Zooplankton Migration Patterns at Scotton Landing: Behavioral Adaptations

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Summary: Zooplankton have evolved specific migration patterns that increase their chances of survival. These migrations patterns are behavioral adaptations and they are unique to each species of zooplankton. Students will determine how zooplankton from the St. Jones River migrate and how these adaptations increase their chances of survival.

Activity Use: This activity can be used as a part of any unit on biology, evolution, adaptations, ecology, and more.

Target Grade Level: Middle School

Standards Addressed:
LS1.A: Structure and Function
LS1.B: Growth and Development of Organisms
LS1.C: Organization for Matter and Energy Flow in Organism
LS1.D: Information Processing
LS2.A: Interdependent Relationships in Ecosystems
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
LS2.C: Ecosystem Dynamics, Functioning, and Resilience
LS2.D: Interactions and Group Behavior

Lesson Time: 45 minutes

Essential Question: How do behavioral adaptations of zooplankton, specifically their migration patterns, increase their chances of survival?

SMART Objectives:
After completing this activity, students will be able to:

1. Name two zooplankton species in the Delaware Bay.
2. Describe two different migration patterns that zooplankton use.
3. Explain how behavioral adaptations of zooplankton increase their chances of survival.

Vocabulary/Key Terms: Behavioral Adaptation, Diel Vertical Migration, Tidal Migration, *Acartia tonsa*, *Rhithropanopeus harrisii*, Estuary, Holoplankton, Meroplankton

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This work is supported by a grant from the Delaware National Estuarine Research Reserve. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the organizer(s) and do not necessarily reflect the views of the Delaware National Estuarine Research Reserve.

Introduction: Teacher Reading Material

Where is Scotton Landing?

- Scotton Landing is located along the St. Jones River near Dover, Delaware. The St. Jones River flows into the Delaware Bay. This area is an estuary. An estuary is a body of water where salt water from the ocean meets freshwater from a river. Estuaries are physically and biologically protected regions that are nursery habitats for many local species. Refer to the map provided.
  Learn more about estuaries here: http://oceanservice.noaa.gov/facts/estuary.html

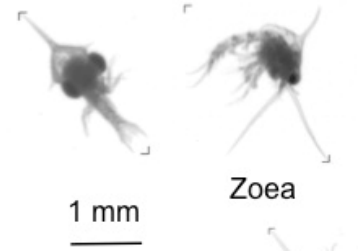
- Scotton Landing experiences mixed semidiurnal tides. Tides are the daily rising and falling of the water level caused by the gravitational pull of the moon and the sun. A mixed-semidiurnal tide means that everyday there are two high tides and two low tides. However, the two high tides are different heights and the two low tides are different heights.
  Learn more about tides here:
  http://oceanservice.noaa.gov/education/tutorial_tides/tides01_intro.html
  Learn more about mixed semidiurnal tides here:
  http://oceanservice.noaa.gov/education/tutorial_tides/tides07_cycles.html

What are Zooplankton?

- Zooplankton are organisms that live in the water column and drift with the currents. Organisms that are zooplankton are called zooplankters. They feed on smaller phytoplankton, which photosynthesize in the surface water to create their own food. Phytoplankton must remain in the surface water where sunlight can penetrate to photosynthesize. Zooplankton migrate to the surface to feed on phytoplankton. Zooplankton are also an important food source for many local species, such as fish, that use eyes and vision to find food. Therefore, zooplankton must migrate to the surface water to feed while avoiding predation.

- Two common types of zooplankton sampled at Scotton Landing on the St. Jones River are copepods and crab larvae. Both are crustaceans. Copepods have large antennae and an exoskeleton. *Acartia tonsa* is the most abundant copepod found at Scotton Landing. Crab larvae, including white-fingered mud crab larvae (*Rhithropanopeus harrisii)*, are also common zooplankters found at Scotton Landing. *Rhithropanopeus harrisii* is a **meroplankton**: it spends only part of its life cycle as a zooplankter. *Rhithropanopeus harrisii* eggs hatch into small larvae (zoea) that live in the water column as zooplankton. The larvae will then develop into full sized mud crabs which live on the bottom of estuaries. However, the copepod *Acartia tonsa* is a **holoplankton**: it remains a zooplankter for its whole life cycle. Both *Acartia tonsa* and *Rhithropanopeus harrisii* larvae are only about the size of a grain of rice!
  Read more about crab larvae here: https://www.underthescope.udel.edu/who-am-i/large-shrimp-zooplankton
  Read more about copepods here: https://www.underthescope.udel.edu/who-am-i/small-shrimp-zooplankton

Copepod
Acartia tonsa



White-Fingered Mud Crab
Rhithropanopeus harrisii

What are Behavioral Adaptations?

