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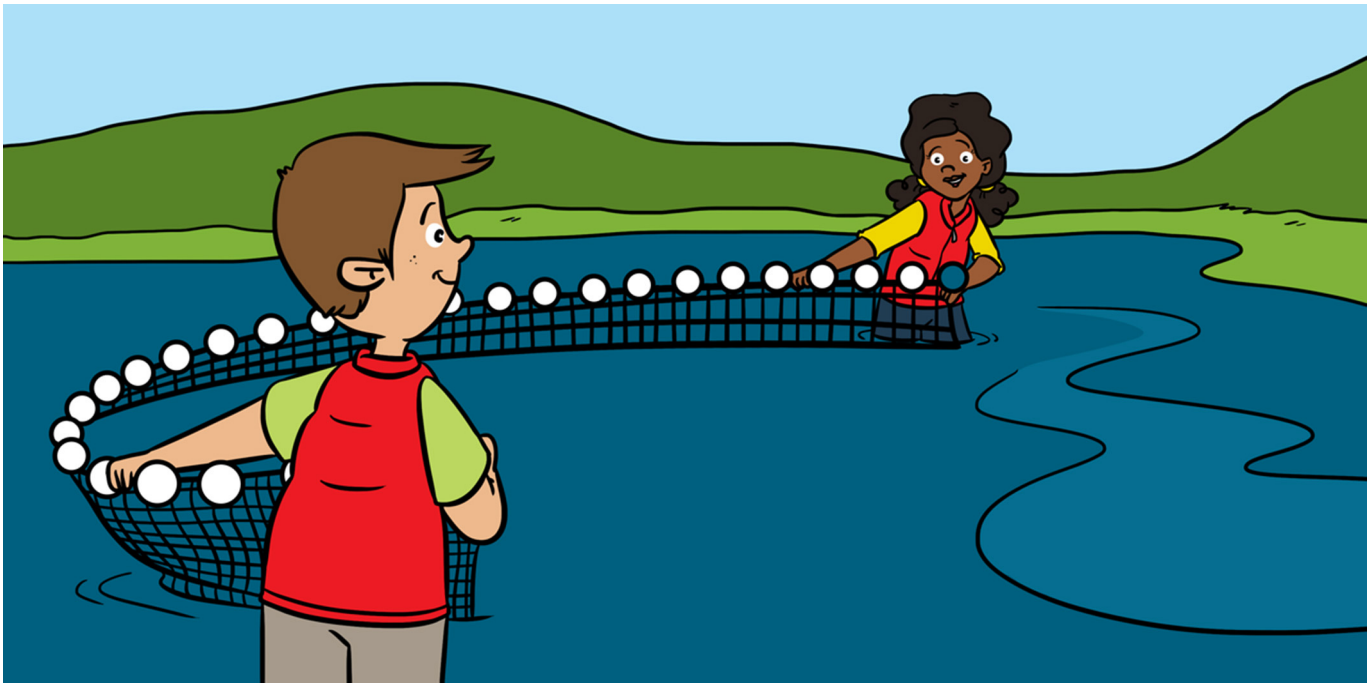

FISH LOVE FLOODS: BENEFITS OF FLOODPLAINS IN SAN FRANCISCO ESTUARY

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YOUNG REVIEWERS:

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Lots of rain can make rivers rise, causing them to spill into low-lying areas called floodplains. Floodplains protect cities from flooding and provide food-rich, safe habitats for freshwater creatures. The largest floodplain of the San Francisco Estuary is the Yolo Bypass. The Yolo Bypass is connected to the Sacramento River and protects Sacramento and surrounding areas from flooding. A twenty-plus year scientific monitoring program in the Yolo Bypass has documented many benefits that this floodplain provides to the Estuary. For example, the Yolo Bypass is a nursery area for baby fish such as young Chinook salmon and Sacramento splittail, and it is an important food bank that transports fish food to the rest of the Estuary. This article discusses some of the benefits that floodplains provide for fish species, and it highlights the importance of long-term monitoring to help scientists and managers make decisions for the benefit of fishes and ecosystems.

WHAT IS A FLOODPLAIN?

FLOODPLAIN

Low-lying land adjacent to a river that becomes flooded when the river overflows.

