

# UC San Diego

## Capstone Papers

### **Title**

It's Not About the Classroom: Teaching Applied Science Using Experiential Learning

### **Permalink**

<https://escholarship.org/uc/item/4762093q>

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### **Publication Date**

2015-04-01

# It's Not About the Classroom: Teaching applied science using experiential learning

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May 30, 2015

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## I. EXECUTIVE SUMMARY

In 2012, the Waitt Institute began developing the Barbudan Blue Halo Initiative in collaboration with the local government and island community. The Waitt Institute provided the toolkits and resources, and the Barbudan community provided motivation and the commitment to make responsible and sustainable ocean policy decisions that will support coastal and fishing livelihoods. In August of 2014, based on the scientific research and community interviews conducted by the Waitt Institute and its partners, the Barbudan Council formally signed new legislation to protect the island's territorial fishing grounds.

I collaborated with the Waitt Institute to help develop the education toolkit for the Blue Halo implementation plan. These materials are tailored to the island's school system and resources are developed for primary school fifth and sixth graders. They are based on the existing curriculum and science standards set by the Organization of Eastern Caribbean States (OECS), and use best-practices experiential teaching techniques developed by SEACAMP San Diego. They were reviewed for accuracy by the staffs of Ocean Classrooms and Scripps Institution of Oceanography.

The lessons were developed after an observation period on Barbuda where I discussed the needs and goals of the school system with the local headmistress and worked with a sixth-grade class to assess the students' level of understanding for core marine science principles. They take key concepts from the island's current science curriculum and integrate them into new lessons that use a holistic teaching approach favoring hands-on activities and student interaction over the traditional lecture and note-taking format.

## II. ACKNOWLEDGEMENTS

This project couldn't have been completed without the help and support of the following people: Dr. Ayana Johnson, Stephanie Roach, and Andy Estep of the Waitt Institute, whose tireless efforts provided the platform for me to begin my work, and the resources to accomplish everything within the constraints of the MAS program; Dr. Jen Smith, whose provided invaluable insight into how to prioritize scientific data in education; my mentor Jill Harris, who had a unique suggestion for me at every one of our update meetings, my fellow MAS students, who kept me sane during the long nights and tight deadlines, and Phil Zerofski, the link to SEACAMP San Diego's decades of teaching experience, who proved time and time again that learning doesn't just take place inside the classroom.

### III. INTRODUCTION

Caribbean island nations are impacted by a host of anthropogenic threats, including land-based pollution runoff, marine debris, ocean acidification, and overfishing<sup>1</sup>. Overfishing, and the subsequent loss of biodiversity represent one of the most immediate threats to the sustainability of an ocean that many Caribbean communities depend on for their livelihoods.

The Waitt Institute's (WI) mission is to empower island communities, giving them the tools they need to protect, restore, and sustainably use their ocean resources for generations to come. This work began on the island of Barbuda in 2012, when the Waitt Institute's Executive Director Dr. Ayana Johnson began a series of conversations with local community members and government officials about assisting with developing a comprehensive ocean zoning policy for Barbuda.

After nearly two years of community meetings, scientific surveys, legal analysis, habitat surveys, and enforcement studies, the Barbudan Council passed legislation based on the Waitt Institute's recommendations and findings and the input gathered from the local community. Portions of this legislation regulated the harvesting of certain species identified by the scientific surveys as critical to Barbuda's marine ecosystems, while others limited the types of fishing equipment allowed in certain vulnerable areas<sup>2</sup>.

The Waitt Institute provides Blue Halo sites with a resource toolkit that includes policy development, legal analysis, financial planning, scientific monitoring, and education and outreach materials. These resources are designed to enable the island to have a robust and self-sustaining ocean zoning policy in place within four years.

### IV. PERSONAL BACKGROUND

Prior to enrolling in the Masters of Advanced Studies degree program at Scripps Institution of Oceanography, I had worked as a submarine nuclear mechanic for the U.S. Navy, as a dive instructor and supervisor for recreational dive trips and scientific field expeditions, and as a design and content developer for an online marine science organization. I enrolled in the MAS program with the intent of improving my understanding of current oceanographic research and identifying ways to make it applicable to students around the world.

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<sup>1</sup> [Status and Trends of Caribbean Coral Reefs: 1970-2012](#)

<sup>2</sup> [Barbuda Ecological Assessment](#)

During my second quarter in the program, I was introduced to the Waitt Institute staff and their work on Barbuda. Their program manager, Stephanie Roach, is an alumna of the MAS program, Dr. Johnson completed her Ph.D. work at SIO, and various other SIO faculty and staff have been involved in the scientific and legal analysis conducted for the Barbuda Blue Halo Initiative. Their work on Barbuda was timely, relevant, and aligned with my goal to provide applied science education using modern data to the people who can most benefit from it.

I also began working with Phil Zerofski, an employee of SIO and the owner of SEACAMP San Diego. SEACAMP San Diego runs an experiential marine science camp that teaches over 4,000 primary and secondary students each year about marine ecosystems. The camp's instructors teach using modern scientific principles and a hands-on teaching system that relies on multi-modal teaching techniques that engage visual, kinesthetic and auditory learning styles. The instructors encourage the camp's attendees to think critically about the concepts they are being taught by integrating questions into the games and activities that their students participate in.

## V. PROJECT BACKGROUND

My project began with a conversation with Ms. Roach about the Barbuda Blue Halo Initiative's needs. Initially we discussed the feasibility of creating a snorkeling camp experience that would encourage the local students to spend time in the local lagoon, observing the juvenile marine species that had recently become protected by the new legislation. I would apply my experience as a dive instructor, and the relationships I had developed in the snorkeling and scuba industry to obtain equipment and training materials for the snorkeling camp.

We identified the education and outreach goals for the Blue Halo Initiative and the project gradually shifted to a more formal school-based curriculum. The focus was still on experience-based learning, but the implementation plan needed materials that could be taught by the island's teachers without relying on outside assistance. I reached out to my old co-workers with Ocean Classrooms for materials on building lesson plans and developing curriculum based on STEM principles. I also started shadowing the SEACAMP San Diego staff and had regular meetings with Phil about the best ways to incorporate hands-on learning into traditional classroom settings.

By Mid-March of 2015, we narrowed our focus to the primary school. At this point it became apparent that creating materials based on American or European (many OECS countries are current or former overseas territories) training standards would not be

effective. Nearly every lesson plan offered by one of these country's involved multi-media presentations or assumed students had easy access to online resources.

In April of 2015, I travelled to Barbuda to observe the Blue Halo Initiative's progress. While visiting, I observed lobster exports, attended and assisted with enforcement training led by WildAid – a San Francisco-based nonprofit attempting to end the illegal animal trade, and conducted a scuba training seminar with local Fisheries employees. These experiences gave me a better understanding of the Barbudan community and the progress of the Blue Halo Initiative, and prepared me for the second part of the trip.

Step two involved observing the educational system on Barbuda. I interviewed the headmistress of the island's primary school, discussing the OECS curriculum, the objectives and structure for the existing science lessons, and the long-term goals of the school's science program. I assessed the knowledge level of a sixth-grade class on subjects like marine ecosystems, the water cycle, and general oceanography.

Before leaving Barbuda, Ms. Roach and I conducted a series of science lessons with the students. We focused on topics that highlight species or policies that are core parts of the Blue Halo Initiative, like lobster, marine debris, mangroves, and the lagoon. These lessons allowed me to gauge the students' ability to grasp scientific principles, assess their interest level in science subjects, and identified some unique teaching practices that could be used for developing Blue Halo-specific content.

Our last stop was Montserrat, another island in the early stages of the Blue Halo process to assess benthic conditions. Ms. Roach and I visited a private school and conducted a quick introduction to the Blue Halo Initiative with a combined third- and fourth-grade class. I walked the students through another round of questions to see if there were any similarities between the Barbudan and Montserratian education systems that we could use to more effectively tailor our lesson plans.

## VI. OBSERVATIONS

Islands within the OECS have many similarities – they often have economies driven by tourism or ocean-based industries, and many rely on some assistance from foreign governments or have governments that are transitioning from foreign supervision – but they can also be markedly different from their neighbors. In stark contrast to the neighboring islands of Antigua and Guadeloupe, with populations in the tens of thousands, Barbuda has a mere 1,500 citizens and an infrastructure that sometimes struggles to provide amenities for the island.

### a. The School System

The Barbudan school system has 22 teachers for 292 students, almost no electronic teaching aids, and minimal capacity for purchasing modern materials or teaching aids. They use the same curriculum as other schools within the OECS, but it has been simplified to a degree to fit the capacity available to Barbuda's school system. Students are divided into classes of approximately 20 students per teacher, and lesson plans are broken into three-week segments that focus on particular subjects.

The teachers are very experienced, and comfortable with a wide range of scientific subjects. The background materials they have available for creating their lesson plans are fairly simplistic and tend to focus primarily on terrestrial ecosystems, so any subject matter involving marine ecosystems should come with sufficient background information to make teaching it easy and straightforward.

The primary school has limited access to modern educational resources. Classroom materials primarily consist of chalkboards, a few textbooks and basic arts and craft supplies. The school has a few desktop computers, but during my stay they were completely disassembled and stored in a backroom. Internet access is non-existent and there is no capacity for electronic presentations during day-to-day classes.

### b. The Students

There is no shortage of energy among the Barbudan students. Their enthusiasm is sometimes hard to contain – teachers would have to refocus the students' attention at regular intervals. This is also an asset because they are eager and ready to display their knowledge level when they know a question's answer, but a new or visiting teacher needs to carefully manage the students' energy and attention spans.

During my visit, the students displayed a thorough understanding of complex concepts like water cycles, the life cycle of a lobster, and predator-prey relationships. They had less comfort with topics that discussed what coral reefs are, or how species interact in a marine ecosystem. There was considerable confusion caused by exposure to fictional or misleading information from Internet sources like Youtube and Discovery Channel. Some students expressed ideas that they had learned from older family members, and care had to be taken to avoid confusing or offending the students while trying to correct the misinformation.

## VII. DEVELOPMENT

I identified three metrics needed for these lesson plans to have a likelihood of success. They had to closely follow existing science requirements for OECS schools, they must

be teachable using resources readily available to the school's faculty, and they needed to take advantage of the unique aspects of the island's culture and the personalities of the students. Five subjects for the lesson plans were chosen by the Waitt Institute team based on knowledge of the topics most important to the community and central to Barbuda's new ocean laws.

#### a. Matching OECS Science Standards

The headmistress of the primary school provided me with the entire science curriculum and allowed me to review the Common Entrance Exam (CEE) that students take at the close of their sixth year of education. Ms. Roach obtained the Montserrat version of the standards so I was able to do a side-by-side comparison for the two islands with the intent of building lesson plans usable by either island's educators.

From this review I identified key vocabulary words, core objectives, and concepts that could be applied to the new Blue Halo lesson plans. This minimizes additional workload for the teachers since it allows them to reinforce pre-existing information from a marine science perspective. I then drafted the lessons (called "strands" in the OECS system), focusing on the species identified by the Waitt Institute with five activities for each lesson.

An emphasis on local species and their role in the community is one of the OECS standard's learning objectives. During the site visit, I noted that many of the reference material addressed species or ecology outside of Barbuda, like the Atlantic lobster, or a tundra ecosystem. I created custom designs for the lesson plans of species found in Caribbean waters to replace these generic textbook examples that won't typically be seen by the students during their studies.

I also created an exam that follows the format of the CEE. This exam focuses on the material taught in the Blue Halo lessons, and uses a combination of fill-in-the-blanks, short answer, and multiple-choice questions to test the student's knowledge retention. The format of the exam should allow the students to practice for their CEE as well.

#### b. Resources

The Waitt Institute set a four-year initial timeline for each Blue Halo site to become self-sustaining. For Barbuda, I decided to create materials that could easily be printed using a standard multi-purpose printer – available in the headmistress's office – or a desktop computer printer. Many of the activities rely on student participation to color, cut out, and assemble. This has the dual-benefit of increasing class participation and reducing the cost of printing color copies.



From an educational standpoint, Barbuda's strongest asset is the proximity of ocean and town. There is a robust mangrove ecosystem located next to the Fisheries building only a few minutes walk from the school complex. A Caribbean spiny lobster export occurs almost every week at the Fisheries building, providing teachers with excellent opportunities to give hands-on demonstrations of a key species on a regular basis. The lesson plans take advantage of these natural resources by taking students on field trips that reinforce lessons learned in the classroom.

After speaking with the sixth-grade teacher, I learned that the OECS education system has started working towards experience-based learning. This is an opportune time to start using these lesson plans, since they incorporate the lessons I learned while observing the instructors at SEACAMP San Diego. The program has been refining its teaching model for over 20 years so there is a significant opportunity to build teaching capacity by implementing their best-practices into the Blue Halo lesson plans.

### c. Cultural Strengths

It was important to remember that I was on Barbuda initially as a new observer. There is a significant cultural difference between the students I worked with in the past and the sixth graders on the island. The Waitt Institute does an excellent job of providing recommendations, listening to citizen feedback, and supplying impartial scientific data, while allowing the residents to take the initiative to make policy and build capacity.

The lessons focus on the strengths displayed by students during the Barbuda site visit. The students were quick to provide answers to questions, and had considerable enthusiasm for the activities that involved drawing and coloring. Many of the Blue Halo lessons build on that enthusiasm, using coloring activities to set the stage for a deeper look at animal anatomy or protective camouflage.

Writing exercises that were more complex were less popular, and some students had a tendency to avoid doing activities – like drawing – that they believed they weren't proficient at. I attempt to compensate for these problems by ensuring the lessons that do have writing activities have the students participate as a group, with no individual is singled out for an activity they may not be comfortable with.

## VIII. THE NEXT STEP

Curriculum development is a cyclical process. Lessons are drafted, reviewed and revised, field-tested in the classroom, and then revised again to incorporate feedback from teachers and students. Educational standards and accepted scientific findings

also periodically change, requiring review and possible altering of lesson plans and exams. Due to scheduling constraints, and the short duration of the MAS program, the Blue Halo lesson plans are currently in the initial review and revision phase.

#### a. Testing

Once the plans are complete, they need to be tested in a classroom environment. Ideally this will happen over the course of a school year, so teachers have the ability to integrate the new information in discrete quantities. Alternatively, these lessons can be taught as part of summer camps or workshops that focus primarily on marine sciences. If this method is used, care should be taken not to oversaturate the students with vocabulary words and more complex concepts. Instead, focus should be on the hands-on activities and field trips to get students thinking about these concepts in a broader, less detail-oriented manner.

#### b. Revisions

Feedback from both students and teachers should be gathered after the lessons have been taught for the first time. Administering the mock exam can identify how well the students retain the information, or by reviewing the key vocabulary words and core objectives from each lesson plan after the activities are complete. This feedback should be incorporated into future revisions.

A periodic review of the information used in the lesson plans should be conducted to ensure that students are learning accepted scientific principles. If classifications change or new data is gained, it should also be entered into the lessons. The digital format of these lessons allow changes to be easily entered by the Waitt Institute staff and electronically disseminated to the school faculty where they can be printed locally.

## IX. CONCLUSION

Effective and sustainable ocean policy requires a collaborative effort from government, local industry, fishing interests, and educators. The Waitt Institute is working towards this goal on Barbuda through the Blue Halo Initiative, which uses scientific surveys, legal and political framework assessments, and input from the local community to make recommendations for policy changes that protect ocean resources.

A comprehensive program involves every aspect of society, from politicians to local fishermen to the students who will eventually become the stewards of their community's resources.

This project focuses on those students by increasing their awareness of the importance of their marine ecosystem. It uses the information gathered by the Waitt Institute, along with techniques from SEACAMP San Diego and advice from marine science educators, to educate the Barbudan students about key species identified by the Blue Halo Initiative for maintaining the ocean's health.

This project emphasizes local resources, minimizes reliance on technology, and tailors its content to the capacity of specific communities and school programs. Long-term effectiveness and improvement of the program will require investment from both school faculty and the Waitt Institute staff for the duration of the Blue Halo Initiative. The goal is to make the new information as accessible and streamlined as possible to minimize the effort required to incorporate it into existing curriculum.

## X. APPENDIX

### A. Lobster Lesson Examples

1. Lobster Curriculum
2. Lobster Food Web
  - a. Activity Walkthrough
  - b. Teacher Aid – Card Deck
  - c. Teacher Aid – Food Web
3. Lobster Life Cycle
  - a. Activity Walkthrough
  - b. Teacher Aid – Trifold
  - c. Teacher Aid – Card Deck
4. Name That Lobster
  - a. Activity Walkthrough
  - b. Teacher Aid – Name that Lobster
5. Population Game
  - a. Activity Walkthrough
  - b. Teacher Aid – Population Game
6. Export Field Trip
  - a. Activity Walkthrough
  - b. Export Record Sheet

### B. Mangrove Lesson Examples

1. Mangrove Curriculum
2. Grow-A-Mangrove
  - a. Activity Walkthrough
  - b. Teacher Aid – Grow-a-Mangrove
  - c. Mangrove Growth Chart
3. Mangrove Botanist
  - a. Activity Walkthrough
  - b. Teacher Aid – Mangrove Botanist
4. Mangrove Habitat
  - a. Activity Walkthrough
  - b. Teacher Aid – Habitat Deck
  - c. Animal Passport
  - d. Teacher Aid – Mangrove Habitat

**GRADE VI****Term:** 1**Strand:** Life Science**Topic:** Blue Halo Lobster**Focus Question:**

(1) How is a lobster classified and what does its basic anatomy look like?

(2) Why is it important to protect lobster in Barbuda's waters?