- Behavioral adaptations are actions that organisms perform to increase their chances of survival. Behavioral adaptations include migration and hibernation. For example, bears hibernate in the winter to escape the cold and conserve energy when food is scarce; this behavioral adaptation increases their chances of survival. Zooplankton migrations are examples of **behavioral adaptations** that increase survival. Two types of zooplankton migrations are **diel vertical migration** and **tidal migration**.

- **Diel vertical migrators** move up and down in the water column at specific times of the day. They are deep in the water column during the day and migrate to the surface water at night. At night, vertical migrators swim to the surface of the water to feed on phytoplankton while it is dark and they cannot be seen by predators. During the daytime, the sun penetrates the water column, and prey becomes visible to predators. During the day, vertical migrators sink deeper in the water, where it is darker, so predators like fish cannot see them. Vertical migration is an example of a behavioral adaptation. By migrating and hiding from predators, diel vertical migrators have a greater chance of survival. *Acartia tonsa*, one of the most common zooplankton species at Scotton Landing, is a diel vertical migrator.

- Another behavioral adaptation is called tidal migration. **Tidal migrators** migrate to the surface water on incoming tides to maintain their position in the estuary. On incoming tides, when the water level is rising, the surface currents are being pushed upstream into the estuary. Tidal migrators drift with these currents and are pushed further into the protected estuary instead of being swept out into the ocean. This migration pattern allows zooplankton to remain protected in the estuary which increases their chances of survival. *Rhithropanopeus harrisii* is an example of a tidal migrator.

Learning Activity:

- In research funded by the Delaware National Estuarine Research Reserve in 2016, scientists at the University of Delaware sampled water from the St. Jones River at Scotton Landing to determine the number of species and abundance of zooplankton present. In the activity, we will use water samples taken over the course of one day during that study.
- Students will be introduced to zooplankton behavioral adaptations. They will then graph zooplankton abundance at Scotton Landing to understand zooplankton migration patterns. The zooplankton abundance data used in the activity was sampled at Scotton Landing from August 31st to September 1st 2016.
- There are two versions (A and B) of the student worksheet depending on the time available to complete the activity. Version A is more complex. Students are given exact zooplankton abundance data and will plot two data series on a single graph. In Version B, students are given rounded zooplankton abundance values and are plotting the data on two separate graphs.

