Spawn

FOCUS
Environmental needs of spawning deep water reef fishes

GRADE LEVEL
9-12 (Biology)

FOCUS QUESTIONS
What environmental conditions are necessary to ensure the success of spawning deep water reef fishes?

LEARNING OBJECTIVES

- Students will understand that the ability of certain deep water reef fishes to spawn successfully is dependent on numerous environmental conditions.

- Students will be able to list the critical factors needed by deep water reef fishes in the *Oculina* Banks Habitat Area of Particular Concern (OHAPC) to spawn successfully.

- Students will learn about some fish species found at the *Oculina* Bank and the methods they use to spawn.

MATERIALS
- Card stock paper
- Six decks of “Spawn” cards

AUDIO/VISUAL MATERIALS
Internet-enabled computer with projector (optional).

TEACHING TIME
One 45-minute class period, plus time for student research

SEATING ARRANGEMENT
Groups of 4 students

MAXIMUM NUMBER OF STUDENTS
24

KEY WORDS

Evolution	Larvae
Habitat	Estuary
Territorial	Upwelling
Spawning aggregation	Milt
Fertilized	Chlorophyll
Coral thicket	Current
Hard or live bottom habitat	Phytoplankton
Oculina varicosa	Haremic spawning
Oculina Banks	Limestone ridge
Pinnacle	Gag grouper
Scamp	Eddy
Gyre	Relief
Florida Current	Gulf Stream
Detritus	Mangrove wetland

BACKGROUND INFORMATION

Like all species, the deep water reef fishes of the *Oculina* Bank, such as gag and scamp groupers, are dependent on the environment where they live. Groupers are solitary, territorial fishes that claim a spot on a reef habitat, remaining there almost the entire year. Although these fishes have sufficient food resources, their solitary lifestyle does not easily provide an opportunity for reproduction and genetic exchange. Therefore, groupers and other territorial reef fishes meet at the same site at the same time each year, forming large spawning aggregations, where they release eggs and milt into the water for external fertilization. These aggregations may involve hundreds or thousands of fish because the higher the number of fish releasing thousands or even millions of eggs and sperm into the water increases the probability of successful fertilization. Spawning aggregations occur in places where certain environmental conditions are conducive to the survival of newly-released eggs and sperm, fertilized eggs and hatching larvae. Another spawning strategy used by fishes living on the *Oculina* Bank is haremic spawning. This occurs when one male and several females come together in a small group to reproduce.

Groupers and other reef fishes such as snapper, spawn on rocky reef habitats generally located in or near a current that will carry eggs and larval fishes to an area suitable for their growth into juveniles and adults. In particular, shelf edge reefs such as the deep water *Oculina varicosa* reefs provide important habitat for grouper spawning. In the *Oculina* Banks, scamp and gag groupers form spawning aggregations around high-relief *Oculina* pinnacles. The *Oculina* Bank is an area near the western edge of the Florida Current that extends from Cape Canaveral to Fort Pierce, Florida. At depths of 70 to 100 m along the edge of the continental shelf, *O. varicosa* forms a unique and complex habitat called the *Oculina* Banks. The habitat consists of a series of clustered limestone pinnacles that range from 5 to 30 m in height and are separated by flat, soft-bottom sediment. The pinnacles are topped with ivory tree coral, *O. varicosa*, which grows in spherical heads 1 to 2 m in diameter and provides the primary habitat structure of the reefs in this area (Reed, 1980). However, intensive fishing and habitat damage since the 1970s have decimated these aggregations.

There are several hypotheses why fishes depend on reef habitats for successful spawning. One hypothesis states that currents flowing in the vicinity of these reefs form eddies and gyres that carry the eggs to areas where the larval and juvenile fishes have a better chance of finding food and shelter. Most of the reef fishes in the *Oculina* Banks spawn near the Florida Current, which is considered the “official” beginning of the Gulf Stream System. The Florida Current is generally defined as the section of the system that stretches from the Florida Straits up to Cape Hatteras. The Florida Current was first reported by the Spanish explorer Ponce de Leon in 1513 when he discovered Florida (Galstoff, 1954).

