Hood Canal Bridge and Its Impacts on the Ecosystem

Bridge structure affects predation of steelhead, water quality, and salmon behavior. Modifications are likely to improve fish survival.

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The Hood Canal Bridge provides a vital transportation link across the 68-mile-long fjord, but the bridge also impedes the migration of salmon and steelhead from many high-quality streams on the Olympic and Kitsap Peninsulas.

When the Hood Canal Bridge opened to traffic in 1961, nobody knew that the unique floating structure would become a trap of sorts for untold numbers of young salmon and steelhead.

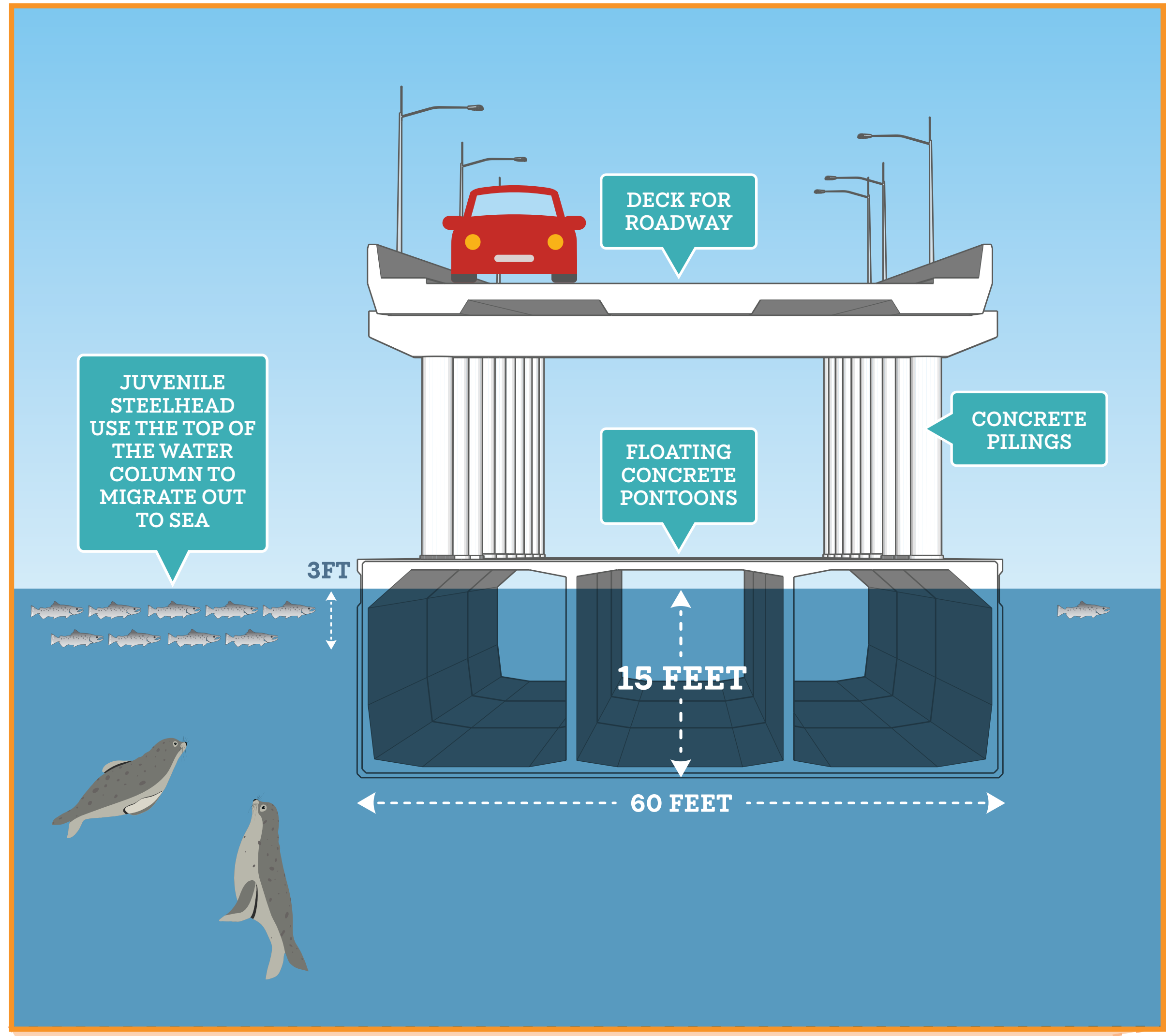
Over the years, the 1.5-mile-long bridge has become a vital traffic corridor, carrying thousands of vehicles each day to and from the Olympic Peninsula. But scientific studies have shown that the bridge also impedes the migration of juvenile steelhead — and affects Chinook and chum salmon as well. Predators, including harbor seals, have been found to wait at the bridge, picking off the young fish, one by one.

