Continental Slope Communities

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Summary and Introduction

In the shallow coastal areas of the Gulf of the Farallones, as in other regions of the world, fishing pressure has increased and numbers of fish have decreased over the past few decades. As many fish stocks have declined, some fishermen have been forced to look elsewhere to fill their nets.

Traditional fishing grounds in the gulf have been located on the Continental Shelf, a rather flat, relatively shallow area of the sea floor adjacent to the coast. At a depth of about 200 m (660 ft), the bottom starts to drop off more rapidly on what is called the Continental Slope. It is on upper and middle parts of this steeper slope that the new fishing grounds have been established. Because the fish inhabiting these deeper waters are less understood than those in shallower water, there is a danger of overharvesting, which could threaten the long-term viability of these newer fisheries.

The deep waters of the Continental Slope are characterized by nearly freezing temperatures, extremely low light conditions, and very high pressures. Because of the cold, organisms that live at these depths have slower metabolisms—they eat less frequently, are slower in digesting their food, and move and grow more slowly. They also attain greater ages than their counterparts that live in shallower waters—some deep-sea rockfish live more than 70 years.

Many of the animals living in the perpetual darkness of the Continental Slope have developed light-producing organs. These serve various functions, such as communicating with members of their own kind (as in courtship), attracting food (like attracting moths to a flame), and avoiding being eaten (flashing a light in a predator's eyes can give an animal a chance to get away).

Another adaptation to the darkness is an absence of color diversity. With no light, colors have little function. Therefore, animals living on the Continental Slope are generally a dark color, like black, brown, or red. Among the fishes, rockfish and thornyheads are dominantly red. Red objects appear black at depth, allowing red organisms to blend in with their dark surroundings.

The water pressure on the sea floor at the top of the Continental Slope is more than 10 times higher than at the surface, and at the bottom of the slope the pressure can be more than 100 times higher than at the surface. To compensate for this high pressure, organisms have a large percentage of water in their tissues, bones, and shells that replaces other substances, such as gases and calcium. Owing to the high water content of their tissues, many larger, older fish caught from deeper waters are limp and soft when brought to the surface.

Fishes living at different depths on the Continental Slope have different life histories. Species living near the top of the slope produce pelagic (open-ocean) young that spend the first few months to years of life swimming in the upper water column and then settle out in relatively shallow water and migrate downslope as they grow and mature. Dover sole, sablefish, and rockfish have this type of life history; however, most species living deeper, such as rattails, deep-sea soles, and slickheads, have young that live in the same depths as the adults.

Relatively few species occur at all or most depths on the Continental Slope. Species occupying one depth commonly are replaced by similar species at other depths. An exception is the eel-like hagfish, which is found at all depths on the slope.

Productive commercial fisheries operating today on the Continental Slope off California's coast catch Dover sole, sablefish, deep-living rockfishes, and thornyheads. Many of these fishes

occupy similar habitats and generally are caught together. One increasingly active fishery is for rattails, a deep-living fish with a large head and a long tail that tapers to a point.

One major fishery of note is for hagfish, the skin of which is used to make what are sold as "eel skin" wallets. Hagfish are not true eels but are a primitive group of fish that have no bones or jaws. Instead of bones, they have cartilage, and instead of jaws, they have a large sucker-like mouth similar to that of a lamprey or a leech. Once attached, hagfish use a tongue with many tiny teeth to dig into their prey. Once inside, the prey is eaten from the inside out. Besides its unique method of eating, the hagfish has another interesting trait—it produces copious amounts of slime, probably used to discourage predators, which gives the fish its nickname, the "slime eel."

Except for fishing activities, the Continental Slope and its communities of fish and invertebrates are still virtually untouched by humans, offering scientists the opportunity to study a generally undisturbed natural system. New methods, such as viewing animals and their habitat by underwater video cameras in submarines and in remotely operated vehicles, have been particularly productive in providing a new understanding of fish and invertebrates living on the slope. In the Gulf of the Farallones, scientists are using these methods to collect data at increasingly greater depths, providing critical information needed to better protect these areas from overuse.

