**Measuring Crayfish Habitat Use and Selection**

**Abstract:**

Changes in crayfish populations within streams can indicate shifts in habitat preferences, which often reflect environmental conditions such as shelter availability and food resources. Variations in crayfish measurements, such as body size, can signal differences in habitat quality. Streams that offer diverse substrates, ample hiding spots, and abundant food sources typically support larger and healthier crayfish populations. This field lesson combines habitat observations with crayfish sampling to investigate how different habitat characteristics influence crayfish distribution and abundance. Designed for upper undergraduate students, the lesson includes the collection of habitat data (water quality parameters, substrate type, vegetation cover) and crayfish data (including body measurements and species identification). An optional Excel sheet is provided for students to formulate predictions about expected habitat preferences and then analyze the collected data. Students are encouraged to reflect on their observations and initial predictions regarding how various habitat features affect crayfish populations.

**Tags/Keywords**: Crayfish, Freshwater Crustaceans, Habitat quality, Environmental Monitoring, Conservation Biology, River Field Studies Network, Biodiversity

**Instructor Notes:**

1. **Target audience**

This lesson is designed for undergraduate students and is suitable for both lower and upper-division courses, provided students have some background knowledge of aquatic systems (such as an environmental science, limnology, aquatic biology class or other special topic) and basic skills in scientific observation, data collection, and analyses. While a student's prior knowledge and skills may affect their engagement with the material, a brief introduction by the instructor at the beginning of the lesson would be beneficial. Accessibility should be considered, ensuring that all students can participate in fieldwork activities. Also, access to appropriate field equipment, transportation to field sites, and time for data analysis can affect the ability of students to fully participate and benefit from the lesson. Additionally, a student's level of interest can significantly influence their experience of this lesson.

1. **Summary of the lesson**

Students will begin by identifying one wadable stream sites in their local environment for comparison. Ideally, this should be a site without a known impairment (such as being listed on a state 303d list, undergoing a recent renovation project, or experiencing higher levels of disturbance, such as in urban areas) and should be relatively unimpaired or less affected by human influence. If no such site is available, an impaired site may be used so long as this is a factor students taken into consideration. Students will reflect and write a hypothesis about what habitat factors might impact crayfish populations. Next, students will journal and take notes about the habitat type and the level of human activity. They will then manually collect crayfish samples and learn how to identify different crayfish species, taking several measurements in the process. After completing the exercise, students will analyze the data to identify differences in crayfish populations and measurement metrics, revisiting their initial hypotheses in light of their findings.

1. **Approach to engagement**
2. Connection to nature: Where able, it would be ideal for instructors to let students choose the stream site that the class visits to personalize and engage students with their local environment. Additionally, the instructor may have students do pre-activity work by looking up local history or posted data/information available from the selected sites.
3. Discussion: Instructor may ask students to draw conclusions about how habitats differ between each sampled area and in turn how changes in habitat may impact crayfish communities. These discussions may take place at both the beginning and end of the field experience.
4. Experiential learning: Students will be collecting field data such as habitat assessment and crayfish measurements. During field collection, the instructor can prompt students to make additional observations on their worksheet or in a field journal to help students formulate hypotheses about the influence of habitat on crayfish communities. Instructors may also prompt students to develop additional questions they have about either stream conditions or crayfish communities.
5. **Logistics and materials needed**

Field Site

Should be wadable and accessible so that students can safely work within the stream channel and conduct measurements. Flow conditions should be checked before conducting fieldwork. It is not recommended to do this lab in streams deeper than thigh height or in streams that may experience high flows after a recent rain event. For accessibility, road crossings or parks are often convenient sampling sites. Consider student accessibility: ensure smooth access paths where possible for mobility aids, consider the terrain, and if the chosen site proves difficult, consider alternative locations that are similar. Parks, nature reserves, and protected areas with similar infrastructure might be suitable. For students unable to enter the stream, a live video feed or recorded video could be shared for virtual participation. The student may also play a larger role in helping to scout the site via Google Earth. Students may also sample near shoreline, or use long-reach tools to allow them to sample without entering the stream. If a student requires additional help, assign a field assistant or teaching assistant to support them during field work.