**Grade V Review:** 39 (resources), 36 (population), 35 (food webs), and 34 (growth and development)**Strand reference pages:** 52, 56, 57, 62**Duration:** 3 periods

Learning Outcomes	Specific Objectives
<ul style="list-style-type: none"> <li>Use taxonomy to classify the Caribbean spiny lobster.</li> <li>Describe the importance of the lobster harvest to the Caribbean, and Barbuda.</li> <li>Understand the various stages in the lobster lifecycle.</li> <li>Understand regulations and reasons for maintaining a sustainable lobster fishery.</li> <li>Understand the specific role that the Blue Halo Initiative plays in protecting Barbuda's lobster population.</li> </ul>	<ol style="list-style-type: none"> <li>Using taxonomy, classify a lobster as an invertebrate crustacean, distinct from Atlantic and Pacific lobster (no claws, etc).</li> <li>Identify the feeding habits, food sources, and predators of the Caribbean spiny lobster.</li> <li>List factors that would cause the lobster ecosystem to change.</li> <li>Learn the benefits and risks of a large lobster harvest.</li> <li>Describe methods to ensure the lobster harvest is sustainable.</li> <li>Describe how Barbuda directly benefits from having a healthy lobster population.</li> <li>Calculate Maximum Sustainable Yield (how many lobster are required to survive each year to ensure there are lobster for next year's harvest).</li> </ol>

Key Vocabulary Concepts	Procedures/Activities	Skills and Attitudes
<ul style="list-style-type: none"> <li>Taxonomy</li> <li>Crustacean</li> <li>Conservation</li> <li>Sustainable resource</li> <li>Poaching</li> <li>Invertebrate</li> <li>Ecosystem</li> <li>Anatomy</li> <li>Exoskeleton</li> </ul>	<ul style="list-style-type: none"> <li>"Name that Lobster" - Chalkboard diagram of lobster anatomy identifying parts of the body and their function.</li> <li>"Lobster Life Cycle" - Students will describe the life cycle of a lobster, including the habitats in each stage.</li> <li>"Lobster Food Web" - Students will assume roles of animals in a lobster food web to learn about predator-prey interactions.</li> <li>"Lobster Export Field Trip" - Students will see a lobster export first hand at the Barbuda Fisheries Complex. Fisheries staff will show the procedures for recording lobster catch data, and describe the regulations for the lobster fishery. Note: Requires coordination with Fisheries staff.</li> <li>"Population game" - This game teaches Maximum Sustainable Yield, with different students taking on the roles of fishermen, Fisheries Officers, CLNP Rangers, and foreign fishing interests.</li> </ul>	Classifying Observing Communicating Recording Investigating Discussing Cooperation Group Dynamics Curiosity

Required Content	Content Principles
<ul style="list-style-type: none"> <li>Invertebrates lack a backbone and internal skeleton. Lobsters have an exoskeleton to provide support that they shed throughout their lifespan.</li> <li>Marine ecosystems consist of different communities that interact with each other and the physical environment.</li> <li>Lobster play a crucial role in Barbudan Fisheries, and require protection to ensure that the harvest remains sustainable for future generations (conservation).</li> <li>Lobster is a renewable resource.</li> </ul>	<ul style="list-style-type: none"> <li>Animals are grouped according to their characteristics. Lobsters are classified as invertebrates.</li> <li>Ecosystems change due to natural and human influences.</li> <li>We should conserve our marine environment to maximize its utility.</li> <li>With proper management, lobster will continue to be a renewable resource for generations.</li> </ul>

Integration with other subject areas: Art, Math, and Social Studies.

Additional Resources:

[IUCN Redlist description](#)

[Smithsonian Marine Station description](#)

[FAO Fisheries Information](#)

[Video of a lobster molting](#)

[Video of lobster migration/triggerfish predation](#)

[Lobster Activities](#)

[Online game that develops understanding of various reef components](#)

## Lobster Blue Halo Activity: Lobster Food Web

**Key Principle:** Lobster are preyed upon, and are prey for other marine species.

### **Materials:**

Lobster Food Web card deck  
Long ball of heavy yard or a thin rope  
Blue Halo Notebooks and writing tools

### **Procedure:**

The students will each have a card from the predator card deck that represents an organism from the lobster food web. Starting with the card that describes the adult spiny lobster, have the students form a food web with the yarn linking each organism to its prey and predators. Once all the students are linked in the web, ask them to identify what would happen if an organism were removed from the web.

Show the students how some prey species can be removed without the web failing, and how some organisms are critical linkages. If you are using yarn, you can cut the thread to show how the web loses strength when an organism is removed. Walk the students through the three trophic levels, explaining the role that organisms in each level play in the marine ecosystem.

Use humans as an example of a predator that may take too many lobsters, and allow the students to see the effect of lobster leaving the food web. Have the students discuss the benefits of maintaining a healthy and balanced ecosystem.

When the exercise is complete, have the students draw a food web in their Blue Halo Notebook.

### **Glossary of Terms:**

Ecology – The study of relationships between living things and their environment.

Habitat – an environmental or ecological area where a specific species lives. For lobsters, this changes based on what part of the lobster's life cycle you are observing.

Predator – An organism that eats another organism.

Prey – An organism that is a food source for another organism.

Life Cycle – a series of stages through which an organism passes from birth until death. For lobster, these stages are: Egg, Phyllosoma (larval), Puerulus (juvenile), and adult.

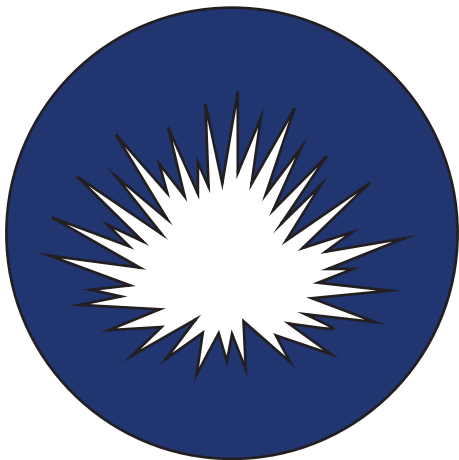
Scarcity – When a resource exists in a very limited supply.

Food Web – A group of interacting food chains in an ecological community.

### **Questions for Further Inquiry:**

- 1) What predator has the greatest impact on lobster populations?
- 2) What defense mechanisms does the lobster have to protect it from predators?
- 3) What can we do to ensure there are plenty of lobsters available for years to come?
- 4) What will happen to the predators if their food source becomes scarce?
- 5) What other kinds of organisms exist in food webs? (Ex. detritivores)

# Lobster Food Web



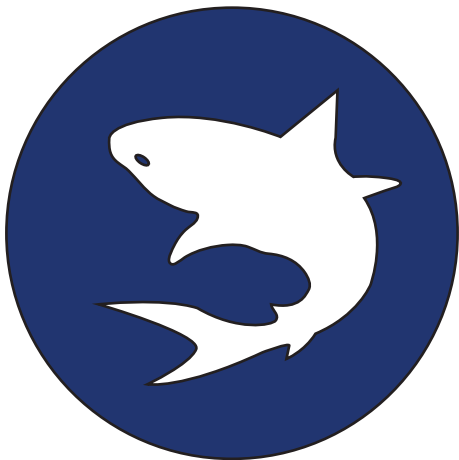
## Sea Urchin

I'm small and slow moving, but I have spines for protection from predators. I live on coral reefs and I graze on algae, which keeps the coral healthy.

***What eats me?***



# Lobster Food Web



## Nurse Shark

I'm a slow moving shark that likes to rest on the bottom for long periods of time. I can grow pretty big, so you don't want to pet me, but you don't need to be scared.

***What do I eat?***

# Lobster Food Web



## Loggerhead Sea Turtle

My cousin the Green sea turtle eats algae, but I like the crunch of a crustacean. The spiny and antenna don't bother me when I'm searching the reef for dinner.

***What do I eat?***

# Lobster Food Web

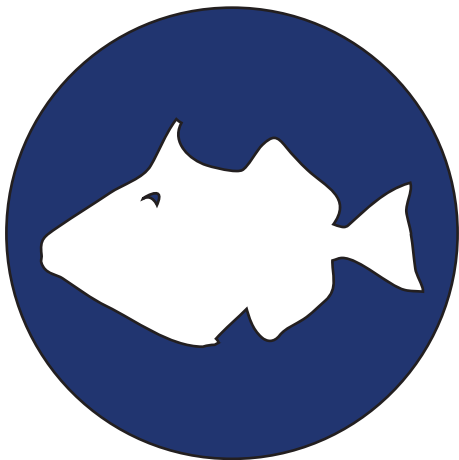


## Octopus

I use my eight legs to pry prey from beneath ledges and a sharp beak to crunch through hard shells and carapaces. I'm not very big though, and I'm very soft.

***What do I eat?***

# Lobster Food Web



## Triggerfish

I love hunting for my prey in sea-grass and among the corals. I'm fast and agile, which means I can hunt prey that can move quickly as it tries to escape.

***What do I eat?***

# Lobster Food Web



**Stingray**

I like to search along the ocean bottom for my food. I don't have sharp teeth, so I rely on camouflage to protect me from other predators while I hunt.

***What eats me?***

# Lobster Food Web



## Humans

I'm the top of the food chain! I eat almost everything that comes out of the ocean, but I have to be careful to avoid taking too much out.

***What do I eat?***

# Lobster Food Web



## Seagrass and algae

I don't look very fancy, but I convert sunlight into energy, and many ocean creatures wouldn't survive without the food and shelter I provide.

***What eats me?***

# Lobster Food Web



## Snails

I have a rough tongue to scrape my food apart. I don't move very fast, so I rely on my hard shell and small size to protect me from larger predators.

***What do I eat?***



# Lobster Food Web



Coral

I may look like a plant, but I'm actually an animal! I get nutrients from the ocean, and have a very interesting relationship with algae to get extra energy.

***What eats me?***

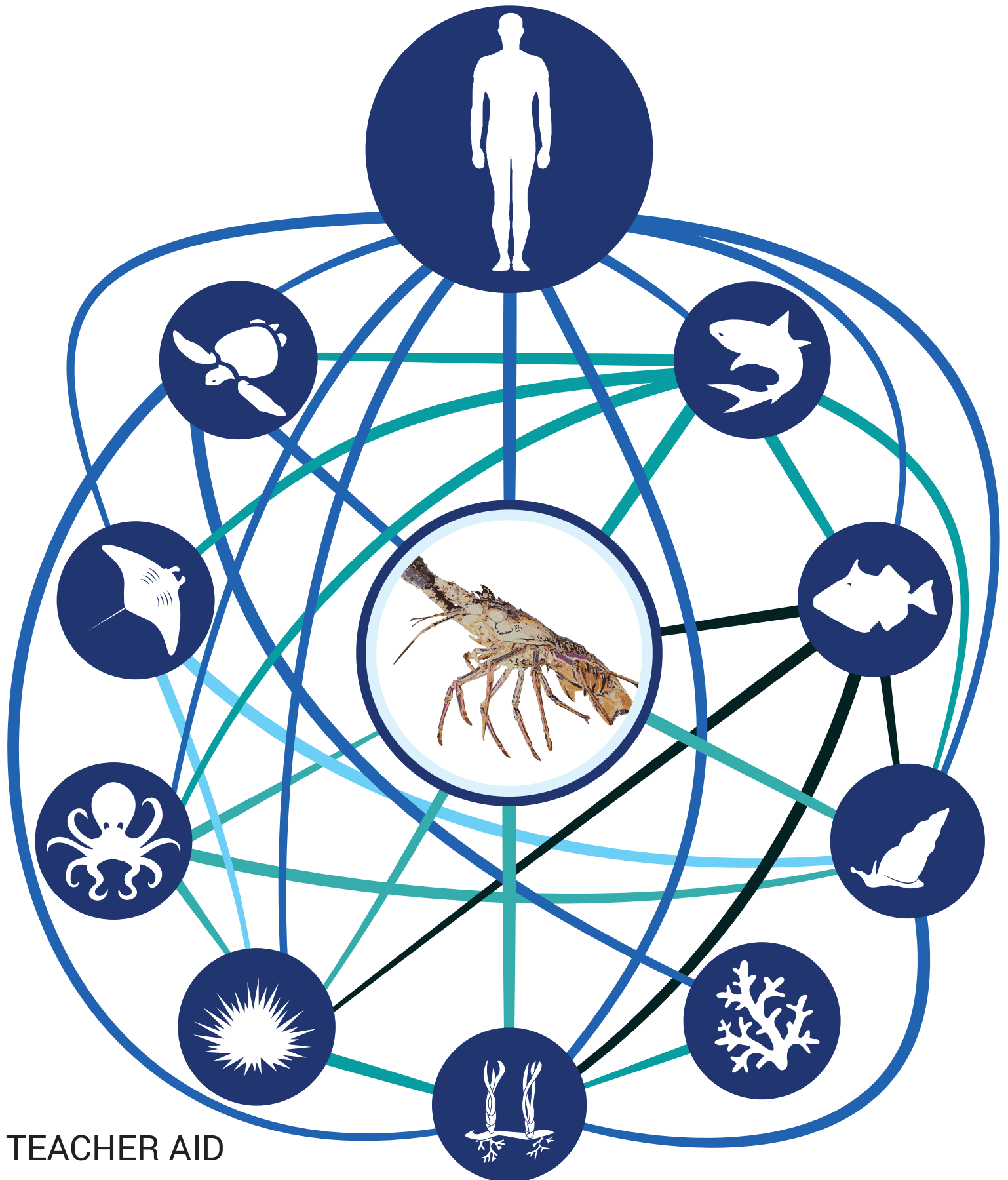
# Lobster Food Web



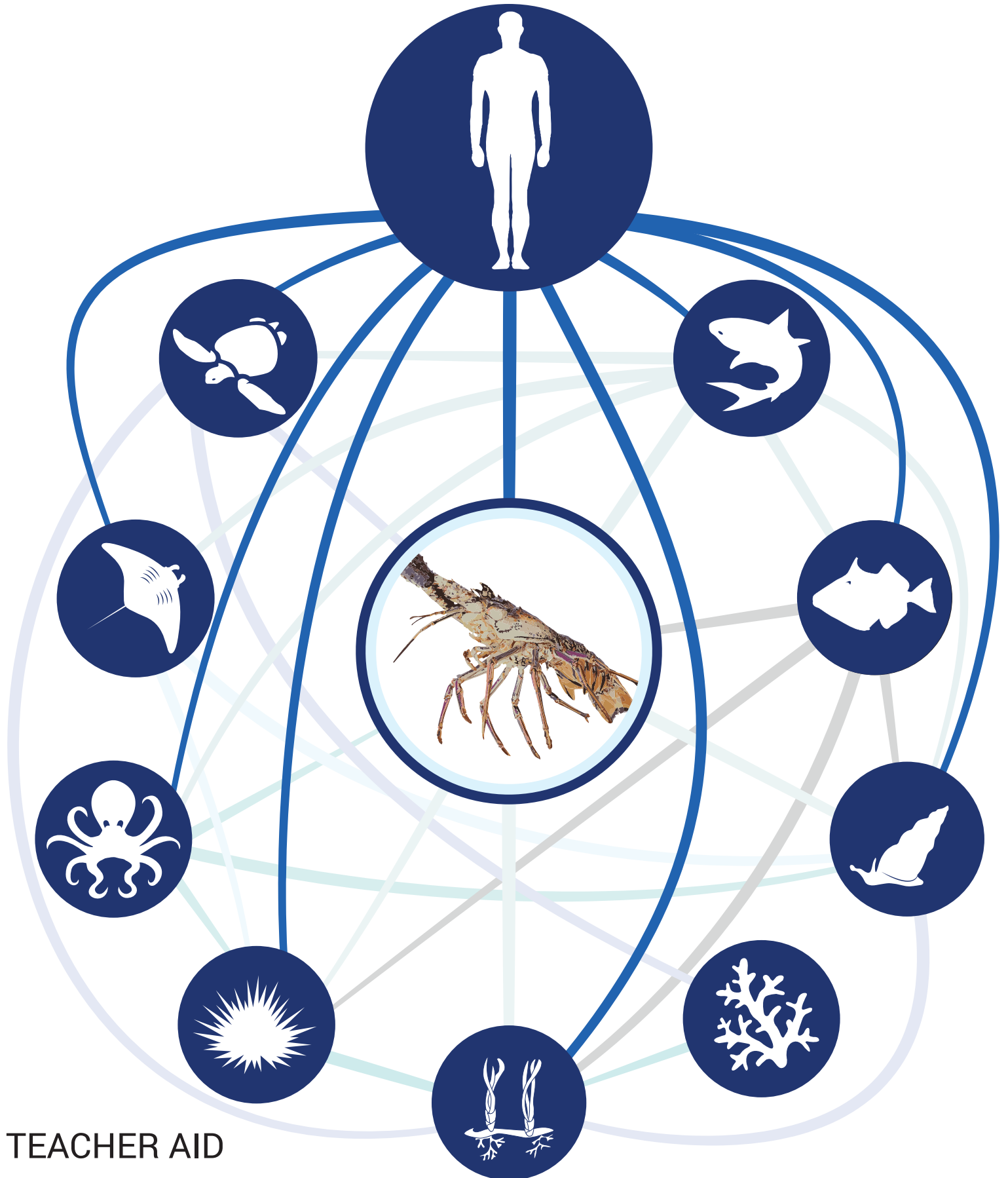
## Spiny Lobster

When I'm full grown, I like to hunt things that are smaller and slower than me. I hide under ledges to protect myself from larger predators that might try to eat me.

***What do I eat?***



Humans exist at the top of the food chain – we use or eat nearly every animal in the marine food webs. Humans can be described as “apex predators” or the top of the trophic ladder.



