Communicating Ocean Sciences to Informal Audiences

Crayfish Investigations
Lawrence Hall of Science

This activity outline was developed for use in a variety of informal venues. By design, it provides the content, pedagogy and strategy necessary for implementation by both the novice and experienced informal educator. It is expected that this outline will be adapted and improved upon by the user. We welcome your feedback!

Synopsis of the Activity
Visitors are invited to interact with crayfish while facilitators guide them to make observations and design investigations to learn more about crayfish. If they wish, visitors can set up an investigation to answer their question(s) and/or collect data to provide evidence for a previously asked question. Visitor observations and questions are added to a public board, and results to a notebook where others can read and build on them.

Audience
The general public of all ages. Suited for 1 -3 small groups of participants.

Setting
Open areas on the floor, or in a classroom setting; recommend avoiding high-traffic areas. At times, this can be a very demanding activity for facilitators and having more than one facilitator is recommended.

Activity Goals
Learners will become familiar with the processes of inquiry. Learners will also be encouraged to take a closer look at the world around them and to help focus them on the types of questions they can ask, how to answer those questions and how their answers can be applied beyond the specific situation. Learners also gain an understanding of the structures and function of crayfish.

Concepts
This activity is primarily process-oriented, so the concepts and vocabulary deal with inquiry, not crayfish. The activity could be done with a variety of organisms such as hermit crabs, shrimp, etc and appropriate life science concepts and vocabulary developed.

- Scientists try to answer questions they have about the world by doing investigations where they make observations and gather data.
- Scientists predict what they think will happen in an investigation and describe their reasons for why they think that. Together these two things are a hypothesis.
- Evidence is used to support an explanation or idea
- Certain findings can be generalized to other situations

Ocean Literacy Principles
7. The ocean is largely unexplored.

b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

Materials

For each group:

- 1 clear plastic shoe box or similar aquarium
- clean, dechlorinated water to fill plastic shoeboxes about 5 – 10 cm deep
- 1 crayfish

For the table or cart:

- I Notice/I Wonder/Investigation board
- 100 colored index cards (three colors)
- colored markers
- 1 copy of Crayfish Information Cards
- Various materials for conducting crayfish investigations (e.g. sand, gravel, various-sized/colored/shaped clay pots, pipes, and/or containers for hiding, tubifex worms, fish flakes, bits of meat or fish, lettuce, large squares cut from black plastic garbage bags, large squares cut from white plastic trash bags, vegetable bags, strawberry baskets, mirrors, flash lights, blocks or other barriers, etc.)
- Notebook with copies of Investigation Journal

Preparation and Set-up

- Prepare I Wonder/I Notice/Investigations Board. Using chalk or white board, bulletin board, or large sheets of paper taped to the wall, post the headings "I Wonder", "I Notice" and "Investigations" in colors corresponding to the respective colored index cards. Have available a means to attach the cards visitors fill out under the appropriate headings.

- Gather all materials; place crayfish information cards and a tub with a crayfish or two on the table. Have all other materials near the table or cart for easy access when needed.

Guiding Questions

What do you see or notice about the crayfish?
What is it doing?
What does it look like?
How is it moving around?
What do you want to know about the crayfish?
What do you wonder about the crayfish?
How could we answer that question?
Would that be true for all crayfish? All crustaceans? All animals? How do you know/What evidence do you have?

Activity Description

Introduction: Invite visitors to come and observe the crayfish in their aquariums. Visitors are often very attracted to the opportunity to observe and touch living organisms. Also, noting that they can actually design and participate in an actual scientific investigation could help gain visitor interest. For instance, you could say, "Have you ever seen a living crayfish? Do you have a question about crayfish that you would like to investigate? Come over and find out what you can discover about them."