Crayfish reside in a variety of habitats, so ensure locations have a variety of substrate including rocks, vegetation, and sand. Instructor should access site ahead of time to check these requirements. The ideal sampling period is when crayfish are most active, which is usually from late spring through early fall and during breeding seasons when they are more distinctive. Additionally, crayfish are less active when water temperatures are below 12 °C (54 °F) – check your state recommended sampling period. Check your local crayfish species information to know when this occurs.

Crayfish collection

The native crawdad species west of the continental divide are in the Astacidae, while all the species east of the divide are Cambaridae. One non-native invasive species from Australia in the Parastacidae has been introduced to Mexico and Puerto Rico. The sexing crayfish figure included in the text below will not work for the other families (Parastacids have intersex forms and neither Parastacids nor Astacids have the pleopod I modified in the males). Additionally, the keys for these species are only good for identification of form I males. This means that this lesson plan is only useful at certain times of the year (when form ones are present) and not useful for immatures, form IIs, and females. Check local crayfish species and identification keys to plan for field sampling and identification.

Many states have federally listed crayfish species, and additionally may require fishing licenses or special permits to collect crayfish. If collecting on private property, you will need landowner permissions. Make sure you have the proper permissions and licenses for this.

Students will need:

* Paper or field journal and a writing utensil
* Appropriate clothing: waders (if available) or clothing that can get wet, rubber boots, sun protection (hat, optional), polarized sunglasses (optional), snorkel mask (optional)
* Printed copies of: data sheet, crayfish identification sheet (if available)
* Check to see if a fishing license or scientific collectors permit is required in your state for collecting crayfish

Instructors will need:

* Copies of handouts: data sheet, crayfish identification sheet (if available)
* Waders, rubber boots, or other clothing for students (if available)
* Thermometer
* Optional water quality measurement tools: Dissolved oxygen kit/probe
* pH kit or probe
* Colorimeter or multi-probe
* Yard Stick
* Measuring devices (rulers, calipers)
* Portable scale (such as food weighing scale) and mesh bag
* D-nets or hand-held nets
* First aid kit

1. **Further reading for the instructor**

* Wisconsin Crayfish Sampling Protocol (or find one appropriate for your area): <https://wateractionvolunteers.org/files/2019/01/Protocol2007CrayfishSampling.pdf>
* Crayfishes of Oklahoma (find a list appropriate for your area): <https://www.researchgate.net/publication/257326672_Crayfishes_Decapoda_Cambaridae_of_Oklahoma_Identification_distributions_and_natural_history>
* Ecological Roles of Crayfish in Freshwater and Terrestrial Habitats: <https://www.researchgate.net/profile/Catherine-Souty-Grosset/publication/259758408_Ecological_Roles_of_Crayfish_in_Freshwater_and_Terrestrial_Habitats/links/02e7e52fe22dfe03df000000/Ecological-Roles-of-Crayfish-in-Freshwater-and-Terrestrial-Habitats.pdf>
* Semi-Quantitative Methods for Crayfish Sampling: Sex, Size, and Habitat Bias: <https://academic.oup.com/jcb/article/29/2/208/2548003>
* The River Mile Network – Crayfish Study Resources: <https://therivermile.org/network-projects/the-river-mile-crayfish-study/resources/>

**Learning Outcomes**

1. Students will be able to analyze, form hypotheses, and compare stream habitat and crayfish communities.
2. Students will apply observational skills by documenting habitat types and the level of human activity.
3. Students will apply hands-on skills by manually collecting and identifying crayfish samples, including taking accurate measurements.
4. Students will evaluate collected data by comparing metrics between habitat types, identifying significant differences or trends.
5. Students will create a written report that effectively communicates their findings.

**Assessment of Learning Outcomes**

Pre-Assessment

* Hypothesis development: Based on pre-activity lecture and overview of field lesson, students will be asked to develop a hypothesis about how changes in habitat influence crayfish communities.

Post-Assessment

* Questions at end of data sheet: Students will be asked what differences/similarities were noted between the sampling locations in site in terms of habitat and crayfish measurements. Students will be asked to draw conclusions and revisit their original hypothesis based off observational data. Finally, students will be asked to predict how further changes in environment might lead to changes in crayfish communities.

