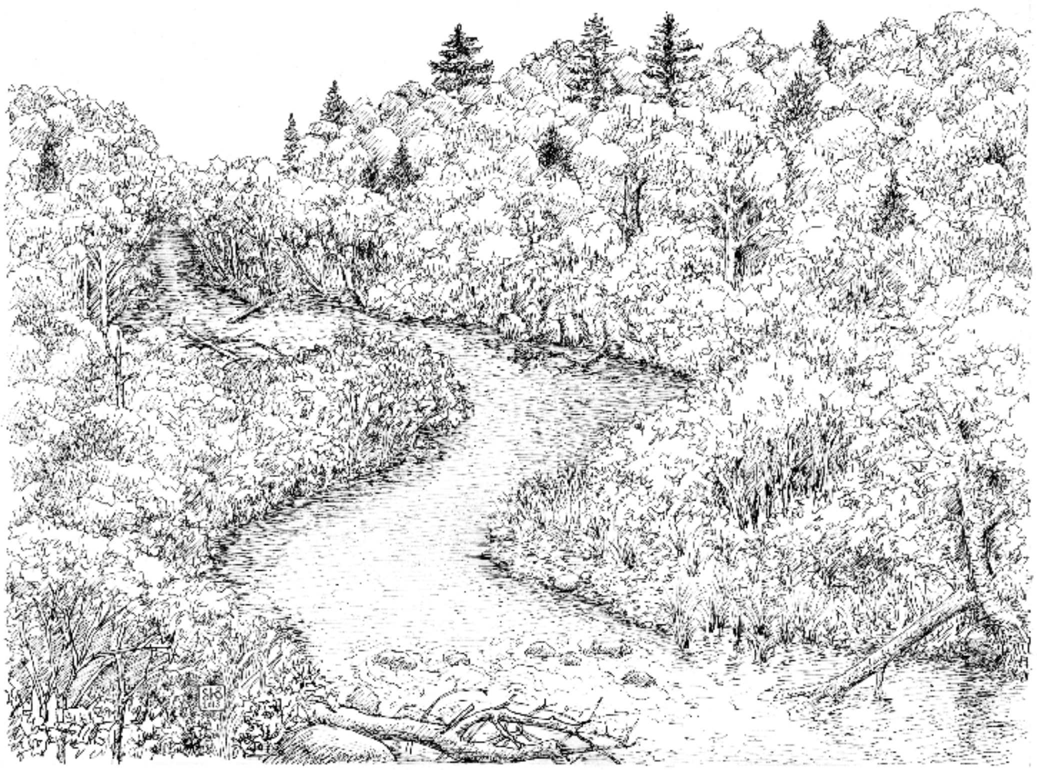
Crayfish

Important Members of River Ecosystems



A Curriculum Unit of the Program

Monitoring the White River (MWR)

Developed by
The White River Partnership
Verdana Ventures LLC

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Crayfish

Important Members of River Food Webs

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Unit Summary

Lively behavior and ecological importance make crayfish a great subject for scientific studies. The four species of crayfish in the White River watershed can help students learn anatomy and identification skills that can be applied across the biological sciences. As an opportunistic omnivore, the crayfish connects many strands of a river food web, helping to move energy throughout the ecosystem.

An invasive species, the rusty crayfish, is causing alarm in Vermont and elsewhere, giving students who survey its populations a dynamic service-learning opportunity. Schools, watershed organizations, and Vermont state biologists are all monitoring crayfish in their areas to document the presence and abundance of rusty crayfish and other crayfish species. The recently discovered big water crayfish is being watched to see if it too becomes invasive. Crayfish data collected each year can help us track crayfish populations, and associated outreach activities can help the public understand how to minimize the spread of non-native aquatic species that might threaten our native species.

Crayfish surveys can be implemented by schools in the fall and/or spring, when water levels and temperatures allow students to work safely along their rivers. Crayfish are easily caught with simple traps and nets, and can be successfully kept in classroom aquaria for many months to extend student learning. A *Crayfish Teaching Kit,* offered free of charge by the White River Partnership, contains needed equipment for crayfish surveys.

A. Setting the Stage

Monitoring the White River: **A School-Based Program**

Monitoring the White River (MWR) is a school-based program sponsored by the White River Partnership, a nonprofit organization, and Verdana Ventures, an educational consulting firm. MWR uses a teacher-directed approach to involve students in grades 3 through 12 in investigating natural components of the White River watershed to produce information that fosters the health of our shared landscape. Fieldwork methods adapted from professional scientists help to address real-world issues identified by watershed stewardship projects. As such, MWR is an authentic "science to service" program.

Four **MWR units** can be tailored to address individual school goals. They are:

- ***Waterbugs*** (benthic macroinvertebrates) – indicators of river health and water quality
- ***Crayfish*** – key members of river and riparian food webs that may be impacted by the arrival of invasive crayfish species
- ***Riparian Trees*** – riparian trees planted to prevent erosion and improve river health
- ***Riparian Tracks & Sign*** – evidence of wildlife activities along river corridors

Each of these units can be tailored to meet the specific goals of schools and their districts. Whenever possible, we promote collaborative programming among grades within a school and between various schools.

Participating schools are invited to borrow an *MWR Teaching Kit* for each unit, which includes all or most of the supplies needed for the activities described in the unit.

The White River Partnership (WRP) is a non-profit organization that was created in 1996 by local community members who were concerned about the long-term health and sustainability of the White River and its watershed. That same year, the Partnership organized a series of public forums to help identify community concerns about the watershed. Streambank erosion, water quality, declining fish populations, and public access to the river were the major concerns. The WRP addressed these concerns through the implementation of programs. Currently, the programs focus on monitoring the health of the watershed through various assessments, restoring and protecting the river watershed, and promoting education and long-term stewardship. The WRP encourages local communities, businesses, and organizations to become involved, and also provides public information on a range of issues relating to the watershed.

Verdana Ventures LLC (VV) is an educational consulting company based in Randolph, VT, focused on sustainable development and environmental literacy. VV partners with local non-profit organizations (such as the WRP) to offer watershed education programming, focused on student fieldwork, to schools in central Vermont. VV has conducted school and community programs in the U.S and Asia.

The White River Watershed

The uneven **topography** of the land creates natural basins that drain rain, snowmelt, springs, and groundwater into a water body at the lowest elevation, such as a stream, river, wetland, pond, or lake. These basins are called **watersheds.** The boundary, or divide, of a watershed is the "rim" of the basin, which can be drawn by connecting the highest points of land around it. Streams and rivers function as the "arteries" of the watershed by carrying water downhill.

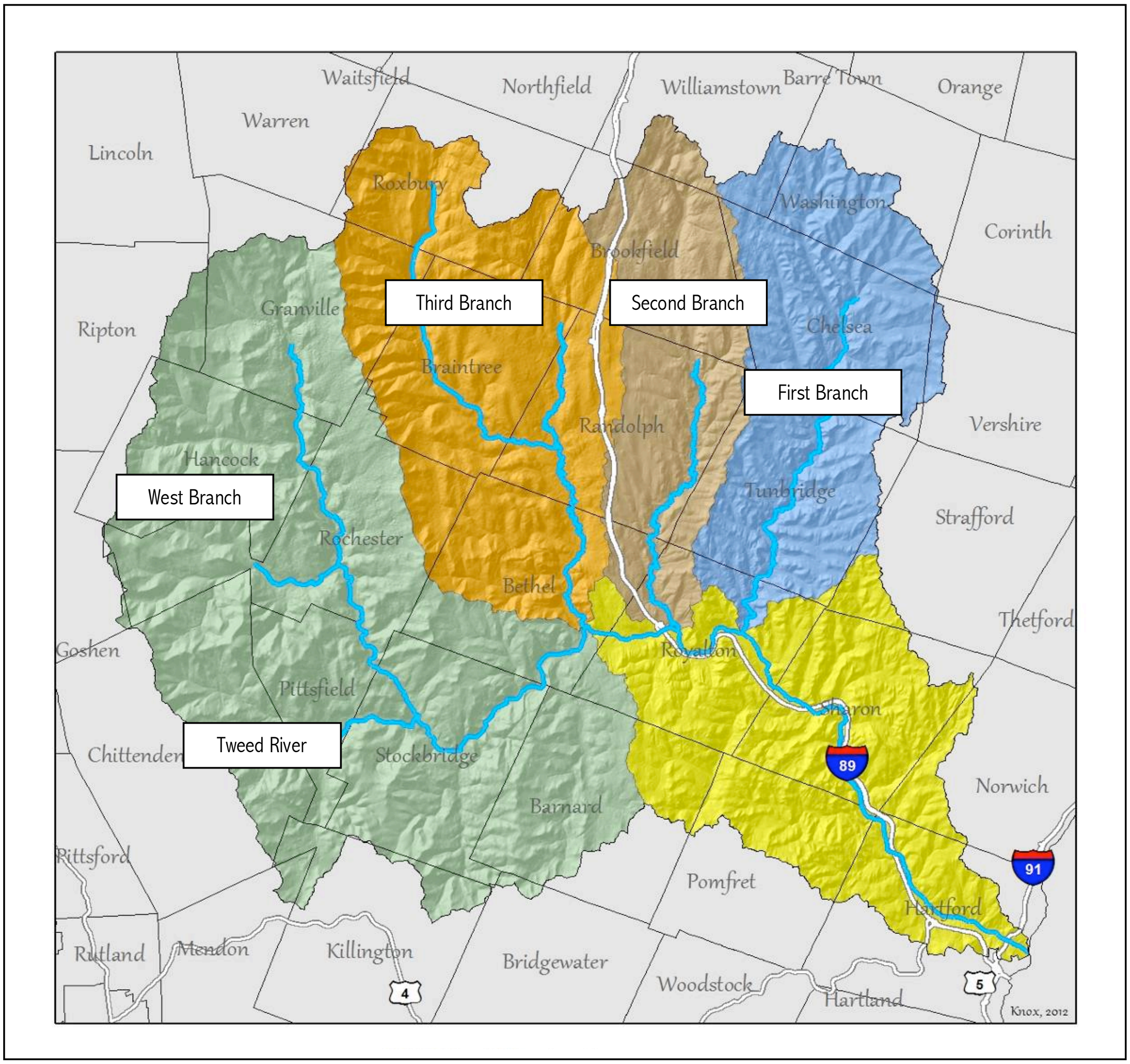
The White River watershed encompasses 710 square miles in central Vermont, draining portions of 5 counties (Addision, Orange, Rutland, Washington, and Windsor) and all or part of 23 towns (see map below). About 50,000 acres of the Green Mountain National Forest are contained within it. The **White River mainstem** is one of the last free-flowing rivers in Vermont. It begins in the Town of Ripton, where it flows in a southeastern manner until it merges with the Connecticut River in the Town of Hartford. The main stem is 56 miles long and has 5 major tributaries:

