**Case study: Do sea otters influence the effects of eutrophication in seagrass beds?**

Nitrogen (N) cycle: Use the figure below to answer the following questions with a neighbor. Numbers are 10^{12} g N (per year for processes).

1. What is the largest reservoir of N?

2. What process removes the most N from the atmosphere?

3. Examine the processes caused by humans. What is the <u>net effect</u> of humans on the nitrogen cycle? Give a number!

4. Based on your preparation for today, what are some biological effects of human changes to the N cycle?
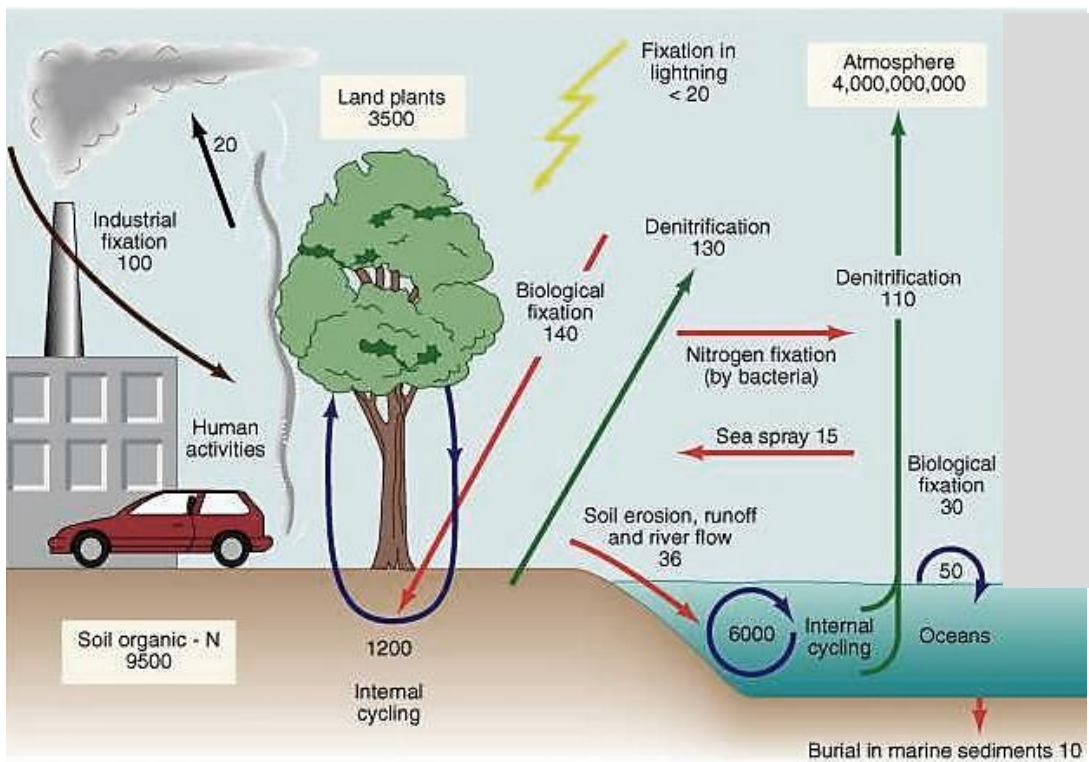
Effects of eutrophication on seagrasses
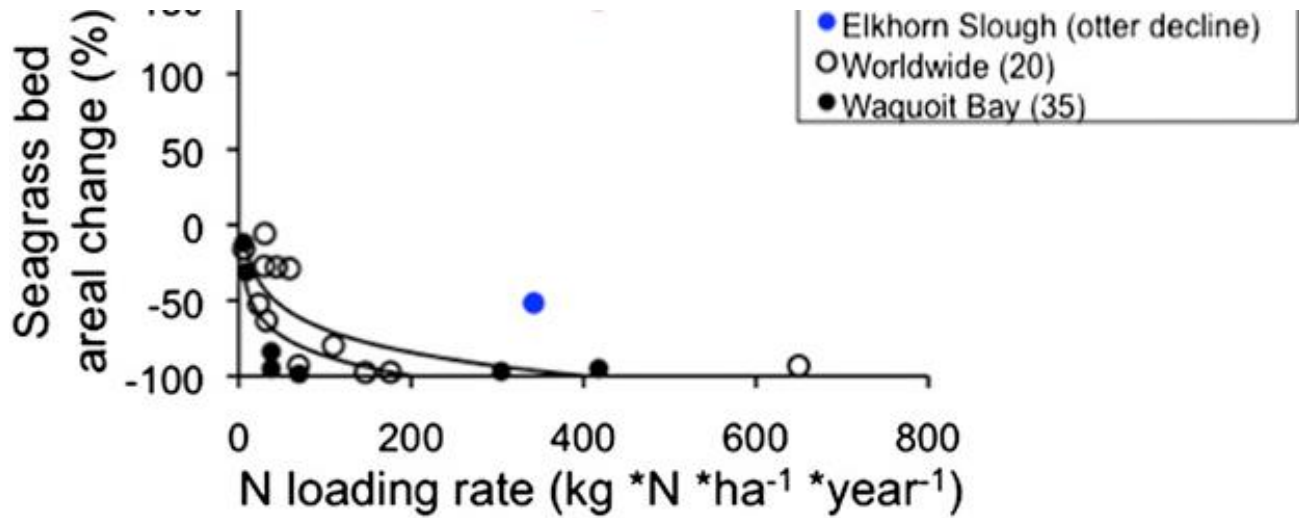
Describing the figure:

x-axis in your own words:

y-axis in your own words:

black circles:

open circles:

Overall pattern:

Interpretation: What is the take-home message from this figure?


What might cause this pattern?

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With your group, analyze the figures below.

Figure 1: Elkhorn Slough food web & species interactions
This figure shows a simplified food web from Elkhorn Slough. Crabs are the primary intermediate predators, and mesograzers include crustaceans (isopods) and sea hares. Epiphytes are organisms that grow on leaves—in this case, algae grow on the eelgrass leaves. Arrows point to the organism being consumed (e.g., sea otters consume crabs). Plus signs indicate positive interactions and minus signs indicate negative interactions. Focus on the solid arrows, which represent direct interactions.
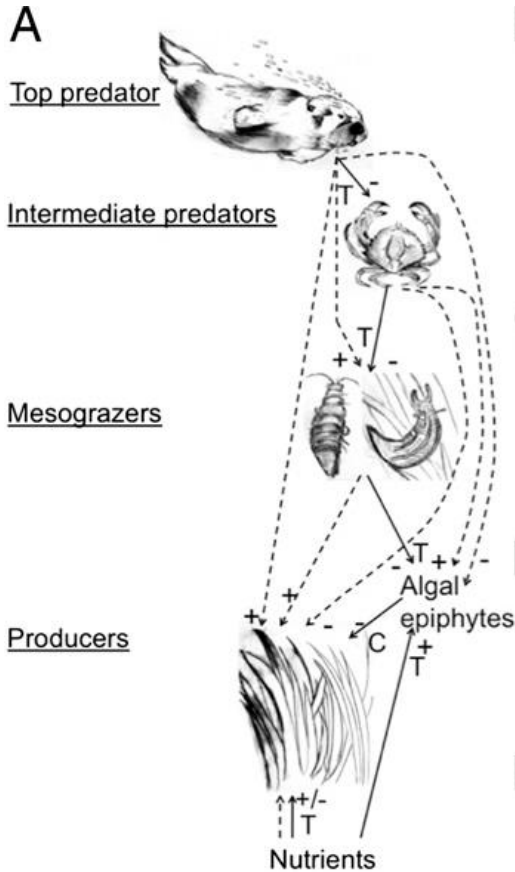
1. Identify the trophic level (e.g., primary consumer) of each species below.

| Species	Trophic level
Crab	
Isopod	
Sea hare	
Eelgrass	
Algae	

2. Why would algal growth on seagrasses be a problem for them? (*Hint: remember that seagrasses are plants*)

3. Adding N increases algal growth in this system. Is this an example of bottom-up or top-down control? Briefly explain.

Figure 2: Effects of sea otters on crabs
In 1984, sea otters naturally recolonized Elkhorn Slough. Sea otters consume marine invertebrates, including sea urchins, crabs, and bivalves. They typically dive to collect their food and return to the surface to eat it; there, they lie on their backs and smash open the invertebrates with a rock.

Analyze the figure below, using the questions as a guide.
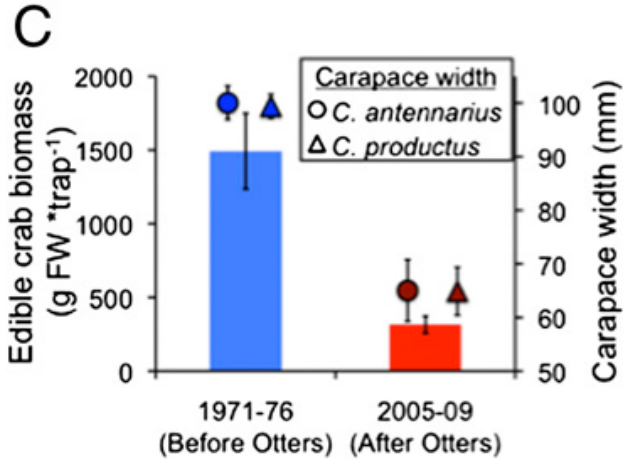
1. Describe the x-axis in your own words.

2. Explain both y-axes in your own words. FW stands for fresh weight (weighing the crabs right out of the water); trap^{-1} indicates per trap. Carapace is the upper crab shell.