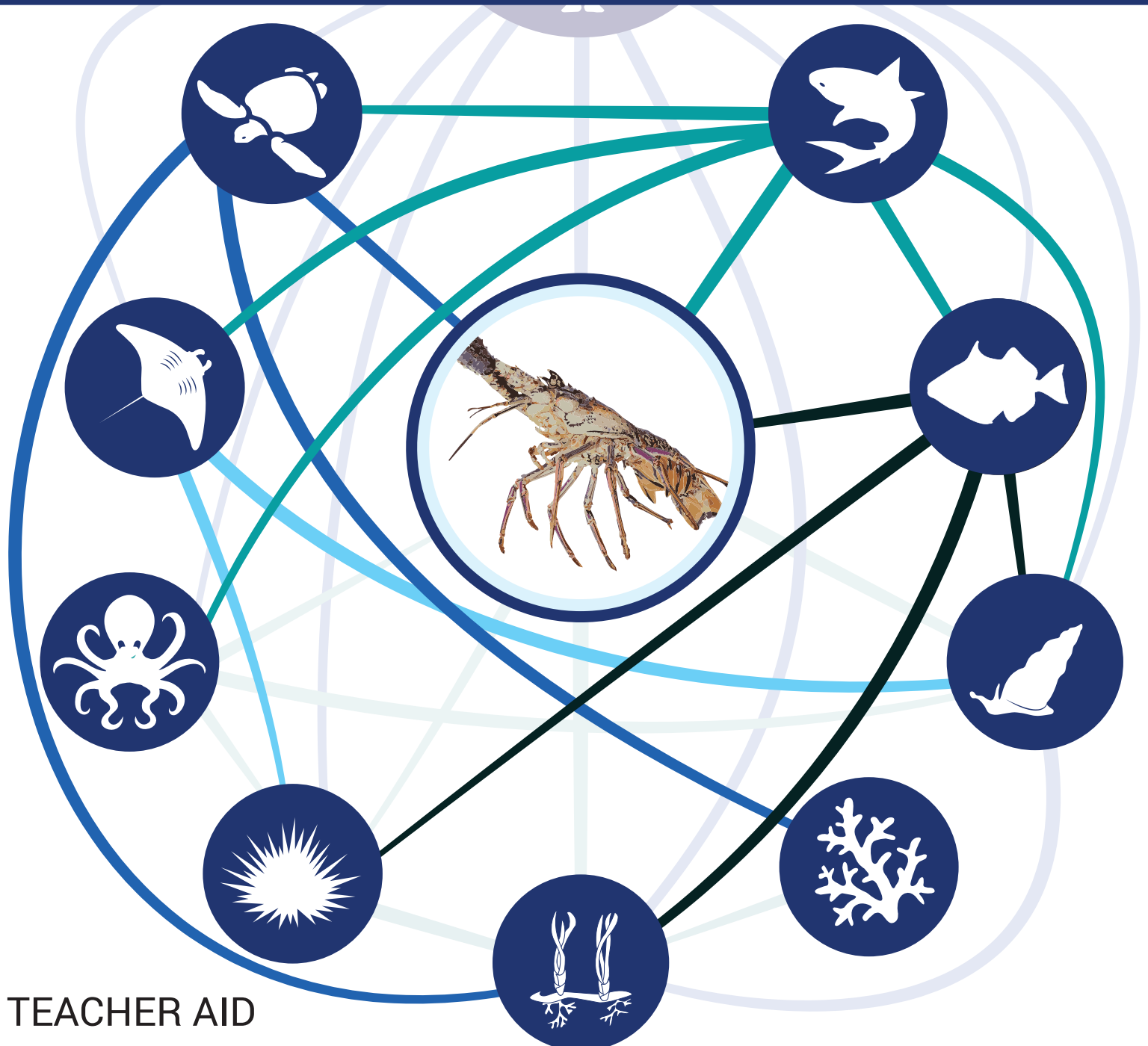
TEACHER AID

## UPPER TROPHIC LEVEL

This level is made up of carnivorous predators that hunt other carnivores. Predators at this level that hunt lobsters may include:

- Loggerhead Turtle
- Nurse shark
- Triggerfish

*Note: Students should understand that animals at this trophic level hunt other animals that are also predators. Removing these animals may cause an overabundance of smaller carnivores and a loss of lower trophic level species.*



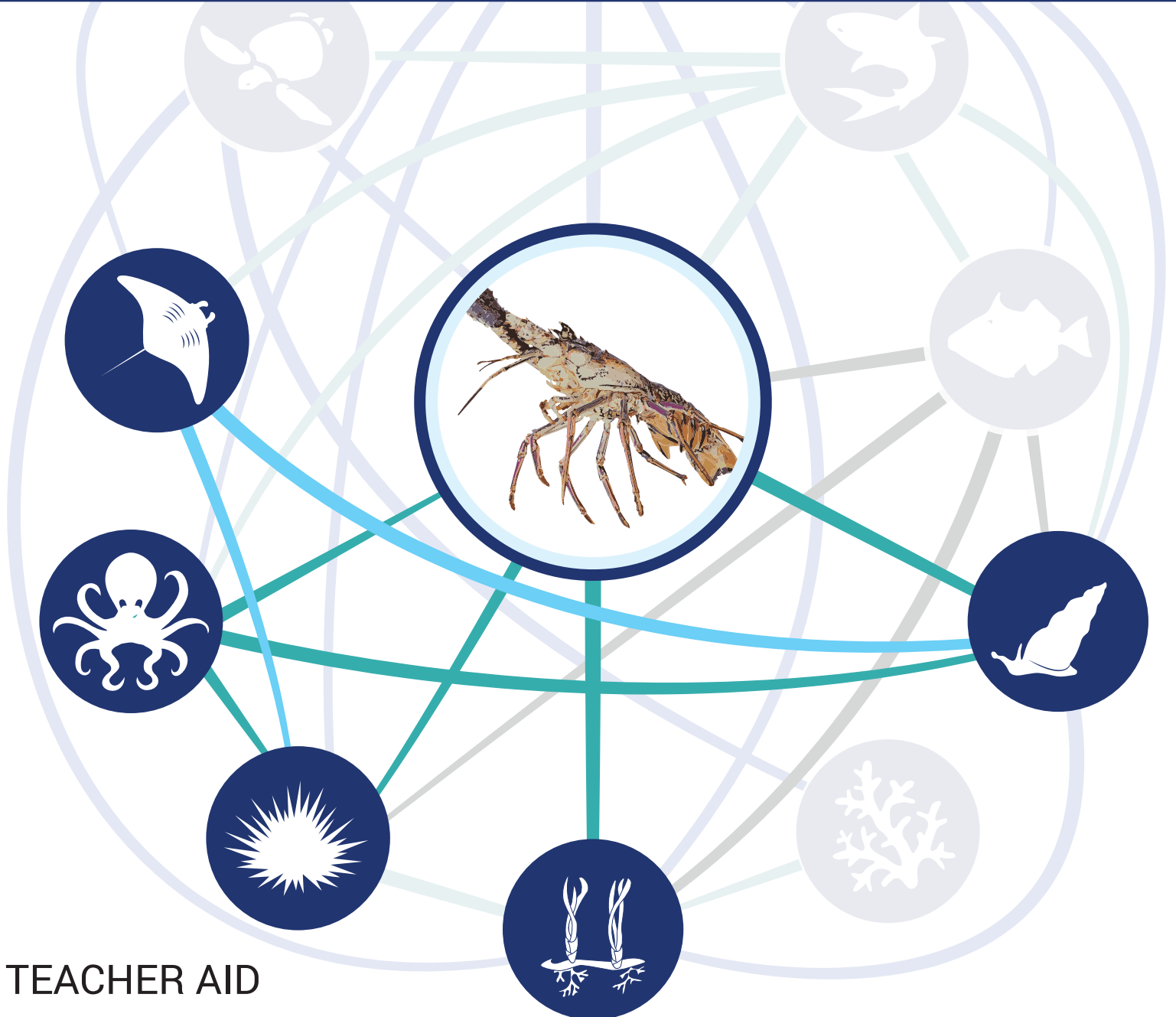
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## MIDDLE TROPHIC LEVEL

This level is made up of carnivorous predators that hunt herbivores (plant eaters). Predators at this level that hunt lobsters may include:

- Other lobster
- Octopus
- Small fish species
- Stingrays

*Note: Students should understand that removing too many of these species from the food web can cause an overabundance of herbivores. In some cases (like sea urchins), this can actually degrade the reef and cause habitat loss.*



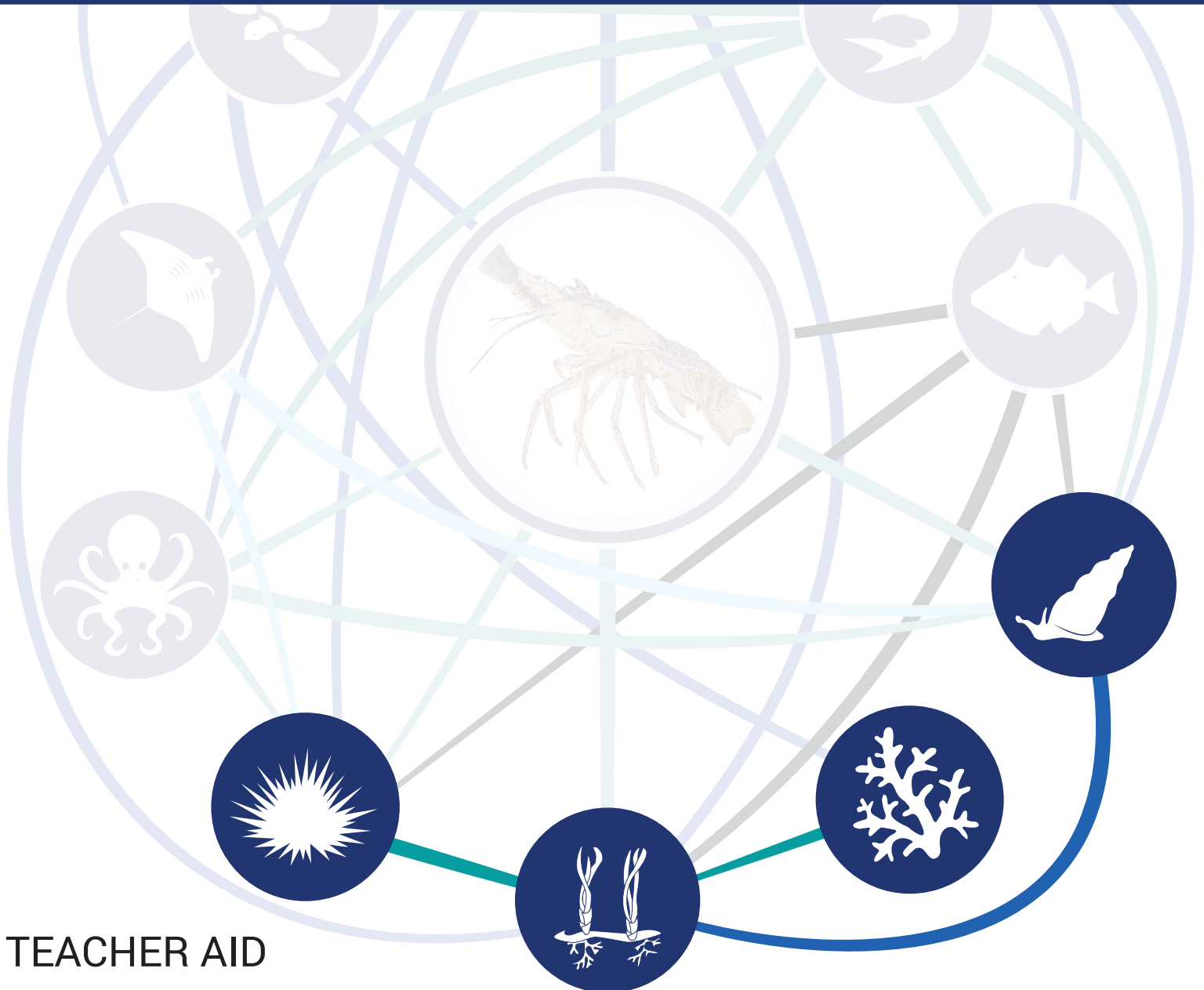
TEACHER AID

## LOWER TROPHIC LEVEL

This level is made up of primary producers (plants and algae that make their own food from sunlight) and primary consumers (herbivores that eat the plants and algae). Some examples include:

- Seagrass
- Sea Urchins
- Snails
- Corals

*Note: Students should understand that removing too many of these species from the food web can cause an overabundance of herbivores. In some cases (like sea urchins), this can actually degrade the reef and cause habitat loss.*



TEACHER AID

## Lobster Blue Halo Activity: Lobster Habitat and Life Cycle

**Key Principle:** Lobsters begin life as an egg on their mother's tail, spend their juvenile stage in the open ocean, move to the shallows (mangroves and seagrass), then back to the deeper reefs as mature adults.

### Materials:

Lobster card deck  
Ecosystem trifold

### Procedure:

Have the students identify the four stages of the lobster's life cycle. Describe the scientific names for the stages, and the habitat characteristics for each. Each card has a description and a follow up question that the students should read out loud. Once all the cards have been read off, the students should find the cards that match theirs.

Each group will have at least one habitat and lifecycle card (E.g. Mangroves go with the Puerulus lifecycle). Verify the groupings match (**list out each grouping**) and have the students decide where on the Ecosystem trifold where their cards belong. Pick one of these students to read their card and have the class discuss whether the answer is correct.

### Glossary of Terms:

Habitat – the part of the environment that is occupied by a particular species of animal or plant.

Predator – an animal that preys on other animals for food.

Lifecycle – A series of changes that occur to an organism during its lifespan.

Phyllosoma – the first (larval) stage of the spiny lobster.

Puerulus – The second stage of the spiny lobster's life cycle. The puerulus is dorsally flattened, transparent, and does not eat before it molts and enters its juvenile stage.

Juvenile – the last stage of a lobster's lifecycle before it enters the adult phase and becomes sexually mature.

Panularis argus – the scientific name of the Caribbean spiny lobster.

### Questions for Further Inquiry:

- 1) Do lobsters mate and create eggs year-round?
- 2) Why would it be a good idea to limit lobster fishing during the mating season?
- 3) How does the lobster change as it grows into a mature lobster? What is this process called?
- 4) What parts of the human lifecycle are similar to the lobster lifecycle?

### Links:

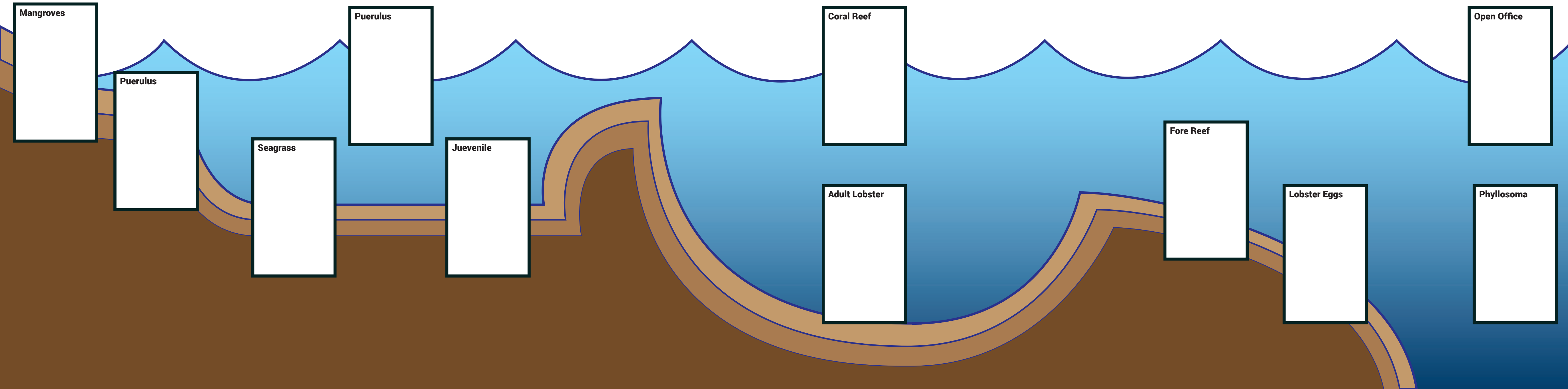
[Detailed description of Panulirus argus](#) from the Smithsonian

[Lobster Activities](#)

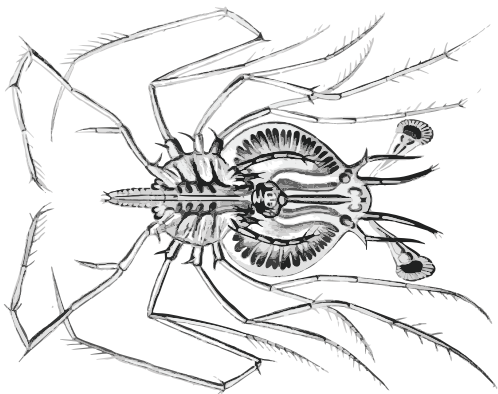
[Online game that develops understanding of various reef components](#)



# Lobster Ecosystem



# Lobster Life Cycle

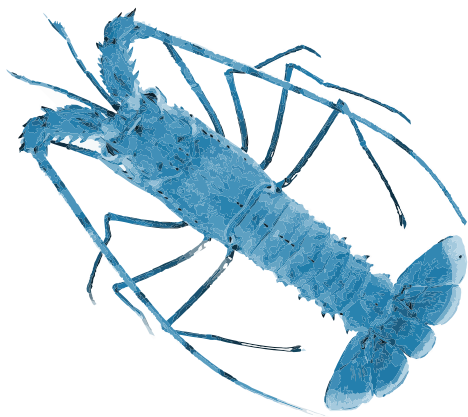


## Phyllosoma

I'm a baby lobster. I will look this way for about a year once I leave my egg. I rely on my extremely small size to protect me from most predators.

***Where do I live?***

# Lobster Life Cycle



## Puerulus

I'm almost a juvenile lobster, so I look very similar to my adult form. I like living in very shallow areas where prop roots keep bigger animals away.

***Where do I live?***

# Lobster Life Cycle



## Juvenile

I'm a teenage lobster. I have started to develop my adult camouflage. I need to live in a habitat that has calm water and lots of areas for me to hide.

***Where do I live?***

# Lobster Life Cycle

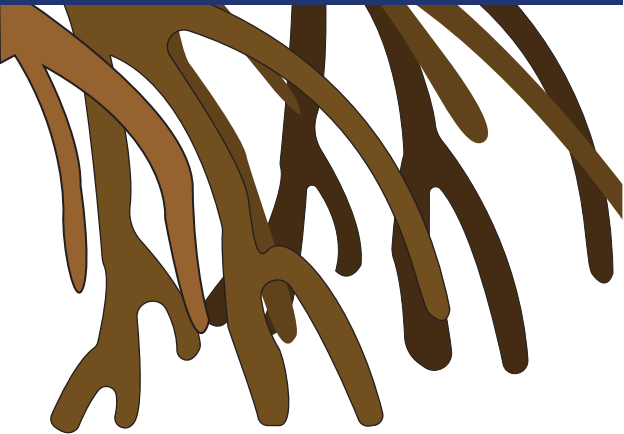


## Panulirus argus

I'm an adult lobster! I have a hard outer shell, move around at night, and shed my shell as I outgrow it. I like places where I can hide in deep water.

***Where do I live?***

# Lobster Life Cycle

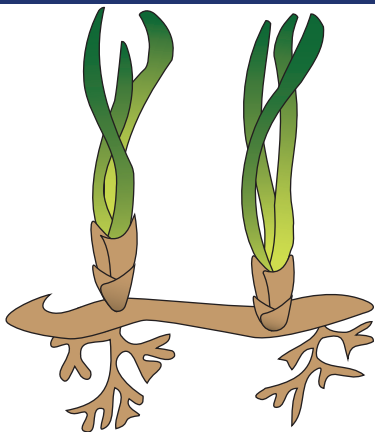


## Mangroves

My root system creates many small places for animals to hide, and slows down waves to make the water calm for the creatures that aren't good swimmers.

***Who do I protect?***

# Lobster Life Cycle

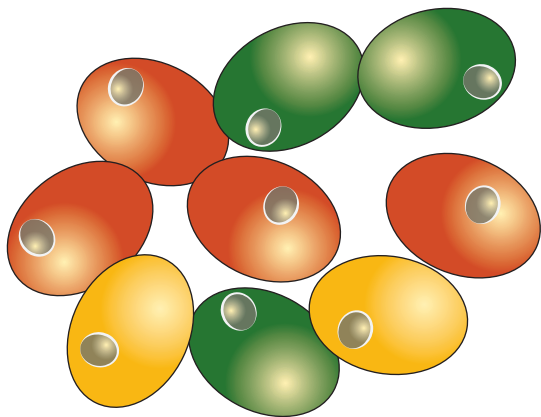


## Seagrass

I'm often found in calm waters like lagoons or just offshore. I trap floating sediment (sand), and provide a place for young creatures to grow into adults.