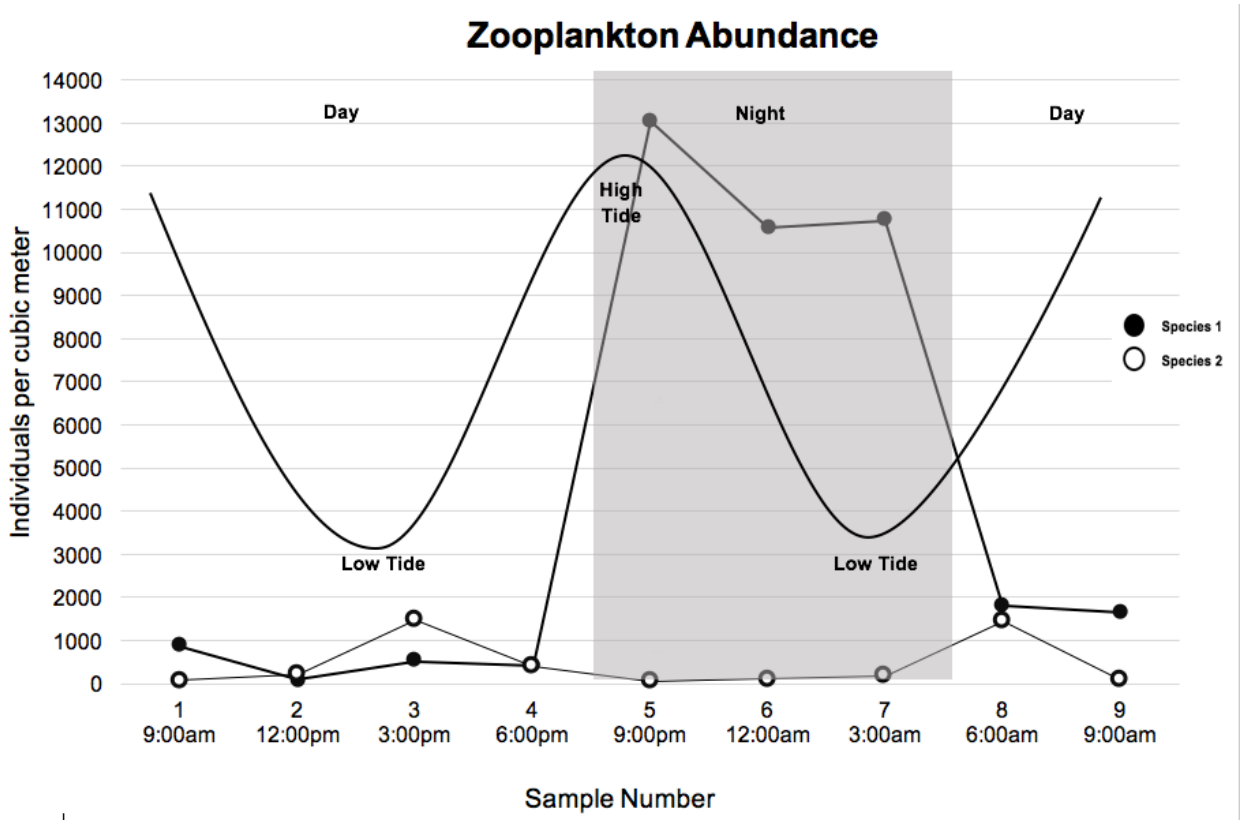
Completed Graphs and Answers to Thinking and Discussion Questions:
The information and data below are provided to students to construct zooplankton abundance graphs.

In research funded by the Delaware National Estuarine Research Reserve in 2016, scientists at the University of Delaware sampled water from the St. Jones River at Scotton Landing to determine the number of species and abundance of zooplankton present. In the activity, we will use water samples taken over the course of one day during that study. Every three hours, water samples were taken from the surface of the St. Jones River at Scotton Landing. The amount of water collected in each water sample is one cubic meter: enough water to fill two large bathtubs. The total number of *Acartia tonsa* and *Rhithropanopeus harrisii* larvae in each water sample was counted. Using your knowledge of the migration patterns of *Acartia tonsa* and *Rhithropanopeus harrisii*, graph the data below to determine which zooplankton is Species 1 and which is Species 2. Plot solid circles for Species 1 and open circles for Species 2. You may connect the points of each individual species to view the overall trend. Sample Number 1 for both species has been plotted for you.

Data table for Version A.

Sample Number	Time of Sample	Abundance of Species 1 (per cubic meter)	Abundance of Species 2 (per cubic meter)
1	9:00am	872	75
2	12:00pm	92	225
3	3:00pm	528	1,476
4	6:00pm	426	406
5	9:00pm	13,043	48
6	12:00am	10,582	114
7	3:00am	10,747	185
8	6:00am	1,806	1,442
9	9:00am	1,665	98