**Required Background Information for Students**

Students should receive introductory lessons on macroinvertebrates in streams that focus on crayfish (morphology, ecology, and conservation) prior to the field lesson.

* It is recommended that instructors provide instructional materials on how to measure and assess crayfish in a manner that aligns with state/federal protocols.
* Recommended lecture: An Introduction to Crayfish. This video covers: etymology, classification and characteristics, North American families, morphology, life cycle, sexual characteristics, and endangered taxa. <https://www.youtube.com/watch?v=E-P6-hbqOd4>
* Optional:
  + Video on crayfish anatomy to familiarize students with terminology. <https://www.youtube.com/watch?v=2cBGuEDxvNo>
  + Video on crayfish sexing, including the differences between form 1 and form 2 males. <https://www.youtube.com/watch?v=XKc9R5pKXSk>
  + Video on handling crayfish. <https://www.youtube.com/watch?v=6pCfMP4jtyY>

If applicable: A discussion activity with students to pick local stream site for investigation. The instructor may want to provide students with a list of local sites, data (if available) from online resources, or other materials to help in identification of sampling locations.

* Site Selection of Impaired Streams – Fact Sheet on the Introduction to Clean Water Act (CWA) Section 303(d) Impaired Waters Lists:

<https://nepis.epa.gov/Exe/ZyPDF.cgi/P1008DPU.PDF?Dockey=P1008DPU.PDF>

* Oklahoma 303(d) list (find applicable for your area): <https://www.deq.ok.gov/wp-content/uploads/water-division/2020_OK_IR_Final-Appendix-C.pdf>
* Pre-Activity Reading –
  + Sustaining America’s Aquatic Biodiversity: Crayfish Biodiversity and Conservation: <https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/420/420-524/CNRE-82.pdf>
  + Larson, E.R. and Olden, A.D. (2016). “Field Sampling Techniques for Crayfish.” In book: Biology and Ecology of Crayfish, pp.287-324:
    - depts.washington.edu/oldenlab/wordpress/wpcontent/uploads/2013/01/Crayfish\_Chapter2016.pdf
* Pre-Activity Documentary (optional) - <https://www.youtube.com/watch?v=MuuIlZyrySE>

**Lesson Content**

The instructor will work with students to identify a local stream site for sampling: ideally one that is unimpaired, defined in this activity as a stream that is not influenced by human activity to a degree that it is altered. Students will sample various types of habitat within the stream (riffle, pool, vegetation, woody debris). Students will answer the general question: What habitat preferences are noticed among crayfish populations?

**Lesson Procedure**

Overview

A step-by-step procedure and timeline of summarized events are presented below. Time allotted for each activity is a recommendation and can be changed as per the instructors’ directions. Activities with an asterisk (\*) have an additional alternative modification or procedure,

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| --- | --- | --- |
| **Step** | **Activities** | **Time** |
| 1 | Site Selection | Completed before activity |
| 2 | Making Streamside Observations | 20 minutes |
| 3 | Collecting Water Quality and Habitat Data\* | 20 minutes |
| 4 | Crayfish Sampling | 40 minutes |
| 5 | Crayfish Measurements | 20 minutes |
| 6 | Data Analysis and Reflection\* | 20 minutes  Complete after activity |
|  | **Total Time** | **2 hours (120 minutes)** |

**1. Site Selection**

For this portion of the lesson, the stream that is being investigated should be wadable and not higher than thigh height (for the safety of participants). Before beginning, instructors should ensure flow conditions are suitable for collection. Streams should be sampled during base flow conditions (no greater than 3cm, ~1inch, above base or regular flow), and not after a rain event or prolonged dry period (5-7 days after). For accessibility, road crossings or parks are often convenient sampling sites. Crayfish reside in a variety of habitats, so ensure locations have a variety of substrate including rocks, vegetation, and sand. The ideal representative stream reach will have a combination of habitats including a riffle, streamside vegetation, and woody debris. If only one or two types of habitats are present, modifications to the lesson can be made. Additionally, crayfish are less active when water temperatures are below 12 °C (54 °F) – check your state recommended sampling period. Instructor should access site ahead of time to check these requirements.