***Who do I protect?***

# Lobster Life Cycle



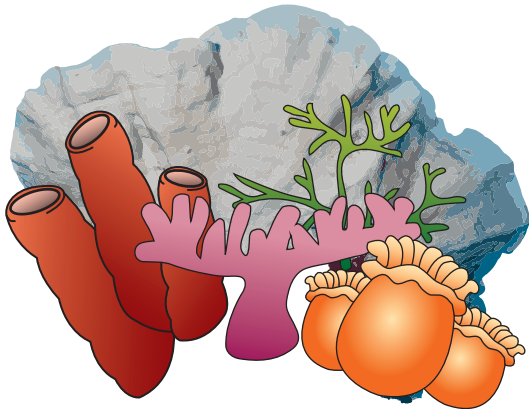
## Lobster Eggs

I spent my first few weeks growing on my mother's tail. She keeps me clean by fanning me with her swimmerets. Once I'm ready to hatch, she shakes me off her tail.

***Where do I go?***



# Lobster Life Cycle



## Coral Reefs

We provide plenty of hard-bottom ledges and hiding spots in deeper water around the island. There's also much more food on coral reef habitats.

***Who do we protect?***

# Lobster Life Cycle



## Fore Reef

I am the outer edge of the reef. Female lobsters will visit this part of the reef during a certain time of each year,. You could say the lobster life cycle begins here.

***What starts the life cycle?***

# Lobster Life Cycle

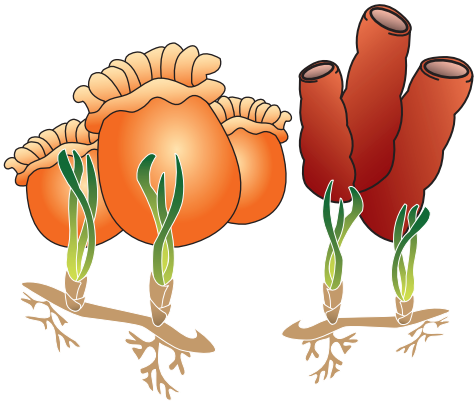


## Open Ocean

There is A LOT of water in the open ocean. Enough to hide many animals, especially ones that are so small you almost can't see them.

***Who do I protect?***

# Lobster Life Cycle



## The Lagoon

My calm waters house seagrass, small corals, and sponges. This means I provide plenty of hiding spaces for animals that are growing big and strong.

***Who do I protect?***

## Lobster Blue Halo Activity: Diagramming a Lobster

**Key Principle:** Lobsters are classified as invertebrates.

### **Materials:**

Chalkboard

Colored Chalk

Paper and drawing materials for the students (recommend graph paper and colored pencils or crayons)

Teacher Aid: Lobster diagram

### **Procedure:**

Begin with a large chalkboard drawing (**Note to Waitt folks: Phil suggested a larger copy of the lobster without labels so that teachers who aren't confident of their drawing ability can use a pre-fab example**) of a lobster as seen from the ventral (bottom) side. Starting with the carapace, have the students draw their own lobster, and have them identify the various components of the animal as they draw each one. Ensure they understand the purpose of each limb (e.g. antenna are used to detect changes in the environment) as each is drawn. Have the students fold their paper in half along the centerline of the lobster to learn about bilateral symmetry. If the students have time to color the lobster, ask them what colors might be most appropriate for the lobster, considering its environment.

### **Alternate Activity:**

Have the students cut out the separated pieces of lobster anatomy. Starting with the carapace, have the students build a lobster, then give them the opportunity to color the lobster. Encourage them to think about where the lobster lives, and what colors would help hide the lobster from its predators.

### **Glossary of Terms:**

Anatomy – The study of an organism and its parts.

Invertebrate – An animal that lacks a spinal column.

Crustacean – A group of animals classified as having two-part limbs, three body segments and a hard outer shell called an exoskeleton.

Bilateral Symmetry: When an object is divided into two mirrored halves.

Exoskeleton – a hard outer shell that acts as a support structure for the animal's internal organs.

Periodic molting (shedding the old exoskeleton) allows the lobster to grow larger.

Mandible – The lobster's mouth and feeding limbs.

Carapace – The hard upper shell that protects the lobster's thorax.

Thorax – the portion of the lobster between the tail and the head.

Swimmerets – small, feathery limbs on the lobster tail that aid in swimming. In females, the swimmerets protect the eggs before they hatch.

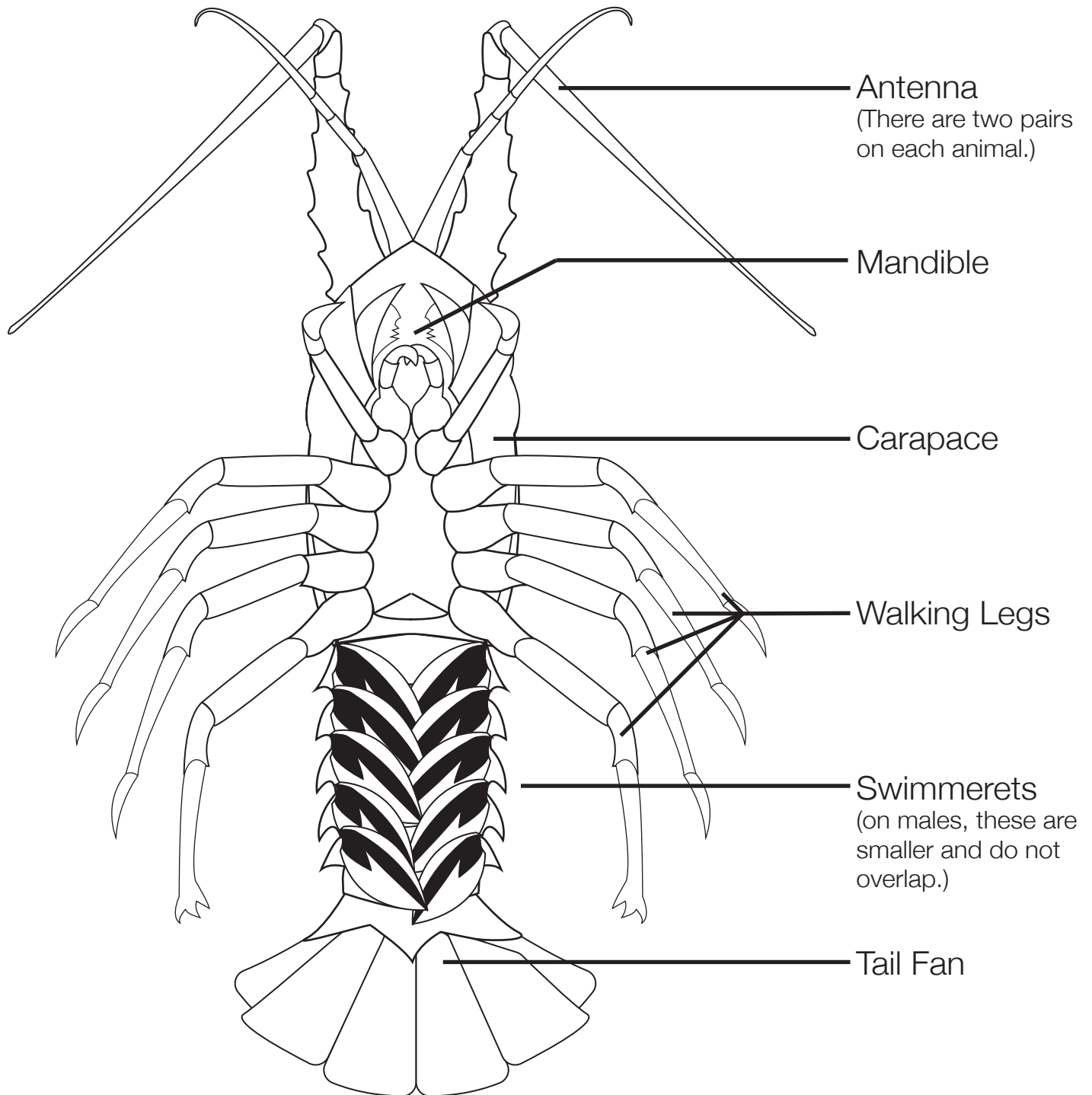
Antenna – Two long, whip-like limbs on the lobster's head. They detect changes in the lobster's environment.

### **Questions for Further Inquiry:**

- 1) What happens to the lobster when it sheds its shell during a molting event?
- 2) What is the primary food source of a lobster, and how does it eat its food?
- 3) Why is it important to protect our island's lobster population?
- 4) What other animals have exoskeletons, and how are they related to the lobster?

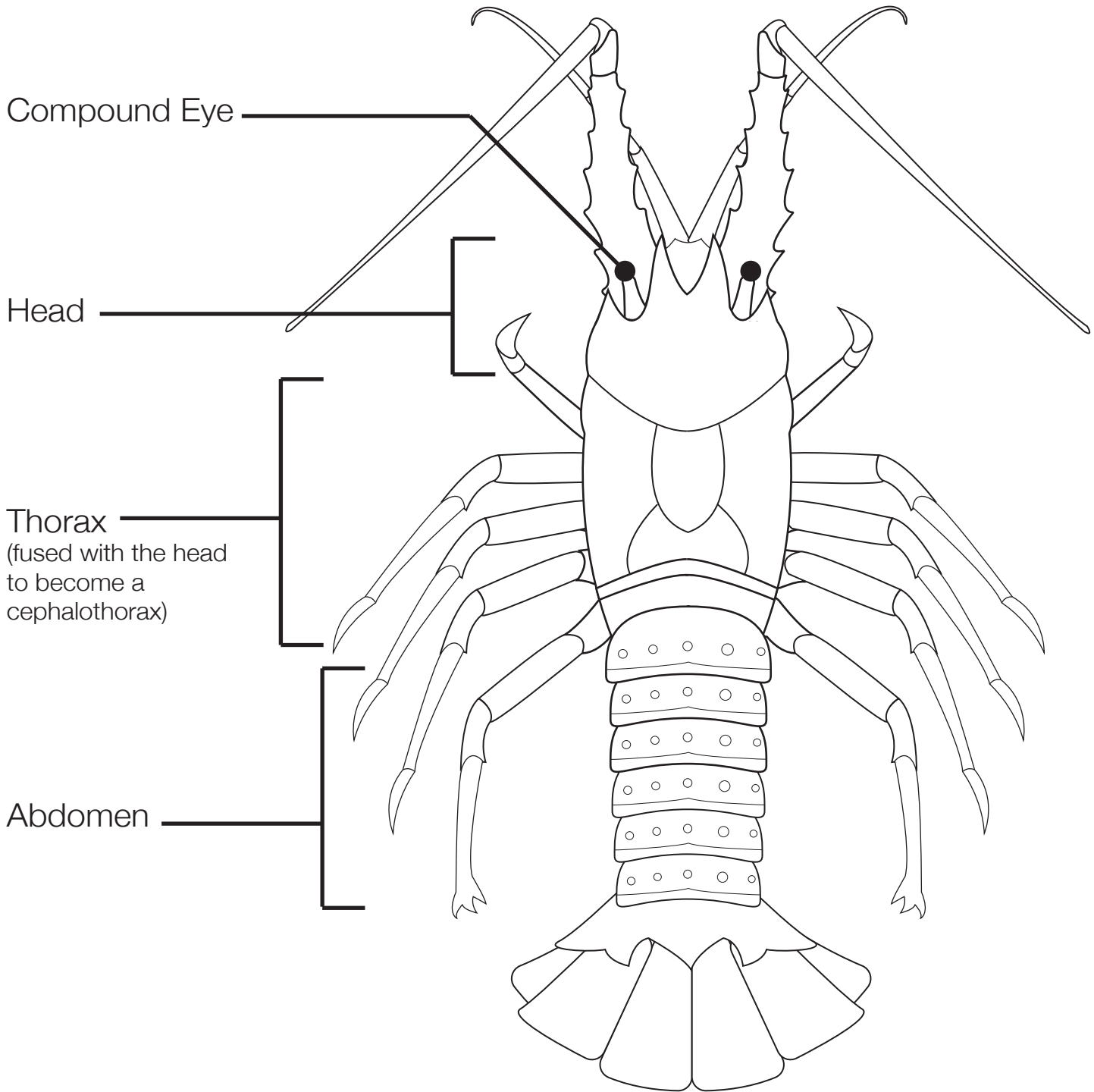
# Caribbean Spiny Lobster Anatomy

## Ventral View



# Caribbean Spiny Lobster Anatomy

Dorsal View



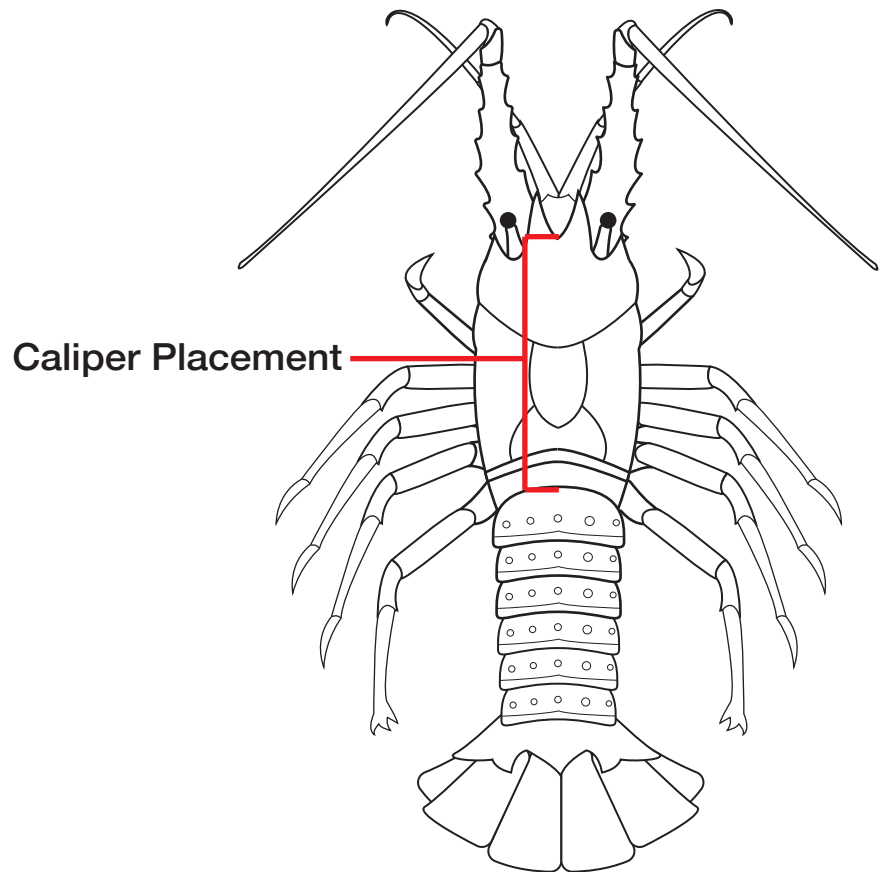
### IS THIS LOBSTER LEGAL?

A lobster is legal if:

- The carapace is longer than 95mm
- The total meat weight is greater than 1.5 pounds
- The minimum tail weight is greater than 7 ounces
- There are no eggs being held between the bottom of the tail and the swimmerets



Figure 1: Caliper Placement



### HOW TO MEASURE A LOBSTER

Measure the lobster from between the eyes to the end of the carapace using an approved caliper. The caliper will be labeled for lobster and conch – ensure you are using the shorter side marked for lobster.

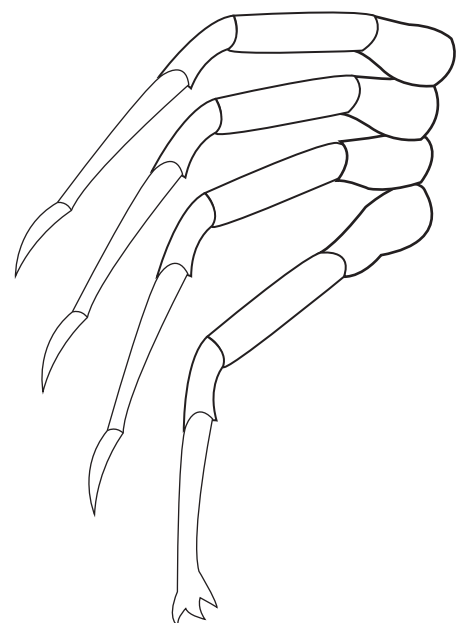
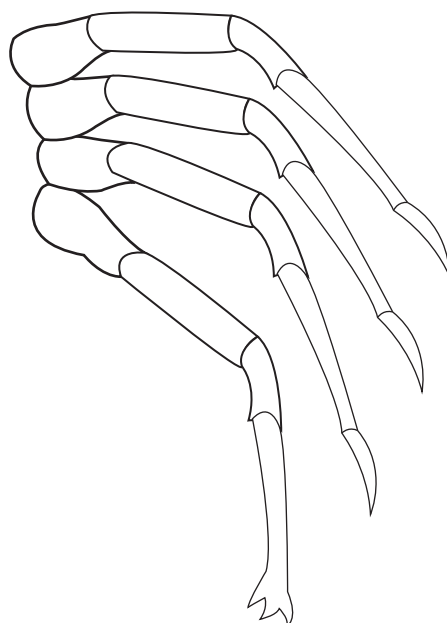
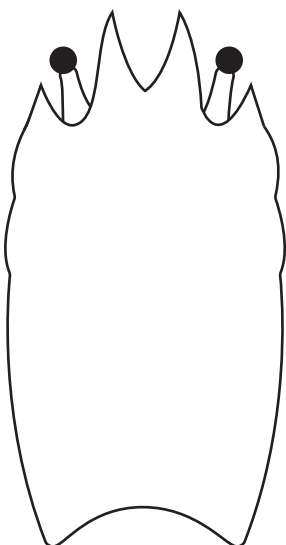
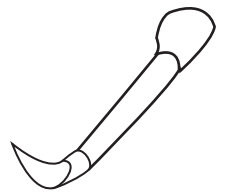
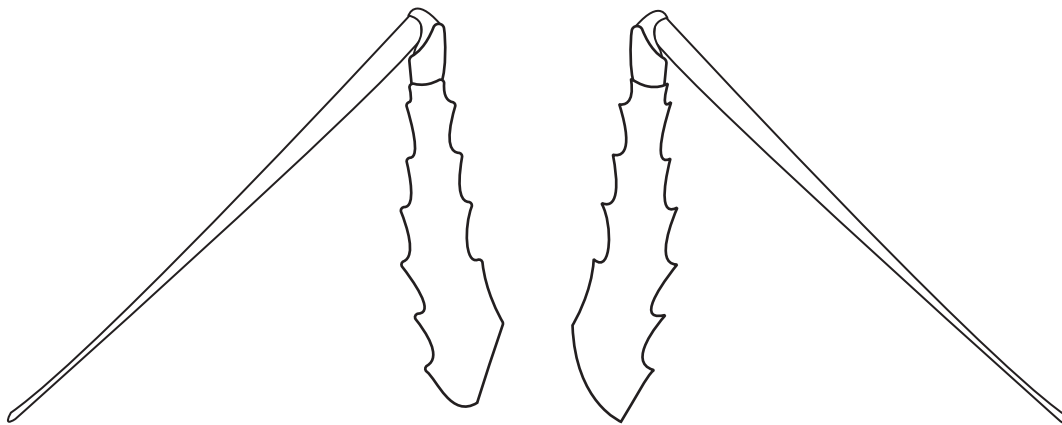
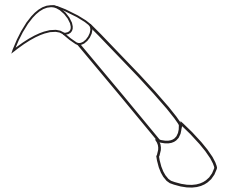
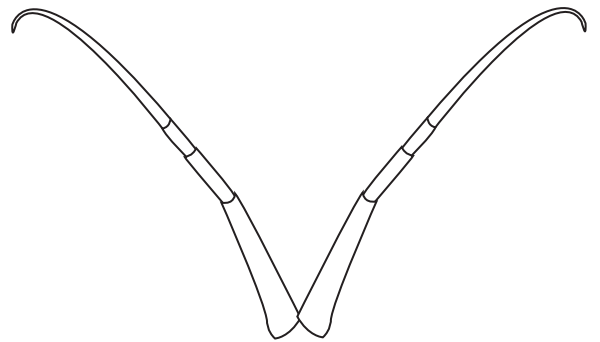
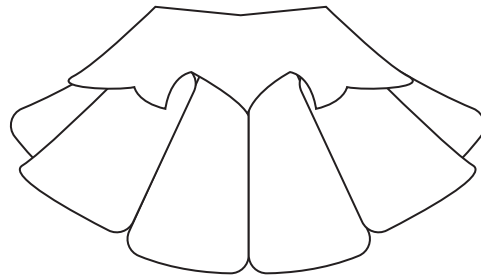
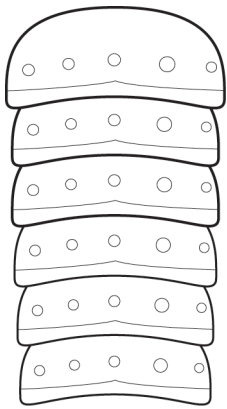
See Figure 1 for correct technique. Firmly place the lobster between the inside edges of the caliper's teeth. If there is any space between carapace and caliper, the lobster is below the legal limit and should be returned to the water.

