Version B
Name: _____

Zooplankton Migration Patterns at Scotton Landing: Behavioral Adaptations

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.

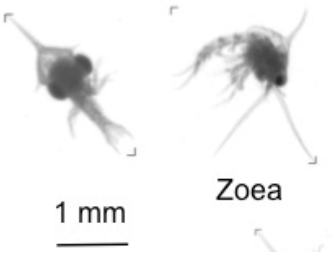
- Scotton Landing experiences mixed semidiurnal tides. Tides are the daily rising and falling of the water level caused by the gravitational pull of the moon and the sun. A mixed-semidiurnal tide means that everyday there are two high tides and two low tides. However, the two high tides are different heights and the two low tides are different heights.

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!

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 to escape the cold and conserve energy when food is scarce; this behavioral adaptation increases their chance of survival. Zooplankton migrations are examples of **behavioral adaptations** that increase survival rate. 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.

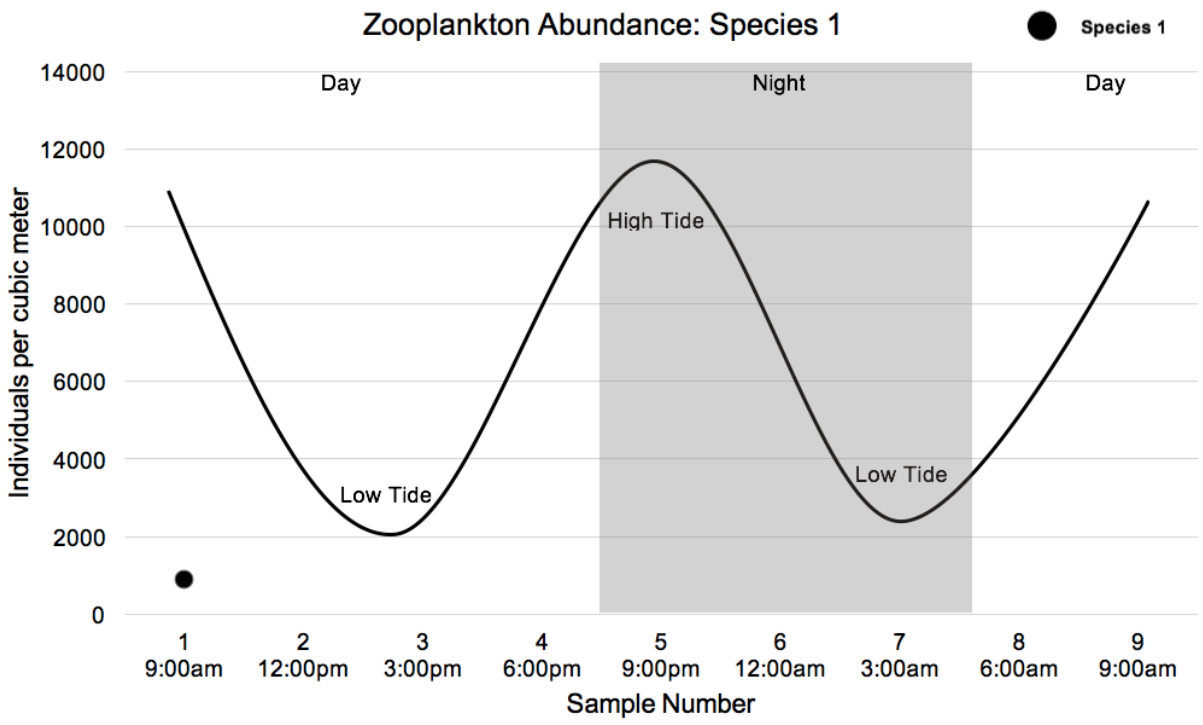
- Another behavioral adaptation is called tidal migration. **Tidal migrators** migrate to the surface water on incoming tides to maintain their position in the estuary. On incoming tides, when the water level is rising, the surface currents are being pushed upstream into the estuary. Tidal migrators 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.