Some groupers spawn in the gyres and eddies that spin off the Florida Current and Gulf Stream towards shore. These currents lead to inshore estuaries and mangrove wetlands; areas of high food production that provide nursery and refuge habitat for juvenile fishes. Wetlands and estuaries also produce and export detritus, which is an important component of marine and estuarine food chains. Nutrients enter the estuaries, thus providing a nutrient-rich environment in which phytoplankton and seagrasses grow. These plants support a large community of animals from the larval and juvenile offspring of spawning snappers and groupers, as well as tiny herbivores to large predators. By spawning in currents that bring them inshore, these young fishes have greater access to resources and increase their probability of survival.

There are also abundant food resources in the Florida Current. The Florida Current spins inshore affecting successful spawning of reef fishes off the Gulf Stream. The gyres and eddies carry warm water of the Gulf Stream into colder waters above the continental shelf. When warm water comes in contact with cold water, the colder, more dense water sinks below the warm water stirring the nutrients on the ocean floor left behind by decomposed marine organisms. Upwelling occurs when these nutrients are carried to the surface and are taken up by phytoplankton. Phytoplankton resulting from upwelling, is an integral component of the marine food chain and can support large communities of animals. In some gyres such as the Charleston Gyre, upwelling is constantly occurring and as a result it is one of the highest areas of food production in the South Atlantic Bight. The larval reef fishes spawned in the Gulf Stream in the South Atlantic Bight are spun into the gyres where the abundance of food offers a better probability of survival.

To spawn successfully, reef fish require hard bottom habitats and strong currents to carry fertilized eggs and larvae to areas of high food production. Successful spawning is vital because the protection of ecologically and economically important fishes such as snappers and groupers cannot be guaranteed solely through catch and size limit regulations. As reef fish are dependent on their environment for survival, entire ecosystems need to be protected.

Because the deep *Oculina* reef habitat exists nowhere else in the world, it provides an excellent opportunity for scientific studies. Little is known about the biology, population status, or ecological role of these unique deep water corals and the fishes supported by this unique habitat. The rarity of deep water corals also makes them vulnerable to human activities such as trawling and dredging. The 2008 *Oculina* Expedition will continue research and monitoring objectives within the *Oculina* Habitat Area of Particular Concern (OHAPC), including documenting grouper spawning and other reproductive activities.

LEARNING PROCEDURE

1. Print “Spawn” cards onto card stock and cut out each individual card. Print enough sets that the class can be divided into groups of four and each group can receive a deck of cards.
2. Discuss with the students how organisms adapt to their environment and how they become dependent on certain features of their environment in order to ensure their survival. Explain that the reef fishes of the OHAPC are an example of this. Explain that fishes, such as snappers and groupers, are solitary and live on reef habitats. However, when they spawn, they come together in groups of hundreds or even thousands over reef habitats in currents that can carry eggs to areas that have an abundance of food. Explain that without these conditions, the resulting fertilized eggs and hatching larvae may not be in an environment suitable for survival.
3. Tell the students that they will be playing the card game “Spawn.” Divide students into groups of four. Give each student group a deck of the “Spawn” cards and explain the rules. The object of the game is to have a hand that includes a reef fish card, a rocky reef habitat card, a current card, and a nearby habitat with high food production card. When all of these cards are in hand, the student has a successful “Spawn” and wins the game. Cards are shuffled and each student is dealt four cards. The rest of the deck is placed face down in the center of the students. The top card is flipped over and laid face-up next to the deck. The student to the left of the dealer goes first by taking the flipped over card or the card at the top of the deck. A student will finish his/her turn by discarding one card from his/her hand and placing it face up on the flipped over card. Students will keep the cards that make the best hand (those that together provide the conditions necessary for a reef fish to have a successful spawning) and should discard all other cards (non-reef fish, non-reef habitats, oceanic conditions without currents and nearby habitats with low food production), as these will not produce a winning hand. When the student has all four cards needed, the student will lay them face down, say “Spawn” and be declared the winner. If all the cards in the face-down deck have been drawn and no one has successfully “spawned” (i.e., won), shuffle the cards in the face-up deck, place this deck face-down, flip the top card over to make another face-up deck, and continue playing.
4. Have students play a few hands to allow them to learn the connection between spawning reef fishes and the environmental conditions they need to spawn successfully.
5. Follow up the card game by leading students in a discussion using the following discussion questions:
   a. Why do fish aggregate to spawn?
   b. What other methods do fish use to reproduce?
   c. What impact does fishing and/or habitat destruction have on spawning aggregations?
   d. Why do some spawning aggregations form at the same place and the same time every year?
   e. How do fish find a spawning aggregation?
   f. How can humans protect spawning aggregations?