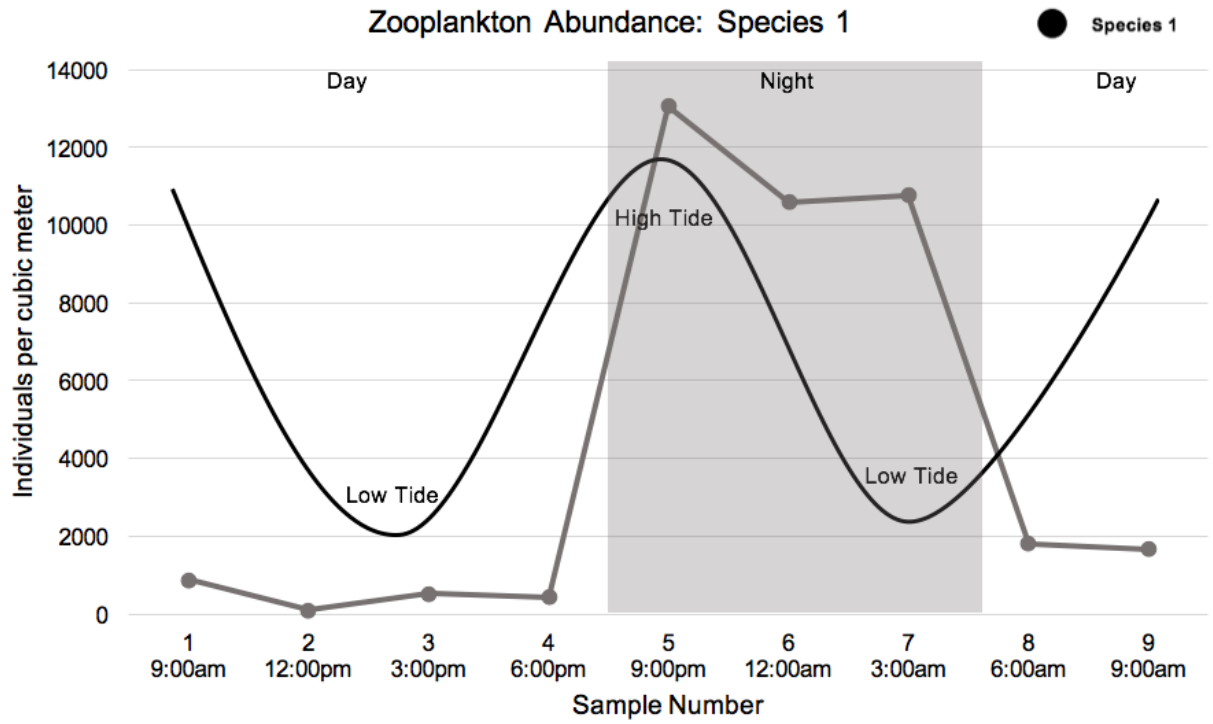
Completed Graph of Zooplankton Abundance: Version A



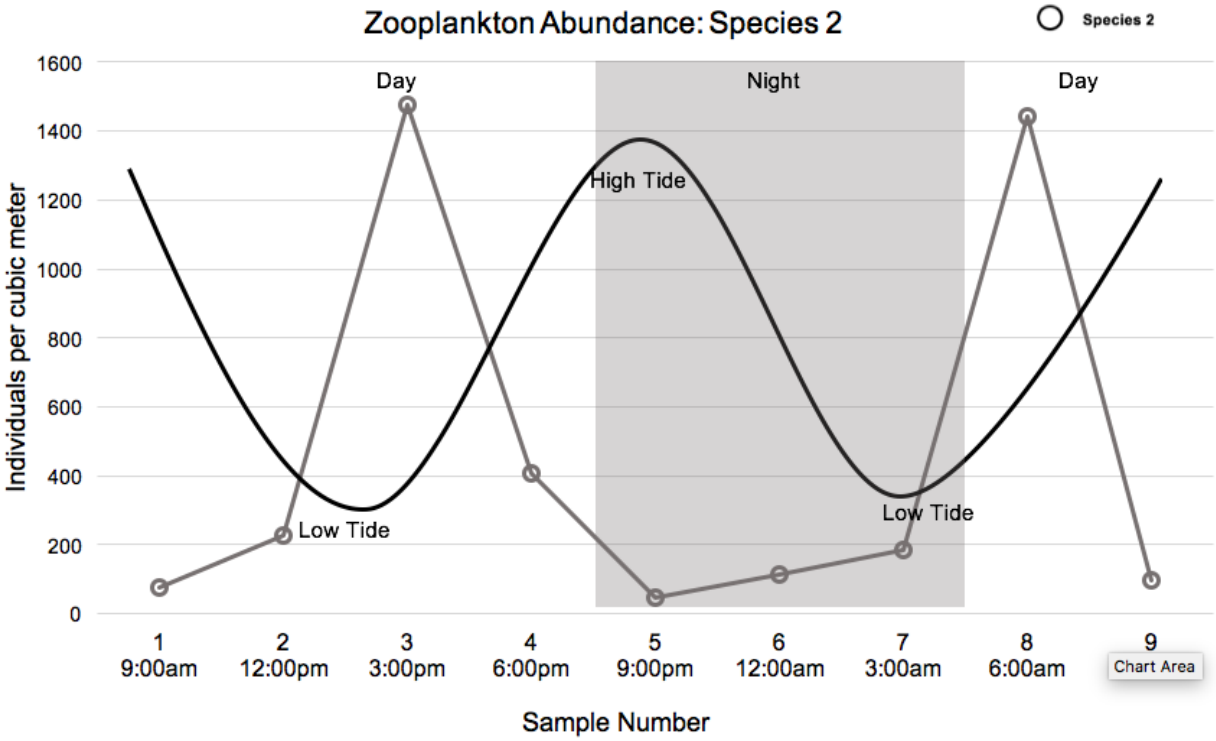
Data table for Version B.