If the lobster is above the legal limit, ensure it is not a gravid female (indicated by the presence of eggs below the swimmerets), and record the gender, weight and size (using a vernier caliper) on a Fisheries export datasheet.



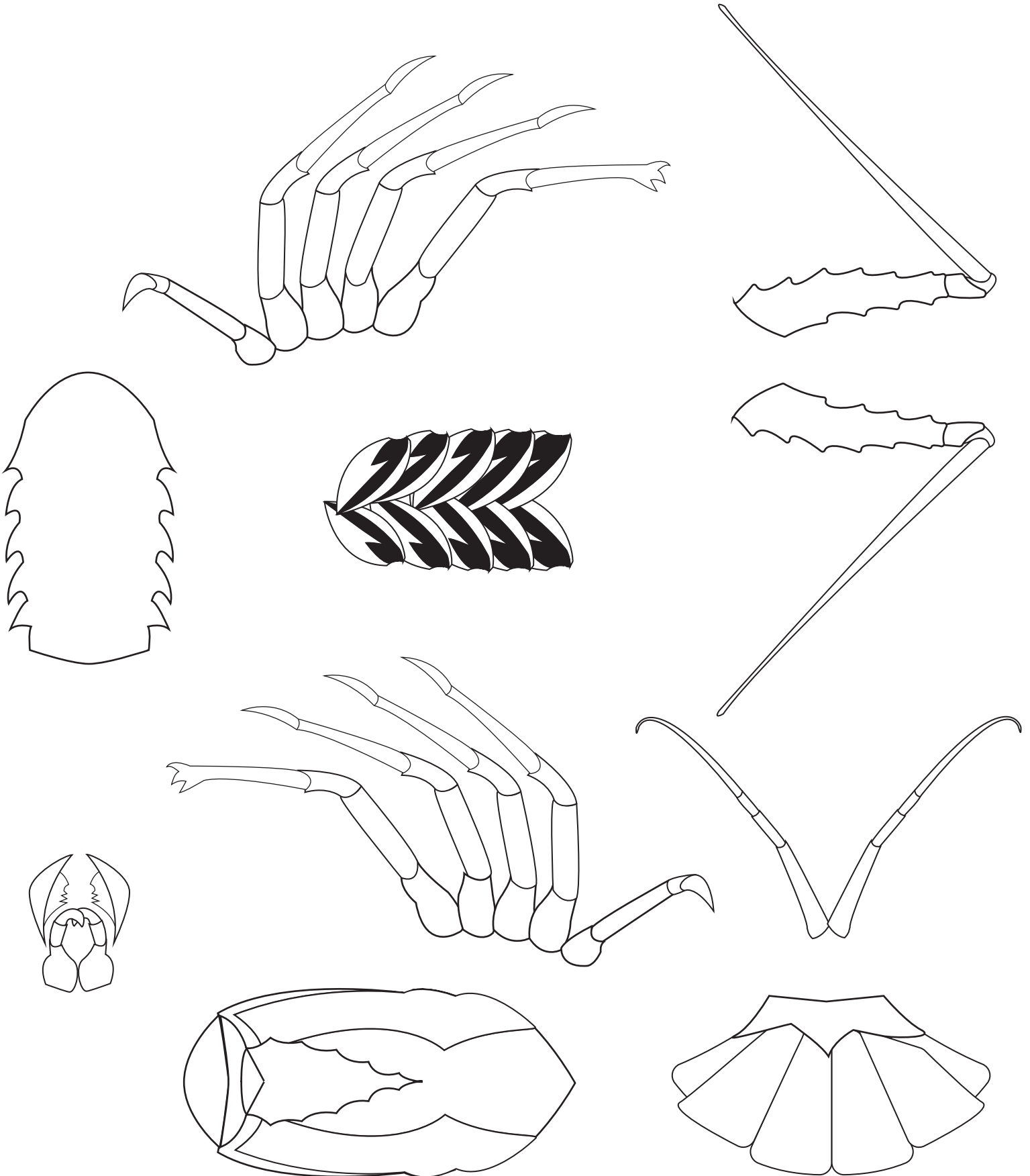
# Caribbean Spiny Lobster Anatomy

## Dorsal Puzzle



# Caribbean Spiny Lobster Anatomy

## Ventral Puzzle



## Lobster Blue Halo Activity: Population Game

**Key Principle:** Lobster populations are finite; requiring the efforts of everyone involved in their harvest to ensure a healthy population is maintained.

### **Materials:**

Large bowl (the ocean lobster population)

Two medium bowls (the lagoon population and international fleet)

Two or more small bowls (local fishermen)

Labels for each of the bowls

Enough beans (or other appropriate small object) to fill the large bowl halfway

(Optional) a small measuring cup or scoop

A chalkboard and writing materials to record the number of turns in each round

### **Procedure:**

This game teaches students the effects of harvesting a species over the course of three rounds.

Students assume the roles of various fishing interests (local fishermen, local Fisheries, global exporters) and take beans from the large bowl. This continues in each round until the large bowl is empty.

The rules change for each round to show the effects of various fishing regulations.

**Round 1 – Free-for-all:** In this round, there are no limitations on how many lobsters can be taken by each fisherman. Set the playing table according to the Teacher Aid sheet. The student acting as the international fleet goes first by removing two handfuls (or scoops) of beans from the large bowl. Each of the local fishermen then pulls one handful of beans from either the lagoon or ocean per turn. For a stronger impact, have the fleet go more than once per turn to simulate a greater ability to export lobster. Record the number of turns until both bowls are empty. The student acting as the Fisheries Officer should only pull a small handful every three turns. These lobsters represent lobster collected for research. Separately record each time a Fisheries collection is made.

**Round 2 – Limited access:** Reset the playing table. Tell the students that they will go again, but this time the international fleet is not allowed to harvest. Continue until the lagoon and ocean populations reach zero, and record the number of turns it takes.

**Round 3 – Limiting access and creating a nursery:** Reset the playing table. This round has the same rules as Round 2, but fishermen aren't allowed to take from the lagoon. After every turn, pour some of the collected beans back into the ocean population, and tell the students that this represents lobsters that grow up in the lagoon and migrate to the deeper ocean. Specific amount isn't critical, but ensure that Round 3 lasts longer than Round 2.

Add up the number of turns for each round and show the students how much longer they can harvest lobster with the regulations. Have the students think about what it means when the bowls are empty. Ask them what they would do if they weren't able to harvest lobster, and what they can do to ensure the population stays healthy.

Note how many times the Fisheries Officers were able to collect data for each round. Stress the importance of good data for regulating sustainable lobster harvests.

**Glossary of Terms:**

Sustainable Resource – A resource that we are able to use without using it up.

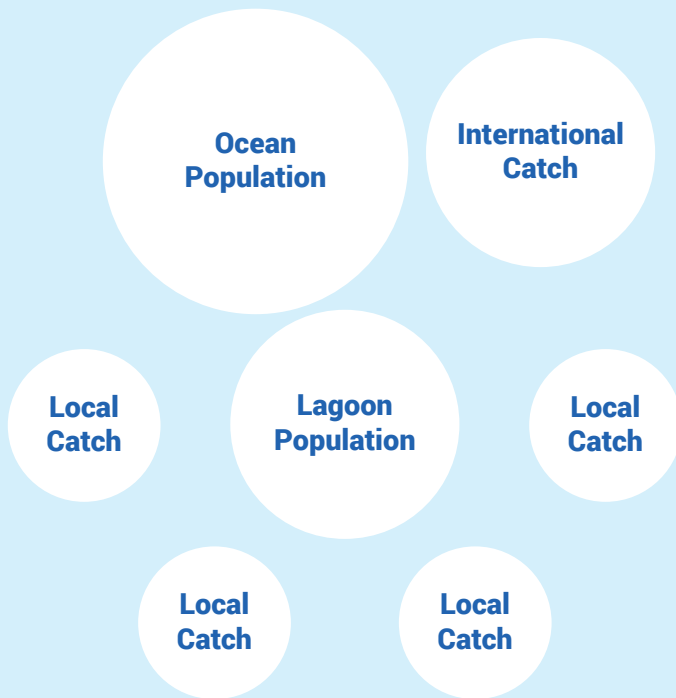
Yield – The full amount of a product, e.g. how many lobsters the ocean is able to provide.

Ocean Regulations – Rules put in place to ensure the ocean is managed sustainably.

**Questions for Further Inquiry:**

- 1) How does closing the lobster harvest during the breeding season help the fishermen?
- 2) How do the Fisheries Officers keep track of how healthy the lobster population is?
- 3) Why is it important to keep careful track of the size/sex/weight of lobsters that are being caught?

### BOWL ARRANGEMENT



This board layout encourages the students acting as local fishermen to draw from the lagoon first. Supplies of the lagoon resource will quickly become exhausted, requiring more effort (per catch) from the fishermen.

For Rounds 2 and 3, remove the bowl that represents the international catch. After each turn, have students put a portion of their catch into this bowl to represent lobsters that are exported from the island on each round.



### ROUND ONE

Fill the large bowl with most of the bean. Fill the lagoon bowl with the remainder. The round begins with the international fleet removing two scoops from the ocean, then each local fisher removing a single scoop from either the ocean or the lagoon.



### ROUND TWO

Refill both population bowls as in Round One. Remove the International Fleet bowl, but leave the Local Catch bowls in their original positions.



### ROUND THREE

Refill both population bowls. This time you remove the lagoon bowl and use it to refill the ocean population bowl as the round progresses.

## Lobster Blue Halo Activity: Lobster Fisheries Field Trip

**Key Principle:** Understand the process by which lobster are collected by local fishermen, weighed/measured/sexed, and exported off-island.

### **Materials:**

Blue Halo Notebooks and writing tools for the students to record their observations from the field trip.  
Datasheets for recording lobster size/weight/sex.  
Calipers for measuring lobster carapace lengths.

### **Procedure:**

Arrange a convenient time for the students to visit the local Fisheries department. Ideally, this will coincide with a lobster export so students can see the entire process. In the classroom, have the students prepare two or three questions each that they can ask the Fisheries Officers. Coordinate with the Fisheries Officers to show the students how lobsters are collected from local fishing boats, counted, measured and weighed, and how the data is collected for analysis. Have the students record the things they've learned in their Blue Halo notebook. With the assistance of the Fisheries Officer, have the students measure lobster carapaces, identify gender, and weigh the lobsters. Record this information on the Fisheries datasheets.

### **Sample Questions:**

- How do you measure the size of the lobsters to ensure they are legal for export?
- Where are the fishermen catching lobsters? How long are the traps in the water?
- How can you tell the male and female lobsters apart?
- What happens to the lobster that aren't big enough to export?
- Where are the lobsters being exported?
- How many lobster are in a typical export?
- Is there a limit on how many lobster each fisherman can catch?
- When are the fisherman not allowed to catch lobster?
- Can anyone harvest lobster, or is it restricted to Barbudan fishermen?
- Why did you become a Fisheries Officer?
- What is the best part of your job as a Fisheries Officer?
- Why is the lagoon so important to our lobster population?

### **Measuring a Lobster:**

A lobster over the legal limit will be 95 millimeters long when measured from between the eyes to the rear end of the carapace. To determine this, use an approved caliper (provided in the Toolkit). The caliper will be labeled for lobster and conch – ensure you are using the shorter side marked for lobster. See Figure 1 for the correct technique. Firmly place the lobster between the inside edges of the caliper's teeth. If there is any space between carapace and caliper, the lobster is below the legal limit and should be returned to the water. If the lobster is above the legal limit, ensure it is not a gravid female (indicated by the presence of eggs below the swimmerets), and record the gender, weight and size (using a vernier caliper) on a Fisheries export datasheet.

### **Glossary of Terms:**

Import – a good (product or service) brought into a jurisdiction. In Barbuda, goods are often imported from Antigua.

Export – a good (product or service) sent to another country for sale. In Barbuda, lobsters are exports.

Caliper – a device that accurately and quickly measures the size of a lobster.

Conservation – The act of preserving, guarding, or protecting a resource.

Ecosystem – A community of living things and the non-living parts of their environment. A marine ecosystem can include things like lobster, fish, corals, minerals, and water.

**Questions for Further Inquiry:**

- 1) How can we identify how many lobster can be harvested without using up the population?
- 2) What happens if lionfish or other predators enter the lagoon?
- 3) How can we tell if our lobster population is increasing or decreasing?





**GRADE VI****Term:** 1**Strand:** Life Science**Topic:** Blue Halo Mangroves**Focus Question:**

(1) How are mangroves classified?

(2) What role do mangroves play in marine ecosystems?

**Grade V Review:** 39 (using and conserving resources), 40 (soil), 42 (plant reproduction).**Strand Reference pages:** 54, 56, 62, 72**Duration:** 3 periods

Learning Outcomes	Specific Objectives
<ul style="list-style-type: none"> <li>Use taxonomy to classify red, white, and black mangroves.</li> <li>Understand the adaptations that mangroves have developed to survive in brackish water.</li> <li>Describe the role mangroves play in marine and intertidal ecosystems.</li> <li>Understand how mangroves protect land and build beaches.</li> <li>Understand the methods by which mangroves take in nutrients and sunlight and convert them into energy.</li> </ul>	<ol style="list-style-type: none"> <li>Use taxonomy to classify three Caribbean mangrove species (red, white, and black)</li> <li>Describe adaptations of each mangrove that enable them to survive in brackish water</li> <li>Identify ways mangroves provide habitat (specifically for juvenile marine species, terrestrial species, and bird species)</li> <li>Learn how mangroves act as “island-builders,” and the effects of removing mangroves from an ecosystem.</li> <li>Learn the methods and internal systems used by the mangroves to convert sunlight and nutrients into energy that can be used by the tree.</li> <li>Understand how mangrove seeds germinate and create offshoots called propagules.</li> </ol>

Key Vocabulary Concepts	Procedures/Activities	Skills and Attitudes
<ul style="list-style-type: none"> <li>Taxonomy</li> <li>Ecosystem</li> <li>Habitat</li> <li>Germinate</li> <li>Propagule</li> <li>Phloem</li> <li>Xylem</li> <li>Erosion</li> <li>Sedimentation</li> <li>Adaptation</li> <li>Photosynthesis</li> </ul>	<ul style="list-style-type: none"> <li>“Mangrove Taxonomy” – Drawing exercise that teaches the root, leaf, and propagule of red, black, and white mangroves.</li> <li>“Grow-A-Mangrove” – Students will grow their own mangroves from propagules and record their progress over time.</li> <li>“Mangrove Habitat” – Students will learn about the various animals that made their homes in the mangrove roots and branches.</li> <li>“Mangrove Field Trip” – Students will visit mangrove habitat to apply what they learned in the classroom about mangrove ecosystems.</li> <li>“Red (Mangrove) Rover” – This game teaches students how mangroves protect coastal habitats from storms and create habitat .</li> </ul>	<ul style="list-style-type: none"> <li>Classifying</li> <li>Observing</li> <li>Communicating</li> <li>Recording</li> <li>Investigating</li> <li>Discussing</li> <li>Cooperation</li> <li>Group Dynamics</li> <li>Curiosity</li> </ul>

Required Content	Content Principles
<ul style="list-style-type: none"> <li>Mangroves are classified as plants, and grow in the intertidal region between shore and saltwater.</li> <li>Through photosynthesis, mangroves convert sunlight to chemical energy. They also absorb nutrients through their root systems and transport nutrients through phloem and xylem.</li> <li>Mangrove forests provide habitat for juvenile marine species, and protect and create additional shoreline.</li> <li>A mangrove ecosystem consists of different communities that interact with each other and the physical environment.</li> </ul>	<ul style="list-style-type: none"> <li>Plants are classified differently from animals. They use energy from the sun, and nutrients from the soil and water.</li> <li>Mangrove ecosystems can change due to natural and human influences.</li> <li>We should conserve our marine environment to maximize its utility.</li> <li>Mangrove ecosystems are necessary to ensure a healthy ocean and a healthy island.</li> </ul>

Integration with other subject areas: Art, and Social Studies.