When rivers overflow their banks, they produce flooding. The low areas most likely to flood are called **floodplains**. Floodplain habitat is unique because it changes dramatically during flood events, turning from dry land to a large area of water that can resemble a shallow lake. Floodplains can benefit humans by directing flood waters away from cities and towns where lots of people live. However, many floodplain habitats have been built on, removed, or altered by humans, which can result in flooded homes and crops, and may destroy the livelihoods of humans living on the floodplain. Development can also decrease some of the benefits that floodplains provide.

However, when floodplains are permitted to flood naturally, they provide great habitats for fish, birds, and other wildlife, by producing food and providing protection. Around the world, many species of fish and wildlife have evolved to consume the large numbers of insects and **plankton** that are produced on floodplains. Floodplains are often important places for endangered animals, and many floodplains are being restored to more natural conditions to try to help these disappearing species. While there are floodplains on rivers all around the world, this article will use the example of a floodplain in California (United States). We will discuss how floodplains are studied and describe some of the interesting results that were obtained.

PLANKTON

Very small plants or animals that drift or float in the water. These can include microscopic plants and invertebrates, as well as egg and larval stages of larger animals.

THE YOLO BYPASS FLOODPLAIN

The Yolo Bypass is a floodplain of the Sacramento River in the Upper San Francisco Estuary. While the main role of the Yolo Bypass is to protect the city of Sacramento and its residents from flood damage, it is also an important area for farming and ranching, and an important wildlife habitat. During the spring and summer, farmers grow beets, tomatoes, corn, rice, and other grains on the floodplain [1]. In the winter, flooded wetlands and farmlands on the floodplain provide a food-rich habitat for migrating birds, such as ducks and geese, as well as other animals.

Flooding on the Yolo Bypass changes from year to year due to the unpredictable rain and snow patterns of the region. During the winter and spring, heavy rain and melting snow from the mountains can cause water levels in the Sacramento River and other nearby creeks to rise, overflowing into the Yolo Bypass. However, flooding is extremely variable, so it does not occur every year [2]. When flooding does occur, the water can come from different sources, which may have unique nutrients and food. Flooding can last anywhere from 1 day to several months. The timing and length of flooding influence the amount of food resources that can build up in the floodplain, as well as whether

and how species can enter and use the habitat and benefit from these resources [1].

HOW DO WE STUDY THE FLOODPLAIN?

To understand how the Yolo Bypass changes over time and how these changes affect the animals that use the floodplain, scientists monitor the system year-round. The Yolo Bypass Fish Monitoring Program was created in 1998 and has been providing information about fish, invertebrates, and water quality for over two decades. This is called a long-term monitoring program because it allows scientists to explore trends in the habitat and the organisms that live there, over many years. Floodplains can have highly variable habitats and conditions depending on the season and weather. Thus, the monitoring program is designed to provide information about the floodplain during a variety of different conditions, and it is also designed to adapt to changing conditions. For example, the floodplain provides more benefits to native and endangered fish when it is flooded, so scientists increase sampling during these periods and reduce sampling in the summer, when very few native fish are present in the floodplain.

Scientists in the monitoring program use three different sampling methods to target fish in various habitats and stages of life: the rotary screw trap, fyke trap, and beach seine (Figures 1A–C). To study insects and plankton in the floodplain, scientists use nets of varying sizes (Figure 1D). Once caught, fish, insects, and plankton are counted, identified, and some species are measured and weighed. To study water quality, scientists take daily measurements of the

Figure 1

Figure 1

Sampling methods used by the Yolo Bypass Fish Monitoring Program. **(A)** Fyke traps are used to monitor the movements of adult Chinook salmon, sturgeon, and other fishes moving upstream. **(B)** Beach seines are used year-round to monitor fish living in shallow shoreline habitat. **(C)** A rotary screw trap is used to monitor juvenile fish as they leave the Yolo Bypass. **(D)** Drift nets are used to identify the water- and land-based insects available for juvenile and adult fish as food.