Fishing Grounds

Traditional fishing grounds in the Gulf of the Farallones have been located on what is called the Continental Shelf, a rather flat area of the sea floor adjacent to the coast that slopes gradually down from the shore to water depths of about 200 m (660 ft). From there, the bottom drops off more rapidly on what is called the Continental Slope, until it meets the deep-sea floor (abyssal plain) at about 3,200-m (10,500 ft) water depth. It is on upper and middle parts of this steeper slope that the new fishing grounds have been established. Because the fish inhabiting these deeper waters are less understood than shallower species, there is a danger of overharvesting, which could threaten the long-term viability of these newer fisheries.

Environment of the Continental Slope

The deep waters of the Continental Slope are characterized by cold temperatures, low light conditions, and very high pressures. Sunlight does not penetrate to these depths, having been absorbed or reflected in the water above. In absorbing sunlight, surface waters are heated, while deeper waters stay cold, typically just a few degrees above freezing. Some mixing of the warm and cold waters occurs, generally in the top 100 m (330 ft) of the water column.

Adaptations to Life on the Slope

Because of the cold environment, organisms that live at greater depths have slower metabolisms. As a result, they eat less frequently, are slower in digesting their food, and move more slowly. When these organisms are observed at depth with video equipment, they typically are seen sitting immobile on the bottom or floating with the current just off the bottom. Another consequence of slower metabolism is that the animals grow more slowly and attain greater ages than their counterparts that live in shallower waters. It has been determined that some deep-sea rockfish live more than 70 years.

Many of the animals living in the perpetual darkness of these depths have developed light producing organs. Among organisms with these structures are shrimps and several fishes, including midshipman, flashlightfish, lampfish (fig. 1), and headlightfish. Each species has its own

distinctive pattern of lights that serve various functions, such as communicating with members of their own kind (as in courtship), attracting food (like attracting moths to a flame), and avoiding being eaten (flashing a light in a predator's eyes can give an animal a chance to get away).

Another adaptation to the darkness is an absence of color diversity. With no light, colors can have no function. Therefore, animals living on the Continental Slope are generally either a dark color, like black or brown, or red (fig. 2). Among the fishes, rockfish and thornyheads are dominantly red. Red is also the basic color of many invertebrates, including certain crabs and shrimps. The red wavelengths of sunlight are absorbed in the water near the surface, and so do not penetrate to deeper areas. Because of this, red objects appear black at depth, allowing red organisms to blend in with their dark surroundings. Most animals living on the Continental Slope are dark. Among the few exceptions is the deep-sea sole, which is mostly blue, with some black and brown.

The water pressure on the sea floor at the top of the Continental Slope is more than 10 times higher than at the surface, and at the bottom of the slope the pressure can be more than 100 times higher than at the surface. To compensate for this difference in pressure, organisms have a large percentage of water in their tissues, bones, and shells that replaces other substances, such as gases and calcium. Owing to the high water content of their muscle tissues, many larger, older fish caught from deeper waters are limp and soft when brought to the surface. An example is the Dover sole, which as it grows and matures, moves deeper downslope, increasing the water content of its tissues. Because of their high water content, mature Dover sole brought to the surface become "jellied" and slimy, leading to one of the fish's original names, "slime sole." Another such example is the shells of some deep-slope crabs, which are rigid at depth but are easily crushed when they are brought to the surface.

Different Slope Communities

Fishes living at different depths on the Continental Slope have different life-histories. Species living near the top of the slope produce pelagic (open ocean) young that spend the first few months to years of life swimming in the upper water column and then settle out in relatively shallow water and migrate downslope as they grow and mature (fig. 3). Dover sole, sablefish, and rockfish (fig. 4) have this type of life history; however, most species living deeper, such as rattails, deep-sea soles, and slickheads, have young that live in the same depths as adults.