Juvenile salmon and steelhead originate from dozens of streams flowing into Hood Canal. They make their way into the main body of the 68-mile-long fjord and head north toward the Strait of Juan de Fuca and the Pacific Ocean. When they reach the Hood Canal Bridge, they suddenly encounter an artificial barrier. **Half of the juvenile steelhead that reach the bridge die there.**

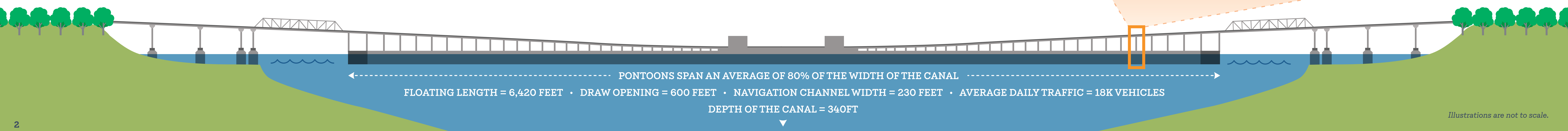
Thirty-six concrete pontoons, all jammed together with no space between, support the floating highway for 1.2 miles. Steelhead must alter their route by diving under the pontoons or work their way along the barrier to a 230-foot opening, one at each end of the pontoons. A tiny fraction of the young fish may get through the mid-channel drawspan when the bridge is opened on occasion to allow boats to pass through.

While extensive studies have been conducted on Puget Sound steelhead, which are listed as Threatened under the Endangered Species Act, the bridge also affects several salmon species — although specific effects on their survival are yet to be fully studied. Local stocks of concern include Puget Sound Chinook and Hood Canal summer chum — both listed as Threatened.

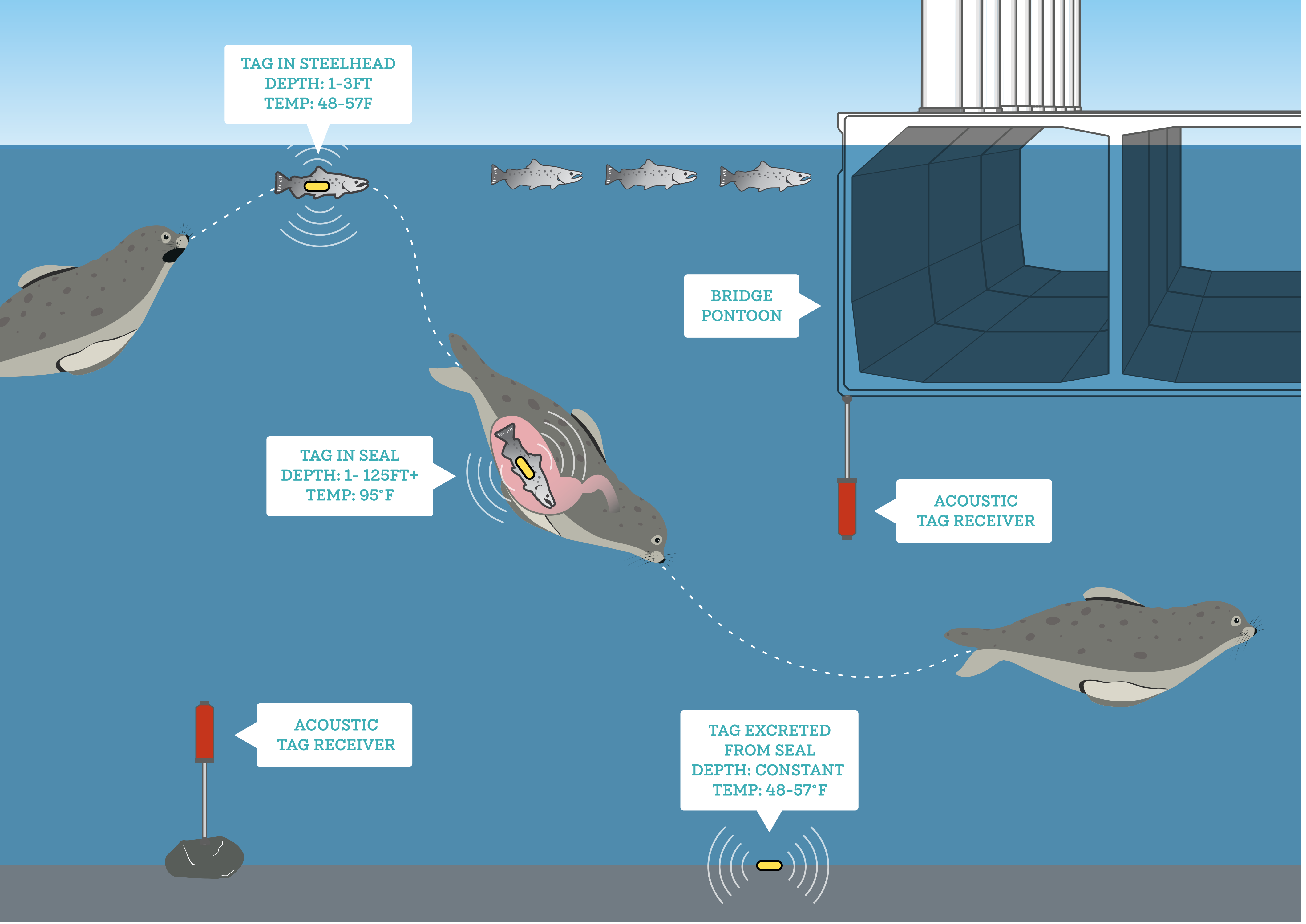
After six years of investigation, including two years of intensive data collection and analysis, experts have developed several ideas for improving salmon and steelhead migration — and reducing predation — at the bridge. A new report, "Hood Canal Bridge Ecosystem Impact Statement: Phase 1 Report," outlines the research conducted so far, describes possible short-term projects to save salmon and steelhead, and suggests additional studies that would inform a new, fish-friendly bridge design.



