

# Lesson 1: The Life Cycle of Marine Fishes

## Focus

The life cycle of marine fishes and the abiotic and biotic factors influencing survival.

## Grade Levels

6-8 (Science)

## Focus Question

What are the abiotic and biotic factors that cause mortality of marine fishes at the different developmental stages of the life cycle?

## California Science Education Standards

Grade 6: Ecology (Life Sciences)

5e. Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

Grade 7: Genetics

2a. Students know the difference between the life cycles and reproduction methods of sexual and asexual organisms.

## Number of Participants

All students (no minimum or maximum)

## Teaching Time

One 45-minute class period

## Objectives

1. Students will learn the life cycle of marine fishes.
2. Students will learn about the abiotic and biotic factors that influence the survival of marine fishes from the egg to adult stage.
3. Students will learn that the environment is an important determinant of mortality for marine fishes, especially in the egg and larval stages.
4. Students will learn that mortality is very high for marine fishes.

## Materials

1. "Statement" cards (provided)
2. Clock or timer (alternatively, electronic device capable of playing music)
3. Dice
4. Projector for showing images and movies
5. Video of surgeon fish spawning: [http://www.youtube.com/watch?v=214rBDcf\\_gE](http://www.youtube.com/watch?v=214rBDcf_gE)  
(Optional: Start at 1:09)
6. Video of zebrafish (freshwater fish) egg development over 48 hrs:  
[http://www.youtube.com/watch?v=fJkQTM\\_iWsl](http://www.youtube.com/watch?v=fJkQTM_iWsl)

7. Images of ichthyoplankton (fish eggs and larvae):

<http://www.larvalbase.org/PhotoArchive/Photothumbnails/PhotoArchive.htm>

### **Key Words**

Spawning (broadcast), egg, yolk-sac larvae, juvenile, adult, ichthyoplankton, critical period, metamorphosis, recruit, starvation, predation, advection, biotic, abiotic, environment, mortality.

### **Background Information**

#### ***Spawning***

**Broadcast spawning** is the most common mode of reproduction for marine fishes, both **pelagic** (in the water column) and **benthic** (associated with the seafloor) fishes. **Spawning** refers to the release of unfertilized **planktonic** (floating, drifting in the water column) eggs by female fishes. Males and females swim close together and release (or broadcast) **gametes** (eggs and sperm) into the water column (**pelagic zone**). The eggs are fertilized externally and called **pelagic eggs**. Eggs are found at or near the surface.

Many female fishes can broadcast 1 million or more eggs! Eggs are generally  $\leq 1$  mm, transparent, develop in  $\sim 1$  week and disperse great distances in the ocean.

#### ***The Life Cycle***

The life cycle of marine fishes is comprised of four developmental stages: egg (or embryonic), larval (yolk-sac and non-yolk-sac), juvenile and adult. The eggs and larvae of marine fishes are called **ichthyoplankton**. This is because they reside in the **plankton**, or the drifting and weakly swimming microscopic organism community suspended in the pelagic zone whose horizontal position is dependent on the flow of water.

The egg stage begins at fertilization and ends at **hatching**, or emergence from the egg. During the egg stage, a single cell develops into a complex organism, a fish!

At hatching, fishes enter the larval stage. Newly hatched larvae differ (sometimes dramatically) morphologically from adults. They are poorly developed (lack functional mouths and pigmented eyes) and possess a **yolk sac**, or membranous sac containing yolk that provides nourishment for the larvae. At this stage, larvae are termed **yolk-sac larvae**. When the yolk sac is depleted, larvae must feed **exogenously** (externally) on **phytoplankton** (plantlike, usually single-celled members of the plankton) and **zooplankton** (animal members of the plankton, e.g., copepod, an arthropod).

The transformation of larvae into juveniles is termed **metamorphosis** and is marked by the complete development of fin rays and beginning of scale development. Juveniles look like adults, but are smaller in size. They do not drift in the plankton like larvae, but instead actively swim. Juveniles become adults when the **gonads** (sexual organs in which gametes are produced) first mature.

The adult stage is characterized by active reproduction. Most marine fishes can reproduce multiple times and are termed **iteroparous**. Adults can migrate many hundreds of kilometers to feed and reproduce.