> *Focus on Inquiry*
> *There is no order in which the explorations need to be done, and visitors do not need to do every exploration. The common goal across all of the explorations is the process of inquiry. Thus the facilitator does need to encourage visitors to observe, question, and investigate, and also to help visitors make connections between the explorations if visitors do more than one exploration and are not making the connections on their own.*
>
> *Multiple Entry Points*
> While facilitators may progress from Free Exploration, to I Notice/I Wonder, to Investigation etc, the reality is that visitors may not want to or be able to explore in that order. Acknowledging this, the design of the activity is open enough that each subsequent section in the write up is a mini-activity/task within the whole activity, and the facilitator can weave a series of mini-tasks for visitors while keeping the goal of the activity in mind.

Free exploration (Observe, Question): Invite visitors to come close and observe the crayfish in the aquarium tanks. Encourage them to make observations and ask questions about what they wonder about. As visitors freely explore, ask them questions about their observations of the crayfish to encourage them to think about the biology of the organism, and what they notice about how it uses its different body parts. Encourage visitors to ask questions and talk with others in their group.

Suggested questions:

- Have you seen crayfish before? Where?
- Can you tell me something you know or have heard about them?
- What do you notice about the crayfish?
- Can you describe more about that?
- What else do you notice?
- What kinds of things do you wonder about the crayfish?
- What is really interesting to you so far about the crayfish?
- Would you like to do an investigation or design an experiment to see if you can figure out the answer to your question?

Key ideas to address in this conversation:

- Crayfish live in freshwater ponds, lakes, and streams.
- They are related to crabs, lobsters, and shrimp.

- Scientists find out about living organisms by observing them very carefully in their natural habitat.
- These aquariums are not the crayfish natural habitat, but we can find out some interesting things about them by observing them carefully in these model ponds.
- Scientists do investigations to find answers to their questions.

Form, Function, and Feeding (Observe): Let visitors know that, just like scientists, they can find the answers to many questions they wonder about. Invite visitors to take a closer look at the body parts of the crayfish, and challenge them to share something they notice about the crayfish. Remember to encourage visitors to explain and provide evidence for their observations and ideas.

Suggested Questions:

- What does it seem to be doing?
- What makes you think that? What's your evidence?
- How is the crayfish moving around?
- What body parts is it using?

Key ideas to address in this conversation:

- Engage the visitor in a conversation about the crayfish based on what they find is interesting about the structures and function, and life history of the crayfish.
- If they are interested and can read the Crayfish Information Cards, consider choosing one of the cards that addresses what they are interested in and after reading the card, have them share the information with other visitors at the cart.

I notice, I wonder (Observe, Question): Encourage visitors to write down as many observations on the cards about crayfish as they like (one observation per card) and place it on the board under the heading "I Notice". Also challenge them to share one or more questions they wonder about. Encourage them to pick at least one of the questions to write on a card and post it on the board under the heading "I Wonder".

Suggested questions:

- What would you like to find out about the crayfish?
- What do you wonder about?
- Do you think you know the answer?
- How sure are you? How could we be more sure?
- What could we do to find out the answer to your question?

Holding the crayfish (Observe): Show visitors how to carefully touch and pick up the crayfish to look at its underside. They will now be able to use their sense of touch. Emphasize that no one has to touch it or pick it up and the crayfish must be treated very, very gently. Show them the difference between male and female crayfish.

Suggested questions:

- What do you notice about the underside of the crayfish?
- What does the crayfish do when it is held out of water for a few seconds?
- What does it do when it is put back in the water?
- Looking at two different crayfish, what do you notice is the same and what is different?

Choosing a question to investigate (Question, Investigate): Encourage the visitors to choose one of their questions to investigate or you may suggest some already prepared investigations for visitors to consider (see Attachment B at end of this activity). You can also invite visitors to look at the board or talk to other visitors for ideas of questions to investigate.

Suggested questions:

- What would you like to find out about the crayfish?
- What do you wonder about?
- Do you think you know the answer?
- How sure are you? How could we be more sure?
- What could we do to find out the answer to your question?
- What do you think might happen if we do that investigation?
- What makes you think that?
- What kind of materials will you need to do the investigation?