The Hood Canal Bridge's large concrete pontoons pose a challenge for fish and an opportunity for predators.



Illustrations are not to scale.



Temperature, depth (pressure), and location data are gathered from acoustic tags inserted into juvenile steelhead. Observed changes to these variables can help scientists identify predators and the location where the fish was consumed.

Danger at the bridge

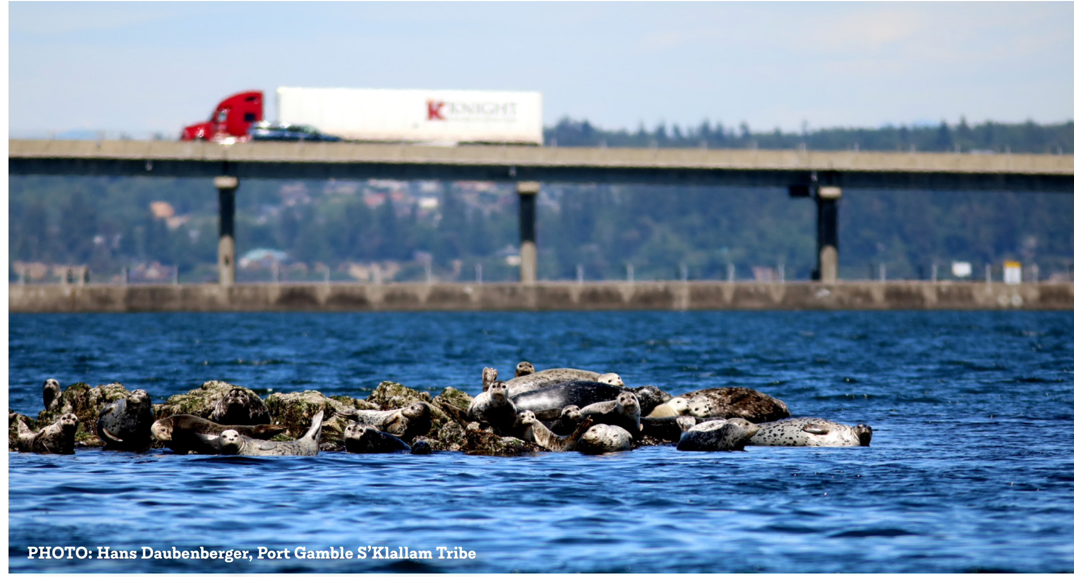
Much of what is known about steelhead encounters at the bridge come from studies involving tiny acoustic transmitters implanted in juvenile steelhead. To track the fish carrying these acoustic "tags," receivers were placed along the migration route, from southern Hood Canal to the bridge, at the bridge itself, and beyond in the Strait of Juan de Fuca.

The research, led by Megan Moore and Barry Berejikian of NOAA's Northwest Fisheries Science Center, found that the Hood Canal Bridge delayed the migration of steelhead by one to two days, on average. About half the tagged steelhead that encountered the bridge died there.

Acoustic receivers at the bridge showed that steelhead were likely to be found in corners where longer pontoons jutted out into the water to support the two bridge spans at each end of the bridge as well as the center drawspan. (The two bridge spans, which connect the land-based roadway to the floating structure, pivot to adjust to changing tides.)

The studies confirmed that steelhead normally travel within three feet of the surface. When a fish is eaten by a seal, bird or other predator, the acoustic receiver picks up erratic movements from the transmitter lodged in the belly of a predator, which behaves quite differently from a fish. The tag is then excreted and becomes stationary on the seafloor. Researchers mark the event as a mortality. Most mortalities were seen along the south side of the bridge and in corner locations, rarely in open water away from the bridge.

Some of the acoustic tags were equipped with temperature sensors. Of those, 69 percent of the mortalities showed elevated temperatures, suggesting that the fish were eaten by a marine mammal or a bird. Some 55 percent of those with elevated temperatures were later detected about half a mile south of the bridge near Sisters Rock, a known haulout area used by harbor seals.



Harbor seals commonly haul out on Sisters Rock, about half a mile southwest of the bridge.

Many steelhead that survived and were later recorded on the north side of the bridge were found to have dived under the bridge pontoons (51-77 percent) with somewhat fewer (23-49 percent) going through the open bridge spans at each end. For those diving under the pontoons, most (84 percent) did so during daylight hours, with the vast majority crossing under during outgoing tides.

In separate studies of predators, observers took note of marine mammals and birds spotted at or near the bridge. From the bridge deck and during dedicated boat-based surveys, observers noted predators during every outing in this research by Hans Daubenberger of the Port Gamble S'Klallam Tribe, Emily Bishop of Westward Ecology, and Scott Pearson of the Washington Department of Fish and Wildlife.

Three species of marine mammals — harbor seals, California sea lions and harbor porpoises — and 22 fish-eating birds were noted. Among the birds, pigeon guillemots were the most common, and they were also seen to be feeding on chum and Chinook salmon.

Corner traps, bridge pools, lights and noise

At each end of the 36 floating pontoons — which support nearly the entire bridge deck — the last pontoon juts out into the water, forming a 90-degree "corner" with the other pontoons. Similar corners are created by the pontoons that support the two floating structures that make up the center drawspan with its movable sections of roadway and movable pontoons.

