SURVIVE THE SEASCAPE: EXPLORING BLUE CRAB ECOSYSTEMS & HUMAN IMPACTS

Zoe Benson
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Grade Level
7th Grade

Subject Area
Biology

The Virginia Scientists & Educators Alliance (VA SEA) is a project of William & Mary's Batten School & VIMS Office of Outreach and Engagement. The VA SEA project is made possible through funding from VIMS, Virginia Sea Grant, the National Science Foundation, and the MacWhorter Family.

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Title: Survive the Seascape: exploring blue crab ecosystems and human impacts

Focus: Understanding the direct and indirect effects of predation, fishing, habitat loss, restoration, and disease on ecosystem dynamics within a seascape that lead to blue crab growth and survival through different life stages.

Grade Level: 7th Grade

Virginia Standards of Learning:

LS.6: The student will investigate and understand that populations in a biological community interact and are interdependent.

a: Relationships exist between predators and prey and these relationships are modeled in food webs

b: The availability and use of resources may lead to competition and cooperation

LS.7: The student will investigate and understand that adaptations support an organism's survival in an ecosystem

a: biotic and abiotic factors define land, marine, and freshwater ecosystems

b: physical and behavioral characteristics enable organisms to survive within a specific ecosystem

LS.8: The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time.

a: organisms respond to daily, seasonal, and long-term changes

b: changes in the environment may increase or decrease population size

c: large-scale changes such as eutrophication, climate changes, and catastrophic disturbances affect ecosystems

LS.9: The student will investigate and understand that relationships exist between ecosystem dynamics and human activity.

a: changes in habitat can disturb populations

b: disruptions in ecosystems can change species competition

c: variations in biotic and abiotic factors can change ecosystems

Learning Objectives:

Students will:

- Model how direct and indirect factors (like predation, fishing, habitat loss/restoration, and disease) influence blue crab populations by playing a simulation game.
- Compare and contrast how juveniles and adults experience different trade-offs between food and shelter as they grow.
- Assess how changes in environmental conditions and human activities affect the crab population.
- Explain how blue crabs depend on multiple, connected habitats within the Chesapeake Bay.

Total length of time required for the lesson: ~90 minutes

Vocabulary:

Habitat: the place where an organism lives and gets what it needs, like food/shelter (small scale)

Ecosystem: all living and non-living things in one area that interact with each other (medium scale)

Seascape: a large area of the ocean made up of many connected ecosystems (large scale)

Spawning: when a water animal releases eggs (and sometimes sperm) into the water

Metamorphosis: when an organism undergoes a major physical body change

Primary Dispersal: The first time a young organism leaves where it was born to live in a new place

Nursery Habitat: a safe place that gives young organisms food and shelter while they grow

Carrying Capacity: the maximum number of organisms that an area can support

Secondary Dispersal: when an organism moves later in life to a better place to live for its current needs

Fishing Limits: rules that control how many or how large of a fish can be caught

Marine Protected Areas: parts of the ocean that are protected to help plants and animals survive

Habitat Restoration: fixing damaged habitats so they can be healthy again

Tradeoffs: a compromise where gaining one thing means losing another

Background Information:

1. Blue Crab Life Cycle

Adult female blue crabs spawn, releasing eggs near the mouth of the Chesapeake Bay or the coastal ocean, where the water is saltier. The eggs hatch into larvae that drift in the open water. As larvae grow, they transform into megalopa. These young crabs begin moving back into the Bay with the tides, searching for nursery habitats. The first place young crabs settle and **metamorphose** into juveniles is called their **primary dispersal site** (gameplay starts here), which also serves as an important **nursery habitat,** such as a seagrass or marsh edge. As crabs grow larger or conditions change, they may move to new habitats. They leave their first home if it exceeds the **carrying capacity**. This may result from the habitat becoming too crowded, low in food, or degraded for a variety of reasons. This movement is called **secondary dispersal.** Adult crabs often live in deeper water habitats, such as sandy or muddy

unstructured bottoms or oyster reefs, where there is an abundance of food. Their goals are to survive, find mates, and reproduce. Mature egg-bearing females eventually migrate back toward the mouth of the Bay, where they spawn, restarting the life cycle.

