Why can some fish live in freshwater, some in salt water, and some in both?

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The various species of fish found in oceans, lakes, rivers and streams have evolved over millions of years and have adapted to their preferred environments over long periods of time. Fish are categorized according to their salinity tolerance. Fish that can tolerate only very narrow ranges of salinity (such freshwater fish as goldfish and such saltwater fish as tuna) are known as stenohaline species. These fish die in waters having a salinity that differs from that in their natural environments.

Fish that can tolerate a wide range of salinity at some phase in their life-cycle are called euryhaline species. These fish, which include salmon, eels, red drum, striped bass and flounder, can live or survive in wide ranges of salinity, varying from fresh to brackish to marine waters. A period of gradual adjustment or acclimation, though, may be needed for euryhaline fish to tolerate large changes in salinity.

It is believed that when the newly formed planet Earth cooled sufficiently, rain began to fall continuously. This rainfall filled the first oceans with fresh water. It was the constant evaporation of water from the oceans that then condensed to cause rainfall on the land masses, which in turn, caused the oceans to become salty over several billion years. As rain water washed over and through the soil, it dissolved many minerals -- sodium, potassium and calcium -- and carried them back to the oceans.

Vertebrate animals (fish, birds, mammals, amphibians and reptiles) have a unique and common characteristic. The salt content of their blood is virtually identical. Vertebrate blood has a salinity of approximately 9 grams per liter (a 0.9 percent salt solution). Almost 77 percent of the salts in blood are sodium and chloride. The remainder is made up primarily of bicarbonate, potassium and calcium. Sodium, potassium and calcium salts are critical for the normal function of heart, nerve and muscle tissue.

If the salinity of ocean water is diluted to approximately one quarter of its normal concentration, it has almost the same salinity as fish blood and contains similar proportions of sodium, potassium, calcium and chloride. The similarities between the salt content of vertebrate blood and dilute seawater suggest a strong evolutionary relationship among vertebrates and with the primordial oceans.

Indeed, it seems likely that vertebrate life evolved when the oceans were approximately one quarter as salty as they are today. As the oceans became saltier and vertebrates evolved further, several groups of vertebrates (birds, mammals, reptiles and amphibians) left the oceans to inhabit the land masses, carrying the seawater with them as their blood. They maintained their blood salt concentrations by drinking freshwater and absorbing salts from food.

But fish stayed in the aquatic environment. To adapt, they had to either remain in low salinity environments, such as bays and estuaries, or they had to evolve mechanisms to replace water lost through osmosis to the seawater and to remove salts absorbed from the increasingly saline oceans. To inhabit fresh water, fish had to replace salts lost through diffusion to the water and eliminate excess water absorbed from the environment. Kidney function had to be altered accordingly for fish to survive in these different habitats. Eventually, the gills developed the ability to excrete salts in seawater and absorb salts from fresh water.

In seawater, fish must drink salt water to replace lost fluids and then eliminate the excess salts. Their kidneys produce small volumes of fluid containing high concentrations of salt. Freshwater fish produce large volumes of dilute urine, which is low in salt. High concentrations of environmental calcium help reduce salt loss through the gills and body surfaces in freshwater environments. Less demand is placed on the kidneys to maintain stable concentrations of blood salts in brackish or low salinity waters.

Ultimately, fish adapted to or inhabited marine, fresh or brackish water because each environment offered some competitive advantage to the different species. For instance, it has been suggested that euryhaline fish are able to eliminate external parasites by moving to and from fresh and saltwaters. Habitats of differing salinity offered new or more food, escape from predators and even thermal refuge (stable temperatures).

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http://www.ca.uky.edu/wkrec/Wurtspage.htm