During the tagged steelhead studies, these various corners were associated with high densities of young fish, possibly the result of altered currents around the bridge structure. Observers noted that when fish swimming along the edge of the bridge encountered a 90-degree turn, they often turned around and moved down the bridge in the direction they came, resulting in a circular swimming pattern.

As a foraging strategy, harbor seals could be corralling fish in these corners for an easy meal, observers say. How to reduce these corner effects has been a focus of attention in the search for ways to reduce predation.

Another issue under discussion relates to the so-called "pools" formed by the two drawspan structures, which are used to pull back the roadway for ships to pass through the bridge. On each side of the drawspan, a recess between anchored pontoons serves as a holding area for the movable pontoons that retract with the roadway.

These recessed holding areas, or pools, are about 300 feet long and 65 feet wide and consist of relatively quiet waters. Limited studies suggest they harbor slightly higher concentrations of zooplankton, which can be food for juvenile salmon and steelhead. General observations indicate that juvenile salmon, including Chinook and chum, congregate in the pools, either because of entrapment or because of an abundance of food there.

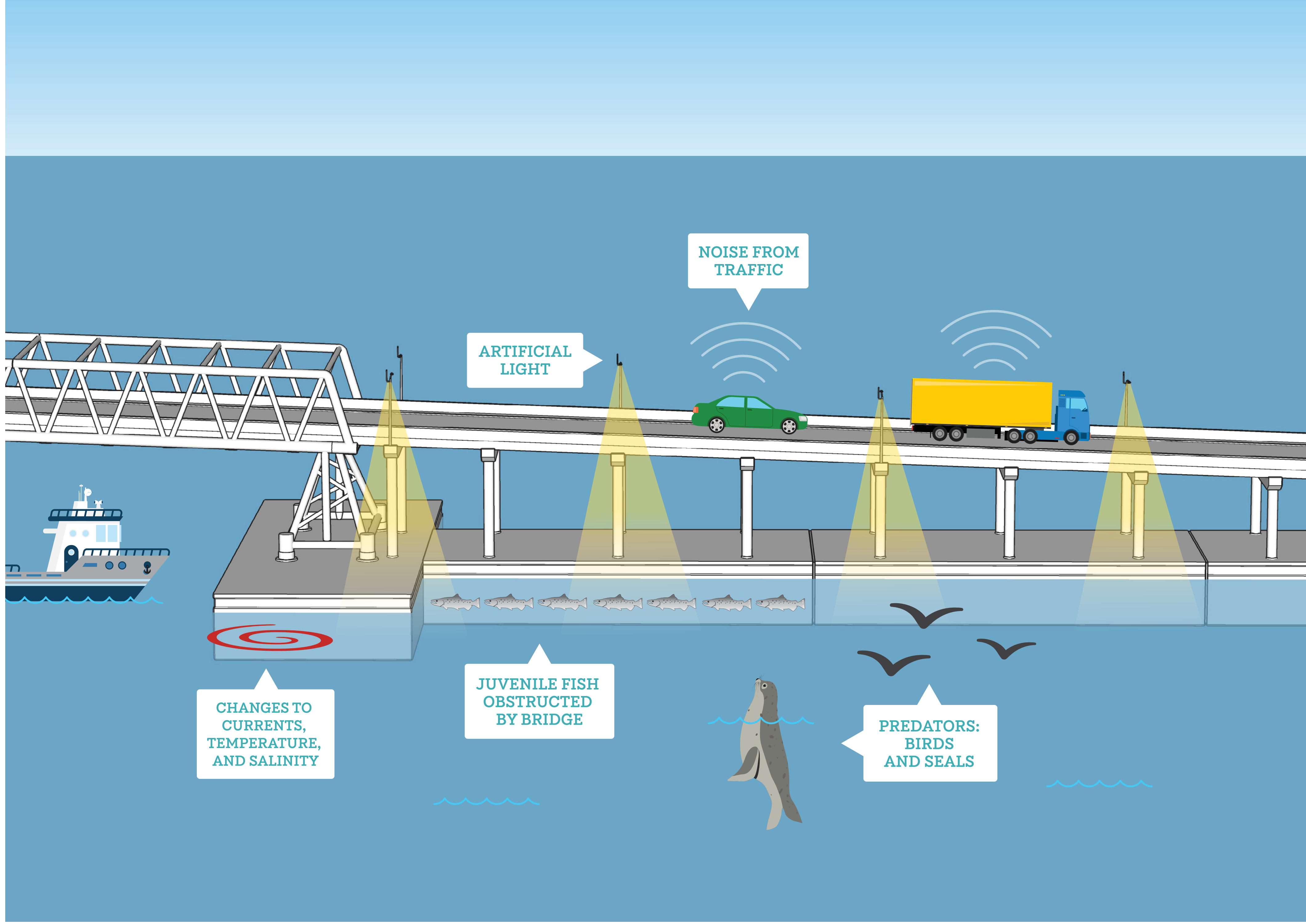
Predators of fish, including pigeon guillemots and harbor seals, were observed within the pools.

Other issues undertaken in the initial assessment include light and noise, which were measured at the bridge to see if they might have an effect on fish behavior or predation. Lights are mounted on poles along the south side of the bridge deck with additional lights around control towers at each end of the bridge. A navigation light can be seen at the center drawspan.