Section I: Zooplankton Migration Patterns

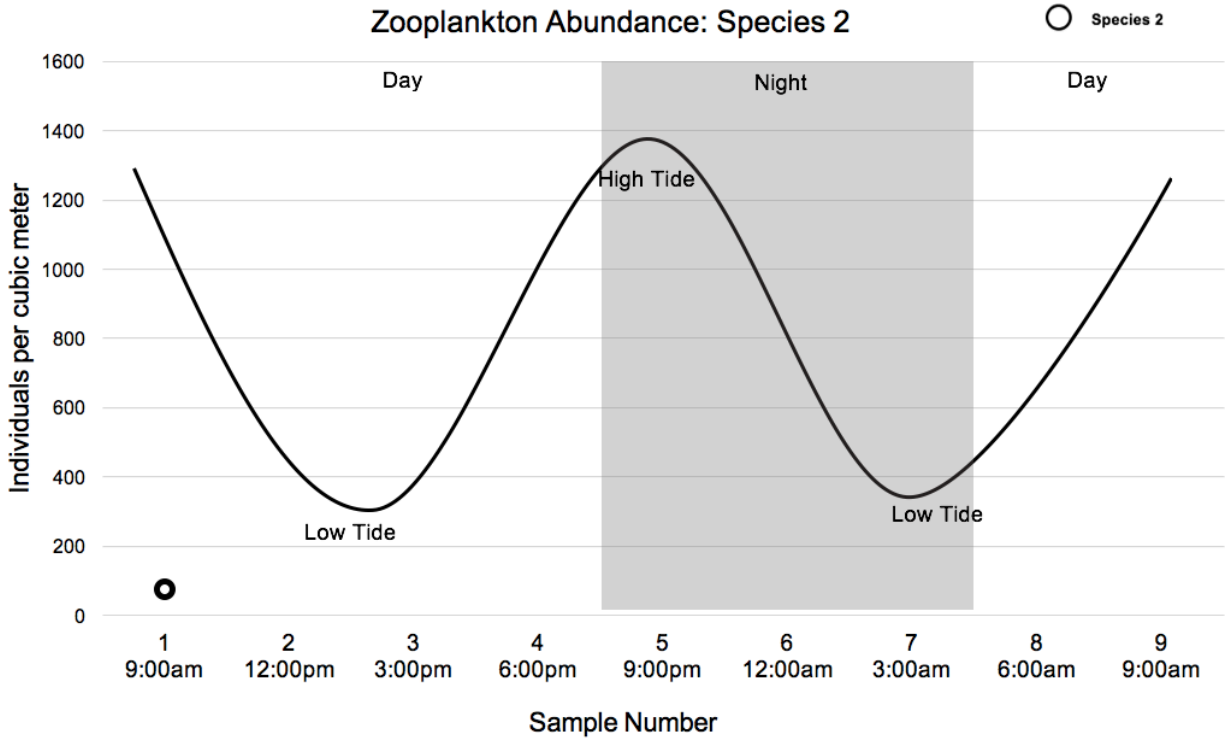
- In research funded by the Delaware National Estuarine Research Reserve in 2016, scientists at the University of Delaware sampled water from the St. Jones River at Scotton Landing to determine the number of species and abundance of zooplankton present. In the activity, we will use water samples taken 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.

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

Use the graph below to plot the abundance of Species 1.



Use the graph below to plot the abundance of Species 2.



Once you have completed your graphs, answer the following questions.