2. Blue Crabs and People

Blue crabs are important to people who live and work around the Chesapeake Bay. Many watermen depend on catching crabs to make a living. To make sure we don't catch too many and run out in the future, scientists study the crab population and share what they learn with fishery managers. These managers make rules to help protect crab numbers while still allowing people to fish. Some of the ways they do this include setting **fishing limits**, creating **marine protected areas**, and helping to **restore habitats,** like seagrass beds and marshes. Healthy habitats help crabs grow, which means more crabs for the ecosystem and for people to catch in the future.

3. Surviving in a Seascape

A **seascape** is a mix of many connected ecosystems, like how a town is made up of different neighborhoods. Instead of looking at just one place, a seascape helps us see how all the habitats work together. If one ecosystem is damaged, the survival of a species may depend on the health of the entire seascape.

You will now experience life in the seascape firsthand by playing a board game where you are a blue crab! As you move through habitats, meet your energy needs, and face challenges, you will see how survival depends on the whole seascape. You will also learn that there can be **tradeoffs** between food and shelter within different habitats.

Materials & Supplies:

Preparation

- Scissors or paper cutter (all straight cuts)
- Binder Clips (optional)
- Laminator (optional)

Per Group of 3-4 Students

- 1 Cut board game packet (See Appendix, print from PDF)
- 1 6-sided die
- 1 Manila Envelope for storage (8.5 x 11 inch minimum)

Teacher Preparation (~10 minutes per game packet, excluding lamination time):

1. Print and cut out the "game packet" PDF along the dashed lines. Laminate materials so they can be reused for future lessons

Note that 1 game packet PDF= 4 students (but can be played with 3), and it must be printed double-sided flipping on the long edge. The game packet PDF will contain the following:

- 1 Game Instruction Sheet
- 4 turn sequence quick reference sheet/energy tracking cards
- 4 game board tiles
- 4 player tokens
- 4 mate tokens

- 4 energy tracking tokens
- 4 crab sheets
- 24 event cards

2. Binder clip together 1 of each of the following for each player to speed up setup. All components are color/symbol-coded.
    - 1 turn sequence quick reference sheet/energy tracking cards
    - 1 energy tracking token
    - 1 game board token
    - 1 crab sheet
3. Binder clip together 24 event cards and 4 game boards to speed up setup
4. Place 1 6-sided die and the cut/clipped game packet materials in a manila envelope

Procedure:

1. Introduction (10–15 minutes)

**Presentation has extensive speaker notes to aid you.

- (SLIDE 2) Meet the scientist.
- (SLIDE 3) Begin with a hook referring to PowerPoint speaker notes.
- (SLIDE 4) Introduce students to learning objectives to focus on during the lesson.
- (SLIDES 5-9) Briefly review the blue crab life cycle, emphasizing habitat shifts and movement and the concept of a seascape (multiple, connected ecosystems & habitats).
- (SLIDE 10) Briefly relate back to the hook to reinforce understanding.
- (SLIDES 11-15) Optionally get into more detail about commonly used habitats. This may help students understand tradeoffs and why they have different energy and shelter values in the game.
- (SLIDE 16) Introduces idea of human impacts
- (SLIDE 17) Shows that the ecosystem and people are intertwined
- (SLIDE 18) Introduce idea of a direct vs. an indirect effect. This will be important for the worksheet as well.
- (SLIDE 19-20) Explain the difference between an ecosystem and a seascape and why we should care about the seascape for blue crabs. Then clarify the small to large scale differences of habitats, ecosystems, and seascapes.
- (SLIDES 21-24) Transition to activity. Introduce the main question: “How do blue crabs survive as they move through different habitats in different life stages, and what happens when those habitats change ?” Instead of these slides, you can also use the video linked below.

2. Gameplay/Setup (~30-45 minutes)

VIDEO LINK HERE (https://youtu.be/vUN-gowEgdU)

- Divide students into small groups (3–4 players per group).
- Each group receives one game packet envelope. You can explain the instructions to them (SLIDES 21-24), play the setup/gameplay video, or just have them refer to the game instructions inside and use the QR code to the video on it if needed. Playing through a round together may help students.
- Assign groups to a habitat-rich or habitat-limited system by including/excluding 2 of the game board tiles. Have half the class play each way and discuss at the end.

3. Worksheet (~10-15 minutes)

- Have students work in a group and pay attention to their discussion to gauge understanding.

4. Reflection & Discussion (10–15 minutes) (SLIDE 25)

- Ask students to raise their hand if their group experienced the most mortality in stages 1-4, going through the stages in order. Then ask why they might die more as a juvenile than an adult? Habitat-rich areas should have more resources and less competition, leading to greater survival than habitat-limited seascapes.