Light levels near the surface of the water were found to be highest on the south side of the bridge and in pool areas in the two drawspan structures. Light generated from the bridge is greater than what would be seen during a full moon. Those light levels might be enough to affect juvenile chum or Chinook salmon, according to findings from studies in other ecosystems. Further research is needed to determine if the bridge lights actually affect fish or predator behavior in Hood Canal.

As for noise, three sets of sound and vibration monitors, including hydrophones and accelerometers, were installed along the bridge near the metal sections of roadway, where the loudest noises are produced as vehicles cross over them. The noise was easily detected with the instruments and correlated with traffic volumes, even accounting for the type of vehicle — whether a motorcycle or a triple-unit truck.

Although sound thresholds for salmon are not well defined for saltwater conditions, the levels of noise at the bridge were generally below what might be expected to elicit an adverse effect. No change in behavior or mortality was observed among tagged steelhead when comparing daytime — when traffic and noise levels were high — to nighttime — when traffic and noise levels were low.



The bridge structure presents an obstacle to migrating fish, which then become more vulnerable to predation. Other factors that can affect migration include light, noise and water quality.

The bridge impacts temperature, currents, and salinity 65 ft below the surface and up to 3 miles away from the bridge.

View from the bridge control tower showing the bridge's effect on surface conditions.

Water quality and Hood Canal

Early circulation models for Hood Canal suggested that the floating bridge has the potential to alter water circulation and slow the exchange of incoming ocean water. Circulation is an important concern for Hood Canal, where its slow flushing rate is believed to contribute to low-oxygen conditions that affect marine life. Those early models were developed at a large spatial scale and without sufficient data near the bridge to predict the overall effects on the canal.

As part of the latest effort, researchers collected oceanographic data near the bridge, increased model resolution and accuracy, and used the improved model to investigate circulation and water quality near the bridge and throughout Hood Canal.

The revised model confirms that the floating bridge obstructs the natural outflow of the surface layer of water. That surface layer, which includes a good deal of freshwater from Hood Canal's many streams, tends to float on top of the water that contains a greater proportion of heavier seawater.

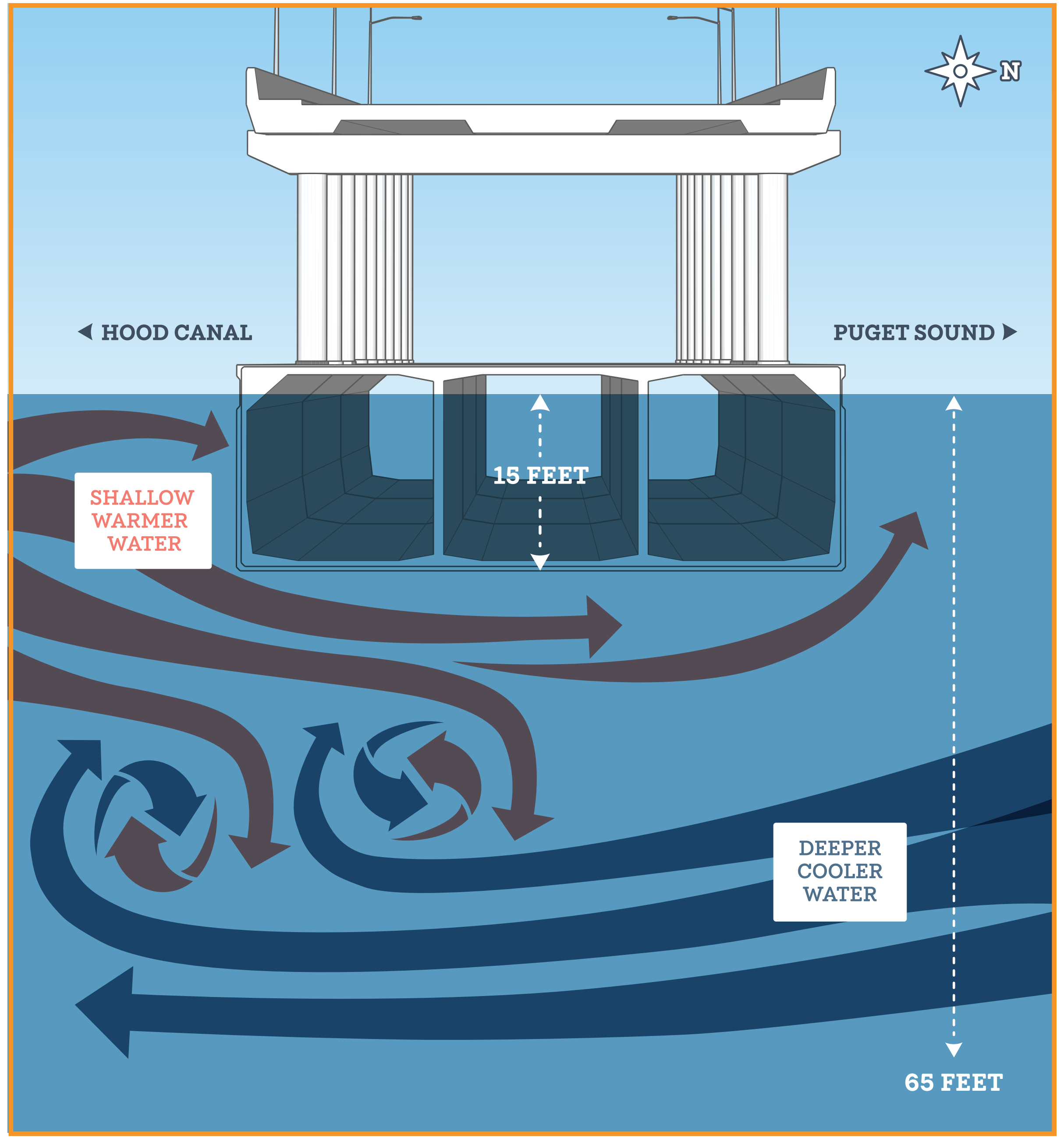
As the outflowing surface layer encounters the bridge, the freshwater tends to pool up while also mixing to a greater extent with the deeper waters on the south side of the bridge. At the same time, the fresher surface layer is pushed under the bridge pontoons, resulting in warmer, fresher waters at depth, according to the modeling work by Tarang Khangoankar and colleagues at Pacific Northwest National Laboratory.