1. First Branch
2. Second Branch
3. Third branch
4. West Branch
5. Tweed River

The White River watershed is important both locally and nationally. The State of Vermont has implemented programs for the protection, restoration, and management of the White River in order to enhance its ecological and economic functions. It is a subset of the Connecticut River watershed, which is wholly contained by the Silvio O. Conte National Fish & Wildlife Refuge. The White River has been designated a *Special Focus Area* within this refuge because it provides a nursery and rearing habitat for juvenile Atlantic salmon and spawning habitat for the adults.

The **Connecticut River** begins in northern New Hampshire and travels south 410 miles, forming much of the border between Vermont and New Hampshire, then coursing through Massachusetts and Connecticut before emptying into the Atlantic Ocean at Long Island Sound. On its way to the ocean, the Connecticut River collects the waters of many other rivers that drain forests, wetlands, farmlands, towns, and cities while providing food, power, and transportation for human communities across the region. Many animals, plants, and other organisms find habitats and water sources within its boundary. Its designation as one of 14 American Heritage Rivers protects such values as ecological diversity and cultural heritage for a significant portion of New England.

The White River Watershed and Its 5 Main Tributaries



For more information on the White River watershed, please visit the website of the White River Partnership: http://www.whiteriverpartnership.org.

Why Monitor Your River?

It is said that a river is a reflection of the land through which it flows. Water and land are interwoven to create a dynamic natural system, so monitoring a river is a good way to check the overall health of the landscape. Evidence of land and water uses shows up in river monitoring data, which can determine that a landscape is healthy or reveal that human activities are impairing it.

A healthy Vermont river generally has a variety of trees and other plants growing along its banks, lots of dissolved oxygen in its waters, and a diverse food web that includes resident aquatic organisms and terrestrial organisms that visit the river to find resources. Good river health usually correlates with high water quality, and poor river health is often indicative of poor water quality. Water quality is defined by the United States Geological Service (USGS) as follows:

> **Water quality** can be thought of as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics. To determine water quality, scientists first measure and analyze characteristics of the water such as temperature, dissolved mineral content, and number of bacteria. Selected characteristics are then compared to numeric standards and guidelines to decide if the water is suitable for a particular use. (http://pubs.usgs.gov/fs/fs-027-01/)

For more information on water quality, please consult the USGS website above or the Water Quality Standards website of the United States Environmental Protection Agency (USEPA) (http://water.epa.gov/scitech/swguidance/standards/).

Monitoring and Assessments

When we *monitor* something, we assess it at regular intervals to see whether and how it is changing. Monitoring shows trends over time, which can help us to maintain a healthy condition, detect a change in condition, or improve a poor condition. Scientific *assessments* measure the status of particular components of the river system. A river monitoring program uses specific scientific assessments at regular intervals to gather information about the health of the river's ecosystem and its water quality.

River assessments fall into 3 broad categories: biological assessments, physical assessments, and chemical assessments. Each of these categories provides a particular set of water quality data, and many river monitoring programs incorporate two or all three categories. Each kind of assessment is briefly described below. Please consult other resources for more detailed information.

Biological assessments. Examples: benthic macroinvertebrates (waterbugs), crayfish, riparian wildlife tracks and sign, riparian trees. These assessments measure elements of natural communities in and along a river and are contained in the four MWR units.

The composition of a river's natural communities offers a lot of information about the health of that river and its water quality. A natural community occupies a particular area because conditions, over time, are conducive to its survival. Therefore, assessments of biological communities can help to determine the overall condition of a river and its landscape. Biological assessments conducted at regular intervals over time (biomonitoring) contribute to a useful record of the river's overall health and water quality.

In general, good river health is indicated by the following community profiles:

- a high diversity of natural species
- the presence of species that are sensitive to pollution and/or physical disturbance
- the presence of native species and the absence of invasive species

Chemical assessments. Examples: dissolved oxygen, pH, nitrates, phosphates.

Each chemical assessment measures a specific parameter of the river's chemistry at a particular moment in time. Chemical conditions are constantly changing as the water flows along, so one chemical assessment does not indicate the overall chemical condition of a river. Chemical assessments conducted at regular intervals over time (chemical monitoring) contribute to a useful record of the river's water quality.

Physical assessments. Examples: velocity, river discharge, embeddedness of the streambed.

Because the physical environment influences both water quality and river health, physical assessments are often used in conjunction with chemical and biological assessments.

Promoting Environmental Literacy

Monitoring the White River (MWR) encourages schools and communities to monitor one or more natural components in their part of the watershed to build their own knowledge base about their unique place, and then to share their knowledge with other groups across a broader area. MWR promotes environmental literacy by:

1. Connecting students to their place so that they feel invested in the well-being of their environment and their community.
2. Helping students learn how to use scientific inquiry to explore their world (see E. CULMINATING ACTIVITIES, USING THE SCIENTIFIC METHOD).
3. Helping students achieve pertinent academic standards in the Common Core and Next Generation Science Standards (see G. HELPFUL TOOLS, CRAYFISH RESOURCES).
4. Helping students understand how society uses scientific information and collaboration to make informed decisions as democratic citizens.
5. Helping students gather useful information about their place, which contributes to thoughtful river stewardship. This service learning approach builds a positive alliance between the school and its community.

B. UNIT BACKGROUND
CRAYFISH: IMPORTANT MEMBERS OF RIVER ECOSYSTEMS

Why Monitor Crayfish?

Crayfish are fascinating to watch. Their antennae sweep the surroundings for environmental clues, their ten legs and fan-shaped tail allow them to maneuver like a high-performance athlete, and they wield their powerful claws like armored hands. Even squeamish students are drawn to them. Because of their natural appeal, crayfish make excellent subjects for scientific studies.

River ecologists, too, are interested in crayfish because they help to weave together the river's food web. By eating vegetation, decaying organic material, and invertebrates, they incorporate the energy stored within these food items and pass it along to predators when they, in turn, are eaten. Recently, river ecologists have become concerned about an introduced invasive crayfish species, the rusty crayfish (*Orconectes rusticus*), which is displacing other crayfish species and may be disrupting Vermont's river food webs. In 2010, another introduced crayfish, the big water crayfish (*Cambarus robustus*) was discovered in Bethel and Rochester in the White River watershed. Ecologists are watching these two non-native crayfish to understand their ecological impacts in our region.

Because crayfish are easy to catch and are of interest to Vermont's river ecologists, the White River Partnership is encouraging schools to survey their streams and rivers to build information about the crayfish populations in our watershed.

Crayfish Ecology

White River Crayfish & "Residency"

There are 8 species of crayfish found across Vermont. The four species that inhabit the White River watershed are:

- the northern clearwater crayfish *(Orconectes propinquus)*
- the virile crayfish *(Orconectes virilus)*
- the rusty crayfish *(Orconectes rusticus)*
- the big water crayfish *(Cambarus robustus)*

Each of these crayfish species belongs to one of the following *"residency"* categories.

- A **native species** is one that has always inhabited a particular area and is in balance with other organisms living there. The *northern clearwater crayfish* is the only one of our four species that is considered native to Vermont.
- A **non-native species** has been introduced into an area either by people or by expansion of its natural range. The *virile, rusty,* and *big water crayfish* are all non-

native species found within the White River watershed. More research is needed to determine how these introduced species are affecting the river's ecosystem.

Other terms such as naturalized, alien, invasive or nuisance are sometimes used to describe non-native species. These terms can be confusing because experts do not agree on definitions; some people use them interchangeably while others feel there are distinct differences. Most people agree that an invasive species is a non-native species that spreads rapidly and causes harm to an ecosystem, economic activities, and/or human health. Please see the *Field Guide to the Crayfish of the White River Watershed, East-Central Vermont* on the White River Partnership's website for information on pertinent laws regarding aquatic nuisance species (http://www.whiteriverpartnership.org).

The lack of consensus on terms can be a particular problem when it comes to laws and regulations. For the purposes of legislation, the state of Vermont uses the term *aquatic nuisance species* to describe those aquatic species that threaten the diversity or abundance of native species, ecological stability, and/or commercial, agricultural, aquacultural or recreational activities.[1]

Habitat

Globally, crayfish can be found in a variety of habitats, such as lakes, ponds, large rivers, small streams, wetland areas, and even caves. In Vermont, the three species in the genus *Orconectes* (northern clearwater, virile, and rusty crayfish) inhabit both streams and lakes, where they prefer rocky substrates. They can also be found on sand or mud or in areas with dense plant growth. These crayfish usually hide under rocks or dig shallow pits under rocky debris, but they have been known to create more extensive burrows when cover is inadequate. The species in the genus *Cambarus* (the big water crayfish) is generally found in rivers and streams in or around areas of high water flows, such as rapids or waterfalls.