Resources:

[Smithsonian Marine Station](#)

## Blue Halo Classroom I Activity: Grow-A-Mangrove

**1. KEY PRINCIPLE:** Mangroves start life as propagules, and take in nutrients and water to grow into mature trees.

### **2. MATERIALS:**

Mangrove propagules-ideally red mangroves

Glass jars or small watertight flowerpots

Enough soil to cover the bottom of the jars

Measuring cup

Ruler

Notebook

Tape

### **3. PREPARATION:**

This lesson should be taught after students have taken the Mangrove Botanist lesson. They will need to have a basic familiarity with the red, black, and white mangrove propagules, and an understanding of how trees take in nutrients and water.

Propagules that are ready to be planted should be very dark green or almost brown, but still attached to the tree. You may enlist the students to harvest propagules during the Mangrove Field Trip.

Try to use clay or silt for your planting soil. Sand will cause the propagules to grow less quickly.

### **4. PROCEDURE:**

Begin the lesson by reviewing the glossary words with the students. Ensure they understand that a propagule is a baby mangrove, and will take in nutrients – just like a human or animal – to grow bigger. Mangroves need water, air, and minerals (fertilizer), as well as sunlight.

Separate the students into small groups and give each group a propagule and a jar or pot. Place the propagule in the container, and have the students measure the length of the propagule and record it on the Mangrove Growth Chart. The group should also enter their names, and assign a name for their propagule. Label a piece of tape with the propagule's name and apply it to the jar.

Each group should put a layer of soil about 2cm deep into their jar to support the propagule, and then measure out enough water to nearly fill the jar. Record the amount of water on the Growth Chart in the first row.

Place the jars somewhere where they will have access to direct sunlight. Measure the growth of the propagules weekly and record the information on the Growth Chart. Ensure the water level doesn't drop more than 4cm above the soil in the jar. Record the amount of water added to the jars on the Growth Chart.

## **5. GLOSSARY OF TERMS:**

Facultative Halophyte – a plant that can survive in salt water.

Propagule – A germinated mangrove seedling that detaches from its parent plant to create a new plant.

Photosynthesis – the conversion of sunlight into sugars that takes place in the leaves of a plant.

Brackish – A mixture of saltwater and freshwater. Typically seen where rivers run into seas or oceans.

## **6. QUESTIONS FOR FURTHER INQUIRY:**

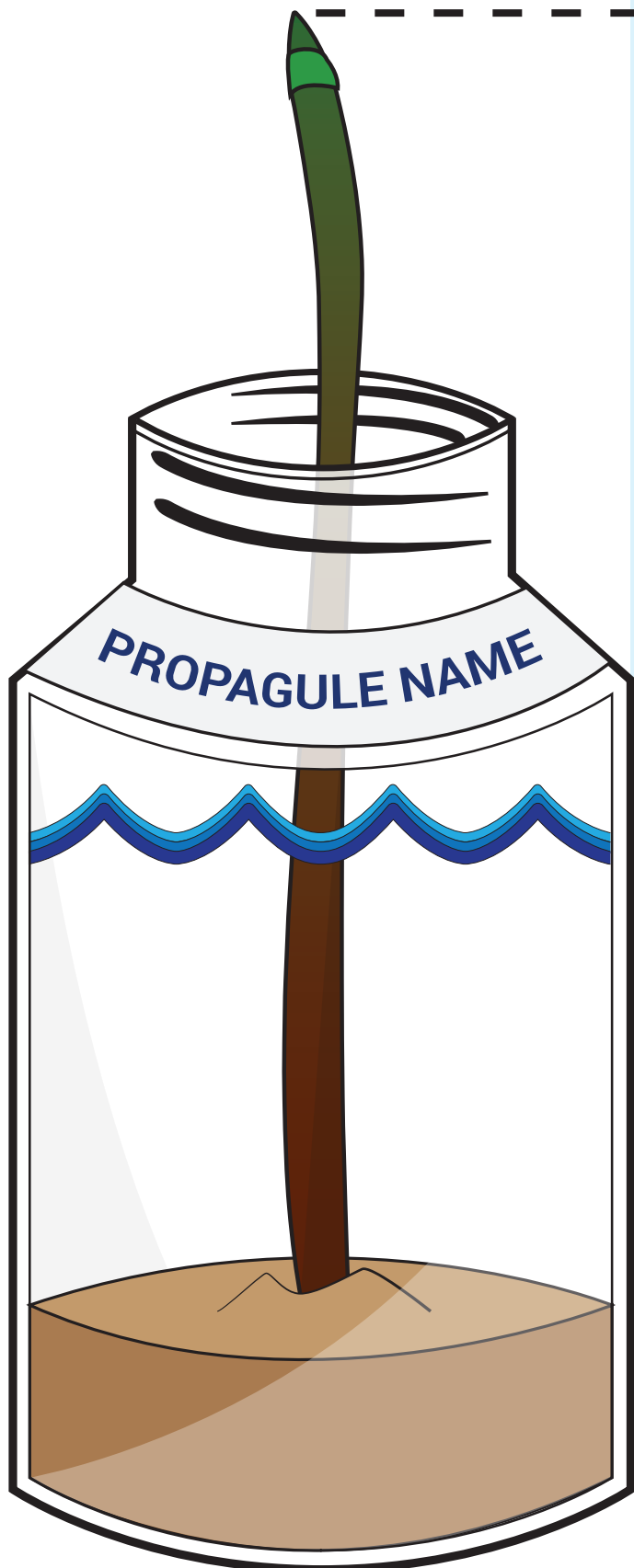
1) What factors (sunlight, soil composition, water quality) would effect the growth rate of a mangrove propagule?

2) How tall can a red mangrove grow? Is this different from black and white mangroves? Why might each species have a maximum height?

3) What will happen when the mangrove grows too big for its container?

# TEACHER AID

## GROW-A-MANGROVE



### MEASUREMENTS

With the propagule planted, measure from the bottom of the jar to the top of the propagule. Record this information on the Mangrove Growth Chart.

### WATER LEVEL

Ensure water levels stay approximately 4 cm above the level of the soil. Freshwater or saltwater can be used. Record the amount of water added on the Mangrove Growth Chart.

### SOIL LEVEL

Try to use clay or silt for the propagule's base. Sand will slow growth, but a small layer can be used to support the plant. Use about 2-4cm of soil around the base of the propagule.



**1. KEY PRINCIPLE:** Understand basic anatomy of mangroves and how they adapt to salt-water conditions.

**2. MATERIALS:**

- Notebooks
- Drawing and writing tool
- Leaves from red, black, and white mangroves
- Propagules from red, black and white mangroves

**3. PROCEDURE:**

Bring in examples of the three different mangrove leaves (red, black, white). Show the students the differences between the leaves, and teach them the mnemonics for each. Do the same with propagules of the three species.

Ask students to think about animals that would make their habitat in the tops of the mangroves. Use the root system as an example, and have them think about what animal would specialize in treetop habitat. The goal is to get them thinking of the frigate bird.

Have the students draw the three leaf types, the entire mangrove, and a line diagram showing the flow of nutrients and energy through the tree from roots to leaves.

**RED MANGROVE**

DRAW	EXPLANATION
Trunk and branches	The trunk supports the rest of the tree like walls in the schoolhouse. Explain that xylem and phloem are like the two side of the road, and that nutrients flow in each direction.
Prop and drop roots	Red mangroves have prop roots that grow out from the trunk, and drop roots that grow down from the branches for support in shallow soil. This is different from inland trees that have roots that go deep in the ground. These roots provide habitat for small animals and break up wave action. Suspended soil in calm water falls to the bottom, becoming new land. These roots also prevent salt from entering the tree.
Leaves	Characterized by pointed leaves with a waxy surface, which grow to ~2-7 cm (1-3 in) in length.
Propagules	Long, thin, pencil-shaped seeds with no dormant phase. Spend at least 40 days in seawater before germinating. Can spend over a year adrift before taking root. Grow vertically.

## BLACK MANGROVE

DRAW	EXPLANATION
Trunk and branches	The trunk supports the rest of the tree like walls in the schoolhouse. Explain that xylem and phloem are like the two side of the road, and that nutrients flow in each direction.
Pneumatophores	These are roots that grow up from under the water to allow black mangroves to breath. Also known as snorkel roots because they act just like a snorkel for a human.
Leaves	Characterized by rounded leaves, ~5-10cm in length. Salt crystals form on the backs of the leaves as part of the black mangroves adaptation to excrete salt.
Propagules	Small, fleshy, tear-shaped seeds. Spend at least 14 days in seawater before germinating. Can spend almost four months adrift.

## WHITE MANGROVE

DRAW	EXPLANATION
Trunk and branches	The trunk supports the rest of the tree like walls in the schoolhouse. Explain that xylem and phloem are like the two side of the road, and that nutrients flow in each direction.
Roots	White mangroves grow high above the tide line, and do not have specialized roots like the red and black mangroves.
Leaves	Characterized by are broad leaves, yellow-green in color and ~5-10 cm (2-4 in) in length that contain pores used to excrete salt.
Propagules	Smallest of the three species. Oval shaped with an outer layer that floats the seed when it is adrift. Propagules spend eight days in saltwater before germinating and can stay viable for up to 35 days.

### 4. GLOSSARY OF TERMS:

Habitat – An environmental or ecological area where a specific species lives. Mangrove habitat is the shoreline between saltwater and land.

Phloem – The tissue in a plant that transports sugars from the leaves to the trunk and root system.

Xylem – The tissue in a plant that transports water and nutrients from the roots to the rest of the plant.

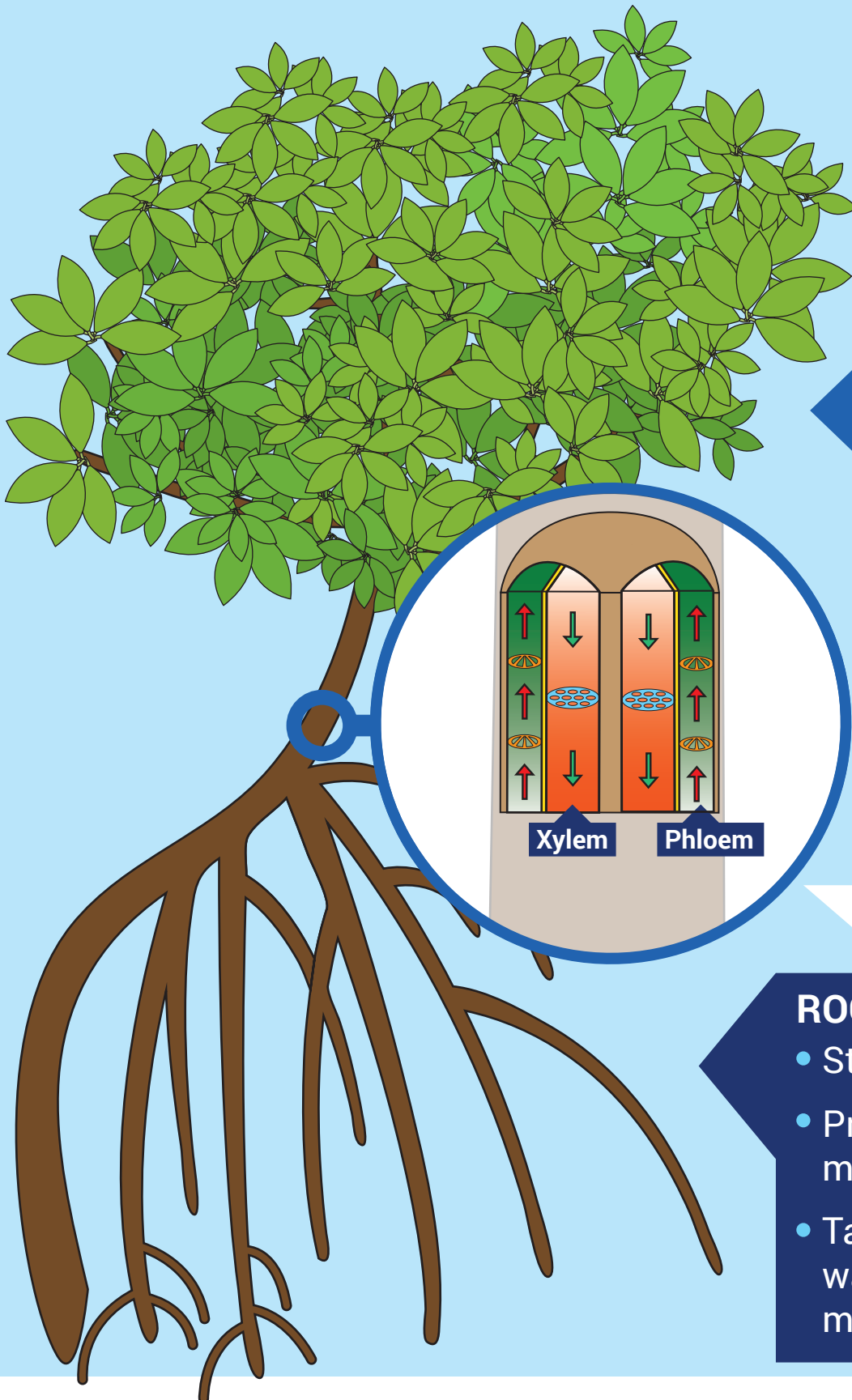
Sediment – Solid material in the water column that settles out at the bottom. Often refers to sand or small minerals in saltwater.

### 5. QUESTIONS FOR FURTHER INQUIRY:

- 1) How would the landscape change if we were to remove all the mangroves?
- 2) What would the effects be on the lagoon if we removed the mangroves at the entrance?
- 3) If mangroves remove sediment from the water, what else might get trapped in their root systems?
- 4) How do *lenticels* (specialized cells on the roots and trunks) prevent water from entering the mangrove tree's tissues?

# TEACHER AID

## MANGROVE BOTANIST



### LEAVES

- Convert sunlight into energy
- Specialized shape for each species
- Upper branches provide habitat for birds species and shade

### TRUNK

- Supports the branches and leaves
- Provides paths for nutrients and water
  - Xylem - from leaves
  - Phloem - from roots

### ROOTS

- Stabilize shorelines
- Provide habitat to small marine organisms
- Take in minerals and water for the rest of the mangrove

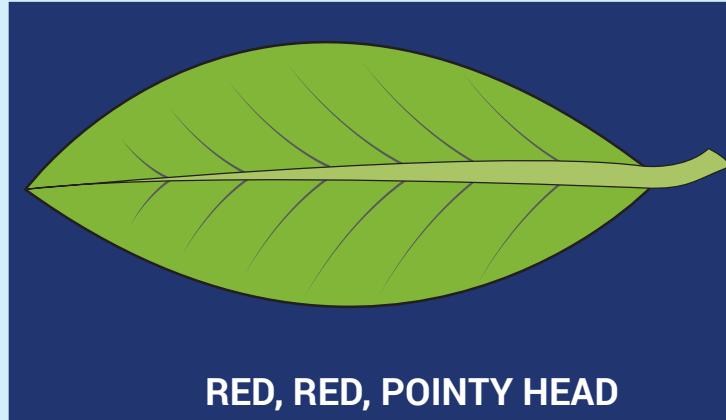


# MANGROVE LEAVES



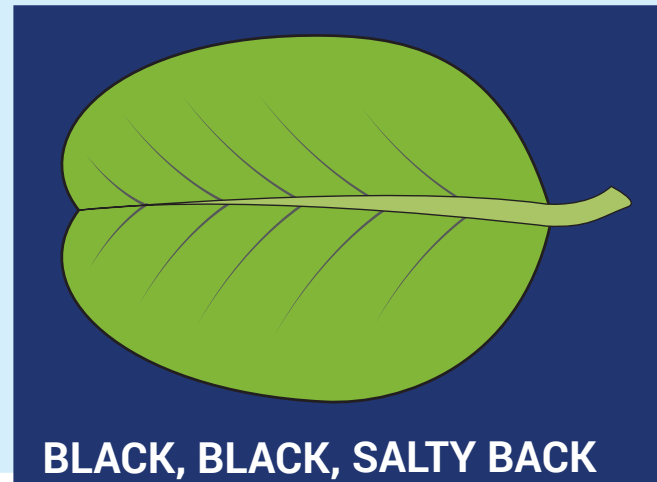
## RED MANGROVE (*Rhizophora mangle*)

- Characterized by pointed leaves with a waxy surface, which grow to ~2-7 cm (1-3 in) in length
- Red mangroves have *prop roots* (roots growing from the base of the tree), and *drop roots* (roots that grow from the branches towards the soil)
- Red mangroves grow closer to the low tide line than black and white mangroves



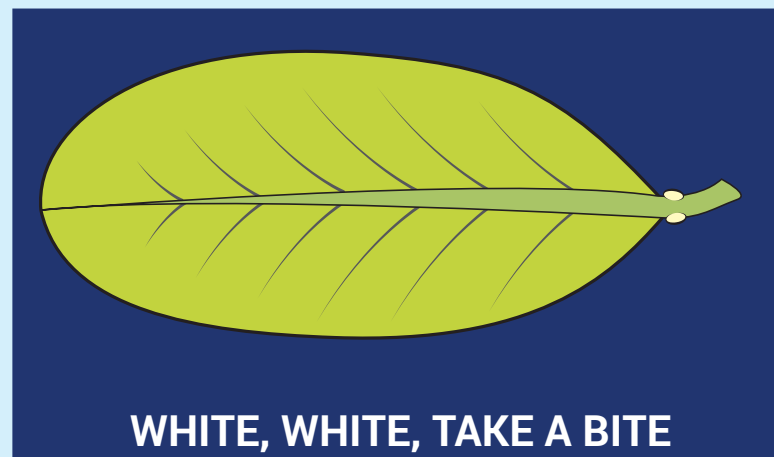
## BLACK MANGROVE (*Avicennia germinans*)

- Characterized by dark, scaly bark and long, horizontal roots. Rounded leaves are ~5-10cm (2-5 in) in length
- Salt is excreted through small pores on the leaves
- Black mangroves typically grow between the high and low tide lines
- Lenticels are small openings in the roots that allow air to reach the root system



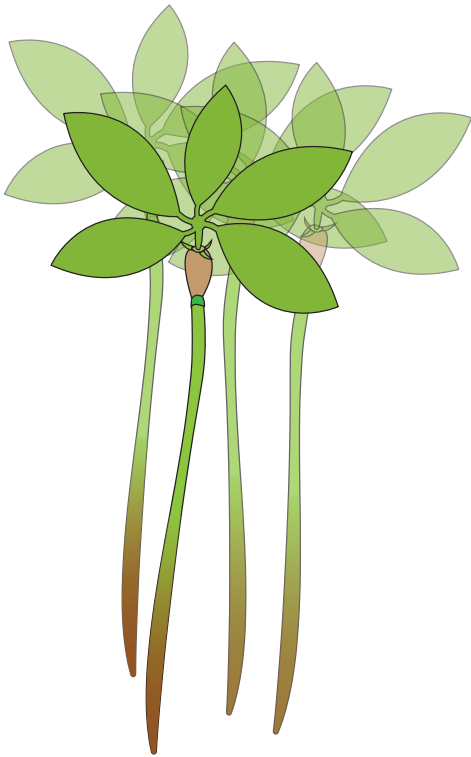
## WHITE MANGROVE (*Laguncluraria racemosa*)