Doing an investigation (Investigate, Observe, Question): If the materials are available, help the visitors set up their experiment (groups with older kids can write in an investigation journal, or the facilitator may summarize the investigation at a later time – see journal pages at end of this activity).

Suggested questions:

- What question about the crayfish are you investigating?
- What do you think will happen when you do that investigation?
- What makes you think that?
- What happened when you did the investigation? What are your results?
- What does that tell you about this crayfish?
- Did you answer your question? What's your evidence?
- Do you think you figured out something about all crayfish or only this one? What makes you think that?

Related Activities/Extensions/Modifications

The Crayfish Investigations activity can be done with animals other than crayfish as long as they are hardy and interesting – mole crabs and brittle stars have been used successfully. Posting an "I Wonder/I Notice" Board and guiding visitors to make observations and ask questions (and to a lesser extent do some investigations) can also be done using animals in a tank.

Additional Resources
Books about crayfish and their relatives as well as photographs are helpful to include for those visitors wanting to learn more. The Crayfish Information Cards are a great resource for visitors to find answers to questions about life cycle, how long they live, where they live and etc.

Background

One of the most successful groups of animals in the world are the members of the phylum Arthropoda, which means "jointed legs." There are three times more species of arthropods than all other animal species combined. This group of invertebrates (animals without backbones) includes the insects, spiders, mites, and the crustaceans such as the crayfish, lobster, crab, barnacle, and shrimp. The crustaceans are almost entirely marine (living in salt water) and many live at the rocky seashore. One of the freshwater exceptions is the incredibly successful crayfish.

There are more than 500 species of crayfish and they are found throughout the world in swamps, marshes, ponds, streams, and even cold lakes and fast-running rivers. They are found in all coastal areas of the United States, including Hawaii, and have been introduced in Costa Rica, Spain, France, Africa and Japan. Although they live only in brackish or freshwater, crayfish are ideal to represent the crustaceans living at the rocky seashore because they have so much in common with their marine relatives and yet are much easier to obtain and keep alive in the classroom.

All arthropods, which includes crustaceans, have several features in common. They are all covered with a hard external skeleton (exoskeleton) that is segmented so they can move. Arthropods must shed or molt the exoskeleton in order to grow because it cannot grow as the inner body does. By the time a crustacean molts, a new, soft exoskeleton has already started to form underneath the old one. As soon as it molts, the animal inflates its new exoskeleton to a larger size by swelling itself with water. This allows for some growing room before the next molt is necessary.

Crustaceans are very successful living between the rise and fall of the tides in the wetlands and these same adaptations allow the crayfish to live in very diverse freshwater systems. All crustaceans have gills covered by a carapace—the shield-like part of the exoskeleton that covers the head and most of the back, and wraps around the sides of the body above the walking legs. In shrimp, lobsters, and crayfish, the tail section, or abdomen, extends back past the carapace and ends in the telson or fanlike tail. Crustaceans can stay out of water for varying lengths of time, but must always keep their gills moist so they can breathe. Most crayfish can remain out of water for only about 10 minutes at a time.

Crayfish, crabs, and lobsters are called decapod crustaceans because they have ten large legs. The first pair of legs are modified into pincers, which are used to defend against predators, help in competition with other crustaceans, and catch and tear food into smaller pieces. Actually, even the mouth parts of decapods are modified legs (not counted among its ten) and are used to sort and manipulate food after the pincers bring it to the mouth.

The next four pairs of legs are used primarily for walking, but also for handling food and cleaning itself. In crayfish, the legs on the abdomen or tail section are used in reproduction to hold masses of dark, spherical eggs until they hatch. They also are used as fans to keep the eggs oxygenated. These abdominal legs are called swimmerets because they help the crayfish to swim, although they are weak swimmers and cannot float. The crayfish uses its strong tail to dart backwards rapidly by flexing it towards the belly. This allows them to escape predators and to right themselves when they end up on their back. In crabs, the tail and abdomen are very much reduced and are wrapped tightly underneath the carapace. Female crabs have a wide rounded abdomen used as a shelf to hold their eggs. Males have a narrow, triangular abdomen.