THE "ME" CONNECTION
Have students collect menus from local seafood restaurants. How many of the fishes discussed in the activity show up on the menu? Discuss with students how these fishes might not be on the menu if some of the environmental factors necessary for the successful spawning of snappers and groupers were altered.

CONNECTIONS TO OTHER SUBJECTS
Social Studies, History, and Language Arts

EVALUATION
Based on everything they have learned about the environmental needs of spawning reef fishes, have each student write a description of a fisheries management plan that would protect both the fishes and their environmental needs.

EXTENSIONS
- Social Studies - Mapping. Have students search the Internet to find maps that show currents and chlorophyll densities (food production) and have them map potential places for reef fishes to spawn, ensuring currents will carry their young to a food source.
- Language Arts - Have students read the sections of Song for the Blue Ocean by Carl Safina on spawning groupers. Students should write a response to these sections, describing what they think about what man has done to grouper populations and how this might impact their lives?

LESSON PLAN RESOURCES

http://fwie.fw.vt.edu/WWW/macsis/fish.htm - Information on the life histories of fishes, including many of the reef fish found in the South Atlantic Bight

http://www.scrfa.org - Official web site for the Society for the Conservation of Reef Fish Aggregations

http://www.scaquarium.org/curriculum/iexplore/sixth_eighth/units/reefs/reefs_back.htm - Information on reefs and reef fishes of the South Atlantic Bight.

http://www.fishbase.org/search.cfm - Detailed information on the life histories of fishes, including many of the reef fishes found in the South Atlantic Bight.

http://oceancurrents.rsmas.miami.edu/caribbean/florida.html - information on the Florida Current

Koenig, C.C, Coleman, F.C., and Grimes, C.B. 2000. protection of fish spawning habitat for the conservation of warm-temperature reef-fish fisheries of shelf-edge reefs of Florida. Bulletin of Marine Science. 66(3):593-616.

Island in the Stream: Oceanography and Fisheries of the Charleston Bump. 2001. Sedberry, G. (Ed.). American Fisheries Society Publication. pp252. - A collection of scientific papers on reef and reef fishes in the South Atlantic Bight.

http://www.safmc.net/ - South Atlantic Fishery Management Council: links "Quick Links" from the homepage that take you to several pages with information relevant to the Oculina Bank, including research activities and links to several documents regarding management of the area. Use this link for deep water coral information:
http://www.safmc.net/HabitatManagement/DeepwaterCorals/tabid/229/Default.aspx

http://www.safmc.net/HabitatManagement/DeepwaterCorals/Oculina/tabid/246/Default.aspx
Evaluation Plan for the Oculina Experimental Closed Area. 2005. South Atlantic Fishery Management Council.

http://www.iucn.org/themes/marine/pdf/AlexRogers-CBDCOP7-DeepWaterCorals-Complete.pdf Rogers, A. 2004. The Biology, Ecology and Vulnerability of Deep-Water Coral Reefs. International Union for Conservation of Nature & Natural Resources (IUCN). 13pp.

http://www.uncwil.edu/oculina/Sections/introduction.htm – overview of *Oculina* reefs

Reed, J.K. 2002. Deep water *Oculina* coral reefs of Florida: Biology, impacts, and management. *Hydrobiologia*. 471:43-55.

Reed, J.K., Weaver, D.C, and Pomponi, S.A. 2006. Habitat and fauna of deep water *Lophelia Pertusa* coral reefs off the southeastern US: Blake Plateau, Straits of Florida, and Gulf of Mexico. Bulletin of Marine Science. 78(2):343–375.

http://oceanexplorer.noaa.gov/explorations/explorations.html - NOAA's Ocean Explorer website contains links to past and future expeditions.

http://oceanica.cofc.edu/Oculina2003/ProjectOverview.htm - Information on the 2003 *Oculina* Bank research cruise

http://www.bio.fsu.edu/ifre/ifre_research_oculina.html - Studies in the Experimental *Oculina* Research Reserve off the Atlantic Coast of Florida (be sure to click on the Ivory Tree Coral link)

Safina, C. 1999. Song for the Blue Ocean. Owl Books. pp384.