- Characterized by the lack of aerial roots
- Leaves are broad, yellow-green in color and ~5-10 cm (2-4 in) in length, and contain pores used to excrete salt
- Trees grow above the high tide line
- Two glands called nectaries at the base of the leaf secrete sugar
- Ants eat the sugar and protect the tree from other insects



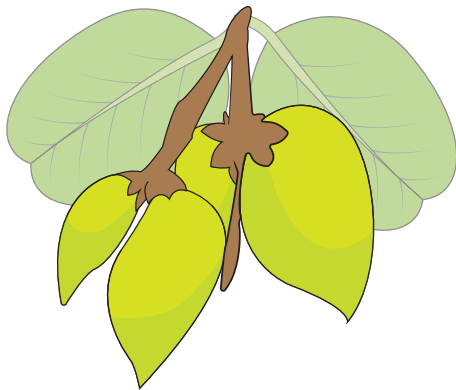
## TEACHER AID

# MANGROVE PROPAGULES (Seeds)



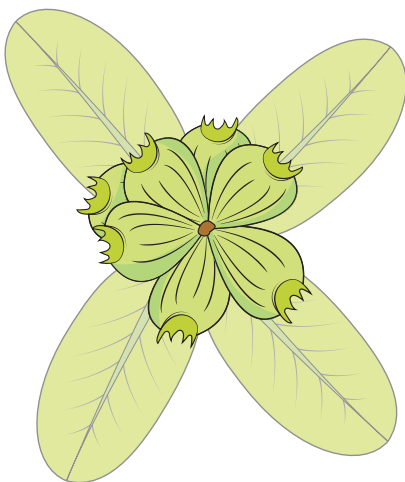
## Red Mangrove

- Characterized by a long, thin, pencil-shaped propagule
- Propagule germinates while still attached to the parent plant and has no dormant phase
- Propagules must spend 40 days in seawater before germinating
- Once the propagule reaches a suitable site, it begins to extend roots from its base into the soil



## Black Mangrove

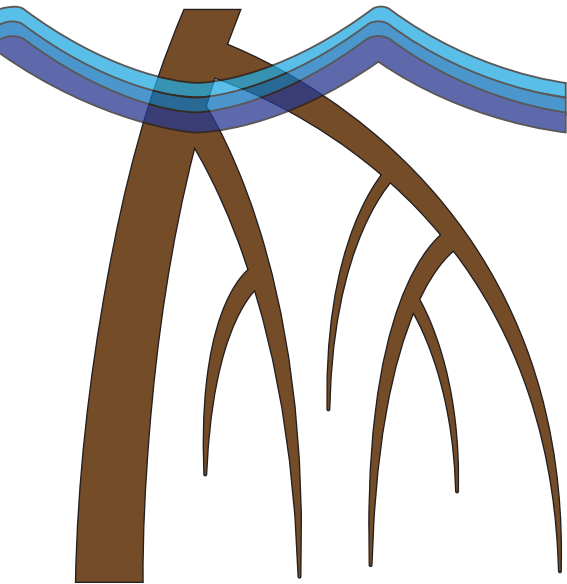
- Characterized by a small, fleshy, tear-shaped propagules
- Each propagule is capable of producing a new mangrove tree
- Propagules must spend at least 14 days in seawater before germinating
- Black mangrove propagules can stay viable for up to 110 days



## White Mangrove

- Characterized by the smallest, oval-shaped propagule of all three mangrove species
- Outer layer serves as a float and is shed when the propagule takes root
- Propagules must spend at least eight days in seawater before germinating
- White mangrove propagules can stay viable for up to 35 days

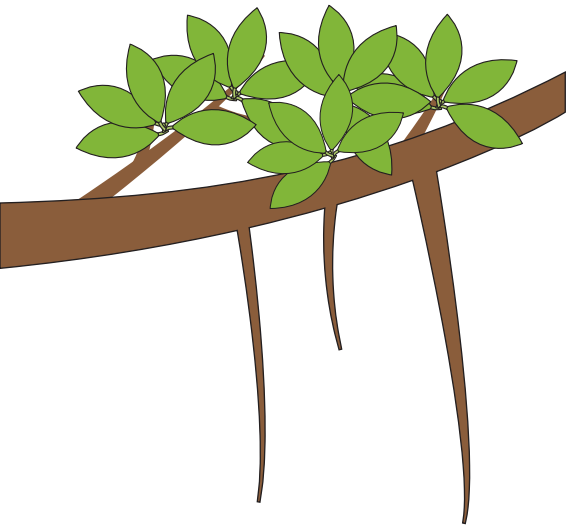
# MANGROVE ROOT ADAPTATIONS



## Prop Root

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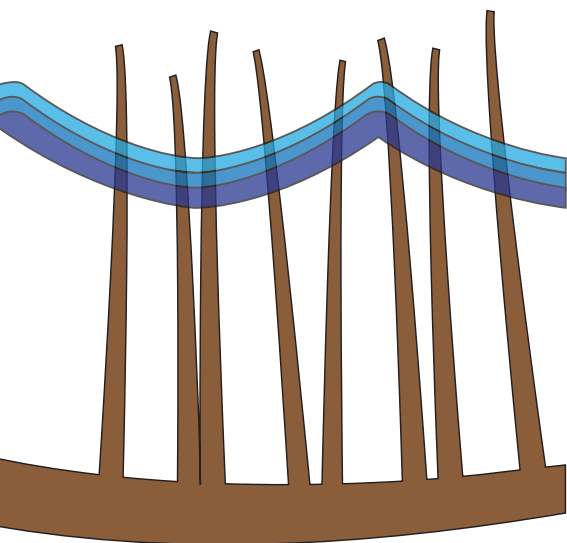
- Extend out from the trunk to anchor the tree in shallow soil
- Sometimes called “walking roots” because they make the tree appear to be walking
- Only found on red mangroves and are usually submerged
- Roots allow freshwater to enter the tree and prevent salt from entering (salt excluders)



## Drop Root

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- Grow vertically down from red mangrove branches to help anchor the tree in shallow soils
- Allow oxygen into the tree through small pores called lenticels
- Only penetrate the soil to depths of a few centimeters
- Roots allow freshwater to enter the tree and prevent salt from entering (salt excluders)



## Pneumatophores

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Grow vertically upwards from the cable roots of black mangroves

May grow up to 20cm and higher past the surface of the water to provide provide for gas exchange

Contain lenticels that allow oxygen to enter the black mangrove roots

Often form thick mats surrounding the main trunk of the black mangrove

## Blue Halo Classroom | Activity: Mangrove Habitat

**1. KEY PRINCIPLE:** Understand how mangroves provide habitats for marine, terrestrial, and aerial species.

### **2. MATERIALS:**

Teacher Aid: Animal Passport (at least 8 copies)

Teacher Aid: Mangrove Habitat

Teacher Aid: Habitat Card Deck

Scissors

Crayons or Colored Pencils

Tape

### **3. PREPARATION:**

Have the students fill out the Animal Passport sheets with the names of eight species found in the mangroves. If you have more than eight students, print off multiple copies or have the students work in groups.

### **4. PROCEDURE:**

Begin this lesson by having students complete the Animal Passports, using the Habitat Card Deck. Some answers are on the cards, and some will require students to use critical thinking skills. A complete list can be found at the end of this document. Have students tape the cards onto their animal passports and encourage them to color them for camouflage from predators.

Once students have completed the Animal Passports, have them cut out the labels and additional animals for the Mangrove Habitat Teacher Aid. Ask the students where each label should go on the Game Board, and what is special about each part of the mangrove (e.g. prop roots bring in nutrients and support the tree). Once the labels have been applied, have the students place the animals in the mangrove tree according to the answers they put on their Animal Passports.

When students have finished assigning their animal passports to the appropriate spot on the mangrove, the tree will be covered in animals, and you will have at least eight complete Animal Passports that can be used as posters for the classroom.

### **5. GLOSSARY OF TERMS:**

Habitat – An area where a species or organism lives in nature.

Prop Roots – Specialized roots on a red mangrove that grow out from the main trunk to provide support for the tree. Also provide oxygen for the mangrove through specialized cells called *lenticels*.

Drop Roots – Specialized roots that grow out from the branches and trunk of the mangrove to provide the tree with oxygen.

Migrate – To move from one area to another. Lobsters migrate from the open ocean to the mangrove root systems when they reach their juvenile stage.

Juvenile – an organism (in this case a lobster or fish) that hasn't reached sexual maturity.

### **6. QUESTIONS FOR FURTHER INQUIRY:**

1) What happens to the animals when they become too big to fit among the mangrove roots?

2) What would happen to each species of mangrove if the water level became permanently higher? What if it became permanently lower?

3) What other species of animals might use the mangroves as habitat?

\* Think of a few more that talk about spp interaction, camouflage, why mangroves make such good habitats, etc.

### Animal Passport Suggested Answers:

- **Common Name:** Mussels
- **Where do I live?** Attached to mangrove roots
- **What do I eat?** Very small sea creatures
- **Where do I find my food?** Filter it from the surrounding water
- **Who eats me?** Humans, seabirds, fish, crabs and lobster
- **How do I hide from predators?** Hard protective shell
  
- **Common Name:** Spiny lobster
- **Where do I live?** Juvenile lobsters live among the mangrove roots
- **What do I eat?** Smaller sea creatures
- **Where do I find my food?** In the soil around the root system
- **Who eats me?** Larger fish, humans, sharks
- **How do I hide from predators?** Camouflage and by hiding in small spaces among the roots
  
- **Common Name:** Shrimp
- **Where do I live?** Among the mangrove roots
- **What do I eat?** Very small sea creatures (plankton) and algae
- **Where do I find my food?** Floating in the water column
- **Who eats me?** Larger fish, birds, humans
- **How do I hide from predators?** My small size let's me hide among the closely packed roots
  
- **Common Name:** Parrotfish
- **Where do I live?** Among the mangrove roots as a juvenile
- **What do I eat?** Algae
- **Where do I find my food?** Growing on the bottom or on coral reefs
- **Who eats me?** Larger predatory fish, sharks, humans
- **How do I hide from predators?** Colorful camouflage, hide in the root system
  
- **Common Name:** Mangrove Crab
- **Where do I live?** In the upper branches and leaves of the mangrove
- **What do I eat?** Mangrove leaves and small insects or invertebrates
- **Where do I find my food?** Among the leaves of the mangroves
- **Who eats me?** Birds, rodents, larger crabs
- **How do I hide from predators?** By quickly climbing higher in the mangrove or by jumping away from the tree
  
- **Common Name:** Iguana
- **Where do I live?** Upper branches of mangroves
- **What do I eat?** Mostly leaves, flowers and fruit
- **Where do I find my food?** On the ground and up in the branches of the mangroves
- **Who eats me?** Large predatory birds, humans, large rodents
- **How do I hide from predators?** Camouflage and a tough scaly skin
  
- **Common Name:** Snails
- **Where do I live?** Anywhere from the roots to the upper branches of the mangroves
- **What do I eat?** I eat plants using a tongue that scrapes pieces off of my food
- **Where do I find my food?** On mangrove leaves or in the ocean
- **Who eats me?** Anything bigger than me. Fish, crustaceans, birds
- **How do I hide from predators?** I have a hard protective shell and I'm very small
  
- **Common Name:** Frigate Bird
- **Where do I live?** In nests on the tops of the mangrove canopy
- **What do I eat?** Mostly fish, crustaceans and small molluscs
- **Where do I find my food?** In the open ocean
- **Who eats me?** Humans, or large rodents and cats may hunt my young
- **How do I hide from predators?** My nest is high up in the trees or I can fly away from danger

# Marine Habitat

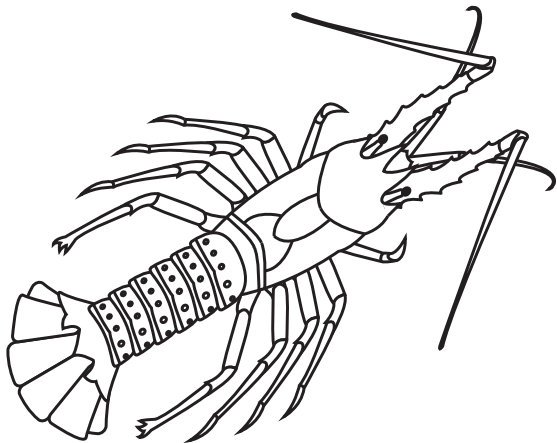


## Mussels

We attach to solid surfaces then filter water to find food. We can close our shells if the water level gets too low, but we can't survive in open water.

***Where do we live?***

# Marine Habitat

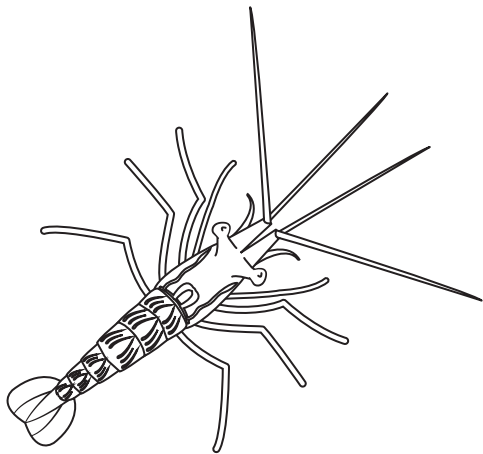


## **Spiny Lobster**

When I'm a juvenile, I need to find a place to hide that protects me from larger animals. I can't live out of the water because I have gills, but I can move around very quickly.

***Where do I live?***

# Marine Habitat



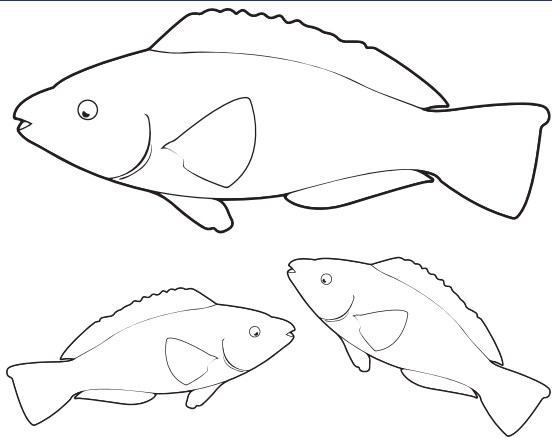
## Shrimp

I look a lot like my cousin the spiny lobster, but don't be fooled! This is as big as I will grow, so I need a home with lots of protection from larger animals.

***Where do I live?***



# Marine Habitat

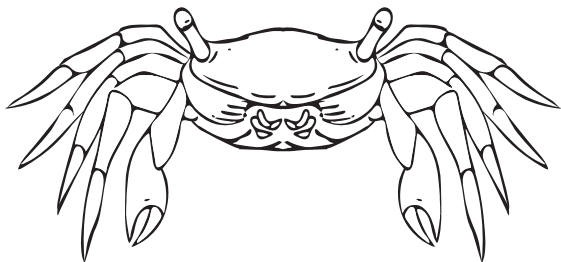


## Fish

Like many other juvenile fish, I will hide and hunt inside the lagoon until I grow big enough to move to the reef. I like living where bigger animals can't reach me.

***Where do I live?***

# Marine Habitat

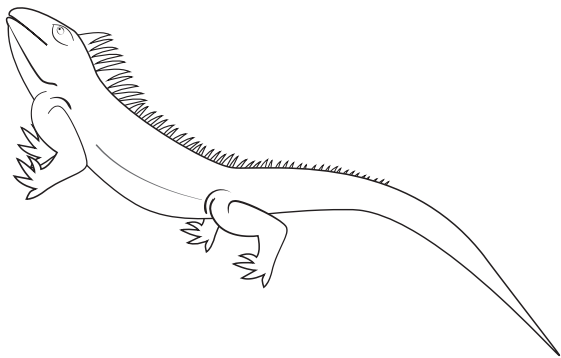


## **Mangrove crab**

I look like I belong in the water, but I'm quite comfortable above the root system. I eat everything I can, but my favorite food is mangrove leaves!

***Where do I live?***

# Marine Habitat

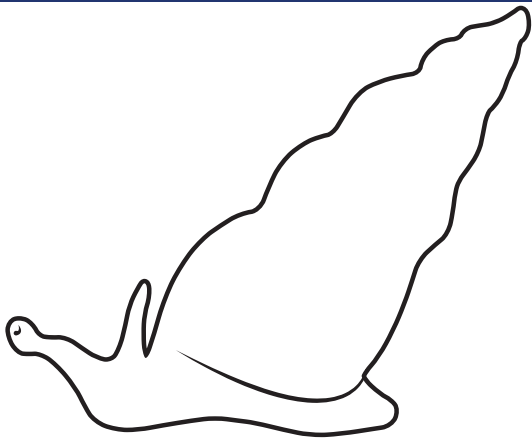


## Iguana

I'm a cold-blooded reptile, so I need to spend plenty of time warming up in the sunshine. I like to eat the flowers and leaves of the mangroves when I'm not asleep.

***Where do I live?***

# Marine Habitat



## Snails

I can live almost anywhere on a mangrove! I like to hide lower down where I'm safe from predators, but my favorite foods are found higher up in the branches.

***Where do I live?***

# Marine Habitat

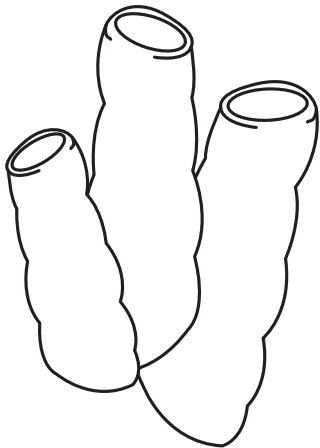


## **Sea birds (Frigatebird)**

I spend most of my life at sea, but I fly back to the mangroves when it's time to raise a family. I'm not a good climber or swimmer, so I make my nest up high.

***Where do I live?***

# Marine Habitat



## Sponges

I may look like a plant or a rock, but I'm actually an animal! I stick myself to a wide surface then grow up as I filter water through my insides to get my dinner.