Crayfish can be very aggressive towards one another. It is important, if you are keeping them for any length of time, that each crayfish be given a place to hide. Crayfish will eat almost any kind of fresh or frozen fish and can actually live for over a month without being fed. They will also eat live food such as goldfish and water plants.

Crayfish have to contend with fast moving rivers, whereas its seashore relatives, crabs and shrimp, have the changing tides and crashing waves to deal with. Crayfish have pincers like crabs and walking legs like shrimp. Also, like crabs, they can hang onto rocks and water plants so it isn't dislodged with strong water movement. By observing crayfish that live in streams and ponds, we can begin to understand how their ocean relatives live as well.

1. Ordering Crayfish

Crayfish can be ordered from scientific supply houses such as Carolina Biological (800) 547-1733. Order a few extra crayfish than you think you will need in case some die, are reluctant to move around or have recently molted. When you order them we recommend you try to obtain the red eastern crayfish, which live in still water. These are the easiest to keep alive and don't require refrigeration or an air stone. The western brown crayfish are harder to keep alive, as they live in cold flowing water. To maintain these crayfish, keep them in an aquarium with an air pump (aerator).

You can also collect your own crayfish if there is an appropriate wetland, stream or pond nearby. In some areas crayfish can be bought from bait shops, or even from pet stores, which is usually the most expensive option. Most supply houses also provide several other preserved or live crustaceans for comparison, such as hermit crabs, brine shrimp, barnacles, crabs, etc.

You can keep crayfish in the refrigerator for up to two days if you wrap them in wet newspaper or pond plants. But you must keep their gills wet, so they can breathe.

2. Keeping Crayfish

Crayfish are quite hardy, but there are a few important procedures that should be followed to keep the crayfish healthy and alive.

• First of all, be sure to put dechlorinating drops (follow the package directions) in the fresh, clean water you use and remember to change the water frequently.

• Feed the crayfish in a different aquarium than the one that is their habitat so that the water isn't fouled by old food. The exceptions are living tubifex worms and living feeder fish. You can put these live prey directly into the crayfish habitat and they will live there. The crayfish can then eat them as they catch them. Dead food like pieces of fish, catfood, crayfish chow or even hamburger should never be put in their habitat - put these in an aquarium reserved for feeding.
• Give the crayfish plenty of hiding places because they are quite aggressive with each other and are likely to eat the smaller ones if they get the chance. Sometimes, if you have a crayfish or two which are much larger than the others, you might want to separate them so the smaller ones don't become dinner. Broken clay flower pots work great for hiding places.

3. Designing the Crayfish Habitat

Crayfish survive very well in an aquarium that is large enough for each of them to find a hiding place and not foul the water too quickly with their wastes. There also needs to be enough surface area of water so that an adequate supply of air in the water is available. The ideal habitat is a small wading pool, filled to a level of about 8 - 10 centimeters and housing 10 or so animals. Smaller aquariums call for fewer crayfish, with a rule of thumb being about 5 crayfish for a 40 liter aquarium. Fill the aquarium about 8 – 10 centimeters deep with dechlorinated water, add clean gravel to cover the bottom, add the broken flower pots for shelter and finally add 10 or so Elodea sprigs to provide oxygen to the water.

4. Obtaining other supplies for the crayfish

Elodea plants, dechlorinating liquid, feeder goldfish and live tubifex worms can all be purchased from a supply house like Carolina Biological, or they are usually easily and inexpensively obtained at your local aquarium store.

Crayfish Information Cards

Crayfish are **invertebrates**. Invertebrates are animals without backbones. Worms, jellyfish, anemones, crabs, insects and many other animals are invertebrates. People and other mammals, reptiles, amphibians, fish and birds are all **vertebrates** and have a backbone.

