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M2A2: Category I Lab Assignment: Keystone Predator
All information from SimUText and SimBio Labs

This lab explores community ecology in a rocky intertidal area. You will collect and analyze data from transplant experiments, gut-content sampling, and removal experiments to evaluate how direct and indirect effects impact community structure and to generate and test predictions about keystone species.

Section 1: Rocky Intertidal Community Dynamics

The laboratory simulation is based on a series of experiments conducted along the rocky shores of Washington State.

Where were the experiments performed? The experiments were performed in the Pacific Northwest, on the rocky shores of Washington State, along an island known as Tatoosh Island (Paine, 1966; Paine, 1969).

Which are the nine species studies in the intertidal community?

- Nori Seaweed (*Porphyra* sp.) - Algal
- Mussel (*Mytilus* sp.) - Algal
- Coral Weed (*Corallina* sp.) - Algal
- Starfish (*Pisaster ochraceus*) - Animal
- Whelk (*Nucella* sp.) - Animal
- Chiton (*Katharina* sp.) - Animal
- Gooseneck Barnacle (*Pollicipes polymerus*) - Animal
- Black Pine (*Neorhodomela* sp.) - Animal
- Acorn Barnacle (*Semibalanus* sp.) - Animal

Primary producers?

- Black Pine (*Neorhodomela* sp.) - Sessile producer
- Nori Seaweed (*Porphyra* sp.) - Sessile producer
- Coral Weed (*Corallina* sp.) - Sessile producer

Consumers?

- Starfish (*Pisaster ochraceus*) - Mobile consumer
- Whelk (*Nucella* sp.) - Mobile consumer
- Chiton (*Katharina* sp.) - Mobile consumer
- Gooseneck Barnacle (*Pollicipes polymerus*) - Sessile consumer
- Mussel (*Mytilus* sp.) - Sessile consumer
- Acorn Barnacle (*Semibalanus* sp.) - Sessile consumer

Define the population size index used in the simulation. According to the lab, the population size index is the number of individuals of each species in the community that are present in the lab simulation. The lab shortens it to the expression “population size.” In the simulation, this means the number of each distinct

animal species (mobile/sessile consumers) and the number of each distinct algal species (primary sessile producers) present within the lab simulation.

Define competitive rank in a competitive dominance hierarchy. The species that outperforms other species, or displaces other species' through the competitive exclusion principle if they have the same niche (Roeleke, Johannsen & Voigt, 2018) is referred to as competitively dominant. When looking at competitive rank within a competitive dominance hierarchy, arrows pointing from one species to another indicate a species that is competitively weaker (arrows coming from) than the more dominant species (arrows going to). The total number of arrows pointing to each species in a competitive dominance hierarchy diagram indicates the species rank as one competing for the same resource.

Define the term keystone species. A keystone species is a species in an ecological community that, despite having a low abundance, has a large impact on the structure of the ecological community. If the population of that species declines significantly or is removed altogether, the structure of the ecological community would be drastically altered.

Section 2: Ruling the Rock

This exercise will allow you to create competitive dominance hierarchy and food web diagrams to understand the community structure in the intertidal zone.
What do you think? List the competitive dominance hierarchy of the nine species in the simulation, based on your readings about the characteristics of the species. Write this list BEFORE you complete experiments. (Please list from lowest to highest.)

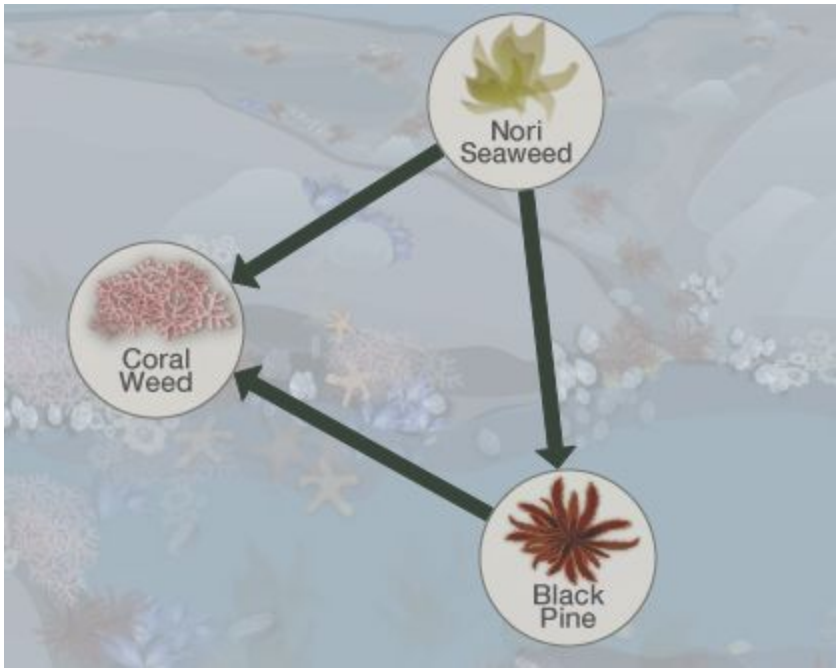
Lowest to Highest

- Nori Seaweed (*Porphyra* sp.)
- Black Pine (*Neorhodomela* sp.)
- Coral Weed (*Corallina* sp.)
- Acorn Barnacle (*Semibalanus* sp.)
- Gooseneck Barnacle (*Pollicipes polymerus*)
- Mussel (*Mytilus* sp.)
- Whelk (*Nucella* sp.)
- Chiton (*Katharina* sp.)
- Starfish (*Pisaster ochraceus*)

Complete experiments.

Sessile Producers (Algae) Competitive Dominance Hierarchy

- Nori Seaweed (*Porphyra* sp.) - Weakest
- Black Pine (*Neorhodomela* sp.) - Second Strongest
- Coral Weed (*Corallina* sp.) - Strongest

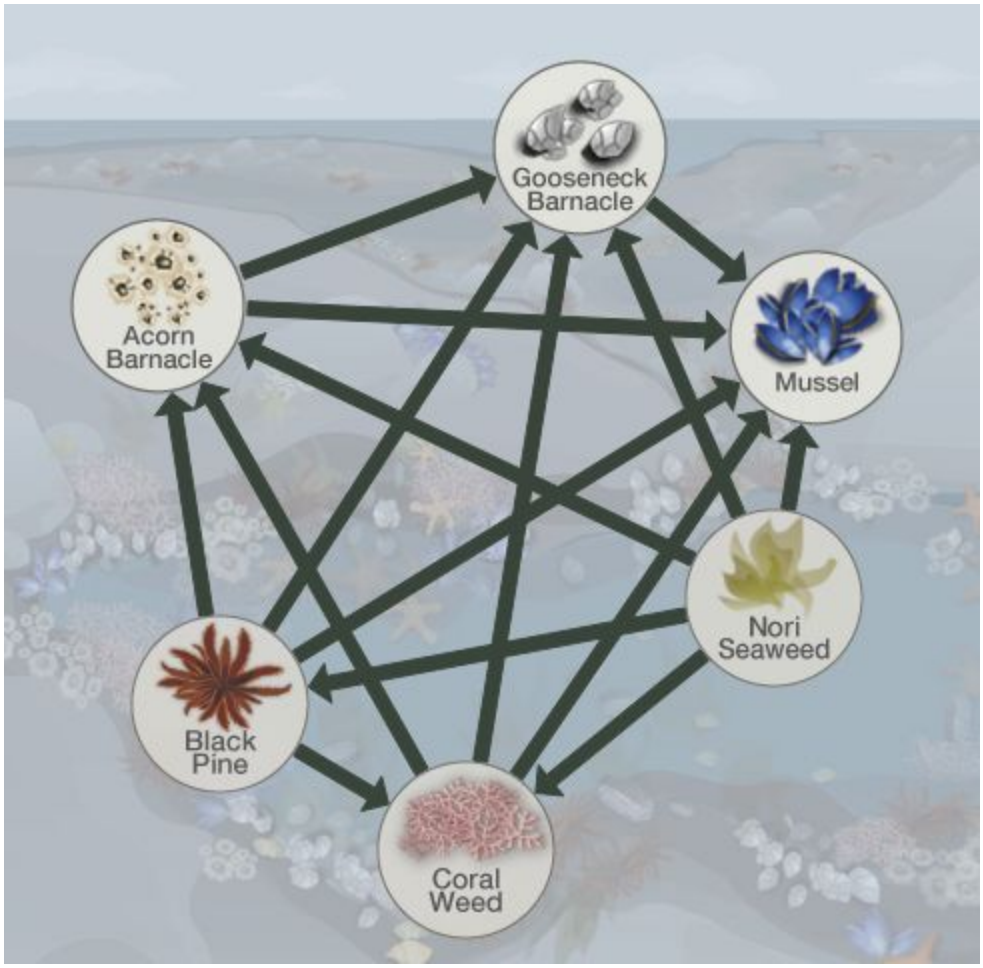


Sessile Consumers (Animal) Competitive Dominance Hierarchy

- Acorn Barnacle (*Semibalanus* sp.) - Weakest
- Gooseneck Barnacle (*Pollicipes polymerus*) - Second Strongest
- Mussel (*Mytilus* sp.) - Strongest

Copy the finished diagram into this worksheet and paste it below.

Sessil Producer & Sessil Consumer Dominance Hierarchy Diagram



Complete the activity “You are what you eat! (Page 7)”

Gut Contents for Mobile Consumers

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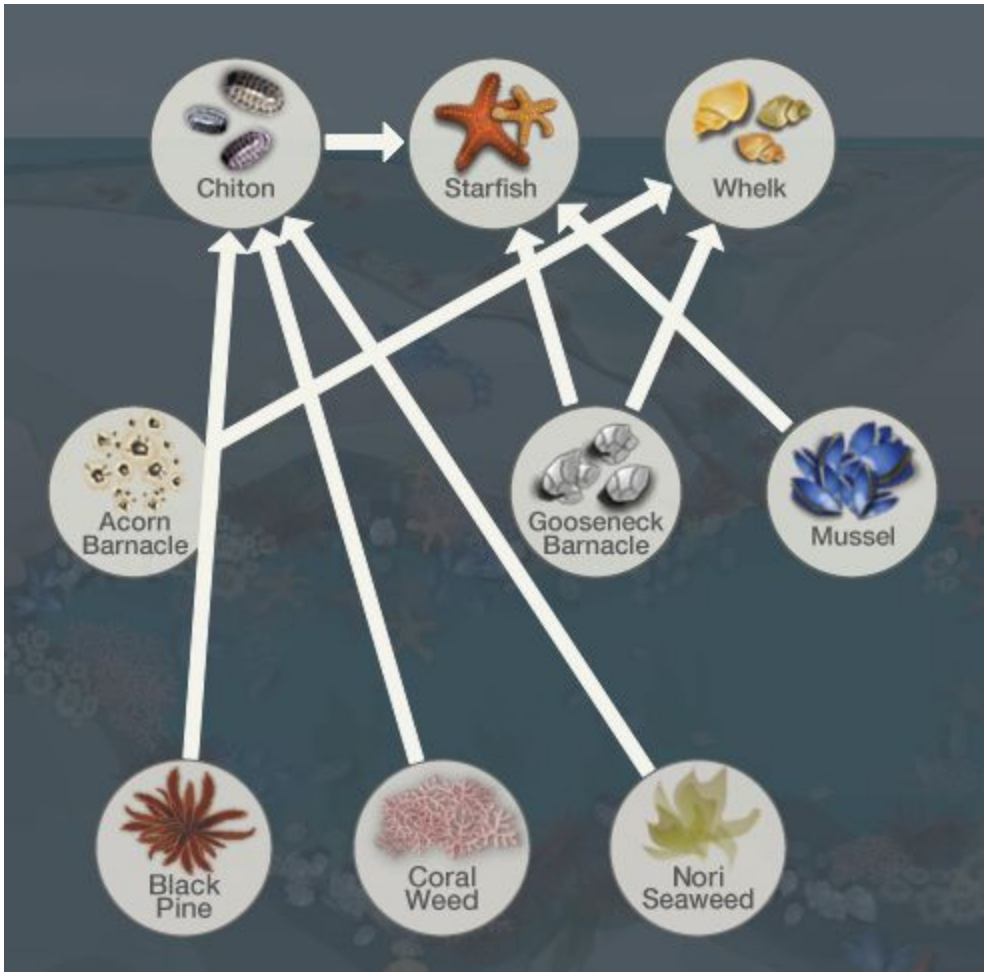
Sample:	WHELK	CHITON	STARFISH
1	Acorn B.	Coral Weed	Chiton
2	Acorn B.	Coral Weed	Gooseneck B.
3	Acorn B.	Black Pine	Gooseneck B.
4	Acorn B.	Black Pine	Gooseneck B.
5	Gooseneck B.	Coral Weed	Mussel
6	Acorn B.	Black Pine	Mussel
7	Gooseneck B.	Coral Weed	Mussel
8	Acorn B.	Nori Seaweed	Mussel
9	Acorn B.	--	Gooseneck B.
10	Gooseneck B.	Black Pine	Mussel

Copy the finished Mobile Consumer Diet Summary into this worksheet and paste it below.

Mobile Consumer Diet Summary

	WHELK	CHITON	STARFISH
Prey Species:	Acorn B.	Coral Weed	Mussel
% of Diet:	70	40	50
Prey Species:	Gooseneck B.	Black Pine	Gooseneck B.
% of Diet:	30	40	40
Prey Species:	--	Nori Seaweed	Chiton
% of Diet:		10	10
Prey Species:	--	--	--
% of Diet:			

Copy the finished Food Web Diagram into this worksheet and paste it below.



Explain the reasoning for removal experiments. List your predictions for results of removal experiments (Whelk, Chiton or Starfish) and summarize experimental results. I suggest a table.

The complexity of community interspecific interactions (direct and indirect) results in difficulty assessing the importance of a species to an ecological community's structure (e.g. keystone species). As such, removal experiments are performed in order to understand community composition, including exploring and better understanding which are considered the most important species for proper ecological community structure. Moreover, researchers utilize removal experiments to explore relationships between community diversity and ecosystem function (Díaz et al., 2003).

I predicted that removing starfish from the food web will have a more profound impact on intertidal community structure in lieu of removing whelk or chiton. The following table shows the results:

Abundance Data for Removal Experiments

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Species:	BEFORE REMOVALS	AFTER WHELK REMOVAL	AFTER CHITON REMOVAL	AFTER STARFISH REMOVAL
Black Pine	159	25	202	8
Coral Weed	229	185	240	14
Nori Seaweed	107	83	93	4
Acorn Barnacle	125	442	159	50
Gooseneck Barnacle	89	204	86	149
Mussel	207	76	285	1159
Whelk	90	0	94	5
Chiton	29	3	0	2
Starfish	24	70	24	0

Copy the finished Qu.2.20 into this worksheet and paste it below.

Answer Qu2.24 and explain your result briefly (based on the experiments you completed).

The reintroduction of a keystone species does not necessarily mean that an ecological community would return to its former state prior to that keystone species having been extirpated. For example, removal could have been concomitant with environmental changes, such as unfavorable conditions for starfish in an intertidal community resulting from human action. Additionally, an invasive species might prevent starfish from completely restoring ecological balance. Finally, another species (such as Chiton) might go regionally extinct and therefore unable to return following a starfish reintroduction.

Section 3: Invasion

The European green crab, Carcinus maenas has successfully invaded intertidal shores of Washington State. Why has the European Green Crab been so successfully at colonizing? What are likely long-term consequences of the invasion to the rocky intertidal areas of the Pacific Northwest? Write a short prediction, BEFORE you complete experiments. Do justify your answers.

It is likely that the European Green Crab (*Carcinus maenas*) is successful at colonizing since they can outcompete other native predator species, such as Starfish. This would be an indirect impact. This is especially true if both species consume the same prey species. At the same time, European Green Crabs may have no natural predators in this new environment. A likely long-term consequence might be the possible decline of competing predator species (e.g. Starfish), along with the indirect increase in a producer species since the Green Crabs might consume mobile and sessile consumers.

Qu.3.1 What did the crabs you tested consume?

- Acorn Barnacle (*Semibalanus* sp.)
- Chiton (*Katharina* sp.)
- Gooseneck Barnacle (*Pollicipes polymerus*)
- Mussel (*Mytilus* sp.)
- Whelk (*Nucella* sp.)

Copy the Crab Invasion Data table into the worksheet and paste it below.

Crab Invasion Data

Species:	BEFORE CRABS Record Data	AFTER 100 WEEKS Record Data	AFTER 200 WEEKS Record Data	AFTER 300 WEEKS Record Data
Black Pine	159	170	230	215
Coral Weed	229	231	349	361
Nori Seaweed	107	113	149	137
Acorn Barnacle	125	155	97	87
Gooseneck Barnacle	89	86	67	61
Mussel	207	145	30	28
Whelk	90	25	0	0
Chiton	29	30	0	1
Starfish	24	23	4	1
Green Crab	0	74	230	234

Summarize the new community structure you discovered in the rocky intertidal zone.

There is clear evidence of direct and indirect effects on native species after the introduction of Green Crabs to the experimental rock pool, which has dramatically altered the community structure at the trophic level. Notice that after 300 weeks, there remains one Starfish. This indirect effect could lead to the extinction of a keystone species, which would have far reaching implications for community structure.. A direct effect is the decline in Mussels and the extinction of Whelk. In turn, the dramatic decline of Starfish has resulted in an indirect effect of the increase in producer species, such as Black Pine, Coral Weed, and Nori Seaweed.

References

Díaz, S., Symstad, A. J., Stuart Chapin, F., Wardle, D. A., & Huenneke, L. F. (2003). Functional diversity revealed by removal experiments. *Trends in Ecology & Evolution*, 18(3), 140-146. doi:10.1016/s0169-5347(03)00007-

Paine, R. T. (1966). Food web complexity and species diversity. *The American Naturalist*, 100(910), 65-75. doi:10.1086/282400

Paine, R. T. (1969). The Pisaster-Tegula interaction: Prey patches, predator food preference, and intertidal community structure. *Ecology*, 50(6), 950-961. doi:10.2307/1936888

Roeleke, M., Johannsen, L., & Voigt, C. C. (2018). How bats escape the competitive exclusion principle—seasonal shift from intraspecific to interspecific competition drives space use in a bat ensemble. *Frontiers in Ecology and Evolution*, 6. doi:10.3389/fevo.2018.00101