

# South Sound Science Symposium

October 15, 2026

## 2026 Poster Abstracts

The 2026 South Sound Science Symposium (S4) highlights emerging research on ecosystem status, trends, and conditions to help inform recovery, restoration, and protection efforts in the South Puget Sound region (generally, upland areas draining into marine waters south of the Tacoma Narrows, and those marine waters). The slate of posters featured at this year's event covers research conducted by scientists and technical staff from educational institutions, government and tribal natural resource agencies, non-profit groups, and the private sector across the South Sound region, as well as research conducted elsewhere that can be directly related to the South Sound.

For more information on the South Sound Science Symposium, visit:

<https://southsoundscience.org/>

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S42026-01

## Evaluating the Relationship Between Eelgrass and Sediment Characteristics across Central and South Puget Sound

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Eelgrass (*Zostera marina*) is an aquatic flowering plant that provides critical habitat to many species, promotes the deposition of fine sediment by slowing water movement, stabilizes sediments through their rhizomes, and stores and sequesters carbon. The goal of this project was to evaluate whether patterns of sediment composition and organic carbon content were associated with eelgrass cover and how that relationship changed across sites and basins in Central and South Puget Sound. In 2025, the Acidification Monitoring Network (ANeMoNe) surveyed eelgrass and sediment characteristics at two sites in the South Puget Sound (SPS): Nisqually Reach and Case Inlet and two sites in the Central Puget Sound (CPS): Maury Island and Elliott Bay. We visited sites in May (spring) and August (summer) 2025 where we measured *Z. marina* percent cover, shoot density, and shoot length and collected sediment cores in eelgrass beds. Sediment samples were analyzed for loss-on-ignition organic carbon content and grain-size composition. At all sites, organic carbon content was higher in quadrats with higher eelgrass shoot densities. We found that Case Inlet (SPS) and Elliott Bay (CPS) shared similar sediment composition and Nisqually Reach (SPS) and Maury Island (CPS) were more similar to each other than the other site within their same basin. Eelgrass characteristics also varied across sites within the same basin but may be similar to sites within a different basin. These results suggest that eelgrass may influence sediment characteristics, but that other site-specific conditions also play a role. Examples of other site-specific conditions include urbanization and water flow, as all sites differ in water residence times. For example, Nisqually Reach is the marine outflow point of the Nisqually River watershed, so water residence times in the eelgrass bed is low. Overall, these site-level differences suggest that geographic proximity does not necessarily result in similar eelgrass and sediment characteristics and that site-specific conditions can be strong drivers of the influence eelgrass has on the surrounding sediment.

S42026-02

## Evaluating Phosphorus Inactivation and Adaptive Management Outcomes in Spanaway Lake (2024-2026)

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Spanaway Lake is a large, mesotrophic natural kettle lake in central Pierce County, Washington that experiences toxic cyanobacteria blooms. These algae blooms significantly impact aesthetic and recreational enjoyment and left unaddressed, may affect human health, ecological diversity, habitat quality, and water quality conditions long-term. In 2021, the Spanaway Lake Management District (District) was created by the Pierce County Council as a pilot program to address these concerns.

In 2023, the District published a Cyanobacteria Management Plan (LCMP) for Spanaway Lake with the objectives of reducing the frequency and duration of toxic algae blooms and reducing the average amount of algae in the lake by managing phosphorus loading. The LCMP recommended an adaptive management approach that provides near-term relief from toxic algae blooms through in-lake treatment and long-term prevention through internal load reduction and watershed phosphorus control.

Implementation of near-term strategies began in 2024 with the application of phosphorus inactivation chemicals to strip phosphorus from the water column. To evaluate the near- and long-term effectiveness of recent management actions, a comprehensive water quality monitoring program was established for Spanaway Lake. This program includes monthly lake sampling, monitoring at lake inlet and outlet locations, and groundwater sampling from two nearby wells. We present key data such as total phosphorus concentration at various depths across all sampling locations, vertical profiles of temperature and dissolved oxygen, TKN:TP ratios, and chlorophyll-a measurements from 2024 through 2026. We also discuss how these data demonstrate the near-term success of phosphorus inactivation treatments and 2026 observations on lake clarity and cyanobacterial toxin concentrations.

