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Seagrass Survivor. Subjects: Life Science / Biology, Environmental Science, Marine / Ocean Science Grades: 6-8

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SEAGRASS SURVIVOR

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Grade Level
Middle School

Subject area
Life, Environmental, or Marine Science

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Focus: Ecological Interactions: The Influence of Habitat and Size Refuge on Prey Survival

Subject: 7th Grade Life Science

VA Science Standards addressed:

(SOLs can be found at www.doe.virginia.gov/testing/sol/standards_docs/science/index.shtml)

LS.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:

a) data are organized into tables showing repeated trials and means;
f) dependent variables, independent variables, and constants are identified;
h) data are organized, communicated through graphical representation, interpreted, and used to make predictions;
i) patterns are identified in data and are interpreted and evaluated;
j) current applications are used to reinforce life science concepts.

LS.8 The student will investigate and understand interactions among populations in a biological community. Key concepts include the relationship between predators and prey.

LS.11 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include change in habitat size, quality, or structure.

Learning Objectives:

- ✓ Students will simulate predator-prey interactions in a seagrass bed through a role-playing and decision-making game.

- ✓ Students will make inferences about the influence of structured habitat and size on juvenile blue crab survival.

Total Time Required: 2 ½ hrs

Vocabulary:

Definitions are offered for terms that are included in the standards of learning, in addition to specialized vocabulary relevant to the lesson.

- **Independent variable** – The variable that is controlled or manipulated in a scientific experiment to determine its effect on the variable of interest. Adapted from www.chemistry.about.com.
- **Dependent variable** – The variable being tested in a scientific experiment whose values are dependent on the values of the independent variable. Adapted from www.chemistry.about.com.
- **Habitat** – The area or natural environment in which an organism lives. Adapted from www.dictionary.com.
- **Abundance** – The number of individuals per species. Adapted from www.britannica.com.
- **Predator/Predation** – An animal that obtains its energy by eating other animals; the act of one animal eating another. Adapted from www.dictionary.com.
- **Bar graph** – A graph that uses columns of different heights to show and compare different amounts. Adapted from www.dictionary.com.
- **Eutrophication** – The process in which a body of water acquires a high concentration of nutrients, typically promoting excessive algal growth and decreased water quality. Adapted from www.usgs.gov.
- **Recruit/Recruitment** – The movement of young juveniles from offshore waters into estuarine seagrass beds OR the movement of juveniles into adult populations. Adapted from Lipcius et al. (2007).
- **Juvenile** – Refers to blue crabs < 60 mm carapace width. Adapted from http://dnr2.maryland.gov.
- **Size refuge** – The size at which a juvenile blue crab is no longer vulnerable to predation. Adapted from Hines et al. (1987).

Background Information:

Juvenile blue crabs typically recruit into Chesapeake Bay seagrass beds where they remain until they reach a size refuge at ~ 25 mm carapace width (Hines et al. 1987; Orth & van Montfrans 1987). Several studies have found that juvenile blue crabs are found at higher densities and experience greater survival in vegetated habitats such as seagrass beds, likely due to predators' limited ability to detect and capture juvenile prey (Pile et al. 1996; Johnston & Lipcius 2012). Juvenile blue crab mortality is evaluated using tethering experiments in which juveniles are tied to stakes in shallow water areas such as seagrass beds. The tethered juveniles are checked after a certain amount of time to determine the proportional mortality. Scientists often tether crabs of various sizes and in varying seagrass densities to quantify relative predation mortality for these factors. Many of these studies have shown that juveniles are more likely to survive if they are larger than 25 mm or if they are in vegetated habitats. More information about tethering experiments can be found in Pile et al. (1996) and Johnston and Lipcius (2012).

Seagrass is clearly an important habitat for juvenile blue crabs; however, seagrass abundance in Chesapeake Bay has experienced severe declines due to warming temperatures (Moore et al. 2014) and increased eutrophication (Orth et al. 2010) as a result of global climate change and human activity. The loss of seagrass could have serious consequences on the blue crab population if juveniles cannot find a suitable nursery habitat in which to live until they reach the size refuge. Juvenile survival would likely decrease and, consequently, the blue crab population will decrease because there will be fewer juveniles to recruit into the adult population the following year. The importance of seagrass as a nursery habitat has necessitated restoration and conservation programs throughout Chesapeake Bay.