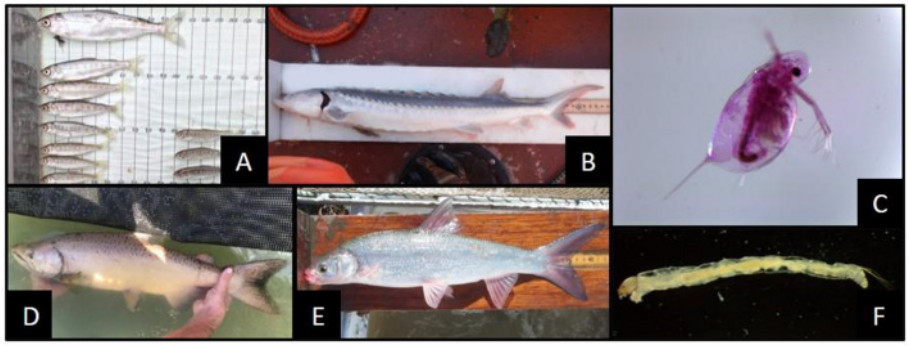

Figure 2

Figure 2

Fish and invertebrates sampled in the Yolo Bypass by the California Department of Water Resources. **(A)** Juvenile Chinook salmon; **(B)** juvenile white sturgeon; **(C)** water flea; **(D)** adult Chinook salmon; **(E)** adult Sacramento splittail; and **(F)** larval midge [Photograph credits: **(C)** Michelle Avila, California Department of Fish and Wildlife; **(F)** Tricia Bippus, California Department of Fish and Wildlife].

water temperature, acidity, oxygen levels, and nutrient levels. Finally, the monitoring program also conducts special studies when there is something especially interesting that needs a closer look, like the question of whether fish grow better in certain areas of the floodplain, or whether there are predators eating threatened or endangered fish species.

WHICH ANIMALS USE THE YOLO BYPASS?

SPAWNING

The process of producing and releasing eggs or sperm. For many fish species, spawning only occurs during specific periods of the year or certain environmental conditions.

LARVAE

The early period of an animal's life when it first hatches from an egg and looks and behaves very differently from an adult.

The Sacramento splittail (Figure 2E) is a sleek, silvery native fish species with (you guessed it!) a split, or forked, tail. Splittail respond to the flooding and fast-flowing water that occur in the winter and spring, and they swim into the Yolo Bypass because flooding creates a shallow, protected, warm, and food-rich habitat that is suitable for splittail **spawning** and growth [1]. Once flooding stops, splittail and other fish quickly move out of the floodplain into the Sacramento River, where they continue to grow. For splittail to fully benefit from the floodplain, the land must be flooded long enough to allow adults to swim into the floodplain, spawn their eggs, and for the resulting **larvae** to grow and feed. When fish use a habitat to spawn and grow, this means they use the floodplain as a nursery area. Scientists have found that flooding needs to last at least 1 month for large numbers of splittail larvae to hatch and survive [3]. In years when the Yolo Bypass was not flooded, scientists did not catch many larval splittail, and after a long drought period, scientists thought splittail were going extinct. However, these fish have a talent for bouncing back once favorable conditions, such as flooding and high river flows, return (Figure 3).

Another fish that uses the floodplain as a nursery is the Chinook salmon (Figures 2A,D). Juvenile (young) salmon arrive in the Yolo Bypass in the winter and spring, when high river flows guide the fish down from their hatching grounds. After spending some time growing in the floodplain, the salmon swim to the ocean to mature, then return to their freshwater spawning grounds after several years. Juvenile salmon that have spent time in the Yolo Bypass have been found to grow