Relatively few species occur at all or most depths on the Continental Slope. Species occupying one depth commonly are replaced by similar species at other depths. An exception is the eel-like hagfish, which is found at all depths on the slope. In general, the distribution of most groups changes with increasing depth. For example, on the upper part of the slope, greenstriped and stripetail rockfishes live on muddy bottoms, whereas at greater depth, they are replaced by two species of thornyheads (fig. 5). Another example is skates, which are similar to rays. About five common species of skates live in the shallow waters of the slope, whereas three different species live at greater depths on the slope.

Fisheries

Currently productive commercial fisheries on the Continental Slope off California's coast catch Dover sole, sablefish, deep-living rockfishes, and thornyheads . Many of these fishes occupy similar habitats and generally are caught as a group. One increasingly active fishery is for rattails, a deep-living fish with a large head and a long tail that tapers to a point. Another fishery

exists for spot prawn, a rather large, spotted shrimp that lives on muddy bottoms along the slope. Smaller fisheries include one for a large shell-less snail (a nudibranch) that is sold for scientific research.

One major fishery of note is for hagfish, the skin of which is used to make what are sold as "eel skin" wallets. Hagfish are not true eels but are a primitive group of fish that have no bones and no jaws. Instead of bones, they have cartilage, and instead of jaws, they have a large sucker-like mouth similar to that of a lamprey or a leech. Once attached, hagfish use a tongue with many tiny teeth to dig into their prey. Once inside, the prey is eaten from the inside out. Besides its unique method of eating, the hagfish has another interesting trait—it produces copious amounts of slime, probably used to discourage predators, and giving the fish its nickname, the "slime eel."

Conclusion

Except for current fishing activities, the Continental slope and its communities of fish and invertebrates are still virtually untouched by humans, offering scientists the opportunity to study a generally undisturbed natural system. Studying these deep areas is difficult. The traditional method has been to use nets towed along the sea floor to collect animals for study. Though effective in collecting certain kinds of data, such on diet, physical health, and numbers of eggs of fishes and invertebrates, this method can be destructive to the environment because it disturbs the ocean bottom. New methods have been developed in recent years. The first such method was the use of underwater cameras that are activated by the organisms being photographed or that operate automatically after a certain time interval. These cameras have provided much new information on the habits of deep-living animals. Two other new methods—viewing animals and their habitat by underwater video cameras in submarines and in remotely operated vehicles—have been particularly productive. In the Gulf of the Farallones, scientists are using these new methods to collect data at increasingly greater depths, providing critical information needed to better protect these areas from overuse.

Further Reading

Eschmeyer, W.N., Herald, O.W., and Hammann, H., 1983, A field guide to Pacific Coast fishes: Boston, Houghton Mifflin, 336 p.

Fitch, J.E., and Lavenberg, R.J., 1968, Deep-water fishes of California: Berkeley, University of California Press, 155 p.

Gage, J.D., and Tyler, P.A., 1991, Deep-sea biology; a natural history of organisms at the deep-sea floor: Cambridge, Mass., Cambridge University Press, 504 p.

Hart, J.L., 1973, Pacific fishes of Canada: Fisheries Research Board of Canada Bulletin 180, 740 p.

Figure 1. Northern lampfish with light organs (small white circles) along its underside. This small fish, only about 6 cm (2.5 in) long, also displays the dark coloration typical of many animals on deeper parts of the Continental Slope. (Photograph courtesy of K. Sakuma and D. Roberts.)