**2. Making Stream Observations**

Walk to site and unload/prep any equipment. Instructor hands out copies of data sheet and crayfish identification sheet (if available), walking students through the recorded measurements. Students are instructed to retrieve their field notebook/paper and writing utensils for the rest of the lesson. Instructors direct students attention to the stream reach. A designated area of stream reach (for example: 100m) is identified and marked, depending on local and federal recommendations. Students are instructed to complete the following:

* Draw and label the stream reach. Include major stream characteristics such as: types of habitats present, types of substrates, any human-made structures or altered habitat. Additionally, include indication of scale and direction.

**3. Collecting Water Quality and Habitat Data**

Instructor divides students into groups that collect water and habitat data. The data that is collected is based upon whatever equipment the instructor can provide. Recommended parameters include at minimum water temperature (with a thermometer) or air temperature (via phone/internet), average stream depth (take three depth readings within the selected reach and average, recommend use of a yard stick or other measuring device), and substrate (the type of material present along the bottom of the stream reach). Additional parameters might include: dissolved oxygen (with a probe or a water testing kit), pH (with a probe or a water testing kit), and more depending on equipment availability

\*An alternative to this section is to: Find streams that have water quality measurements already available, such as those being monitored by citizen science or state/federal organizations. Compete a field activity prior to this field experience to investigate water quality parameters at each site. Students should still be encouraged to look around the site if data was collected beforehand. Additionally, an entire lab could be done before this one that involves water quality and habitat assessment. See additional lesson suggestions at end.

**4. Crayfish Sampling Methods**

Students begin by writing a hypothesis about how the measured and observed habitat parameters may alter crayfish communities or measurements. Students will collect in multiple habitat types depending on availability. Sequence for collection is determined by site characteristics. In general, an appropriate riffle should be identified and sampled first. Next, streamside vegetation can be sampled by moving up the reach and woody debris sampled on the return trip. Students should identify three 1 m2 areas of each habitat to be sampled and add a label to their sketch to indicate where these occur.

* In riffles, this includes the fastest part of the riffle, the slowest part of the riffle, and an intermediate area between the two.
* For vegetation, any streamside vegetation in current that offers fine structure for crayfish to dwell in or upon is suitable. Check the undercut of banks of runs and bends, where there are fine grasses, roots, edges of sedges and trees.
* For woody debris, any dead wood with or without bark in the stream should be examined and moved to check underneath for crayfish specimens.

Collection Method

1. Begin sampling at the downstream-most site and work upwards in the stream to avoid turbid water or scaring specimens. Use a collection technique for the present conditions.
2. If water is slow-moving, such as in a pool: Have students carefully lift rocks, logs, and other debris to find hiding crayfish. Instruct students to place a net behind the rock such that crayfish escaping backwards (as they tuck their tail) will enter the net.
   1. Make sure to put the rocks and debris back in their original place to minimize habitat disturbance.
3. Students should be instructed to handle crayfish by holding the back of the carapace to avoid being pinched. See example Figure #1. Crayfish can move quickly, so be prepared for sudden movements.

Figure 1: Proper handling of crayfish specimen in field.

1. Collect within each site until 30 crayfish have been retrieved, or 40 minutes of “total search time” has elapsed. Modify the time based on local protocols or lesson needs.
2. In swift or turbid water, it is recommended to use a seine or dip net. Modify by placing a seine or net in the swift current downstream from where rocks or debris is being disturbed.
   1. In shallower waters, such as riffles, students can be instructed to lightly kick and move rocks and debris so that materials float downstream into the net.
   2. Modify based on the size of the net available
3. Using a 1-meter kick net, have students perform 2 or 3 “kicks” at various velocities within a riffle. Each kick involves stationary sampling by positioning the net and disturbing a one-square-meter area upstream. To do this, instruct students to use the toe or heel of their shoe to dislodge the upper layer of cobble or gravel and any other debris crayfish may hide under.
   1. Repeat collection procedures.
4. Have students who are not actively collecting crayfish making notes about where crayfish are found. Are they under rocks, woody debris, in a burrow? This data will help to identify what habitat characteristics crayfish prefer.