Alterations in currents, salinity and temperature are highest at the bridge structure and diminish with increasing distance from the bridge. The measured zone of influence extends some 65 feet below the surface and affects salinity and temperature up to three miles away (where model simulations with and without the bridge begin to show less than a 10-percent difference in salinity and temperature).

Water quality — including temperature, salinity and currents — could have an effect on juvenile salmon and steelhead at the bridge, researchers say, but those fine-scale effects on behavior at the bridge are yet to be quantified.

While changes in water conditions were significant at the bridge, the latest modeling efforts suggest that water quality effects are minimal for Hood Canal as a whole. That issue has been the subject of a great deal of concern, because Hood Canal is well known for its low-oxygen problems and occasional fish kills at the south end of canal.

The modelers were able to simulate the entire Salish Sea domain for a full year, using scenarios with and without the Hood Canal Bridge in place. A third scenario considered the effects of the bridge assuming the center drawspan were open all the time. Even in Lynch Cove at the southern end of Hood Canal, where the most changes were expected because of the low flushing rate, the model showed no real difference in water quality.



A recent modeling study shows that the bridge can affect water quality. Outgoing surface waters, which tend to collect freshwater from streams in Hood Canal, collide with and dive under the bridge pontoons, with increased mixing down to 65 feet under the bridge

Recommendations to reduce fish mortality

If juvenile steelhead could make it past the Hood Canal Bridge with minimal delay and without concentrating in specific locations along the structure, the risk of predation would go down and survival of the young fish would go up, according to conclusions from a select group of scientific, engineering, and management experts. Their suggestions are spelled out in the "Hood Canal Bridge Ecosystem Impact Assessment: Phase 1 Report."

Studies and designs are underway for some near-term projects expected to reduce steelhead mortality. Construction could begin in two years, provided that funding is made available:

CORNER FILLET STRUCTURES: The goal is to block fish access to inside corners, where longer pontoons jut out from the standard-width pontoons. This can be accomplished by installing flexible or solid barriers called fillets in front of the corners to reduce back eddies caused by the 90-degree angles. Water flow would be smoother around the fillets, and juvenile salmon and steelhead would follow a more linear path as they make their way along the bridge structure.

The fillets are expected to be effective for steelhead at the 15-foot depth of the existing pontoons or even at a lesser depth of 8 feet. A plate installed on top of the fillet structure is proposed to prevent seals and sea lions from hauling out there.

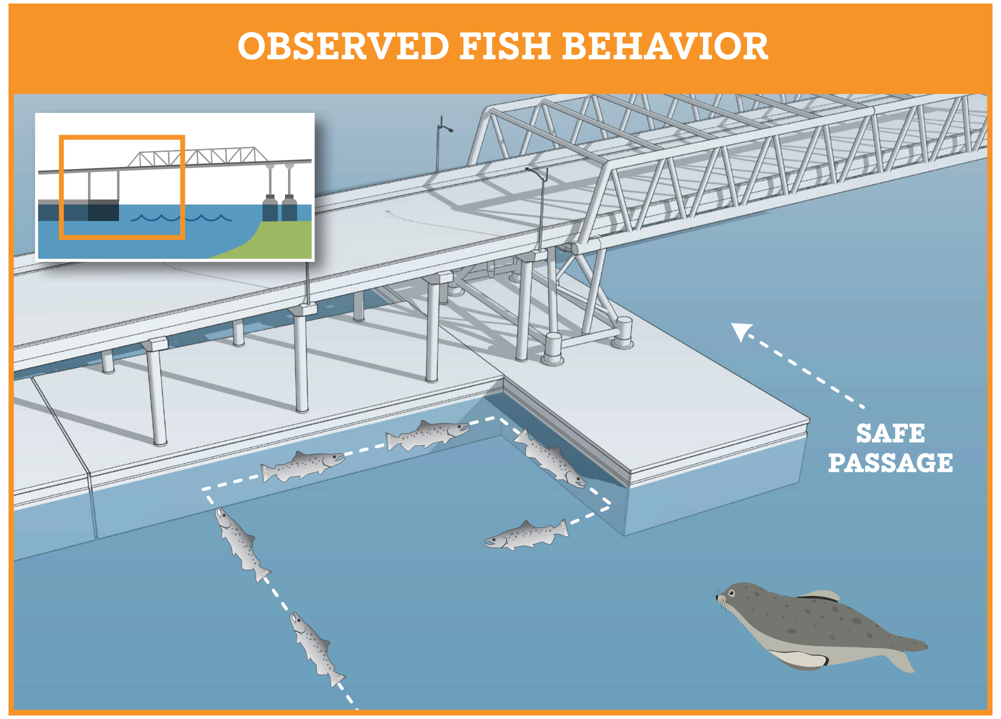
The removable fillet would be put in place for the steelhead and/or salmon migration. During a testing phase, observers and telemetry equipment could record fish behaviors and mortality as well as predator behaviors around the bridge with and without the fillet in place.