S42026-03

## Whiteman Cove Restoration Part III: Linking Pre-existing Genetic Variation to Demographic Declines Following the Reintroduction of Tidal Flow

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Eelgrass (*Zostera marina* L.), a nearshore foundation species found worldwide, faces unprecedented threats following accelerated climate change and a global trajectory of decline. Restoration has emerged as a key tool in recovering eelgrass populations, yet the role of plant provenance in transplantation success remains largely unknown. The Washington State Department of Natural Resources restoration site at Joemma Beach State Park serves as a common garden experiment where diverse phenotypes from across South Puget Sound were planted along a depth gradient over a decade ago. These populations provide an unprecedented opportunity to investigate phenotypic and genetic changes following transplantation into a novel environment and which in turn would inform source site selection for future eelgrass restoration. The nearby Whiteman Cove restoration provides an opportunity to evaluate the long-term resilience of different phenotypes and genotypes in the face of environmental disturbance. Shoots were collected across six source sites and at the common garden to investigate how source populations with different morphological and life history traits respond to initial transplantation. Patterns of trait variation across source sites, dominated by differences in plant size, were largely maintained in the common garden. Source population accounted for considerably more variation in traits (66.7% and 44% at origin and outplant location, respectively) than did elevation (8.6% and 1.7%), providing evidence for local adaptation. Next, we will characterize population structure and genetic diversity at origin and outplant locations to describe how they change following transplantation. We will then link genetic variation of eelgrass at Joemma to demographic declines following the reintroduction of tidal flow at Whiteman Cove, in order to assess the role of genetic diversity in conferring resilience to this disturbance.

S42026-04

## Characterizing Contamination of the Puget Sound Benthic Environment and the Effects on English Sole

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English sole (*Parophrys vetulus*) is a key species for assessing contaminant trends in Puget Sound's benthic ecosystem due to their wide distribution, close association with bottom sediments, benthic diet and local foraging. These characteristics make English sole a valuable species for monitoring sediment contamination and understanding the health of Puget Sound's benthic food web. Here we provide an update to our long-term monitoring effort through 2023, using a Generalized Additive Mixed Model (GAMM) for determining temporal trends of contaminant concentrations while also identifying the biological effects of contaminants in English sole. Spatial variation in contaminant concentrations suggests low PCB inputs in North Puget Sound and Hood Canal, with higher inputs in Central and South Puget Sound. However, for the first time, all sites exceeded the PCB human health screening value (8 ng/g ww) in 2023. The highest PCB concentrations are associated with urbanized and industrialized areas within Central Puget Sound. Anderson Island and Carr Inlet had PCB concentrations considerably lower than the most contaminated sites, yet both still exceed the human health screening value. Evaluation of PAH-related liver disease and EDC-related reproductive impairment provide direct measures of contaminant related impacts to English sole health, and potentially other species in benthic habitats. Liver disease peaked in the mid-1990s throughout Puget Sound, particularly in urban and near-urban sites, but as recently as 2019, there was no evidence of elevated odds of liver disease compared to baseline conditions. In 2023, male English sole throughout Puget Sound showed a marked increase in vitellogenin production, with Carr Inlet and Elliott Bay having the highest odds of expression compared to reference sites. Additionally, female English sole are expected to be in a "post-spawning" state during spring sampling, following their winter spawning. However, a high proportion of females at Carr Inlet and Elliott Bay were in a "ripe" or "spawning" state, further supporting the conclusion that these areas are contaminated with xenoestrogenic chemicals. Overall, anthropogenic contamination in the Puget Sound benthic environment is still prevalent and results in toxicopathic disease of English sole, exhibiting the need to continue monitoring efforts throughout the region.

S42026-05

## Salish Sea Restoration Platform - Peer-to-Peer Knowledge Management for Stewardship

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If you are working to restore ecosystems you depend on place-based knowledge to do the work. We are each carriers of knowledge and building a shared knowledge exchange is collective empowerment. Salish Sea Restoration is the only peer-to-peer platform supporting an open knowledge network created by and for ecosystem professionals.

This ongoing and evolving project is built around a peer-to-peer learning platform to support the stewardship of our lands and waters. Volunteer contributors and editors create and revise Pages of Information using our Style Guide under a shared Social Contract. Each page is interlinked and organized using Categories. Using this platform anyone can share evidence that supports ecosystem stewardship. We use evidence to build knowledge to be more effective and efficient in supporting the regeneration of our temperate maritime biome. We invite you to join in our effort.