Niche

Crayfish are opportunistic omnivores, consuming anything that can be picked up with their claws or mouthparts, such as plants, aquatic insects, *detritus*, fish eggs and even other crayfish. They are eaten in turn by fish, otters, raccoons, bullfrogs, herons, and other predators that hunt in and along water bodies. Studies have shown that crayfish are often very important members of their communities and can strongly influence the ecology of an ecosystem. If their numbers grow too large, they can deplete aquatic vegetation and macroinvertebrates and disturb fish populations. A drop in their numbers can interrupt the flow of energy through the river food web.

[1] Aquatic Nuisance Species Task Force

The Rusty Crayfish

It is widely agreed that the rusty crayfish (*Orconectes rusticus*) is an aquatic invasive (nuisance) species in Vermont. Native to the Ohio River basin, it spread throughout the Great Lakes and the Northeast by human activities. Rusty crayfish have been shipped to different locations as bait for fishing, and sold by biological supply companies for distribution to ponds and aquarium tanks. A feature of crayfish reproductive biology can cause new introductions to occur rapidly. After mating, a female crayfish stores the male's sperm until she is ready to release her eggs, at which time her eggs are fertilized by the stored sperm. As a result, one "pregnant" rusty crayfish female dropped into a stream can populate the stream with rusties.

Relative to other crayfish species, the rusty crayfish has a high metabolic rate and therefore eats lots of food, reducing available food for other crayfish and fish. It aggressively pushes other crayfish out of sheltered spots, forcing them into the open where they are more vulnerable to fish predation. Rusties use a "claws-up" defensive stance against fish and other predators, which often prevents them from being eaten. In addition, rusty crayfish have been known to eat fish eggs. In these ways, rusty crayfish displace other crayfish species and can harm fish populations. For more information on the rusty crayfish, please see *Rusty Crayfish: A Nasty Invader*, by Minnesota Sea Grant (http://www.seagrant.umn.edu/newsletter/2009/09/rusty_crayfish_a_nasty_invader.html).

Hybrids

Rusty crayfish can also dilute the gene pool of our native crayfish species, the northern clearwater (*Orconectes propinquus*) through inter-species breeding. Generally, two different species cannot mate. But occasionally, mating between species takes place and produces live offspring called *hybrids*. Sometimes the hybrid offspring are not as robust as their parent species or cannot themselves reproduce, but certain crayfish species can mate with other species to produce fertile, healthy hybrids. The rusty crayfish has been shown to hybridize with the northern clearwater crayfish. Studies have found that these adult hybrids actually do better than the pure northern clearwater.[2] Genetically pure northern clearwaters must compete with both rusty and rusty-clearwater hybrids, so they often become less and less common in successive generations (even though some of their genes may still be present in the hybrids). In this way, the rusty crayfish may be diminishing crayfish diversity in the White River watershed.

If a crayfish displays physical and behavioral characteristics of two different species, it may be a hybrid. The most accurate way to confirm a hybrid is to study its genetics. More information and research are needed to understand the identification of hybrid crayfish and their effects on ecosystems.

[2] Perry et al., 2001.

C. CLASSROOM ACTIVITIES

Crayfish PowerPoint Slideshow

Materials	Set-Up / Timeframe
Materials • Crayfish PowerPoint Slideshow • computer • projector or smart board	**Set-Up:** Prepare PowerPoint slideshow **Timeframe:** 50 min

Overview

This slideshow describes crayfish ecology, gives an overview of crayfish anatomy, and introduces the four species of crayfish that are found in the White River watershed.

Instructions

Show the slides to students, using the Notes associated with each slide.

Construct the Crayfish

Materials	Set-Up:
• *Construct the Crayfish Student Packet*, 1 per student • *Crayfish ID Cards*, 1 per group of students • scissors, 1 per student • glue or transparent tape • pencils or pens	• none **Timeframe:** 40 min

Overview

This activity helps students learn crustacean anatomy and field marks for identifying the four species of crayfish found in the White River watershed. It can be done two different ways, depending on student grade level and teacher preference:

- Grades K – 6: Make Crayfish Species Profiles by following the **Student Instructions** in the *Construct the Crayfish Student Packet* below, which involves cutting and pasting anatomy parts.
- Grades 7 – 12: Make Crayfish Species Profiles by having students make free-hand sketches of the different crayfish anatomy parts (rather than cutting and pasting).

Instructions

1. Explain that students need to learn how to identify the four crayfish species in the White River watershed in preparation for conducting a crayfish survey. They will do this by "constructing" each of the four species from individual parts, then adding labels or descriptions that show important *field marks* for each crayfish (see Field Mark Key below).
2. Give each student the *Construct the Crayfish Student Packet*, and explain that it contains four *Species Profile* sheets (1 per species), a *Crayfish Anatomy Parts* sheet, and *Crayfish ID Cards*. Go over the **Student Instructions** with the class.

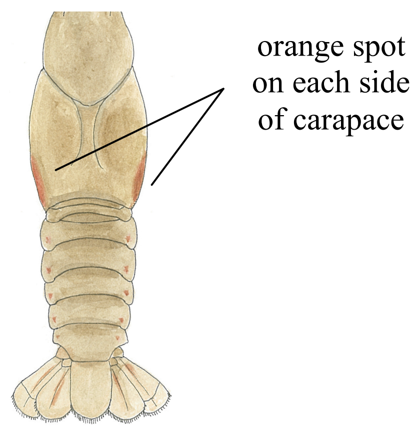
Field Mark Key

Anatomy Piece	Northern Clearwater	Virile Crayfish	Rusty Crayfish	Big Water Crayfish
rostrum	sharp corners carina (keel) in center	sharp corners	sharp corners	rounded corners
chela (claw)	s-shaped dactyl (thumb)	white or yellow bumps	orange tips, black bands s-shaped dactyl oval opening when closed	2 rows of bumps on palm wide, concave palm slight depression on outer margin
body	dark band down center of abdomen	paired spots on each abdomen segment	orange "fingerprints" on each side of carapace	[nothing of note]

Construct the Crayfish Student Packet

Student Instructions:

1. Cut out all *Crayfish Anatomy Parts*.
2. Use the *Crayfish ID Cards* to sort the Anatomy Parts into the four crayfish species.
3. Place the Anatomy Parts on the correct *Crayfish Species Profile* sheet and glue or tape them in place.
4. Refer to the *Crayfish ID Cards* to find the field marks that help to identify each species. Write a brief description of each field mark on your Species Profile sheet and draw an arrow from each description to its field mark. For example, the rusty crayfish has an orange spot on each side of its carapace:



Species Profile: Northern Clearwater Crayfish
(*Orconectes propinquus*)

Body	Rostrum
	Chela

Species Profile: Virile Crayfish
(*Orconectes virilis*)

<table>
<tr><td rowspan="2">Body</td><td>Rostrum</td></tr>
<tr><td>Chela</td></tr>
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Species Profile: Rusty Crayfish
(*Orconectes rusticus)*

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<tr><td rowspan="2">Body</td><td>Rostrum</td></tr>
<tr><td>Chela</td></tr>
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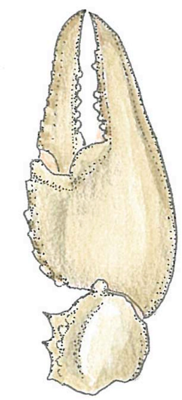
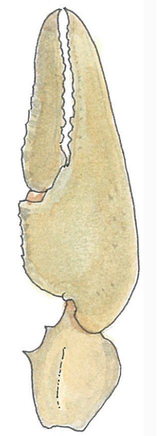
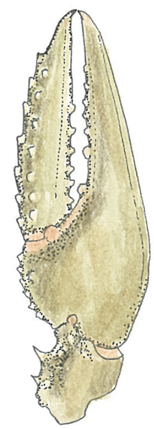
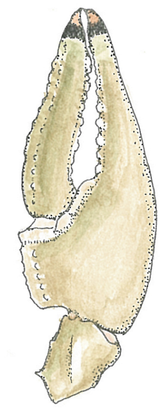
Species Profile: Big Water Crayfish
(*Cambarus robustus)*

Body	Rostrum
	Chela

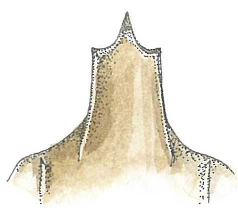
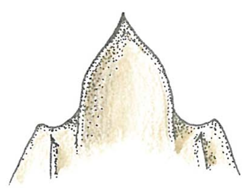
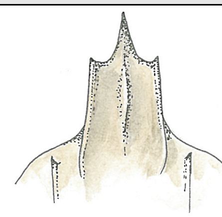
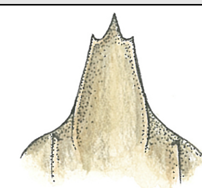
Crayfish Anatomy Parts

Cut out each anatomy part.
Then place each part in its box in the correct Species Profile.