Student Handouts/Materials:

- ❒ Seagrass Survivor Worksheet (Appendix I)
- ❒ Seagrass Survivor Data Table (Appendix II)
- ❒ Crab/Burrfish Cut-Outs (Appendix III)
- ❒ Game START (Appendix IV)
- ❒ Drawing Numbers (Appendix V)
- ❒ Game Board Layout (Appendix VI)

Materials & Supplies:

- ❒ 36 Foam/rubber mats (12 blue, 12 green, 12 yellow)
- ❒ 4 Game STARTs
- ❒ Drawing numbers (1-36)
- ❒ 8 Bandanas (4 colors, 2 of each)
- ❒ 2 Adult blue crab cut-outs
- ❒ 2 Burrfish cut-outs
- ❒ 2 Large juvenile crab cut-outs
- ❒ 2 Small juvenile crab cut-outs
- ❒ Game die (large, preferably)
- ❒ Cup/bowl
- ❒ Black Sharpie
- ❒ Stapler

Classroom Set-up:

The game requires an open area in the classroom large enough for the mats to be placed on the floor in a 6 x 6 grid with plenty of room for movement.

Procedure:

1) **Advance preparation of materials:** 1 hr
   - Randomly number the mats 1-36 with a black Sharpie. In the upper right hand corner of the mats, write + 0 on yellow, + 1 on blue, and + 2 on green.
   - Print 2 copies of the Crab/Burrfish Cut-Outs sheet (Appendix III). Cut out each burrfish and crab picture, and laminate them. Choose a bandana color for each organism (adult blue crab, large juvenile, small juvenile, burrfish). Fold the bandanas so that they can be tied around a head or arm, and staple the cut-outs to the appropriate-colored bandanas to make "Survivor" buffs for each team. For example, the burrfish cut-outs will be stapled to purple bandanas, the adult blue crab cut-outs will be stapled to green bandanas, etc.
   - Print 4 copies of the Game START (Appendix IV) and laminate each.
   - Print a copy of the Drawing Numbers sheet (Appendix V). Cut out the individual numbers and laminate them.
2) **Lab Set-up:** 5 mins

To play the game, place the mats on the classroom floor in a 6 x 6 grid in numerical order. The colors should be randomly distributed within the grid. Place the laminated START sheets at each corner of the game board. The drawing numbers should be placed in a cup or bowl.

3) **Introduction:** 10 mins
This activity follows an "explore before explain" lesson plan so the game will be played first and then students will have an opportunity to figure out why the game worked out the way it did. Therefore, the lesson only requires a brief introduction explaining the purpose of the game, i.e. to understand factors that influence prey survival in predator-prey interactions, and going over the rules.

4) **Activity:** 45 mins (for 3 groups)

Note: This game is meant to be played with 4-8 students. Therefore, this activity is paired with the Dissecting Data Lesson Plan (Appendix VII) so that students can rotate through both lesson plans within an 80-minute class period.

The Game:

The grid of mats represents a patchy seagrass bed of varying seagrass abundance: yellow = low seagrass abundance, blue = moderate seagrass abundance, and green = high seagrass abundance. The purpose of the game is for the predators to eat as many juvenile blue crabs as they can, and the juveniles must use strategy to avoid being eaten. Predators can only eat a juvenile blue crab if they land on the space that is being occupied by the juvenile, and the predator's attack strength has to be greater than the juvenile's life points + seagrass defense of the space the juvenile is standing on. The points system is as follows:

Predator	Attack Strength
Burrfish	3
Adult crab	4

Prey	Life Points
Small Juvenile	2
Large Juvenile	3

Seagrass	Defense
Low (yellow)	+ 0
Moderate (blue)	+ 1
High (green)	+ 2

Tip: It may be useful to write the attack strengths and life points of the predators and prey on a whiteboard or chalkboard for student reference throughout game play.

The Set Up:

Two students are assigned to each team (Burrfish, Adult Crab, Large Juvenile, Small Juvenile), and are given their respective “Survivor” buffs to wear on their heads or arms so everyone can identify each other. Team Burrfish and Team Adult Crab are the predators and will stand on the START squares to start the game. Team Large Juvenile and Team Small Juvenile are the prey and they are tethered to a specific patch (mat) in the seagrass bed. To determine which mat they are tethered to, each juvenile crab player must draw a number from the cup or bowl. The number drawn is the number on the grid where they are tethered, and must start the game standing on that space.