#### ***Mortality***

Agents of mortality act on all stages of development, from eggs to adults. **Starvation** and **predation** are two of the largest **biotic** (of, relating to, or caused by living things) factors leading

to mortality. Predation is common to all stages and starvation is a major factor for larval stages. Starvation during the transition from yolk-sac larvae to exogenously feeding larvae can lead to high mortality in a short period of time. This transitional period has been termed the **'critical period,'** because high mortality at this stage can affect the size of the adult fish population. Predation of eggs and larvae is higher than for juveniles and adults since eggs passively drift and larvae have limited swimming and thus escape abilities.

**Advection** (transport) offshore by currents is a source of mortality for eggs and drifting larvae. **Disease**, especially during the larval and juvenile stages can lead to mortality. **Fishing** mortality is high for fishes that have **recruited**, or entered into the phase of their life history where they are exploited by fisheries. Recruitment typically happens as juveniles and adults.

The **environment** plays an important role in mediating mortality. **Currents, turbulence, temperature, salinity** and **food abundance** are examples of important environmental, or **abiotic** (physical rather than biological) factors that affect the survival of fish eggs to adulthood.

## **Learning Activity**

### **Summary**

In this learning activity, students begin as “eggs” and “live” the life cycle of marine fishes, culminating as “adults” over 10 “days,” or 10 rounds of musical chairs. During days 1-2 students are “eggs,” days 3-5, “yolk-sac larvae;” day 6, “feeding larvae;” days 7-8, “juveniles;” days 9-10, “adults.” The start/end of each day is denoted by start/end of a song (similar to musical chairs) or by calling out “End of Day X” after some period of time (e.g., 1 min or random time interval with the use of a clock/timer).

Each day, students move through rows of desks/chairs to music (optional) and when the music (or time) stops, they must take a seat at the nearest desk/chair. A stack of cards with statements (mortality, survival) has previously been placed on each desk. Students reveal their “fate” by reading the top flashcard corresponding to the “day” or current round of the game. Most of the flash cards represent sources of mortality at the egg, yolk-sac larva, larva, juvenile and adult stages. Some flashcards represent survival. Just as in the ocean, very few eggs survive to adulthood, so most students will “die.”

Students that die re-enter the learning activity and further influence the fate of the surviving students. Students that die draw a card from a second stack of cards (“food,” or “predator;” “fisherman” becomes an option on day 8) and become what they draw. They sit in a desk/chair randomly and do not move during the next day. If “surviving” (moving) students end up at one of their desks/chairs, the seated students presents their cards. The surviving student may gain an extra food card (a “second chance” if they receive a starvation card during their larval stage) or die due to predation or fishing.

The learning activity progresses through the life cycle and only a few students will remain at the culmination. Educators are encouraged to have students play the game more than once to show that survival can vary. It is okay if no students survive at the culmination of the game. This in some respects truly reflects nature! But please, play again!

## **Instructions for Learning Activity**

### **Step 1: Preparation**

Prior to the day of the learning activity, educators need to print the cards provided at the end of the lesson plan and cut them out. Print out enough copies so that each student will have one card for each day (there are 10 days/ 10 cards for each student). Fold the printed page of cards in

half so that the days are on one side and the statements on the other side. Staple the folded paper along the left margin and cut apart the days. Now you have individual cards for each day!

It is recommended that you print more cards that are a source of mortality than survival. In fact, we suggest that 30% of “eggs,” 30% of “yolk-sac larvae,” 20% of “larvae,” and 10% of “juveniles” die. Only 10% of the students should make it to adulthood. There should be enough “predator,” “food,” and “fisherman” cards so that each student that “dies” can claim one card to re-enter the learning activity.

### ***Step 2: The Lesson***

Teach students the provided background information with a powerpoint lecture or by using a projector (to show images and movies) and white/chalk board to write down important information. Make sure to define new words. If possible, use these words for this week’s vocabulary lesson!