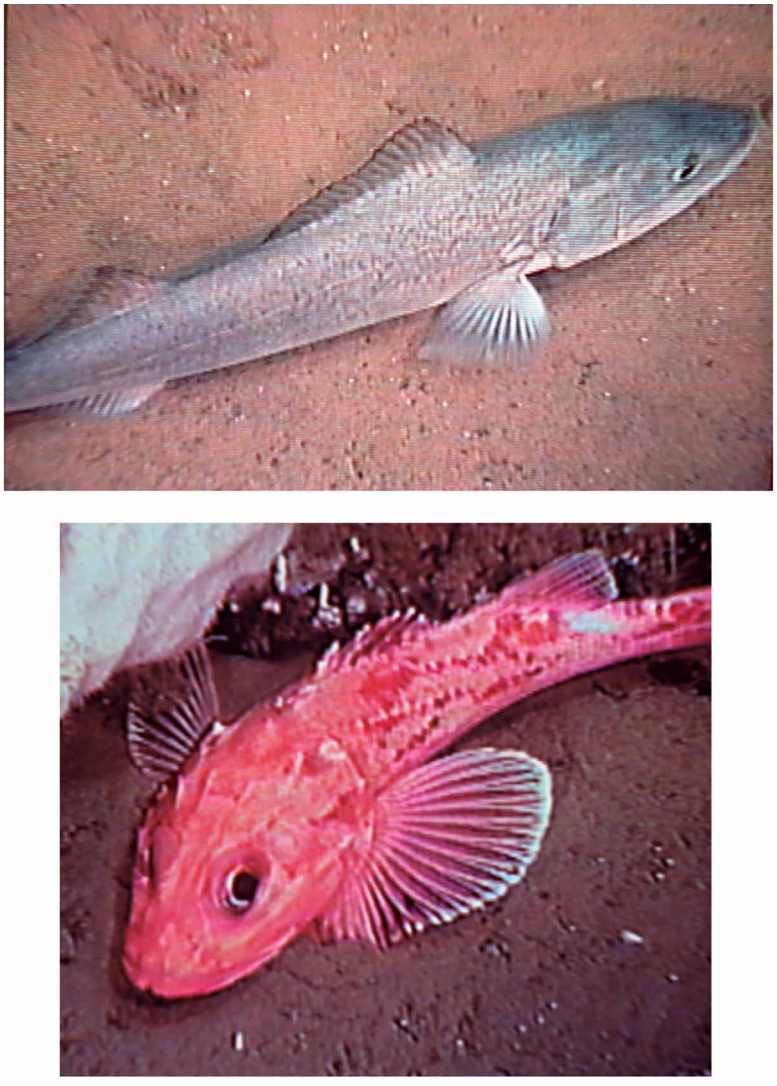

Figure 2. Because of the absence of light on the Continental Slope, animals living there are generally either a dark color, such as the sablefish (top), or red, such as the shortspine thornyhead (bottom).

Figure 3. Juvenile rockfish swimming over Cordell Bank in the northern Gulf of the Farallones. Species of fish living near the top of the Continental Slope in the gulf produce pelagic (open-ocean) young that spend the first few months to years of life swimming in the upper water column and then settle out in relatively shallow water and migrate downslope as they grow and mature. (Photograph courtesy of Robert Schmieder, Cordell Expeditions.)

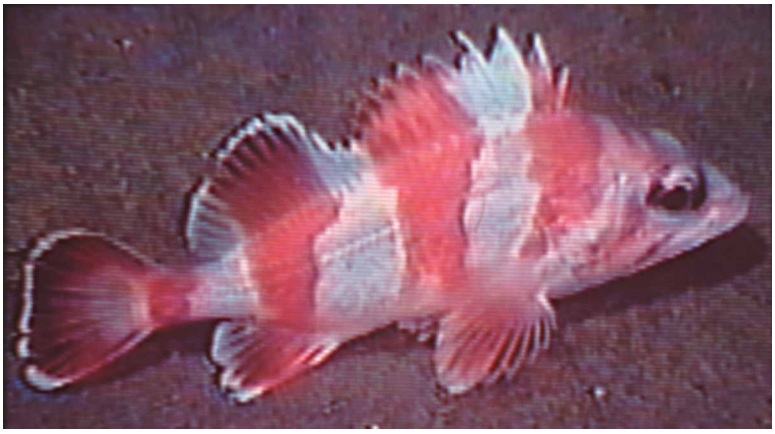

Figure 4. A red-banded rockfish on the Continental Slope in the Gulf of the Farallones. Relatively few species of fish occur at all or most depths on the slope. Those occupying one depth commonly are replaced by similar species at other depths. For example, greenstriped and stripetail rockfishes live on muddy bottoms on the upper part of the slope, whereas at greater depth they are replaced by species of thornyheads.