# Circulate evidence and place-based knowledge about the Places you live and work.

# Share hard-to-find Products and archive Documents that might otherwise be lost.

# Organize resources and identify questions about Topics of interest.

# Map the Efforts of local Workgroups in Places to broaden and connect our networks.

S42026-06

## Eelgrass Monitoring Informs Shoreline Management in South Puget Sound

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Eelgrass (*Zostera marina*) beds provide valuable habitat to a wide range of species due to their high primary productivity and their ability to modify the environment in which they grow. Despite their importance, there is little accurate data on the distribution of eelgrass along the shorelines of South Puget Sound. This data gap is problematic as parts of South Sound are vulnerable to water quality impairments. To alleviate this gap in knowledge, DNR and Pierce County partnered in a project to survey eelgrass along a 180km stretch of shoreline in South Puget Sound, funded by a grant from the Habitat Strategic Initiative (WDFW 25-26813), using methods from DNR's Submerged Vegetation Monitoring Program. In summer 2025 and 2026, DNR collected towed underwater video footage along ~1800 transects, distributed across 180 sites. Transects were oriented perpendicularly to shore and spanned the entire depth range of eelgrass. As of today, we have analyzed footage from 97 sites in the study area. The remaining sites will be analyzed by the end of 2026. There was a clear spatial pattern in eelgrass distribution, with the highest abundance along the shorelines of Carr Inlet and Fox Island. Eelgrass was present at approximately half of sites sampled. The non-native *Nanozostera japonica* was observed at 11 sites. Most eelgrass beds in the study area were relatively small, with area estimates ranging from 0.1 to 14 ha. Eelgrass depth range was limited: the vast majority of eelgrass was found between 0 and -4m (MLLW). Pierce County will combine the updated DNR monitoring data with a synthesis of seagrass science to inform development review and protection standards. The County will evaluate whether existing buffers adequately protect seagrass and consider revisions that prioritize avoidance of impacts to current and historical habitat. Data will also inform standards for overwater and nearshore development, including site inventories, light-transmission requirements, and measures to reduce mechanical damage from mooring, anchoring, vessel traffic, and other activities. This project supports Pierce County's local policies and regulations that protect existing ecological functions, reduce habitat impacts, and guide restoration and long-term resilience of Pierce County's nearshore environment.

S42026-07

## Effects of Invasive Oyster Drill Adult and Egg Removal in Little Skookum Inlet

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Invasive oyster drills (*Ocenebrellus inornatus*) are a widespread aquacultural pest in Puget Sound that have contributed to the decline of the native bivalve *Ostrea lurida*, the Olympia oyster. Adult *O. inornatus* do not typically move long distances and hatching juveniles remain close to their eggs after birth, but hand removal of drills typically fails to reduce *O. inornatus* populations. Theoretical models predict that removing both eggs and mature drills may result in local population reductions.

This community research project removed adult *O. inornatus* from a 21.32m experimental plot in Little Skookum Inlet in South Puget Sound. Randomized sampling of control and experimental sections of intertidal zone measured drill density in 5 0.252m quadrats during May and July of 2025 and 2026 and again in August 2026. Removal of *O. inornatus* adults in the experimental plot occurred after quadrat sampling in May and July 2025 and again in May of 2026. Drill egg removal occurred throughout the area on each of those dates and again in June of 2026 at a nearby intertidal site.

Drill density in the experimental plot declined from 51.2 drills/m<sup>2</sup> in May of 2026 to 0.0 drills/m<sup>2</sup> by August of 2026. Drill density in the control site began and finished at 20 drills/m<sup>2</sup> and 18.2 drill/m<sup>2</sup> respectively and did not decline below 10.4 drills/m<sup>2</sup> over the course of the experiment. In August of 2026, drill density remained high outside the removal zone, increasing from 0.0 drills/m<sup>2</sup> within the site to 29.3 drills/m<sup>2</sup> 3.7m from the removal zone edge. Density outliers were observed on large hard substrates and perched seawater. Numbers of surviving Pacific oysters staked on paired oyster shell cultch were higher in the experimental than control site ( $P=0.02$ ). By locally removing eggs and removing adults from a targeted site, shellfish farmers and conservationists should be able to effectively reduce *O. inornatus* density in 21.3 m<sup>2</sup> plots.

S42026-08

## Closed Depression Drainage Areas for Stormwater Management in Pierce County, WA

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Specific stormwater management requirements are often needed for closed depression areas where there are no, or limited surface water outlets. In support of the release of 2026 Pierce County Stormwater Manual updates, Pierce County Surface Water Management (PCSWM) has recently updated our GIS data for closed depression drainage areas based on new LiDAR data. For this project, we identified closed depressions using the Contour Tree Method documented in "Arc Hydro: Identifying and Managing Sinks." To avoid overregulating, significant depressions were defined as having an area greater than 1 acre and a depth greater than 1 ft with at least one closed elevation contours of 2-ft interval from the best available LiDAR digital terrain model data in the Washington State LiDAR portal. Closed contour areas that intersect streams or have sufficient stormwater drainage systems connecting to streams were removed to form the sinks of the closed depression dataset. Depressions in "Designated Forest Land" were also removed from the dataset due to a low risk of regulated development. Arc Hydro catchment delineation procedures for sinks were then applied to delineate drainage areas to the closed depressions. The impact of stormwater drainage system was considered in the postprocessing. In postprocessing, drainage areas immediately upstream of a closed depression were merged into the depression drainage area. Drainage areas added into or removed from a drainage area due to stormwater drainage systems were manually delineated. Drainage areas connected by stormwater drainage systems were merged together. Historically limited drainage areas known to county maintenance and operation staff were added into the dataset at the end. In unincorporated Pierce County, about 600 closed depression drainage areas were identified, the mean drainage area is about 100 acres and the median is about 40 acres. Most of the closed depressions are located in the Vashon glacial deposit areas, especially the Vashon glacial recession deposit areas.

