THE SEARCH FOR SEA STARS

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Grade Level
7th Grade

Subject Area
Life Science

VA SEA is a collaborative project between the Chesapeake Bay National Estuarine Research Reserve, the Virginia Institute of Marine Science's Marine Advisory Program, and Virginia Sea Grant. The VA SEA project is made possible through funding from the National Science Foundation and William & Mary's Society of 1918 Endowment.

National Science Foundation

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Sea Grant VIRGINIA

Title: The Search for Sea Stars

Focus: Understand the role of keystone species and how to determine percent cover

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. Key ideas include
a) relationships exist between predators and prey and these relationships are modeled in food webs

LS.8 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time. Key ideas include
a) organisms respond to daily, seasonal, and long-term changes;
b) changes in the environment may increase or decrease population size; and
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. Key ideas include
b) disruptions in ecosystems can change species competition; and
c) variations in biotic and abiotic factors can change ecosystems.

Learning Objectives:

- ✓ Students will monitor coastal species
- ✓ Students will estimate percent cover of organisms in a quadrat
- ✓ Students will investigate different years and create graphs based on data collected
- ✓ Students will evaluate potential causes of change

Total length of time required for the lesson: 60 minutes

Vocabulary:

Quadrat: a frame that is usually square or rectangle used to separate out a smaller area. It helps with visually estimating the spread and abundance of organisms within that area.

Transect: a line laid down in a habitat to help scientists count the number of things in an area. Often measured out with rope or measuring tape. There are marks to indicate unit of measure, such as meters.

Percent cover: the amount of area covered by a species or organism, stated as a percentage of the total area (i.e. 5 acres has grass on it out of 10 acres of total land = 50% cover).

Intertidal zone: the area of the shore that is covered by water at high tide and exposed to air at low tide. It is the space between the highest and lowest points of the tide.

Keystone species: an organism that has a big impact on its environment and helps keep the ecosystem balanced. If a keystone species is removed, it can cause major changes to the ecosystem. This often leads to the decline or extinction of other species. In other words, they are crucial to the structure and health of the ecosystem.

Sea star wasting: a mysterious illness that causes sea stars to get sick and die very quickly, or "waste away". It causes their arms to twist, lesions to form, and eventually, their bodies to break down. The exact cause is still unknown. It might be related to bacteria or changes in ocean temperature.

Substrate: the surface or material where an organism lives, grows, or is attached.

Invasive species: a species introduced to an environment where it does not naturally belong. When this happens, it can cause harm to the environment, economy, or human health. These species compete with native species (naturally live there) for resources like food and space. They can grow and spread rapidly.

Background Information:

Sea stars are often called starfish but are now known as sea stars by scientists because they are not fish. These animals do not have backbones, so they are invertebrates. They are part of the Echinoderms group. This group has a water-based system inside their bodies that helps them move and a body shape with five equal parts arranged around a center. Fun fact: all Echinoderms are marine! They are related to sea urchins and sand dollars. While they are an iconic species in West coast tide pools of the United States, they are also star actors on the rocky Eastern Atlantic coast of North America (pun intended).

Sea stars play an important role in coastal ecosystems. They act as keystone species, meaning they help control the populations of other sea animals by eating them. This keeps the ecosystem balanced by making space for a variety of other species. For example, sea stars along the North Atlantic coast eat animals like clams, oysters, barnacles, and snails. They especially like blue mussels. Blue mussels are common and can take up lots of space on rocks, crowding out other animals. Sea stars help keep blue mussel numbers in check by eating them. This allows other species to thrive too.

Sea stars live in the intertidal zone, the area of the ocean that is between the high and low tide lines, where the land and sea meet. They experience changes in temperature, salt levels, and wave strength every day as the tide goes in and out. In 2021, scientists discovered that the number of sea stars along the North Atlantic coast was dropping. To study this, researchers used a similar method they used in 1979: they laid a 5-meter rope along the shoreline at low tide, called a transect. They then walked along it, turning over rocks and looking for sea stars, up to 1-meter away on each side. This method helped scientists count the number of sea stars in a large area by looking at many smaller areas.

The study found that there was a drastic decline in sea star abundance compared to 1979, which might be due to climate and ecosystem changes. Scientists have suggested three main reasons for the decline: 1) fewer food resources due to invasive species, 2) changes in the habitat from climate change, and 3) an increase in sea star wasting, which causes their arms to twist, wounds to form, and eventually, their bodies to break down.

First, one of the invasive species impacting sea stars is the green crab, which likely arrived in the U.S. in the ballast water on ships in the mid-1800s. They began to be spotted in Southern Maine in the early 1900s and have continued to spread along the New England coastline. Green crabs are considered one of the topmost invasive species in the world. They eat blue mussels and there is evidence of a decline in blue mussel numbers, reducing the main food source for sea stars. Therefore, sea stars could be declining because there are less food resources available. While the lesson does not cover this in detail, it could be a significant reason sea stars might be struggling.

Another reason is climate change. Off the coast of Maine is The Gulf of Maine, which is warming faster than 99.9% of the global ocean. Along with higher temperatures, we are seeing higher salinity levels and ocean acidification, also known as saltier and more acidic oceans.

Other human activities, like coastal development, are also causing long-term changes that affect sea stars, such as increased nutrient concentrations.

Finally, cases of sea star wasting are rising along the Northeastern coast of the United States. Historically, cases had only been prevalent on the Pacific Coast. Climate change stress may weaken sea stars and make them more prone to this disease. It seems to spread more frequently and be more severe as temperatures increase.

One important note is that blue mussels, urchins, and algae responses in this lesson plan are not representative of what researchers are finding. These parameters were adjusted to help emphasize the role of sea stars as a keystone species.

Materials & Supplies:

- Rocks and sea stars printout double sided, cut either into squares or ovals
    - The document has all you need: 42 rocks total, 26 with sea stars on the back
- Printed quadrats
- Clear tape
- Green, brown, and red string cut into 1-3 inch strips to have: 38 red, 34 green, and 33 brown
- 17 pompoms or cotton balls
    - Optional: paint or color them black and dark purple like urchins
- Recommended: bags, bins, or envelopes to store individual quadrat materials for easy reset (i.e. one bag for quadrat A, a separate one for quadrat B, etc)
- Optional: add shells or other photos of organisms found in the intertidal zone for variability

Teacher Preparation:

Set up quadrats (see photo below for visual)

The room will be split in half by year: 1979 and 2021. Each year will include 6 quadrats set up (12 quadrats total). Attached is a printout quadrat for regular 8.5 x 11 inch paper with gridlines and percent cover to put on a desk or spread around tables in your classroom. You have six quadrats on each side of the room, 12 quadrats total. Be sure to label which side of the room is which year.

Place the amount of string and pompom balls that represent the other organisms according to the table below in each quadrat by sprinkling them on the empty grids randomly (wherever there are not blue mussels).

Within these quadrats, place the printed rocks (print double sided) in a random array and ensure that each quadrat has the set number of sea stars and rocks. The sea stars face down. Some quadrats are assigned to have some rocks without any sea stars under them. They CAN go on top of the printed blue mussels and algae (but NOT the urchins). The idea is that sea stars are not always present, and they are searching to find them in the mess that is the intertidal zone.

Set up to your creative discretion but so that the quadrats have the following compositions:

1979					
Quadrat	**Blue mussels** (already on the printed sheet)	**# of star rocks**	**# of empty rocks**	**# of algae strings**	**# of sea urchins**
A	20%	4	0	6 red 5 green 5 brown	2
B	30%	3	0	4 red 5 green 4 brown	3
C	30%	3	1	5 red 4 green 4 brown	2
D	20%	4	0	5 red 5 green 6 brown	2
E	30%	3	0	5 red 4 green 4 brown	3
F	40%	2	1	5 red 4 green 4 brown	2

2021					
Quadrat	**Blue mussels** (already on the printed sheet)	**# of star rocks**	**# of empty rocks**	**# of algae strings**	**# of sea urchins**
G	60%	2	2	3 red 1 green 1 brown	1
H	70%	1	2	1 red 2 green 1 brown	0
I	70%	1	3	0 red 1 green 2 brown	0
J	60%	2	1	1 red 3 green	1

				1 brown	
K	70%	1	3	1 red 0 green 1 brown	1
L	80%	0	3	2 red 0 green 0 brown	0

If you are adding your own organisms, use the following guidelines:

- 1979 = high diversity, high abundance of other things
- 2021 = low diversity, lower abundance of other things

Print enough copies so that each student has their own The Search for Sea Stars Note Sheet (optional) and Think, Pair, Share sheet.

Print enough copies also for each group to have their own Coastline Monitoring Datasheet.