**5. Crayfish Measurements**

Instructor should inform students that they will have the opportunity to practice techniques for identifying and collecting data about crayfish species. Have students break into several groups so measurements and identifying crayfish goes quickly.

Students will take the following measurements

**Species:** Use the information provided in the presentation and handout (if available for your local area) to identify species.

* If crayfish cannot be identified to species in the field, the following is recommended: Call all organisms that look similar “Species 1”, “Species 2” and so on for simpler analyses. Using temporary labels for unidentified specimens allows for systematic data collection and ensures that the data can be organized and analyzed later. This method is frequently used in ecological studies where field identification might be impractical (Gotelli & Ellison, 2004). Specimens should be preserved in a suitable manner (e.g., using alcohol or formalin) to maintain their identifying features for later analysis in the laboratory (Baird et al., 1999). If possible, collect both a male and a female. Additional collections of juveniles vs adults may be useful. Follow identification characteristics from your local handout/source.

**Sex:** Male (M) or Female (F). How to sex crayfish should be discussed in the lecture before the field activity. Note that male crayfish have gonopods used in reproduction, which are larger, firmer modified swimmerets on the ventral (bottom side) of their abdomen while females have a seminal receptacle (or hole) in the same location.



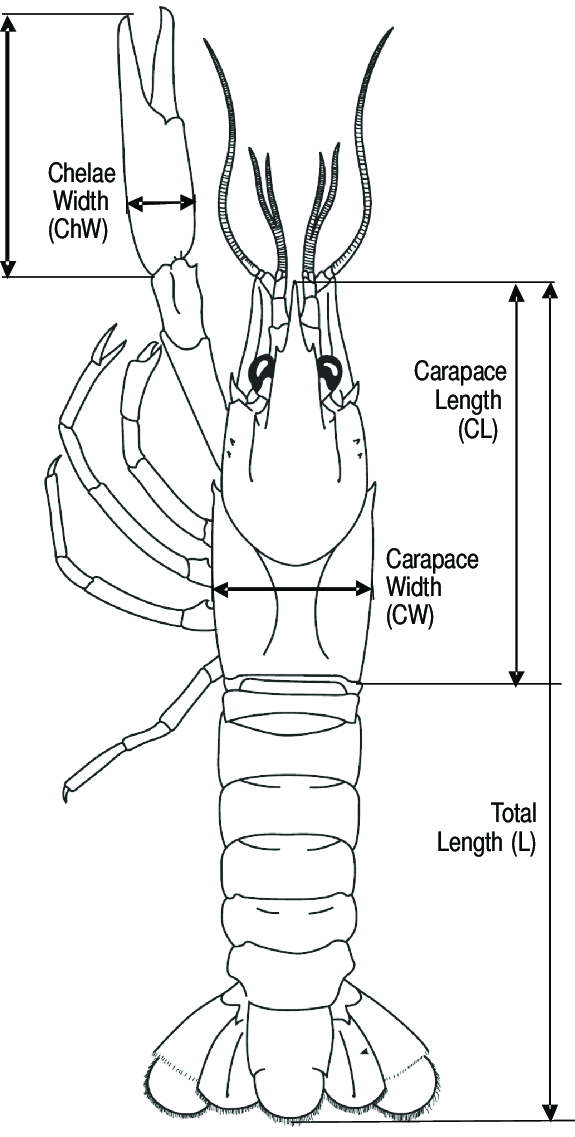
* Male (right) crayfish have two l-shaped appendages (gonopods, modified swimmerets) behind their legs. Males have breeding (F1) and non-breeding (F2) forms in which their gonopods are modified. Most keys will use F1 morphology. Females (left) have a circular sperm receptacle between the bases of the last two pairs of walking legs. Females tend to have wider tails and a larger body size in several species.

Figure 2: Female (left) and male (right) crayfish anatomy.

**Weight:** Students should bring crayfish specimen to scale for weight in grams. Scale should be tested prior to field work to ensure it can handle larger mass. Students will zero/reset the scale after a mesh bag is added and allow calibration before adding crayfish specimen.