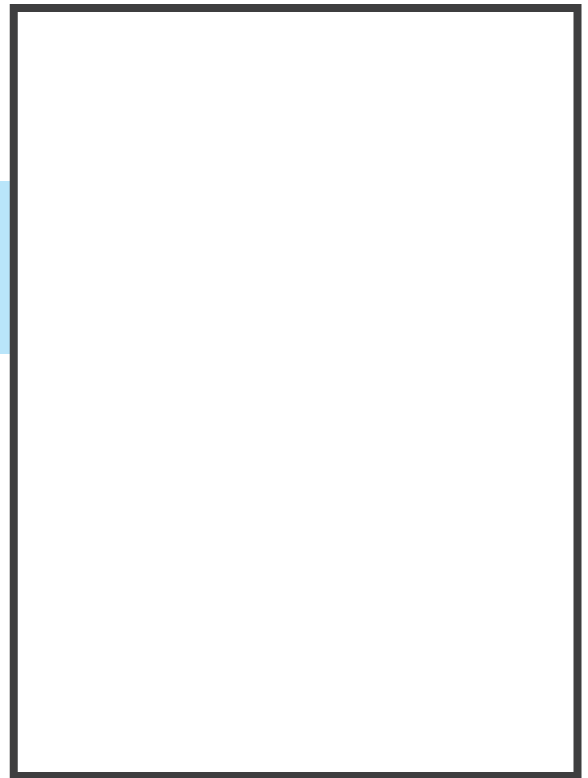
***Where do I live?***

# ANIMAL PASSPORT

Common Name: \_\_\_\_\_

Where do I live?: \_\_\_\_\_

1. What do I eat?
2. Where do I find my food?
3. How do I find my food?
4. Who eats me?
5. How do I hide from predators?



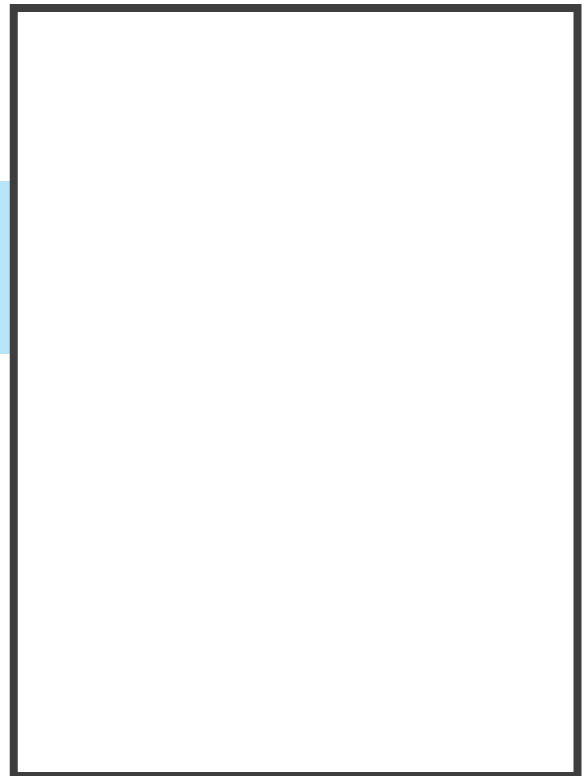
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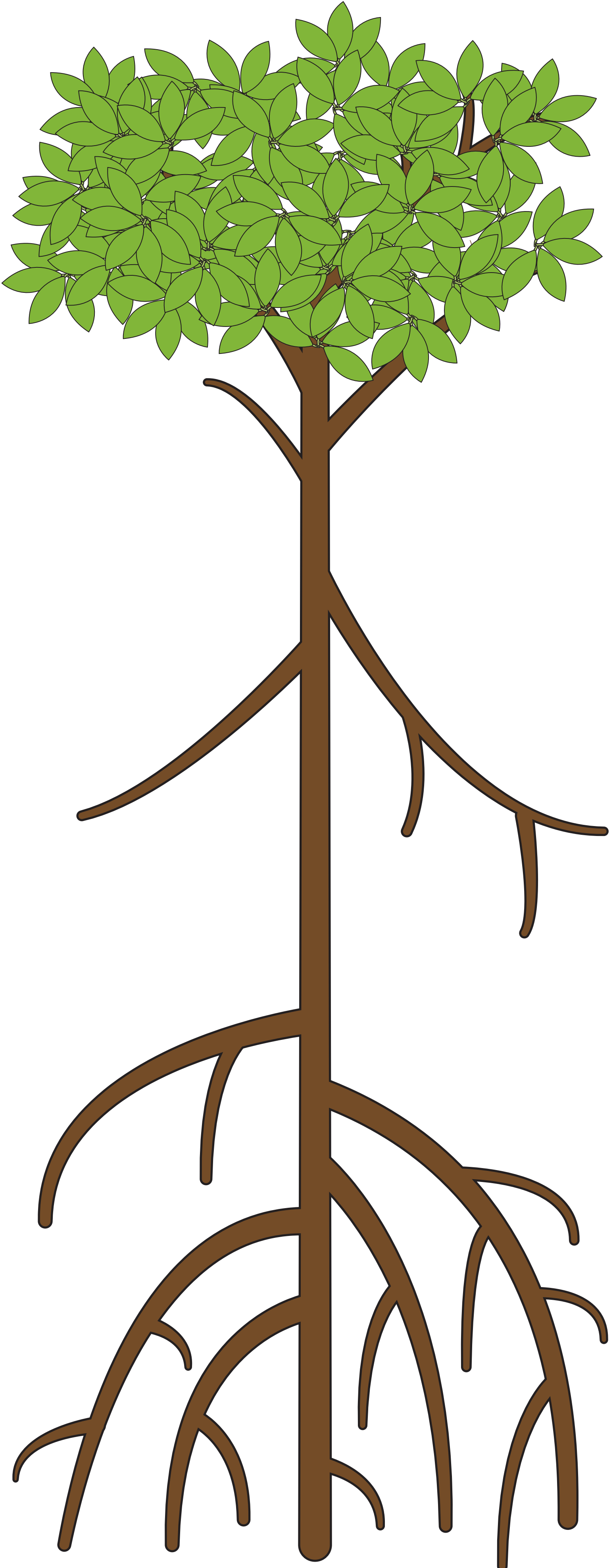
# ANIMAL PASSPORT

Common Name: \_\_\_\_\_

Where do I live?: \_\_\_\_\_

1. What do I eat?
2. Where do I find my food?
3. How do I find my food?
4. Who eats me?
5. How do I hide from predators?





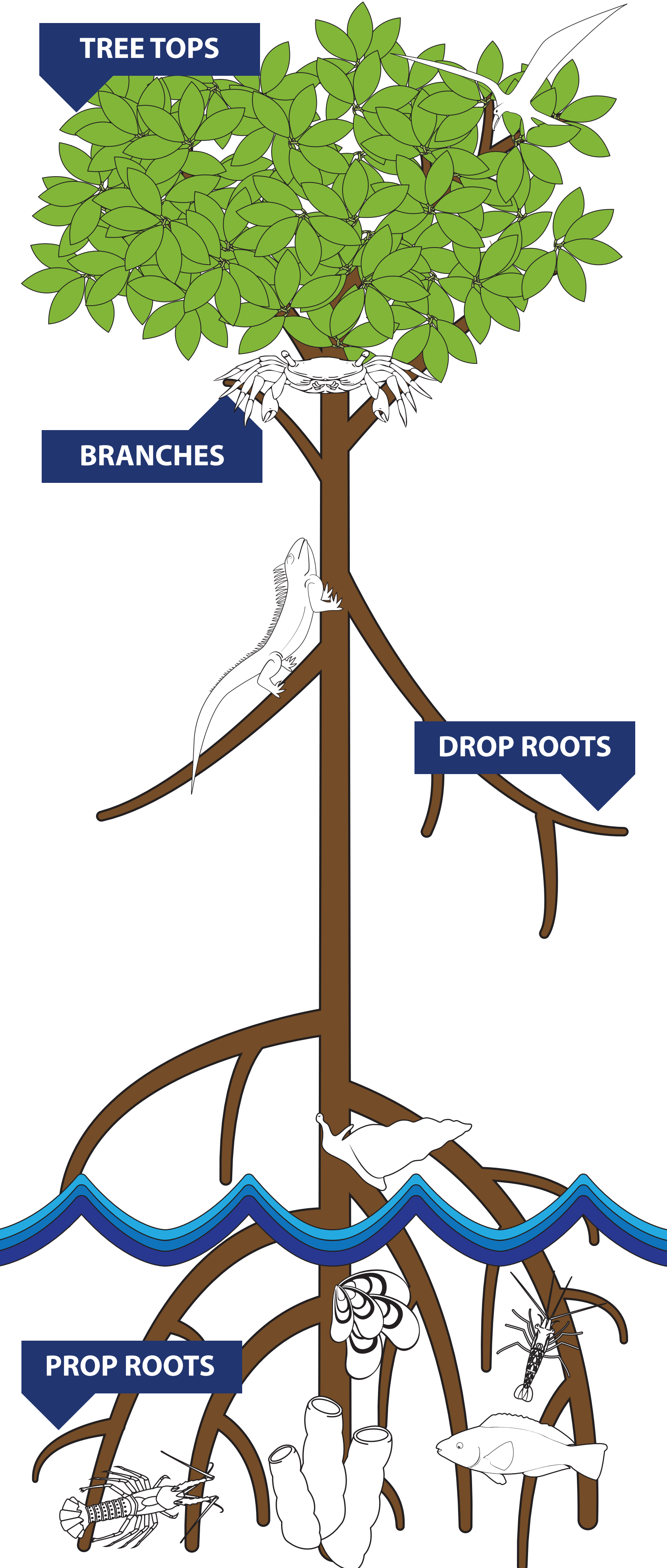


TREE TOPS

BRANCHES

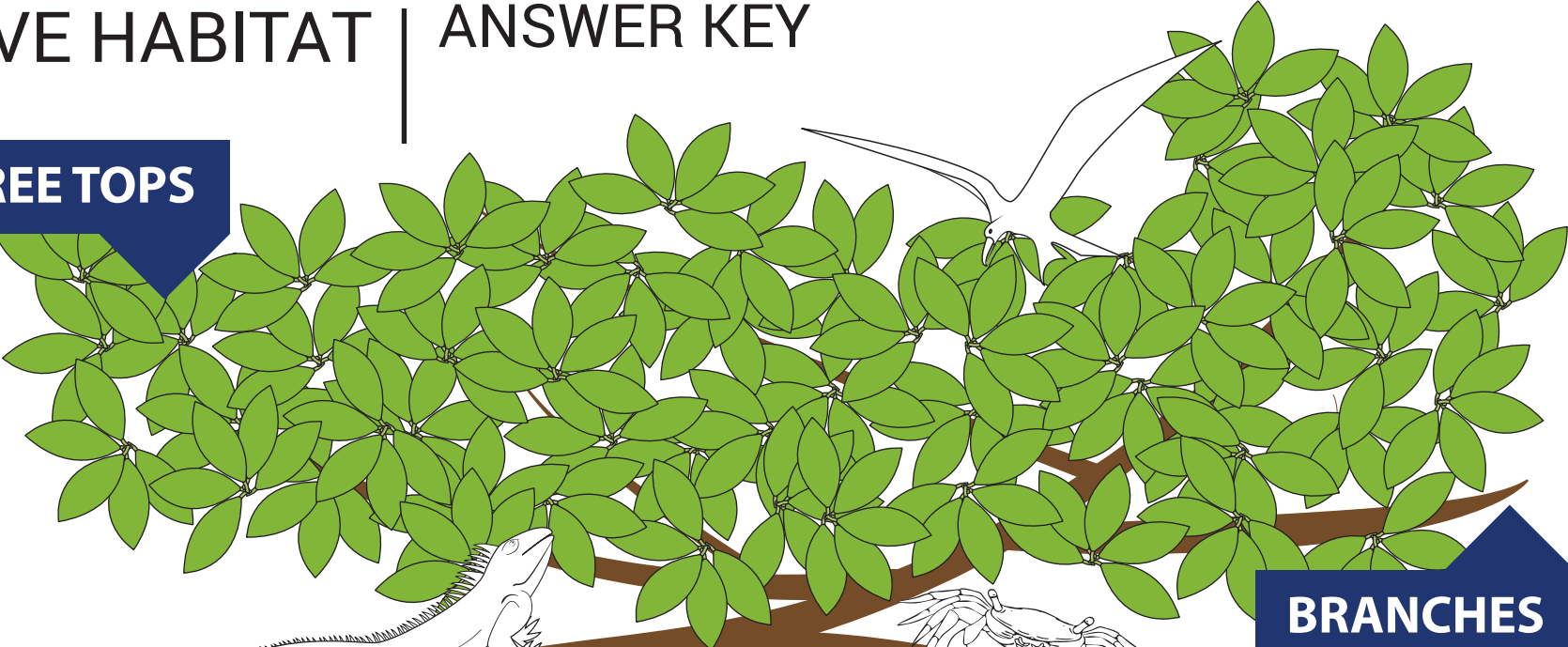
DROP ROOTS

PROP ROOTS

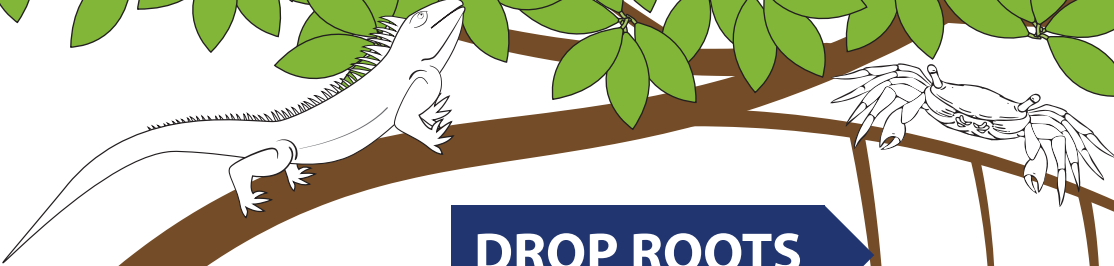


# MANGROVE HABITAT | ANSWER KEY

TREE TOPS



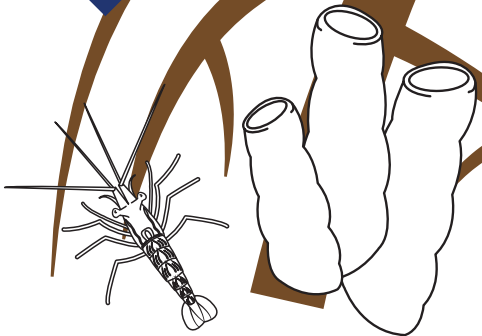
BRANCHES



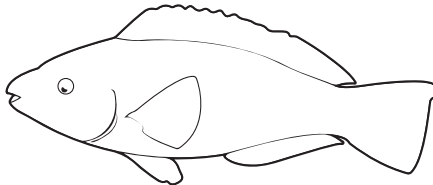
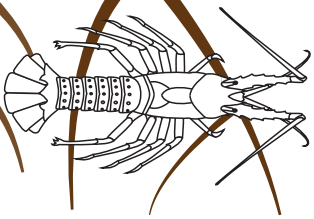
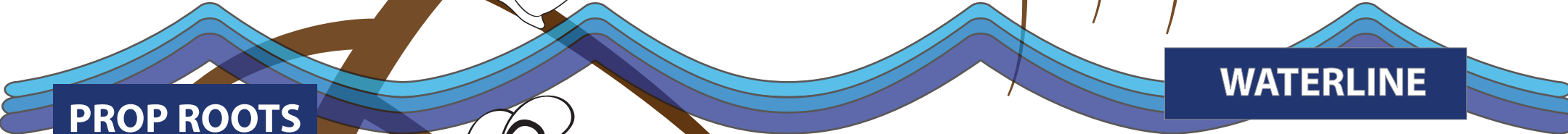
DROP ROOTS



PROP ROOTS



WATERLINE

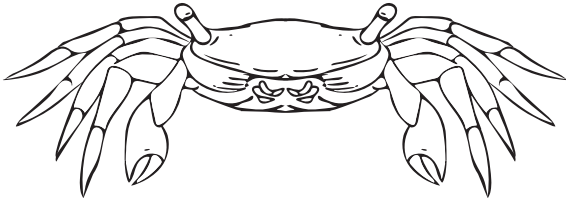


# TEACHER AID

## MANGROVE HABITAT

# Mangrove Species

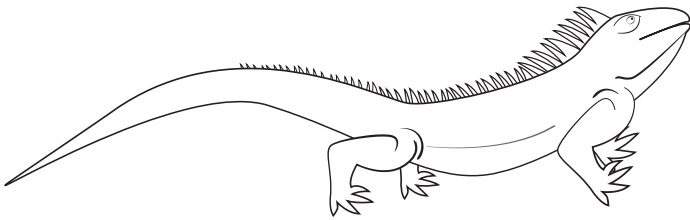
Mangrove Crab



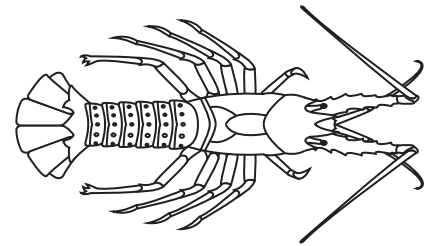
Sea Bird (Frigatebird)



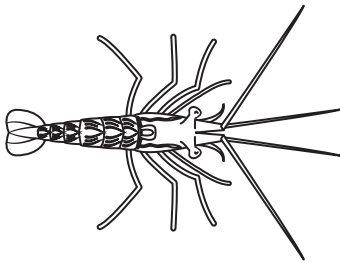
Iguana



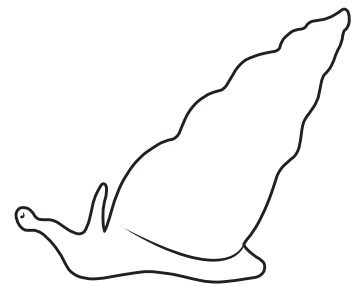
Spiny Lobster



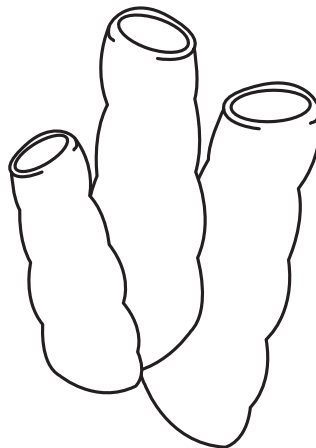
Shrimp



Snails



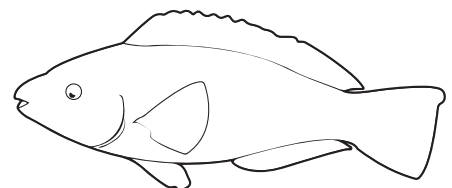
Sponges



Mussels



Fish



# TEACHER AID MANGROVE HABITAT

Labels

**TREE TOPS**

**BRANCHES**

**DROP ROOTS**

**PROP ROOTS**

**WATERLINE**