### ***Step 3: The Activity***

1. Place a stack of cards (with “Day” facing up and the statement facing down) on each desk/chair, one card for each day. The top card is “Day 1” and the bottom card is “Day 10.” There should be 10 cards total. Each stack will be unique.
2. At the front of the room, place a stack of cards (with “Additional- All days” facing up and the statement facing down) on an empty desk/chair. Include “Additional- Day 8, 9, 10” cards beginning on day 8.
3. Have students sit in their desks/chairs and tell them they will be playing a musical-chairs based game called “The Game of Life: Fish Edition.” Explain the rules. The object of the game is to progress through the life cycle of marine fishes and survive to adulthood.
4. Begin the song/timer and instruct the students to walk through each row of desks/chairs. When time is called/song is paused, instruct the students to take a seat in the nearest desk/chair. This denotes the end of day 1.
5. Have the students reveal the top card that says “Day 1”. Students that “survive” will continue to the next round/day. They will remain seated. Students that “die” must move to another area of the room. They will make a line.
6. Roll a die. The number corresponds to the number of students that will draw a card from the second stack of cards (“food” or “predator”). Start from the front of the line and count. Students that draw a “food” or “predator” card (later, “fisherman”) will randomly chose a desk and sit in it. They will not move around when the next day begins.
7. Begin the song/timer and instruct the surviving students to stand up and walk through each row of desks/chairs. When time is called/song is paused, the students must take a seat in the nearest desk. If students are already seated (with a “food” or “predator” card), they must present their cards to the surviving students. If the card says “predator,” the student is eliminated and joins the line. The student will take the next card in the stack (the one they would have drawn) and discard it. If the card says “food” they hold on to it. Food cards allow for a second (third, etc) chance if a student draws, “You don’t have any yolk sac left and never found any food. If you have a food card, you get another chance! If not, you died of starvation.” The student draws the next card (“Day 2,” “Day 3,” etc.) and they either survive or die.

8. Continue through the days until the game is complete! Remember to add the “Additional-Day 8, 9, 10” card that says “fisherman” when you reach day 8.
9. Have the students play a few times to show that the outcome is never the same. Sometimes more and sometimes fewer fishes survive!

#### ***Step 4: Discussion Questions***

Help students get the most of the learning activity by asking them the following questions and discussing their answers.

1. What stages are the most vulnerable to mortality?
2. What were the sources of mortality for eggs? Yolk-sac larvae? Larvae? Juveniles? Adults?
3. Do most marine fish eggs survive to adulthood?
4. What is the ‘critical period’?
5. What are more important, abiotic or biotic factors, in determining survival, or do they contribute equally?
6. Why might the reproductive strategy (i.e. spawning millions of eggs) of marine fishes be beneficial?
7. How do humans influence the survival of marine fishes?

#### **References and Recommended Resources**

*These books provide a detailed background on the life cycle of marine fishes as well as the sources of mortality.*

1. Miller, B.S., Kendall, A.W. Jr. (eds.) 2009. Early Life History of Marine Fishes, University of California Press. 364 p.
2. Houde, E.D. (2009) Recruitment variability. In: Jakobsen, T., Fogarty, M., Megrey, B., Moksness, E. (eds.) Reproductive biology of fish: implications for assessment and management, Wiley-Blackwell, p. 91-171.

#### **Questions?**

Contact Sara Walkup  
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Day 1

Oh no! You were never fertilized!

Day 1

You have not hatched yet, but you are in good condition.

Day 1

You were carried offshore by currents and died. Bad luck!

Day 1

Yikes! You were eaten by a hungry, adult fish!

Day 2

Congratulations! You successfully hatched!

Day 2

Lucky you! You hatched in an area with abundant food! Claim 1 food card.

**Day 3**

You are ok! Your yolk sac is large, providing you with plenty of food!

**Day 3**

Yikes! You were eaten by a hungry, adult fish!

**Day 4**

You are ok! Your yolk sac is large, providing you with plenty of food!

**Day 4**

You found a patch of food! Claim 1 food card.

**Day 4**

Yikes! You were eaten by a hungry, adult fish!

**Day 5**

You don't have any yolk sac left and never found any food. If you have a food card, you get another chance! If not, you died of starvation.

Day 5

You survived the 'critical period' and found plenty of food!

Day 5

Yikes! You were eaten by a hungry, adult fish!

Day 5

You caught a disease and died!

Day 6

You don't have any yolk sac left and never found any food. If you have a food card, you get another chance! If not, you died of starvation.

Day 6

You are ok!

Day 6

Yikes! You were eaten by a hungry, adult fish!

Day 7

You metamorphosed  
into a juvenile fish!

Day 8

You are ok!

Day 8

You were caught by a  
recreational fisherman, but  
he let you off the hook!

Day 9

You made it to  
adulthood!  
Congratulations!

Day 9

You were caught in  
a big net. Bad luck!

Day 9

You swam too close to the  
pier. You were caught by a  
recreational fisherman.

**Day 10**

**YOU  
SURVIVED!**

**Day 10**

You were caught in  
a big net. Bad luck!

**Additional- All  
days**

**Food**

**Additional- All  
days**

**Predator**

**Additional-  
Day 8, 9, 10**

**Fisherman**