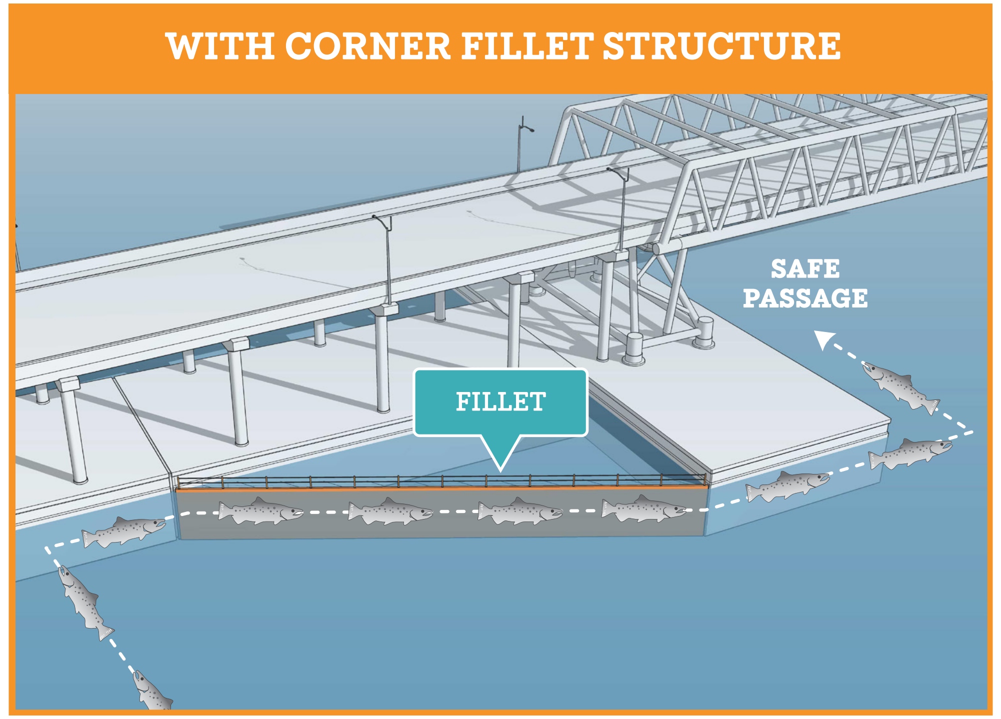
EDDY-REDUCTION STRUCTURES: Another simple structure for reducing eddies near the bridge is called a bullnose, consisting of a vertical half-pipe and fillet installed on the last pontoon in the open channel at each end of the pontoons. The bullnose, which would extend 15 feet deep, could be constructed of high-density polyethylene plastic. It would be designed to reduce the turbulence at the corner of the pontoons, especially during an outgoing tide. That's when most steelhead are on the move.

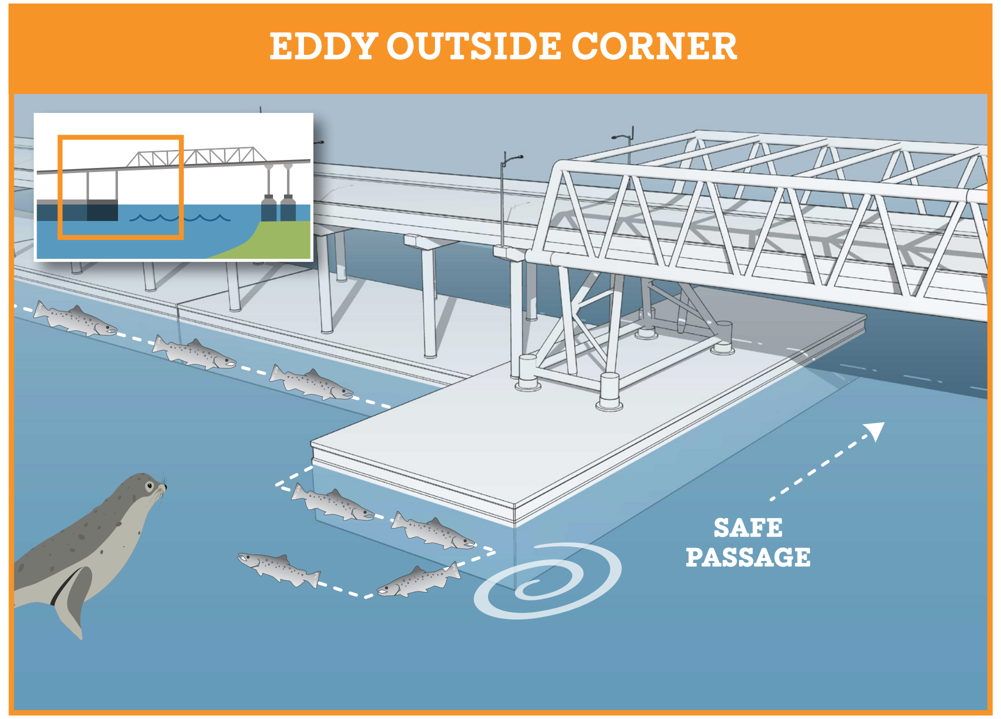
As with the corner fillets, the bullnose would be installed during the steelhead migration and could be tested by recording fish behaviors and mortality as well as predator behaviors with and without the structure in place.