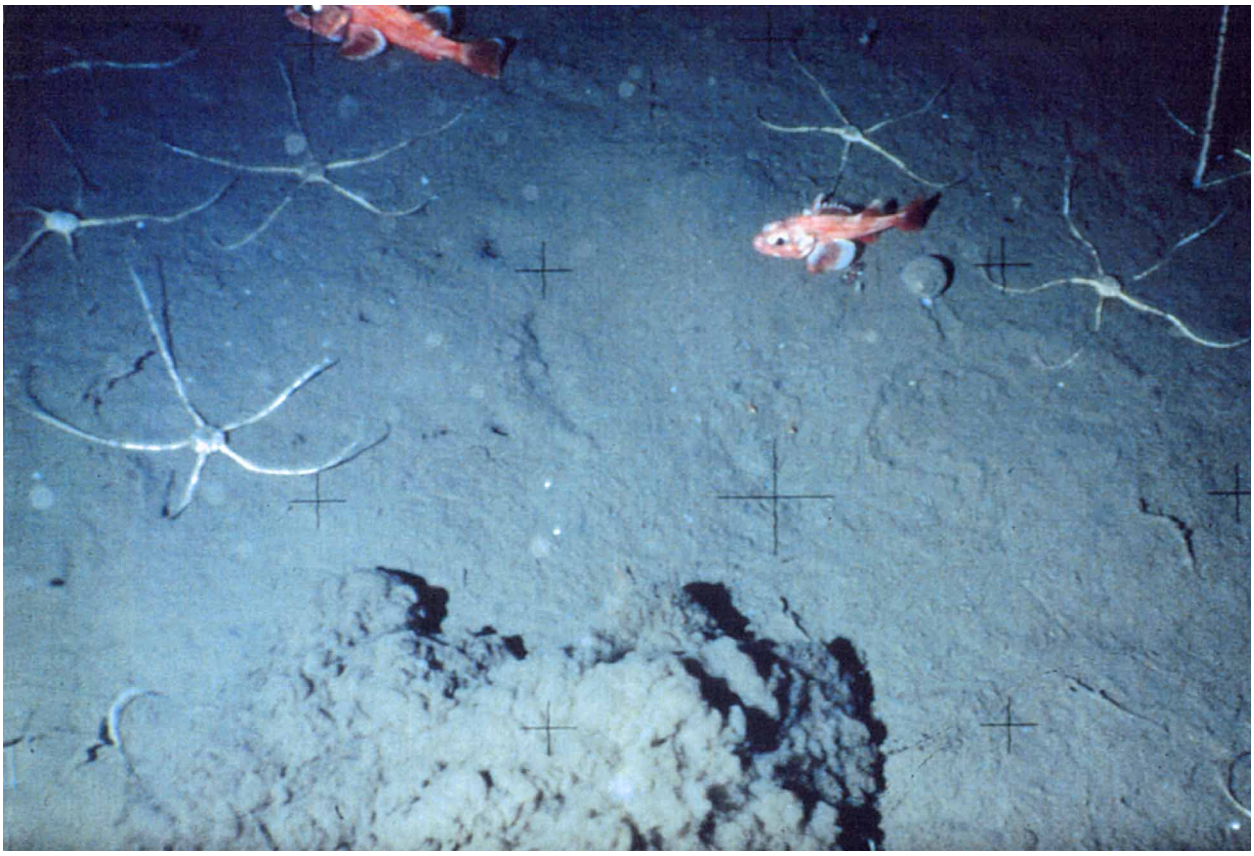

Figure 5. Thornyheads, giant brittle stars, and other animals on the deeper Continental Slope in the Gulf of the Farallones. (Photograph from Gulf of the Farallones National Marine Sanctuary.)