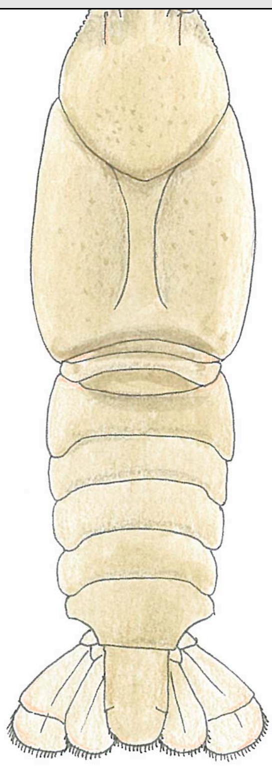
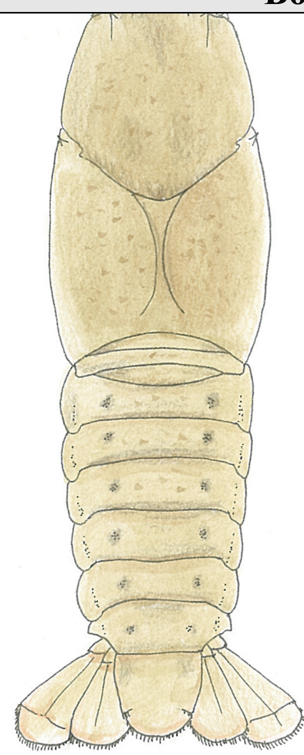
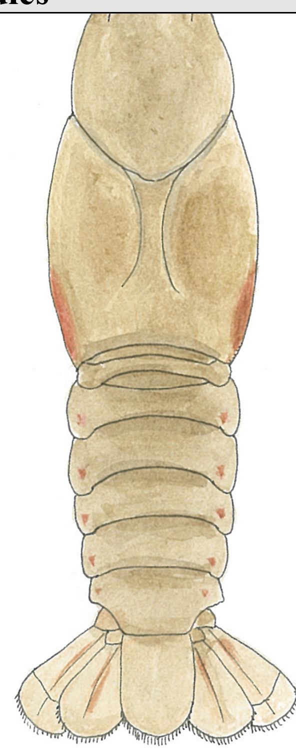
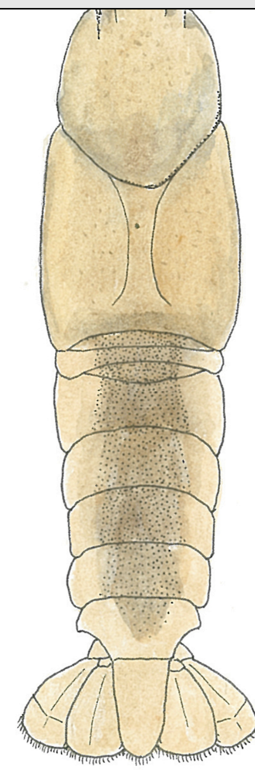
Chelae