S42026-09

## A Sound-wide Survey of 6PPD-Q in Four Species of Adult Salmon Returning to Puget Sound Watersheds

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Stormwater runoff presents a range of issues for aquatic life that are exposed to the complex mixtures of contaminants it contains. The tire-wear chemical 6PPD-Q is of particular interest due to its ubiquity anywhere roads are present and acute toxicity to some salmonids. While 6PPD-Q is known to be widely present in freshwater systems, its occurrence in the tissues of free-ranging salmon is poorly understood. We present results of the first study assessing 6PPD-Q in fillets of Chinook, coho, chum, and pink salmon returning to watersheds across Puget Sound. Across all species and collection areas, 6PPD-Q was detected in less than half of our samples, which is consistent with findings of other studies and indicates limited exposure or bioaccumulation potential. At the species level, 6PPD-Q was detected in roughly half the Chinook, pink, and chum salmon we tested, but only a quarter of coho. There was no clear evidence that any one species of salmon was likely to have greater concentrations of 6PPD-Q than others, which contrasts with findings for lipophilic contaminants. Geographically, detections of 6PPD-Q were more frequent in Central Sound than elsewhere. Given the extent of impervious surfaces and stormwater outfalls in Central Sound, these findings are not surprising and combined with water monitoring efforts, indicate that adult salmon returning to this region may be regularly exposed to 6PPD-Q. 6PPD-Q was present in salmon returning to South Sound at a similar frequency to those in Hood Canal and North Sound. While detection frequencies were low overall, most detections occurred near limits of quantitation, which could downward bias estimates of how common exposure is. Our results provide Sound-wide baseline data to inform exposure and risk associated with salmon consumption for humans, marine mammals, and marine birds. However, it remains unclear how the levels of 6PPD-Q detected in some salmon could influence the health of salmon consumers or the salmon themselves. Future efforts quantifying tire wear compounds, including those that are more persistent and bioaccumulative, in Puget Sound biota would enhance the ability of monitoring programs to assess how widespread exposure to these chemicals is and guide mitigation efforts.

S42026-10

## Predator-induced Shell Responses of Olympia Oysters to Non-native Drills

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Olympia oyster (*Ostrea lurida*) populations have declined along the US Pacific coast in part due to predation by the invasive oyster drill, *Ocenebrellus inornatus*. Strategies are needed to support restoration of *O. lurida* populations in the presence of invasive predators. Olympia oysters demonstrate phenotypic plasticity in the presence of other non-native gastropod predators but predator-induced responses or cues have not been studied for *O. inornatus*. Predator induced epigenetic responses to an invasive predator have implications for oyster survival, growth and development.

To evaluate developmental differences in the presence of this invasive predator, Olympia oysters were kept in 170L experimental systems with and without *O. inornatus*. Calipers were used to track changes in individual oyster maximum length, width and depth to the nearest 0.5mm between December 2025 to March 2025. Protective oyster bags were added to both tanks and a subset of Olympia oysters in the experimental tank were placed inside the bag. Differences between caged and uncaged oysters are inferred to result from differences in exposure to environmental cues triggering epigenetic responses. No oysters were killed by *O. inornatus* during the course of the experiment, but multiple attacks on unbagged oysters were observed.

Oyster growth was generally low but significantly different in systems with and without invasive oyster drills. Olympia oysters growing with *O. inornatus* were narrower ( $P=0.02$ ) and showed trends toward shorter length and greater depth than oysters in the control tank. Caged oysters in experimental systems had morphology more similar to control oysters. Differences between control and experimental oysters and similarity between control oysters and caged experimental oysters supports the hypothesis that epigenetic cues from direct contact caused a predator-induced epigenetic response. Field experiments have begun to evaluate development and survival of *O. lurida* exposed to and sheltered from direct access by *O. inornatus*.

S42026-11

## Whiteman Cove Restoration Part II: Eelgrass Habitat Response to the Reintroduction of Tidal Flow

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The Washington State Department of Natural Resources (DNR) leads the effort to transplant eelgrass, *Zostera marina* L., throughout Puget Sound with goals to restore essential nearshore habitat and the processes common in natural seagrass systems.