Sample Number	Time of Sample	Abundance of Species 1 (per cubic meter)	Abundance of Species 2 (per cubic meter)
1	9:00am	900	100
2	12:00pm	100	200
3	3:00pm	500	1,500
4	6:00pm	400	400
5	9:00pm	13,000	100
6	12:00am	11,600	100
7	3:00am	10,700	200
8	6:00am	1,800	1,400
9	9:00am	1,700	100

Graph of Species 1 Abundance (Acartia tonsa): Version B



Graph of Species 2 Abundance (Rhithropanopeus harrisii): Version B



**Note that the y-axes of the two graphs in Version B are scaled differently for each species.*

Refer to your graph to answer the following questions.
(Versions A and B)

1. What type of migrator is the copepod, *Acartia tonsa*?
   Acartia tonsa is a diel vertical migrator.

2. What type of migrator is the *Rhithropanopeus harrisii* larva?
   Rhithropanopeus harrisii larvae are tidal migrators.

3. Is *Acartia tonsa* species 1 or species 2?
   Species 1 is *Acartia tonsa.*

4. Is *Rhithropanopeus harrisii* species 1 or species 2?
   Species 2 is *Rhithropanopeus harrisii*.

5. *Acartia tonsa* feeds on phytoplankton in the surface water at night. How does this behavioral adaptation increase their chances of survival?
   Acartia tonsa feeds at the surface at night and sinks into the deeper, darker water during the day so that it is not seen by predators. By avoiding predation, *Acartia tonsa*'s migration pattern (a behavioral adaptation) increases their chances of survival.

6. Predict what would happen to the size of the *Acartia tonsa* population if they fed on phytoplankton during the day instead of at night.
   If *Acartia tonsa* fed on phytoplankton during the day, they would be visible to predators. Predators would consume more *Acartia tonsa*, so their population would shrink.

7. *Rhithropanopeus harrisii* larvae migrate to the surface water on incoming tides. How does this behavioral adaptation increase their chances of survival?
   On incoming tides, *Rhithropanopeus harrisii* larvae in the surface water drift with the currents and are pushed up further into the protected estuary. By remaining in the protected estuary and not getting swept out to sea, the mud crab larvae holds its position in the estuary and increases its chances of survival.

8. If *Rhithropanopeus harrisii* larvae migrated to the surface water on outgoing tides, when the water level is decreasing, where would they be positioned in the estuary?
   Rhithropanopeus harrisii larvae would be pushed further out of the estuary and toward the ocean if they migrated to the surface water on outgoing tides.

Assessment
Performance: Was the student engaged during the activity? Did the student actively participate in the lesson and discussion?
Product: Did the student complete the graphing activity? Did the student provide evidence and support for the answers to the provided questions?

Extensions:
1. Explore the website: www.underthescope.udel.edu. Click on the "Magnify it" tab and discover *Acartia tonsa* up close under the "Copepods" tab. Learn more about crab development by clicking on the "Magnify it" tab and then exploring the "From Baby Crab to Steamed Crab" tab.

SCOTTON LANDING, ST. JONES RIVER

The St. Jones River is located at the red star.

The sampling site, Scotton Landing, is located along the St. Jones River at the red arrow.