LITERATURE CITED

Galstoff, P.S. 1954. Historical Sketch of the Explorations in the Gulf of Mexico. Galstoff, P.S. (ed.) In: Gulf of Mexico and Its Origin, Waters, and Marine Life. Fishery Bulletin of the Fish and Wildlife Service. 55:3-36.

Reed, J.K. 1980. Distribution and structure of deep-water *Oculina varicosa* coral reefs off central east Florida. Bulletin of Marine Science. 30:667-677.

SUNSHINE STATE STANDARDS

How Living Things Interact With Their Environment SC.G.1.4
SC.G.2.4

ACKNOWLEDGEMENTS

Activity developed by Kevin Kurtz, South Carolina Aquarium, Charleston, SC. This lesson plan is a modified version of the one available at http://oceanexplorer.noaa.gov

Reef Fish

Gray Triggerfish

Reproductive Method:
Collects seasonally in large groups for spawning. Releases eggs and milt in water for external fertilization.

Reef Fish

Red Snapper

Reproductive Method:
Collects seasonally in large groups for spawning. Releases eggs and milt in water for external fertilization.

Reef Fish

Snowy Grouper

Reproductive Method:
Collects seasonally in large groups for spawning. Releases eggs and milt in water for external fertilization.

Fish

Clearnose Skate

Reproductive Method:
Female and male come together for internal fertilization. Larval skates released in egg cases.

Fish

Oyster Toadfish

Reproductive Method:
Female and male come together. Female attaches eggs to hard surface and male fertilizes externally and then guards eggs until larvae hatch.

Reef Fish

Blueline Tilefish

Reproductive Method:
Collects seasonally in large groups for spawning. Releases eggs and milt in water for external fertilization.

Fish

Sand Tiger Shark

Reproductive Method:
Female and male come together for internal fertilization. Embryo stays inside female and is born fully developed.

Fish

Seahorse

Reproductive Method:
Female and male come together. Female lays eggs in a pouch on the male's stomach. Male carries and protects eggs until after they hatch.

Habitat

Hard Bottom Reef

Habitat **Rocky Outcrop Reef**	Habitat **Rocky Outcrop Reef**	Habitat **Hard Bottom Reef**
Habitat **Muddy Bottom**	Habitat **Sandy Bottom**	Habitat **Saltmarsh Tidal Creek**
Oceanic Condition **Gulf Stream Current**	Oceanic Condition **Gulf Stream Current**	Habitat **Open Ocean**

Oceanic Condition

No Current

Oceanic Condition

Gyre Current Off of the Gulf Stream

Oceanic Condition

Eddie Current Off of the Gulf Stream

Oceanic Condition

No Current

Oceanic Condition

No Current

Oceanic Condition

No Current

Productivity of Nearby Habitats

Salt Marsh

Nutrients from freshwater rivers support abundant phytoplankton production and marsh grass production.

Productivity of Nearby Habitats

Charleston Gyre

Upwelling brings nutrients to the surface to support abundant phytoplankton production.

Productivity of Nearby Habitats

Charleston Gyre

Upwelling brings nutrients to the surface to support abundant phytoplankton production.

Productivity of Nearby Habitats

Charleston Bump

The Charleston Bump is a large reef habitat in the Gulf Stream. The fast moving current of the Gulf Stream does not carry nutrients for phytoplankton production.

Productivity of Nearby Habitats

Charleston Bump

The Charleston Bump is a large reef habitat in the Gulf Stream. The fast moving current of the Gulf Stream does not carry nutrients for phytoplankton production.

Productivity of Nearby Habitats

Salt Marsh

Nutrients from freshwater rivers support abundant phytoplankton production and marsh grass production.

Habitat

Hard Bottom Reef

Oceanic Condition

Gulf Stream Current

Productivity of Nearby Habitats

Charleston Gyre

Upwelling brings nutrients to the surface to support abundant phytoplankton production.

Fish: Reef

Red Porgy

Reproductive Method: Collects seasonally in large groups for spawning. Releases eggs and milt in water for external fertilization.

Productivity of Nearby Habitats

Open Ocean

The open ocean does not have enough nutrients for abundant phytoplankton production.

Productivity of Nearby Habitats

Open Ocean

The open ocean does not have enough nutrients for abundant phytoplankton production.