Set up example photo:

Procedure:

Introduction (20 minutes)

- Instructors should load the accompanying PowerPoint presentation and walk-through slides 1-11 as they introduce the lesson. If using the optional Search for Sea Stars Note Sheet, hand it out prior to beginning introduction.
- NOTE: Slide 8 and 9 can be omitted if you find they are not relevant for your class. Slide 11 can potentially also be omitted if your class has a firm background on invasives species.

Activity (40 minutes)

The goal of the activity is to count the number of stars and estimate the percent cover of blue mussels in each transect to compare changes from 1979 to 2021.

- Using slides 12 - 16, walk students through monitoring methods and give students tips on how to most effectively visually estimate percent cover:
    - Percent cover is usually less than you think
    - Suggest dividing the larger area into smaller areas, so that it is easier to focus
    - Explain to students how they can count squares of dense coverage and total squares and use this fraction to help in estimation of percent cover
- On slide 17, introduce to students how they will monitor in the classroom. Instruct students to methodically survey within each quadrat on their side of the room in their groups in a gallery walk style.
    - Be sure they understand that only ONE group is allowed to survey a quadrat at one time.
    - Emphasize Leave No Trace principles! When monitoring in the intertidal zone, it's important to be respectful of all organisms. This means avoiding stepping on the organisms and putting everything back as you found it.
- Use slide 18 to help familiarize students with what they will be monitoring. Hold up the item you will be using for urchins.
- Use slide 19 to have students formulate a hypothesis. This is where they can use the note sheet or you may ask them to raise hands and state ideas as a group.
- Then, have students form groups of 2-3 so that there are no more than 12 groups. Divide the groups between each side of the room into different years.
- While students are monitoring, have PowerPoint slide 20 up with the site information and conditions. Remind students that they should take a chance to record this data as well, suggest that it could be something to do while waiting for another quadrat.
- Once each group has monitored every quadrat on their side of the room, have them calculate the average number of stars and blue mussel percent cover between all the quadrats on their side to have a total value.
- Think, Pair, Share: Put up PowerPoint slide 21 and assign students into discussion groups with another group from the other year (e.g. one monitoring group from 1979 creates a bigger discussion group with a monitoring group from 2021).
- In these discussion groups, students should answer the questions on the Think, Pair, Share sheet to compare findings between the two years. They should identify what is different and recount to each other how abundant or diverse the other organisms were (i.e. amount of algae and other organisms present).
- Then, students should use each other's data to fill in graphs on their worksheet to show how the number of sea stars and percent cover of blue mussels changed between each year.
- Students should begin hypothesizing why there was a change from 1979 to 2021 using background information learned, temperature differences, and data collected.

- Students should prepare to share their answers the questions with the class.
- Reconvene as a class and ask each discussion group to share out one key takeaway from their conversation using the questions.
    - Lead the discussion to help students connect evidence to their conclusions and loop back to their hypotheses.
    - Ask them to explain why for their answers and try to get them to think of different responses as other groups (as well as they can!)
- Present PowerPoint slide 22 to explain to students what scientists are hypothesizing.
- NOTE: this lesson pairs well with other lessons related to averages, proportions, food webs, and community dynamics.

Assessment:

Student assessment should be based on group participation and contributions to class discussion. You may choose also to assess their Think, Pair, Share sheets.

References:

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Handouts/Worksheets:

1. Optional: The Search for Sea Stars Note Sheet
2. Coastline Monitoring Datasheet
   2A. Coastline Monitoring Datasheet Answer Key: 1979
   2B. Coastline Monitoring Datasheet Answer Key: 2021
3. Think, Pair, Share
   3A. Think, Pair, Share Answer Key

Appendices:

1. Sea Star and Rocks Printout
2. Quadrats

The Search for Sea Stars Note Sheet

Name: _____ Date: _____

Introduction notes:

What is your hypothesis?

Using the background information you just learned, what changes do you predict in species abundance from 1979 to 2021?

Coastline Monitoring Datasheet

Names: _____ Date: _____

Methodically survey within each quadrat for your assigned year. Only ONE group is allowed to survey a quadrat at one time. Remember to Leave No Trace! When monitoring in the intertidal zone, it is important to be respectful of all organisms. This means avoiding stepping on the organisms and putting everything back as you found it.

Site Information:

Site Name	Year	Time	Time of Low Tide	Air Temp (°C)	Water Temp (°C)

Data:

Quadrat Letter (A, B, C, etc)	Number of stars	Percent cover of blue mussels	Notes on other organisms (How many urchins? Types of algae? How much algae?)
Average			

Coastline Monitoring Datasheet Answer Key: 1979

Names: _____ Date: _____

Methodically survey within each quadrat for your assigned year. Only ONE group is allowed to survey a quadrat at one time. Remember to Leave No Trace! When monitoring in the intertidal zone, it is important to be respectful of all organisms. This means avoiding stepping on the organisms and putting everything back as you found it.

Site Information:

Site Name	Year	Time	Time of Low Tide	Air Temp (°C)	Water Temp (°C)
Grindstone Neck, ME	1979	9:00am	10:08am	21.1	12.7

Data:

Quadrat Letter (A, B, C, etc)	Number of stars	Percent cover of blue mussels	Notes on other organisms (How many urchins? Types of algae? How much algae?)
A	4	20%	2 urchins, 6 red, 5 green, 5 brown (does not need to be exact here, general observations are fine)
B	3	30%	3 urchins, 4 red, 5 green, 4 brown (does not need to be exact here, general observations are fine)
C	3	30%	2 urchins, 5 red, 4 green, 4 brown (does not need to be exact here, general observations are fine)
D	4	20%	2 urchins, 5 red, 5 green, 6 brown (does not need to be exact here, general observations are fine)
E	3	30%	3 urchins, 5 red, 4 green, 4 brown (does not need to be exact here, general observations are fine)
F	2	40%	2 urchins, 5 red, 4 green, 4 brown (does not need to be exact here, general observations are fine)
Average	3.17 = ~3	28%	

Coastline Monitoring Datasheet Answer Key: 2021

Names: _____ Date: _____

Methodically survey within each quadrat for your assigned year. Only ONE group is allowed to survey a quadrat at one time. Remember to Leave No Trace! When monitoring in the intertidal zone, it is important to be respectful of all organisms. This means avoiding stepping on the organisms and putting everything back as you found it.

Site Information:

Site Name	Year	Time	Time of Low Tide	Air Temp (°C)	Water Temp (°C)
Grindstone Neck, ME	2021	8:30am	9:25am	22.5	13.3

Data:

Quadrat Letter (A, B, C, etc)	Number of stars	Percent cover of blue mussels	Notes on other organisms (How many urchins? Types of algae? How much algae?)
G	2	60%	1 urchins, 3 red, 1 green, 1 brown (does not need to be exact here, general observations are fine)
H	1	70%	0 urchins, 1 red, 2 green, 1 brown (does not need to be exact here, general observations are fine)
I	1	70%	0 urchins, 0 red, 1 green, 2 brown (does not need to be exact here, general observations are fine)
J	2	60%	1 urchins, 1 red, 3 green, 1 brown (does not need to be exact here, general observations are fine)
K	1	70%	1 urchins, 1 red, 0 green, 1 brown (does not need to be exact here, general observations are fine)
L	0	80%	0 urchins, 2 red, 0 green, 0 brown (does not need to be exact here, general observations are fine)
Average	1.17 = ~1	68%	

Think, Pair, Share

Name: _____ Date: _____

In your small groups of scientists from each year, discuss and answer the following questions in Compare, Visualize, and Evaluate:

Compare

1. What is the average number of stars and percent cover for each year?

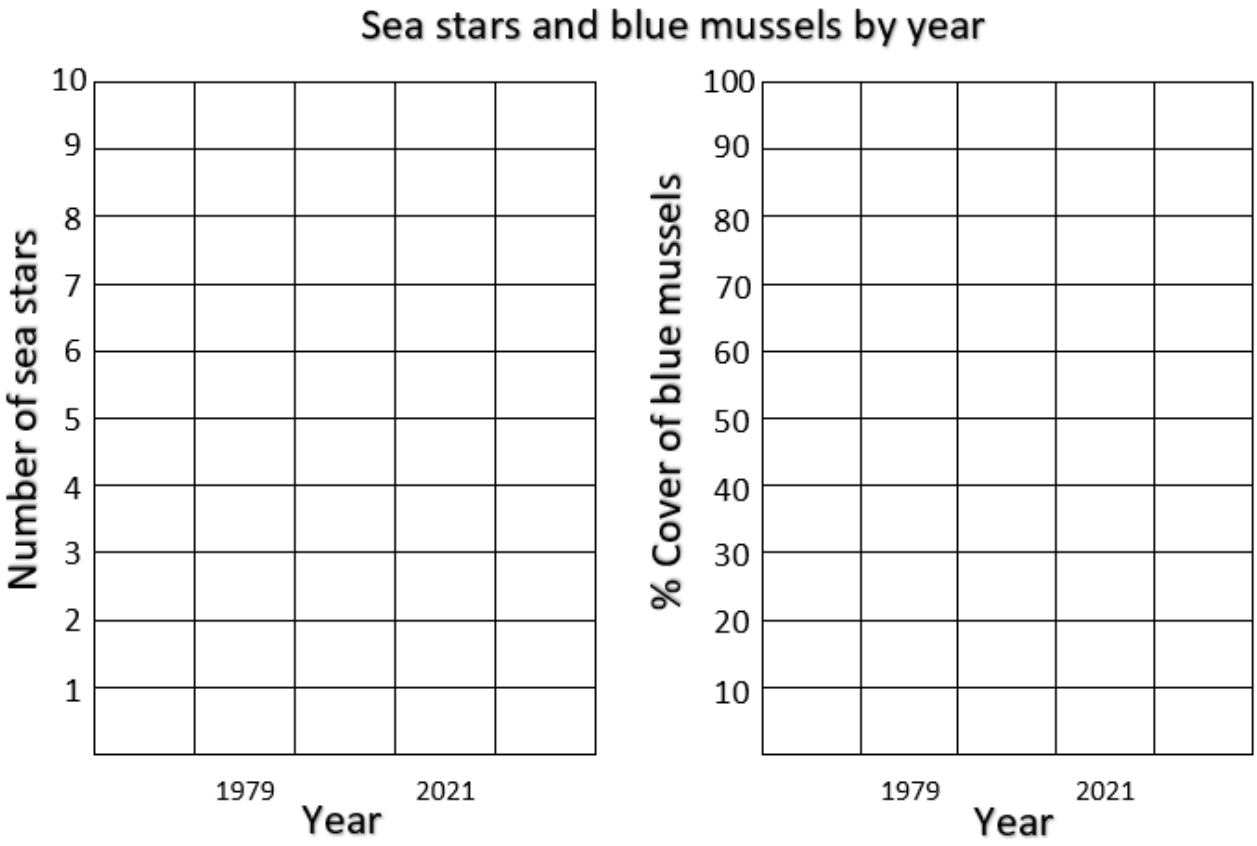
Year	Average # of Stars	Average % Cover
1979		
2021		

2. Compare findings between the two years. What is different?

3. Were there differences in how abundant or diverse the other organisms were (i.e. amount of algae, urchins, and other organisms present)? Explain the differences observed from 1979 to 2021.

Visualize

4. Use each other's data to fill in the following bar graphs to show how the number of sea stars and percent cover of blue mussels changed between each year:



Evaluate

5. Do these results support your hypothesis? Explain. NOTE: this may be different for each person!

6. Why do you think there was a change from 1979 to 2021? Use background information learned about Maine, these species, the site information, and data collected to help you brainstorm.

7. Green crabs are an invasive species on the North Atlantic coast. They eat many types of intertidal ecosystem invertebrates, including blue mussels. What do you think would happen to blue mussels and sea stars if we added green crabs to our simulation of the 2021 coastlines? Explain your answer.

8. Why do scientists use quadrats and transects? Do you think this tool is a fair assessment to understand these intertidal species populations? Explain.

9. Be prepared to share your results and key takeaways for a class discussion. Write discussion notes here:

WHAT changed (sea stars, blue mussels, algae, urchins, etc) and WHY?

Did these results support your hypothesis?

If not, what surprised you? Or what didn't surprise you?

What happens with the addition of green crabs in 2021?

Why do we use quadrats and transects? Should we?

Think, Pair, Share Answer Key

Name: _____ Date: _____

In your small groups of scientists from each year, discuss and answer the following questions in Compare, Visualize, and Evaluate:

Compare

1. What is the average number of stars and percent cover for each year?

Year	Average # of Stars	Average % Cover
1979	3.17 = ~3	28%
2021	1.17 = ~1	68%

2. Compare findings between the two years. What is different?

The average number of sea stars has decreased since 1979. The average percent cover of blue mussels has increased since 1979.

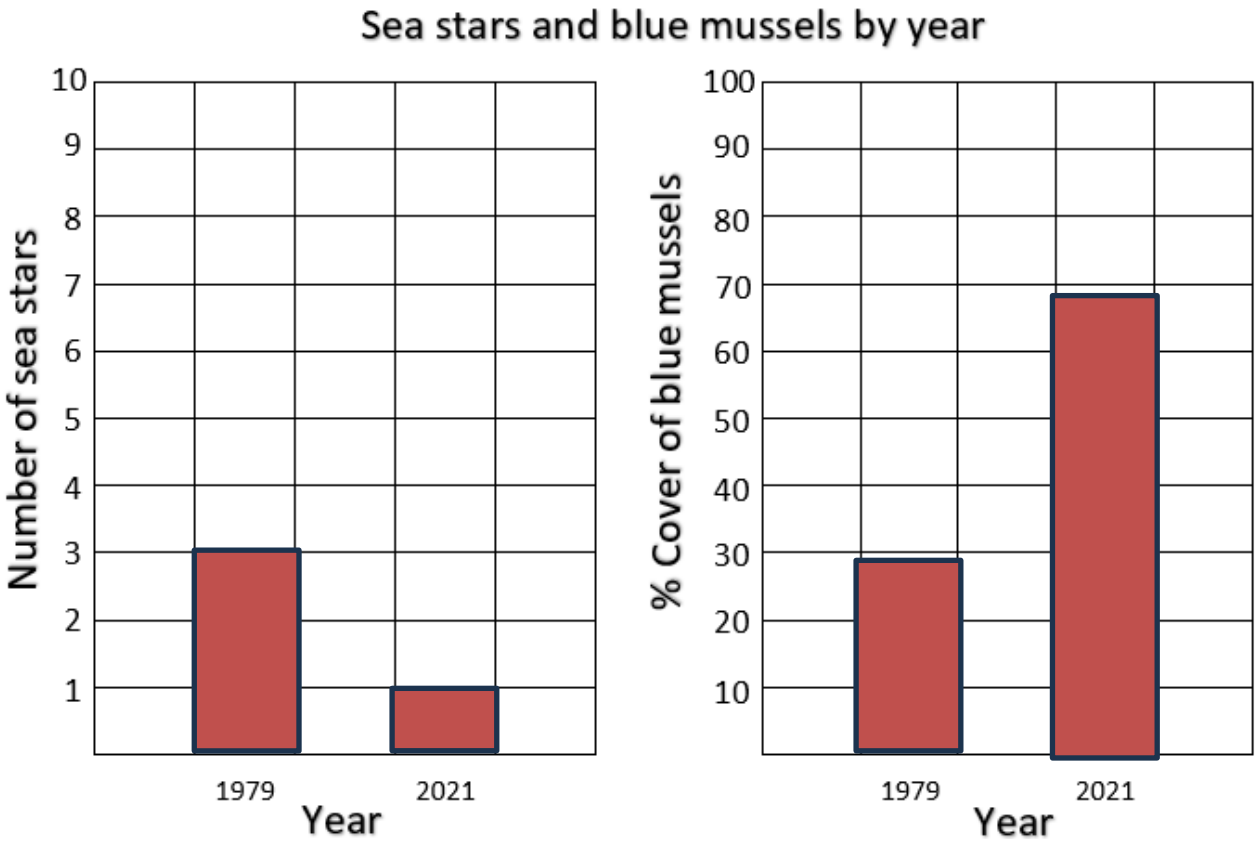
3. Were there differences in how abundant or diverse the other organisms were (i.e. amount of algae, urchins, and other organisms present)? Explain the differences observed from 1979 to 2021.

Yes, there was a decrease in species abundance and less diversity. Less urchins, less algae, and less diversity in algae.

It is okay if they don't identify diversity since it wasn't necessarily a focus here!

Visualize

4. Use each other's data to fill in the following bar graphs to show how the number of sea stars and percent cover of blue mussels changed between each year:



Evaluate

5. Do these results support your hypothesis? Explain. NOTE: this may be different for each person!

Answers will vary.

6. Why do you think there was a change from 1979 to 2021? Use background information learned about Maine, these species, the site information, and data collected to help you brainstorm.

Answers may vary. Increasing temperatures in the Gulf of Maine are stressing out sea stars or sea star wasting disease is killing them or a bacteria is affecting them or a combination of any or all, which decreases their abundance. Blue mussels are not being eaten by sea stars due to this and are able to grow their population size.

7. Green crabs are an invasive species on the North Atlantic coast. They eat many types of intertidal ecosystem invertebrates, including blue mussels. What do you think would happen to blue mussels and sea stars if we added green crabs to our simulation of the 2021 coastlines? Explain your answer.