Joemma Beach State Park, South Puget Sound, was identified as a suitable site for eelgrass restoration based on early test transplant success and its potential for habitat recovery adjacent to a pocket estuary, Whiteman Cove. Since initial test transplants in 2013, DNR and partners transplanted nearly 18,500 eelgrass shoots in the shallow subtidal area at Joemma Beach State Park. DNR monitors the site annually using snorkel surveys and uncrewed aerial systems (drones). By 2022, there were over a million eelgrass shoots growing in various size eelgrass patches across approximately 1,000 m<sup>2</sup> of eelgrass bed area. Over the next two years, shoot density declined slightly but individual patches expanded.

In early 2025 tidal connectivity to Whiteman Cove, a 12-hectare impounded brackish estuary, was restored. The restoration produced a plug of sediment that washed over the adjacent tide flat and subsequent tidal cycles flushed 63 years of organic material out of the estuary, resulting in significant impact to the eelgrass restoration site. Approximately 161 m<sup>2</sup> of eelgrass were lost by the first growing season 6 months after tidal restoration. The average shoot density at the site declined 57%, from 540 shoots m<sup>-2</sup> measured in 2024 to 229 shoots m<sup>-2</sup> in 2025. In 2026, the average shoot density in the remaining eelgrass patches recovered to 510 shoots m<sup>-2</sup>, but overall eelgrass area declined.

Continued monitoring will track whether the remaining eelgrass can recover and revegetate the area as the nearshore and shallow estuarine systems reset. The results of this work highlight the importance of planning freshwater and estuarine restoration efforts while considering changes to downstream marine nearshore habitats.

S42026-12

## Evaluating Ground Beetle Assemblages Following Two Decades of Prairie Restoration in Western Washington

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Prairie ecosystems in western Washington are rare and have experienced extensive habitat loss and alteration. Restoration efforts, including invasive species control, prescribed burning, and reintroduction of native plant species, aim to improve prairie habitat and ecological function. Ground beetles (Carabidae) are useful indicators because they are abundant, easy to sample, and occupy ecological niches that are sensitive to environmental changes. This study revisits a 2005 ground beetle survey to examine how beetle assemblages have changed following two decades of prairie restoration. Sampling was conducted at Mima Mounds and Glacial Heritage preserves in western Washington, two of the three sites included in the original study. Two transects were established at each site, with five pitfall traps spaced 60 feet apart along each transect. Traps were operated for weekly sampling periods and used as a passive sampling method, capturing beetles that encountered the traps without attracting them. Specimens were preserved, mounted, and identified in the lab to family, genus, and species. Preliminary results indicate decreases in beetle abundance, richness, and diversity at both sites compared with the 2005-2006 observations. The three represented genera in the preliminary dataset (*Harpalus*, *Omus*, and *Pterostichus*) showed differences in abundance between sampling periods, with *Omus* and *Pterostichus* particularly less abundant in the current sampling. *Harpalus* plays a role as an omnivore and biological control agent, consuming both pests and weed seeds. *Omus* functions as an apex invertebrate predator that regulates soil pest populations while serving as a bioindicator of habitat ecological health due to its flightless nature. *Pterostichus* functions as a generalist predator and seed consumer that controls pest populations, regulates plant diversity, and accelerates nutrient cycling within grass thatch. More than 100 beetles have been identified to genus, with additional identification and analysis underway. These preliminary findings suggest that ground beetle communities have responded negatively to prairie restoration, highlighting the value of long-term biological monitoring for evaluating restoration outcomes. Continued identification and analysis will provide a more complete assessment of changes in community composition and ecological function in these beetle communities over 20 years.

S42026-13

## Per- and Polyfluoroalkyl Substances (PFAS) in Four Species of Pacific Salmon (*Oncorhynchus* sp.) Returning to Puget Sound