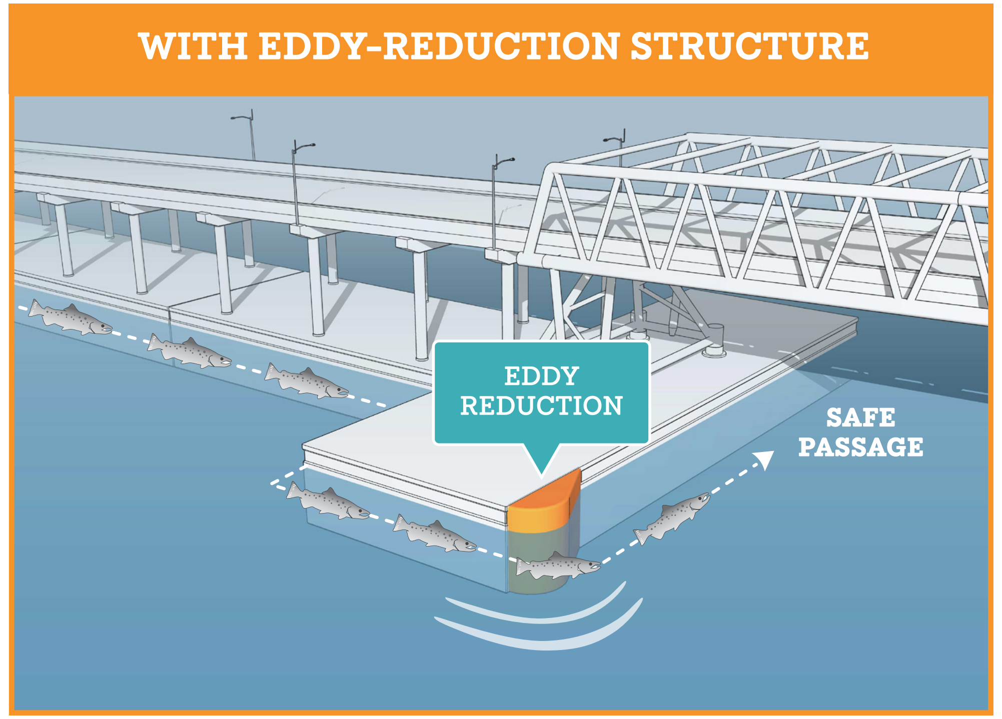
OPENING THE CENTER DRAWSPAN: The idea of studying the drawspan opening is that more juvenile fish might make it safely through the bridge if the drawspan were opened more often or for longer periods of time during peak ebb tides when steelhead are on the move.

The openings could be scheduled so that motorists would know when the bridge would be closed to traffic. Openings of one hour during the strongest ebb tides are likely to provide sufficient information about fish passing through. While not considered a long-term solution, experimentation could provide information useful for future changes in the bridge structure that ultimately address this migration barrier. (See "*fish-friendly*" on next page.)









Recommendations to reduce fish mortality (continued)

MODIFY BRIDGE LIGHTING: Growing evidence suggests that artificial lighting can affect the migration and behavior of juvenile salmon and steelhead. Some researchers speculate that the fish may be responding to the movement of zooplankton, which travel up and down vertically in the water in response to light levels.

Lights on the Hood Canal Bridge are placed higher on light poles than on some other floating bridges, in part because there are no separate lanes for bicycles and extra illumination may improve safety. Some bridges have low roadway light fixtures without illumination on the floating pontoons. The Assessment Team recommended investigating changes in lighting that might put more light on the roadway and less on the water.

Ideas for future study and consideration

"FISH-FRIENDLY" BRIDGE: One or more sections of the Hood Canal Bridge could be designed with openings between the pontoons to allow fish to pass through more easily at any time. The Assessment Team recommends that, eventually, the entire bridge will need to be redesigned with better fish passage in mind.

SEAL OR SEA LION DETERRENCE: Predation by seals and sea lions might be reduced by eliminating haulout areas or by preventing their access to the bridge.

PHOTO: Lucas Hall, Long Live the Kings

Questions for further research

- How long are juvenile Chinook and chum salmon delayed in their migration past the bridge, and does the delay increase mortality for those species as well as for steelhead?
- How do adult salmon and steelhead interact with the bridge on their return trip to spawn, and does the bridge slow their migration or otherwise increase the risk of mortality?
- Are harbor seals and other predators increasing their take of juvenile Chinook and chum salmon because of the bridge?
- Which seals forage at the bridge, and do any of them employ specialized foraging behaviors?

PHOTO: Norwegian Public Roads Administration

Nordland Bridge in Norway was built with pontoons perpendicular to the road deck, allowing for greater fish passage.