  If you have a group/student who, due to chance, does not follow the expected pattern of increased survival in habitat-rich systems and at later adult life stages, explain that: "everyone was playing as different individuals in a population, and even in the best conditions, some individuals will die. Chance plays a role, so variation is normal."
- Ask students what happened when they had an encounter. Did it matter what habitat they were in? Did it matter what life stage they were in?
- Why might it be important for the seascape to have many ecosystems/habitats?

  Encourage students to notice how habitat variety and connections change survival outcomes.

In summary, connect back to key ecological concepts: Carrying capacity and limiting factors, trade-offs between food and shelter, human impacts on ecosystems, and the Importance of connected habitats (seascape ecology).

5. Extension / Wrap-Up (Optional)

- Challenge them to design a management plan to increase crab survival (i.e., create a new marine protected area or restoration event).

Assessment:

Observe students during gameplay and group discussions to gauge understanding of how things can change in an ecosystem seascape and how it can change as you move through the life stages. Students will complete a worksheet that reinforces this concept. The class will discuss what happened when playing and relate it back to real-world concepts.

References:

Hines, A. H. (2007). Ecology of juvenile and adult blue crabs. *The Blue Crab Callinectes sapidus. Maryland Sea Grant College, College Park, Maryland*, 565-654.

Hyman, A. C., Chiu, G. S., Seebo, M. S., Smith, A., Saluta, G. G., Knick, K. E., & Lipcius, R. N. (2023). Model-based evaluation of critical nursery habitats for juvenile blue crabs through ontogeny: abundance and survival in seagrass, salt marsh, and unstructured bottom. *bioRxiv*, 2023-07.

Integration and Application Network, University of Maryland Center for Environmental Science. (n.d.). Media library.

Lipcius, R. N., Eggleston, D. B., Heck Jr, K. L., Seitz, R. D., & Van Montrans, J. (2007). Post-settlement abundance, survival, and growth of postlarvae and young juvenile blue crabs in nursery habitats. *The Blue Crab Callinectes sapidus. Maryland Sea Grant College, College Park, Maryland*, 535-564.

Handouts/Worksheets:

Name:_____ Date: _____

Survive the Seascape: exploring blue crab ecosystem connections and human impacts

Instructions

When your teacher tells you to, open your board game and locate the "Game Instructions" sheet. Read through and follow along to begin playing. Write down your selected game board setup and fill in the table below as you play. After playing, fill out the questions below.

Gameplay Option Selected (circle one): Habitat-Rich OR Habitat-Limited

Life Stage	Number/Cause of Deaths (place tally marks beside the causes)		Group Total Number of Deaths
Juvenile 1	Predation:	Disease:	
	Fishing:	Negative Energy:	
Juvenile 2	Predation:	Disease:	
	Fishing:	Negative Energy:	
Juvenile 3	Predation:	Disease:	
	Fishing:	Negative Energy:	
Adult 4	Predation:	Disease:	
	Fishing:	Negative Energy:	

Questions

1. Are you more likely to die as a juvenile or an adult? (circle 1)

Juvenile OR Adult

2. Fishing and Predation affect different stages of blue crabs in different ways. Circle the correct answer for each statement.

Juvenile crabs are more likely to die from:
a. Fishing b. Predation

Adult crabs are more likely to die from:
a. Fishing b. Predation

When fishing removes many large predators (like fish or adult crabs), what happens to juvenile crab survival?
a. Fewer juveniles survive
b. More juveniles survive
c. No change

3. Compare and contrast the positives and negatives of different habitats. Were there any tradeoffs? Was it the same for adults and juveniles? (Hint: talk about the energy and shelter for each habitat and how your abilities on the crab card relate to your habitat)

4. There are both direct and indirect influences on the crab population. Sort the following 4 controls into one or more columns in the table below. (Hint: Direct = happens to the crab itself; Indirect = happens to something that affects the crab, like its habitat, predators, or prey)

Marine Heatwave Predation Fishing Habitat Restoration

Direct influences	Indirect Influences

5. Do humans have any control over improving or harming ecosystems? Provide an example of each from the game or real life.

Answer Keys:

Name:_____ Date: _____

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Gameplay Option Selected: Habitat-rich ecosystem OR Habitat-limited ecosystem

Number and causes of death will vary depending on roll outcomes, but you should generally see more deaths in the youngest juveniles (stages 1-3) and less as you get to stage 4.