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Pacific salmon (*Oncorhynchus* sp.) play foundational roles sustaining Puget Sound ecosystems, but populations face uncertain futures due to stressors, such as warming oceans, habitat degradation, and pollution from man-made chemicals. Per- and polyfluoroalkyl substances (PFAS), are a diverse class of man-made organic chemicals that have been widely used in industry and consumer products since the 1950s. Some PFAS chemicals, including PFOS and PFOA, persist in the environment, bioaccumulate in organisms over time, and are linked to a range of adverse health effects in humans. Yet, there is limited information on PFAS in adult salmon originating from Puget Sound. Here, we evaluated PFAS concentrations in 197 muscle tissue samples from Chinook (*O. tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), and pink (*O. gorbuscha*) salmon returning to spawn in watersheds associated with the North/Whidbey, Central, South, and Hood Canal basins of Puget Sound. For all species and sampling locations, PFAS chemicals were detected in 49% of the 197 samples. Fourteen of 40 measured PFAS chemicals were detected, with PFOS detected most frequently (25%). Among species, PFAS was detected most often in Chinook (79% of 63), followed by coho (47% of 57), pink (34% of 47), and chum salmon (13% of 30). Chinook also had the highest detection of PFOS (70% of 63) compared to the other three species (9% of pink, 2% of coho, and 0% chum). Concentrations of  $\Sigma$ PFAS differed among species but not across watersheds. Chinook salmon had the highest  $\Sigma$ PFAS concentrations of the species examined followed by coho. Mean  $\Sigma$ PFOS+PFOA concentrations in Chinook, pink, and coho salmon were 4 to 200 times lower than the Washington Department of Health high consumption advisory screening level of 1 nanogram per gram wet weight, and only two individual Chinook salmon samples exceeded the screening level. Overall, 98% of adult salmon returning to Puget Sound were below current PFAS consumption screening levels but continued long-term monitoring efforts are warranted to confirm PFAS concentrations remain below consumption guidelines. This analysis provides baseline PFAS data for adult salmon returning to Puget Sound that fills important knowledge gaps for salmon consumers and policy makers.

S42026-14

## Whiteman Cove Restoration Part I: Estuarine Responses to the Reintroduction of Tidal Flow

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Small tidal embayments, or pocket estuaries, are important components of the South Puget Sound nearshore environment, providing diverse habitats that support juvenile salmonids, fish assemblages, and other estuarine-dependent species. However, many pocket estuaries have been altered or isolated by shoreline development and infrastructure, reducing tidal exchange and disrupting habitat processes and connectivity. Restoration of these systems provides an opportunity to recover ecological functions while also improving our understanding of how nearshore habitats respond following restoration. Whiteman Cove, a 12-hectare impounded brackish estuary historically connected to Case Inlet, was isolated in the 1960s by construction of a road and tide gates, resulting in decades of restricted tidal exchange and limited fish passage. In 2025 the Washington State Department of Natural Resources (DNR) restored tidal connectivity to the cove, providing a unique opportunity to evaluate habitat responses to restoration. DNR is using an integrated monitoring approach to assess recovery across multiple components of the system, including fish assemblages, sediment characteristics, and habitat composition. Monitoring tools include seining, sediment collection, quadrat sampling, and GIS-based habitat mapping. During the first 1.5 years since restoration, we have observed cooler water, less fine sediment in the western cove, continued tidal-channel adjustment, and chum salmon smolts using the cove shortly after opening. Habitat composition has become less variable, associated with more bare-substrate, likely reflective of increased tidal exchange. These early results indicate that restoration is already influencing physical conditions, habitat composition, and fish use within Whiteman Cove, while tidal channels and habitats continue to adjust. Continued monitoring will help determine whether these initial responses persist and provide insight into the processes shaping recovery in restored pocket estuaries.

S42026-15

## SHARP: Site Hazard Assessment and Ranking Process for Contaminated Sites in Washington State

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Since the Model Toxics Control Act (MTCA) became law in 1989, well over a half million environmental reports have been received by the Department of Ecology (Ecology) regarding potential spills, pollution, and contamination. Over 17,000 sites have been added to Ecology's Contaminated Sites List based on confirmed or probable environmental impacts. Ecology's Toxics Cleanup Program (TCP) handles these sites and assists in cleanup. After the Healthy Environments for All (HEAL) Act was passed in 2021, TCP has changed how chemical data, conceptual site models, historical information, and other details are used to assess contaminated sites. The new site hazard assessment and ranking process (SHARP) report combines a wide range of data sources to assess and contextualize risks related to sites across the state. Efforts to assess the large number of contaminated sites and communicate these results with the public are underway.