Taking Turns:

Burrfish #1 starts the game and is followed by Adult Crab #1. Large Juvenile #1 and Small Juvenile #1 then move simultaneously. After the juveniles make their moves, it is Burrfish #2’s turn, followed by Adult Crab #2. Finally, Large Juvenile #2 and Small Juvenile #2 make their moves. This order should be maintained throughout the game.

Tip: It may be beneficial to keep track of turns on the whiteboard/chalkboard.

Play:

Each turn, the predators (Burrfish and Adult Crabs) roll the die to determine how many spaces they can move. They can only move forward, backward, or sideways, not diagonally. Predators are not required to keep moving spaces if they can encounter a juvenile before using up their moves. A predator’s turn ends if they run out of moves or after an encounter with a juvenile. Two predators cannot occupy the same mat. The juvenile blue crabs can only move 1 space per turn, and are limited to the spaces directly adjacent to their tether patch, i.e. juveniles must always be within 1 space of their tether location. Juveniles must move each turn and are also not allowed to move diagonally.

If a predator lands in the same patch as a juvenile crab, they have an opportunity to eat the juvenile only if their attacks points are greater than the juvenile’s life points + the seagrass defense. For example, if an Adult Crab lands on the same space as a Small Juvenile in moderate seagrass abundance (blue), the adult crab successfully eats the juvenile: 4 > 2 + 1. After a successful predation, the predator must return to their START space and continue play from there. The juvenile crab draws another number from the cup or bowl and is tethered in that new patch. If a predator encounters a juvenile, but has less attack points than juvenile life points + seagrass defense, the predator is unsuccessful and must return to their START space. The juvenile remains on the same space. If a predator encounters a juvenile and the attack points and defense points are equal, the predator and juvenile must play Rock-Paper-Scissors to determine the outcome of the interaction.

Throughout the game, the instructor (or a student) should record the juvenile size, predator species, and seagrass abundance (low, moderate, high) from every predator-prey interaction, successful or not, on the Seagrass Survivor Data Sheet (Appendix II). The outcome column will note a successful predation or survival. The game will end after 10 predator-prey interactions. If the game is being played in groups, each group should have their own data sheet for their game.

Tip: Class size may limit the time that each group can play the game, so setting a time limit for each game may be more reasonable than playing for 10 interactions. See also Lesson Alternative.

Strategy:

The goal of the predators is to eat as many juvenile blue crabs as possible before the game is over. Predators can save time and turns by avoiding encounters with juvenile crabs that they know they cannot consume. The goal of the juvenile blue crabs is to survive until the game is over. Therefore, juveniles should try to remain in patches of high seagrass abundance because seagrass structure provides a refuge from predation by increasing the chances of survival. Teams are encouraged to work together to make the best decisions for successful predation or survival.

5) **Breakdown & Clean Up:** 5 mins
Have students return their drawing numbers and bandanas, and then pick up the START sheets and mats.

Assessment: 25 mins

After every group plays the game, share with each group the data from their game, and have the students copy the data into the data table on their worksheet (Appendix I). Students will use their data to make bar graphs and answers the questions on the worksheet. If there is time left at the end of class, students can discuss their findings as a class. Students who do not finish the worksheet before class ends can finish answering the questions for homework.

Lesson Alternative:
Instructors may want to consider covering this lesson in two days, learning the rules and practice playing on the first day and collecting and analyzing data on the second day. If classroom space is limited or the class is particularly large, instructors can make game boards on poster board (Appendix VI) and students can play Seagrass Survivor as a board game, following the same rules as above.

References:

Hines, A. H., Lipcius, R. N., & Haddon, A. (1987). Population-dynamics and habitat partitioning by size, sex, and molt stage of blue crabs *Callinectes sapidus* in a subestuary of central Chesapeake Bay. *Marine Ecology Progress Series, 36*, 55-64.

Johnston, C. A., & Lipcius, R. N. (2012). Exotic macroalga *Gracilaria vermiculophylla* provides superior nursery habitat for native blue crab in Chesapeake Bay. *Marine Ecology Progress Series, 467*, 137-146.

Lipcius, R. N., Eggleston, D. B., Heck, K. L. Jr, Seitz, R. D., & van Montfrans, J. (2007). Post-settlement abundance, survival, and growth of postlarvae and young juveniles in nursery habitat. In: Kennedy V. S., & Cronin L. E. (Eds). The blue crab *Callinectes sapidus*. Maryland Sea Grant College, College Park, MD, p 535−564.