**Body Measurements**

* Body Length: Measured in millimeters (mm) from the tip of the rostrum to the end of the telson. A measuring board is helpful for getting more accurate measurements but instructors can make use with alternatives such as a clipboard and a ruler. The students should hold the crayfish so that the rostrum aligns with the front of the board/ruler and the uropods are flattened so that the telson measures to full length. It may be good practice to have each student in a group measure the length to verify accuracy.

Figure 3: Anatomy by Sedik, Yulianus & Rumahlatu, Dominggus & Irawan, Bambang & Soegianto, Agoes. (2019)

* Cephalothorax Length: Measured in millimeters (mm) from the tip of the rostrum to the end of the carapace where it meets the abdomen.
* Chelae Length: Measured in millimeters (mm) from the base of the chela (where it attaches to the body) to the tip of the movable finger of the chela.

Disposal:

* If non-native or invasive crayfish are found during sampling, instructors should contact local authorities for advice on handling and removal. If it is appropriate to euthanize specimens: Non-native crayfish can be placed in a plastic bag and placed in a freezer. Once crayfish have been euthanized it is the responsibility of the instructor to dispose of remains.
* Note: At no time can crayfish that are collected by kept as pets or be consumed. It is against the law to transport live crayfish. Please only collect and handle crayfish in accordance with the laws in your area.

**6. Data Analysis and Reflection**

See attachment. Data Analysis may be carried out as a part 2 (a follow up lecture and assignment in class) or as a take-home assignment. It is recommended for lower-level classes that this portion of the data sheet is completed together, in class, to allow for discussion and an instructor-led example of how to use excel.

Reflection: This portion of the lesson is designed to last 10 minutes and may be done at a part 2 if data analysis is a separate lecture/assignment. A group discussion about how students believe habitat changes could affect crayfish communities should round off the session. Students may be asked to develop new hypotheses in light of potential future developments, or they may be asked to explain their initial hypotheses and any updates or modifications they would make in light of preliminary facts. Teachers may decide to go over the historical and present circumstances of the two streams or the watersheds that are being sampled, along with any relevant events (management, building, fire, urbanization, etc.).

**Data Sheet:** Separate document.

**Data Analysis and Interpretation**

Data analysis can either be completed as homework of carried out in a Part 2 of this lesson. Data analysis will depend on student hypotheses and questions that arise about the site being investigated. Potential data analysis questions include:

* How does a diversity index compare between the areas sampled within the site?
* Are any physical characteristics (such as weight, length) significantly different between the different habitat types?
* How might this data be biased or limited based on sampling methodology?
* An additional option, if this lesson is continued in subsequent years or courses, is to compare data over time to examine how changes in habitat influence crayfish populations.
* Another option is to compare multiple sites, if time allows. Students could compare unimpaired with impaired conditions.

Students will talk about any patterns they see in the data as well as any similarities and differences they find with the instructor and with one another. Students could be required to predict upcoming adjustments or speculative management situations. Give students enough time to review and revise their initial theories and predictions. For low-tech use, this class includes an excel template with instructions.

**Reflection**

The activity concludes with a detailed group discussion of the completed protocol, measurements, and data collection. Students are expected to identify potential sources of differences between the habitats of the site studied and to draw conclusions about how habitat affects crayfish populations. Instructors may wish to challenge students to think more deeply with probing questions. Why didn't there/did there appear to be major differences? What causes could have caused major differences? Instructors may also want to remind students of current and historical conditions that could affect either sampling location. To finish, the instructor should review the learning objectives with the class that were met.

**Links to Other Lessons and Concepts**

Several other QUBES lessons involve collecting stream habitat data. These lessons could be implemented before crayfish collection to incorporate several lessons/trips into curriculum based on instructor needs:

1. [Using Survey123 to Map Physical Habitat Characteristics, Watershed Activities, and Disturbances](https://qubeshub.org/publications/3622/1)
2. [Field sketching, geomorphic data, and the power of perspective](https://qubeshub.org/publications/3613/1)

**Further Reading**

Follow Up Reading: “Crawfish water quality and management.” The Fish Site: https://thefishsite.com/articles/crawfish-water-quality-and-management

**References**

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