3. What do the colors and symbols on the graph represent?

red	blue	circle	triangle

4. What is the key pattern in the graph?

5. Interpret the pattern. What might the importance of this pattern be to the community at Elkhorn Slough?

Predictions
Predict whether the reintroduction of sea otters would increase (I), decrease (D), or have no effect (NO) on each of the other populations in Elkhorn Slough. Be prepared to explain your answer!

| Species	Effect			Species	Effect		
sea hares	I	D	NO	isopods	I	D	NO
algae	I	D	NO	eelgrasses	I	D	NO

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Figure 3: Testing your predictions
The figure below is related to your predictions about effects of sea otters on the different populations in Elkhorn Slough. Analyze it, and determine whether the data support your prediction.

Analysis—you don't have to write down answers to these questions, but discuss them in your group.

- What is the x-axis in your own words? (ha refers to hectares, a measure of area like acres). Remember that variables with a negative exponent are in the denominator (verbally, this is "per *variable*").
- What trophic level is represented by each graph (B, C, D, and E; note that E is seagrasses)?
- What are the y-axes? DW refers to dry weight, CPUE refers to catch per unit effort (or how long you spent crabbing), and variables with a negative exponent are in the denominator (in C, for example, shoot(cm)$^{-1}$ means per cm of shoot).
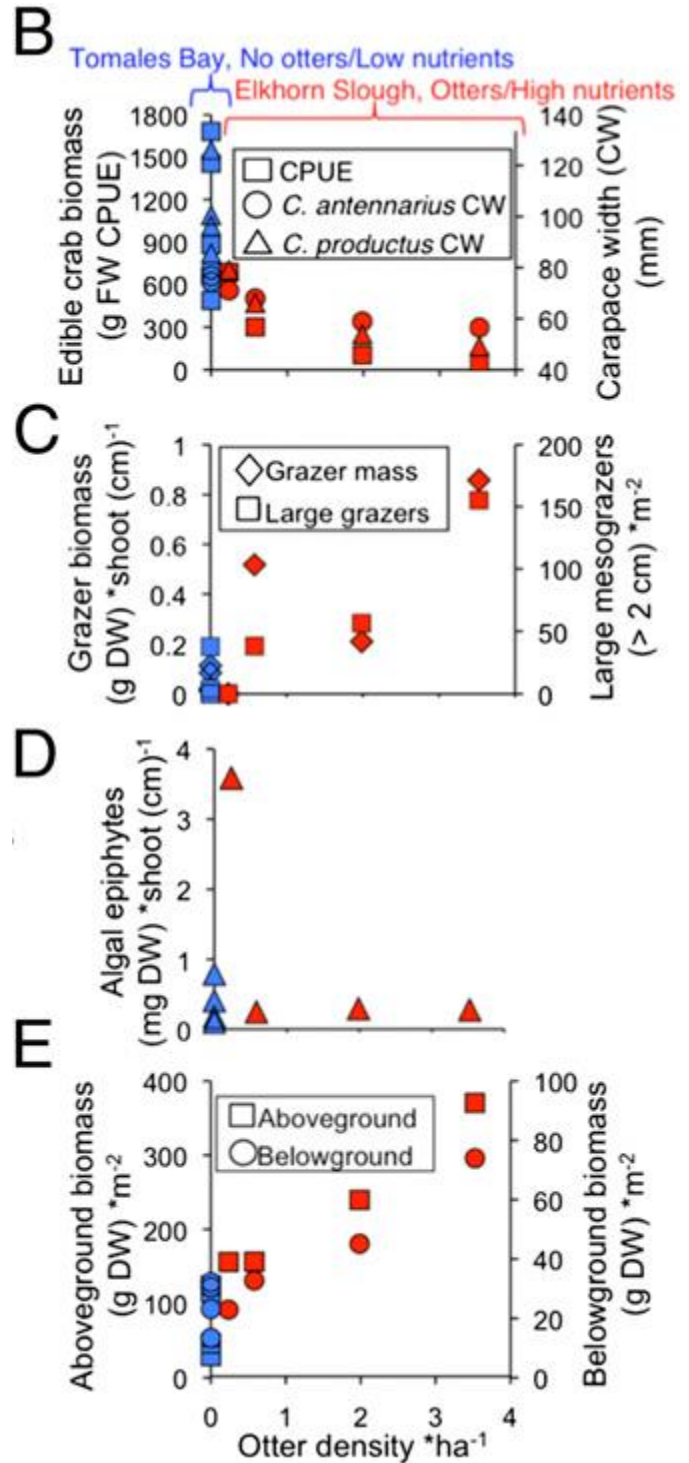
1. Do the figures match your predictions? If not, which ones are mismatch?

2. Do these data suggest a trophic cascade has occurred in Elkhorn Slough? Why or why not?

3. Based on this example, why might focusing on top predators could be a useful conservation strategy. Be sure to consider the information you learned about seagrasses and eutrophication in preparing for this case study.