Rostrums

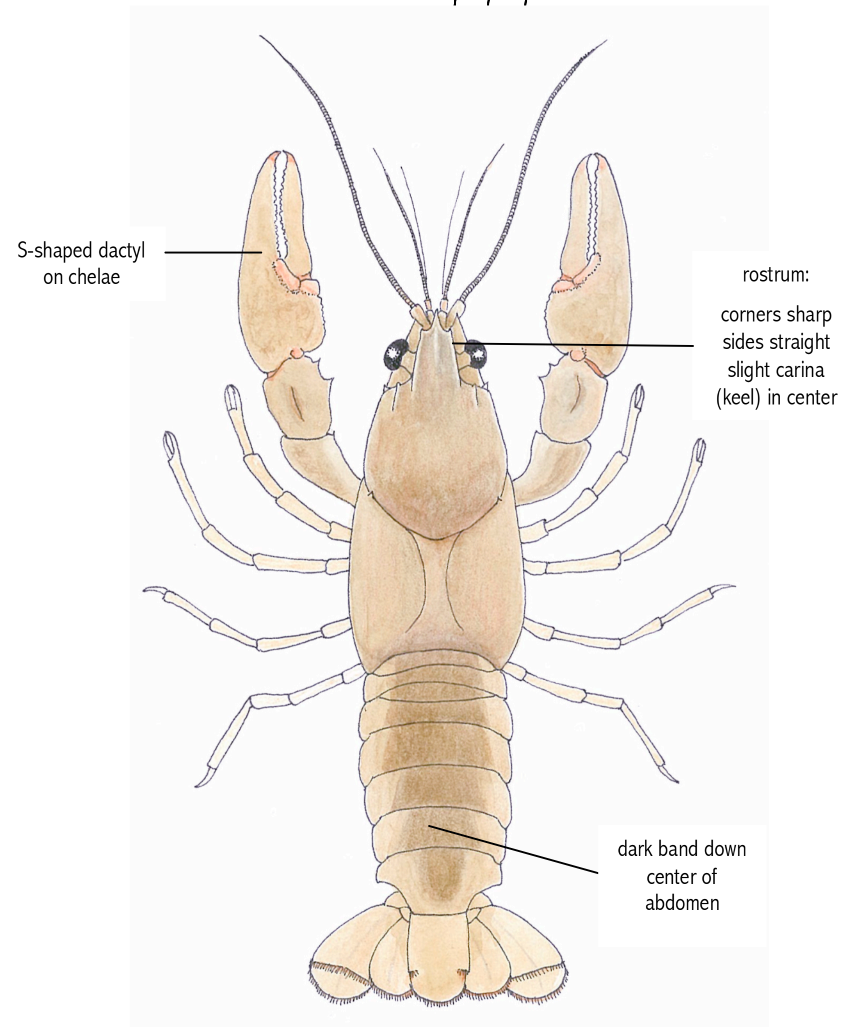
Bodies

CRAYFISH OF THE WHITE RIVER — ID CARD #1

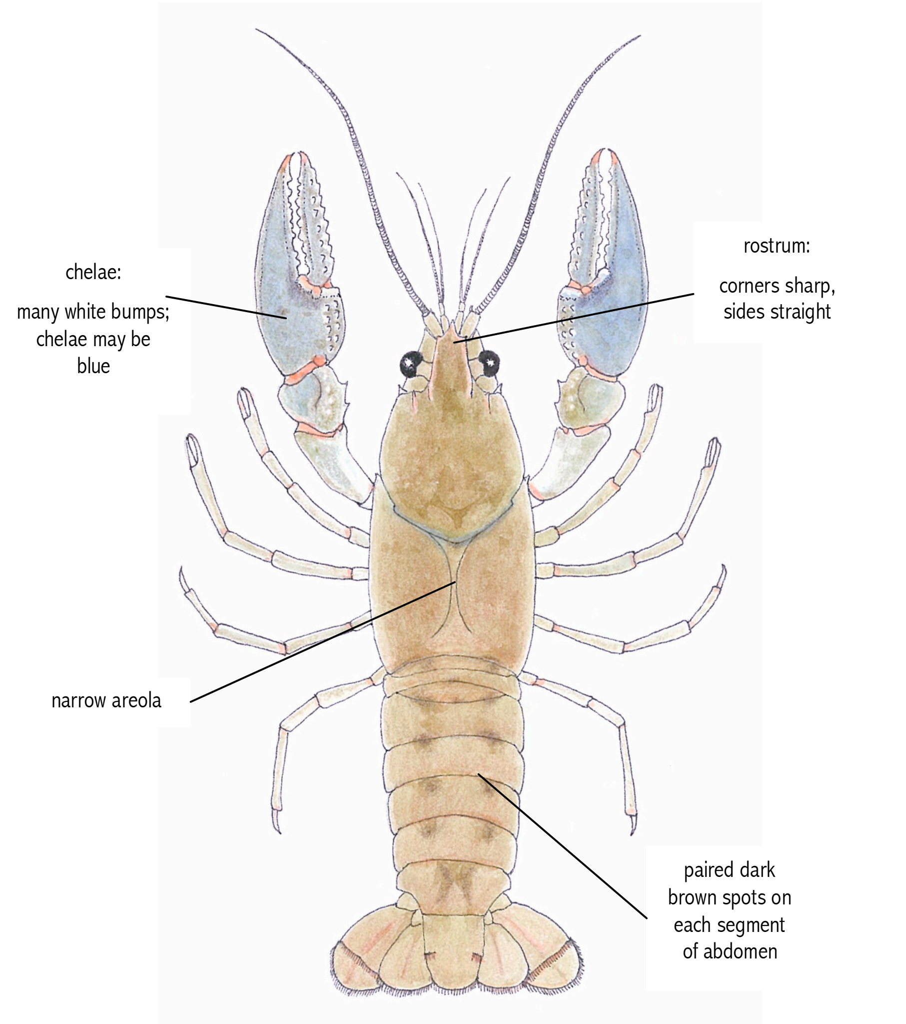
Northern Clearwater Crayfish

Orconectes propinquus



Virile Crayfish

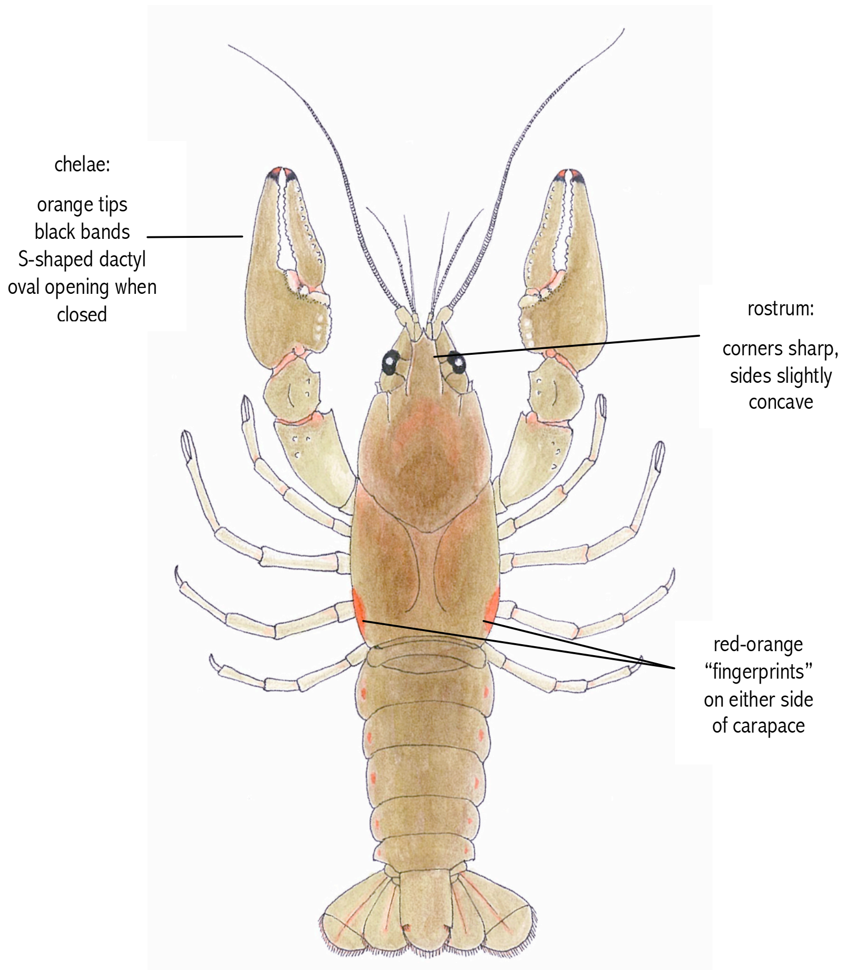
Orconectes virilis



Crayfish of the White River | ID Card #2

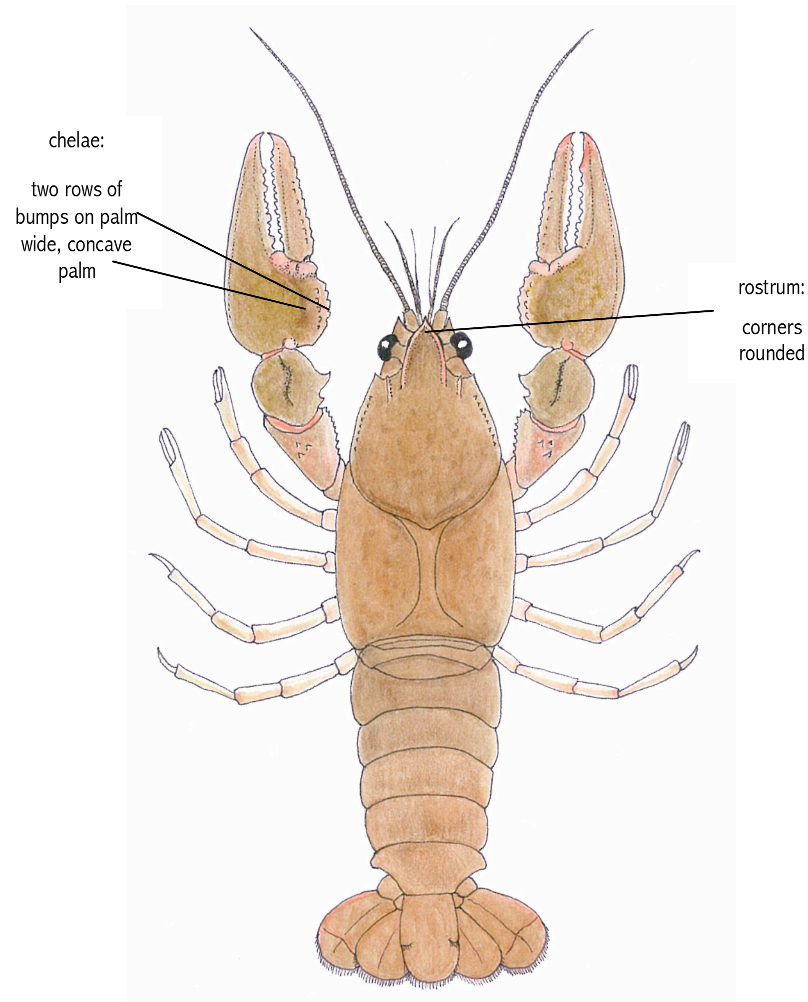
Rusty Crayfish

Orconectes rusticus



Big Water Crayfish

Cambarus robustus



Learning Crayfish Student Fieldwork

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Materials

- copies of *Crayfish Student Fieldwork Packet*, one per student or one per pair of students
- *Crayfish ID Cards* (from WRP's website)
- *Crayfish Teaching Kit* (borrow from WRP or gather supplies)
  - ♦ crayfish or minnow traps (2 or more)
  - ♦ hand nets (3 or more)
  - ♦ bait (canned catfood, chicken scraps, dry dog food)
  - ♦ 2 large white basins, one marked "A" and the other marked "B"
  - ♦ rulers with centimeters (or measuring trays from kit)

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Set-Up:

- Assemble all fieldwork supplies and display them in the classroom for students to see.
- Download the *Crayfish ID Cards* from the WRP website.

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Timeframe: 45 minutes

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Overview

To familiarize students with the *Crayfish Student Fieldwork Packet* and the method they will use to survey crayfish at their river site.

Instructions

1. Explain that students will visit a river site with potential crayfish habitat and survey it for crayfish. They will record data on field marks, the species caught, and measurements of each individual crayfish.
2. Review the information contained in B. UNIT BACKGROUND and D. FIELDWORK ACTIVITIES, STUDENT FIELDWORK GUIDELINES with students.
3. As a class, discuss the purpose of your fieldwork and generate a *Class Purpose Statement*. If you choose, each student can also write a *Student Purpose Statement* based on what he/she would like to gain from fieldwork.

   A possible *Class Purpose Statement* might be:

   To find out which species of crayfish live at our river site.

   A possible *Student Purpose Statement* might be:

   To see if I can catch a crayfish with a hand net.

4. Give a copy of the student packet to each student and review it with the class. Have students record their *Class Purpose Statement* (and optional *Student Purpose Statement*) and *Materials* they will need in the spaces provided on the Student Fieldwork Sheet.

   Important ideas to discuss:

   - ♦ It is possible that you may catch nothing at all in your traps or hand nets. Since this is a real biological survey, you don't know ahead of time what you will or will not find. Chances are very good that you will catch some crayfish in the

White River mainstem and the First, Second, and Third Branches. Crayfish numbers are less reliable in smaller streams in the watershed.

- Information about your fieldwork site and the method you used to survey crayfish can help other people visit the site in the future and gather data using the same method so that you and they can share datasets to gain more information about crayfish in your area.
- Periodic crayfish surveys conducted regularly over time (crayfish monitoring) can provide useful information on crayfish species and relative population levels. They can also help to document any arrivals of recently-introduced crayfish species. MWR teachers helped to establish the first official record of the big water crayfish (*Cambarus robustus*) in Bethel, Vermont in 2010!

D. FIELDWORK ACTIVITIES

Crayfish Student Fieldwork Guidelines

Before your students' fieldwork day:

1. Choose a site with potential crayfish habitat and one that:
   - has solid riverbanks that will not collapse when students walk on them
   - can be easily accessed by a group of students during the school day (either on foot, by car, or by bus)
   - offers space for a group of students to move around and work comfortably
   - provides cover for crayfish (a big rock, a log in the river, an undercut bank, an overhanging tree, etc.)
   - has a flow that is brisk but not too strong
   - offers a place to tie your trap to a solid object (a rock, a log, a tree on the bank)
   - is deep enough that the water covers the trap entirely.
2. Schedule your fieldwork date and time and make arrangements with the school for students to leave. If the fieldwork site is relatively close, 1.5 hours is usually adequate to cover indoor preparations (getting dressed for outside work, gathering supplies, etc.), traveling to the site, doing fieldwork, and traveling back to the school.
3. Arrange transportation and line up adult chaperones. We recommend 1 adult per 5 students (less adults for high school students).
4. Develop a plan to evacuate students from the fieldwork site quickly in the event of an emergency. Consider:
   - how to get students' attention right away (a whistle would be a good tool for this)
   - how to move one or more students out of the site and back to safety quickly (if you arrived on a bus, will it wait for you or come back when you are done? if you are on foot, how can you move a student in an emergency?)
   - how to use the other adult chaperones effectively to help organize students and make decisions
   - how you will notify the school of the emergency (do you have a cell phone? does it have reception at your fieldwork site? is there another phone nearby?)
5. Tell students how to dress for a productive fieldwork session. They should wear/bring:
   - comfortable, warm layers that they can peal off if they get too warm
   - a hat and gloves/mittens (even if the day seems warm, an extended period of time outside can chill a body)
   - warm, waterproof boots
   - a backpack to store items

6. Arrange to borrow the *Crayfish Teaching Kit* from the White River Partnership, or gather the supplies you will need (see *Crayfish Student Fieldwork Packet* for a list).
7. With your students, review the section called "How to Catch Crayfish" below and decide which survey method(s) you will use with students: crayfish/minnow traps, hand nets, or both. Contact the White River Partnership with any questions.
8. With your students, review the section called "How to Hold a Crayfish" below since they will need to handle crayfish during fieldwork. If possible, bring some live crayfish into your classroom to allow students to observe them and learn how to handle them.
9. Check the predicted weather during the days you plan to set and retrieve your traps. They should be in the river for 24 to 48 hours. If a big storm is predicted during this timeframe, please choose other days for setting and retrieving your traps. A big storm often causes the river to rise quickly and the water to pick up a lot of speed. This is not a safe situation for your students, and may cause your traps to get ripped out and carried downstream.

One to two days (24 to 48 hours) before you plan to collect crayfish traps:

1. Bring your traps and bait to your river site. If possible, bring your students with you so they can be part of the setting of the traps.
2. Find a good location for each trap (see *Before your students' fieldwork day* above), set them in place, and anchor them down.
3. Memorize the landmarks near each of your traps so that you can easily find them again, even if the water level changes and things look different.

   Please note: We do not recommend marking your trap sites with orange flagging or some other label because people sometimes find the traps and tamper with them, or take them completely away. Besides, having students identify the trap sites using landmarks is a good observation skill.