Crayfish have two pairs of **antenna** which help them to sense their habitat. One pair is very long and one pair is short. The shorter ones are called **antennules** and each is split into two so it looks almost like they have four short antennules. On the base of the antennules is an organ called a **statocyst**. The statocyst helps the crayfish to know which side is up and which side is down.

Crayfish have a long pair of **antenna** which they use to help them sense their habitat. They use them for their sense of touch to help them find their food when it is nearby. They can also use their antenna to taste or smell the water to find food that is farther away. At the base of the antennas there is an organ called the **green gland**. This is where the urine or pee comes out.

Crayfish have eyes on stalks which helps them to see a very wide area around them at one time. They can probably tell the shape and size of objects and some color, but can't really see an image like we do. They are very good at seeing any movement around them though and will react very quickly.

Crayfish and their very close relatives like crabs, lobsters and shrimp are a special group of animals called **Crustaceans**. This name refers to the hard exoskeleton that covers just about their entire body. Crustaceans and other arthropods wear their skeleton on the outside of their body instead of on the inside, like people do.

One of the most successful groups of animals in the world are the animals in the group called **Arthropoda**. The word Arthropoda means "jointed legs." It makes sense that a jointed-leg animal might be called an Arthropod because that word sounds kind of like the word arthritis - the disease where your joints hurt. There are three times more kinds of arthropods than all other kinds of animals in the world combined.

Arthropods include insects, spiders, mites, and crustaceans such as the crayfish, lobster, crab, barnacle, and shrimp. These animals all have an **exoskeleton**, which means they wear something like a skeleton on the *outside* of their body. The exoskeleton gives strength and support to their body and also gives their muscles a sturdy place to attach. The hard exoskeleton protects the arthropod's soft inner body from many predators or other dangerous things in the habitat.

Almost all crustaceans live in salt water. Crayfish are one of the exceptions. They live in freshwater or some kinds even live in water that is called **brackish**. Brackish water is kind of salty and kind of fresh. It is the kind of water found in wetland estuaries --where the freshwater flowing in from a river mixes with saltwater coming in from the ocean.

There are more than 500 species or kinds of crayfish and they are found throughout the world, but only in freshwater or brackish water (a mixture of salty and fresh). They live in swamps, marshes, wetlands, ponds, streams, and even cold lakes and fast-running rivers. They are found in all coastal areas of the United States, including Hawaii, and have been introduced in Costa Rica, Spain, France, Africa and Japan.

All arthropods, which includes crustaceans, are covered with a hard external skeleton (exoskeleton) that is jointed so they can move. It kind of like they are wearing a suit of armor. This exoskeleton does become a problem when the inner body grows. An exoskeleton doesn't grow or even stretch, so they must shed or **molt** it so their inner body can grow larger.

By the time a crustacean molts or sheds its exoskeleton so it can grow, a new, soft exoskeleton has already started to form underneath the old one. But before its new exoskeleton hardens around its soft body, the animal swells up with water to an even larger size. Then after the exoskeleton hardens, the animal can get rid of all this excess water. But by swelling up it has made sure that it has some room to grow before it has to molt again.

All crustaceans, including crayfish have gills covered by a **carapace**. This is the shield-like part of the exoskeleton that covers the head and most of the back. The carapace also wraps around the sides of the body above the walking legs. In shrimp, lobsters, and crayfish, the tail section, or abdomen, extends back past the carapace and ends in the **telson** or fan-like tail.

Crustaceans can spend some time out of water, but must always keep their **gills** wet so they can breathe. Most crayfish can remain out of water for only about 10 minutes at a time. The gills of crayfish are located under the carapace and just above the walking legs.

Crayfish, crabs, and lobsters are called **decapod** crustaceans because they have ten large legs. The first pair of legs are pincers. Pinchers are used to defend against predators, to help in competition with other crayfish, and to catch and tear food into smaller pieces. A crayfish can definitely pinch hard enough to really hurt, so keep your fingers out of its reach!