Answers may vary. Most should be able to connect that blue mussels and sea stars would likely both decrease in population numbers. Green crabs would be eating blue mussels, lowering their numbers and taking away resources for the existing sea stars. It could be argued that sea stars might not change in numbers and blue mussels would just decrease, but the student should fully explain why (i.e. there's so few sea stars, they won't notice if a few blue mussels are gone).

8. Why do scientists use quadrats and transects? Do you think this tool is a fair assessment to understand these intertidal species populations? Explain.

Scientists use quadrats and transects to get a snapshot representation of the overall population. Coastlines and the intertidal zone are large and vast. This method helps create an estimate for the spread and number of organisms in a set area.

Answers will vary if it is a fair assessment. Be sure they fully explained their reasoning.

9. Be prepared to share your results and key takeaways for a class discussion. Write discussion notes here:

WHAT changed (sea stars, blue mussels, algae, urchins, etc) and WHY?

Did these results support your hypothesis?

If not, what surprised you? Or what didn't surprise you?

What happens with the addition of green crabs in 2021?

Why do we use quadrats and transects. Should we?








top








bottom








top








bottom








top








bottom








top








bottom








top



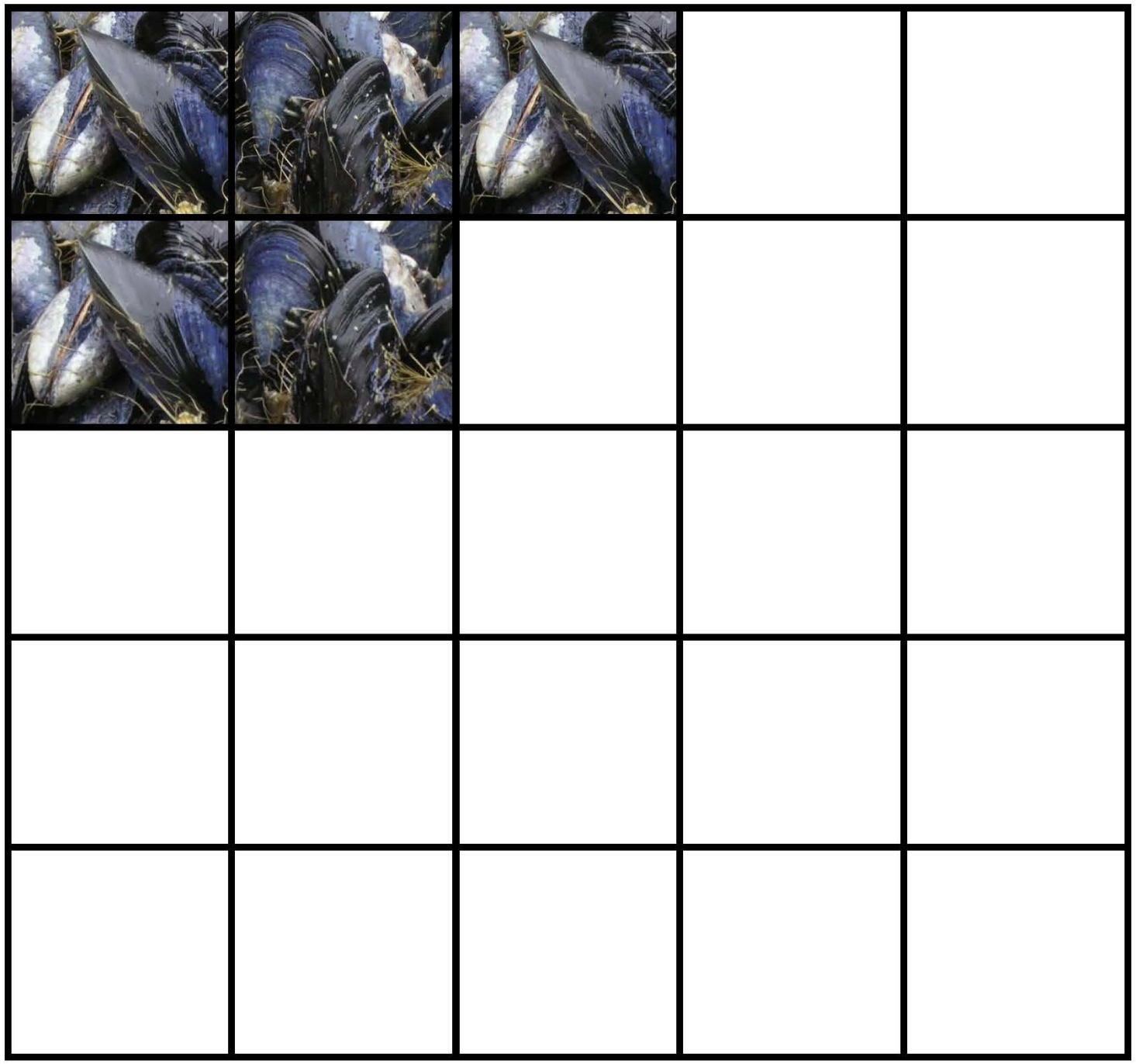





bottom

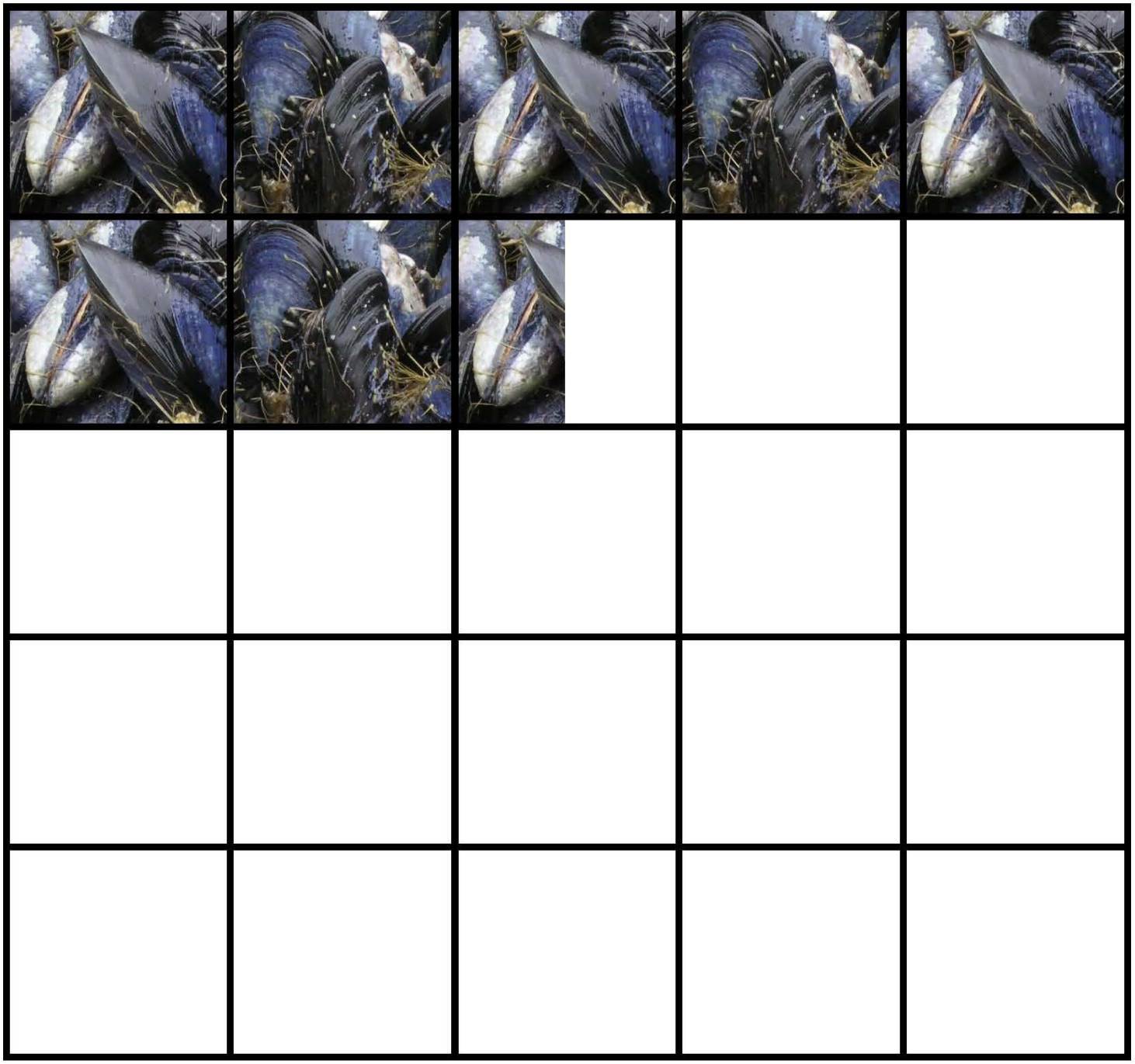
bottom

1979



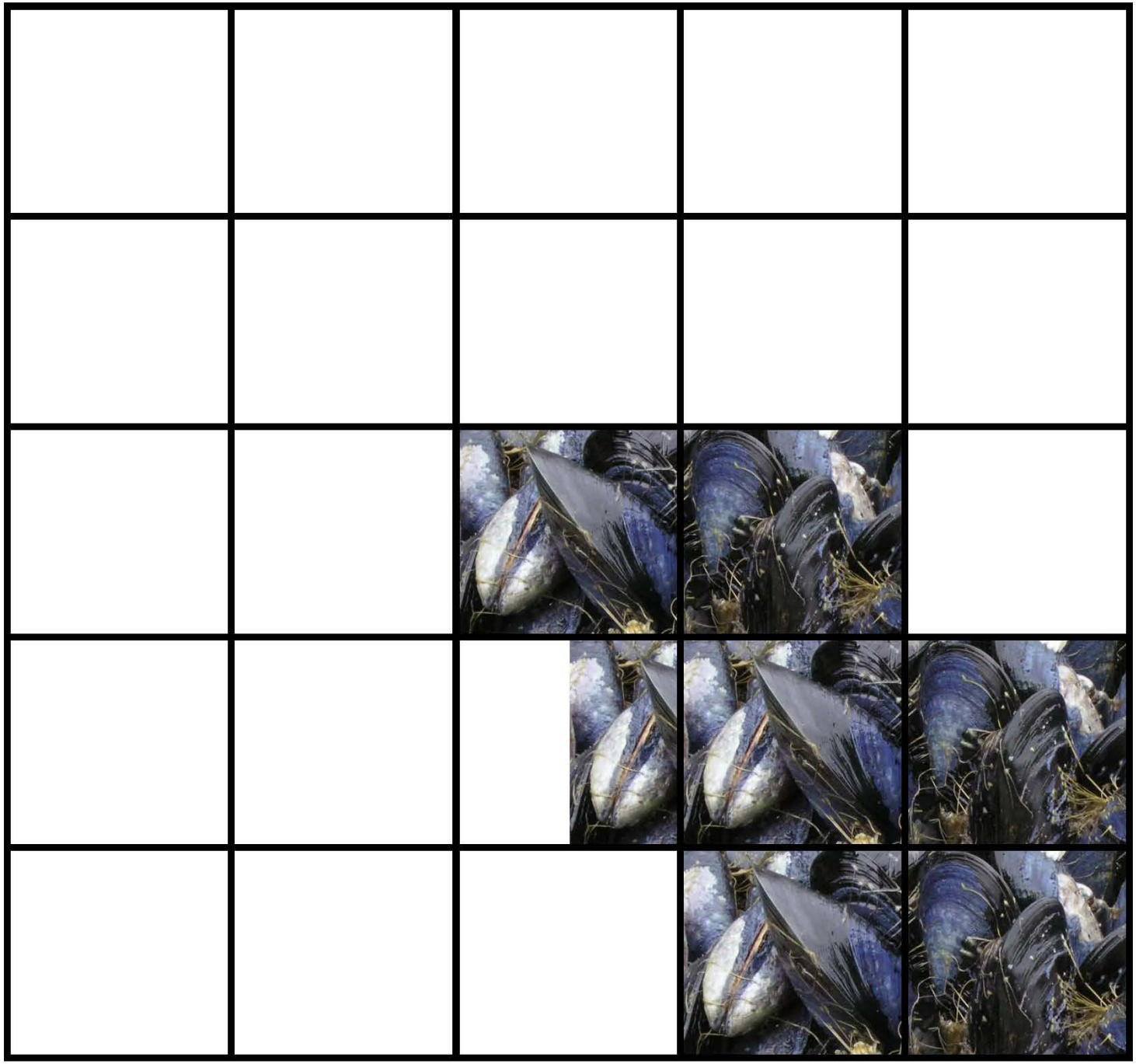
Quadrat A

1979



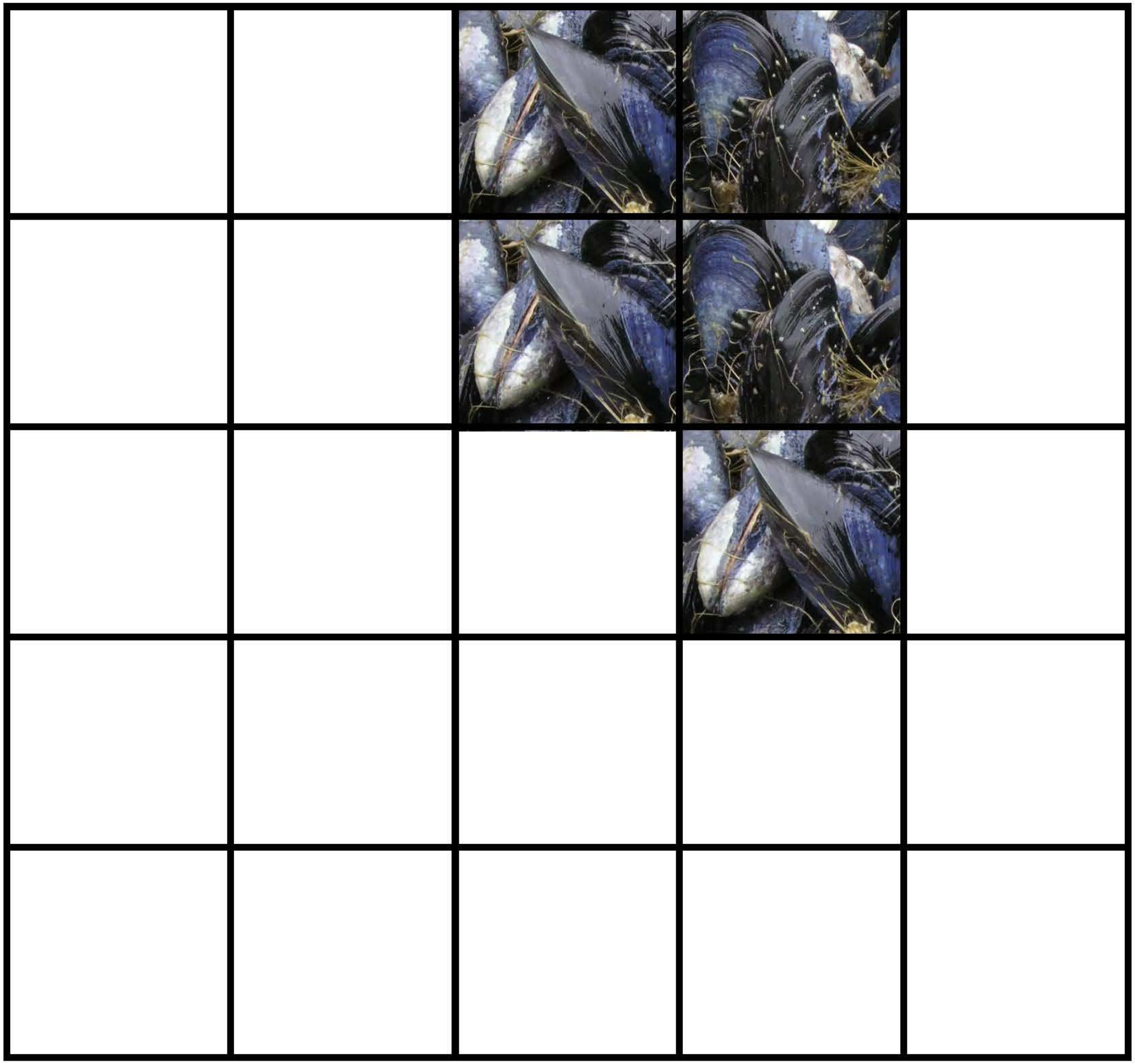
Quadrat B

1979



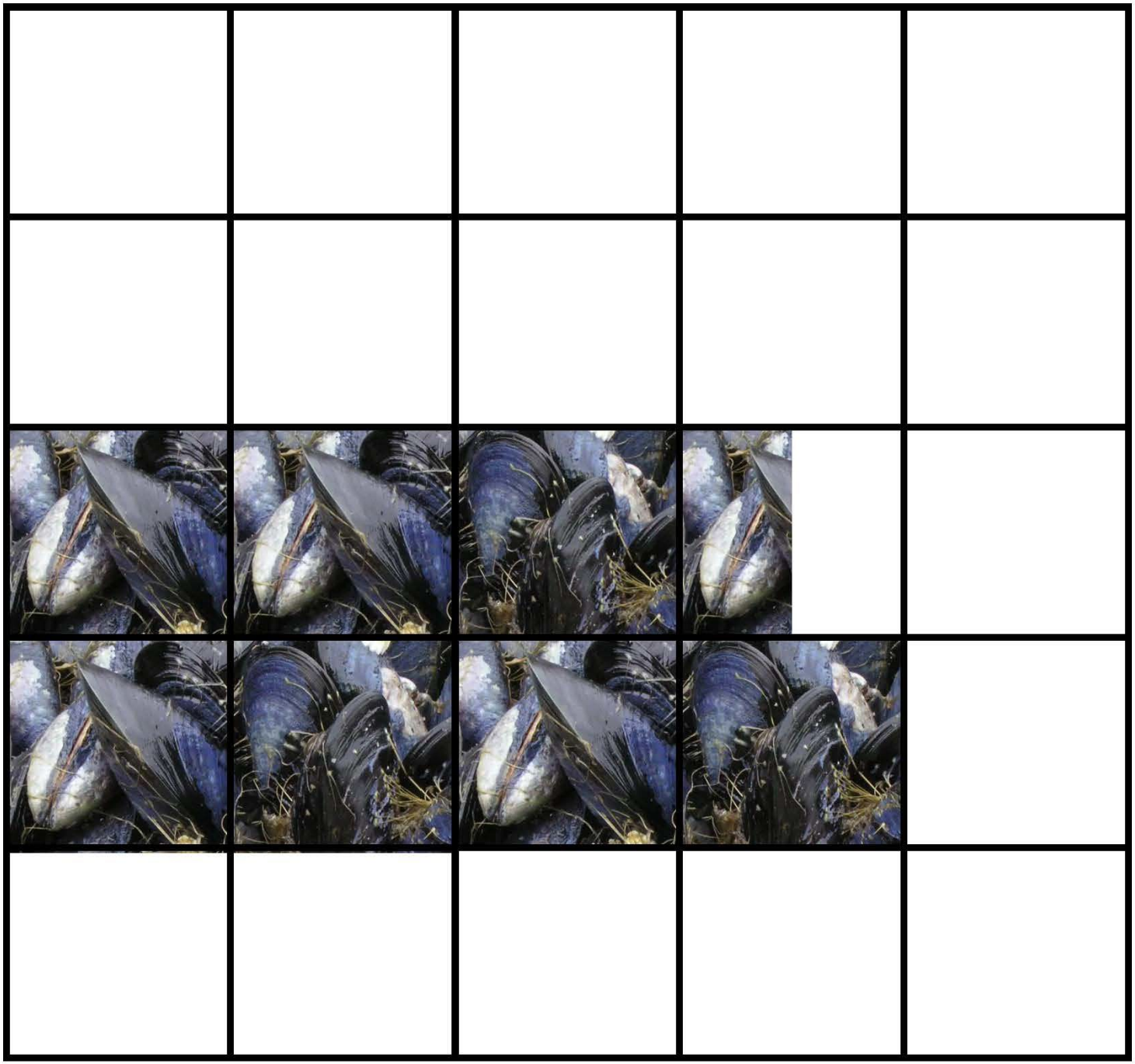