1. What type of migrator is the copepod *Acartia tonsa*? Is *Acartia tonsa* species 1 or species 2?

2. What type of migrators are white-fingered mud crab larvae? Is *Rhithropanopeus harrisii* species 1 or species 2?

3. Explain *Acartia tonsa'*s behavioral adaptation. How does this adaptation increase their chances of survival?

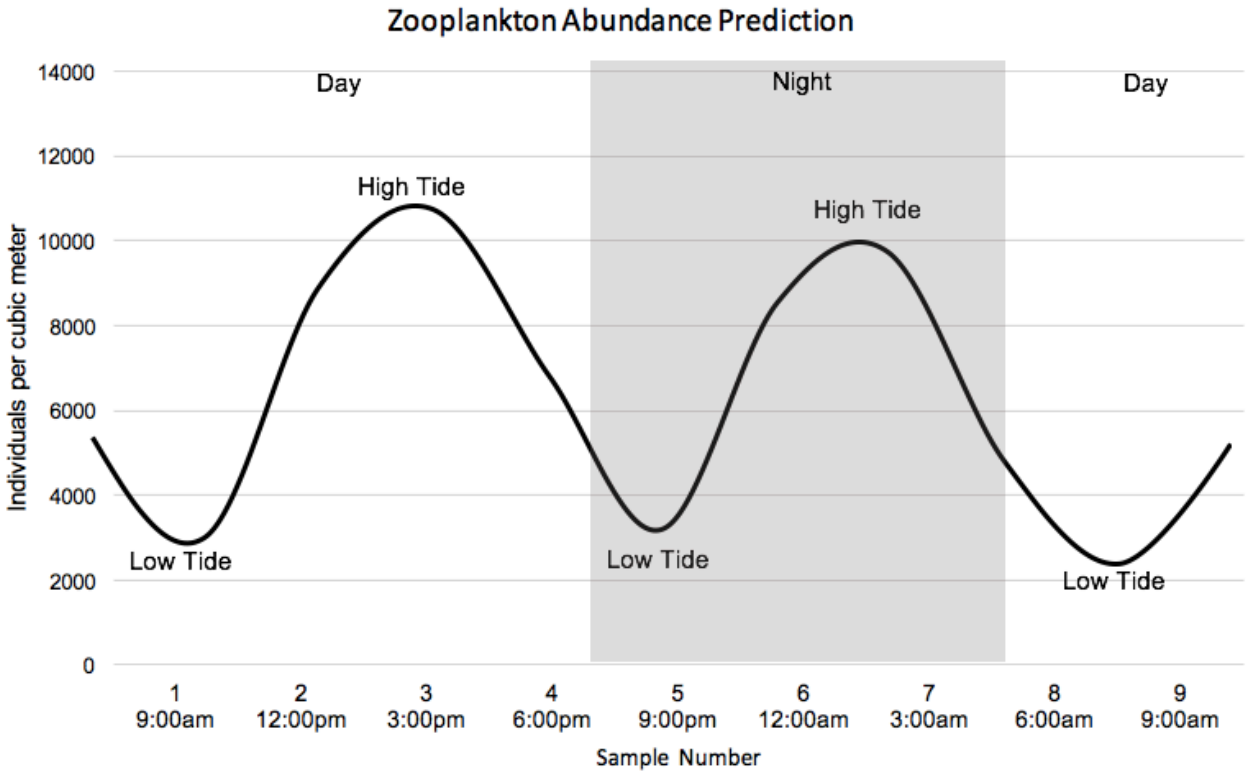
4. Predict what would happen to the size of the *Acartia tonsa* population if they fed on phytoplankton during the day instead of at night.

5. Explain the behavioral adaptation of white-fingered mud crab larvae. How does this behavioral adaptation increase their chance of survival?

6. If white-fingered mud crabs migrated to the surface on outgoing tides, when the water level is decreasing, where would they be positioned in the estuary?

Section II: Predicting Zooplankton Abundance

Zooplankton were sampled at Scotton Landing one week later. Based on the tides and light data provided in the graph below, predict the abundance of the copepod *Acartia tonsa* and the crab larvae of *Rhithropanopeus harrisii* throughout the course of the day in these water samples. Recall that *Acartia tonsa* is a diel vertical migrator and *Rhithropanopeus harrisii* is a tidal migrator. Indicate *Acartia tonsa* abundance with a continuous dashed line and *Rhithropanopeus harrisii* abundance with a continuous solid line on the graph below.



Based on your prediction, answer the following questions:

1. When do *Acartia tonsa* peak? Why did you predict this trend?

2. When do *Rhithropanopeus harrisii* larvae peak? Why did you predict this trend?

Section III: Diversity

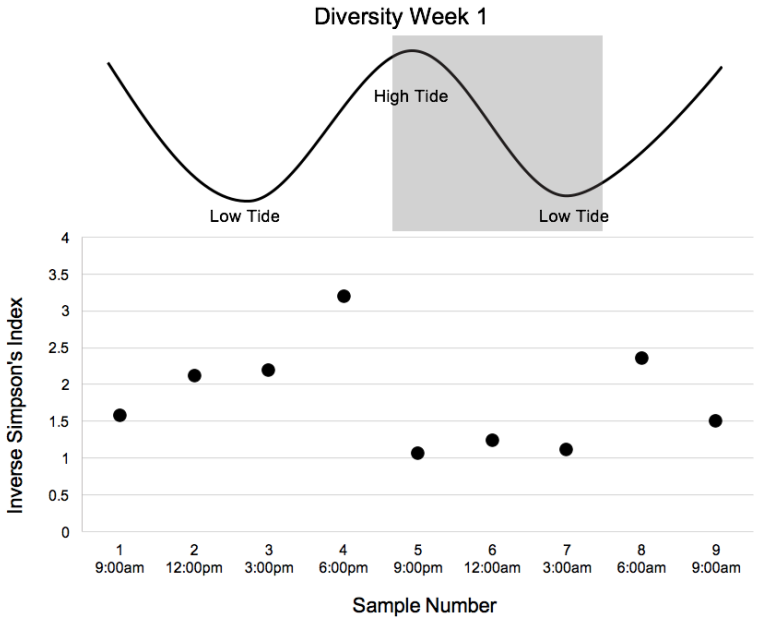
Diversity can describe the variation in a community and how many different species are present. Diversity is commonly measured using several diversity indices.

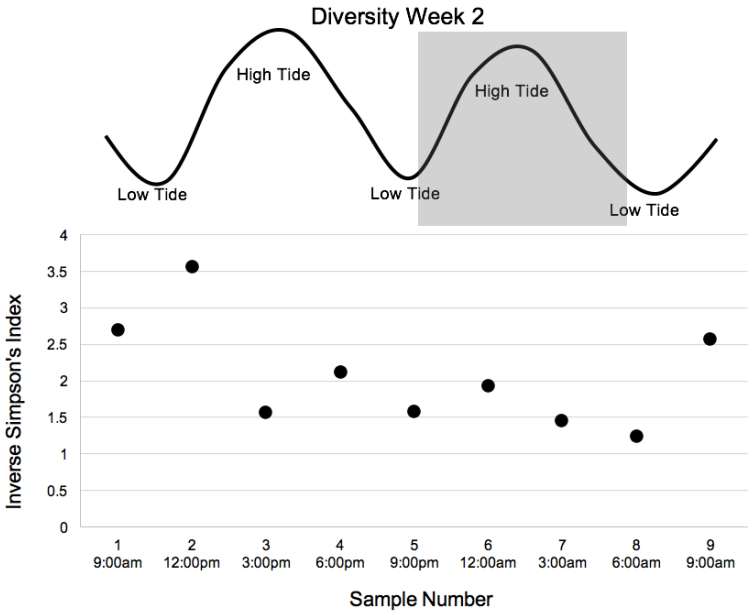
Simpson's Index (D) is one of these indices used to describe the diversity of a community based on the number of species present and their abundance. The Simpson's Diversity Index considers:

- The number of different species present
  - More species present indicates higher diversity.
- The abundance of each species
  - If all species are found in relatively similar abundance, there will be higher diversity.
  - If one species dominates, and the other species have relatively low abundance, the community is less diverse.

To make the data more intuitive, Inverse Simpson's Index is used to present the data. Inverse Simpson Index is simply 1/D. Higher values indicate high diversity while lower values indicate lower diversity.

The diversity of each water sample discussed in Sections I and II was calculated using the Inverse Simpson's Index. Each water sample from Scotton Landing contained a variety of zooplankton species including *Acartia tonsa* and *Rhithropanopeus harrisii*. Based on the zooplankton species present and their abundance, the diversity of the zooplankton community was calculated. The Week 1 graph describes the diversity of the water samples used in Section I of your handout. The Week 2 graph describes the diversity of the water samples from Section II.





Refer to the graphs above showing zooplankton diversity at Scotton Landing. Answer the following questions.

1. Look at the graph for Week 1.

    a. When do we see the lowest diversity? What type of migrator is present around this time?

    b. When do we see the highest diversity? What type of migrator is present around this time?

    c. Is diversity increased or decreased when diel vertical migrators are present?

    d. Is diversity increased or decreased when tidal migrators are present?

2. Look at the graph for Week 2.

    a. What is happening to the water level when we see the greatest diversity? What type of migrators are present at this tide?

    b. What type of migrators are present during sample 6 of week 2?

    c. A*cartia tonsa* dominates when present, due to their abundance. If diversity increases on incoming tides when tidal migrators are present, why is an increase in diversity not seen during sample 6 of week 2?