4. If you have time on this day, have students bring their *Crayfish Student Field Sheets* and make their sketches of the trap sites. This will be one less thing you will need to do when you come back to pull the traps, at which point students are completely focused on what might be in their traps and not so interested in sketching their site.

On the day of fieldwork:

1. Have students gather general fieldwork supplies, including:
   - a clipboard and pencil
   - a backpack (optional but very helpful)
   - a water bottle
   - snacks (optional, but they keep people happy!)
2. The teacher/adult leader should gather:

- extra fieldwork sheets and pencils (students are very creative at destroying fieldwork sheets and losing pencils)
- first aid kit
- whistle (optional, but it really gets their attention!)

3. Have students get ready for fieldwork at least 15 minutes before you leave the school, including visiting the bathrooms.

For more information, please see

G. HELPFUL TOOLS, RIVER FIELDWORK SUPPLIES & SAFETY PLANNING

How to Catch Crayfish

Crayfish are easily caught using a **minnow trap or crayfish trap** that is baited with meat scraps or an open can of catfood. Find a place that you think would provide good cover, such as under a log or behind a big rock, in water that covers the trap and is no deeper than 1 meter. Tie the minnow trap to a solid object so that it is not carried downstream with the current. Leave the trap in place for 24 hours and check it the next day. If you don't catch anything the first day, leave it there for a second day or move your trap to a different spot. Be sure to retrieve all traps after the second day.

Crayfish can also be caught with a **hand net or dip net**, especially the rusty crayfish, which is active during the day and tends to hold its ground when threatened rather than slip away unnoticed. If you have "catchers" who are observant and quick, they are often successful catching crayfish hand nets.

A minnow trap set in rocks to catch crayfish.
Photo by Jennifer Guarino.

Lots of rusty crayfish are sometimes caught in one trap!
Photo by Jennifer Guarino.

Important Note:

The rusty crayfish is an invasive (nuisance) species. If you remove a rusty crayfish from a water body, do not return it or release it in any other water body. It can be humanely killed by freezing it or cooking and eating it. It tastes like its saltwater relative, the lobster!

How to Hold a Crayfish

Crayfish can pinch, so be careful! To pick one up, push down on its carapace to pin it so that it cannot move. Move your thumb and forefinger to either side of the carapace and pick it up. Hold on firmly but gently. Crayfish often snap their tails to startle predators, so be prepared to hold on if this happens! (see illustration below)

If you pick up a crayfish that is soft, it has just molted and is very vulnerable. Please be especially careful with it.

Hold a crayfish so as not to hurt it, and not to GET hurt by the powerful claws.

CRAYFISH STUDENT FIELDWORK PACKET

Collecting Materials

- crayfish trap(s) and bait or hand net
- ruler or calipers with centimeters
- 2 basins, one marked "A" and one marked "B"
- Pencil
- *Field Guide to White River Crayfish* (obtain this identification book from the White River Partnership)
- GPS receiver (optional)
- hand lens (optional)

Instructions on Catching Crayfish

1. Bait your trap with chicken, wet cat food, or something else that is appealing to crayfish. Use the same bait in all traps.
2. Lay your trap in a site that has adequate cover (such as a log, a large rock, or shade from bank vegetation).
3. Tie or anchor your trap so that it/they will not be carried downstream by the current.
4. Leave your trap overnight and collect it/them the next day (24 hours later).
5. You can also catch crayfish with hand nets or by grabbing them with your hands.

Identifying and Measuring Crayfish **(each site should have its own datasheet or be clearly labeled)**

1. Put a few inches of water into two basins, one marked "A" and one marked "B".
2. Put all collected crayfish into basin A.
3. Remove one crayfish at a time from basin A. For each crayfish, use one row in the **Crayfish Data Table** below. Place a check-mark in all appropriate boxes (☑) across this row, and complete all requested information. *You may need two or more copies of this sheet,* depending on the number of crayfish in your traps.
4. After you have recorded data for an individual crayfish, place it in basin B.
5. *IMPORTANT*: Return all **non**-rusty crayfish to the river. Retain all **rusty crayfish** to be killed humanely. Because they are invasive, *they cannot be released back into the river or released into another water body.* Place them in a plastic bag and put them into the freezer, which kills them humanely. They can also be eaten! You can find lots of crayfish recipes on the internet.
6. Clean your gear. We don't want to be transporting invasive algal species or diseases.

Continued next page

CRAYFISH STUDENT FIELDWORK SHEET

Name(s):	Date:
Town:	State:
Organization / School:	

Class Purpose Statement: **Student Purpose Statement:**
Materials:

1. Fieldwork Site (name): ______________________________
Directions to the site:

Continued next page

Description of the site:

2. Sketch Your Site.

Include an outline of the river and direction of flow, in-stream features, **placement of traps and nearby landmarks**, riparian features, human evidence, etc.

Continued next page

Crayfish Student Field Sheet

Collector Name and School / Organization:	Date:
Collection Site (name or landmark):	
Town:	GPS location (optional):

	Collecting Method		**Claws**			**Carapace**	**Measurements**		**Sex**			
Cray-fish #	trap	hand net or grab	orange tips?	black bands?	S-shaped thumbs?	rusty spots on either side?	largest claw (cm)	carapace length (cm)	F	M	Use *Crayfish ID Cards to* identify crayfish	photo (check if yes)
1											ID: **Field marks:**	
2											ID: **Field marks:**	
3											ID: **Field marks:**	
4											ID: **Field marks:**	
5											ID: **Field marks:**	
6											ID: **Field marks:**	
7											ID: **Field marks:**	

E. CULMINATING ACTIVITIES

Debriefing Crayfish Student Fieldwork Sheets

Back in the classroom, have students review their fieldwork sheets. Go over student observations and data. Discuss the *Class Purpose Statement* and the *Student Purpose Statements* if they wrote one.

Please note that the survey methods used in this unit cannot provide a complete profile of crayfish species and numbers because neither one catches ALL of the crayfish in a given area. Discuss the limitations of each survey method with students:

Crayfish or minnow traps. This method only catches those crayfish that are attracted to the bait, find their way into the trap, and don't find their way out again. If a species is found in the trap, then it certainly lives at their site; if a species is not found in the trap, then they cannot say whether it lives there or not. Generally, aquatic biologists find that more males are drawn to traps than females. Therefore, their male/female data may not be an accurate reflection of the actual male/female ratio at their site.

Hand nets. Crayfish caught in hand nets are the ones that students can see in the river and the ones that students are quick enough to nab with the nets. Some aquatic biologists suspect that more rusty crayfish are netted than other species of crayfish because rusties are more active during the day and more apt to stand their ground than to hide.

Ask students to reflect on the information above as well as their observations, experiences, and results and answer these questions:

- If they didn't catch a particular crayfish species, does it mean that it is not there?
- Did they find small and large crayfish? Both male and female crayfish? "Pregnant" crayfish that are carrying eggs? That is, did they find evidence of a reproducing population? If they did not find such evidence, does it mean that there is not a reproducing population? (not necessarily; see above)
- Have them look at their sketches to remind themselves of the river habitat in which they placed their traps. Given their results and what they know about crayfish ecology, do they think that they placed their traps in good habitat? If they were to place traps again, would they use the same locations for their traps or change the locations?

After this discussion, have students write a *Conclusion* to their fieldwork. Their Conclusion should include the following:

- ♦ A restatement of their *Class Purpose* and whether they believe they achieved it. (same with their *Student Purpose* if they wrote one)
- ♦ A summary of the important findings of their fieldwork, based on the new knowledge they built about crayfish at their river site.

- One or more questions that have arisen from their fieldwork experience that could be addressed with another crayfish survey. (For instance: Would our results be different if we placed two traps side by side but used different bait in each?)

Working with Datasets

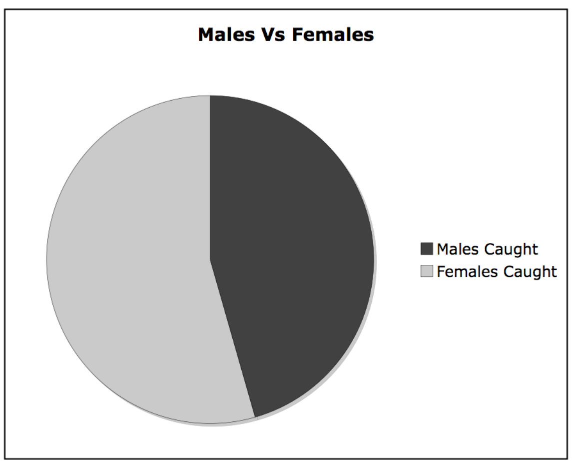
Crayfish fieldwork offers lots of opportunities for working with simple datasets. Students can generate tables that summarize their data, and graph these data to create visual representations of their findings. The graphs may reveal relationships that are less obvious in tables of numbers. In what situations are tables more useful? In what situations are graphs more useful?

Examples:

Males Versus Females Caught

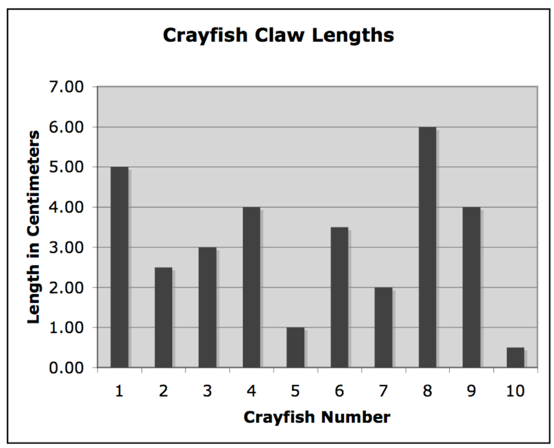
12 females

10 males



Crayfish Claw Lengths

Crayfish #	Length in Cm
1	5.00
2	2.50
3	3.00
4	4.00
5	1.00
6	3.50
7	2.00
8	6.00
9	4.00
10	0.50



Invasive Species Outreach

Students can help to educate others about the problems associated with invasive (nuisance) species like the rusty crayfish by designing posters that can be hung in their school, their town hall, or at local river access sites. They can find lots of information on the Vermont Water Quality Division of the Department of Environmental Conservation website: http://www.anr.state.vt.us/dec/waterq/lakes/htm/ans/lp_ans-index.htm.