S42026-16

## South Puget Sound Floating Kelp Monitoring Update Through 2026: With a Focus on Squaxin Island

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Floating kelp forests provide vital habitats and important ecosystem services in temperate nearshore environments worldwide. Kelp forest losses are a major concern globally, including in portions of Washington State. While floating kelp on the outer coast of Washington State is relatively stable, extensive losses of bull kelp (*Nereocystis luetkeana*) have occurred within the inner basins of Puget Sound, especially South Puget Sound, making monitoring this important resource a management and research priority. Within these areas of concern, intensive kayak and drone surveys are conducted to collect kelp bed area and depth annually at six sites in South Puget Sound (SPS). Bull kelp beds in SPS have declined substantially over the last century and strong continued losses have occurred at individual sites in recent years. Since 2013, bull kelp beds have been lost at three of the six SPS monitoring sites, the most recent at Fox Island, which was completely lost in 2024. Squaxin Island, the innermost bull kelp bed in Puget Sound, has experienced a steep decline in bed area since 2013, until 2025 when the bed disappeared completely. Unexpectedly, a small, one-hectare bed grew at the site in 2026, representing recovery from complete loss in the previous year. The bed area in 2026 was 89% smaller than the area observed in 2013. Many possible stressors could be driving these observed losses, including low nutrients and elevated water temperature. For example, SPS bull kelp losses within the last decade coincide with elevated water temperature during the 2014 marine heatwave when temperature thresholds for physiological damage were met or exceeded at some sites. In 2025, WA DNR and the Squaxin Island Tribe established the Squaxin Island Kelp Protection Zone, which supports current monitoring efforts and the development of new partnerships for kelp recovery. Looking forward, collaborative monitoring of these sites will continue to disentangle the effects of multiple stressors and to inform continued restoration efforts.

S42026-17

## SoundToxins Phytoplankton Monitoring Network - 20 Years of Eyes on the Water

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The SoundToxins Phytoplankton Monitoring Network is a diverse partnership of shellfish growers, environmental learning centers, tribes, and community science volunteers. For 20 years, SoundToxins has been monitoring phytoplankton throughout Washington's marine waters and has provided early warning of harmful algal blooms (HABs) to minimize human health risks and economic losses. The SoundToxins program utilizes a plankton net tow and light microscopy to record phytoplankton communities and abundances at 38 sites throughout Washington's marine waters, including 7 sites in South Sound. The program alerts the Washington Department of Health to the presence of harmful phytoplankton to assist in the management of shellfish harvest, monitors phytoplankton community composition by recording the relative abundance of all species, and documents unusual bloom events and new species entering Washington's marine waters. This summer program volunteers helped provide early detection of an Alexandrium bloom in Hood Canal, protecting public health and minimizing economic losses for local shellfish growers.

S42026-18

## Transport of Fine Sediment in the Puyallup-White River Watershed: Insights from Sediment Composition

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The Puyallup River and its tributaries move sediment from their glaciated headwaters at Tahoma/Mt. Rainier to Commencement Bay. Landscapes around the Puyallup/White River Watershed - and in particular at the glacial sources of these rivers - are changing, affecting sediment supply and transport in the watershed and in turn flood risk, water quality, and ecosystem health. Fine sediment (silt size and smaller), in particular, is carried largely in suspension and is monitored as a contaminant in some subwatersheds. Here we present results of a study characterizing the composition of suspended and bed sediment in the glaciated Puyallup, White, and Carbon Rivers and the non-glaciated South Prairie Creek. Iron oxide and iron silicate concentration in suspended sediment collected during summer (based on magnetic properties) are higher for glaciated catchments than non-glaciated streams. Suspended sediment iron oxide concentrations and characteristics are similar to those of modern alpine glacial till and lahar sediment. Higher variability in winter sediment oxide concentrations suggest that winter storms may also sample local, lower-elevation sediment sources. Mineralogy of the clay-sized ( $<2\ \mu\text{m}$ ) fraction indicates a greater concentration of quartz and feldspar (dominantly plagioclase) relative to clay minerals in suspended sediment from glaciated streams, consistent with glacial rock flour of volcanic origin. In contrast, the composition of silt from bed sediment varies geographically, with the White River and South Prairie Creek containing relatively more mafic minerals than the Puyallup River. When taken together, these results suggest that the distinct compositional signature of high elevation volcanic and (modern) alpine glacial sediment sources persists in summer pulses of fine suspended sediment and can be distinguished from low-elevation sources. In winter, remobilized summer sediment combines with sediment from low-elevation sources. We expect that using suspended sediment composition as a natural tracer of sediment sources will help reveal geographic and seasonal patterns in sediment supply and transport in the Puyallup/White River Watershed, informing future sediment management.

S42026-19

## Do Geoduck Aquaculture Tubes Provide Thermal Refuge for Basket Cockles?

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Despite recent population declines in Puget Sound, basket cockles (*Clinocardium nuttalli*) thrive in intertidal PVC aquaculture geoduck tubes. Geoduck tubes may promote *C. nuttalli* colonization by providing protection from predators and creating favorable nursery conditions, but no peer reviewed studies have measured these effects. This study uses a physical model and field data to test the hypothesis that deeply buried geoducks create favorable thermal environments in their PVC grow tubes by moving cooler subsurface water to the surface during low tide.