Moore, K. A., Shields, E. C., & Parrish, D. B. (2014). Impacts of varying estuarine temperature and light conditions on *Zostera marina* (eelgrass) and its interactions with *Ruppia maritima* (widgeongrass).

Estuaries and Coasts, 37, S20-S30.

Orth, R., & van Montfrans, J. (1987). Utilization of a seagrass meadow and tidal marsh creek by blue crabs *Callinectes sapidus*. 1. seasonal and annual variations in abundance with emphasis on postsettlement juveniles. *Marine Ecology Progress Series, 41*(3), 283-294.

Orth, R. J., et al. (2010). Long-term trends in submersed aquatic vegetation (SAV) in Chesapeake Bay, USA, related to water quality. *Estuaries and Coasts*, *33*(5), 1144-1163.

Pile, A., Lipcius, R. N., van Montfrans, J., & Orth, R. (1996). Density-dependent settler-recruit-juvenile relationships in blue crabs. *Ecological Monographs, 66*(3), 277-300.

Cut-Out Images:

Blue crabs – Maryland Department of Natural Resources. http://dnr2.maryland.gov/Fisheries/Pages/Fish-Facts.aspx?fishname=Shellfish%20-%20Blue%20Crab

Striped burrfish – Maryland Department of Natural Resources. http://dnr2.maryland.gov/Fisheries/Pages/Fish-Facts.aspx?fishname=Striped%20Burrfish

Appendices:

Appendix I	Seagrass Survivor Worksheet
Appendix II	Seagrass Survivor Data Table
Appendix III	Crab/Burrfish Cut-Outs
Appendix IV	Game START
Appendix V	Drawing Numbers
Appendix VI	Game Board Layout
Appendix VII	Dissecting Data Lesson Plan

Seagrass Survivor Worksheet

1. Record the juvenile crab size, predator species, seagrass abundance, and outcome for each predation event.

Crab Size	Predator Species	Seagrass Abundance	Outcome

2. Identify the independent and dependent variables in this experiment.

   Independent variable(s):

   Dependent variable:

3. How many juvenile blue crabs survived that were:

   Small? _______

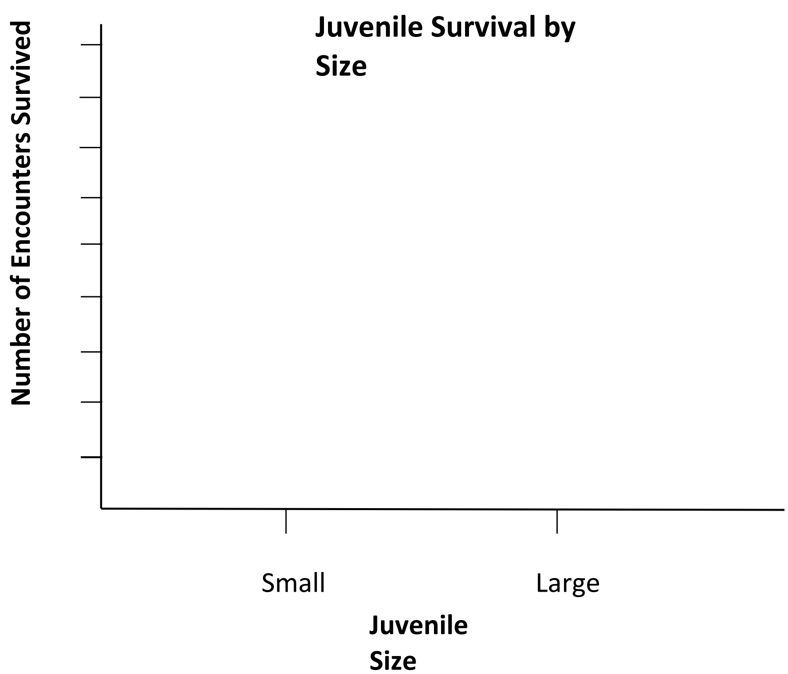
   Large? _______

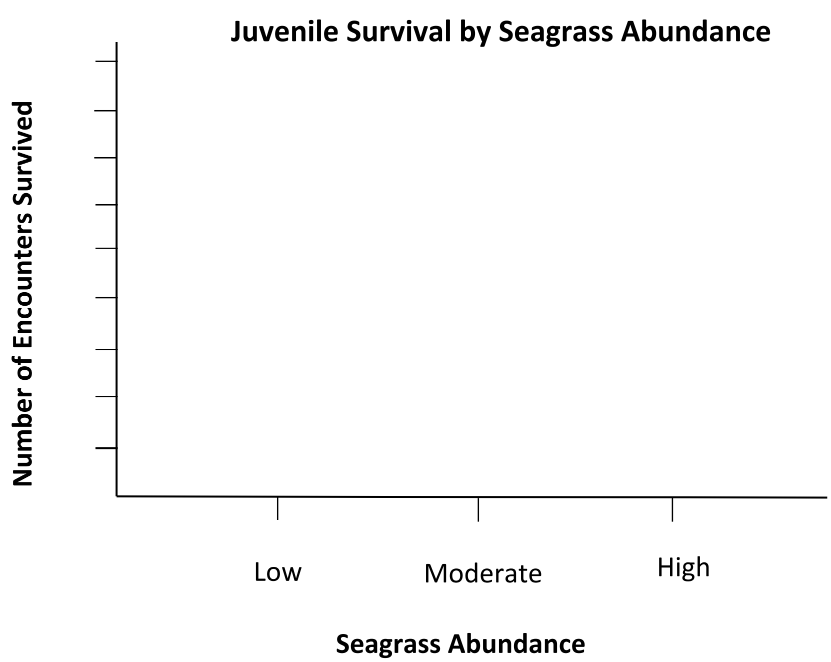
   In low seagrass abundance? _______

In moderate seagrass abundance? ______

In high seagrass abundance? ______

3. Using your answers to the previous questions, make bar graphs to show how often small and large juvenile survived, and how often juveniles survived in low, moderate, and high seagrass abundance.





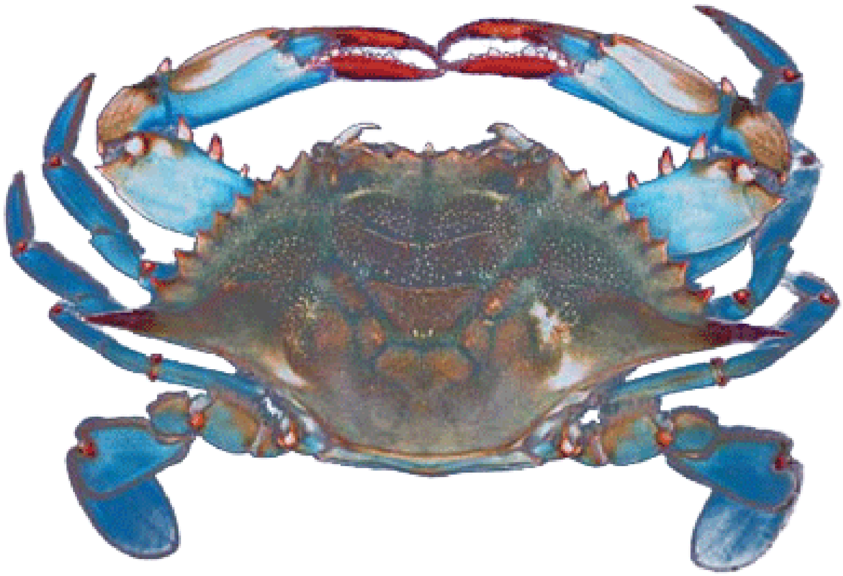
4. Do smaller or larger juvenile blue crabs survive better? How do you know? Why do you think that is?

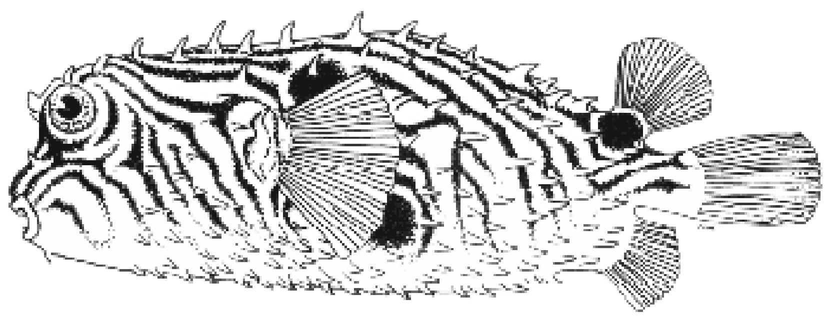
5. Do juvenile blue crabs survive better in low, moderate, or high seagrass abundance? How do you know? Why might this be?