Life Stage	Number/Cause of Deaths (place tally marks beside the causes)		Group Total Number of Deaths
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	Fishing:	Negative Energy:	
Juvenile 2	Predation:	Disease:	
	Fishing:	Negative Energy:	
Juvenile 3	Predation:	Disease:	
	Fishing:	Negative Energy:	
Adult 4	Predation:	Disease:	
	Fishing:	Negative Energy:	

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There is a tradeoff between energy (food) and shelter in the different habitats. Crabs need energy to grow, but they also need shelter to avoid predators. This is more important for juveniles than adults since juveniles are smaller and more likely to be eaten. They will do better in seagrass or marsh habitats that have both energy and shelter, although seagrass is best. For adults, the shelter matters less since they are larger and can bury themselves or swim away better. Thus, the best place for them is in the unstructured habitat, which has the most energy for them. The oyster reef and marsh are good in-between habitats that can be used if the best habitats have been damaged or are risky when another player is there, and you may have an encounter.

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Marine Heatwave Predation Fishing Habitat Restoration

Direct influences	Indirect Influences
Predation Fishing	Marine Heatwave Habitat Restoration Fishing

Note that fishing directly influences adults while indirectly influencing juveniles. In the case of this activity, this happens by increasing or decreasing the adult blue crabs, which are cannibalistic, in a given area. (In reality, this can happen by increasing/decreasing any predator species). This is represented in the fishing limit reduction/increase event cards. Also note that predation can be both, but that is not as explicit in this game.

5. Do humans have any control over improving or harming ecosystems? Provide an example of each from the game or real life.

Yes, they can improve and harm ecosystems. They can harm ecosystems through activities like pollution, which can lead to marine heatwaves, or by overharvesting oysters, which reduces food and shelter for crabs. They can improve ecosystems by creating marine protected areas, setting fishing limits, or doing habitat restoration to rebuild seagrass beds, marshes, and oyster reefs.

Appendices:

Please print the "game packet" PDF for properly sized game materials. Below the instructions and turn sequence sheets are large to explain gameplay, and there is a smaller preview of the whole packet. The 1st and 3rd columns are the fronts and the 2nd and 4th are the backs.

Game Instructions

You are the blue crab! As you play, make note of challenges crabs face (such as predators, disease, and fishing), and the number of deaths during each stage in the table on your worksheet. At the end tally up the group total number of deaths.

Goal: Collect energy ( ) to grow. Be the first to survive to adulthood, find a mate, and reproduce in the mouth of the Chesapeake Bay to win.

How to begin:

1. Select gameplay option using game boards 1-4 for a habitat-rich and 3 & 4 only for a habitat limited seascape. Line up boards by matching arrows on the back of the boards or using the image below.
2. Distribute 1 energy tracking token, 1 game board token, 1 quick reference sheet/ energy tracking card, and 1 crab sheet to each player. They are color coded in blue, pink, yellow, and green for each player.
3. Players will begin in different life stages. If you are a group of 3, exclude the pink circle supplies.
4. Place energy tracking token at 0 energy on the energy tracking card.
5. Place your game board token on any habitat space excluding the mouth of the bay. Player order is diamond, circle, square, heart. **Each turn, follow the steps on your turn sequence quick reference sheet**.

Setup:

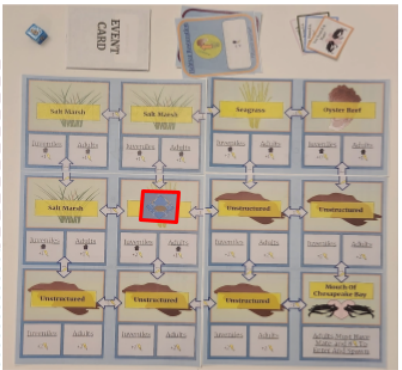
Group materials include:

- 1 Game Board Set of 4 tiles
- 1 Deck of 24 Event Cards
- 4 mate tracking tokens
- 1 6-Sided Die
- 1 Instruction Sheet

Each player will need:

- 1 Energy Tracking Token
- 1 Player Token
- 1 Turn Sequence Quick Reference / Energy Tracking Sheet
- 1 Crab Sheet

= Energy = Shelter



6-sided die | Event Cards | Discard Pile | Mate Tokens

Board 1 *remove for habitat limited

Board 2 *remove for habitat limited

Player Token *start anywhere but mouth of bay

Board 3

Board 4

Turn sequence quick reference sheet

Energy tracking card with token set on 0

Crab Sheet

Turn Sequence Quick Reference Sheet

Death: You may **die during event cards or if you have negative energy.** If you die, remove your player token, reset energy to 0, and remain in your current life stage. Place your token on a habitat of your choice at the start of your next turn.