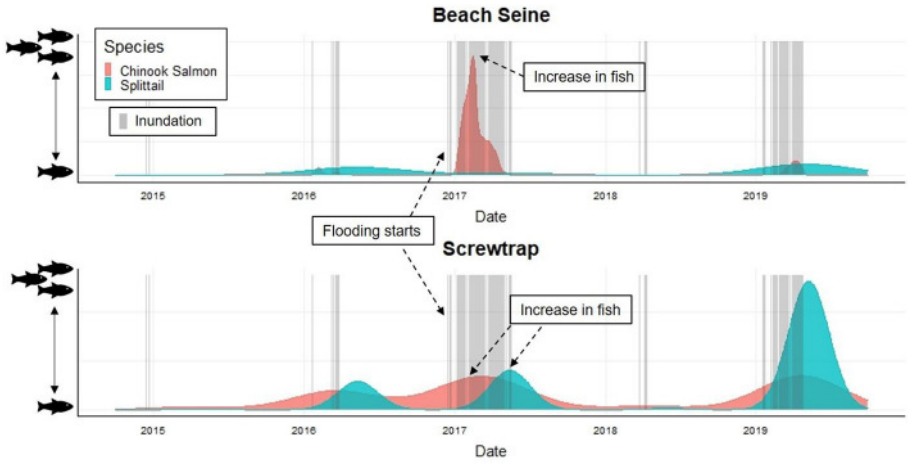

Figure 3

Figure 3

The number of Chinook salmon (pink) and splittail (blue) collected in the Yolo Bypass increases when the Yolo Bypass gets flooded (gray shaded bars, "inundation"). Data were collected from 2015–2019, using a beach seine (top plot) and a screw trap (bottom plot).

particularly quickly, because the Bypass has much more food than the nearby Sacramento River [1, 4]. Some of the salmon's favorite foods include insects and plankton, including different life stages of midges, flies, and water fleas (Figures 1C,F), which are abundant in the Yolo Bypass [2, 4]. These food resources, which increase during flooding, also feed fish living in other parts of the San Francisco Estuary, once the water in the floodplain drains out into the river. While there are usually more salmon during wet, flooded years when the floodplain is under water for longer periods of time (Figure 3), salmon also use the Yolo Bypass during drier years, but they change what they eat, eating more of the plankton that are available under those conditions [2]. Scientists and **resource managers** are particularly interested in how the floodplain helps Chinook salmon because some types of salmon are threatened or endangered. Understanding how the Yolo Bypass can help juvenile salmon grow faster is useful to organizations that are deciding how to best protect and increase the numbers of these fish.

RESOURCE MANAGERS

People from various government organizations who protect and manage the wellbeing and usage of land, water, and wildlife.

WHY IS MONITORING IMPORTANT?

Hopefully, you now see the many benefits that floodplains can provide for humans and fish. It is important to note that without a monitoring program like the Yolo Bypass Fish Monitoring Program, we would miss a lot of important details about how floodplains function and how they help the broader ecosystem. Long-term data collected by this monitoring program are the reason we know that the Yolo Bypass produces a lot of fish food, and that it is an important nursery area for native fishes such as splittail and Chinook salmon [1, 3, 4]. These results, among others, are helping with the **restoration** of floodplain habitat. With these projects, scientists and resource managers hope to improve the wellbeing of native fishes and the overall health of the San Francisco Estuary.

RESTORATION

Changes to a habitat to improve its quality, usually for the benefit of protected species. Restoration can involve constructing a new habitat or reconnecting existing habitats.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ISABEL, AGE: 11
Hello, I am Isabel. I am 11 years old and I really like writing stories. I also like reading. I am really interested in diplomacy.

MARGARIDA, AGE: 13

My name is Margarida, I am 13 years old and I like reading, climbing and writing. I love science, especially anything about black holes and I have absolutely no idea what I want to do when I grow up. I also really like biology.

AUTHORS

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Catarina is an environmental scientist working on the Yolo Bypass Fish Monitoring Program. She grew up in New Jersey and completed her master's in marine science studying sharks and rays in a California estuary. She is interested in fish ecology and supports the monitoring program's database management and data synthesis efforts. *Catarina.Pien@water.ca.gov

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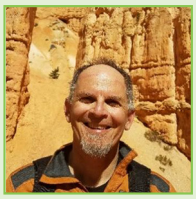
Amanda is a marine biologist currently working at Stantec. She previously worked on the Yolo Bypass Fish Monitoring Program. She grew up in Minnesota then moved to California to get her bachelor's degree and begin her scientific career. She enjoys studying fish and their habitats and spends a lot of her time out in the field collecting data.



TED SOMMER

Dr. Sommer was the lead scientist for the California Department of Water Resources until 2021. He did his Ph.D. on the Yolo Bypass and founded the Yolo Bypass Fish Monitoring Program in 1998. His work focuses on the endangered fish of the San Francisco Estuary and their habitats.

BRIAN SCHREIER

Brian is the lead smelt biologist for the California Department of Water Resources. He led the Yolo Bypass Fish Monitoring Program for 8 years and has been studying the endangered fishes of the San Francisco Estuary for over 10 years. He got his bachelor's degree in Wisconsin and his master's degree in California (studying monkeys!).