Using the Scientific Method

This monitoring program can be used to teach the *scientific method*, which strives to answer a question about the world using a systematic approach. In science, the conclusion of an investigation raises more questions, which can be explored in subsequent cycles of investigation. Introduce students to the scientific method (outlined below) and talk about some ways in which our society uses the information that scientists generate. What happens when we use information from scientific investigations that are not carefully designed and carried out?

Based on their crayfish survey, what new questions do students have? Have the class brainstorm a list. Here are some sample questions that teachers might use to start the brainstorm:

- Would crayfish be more apt to enter traps that are hidden under cover versus traps that are placed on the open streambed?
- Are certain kinds of bait more successful at attracting crayfish than other kinds of bait?
- In a classroom aquarium, which kind of food would crayfish be more apt to choose: an earthworm or algae pellets? (If you feed crayfish algae pellets, choose ones that sinks since crayfish live on the bottom and cannot gather food from the water's surface.)

Students can choose a question from the brainstorm list and follow the scientific method to investigate it. Students can use one or more of these research techniques:

- Design an experiment and implement it.
- Interview people with expertise in the subject.
- Conduct a literary search.

If students want to design their own experiment, they must develop a hypothesis that is *testable* – that is, a hypothesis that they can test readily. Some hypotheses are out of students' reach because they lack the needed scientific training and supplies.

The Scientific Method

Step 1: Ask a question that can be answered through experimentation or investigation.

Step 2: Form a hypothesis (a proposed explanation), based on personal observations and information found on the topic. The hypothesis must be *testable* by the investigators.

Step 3: Design a test (experiment or investigation) for your hypothesis.

Step 4: Carry out your test and record your results as data or other forms of information.

Step 5: Analyze your results, looking for patterns and trends in your data.

Step 6: Review your original question and your hypothesis. Was your hypothesis supported by your work? If not, why not?

Step 7: Ask one or more new questions, based on your experience with your experiment or investigation.

Step 8: If there is time, choose one of your new questions, form a hypothesis that may explain it, and conduct another round of experimentation/investigation (Step 1).

The scientific method can be seen as a *spiral of inquiry* that links successive cycles of experimentation/investigation. Each cycle generates new information that helps to build more knowledge over time. This is how scientists help us increase our understanding of our world.

<u>Sharing the Learning</u>

After completing your culminating activities, hold an Open House or a Science Celebration that invites other students, parents, and community members to learn about the students' work. When students have opportunities to share their learning, their understanding is deepened and they feel the satisfaction of helping to educate others. We also encourage you to share your results with the White River Partnership or other organizations interested in crayfish, aquatic invasives, and river ecology. (see G. HELPFUL TOOLS, CRAYFISH RESOURCES)

F. GOOD MONITORING PRACTICES

Quality Assurance

Schools have many reasons to monitor their river. Usually, the primary motivation is to help students achieve certain academic goals. This kind of fieldwork-based program can also connect students to their place as they keep tabs on the area and get to know its wild inhabitants. Sharing monitoring data with nearby schools and groups increases student investment in their place and weaves their place into the larger landscape.

River monitoring can offer students a meaningful service learning opportunity that allows them to contribute information to local decision-making efforts. If schools decide to generate useful data for decision-making, they should develop a quality assurance system for their program. This can be an informal system or a more formal "quality assurance project plan" as defined by the U.S. Environmental Protection Agency (USEPA) in their publication, *The Volunteer Monitor's Guide to Quality Assurance Project Plans* (http://water.epa.gov/type/rsl/monitoring/upload/2002_08_02_monitoring_volunteer_qapp_vol_qapp-2.pdf). The USEPA defines quality assurance as follows.

> **Quality assurance** is an integrated management system designed to ensure that a product or service meets defined standards of quality with a stated level of confidence. QA activities involve planning quality control, quality assessment, reporting, and quality improvement.

Many schools that want to share their data decide that they don't need a full-fledged quality assurance project plan (QAPP). Yet some teachers choose to inform themselves and their students about this process because it helps them to understand how people can use science to generate valid data to help make natural resource decisions. The box below outlines "Steps to Developing a QAPP." If you are considering writing your own QAPP, please see the document at the USEPA website above.

At a minimum, we recommend that you implement certain QA activities to improve both your students' science education and their fieldwork results. Below we offer General QA Methods for all four MWR units, then specific QA Methods for the Crayfish unit.

General QA Methods

- The MWR fieldwork techniques are based on scientific protocols developed by monitoring experts. If you want to share your students' data with other schools across the MWR network, please use the fieldwork sheets included with the units. (If you don't share data, please feel free to adapt the fieldwork sheets.)

Before fieldwork,

- be sure you have the equipment and supplies specified by the fieldwork techniques you are using;
- read the STUDENT FIELDWORK GUIDELINES carefully;

- go over the fieldwork sheets with your students and adult helpers so they understand all parts of the sheet and they know why they are collecting data in a specific way;
- decide what you will do with student data after collecting it (e.g., will it be summarized in a database? graphed and shared with parents? presented at town meeting?);

During fieldwork,

- encourage students to complete all parts of the fieldwork sheet that they can, and add any information that may clarify or explain their data;
- document important observations using photographs or collections of items.
- if possible, invite an expert to accompany you during fieldwork to confirm results.

After fieldwork,

- discuss observations and data as a group to fill in missing information and correct mistakes and misunderstandings;
- label and store fieldwork photographs using an organized system so that you can retrieve them as needed;
- store fieldwork sheets for future reference. This is especially important if you plan to compare data results from year to year, or share your data with others.
- if possible, ask an expert to visit your students to check their results and discuss findings and conclusions.

QA Methods for Crayfish

- During fieldwork, make sure that each crayfish caught is "processed" (measured, sexed, IDed) only once to ensure accurate data.
- Make a *reference collection* that includes important representatives of species caught and male and female specimens. Obtain some glass jars with tight-fitting lids and ethyl alcohol. Put one crayfish in each jar and add the alcohol.

  Please note: Sometimes, it takes a few minutes for the crayfish to die in the alcohol. This process may be upsetting to some students.

  Label each jar with information on location where caught, date, time, and collector(s). You can then show your specimens to an expert to confirm identification and other information.

Steps to Developing a QAPP

(From the Executive Summary of *The Volunteer Monitor's Guide to Quality Assurance Project Plans*, http://water.epa.gov/type/rsl/monitoring/upload/2002_08_02_monitoring_volunteer_qapp_vol_qapp-2.pdf).

Developing a QAPP is a dynamic, interactive process that should ideally involve state and EPA regional QA experts, potential data users, and key members of the volunteer monitoring project. There are 11 steps a volunteer monitoring project coordinator might take to prepare a QAPP. These are:

Step 1: *Establish a small team* whose members will serve as advisors in helping you develop the QAPP by offering feedback and guidance throughout the entire process.

Step 2: *Determine the goals and objectives of your project* – why it's needed, who will use the data, and how the data will be used.

Step 3: *Collect background information* to help you in designing your project.

Step 4: *Refine your projects goals* once you've collected more information.

Step 5: *Design your project's sampling, analytical & data requirements* – essentiall, what, how, when, and where you'll be monitoring.

Step 6: *Develop an implementation plan* that lays out project logistics.

Step 7: *Draft your standard operating procedures (SOPs) & QAPP.*

Step 8: *Solicit feedback on your draft SOPs & QAPP* from state or EPA regional QA contacts and potential data users.

Step 9: *Revise your QAPP* based on review comments and submit it for approval.

Step 10: *Once your QAPP is approved, begin your monitoring program.*

Step 11: *Evaluate and refine your project over time,* and reflect any major changes in a revised QAPP.

Data Management

Once students have collected data, they should review their data to double-check any calculations and to determine important findings. Ask them to review their *Purpose Statement(s)* on the fieldwork sheet; did they achieve their purpose(s)? If not, what additional data or other information could they collect to help them better achieve their Purpose(s)?

Work with students to design a sheet (an excel spreadsheet works well) that allows them to summarize their data. Then they can organize their data into tables, charts, graphs, or other formats. Have students compare different formats to see how each one presents their data results in a particular way.

Build a database system for storing datasets from year to year. It's a good idea to maintain both a digital storage system and a paper-based storage system. Contact the White River Partnership (WRP) for more guidance on managing data. Also check the *Resources and Information* page of the WRP website (http://whiteriverpartnership.org) to see actual datasets for different water quality parameters.