6. Seagrass is disappearing from Chesapeake Bay due to warming water temperatures. How do you think the loss of seagrass will affect the blue crab population in the Bay?

Seagrass Survivor Data Table

Crab Size	Predator	Seagrass Abundance	Outcome





START

1 2 3 4 5 6 7

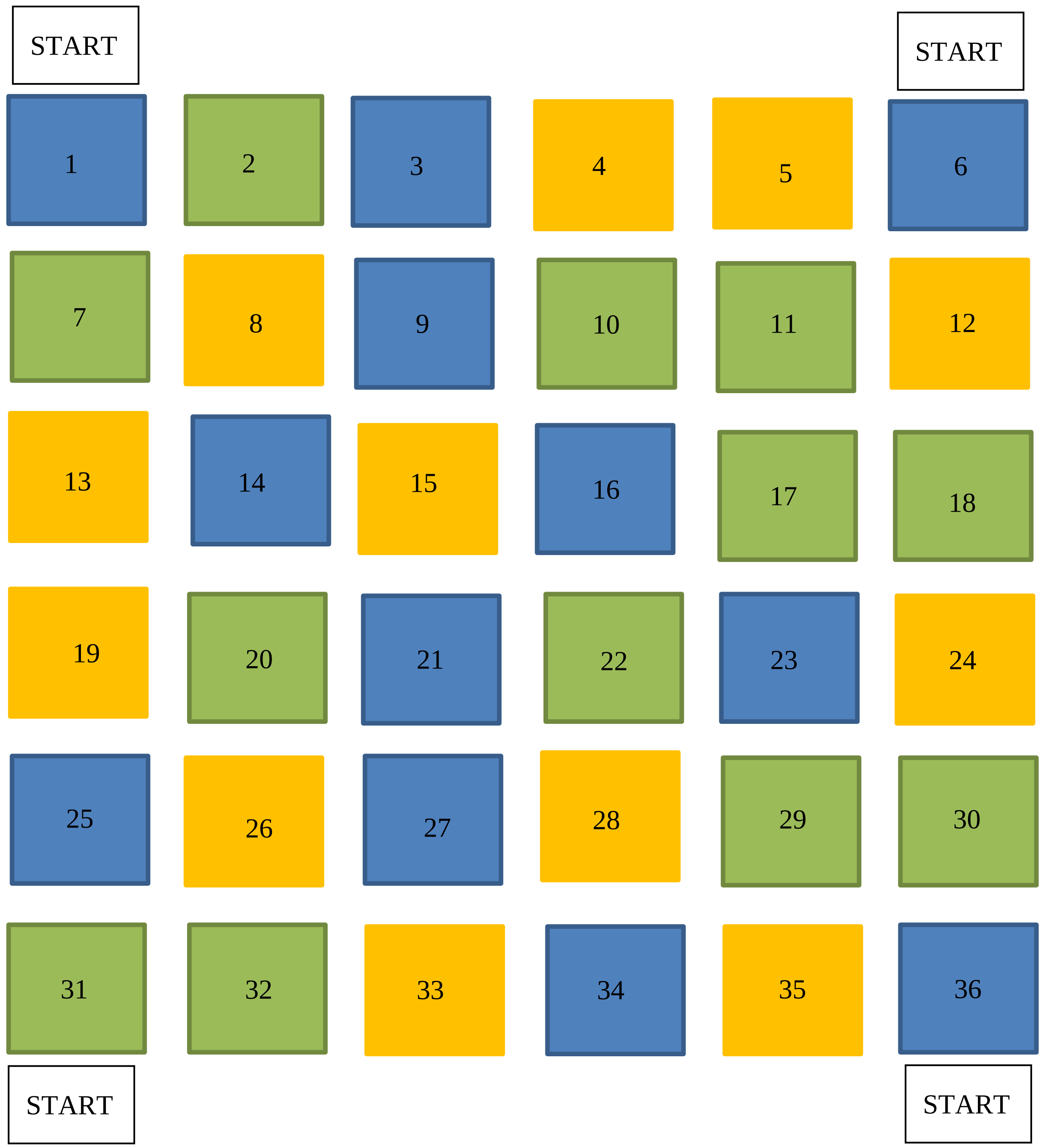
8 9 10 11 12

13 14 15 16 17 18

19 20 21 22 23 24

25 26 27 28 29 30

31 32 33 34 35 36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