Quadrat C

1979



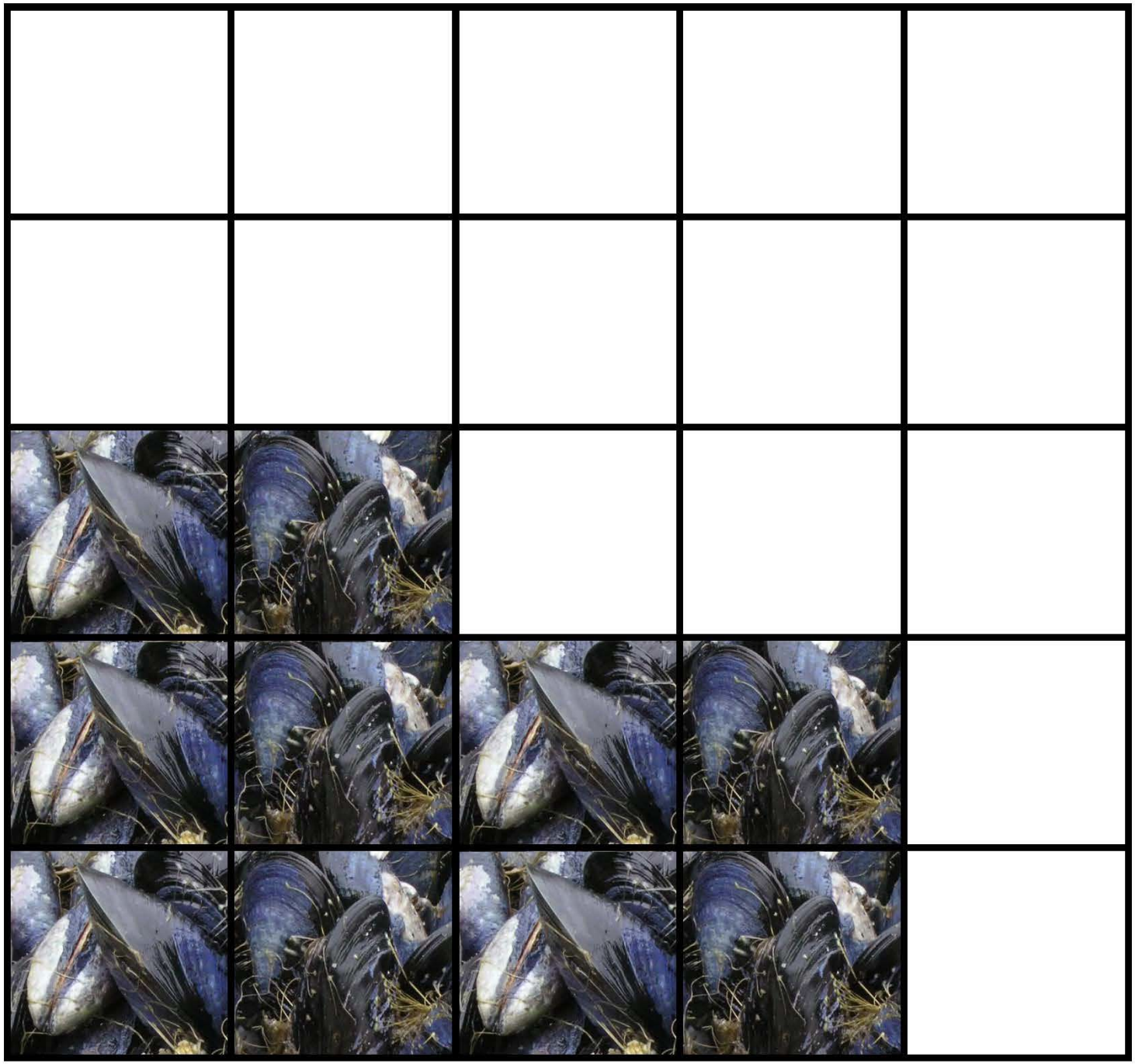
Quadrat D

1979



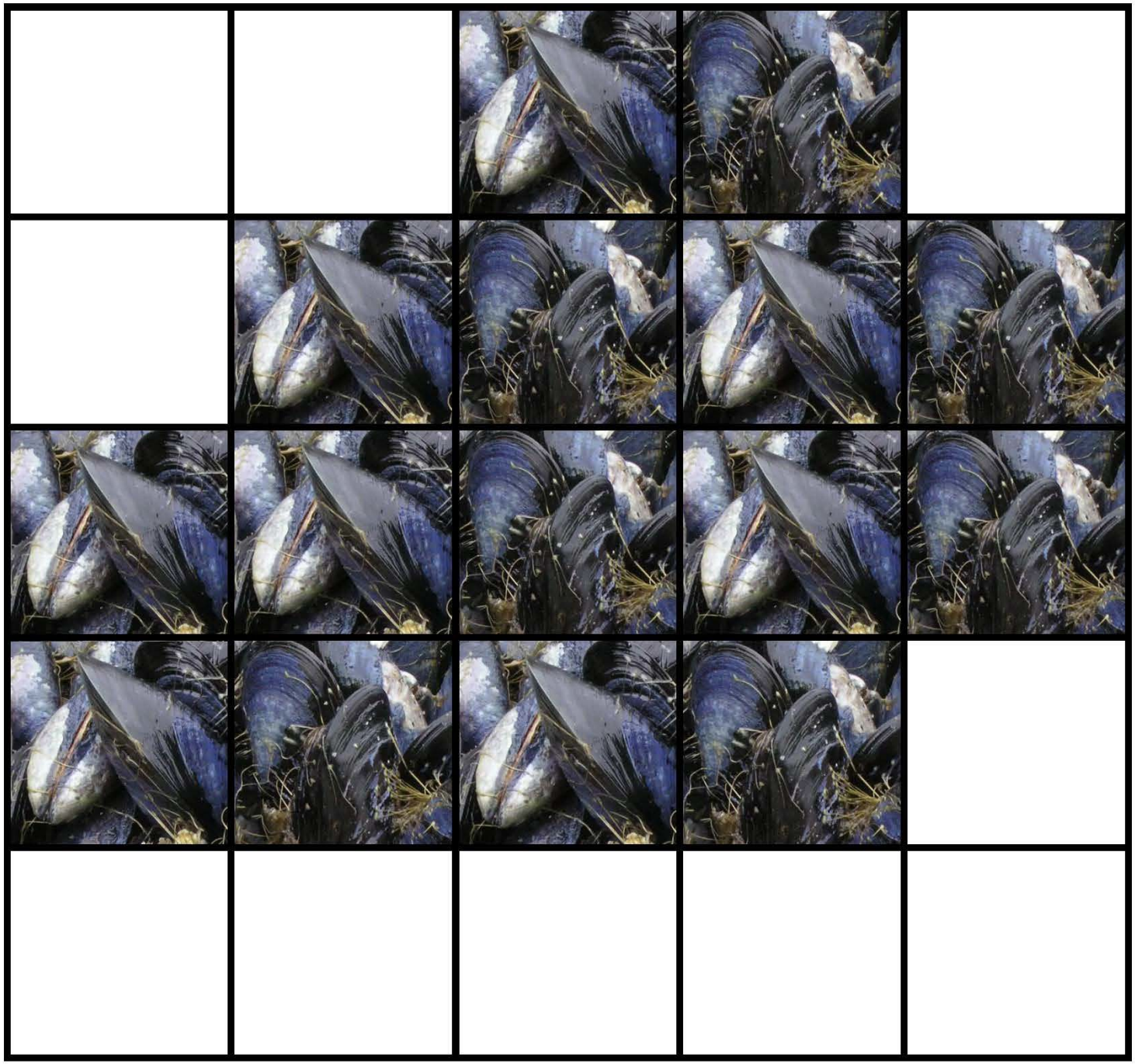
Quadrat E

1979



Quadrat F

2021

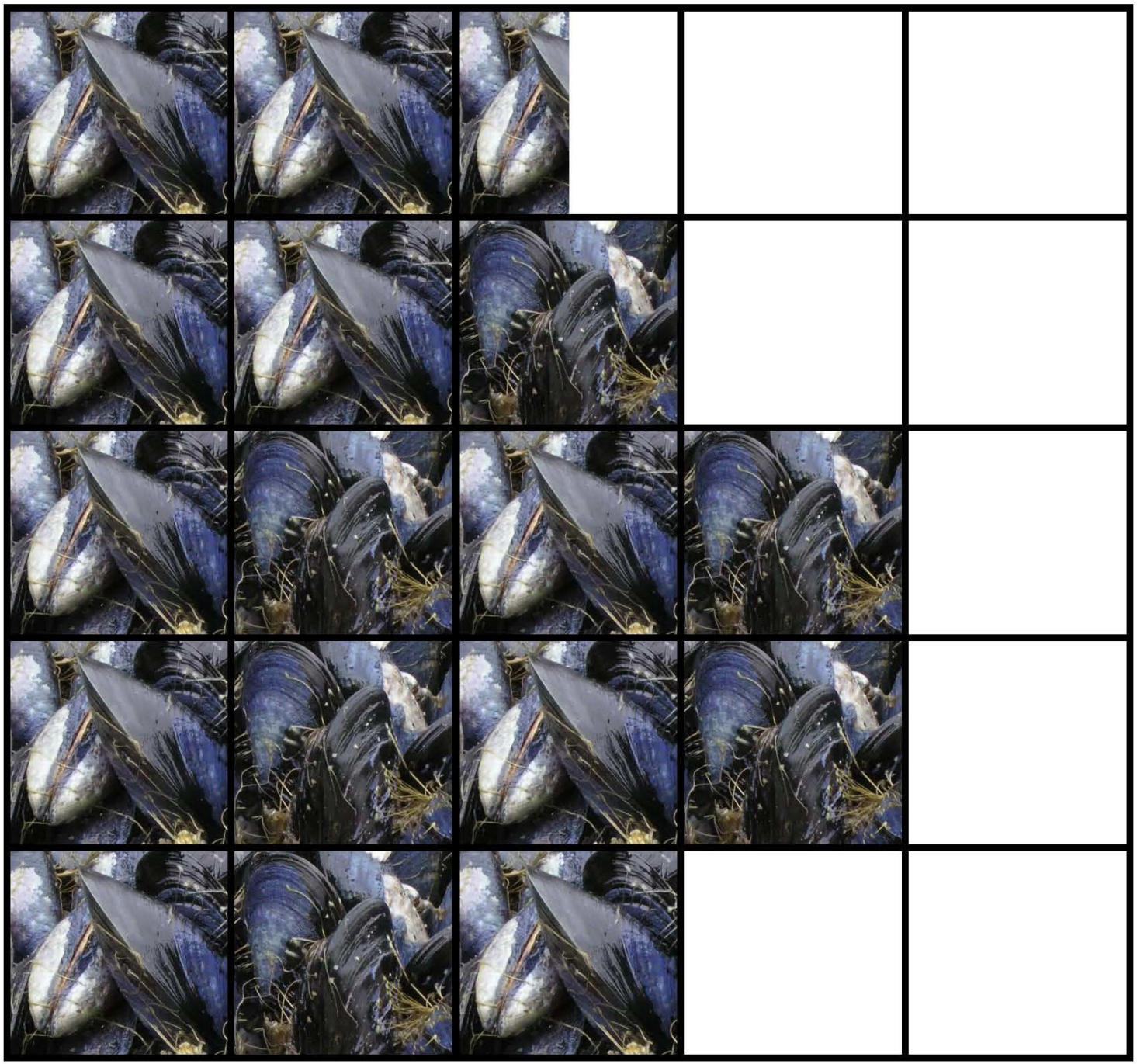


Quadrat G

2021

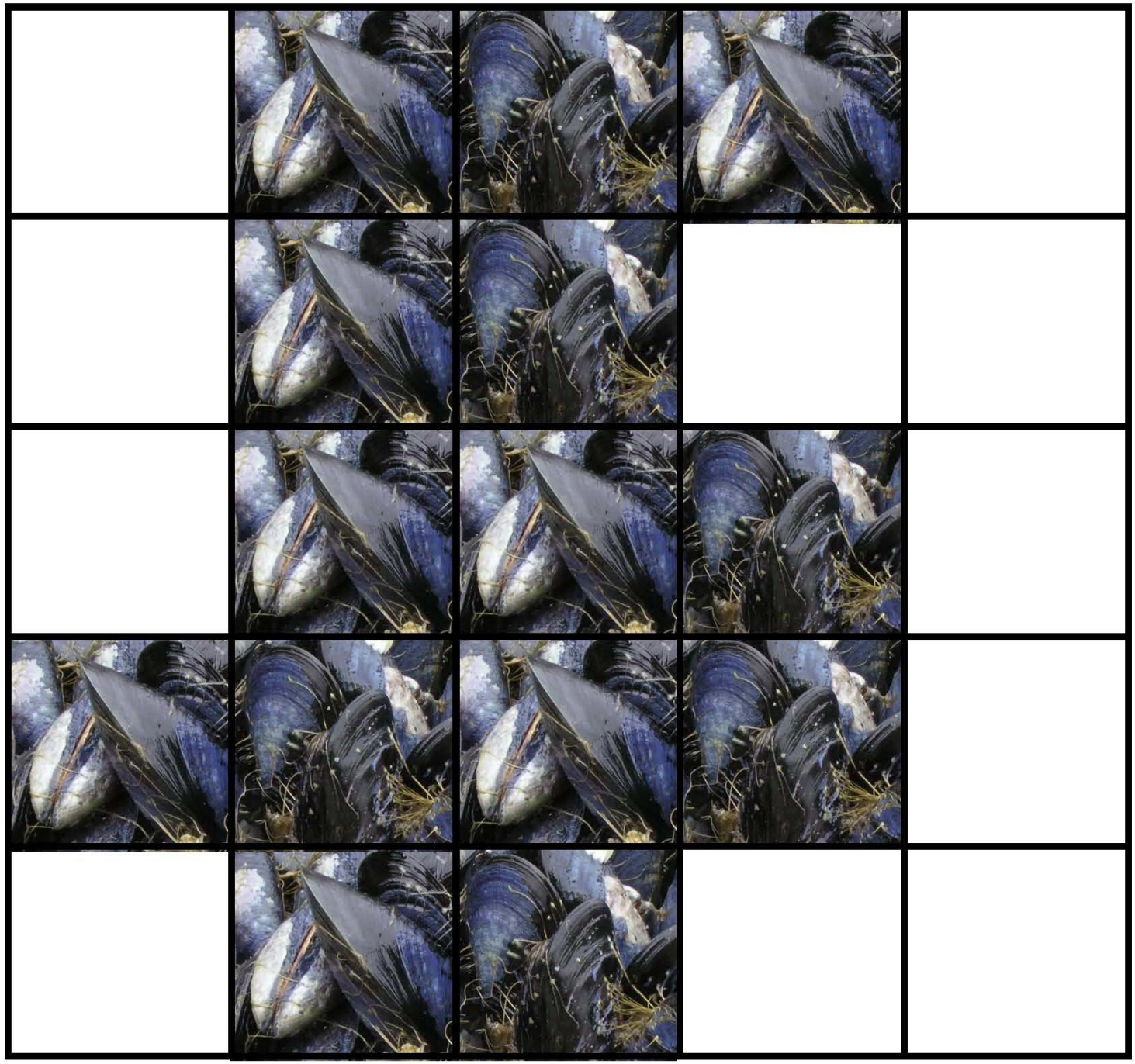
Quadrat H

2021



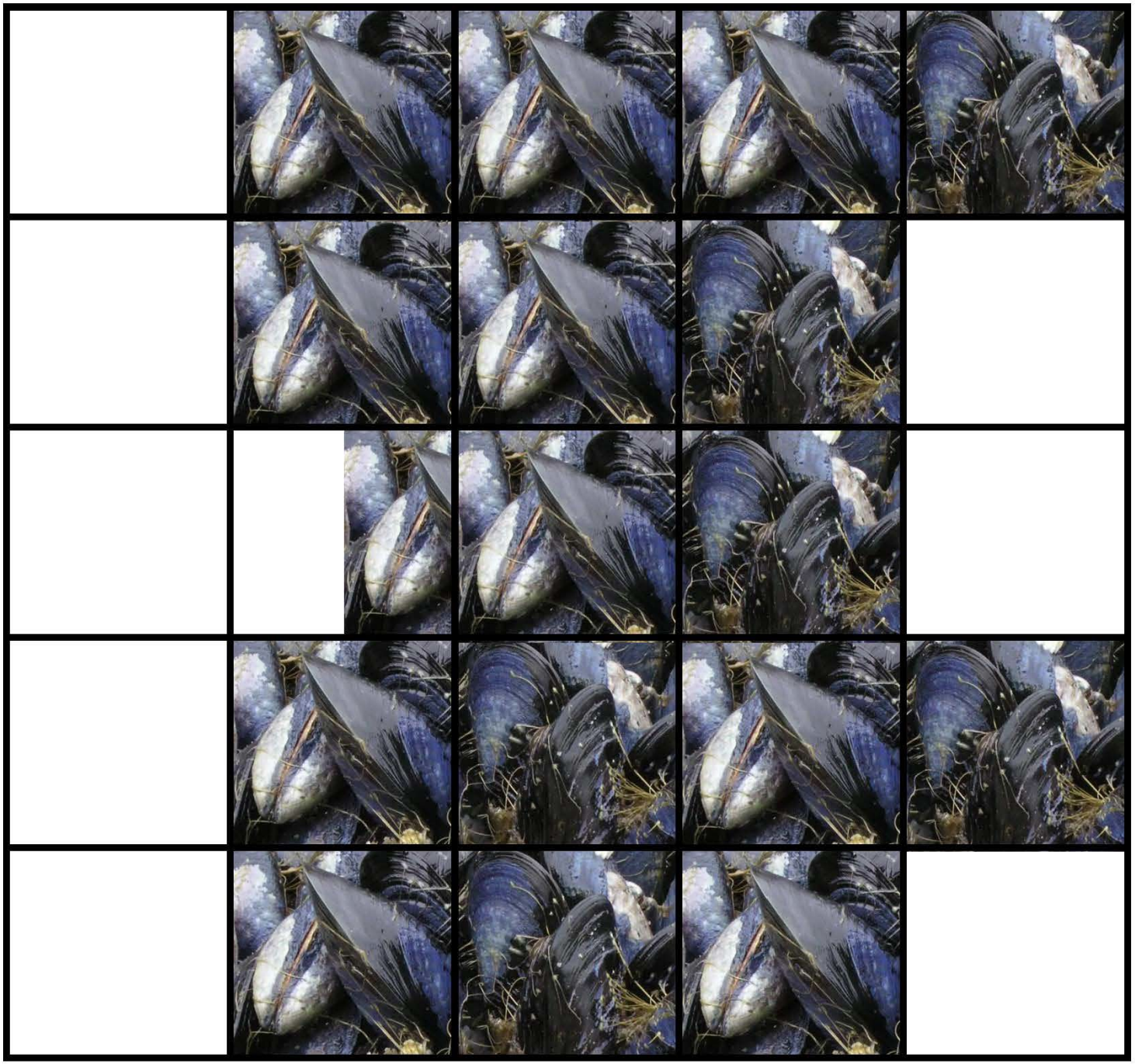
Quadrat I

2021



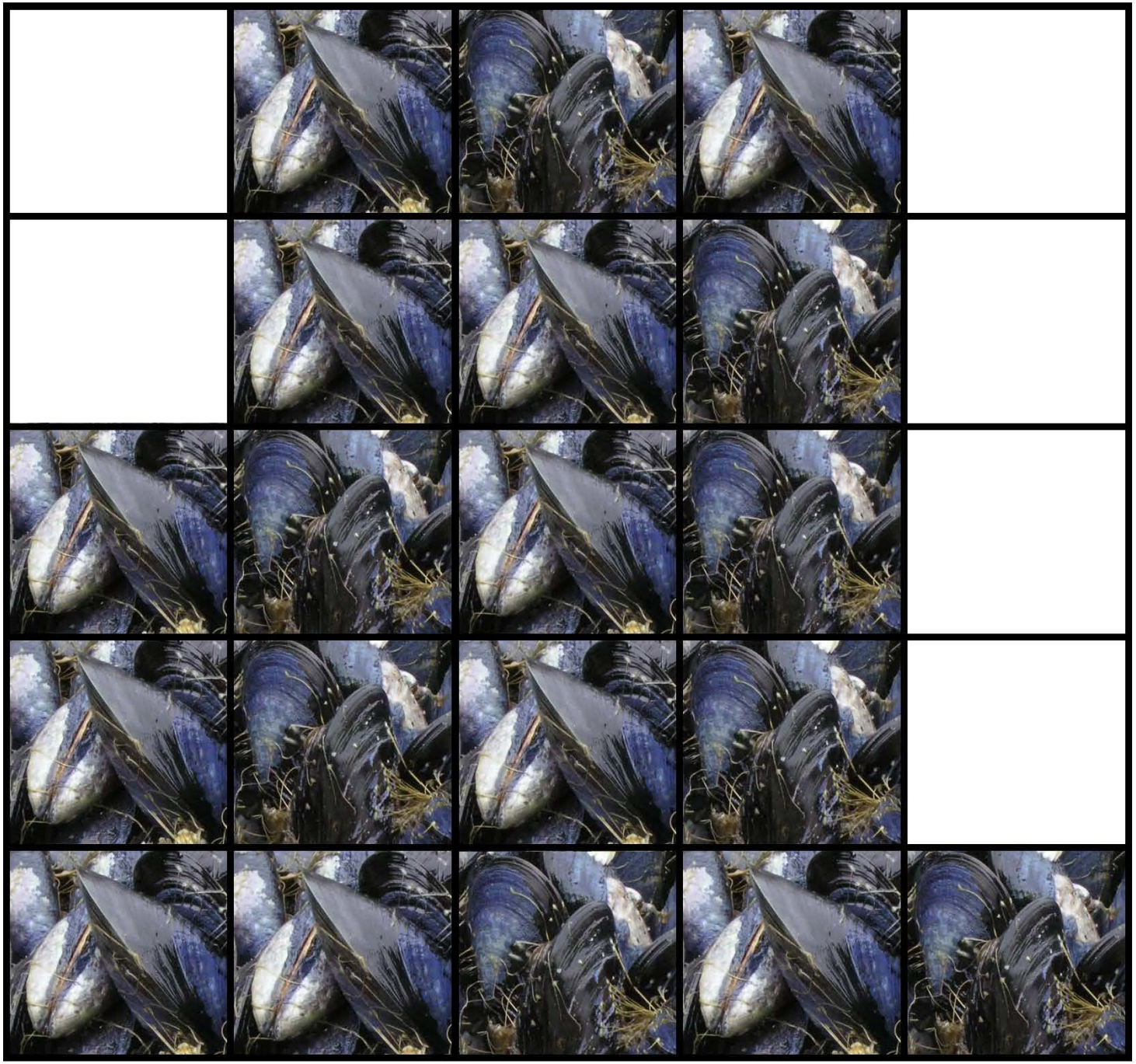
Quadrat J

2021



Quadrat K

2021



Quadrat L