G. HELPFUL TOOLS

Glossary

abdomen – the rear part of the crayfish body containing the reproductive organs on the inside and swimmerets on the underside. The abdomen is divided into seven segments.

antennae – a pair of long, thin organs attached to the front of the head used for touch, taste, and smell. Antennae are longer than antennules.

antennules – a pair of long, thin organs attached to the front of the head used for balance, touch, and taste. Antennules are shorter than antennae.

areola – the space between two curved lines along the middle of the carapace; often used for identification.

arthropod – an invertebrate animal that has jointed legs, a segmented body, and a hard exoskeleton. Insects, arachnids, and crustaceans are examples of arthropods.

assess – to examine something (as a river) in order to evaluate it.

carapace – the portion of the exoskeleton that covers the cephalothorax. Crayfish are typically measured from the tip of the rostrum to the junction between the thorax and the abdomen; this is known as *carapace length*.

carina – the ridge along the rostrum of the northern clearwater crayfish; used for identification of this species.

cephalothorax – the part of the crayfish body that is made up of the head and thorax, which are fused together.

chela – (plural: chelae) – the claw of the crayfish that is made up of the palm and the dactyl ("thumb"). It is used for defense and to capture prey.

crustacean – an arthropod with jointed legs, an exoskeleton, two pairs of antennae, and eyes at the ends of stalks.

data (singular: datum) – pieces of information that are gathered from experiments, surveys, or other investigations to make calculations or draw conclusions.

dactyl – the moveable "thumb" of the chela.

decapod – a crustacean that has five pairs of appendages and a cephalothorax covered by a carapace.

detritus – organic debris formed by the decomposition of plants, animals, and other living organisms, and their solid waste products.

ecosystem – a natural system in which all organisms interact with each other and with the physical features of the environment; examples: river, forest, wetland.

ecotone –an ecological zone between two or more ecosystems; an edge habitat

environmental literacy – the capacity to use an understanding of the natural world to make informed decisions about humans' relationship with it.

exoskeleton – the hardened outer shell on an arthropod that is periodically shed (molted) to allow the animal to grow.

field mark – a physical feature on an organism that aides in identification.

floodplain – the flat or almost flat land along a stream that receives excess water and sediments during floods.

food web – the feeding connections between and among organisms in an ecosystem.

Form I male – a male crayfish that has the physical characteristics used in mating, including large chelae, hooks on a pair of legs used for holding the female, and hardened gonopods.

Form II male – a male crayfish that lacks the physical characteristics used for mating (see Form I male).

glair – a sticky substance secreted by a female crayfish to adhere her eggs to the underside of her abdomen.

gonopods – the male crayfish reproductive organs that transfer sperm to the female.

gonopore – the female reproductive organ that accepts the male's sperm.

habitat – the place that provides all the essential resources for an organism's survival.

hybrid – the offspring of two different species that mate.

macroinvertebrate – an organism that has no backbone and is large enough to see with the naked eye; examples: insect, worm, snail.

mainstem – the largest channel of a river system.

meander (as a river) – verb: to twist and curve through the landscape; noun: the winding or bending pattern of a river.

molting – the process during which the exoskeleton softens and splits, and the crayfish pushes out of it. Male crayfish undergo two stages of molting: Form I and Form II.

monitor – to check something (as a river) at regular intervals in order to find out whether and how it is changing.

niche – the role of an organism in its natural environment that determines its relationships with other organisms and promotes its survival.

palm – the larger part of the chela.

parameter (in a scientific assessment) – a measurable quantity that determines the result of a scientific experiment or investigation.

riparian zone – the area of land along a stream channel where vegetation and land uses directly influence stream processes.

rostrum – the upper front part of the head. Since its shape is unique in each species, it can be used in identification.

substrate – the surface of the streambed and the material that lies upon it, as well as other surfaces within the stream (such as a log) that provide habitat for organisms.

survey – to conduct a study of a sample population.

swimmerets – the leg-like appendages attached to the underside of the abdomen that aid in movement and reproduction. Also called pleopods.

tail fan – the broad region at the end of the crayfish's abdomen made up of the uropods and telson.

taxonomy - the science of classifying organisms into categories based on shared characteristics and natural relationships.

telson – the central section of the tail fan.

tributary – a stream that flows into another stream or river.

uropods – the sections on either side of the telson on the tail fan.

watershed – a basin of land in which all water drains down to a common body of water (stream, river, lake, pond, wetland, ocean).

Crayfish Resources

The White River Partnership (WRP) – a community-based, 501c3 nonprofit organization bringing together people and local communities to improve the long-term health of the White River and its watershed in central Vermont.

http://www.whiteriverpartnership.org/; 802-763-7733

Greg Russ, Project Coordinator: greg@whiteriverpartnership.org

Emily Miller, Monitoring Coordinator: emily@whiteriverpartnership.org

Environmental Literacy and Educational Standards

Environmental Literacy for Vermont http://www.environmentalliteracyvt.org/

Environmental Literacy Council http://www.enviroliteracy.org/

Developing a Framework for Assessing Environmental Literacy, North American Association of Environmental Education http://www.naaee.net/framework

Next Generation Science Standards http://www.nextgenscience.org/

Common Core State Standards Initiative http://www.corestandards.org/

Riparian Buffers/Zones

Introduction to Riparian Buffers for the Connecticut River Watershed, Connecticut River Joint Commissions
http://www.crjc.org/buffers/Introduction.pdf

Crayfish Ecology & Identification

Field Guide of the Crayfish of the White River Watershed, East-Central Vermont (White River Partnership).

Crayfish ID Cards (White River Partnership).

http://www.whiteriverpartnership.org/index.php/programs/crayfish-monitoring

The Rusty Crayfish: A Nasty Invader (Minnesota Sea Grant)
http://www.seagrant.umn.edu/newsletter/2009/09/rusty_crayfish_a_nasty_invader.html

Water Quality & Aquatic Invasives

Vermont Watershed Management Division, Vermont Department of Environmental Conservation
http://www.vtwaterquality.org/

Vermont Aquatic Invasive Species, Vermont Watershed Management Division, Vermont Department of Environmental Conservation
http://www.anr.state.vt.us/dec/waterq/lakes/htm/ans/lp_ans-index.htm

United States Geological Survey (USGS)
http://water.usgs.gov/owq/

United States Environmental Protection Agency (USEPA), Water Quality Standards
http://water.epa.gov/scitech/swguidance/standards/

The Volunteer Monitor's Guide to Quality Assurance Project Plans, U.S. Environmental Protection Agency
http://water.epa.gov/type/rsl/monitoring/qappcovr.cfm

River Fieldwork Supplies & Safety Planning

Please review this sheet before taking a group to the river for fieldwork.

Basic River Fieldwork Supplies

The following items are useful for most river fieldwork sessions. You may also need to collect items geared to your specific fieldwork activities.

- boots or waders
- walking stick to maintain balance in the river (can be used to probe for deep spots and to measure depth)
- sunhat and sunscreen lotion
- refreshments and drinking water
- clipboard
- several pencils
- digital camera to document sites, physical conditions, and/or organisms collected
- plastic gloves (if there is a concern about pollution; see Safety Guidelines below)

Safety Guidelines

1. Develop a ***Safety Plan*** for your river fieldwork sessions (see suggested outline below). Make sure that all adults know what to do in an emergency at the river, and bring your Safety Plan with you during every fieldwork session for important information that will help you deal with the emergency.
2. Never do fieldwork in **severe weather**, and *get out of the water during a lightning storm.*
3. If there is a **dam** upstream of your river site, be aware of the dates and times when water is released from the dam since this results in sudden flooding downstream of the dam.
4. Bring **snacks and drinks** if your group will be outside for a while. If the weather is cold, bring warm drinks to guard against hypothermia.
5. Carry a **whistle** with you during fieldwork to communicate with members of your group and to signal for help if needed.
6. Always wear **footgear** in the river – never wade in barefoot because glass and other sharp objects could pose hazards. Footgear with covered toes (such as old sneakers) are ideal.
7. Remember that getting wet increases the chances of hypothermia. During cool or cold weather, have everyone bring **extra dry clothes and footgear** and keep them dry.
8. Confirm that you are at the **correct river site** by checking maps, site descriptions, and/or directions.
9. Always conduct fieldwork with at least one **partner**. Teams of three or four people are best. Always **let someone else know** where you are and when you intend to return.
10. Find a **safe path** down to the river's edge. If the path is too steep, too slippery, lined with poison ivy, or too heavily forested to keep everyone safe, choose another way to get to your fieldwork site or choose another site.
11. Do not walk on **unstable riverbanks**. This can cause erosion and might be dangerous if a bank collapses. Disturb riverside plants as little as possible.
12. Do not touch river water, or wear plastic gloves, if you know or suspect that it is **polluted**. Both organic pollution (caused by human or livestock wastes) and toxic pollution (caused by certain mines, industries, and pesticides) can create unacceptable human health risks.
13. ***High and/or fast river water*** *can be very dangerous. Please enter the river only if the water level is below the knee and you can move around in the current without struggling.*
14. Be very careful when **walking in the river**. The riverbed can be very slippery and can contain deep pools. If you must cross the river, use a walking stick to steady yourself and to probe for deep water, soft mud, or unseen rocks. Your partner(s) should wait on dry land to assist you if you fall.
15. After fieldwork, and before eating anything, **wash your hands** thoroughly with soap to remove any pathogens or other pollutants that may be present in the river water.

RIVER FIELDWORK SAFETY PLAN
(Suggested Outline)

Name of person supervising your Safety Plan:

Contact information for this person:

Medical facility that is closest to your river fieldwork site(s):

Will person who accompanies the fieldwork group to the river have a cell phone with him/her?

- ❒ Yes
- ❒ No; if not, how will he/she summon help if needed?

Telephone number of closest medical facility:

Directions to medical facility:

Please collect information from all members of your group regarding medical issues that may require attention at the river (e.g., bee sting allergy), and obtain permission to treat members if necessary.

Please check one box below.

- ❒ Medical release forms completed and signed for each member *(essential for children)*.
- ❒ Medical release forms not necessary.

Please check one box below and complete as necessary.

- ❒ There are no medical issues in our group.
- ❒ We have identified the following medical issues and remedies (e.g., bring bee sting kit):

Medical issue: ______________________________

Remedy: ______________________________

Medical issue: ______________________________

Remedy: ______________________________

Medical issue: ______________________________

Remedy: ______________________________

Medical issue: ______________________________

Remedy: ______________________________

Other important notes regarding safety during river fieldwork:

Safety Plan prepared by: Date: