successful field endeavor than a larger crew without such challenges.

5.3 Crew Structure

It is advisable for one member of each crew to be designated as the crew leader. This person will be the one crew member who is ultimately responsible for a number of decisions to be made, the successful completion of the project and the integrity of the data collected. This person is not an authoritarian, rather he/she seeks and considers the opinions of the other crew members and does not attempt to make all decisions alone. Essentially, the crew leader is responsible for the deposition of samples and data forms and the proper maintenance and care of equipment. In addition, the crew leader should be familiar with and a reliable resource for the execution of all sampling protocols, keep the crew motivated and take steps necessary to assure the crew's safety.

Although the crew leader is ultimately responsible for the crew's work, each member of the crew should have his/her individual responsibilities. In essence, each task to be completed should be the sole responsibility of one individual. As a result, all crew members will have a clear understanding of their exact responsibilities and the likelihood of tasks not being completed will diminish.

5.4 Crew Training

Because it is likely that at least some of the crew members will lack experience in conducting ecological research on large rivers, crews should be trained by personnel who

have such experience (Figure 5-2). Proper training will help to ensure that data are gathered properly and safely. Crew training should occur before the beginning of the sampling season and should include safety issues such as proper boat use, first aid/CPR; and the proper methods for collecting, recording, preserving and processing data and samples.

5.4.1 Protocol Training

It is vitally important that crews be specifically instructed on the proper protocols for collecting data. In particular, crew members who have little or no experience executing the designated protocols and crew members who have experience using other protocols need to be given thorough training specific to the protocols they will be using.

Crew members should be made aware of the entire scope of the project in which they are participating. This will enable them to appreciate the overall goals of the project and impress upon them the importance of collecting the most complete and accurate data possible. However, while it is important for crew members to understand the overall project, they should be assigned to and specifically trained for the particular tasks that they will be executing during the field season. This will allow crew members to focus on their particular aspects of field sampling during the early portions of protocol training.

It may be advantageous for crew members to be trained for more than one set of sampling tasks. For example, a crew member may be assigned to and trained primarily for the collection of benthic macroinvertebrate samples and data, but may be secondarily assigned to and trained for the collection of algae samples and data. This would not only allow the crew member to replace someone that was trained primarily for the collection

Figure 5-2. Field crews are trained by experienced personnel. It is often helpful to conduct training sessions in a field setting.

of algae samples and data, should the need arise, but also give the crew member the skills necessary to perform QA/QC checks on the manner in which the algae samples and data are collected.

The standard operating procedures (SOPs) should be demonstrated by experienced personnel and should be accompanied by literature describing the SOPs. In addition to full-length, detailed descriptions, the literature should also include short, one-to-two page summaries that can be easily referenced in the field. During the demonstrations, all equipment that the crew members will be using during the field season should be displayed and the proper maintenance of the equipment should be explained (see section 2).

5.4.2 Safety Training

All safety training should be conducted by personnel that are experienced and/or licensed to administer such instruction. Licensed instructors are particularly important for first aid and CPR training. It may be necessary to obtain training from an outside agency or company. The additional expense of such training is easily justified when considering that it may prevent serious injuries from occurring or that it may save the life of a crew member. Records of all safety training should be kept and each crew member's signature should be obtained for each portion of safety training that he/she completes. This allows the employing agency to verify that each crew member was satisfactorily trained. This will also help protect the employing agency in the event that a crew member is injured during the field endeavor. See Section 3 for further discussion of safety training.

5.4.3 Crew Etiquette

In addition to training crews to properly execute the designated protocols and safely negotiate field hazards, there should also be some time spent impressing upon crew members the relative difficulty of the working conditions that they will encounter. Crew members should be made aware from the beginning of the project that the behaviors of individuals will either make these conditions more difficult or less difficult. A crew that works well as a team will be more efficient and be more likely to collect the best possible data than a team that is strife ridden. While these are lessons that each crew member will learn in time; stressing the importance of teamwork, cooperation, courtesy, and appropriate behaviors at an early juncture could save a crew a great deal of unnecessary stress and periods of inefficiency. Crews should be encouraged to consider other crew members during many aspects of their daily routines. Some of the aspects that crew members should particularly consider are their work ethics, personal hygiene and cooperative attitudes. Essentially, crew members should be aware that every aspect of their behavior will have some impact on the other members of their team and ultimately the research itself.

5.5 Crew Activities

5.5.1 Workday Length

It is important to remember that a crew's workday includes travel time, loading and unloading equipment, processing and logging samples, and proofing field forms. Therefore, five hours spent working on the river can easily translate into a 10-hour work day. It is also important to keep in mind that the number of hours a crew is able to spend on the river will vary during the course of a year. In the summer, when there are more hours of daylight,

the crews usually have ample time to finish their tasks before nightfall. However, in the late autumn, winter, or early spring, there may be less daylight than time required to complete tasks on the river.

5.5.2 Work Flow

One of the most important components in developing an efficient work day is the flow of work used among the crew members. It is important that each crew develop its own work flow that best suits its own duties and the assets of each of its members. The goal should be for each member of the crew to be perpetually executing some task. When each crew member always has some task to execute and these tasks are coordinated in such a way that there is very little inefficient use of time, then a very efficient work flow can be developed. This enhances the likelihood of the crew experiencing a successful field endeavor.

Section 6
Recording Data

by
Bradley C. Autrey and Gerilyn Ahlers

6.1 Field Forms

6.1.1 Field Form Completion

The proper completion of field forms is a vital part of data collection in the field. It is important for the members of the field crew who are completing the field forms to do so legibly. It may be necessary for one member of the crew (i.e., the crew leader) to review all field forms to ensure that they are being completed legibly. Also, field forms should be completed with a soft lead pencil. This will allow for mistakes or illegible handwriting to be corrected. When field forms are to be completed while the field crew is on or near a river, it is also important that the forms be printed on all-weather paper that is resistant to water damage.

6.1.2 Field Form Design

To ensure that field data are collected completely and efficiently, field forms should be comprehensive and easily completed under field conditions. It is helpful if the field forms used for a specific project are designed specifically for that project rather than using forms originally designed for use on a different project. For example, forms designed for wadeable rivers may require that the substrate type at the thalweg depth be recorded. On large rivers, however, these data are often not attainable because the water is too deep to accurately determine the substrate type at the thalweg depth. Therefore, the crew member should be able to indicate that the water was too deep to determine substrate type on the form. Inconsistencies in data recording can occur when forms that are not specifically designed for the relevant research project require field crews to edit forms in the field. Creating forms that are specifically tailored aid in the accurate, complete and efficient collection of data in the field.

A good field form is one that is streamlined to match methods being used and eliminates redundant and or unimportant information. Complicated sets of data should not be recorded on multiple forms. For example, it is not necessary to include accessory physi-

cal habitat information on forms used in the collection of macroinvertebrates if the same data are collected on physical habitat forms. Eliminating this type of redundant information will accelerate the collection of field data. In addition, a concise, streamlined field form will be completed more accurately because it is easier to overlook errors when the forms are redundant and less streamlined.

One way that field forms can be streamlined is by creating data fields in which the recorded data are chosen from a set of options. This increases the likelihood that the person completing the form will do so as intended and in a manner that is more consistent with the way that other field workers would complete them. While not all data can be recorded in this manner, when appropriate, it is a preferred option.

To reduce inaccuracies, field forms should be clear in their content. Inconsistencies occur when the forms do not clarify what data are to be recorded and where they are to be to be recorded. If the forms are necessarily complicated, it may be helpful to include explanations on the forms. This can be done by including text boxes that explain notations and abbreviations and list the options for multiple-choice fields.

It is also helpful to have all measurement units preprinted on the form and include the formula for any calculations that are to be completed in the field. Calculations that are not needed in the field and are easily performed during data analysis should be eliminated from field forms. Many inaccuracies can be eliminated by clarifying the complicated aspects of the form on the form itself.

Another method to ensure the efficient, accurate and complete collection of data on field form is to remain consistent among the different forms and within individual forms. When using separate forms for different types of data, (e.g. macroinvertebrates, algae, and physical habitat) the terminology used should be consistent. All terminology should be clear and specifically defined. All units of measurement should be in either the English system or the metic system and should not vary. An example of a properly-designed field form is given in Figure 6-1.

6.2 Labels

6.2.1 Label Completion

All samples collected in the field must be labeled so that they may be identified at a later date. Labels should be legibly completed using a fine point permanent marker, attached to the sample container and covered with transparent packaging tape. The packaging tape will prevent damage to the label or the writing on the label. An additional measure that will help assure the accurate tracking of samples is to place a second label inside the sample jar. An internal label can be used during data processing if the external label is damaged during transport or storage and information is lost. The internal label should be printed on all-weather paper and be completed legibly using a soft lead pencil.

6.2.2 Label Design

The design of labels should be determined in the early stages of planning the project and should be clearly described in the Project Plan that is produced before sampling begins. All labels should be clearly titled with the project name and the sample type (e.g., benthic macroinvertebrates). Also, all labels should have an area designated for the site identification number, the collection date and the complete name of the sample's collector. The inclusion of the sample collector's full

VERIFICATION FORM - BENTHIC STUDY 2000

SITE NAME: DATE: / / VISIT(X): 1 ☐ 2 ☐

SITE NAME: ___ ___ ___ TEAM ID(X): 1☐ 2☐ 3☐ 4☐ 5☐

STREAM/RIVER IDENTIFICATION FORM

STREAM/RIVER VERIFIED BY (x all that apply): ☐ GPS ☐ LOCAL CONTACT ☐ SIGNS ☐ ROADS ☐ TOPO MAP ☐ OTHER (DESCRIBE HERE): ☐ NOT VERIFIED (EXPLAIN IN COMMENTS)

COORDINATES	LATITUDE (dd mm ss) North	LONGITUDE (ddd mm ss) West	TYPE OF GPS FIX	Are GPS Coordinates w/in 10 Sec. of map?
Map:	__ __° __ __ ’ __ __”	__ __ __° __ __ ’ __ __”	☐ 2D	☐ YES
GPS:	__ __° __ __ ’ __ __”	__ __ __° __ __ ’ __ __”	☐ 3D	☐ NO

INDEX SITE STATUS - X ONE BOX FROM ONE SECTION ONLY

SAMPLEABLE

☐ REGULAR - WADEABLE
☐ REGULAR - NOT WADEABLE
☐ INTERMITTENTLY DRY
☐ DRY
☐ ALTERED - DIFFERENT THAN MAP
☐ OTHER (EXPLAIN IN COMMENTS)

NON-SAMPLEABLE (NO SAMPLE TAKEN)

☐ NO CHANNEL OR WATERBODY PRESENT
☐ IMPOUNDED (UNDERNEATH LAKE/POND)
☐ WETLAND (NO DEFINEABLE CHANNEL)

NO ACCESS

☐ ACCESS PERMISSION DENIED
☐ INACCESSIBLE (UNABLE TO REACH SITE)

DIRECTIONS TO STREAM/RIVER SITE

GENERAL COMMENTS

Figure 6-1. An example of a properly-designed field form.

SAMPLE COLLECTION FORM - BENTHIC STUDY 2000

SITE NAME: DATE: / / VISIT(X): ☐ 1 ☐ 2

SITE NAME: ___ ___ ___ TEAM ID(X): 1☐ 2☐ 3☐ 4☐ 5☐

COMPOSITE BENTHOS SAMPLES

SAMPLE ID (4-DIGIT)	HABITAT (X ONE)		NUMBER OF JARS	FLAG	COMMENTS
	RIFFLE	POOL			
__ __ __ __					
__ __ __ __					

TRANSECT	A	B	C	D	E	F	G	H	I	J	K
RIFFLE OR POOL - (X ONE)	☐ R ☐P	☐ R ☐ P	☐ R ☐P	☐ R ☐ P	☐ R ☐ P	☐ R ☐P	☐ R ☐ P	☐ R ☐ P	☐ R ☐P	☐ R ☐ P	☐ R ☐ P
LEFT, CENTER, OR RIGHT - (X ONE)	☐ L ☐C ☐R	☐ L ☐ C ☐ R	☐ L ☐ C ☐R	☐ L ☐ C ☐R	☐ L ☐ C ☐ R	☐ L ☐ C ☐R	☐ L ☐ C ☐R	☐ L ☐ C ☐ R	☐ L ☐ C ☐ R	☐ L ☐ C ☐ R	☐ L ☐ C ☐ R

GENERAL COMMENTS

Figure 6-1. Continued.

name on the sample label may help to provide a measure of integrity and accountability to the sample's collection. In addition, labels should have an area in which the specific method used to collect the sample (e.g., drift net or kick net) can be indicated. Finally, all labels should be given a unique sample number (see section 7). Fields for additional information such as comments on sampling conditions can be added to the labels. These data may not be necessary, but they may be helpful during data processing or sample tracking. An example of a properly-designed label is given in Figure 6-2.

The design and production of labels should be a cooperative effort between the field workers and the laboratory personnel. This will ensure that information important for laboratory processing of field samples is included on a label that is designed for use in the field. This may include data that is already recorded on field forms but may not be readily available to laboratory personnel.

Remote Sensing Project

Site ID: _____ Date: _____

Collected by: _____

Circle: Algae TSS Water Chem. Chl-A

Circle: Filtered Unfiltered

Circle: Preserved Unpreserved

Volume: _____

Comments:

Sample #0001

Figure 6-2. An example of a properly-designed sample label.

It may be beneficial to design labels so that they can be used for more than one type of sample. For example, it is not necessary, and may be counterproductive to make separate labels for both drift net and kick net samples of benthic macroinvertebrates. Multitasking labels eliminates the possibility of the wrong label being used in the field.

It may be helpful to produce a small set of training labels. These labels can be used as practice for field crews during training. In addition to providing training for field workers, testing labels provides an opportunity to discover any problems with the properties or design of the label.

Labels should generally be completed and applied to the sample containers after the samples have already been processed. This will help avoid the production of samples with inaccurate labels.

6.3 Chain of Custody Forms

In order to ensure that samples are properly tracked, a Chain-of-Custody form should be completed for each sample taken. This form should include the date, site number, sample number, type of sample taken, the name of the person who collected and/or processed the sample, and the steps that have been taken to preserve the sample. This form should also include a space for the signature of the crew member who is relinquishing the sample to laboratory personnel and the signature of the laboratory personnel who is taking responsibility for the sample. The Chain-of Custody form allows samples to be tracked and allows the personnel that had custody of the samples to be documented.

6.4 Logging Samples

When samples are deposited in a sample storage facility, the should be logged. The Sample Log form should include spaces for the date that the samples were collected, the date that the samples were deposited in the storage facility, the type of sample that is being deposited, the name of the person who is depositing the sample, and sample numbers that are given to the deposited samples. An example of a properly-designed Sample Log form is given in Figure 6-3.

Benthic Project 2000
Sample Log

Sample ID #	Site ID #	Number of Sample Jars	Crew ID #	Field Collection Date	Date Lab Received	Logged in by

Figure 6-3. An example of a properly-designed Sample Log form.

Section 7
Preparing the Laboratory

by
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7.1 Sample Storage

Once samples have been collected, it is critical to store them in such a way as to maintain the highest possible integrity. Often this process begins in the field when the samples are first acquired. Therefore, the sampling crews must be supplied with the appropriate containers, labels, preservatives, and training necessary to initiate the steps required to ensure proper sample storage.

7.2 Sample Transport

Planning and care are required for transporting samples from the field to the laboratory. First, the crew must use the proper transport containers. If samples are required to be frozen during transport, a portable freezer or a container with dry ice will be required. If samples are required to be kept cool, then a portable refrigerator or cooler with ice will be required. Samples that can be transported at the ambient temperature should always be packed in such a way that they will not be unduly disturbed during travel. All samples should be packed tightly in the vehicle or alternate container so that they will not overturn while en route to the laboratory.

If samples are required to be shipped to the laboratory via a shipping service, the crew should take steps to ensure that this can be executed efficiently and properly. Shipping containers and shipping labels should be obtained before the field work begins.

7.3 Sample Tracking

Each sample that is collected must be properly tracked. This may be done through the use of Chain-of-Custody forms (Section 6.3). These forms track the samples as they change hands from field personnel to laboratory personnel by recording the names of the personnel who had custody of the samples at each phase. When samples are deposited into a sample storage facility, the deposition should be recorded into a log. The purpose of the deposition log is to create an inventory of the samples in the sample storage facility, track the length of time that samples spend in storage and provide an additional means of tracking the personnel who had custody of the samples at different times.

7.4 Sample Preservation

7.4.1 Water Chemistry

Before they are processed, it is preferable to keep water chemistry samples at ambient river temperature, in a dark container. These samples should be processed (i.e., filtered, and/or preserved) according to the procedure for the respective type of analysis, and refrigerated as soon as possible. It is preferable to keep the water chemistry samples on ice after they have been processed, and before they have been transported from the field to the laboratory.

7.4.2 Algae

Because algae are very sensitive to ambient conditions, it is important to keep the sample collection container under dark and cold conditions. Therefore, while the sampling crew is on the river, it is advisable to keep the sample container in a cooler with ice. Once collection procedures have been completed, the periphyton/phytoplankton sample should be filtered, frozen, and/or preserved with 10% formalin (depending on the type of analysis to be conducted) as soon as possible.

7.4.3 Benthic Macroinvertebrates

Benthic macroinvertebrate samples should be held in river water during collection, then sieved and preserved with 70% ethanol (Figure 7-1). They should be held and stored at room temperature.

Figure 7-1. A member of a field crew processes a benthic macroinvertebrate sample in the field. The proper field processing of a sample is a crucial step to ensure that samples can be properly analyzed.

7.4.4 Fish

Any fish that are saved or vouchered should be preserved in formalin, and also held at room temperature.

7.5 Holding Times

A secondary concern of sample storage for the preservation of integrity is the holding times. Many samples have a defined period within which analysis must occur in order to obtain accurate data. Water chemistry analysis is especially sensitive to prolonged holding times, because many of the trace elements of interest will quickly deteriorate. Chlorophyll a and biomass analysis of algae samples must be performed within 30 days. Most other sample types, especially those that have been preserved, will retain their integrity for longer periods of time.

Section 8
Literature Cited

American Red Cross. 1989. Standard First Aid and Personal Safety. American National Red Cross. 269 pp.

Lazorchak, J.M., D.J. Klemm, and D.V. Peck (eds.). 1998. Environmental Monitoring and Assessment Program - Surface Waters: Field Operations and Methods for Measuring the Ecological Condition of Wadeable Streams. U.S. Environmental Protection Agency, Washington, D.C., EPA/620/R-94/004F.

National Institute for Occupational Safety and Health. 1981. Occupational Health Guidelines for Chemical Hazards (Two Volumes). NIOSH/OSHA Publication No. 81-123. U.S. Government Publication Office, Washington, D.C.

Nielson, L.A., and D.L. Johnson (eds.). 1992. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Ohio EPA. 1990. Ohio EPA Fish Evaluation Group Safety Manual. Ohio Environmental Protection Agency, Ecological Assessment Section, Division of Water Quality Planning and Assessment, Columbus, Ohio.

U.S. Coast Guard. 1987. Federal Requirements for Recreational Boats. U.S. Department of Transportation, United States Coast Guard, Washington, D.C.