Each turn do the following steps in order:

1. If you have **enough energy ( ) , spend it and grow** to the next stage.

2. **Draw an Event Card.** (remove all orange cards from board, add to discards, and shuffle discards **when deck runs out**)
   - Orange cards, **place on the board to modify the habitat written at the bottom of the card** (1 card per habitat space). If no spaces of the habitat are empty, discard and continue to step 3
   - Purple cards, **roll** as instructed. (**Check crab sheet** for helpful **ABILITIES**!)

3. **If another player is on your habitat space, follow the encounter rules below**
   - **All Stages :**
     - **If enough** is available for all players, **only get 1/2** (round down to nearest whole number)
     - **If you can't split** , each player rolls the die. The **higher roll wins** and stays, and the **loser must move** to a new habitat (-1).
   - **Stages 3 & 4:** You may choose to use your **cannibalism** or **find a mate** abilities when conditions are met

4. **Gain Energy** from your habitat including orange card modifier.

5. **Move or Stay.**
   - If you **move**, -1 per tile moved
   - In **stage 4**, if you choose to **stay,** you can use your **find a mate** ability

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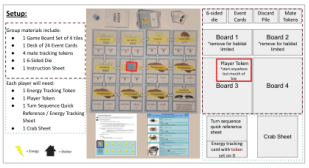

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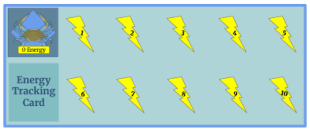

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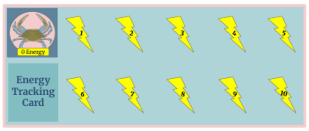

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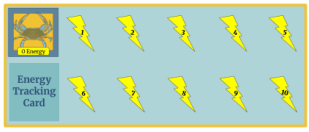

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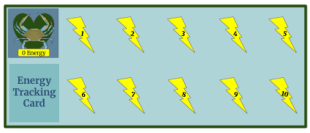
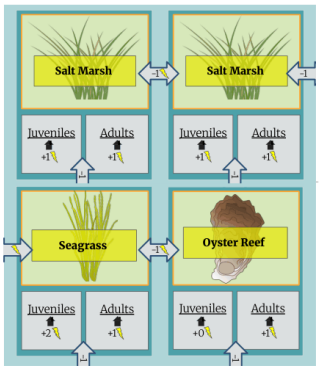
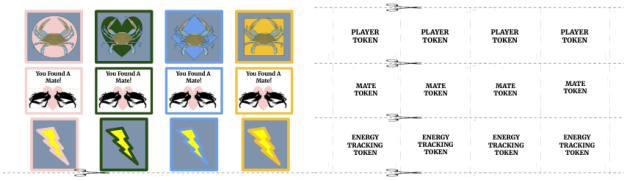
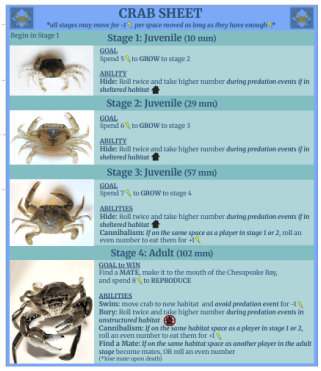
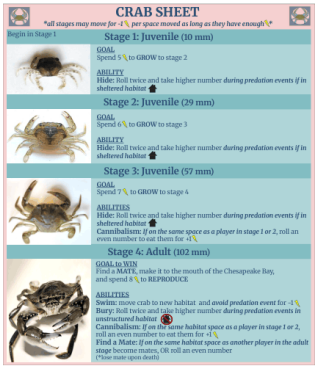
   - If you **move**, -1⚡ per tile moved
   - In **stage 4**, if you choose to **stay**, you can use your **find a mate** ability

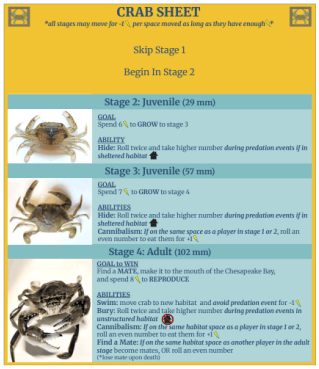


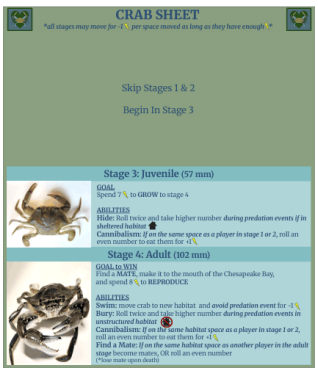


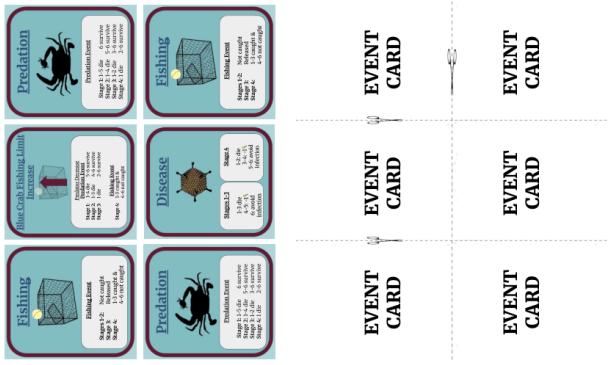

You Found A Mate!
You Found A Mate!
You Found A Mate!
You Found A Mate!
PLAYER TOKEN
PLAYER TOKEN
PLAYER TOKEN
PLAYER TOKEN
MATE TOKEN
MATE TOKEN
MATE TOKEN
MATE TOKEN
ENERGY TRACKING TOKEN
ENERGY TRACKING TOKEN
ENERGY TRACKING TOKEN
ENERGY TRACKING TOKEN

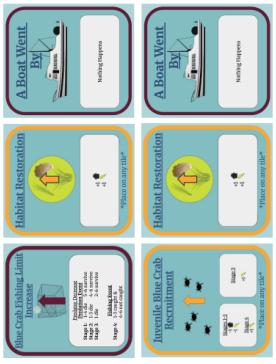

CRAB SHEET
all stages may move for -1 per space moved as long as they have enough
Begin in Stage 1
Stage 1: Juvenile (10 mm)
GOAL
Spend 5 to GROW to stage 2
ABILITY
Hide: Roll twice and take higher number during predation events if in sheltered habitat
Stage 2: Juvenile (29 mm)
GOAL
Spend 6 to GROW to stage 3
ABILITY
Hide: Roll twice and take higher number during predation events if in sheltered habitat
Stage 3: Juvenile (57 mm)
GOAL
Spend 7 to GROW to stage 4
ABILITIES
Hide: Roll twice and take higher number during predation events if in sheltered habitat
Cannibalism: If on the same space as a player in stage 1 or 2, roll an even number to eat them for +1
Stage 4: Adult (102 mm)
GOAL to WIN
Find a MATE, make it to the mouth of the Chesapeake Bay, and spend 8 to REPRODUCE
ABILITIES
Swim: move crab to new habitat and avoid predation event for -1
Bury: Roll twice and take higher number during predation events in unstructured habitat
Cannibalism: If on the same space as a player in stage 1 or 2, roll an even number to eat them for +1
Find a Mate: If on the same habitat space as another player in the adult stage become mates, OR roll an even number
(*lose mate upon death)

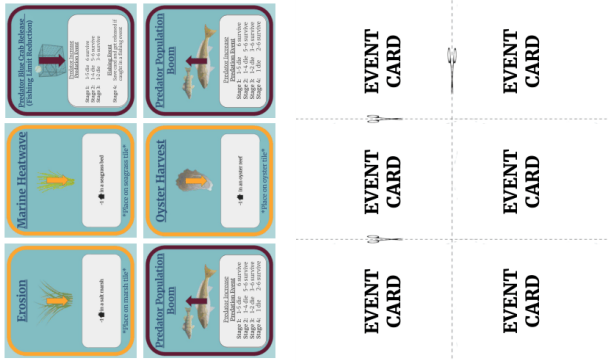

CRAB SHEET
all stages may move for -1 per space moved as long as they have enough
Begin in Stage 1
Stage 1: Juvenile (10 mm)
GOAL
Spend 5 to GROW to stage 2
ABILITY
Hide: Roll twice and take higher number during predation events if in sheltered habitat
Stage 2: Juvenile (29 mm)
GOAL
Spend 6 to GROW to stage 3
ABILITY
Hide: Roll twice and take higher number during predation events if in sheltered habitat
Stage 3: Juvenile (57 mm)
GOAL
Spend 7 to GROW to stage 4
ABILITIES
Hide: Roll twice and take higher number during predation events if in sheltered habitat
Cannibalism: If on the same space as a player in stage 1 or 2, roll an even number to eat them for +1
Stage 4: Adult (102 mm)
GOAL to WIN
Find a MATE, make it to the mouth of the Chesapeake Bay, and spend 8 to REPRODUCE
ABILITIES
Swim: move crab to new habitat and avoid predation event for -1
Bury: Roll twice and take higher number during predation events in unstructured habitat
Cannibalism: If on the same habitat space as a player in stage 1 or 2, roll an even number to eat them for +1
Find a Mate: If on the same habitat space as another player in the adult stage become mates, OR roll an even number
(*lose mate upon death)

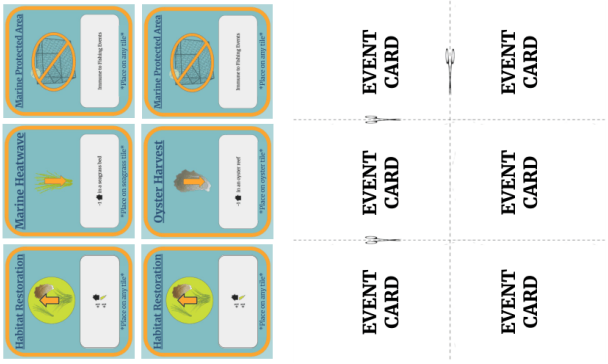

CRAB SHEET
all stages may move for -1 per space moved as long as they have enough
Skip Stage 1
Begin In Stage 2
Stage 2: Juvenile (29 mm)
GOAL
Spend 6 to GROW to stage 3
ABILITY
Hide: Roll twice and take higher number during predation events if in sheltered habitat
Stage 3: Juvenile (57 mm)
GOAL
Spend 7 to GROW to stage 4
ABILITIES
Hide: Roll twice and take higher number during predation events if in sheltered habitat
Cannibalism: If on the same space as a player in stage 1 or 2, roll an even number to eat them for +1
Stage 4: Adult (102 mm)
GOAL to WIN
Find a MATE, make it to the mouth of the Chesapeake Bay, and spend 8 to REPRODUCE
ABILITIES
Swim: move crab to new habitat and avoid predation event for -1
Bury: Roll twice and take higher number during predation events in unstructured habitat
Cannibalism: If on the same habitat space as a player in stage 1 or 2, roll an even number to eat them for +1
Find a Mate: If on the same habitat space as another player in the adult stage become mates, OR roll an even number
(*lose mate upon death)


CRAB SHEET
all stages may move for -1 per space moved as long as they have enough
Skip Stages 1 & 2
Begin In Stage 3
Stage 3: Juvenile (57 mm)
GOAL
Spend 7 to GROW to stage 4
ABILITIES
Hide: Roll twice and take higher number during predation events if in sheltered habitat
Cannibalism: If on the same space as a player in stage 1 or 2, roll an even number to eat them for +1
Stage 4: Adult (102 mm)
GOAL to WIN
Find a MATE, make it to the mouth of the Chesapeake Bay, and spend 8 to REPRODUCE
ABILITIES
Swim: move crab to new habitat and avoid predation event for -1
Bury: Roll twice and take higher number during predation events in unstructured habitat
Cannibalism: If on the same habitat space as a player in stage 1 or 2, roll an even number to eat them for +1
Find a Mate: If on the same habitat space as another player in the adult stage become mates, OR roll an even number
(*lose mate upon death)


Predation
Fishing
Blue Crab Fishing Limit Increase
Disease
Fishing
Predation
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD


A Boat Went By
Habitat Restoration
Blue Crab Fishing Limit Increase
A Boat Went By
Habitat Restoration
Juvenile Blue Crab Recruitment
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD


Predator Blue Crab Release (Fishing Limit Reduction)
Predator Population Boom
Marine Heatwave
Oxyster Harvest
Erosion
Predator Population Boom
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD


Marine Protected Area
Marine Protected Area
Marine Heatwave
Oyster Harvest
Habitat Restoration
Habitat Restoration
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD
EVENT CARD