The mouth parts of decapods are legs which have been greatly changed. They are used kind of like fingers and teeth to sort and move food around after the pincers bring it to the mouth. The mouth parts are not counted as part of the ten legs of decapods.

Crayfish have four pairs of legs that are used mostly for walking, but also for handling food and cleaning itself. These walking legs have small pinchers which they use to grasp onto things. The legs have many small hair-like structures which they use to sense the habitat around them. They can tell that they are touching something if those hairs are moved.

In female crayfish, the legs on the abdomen or tail section are used to hold the eggs until they hatch. They also are used as fans to make sure the eggs have lots of oxygen. These abdominal legs are called **swimmerettes** because they help the crayfish to swim. In male crayfish the first swimmerette points towards the head and is usually white-tipped. In females, all the swimmerettes look very much the same.

The crayfish uses its strong tail to dart backwards rapidly by bending it towards the belly with lightening speed. This allows them to escape predators and to right themselves when they end up on their back. In crabs, the tail and abdomen are very small and are wrapped tightly underneath the body. Female crabs have a wide rounded abdomen used as a shelf to hold their eggs. Male crabs have a narrow abdomen shaped like a triangle.

Crayfish will eat almost any kind of fresh or frozen fish and can actually live for over a month without being fed. They will also eat live food such as goldfish and water plants. Because these animals eat food, they must poop out the wastes. The place the poop comes out can be found at the tip of the abdomen, just before the fan-like tail.

Crayfish have pincers like crabs and walking legs like shrimp. Also, like crabs, they can hang onto rocks and water plants so they aren't dragged away with strong water movement. Although they live only in fresh or nearly fresh water, crayfish have a lot in common with their saltwater relatives, but are easier to get and keep alive in the classroom. By observing crayfish that live in streams and ponds, we can begin to understand how their ocean relatives live as well.

Vocabulary

- Investigation - a process of gathering information or ascertaining facts through detailed or careful examination to answer a question.
- Investigable question - questions that can be answered by gathering data.
- Observation – A close or careful examination; the noting of a fact or occurrence often involving measurement
- Hypothesis - A tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation; includes both a prediction or explanation and rationale.
- Data - Factual information, especially information derived from scientific experiments and organized for analysis or used to reason or make decisions.
- Evidence – Information or data that can serve to prove or disprove something.
- Finding - A conclusion reached after examination or investigation.
- Generalizable – able to infer or form a general principle, opinion, conclusion, etc. from only a few facts, examples, or the like.

Attachment A

Investigation Journal

I Notice…	*I Wonder…*

This is the question I want to investigate:

These are the materials that I need:

This is what I think will happen and why I think so:

This is what happened when I tried my investigation:

This is what my results tell me about this crayfish.

Here are the new questions I have:

Attachment B

If visitors are having trouble coming up with an investigable question with the crayfish, here are a few investigations to suggest. You can laminate the cards and keep them to the side to show to individuals or you can keep the list as reference for the facilitator.

Do crayfish prefer to be in the open or to hide?
Think about what you would need to conduct this investigation then ask the facilitator to help you collect the materials you would like to use. What do you think will happen and why?

Which type of substrate (stuff on the bottom of the tank) do crayfish prefer?
Think about what you would need to conduct this investigation then ask the facilitator to help you collect the materials you would like to use. What do you think will happen and why?

What kinds of food will crayfish eat and which do they seem to prefer? Look at then items available on the table and think about what you would need to conduct this investigation. Then ask the facilitator to help you collect the materials you would like to use. What do you think will happen and why?

Do crayfish prefer to be in the light or in the dark?
Think about what you would need to conduct this investigation then ask the facilitator to help you collect the materials you would like to use. What do you think will happen and why?

If two different sized crayfish (or a male and female) are put together, will the smaller one hide out?
Think about what you would need to conduct this investigation then ask the facilitator to help you collect the materials you would like to use. What do you think will happen and why?