Experimental and control PVC geoduck aquaculture tubes were placed side by side in a 170L laboratory tank containing intertidal sediment and seawater. Heat lamps equalized control and experimental tubes to 30C at the surface. Thermal stress begins at 24C for *C. nuttalli*. In a series of trials, we introduced a likely range of geoduck discharge volumes (5, 10, 15 and 20 ml) at a water temperature of 12C typical of measured subsurface intertidal temperatures in South Puget Sound. Sediment temperature was measured using Vernier surface temperature monitors inserted 6 cm into the substrate where *C. nuttalli* typically rests. Readings were taken at one second intervals before and after seawater injection into control and experimental tubes. In August 2026 readings were taken at the surface and 10cm beneath the surface in geoduck tubes with and without actively growing geoducks and on adjacent intertidal zones (N=50 for all sites).

In laboratory models, subsurface temperatures ranged between 22 to 24C before cool water injections. Subsurface sediment temperatures were unaffected by 5 ml discharges. A 20ml injection caused an 11C decline that remained below *C. nuttalli* stress levels beyond 2 minutes. Reduction of subsurface temperature declined exponentially with injection volume (N = 6,  $R^2=0.94$ ). In field observations, the presence of geoducks in grow tubes reduced average surface temperatures from stressful 28.34C by 7.16C. Subsurface discharges by geoducks could favorably affect survival of *C. nuttalli* by reducing heat in grow tubes during summer low tides.

S42026-20

## Timing of Gravidity of the Western Pearlshell Mussel (*Margaritifera falcata*) in Mill Creek and Skookum Creek, Mason County WA

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Mill Creek and Skookum in Mason County, Washington, are priority salmon streams for the Squaxin Island Tribe. These creeks contain Western Pearlshell mussels (*Margaritifera falcata*) that depend on salmonids as hosts for juvenile mussels (glochidia). Our objective was to determine timing and stream temperature for gravidity of *M. falcata* in spring of 2025 and 2026. The study was focused on Mill Creek, but only by chance, we were present in Skookum Creek at an opportune time. We checked mussels weekly by opening them slightly to observe presence of glochidia in gills (gravidity). We took discrete measurements of temperature of the creek during each visit. We also deployed continuous temperature sensors in two locations in Mill Creek and one location in Skookum Creek in the spring of 2025 and 2026. Mussels showed evidence of gravidity generally during the month of May. Mussels checked after the first of June appeared to have extruded their glochidia. Detection of gravid mussels coincided with a daily stream temperature range of 12.6-20.1°C in Mill Creek. By chance, underwater camera footage revealed mussels outwardly displaying their glochidia (conglutinates) on the afternoon of May 22, 2026 in Skookum Creek. The temperature of Skookum Creek that afternoon was 15°C.

S42026-21

## Pinniped Predation on Salmonids Project

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Harbor seal (*Phoca vitulina*) populations in Puget Sound have increased substantially since the enactment of the Marine Mammal Protection Act, and may be approaching carrying capacity, while many of their salmonid (*Oncorhynchus* spp.) prey populations are in decline or listed under the Endangered Species Act. As abundant, mobile predators with high energetic demands, harbor seals may be consuming enough migrating salmon and steelhead to negatively impact or limit recovery of imperiled salmonid populations. To quantify and characterize predator-prey interactions between harbor seals and salmonids, we designed the Pinniped Predation on Salmonids Project (PPSP). Bringing together the local and multi-disciplinary expertise of tribal, non-profit, state, and federal biologists across Puget Sound, the project's primary objective is to provide monthly, year-round estimates of harbor seal consumption of juvenile and adult salmon and steelhead at two Puget Sound estuary sites (Duckabush and Nisqually Rivers). From late 2024 to early 2026, we collected monthly harbor seal data (i.e., aerial survey counts, scat samples, and movement and habitat use satellite tracking), necessary to populate a bioenergetic consumption model for each species of juvenile and adult salmonid found in seal diets. We also tagged Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) smolts with acoustic transmitters and tracked their freshwater to ocean migration using over 70 stationary receivers deployed throughout the migration corridor to measure survival and predation rates. Data from these models and analyses will be used to gauge the magnitude of harbor seal predation at survival bottlenecks, and will inform predator management actions being considered across the region.

S42026-22

## Making Habitat from Puget Sound's Urban Stormwater Ponds

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Stormwater infrastructure includes artificial ponds designed to minimize impacts of flooding, erosion, and pollution in receiving waters. Habitat is not conventionally incorporated into stormwater pond design and management; yet, as wetlands become more limited, wildlife is increasingly found inhabiting these urban and suburban ponds. Aside from the conservational upside to incorporating wetland-like habitat into pond design and oversight, aquatic native species provide myriad ecosystem services: pest control, sense of place, nutrient cycling, water quality bioindication, and recreational wildlife viewing for their surrounding human communities. As such, many jurisdictions are increasingly interested in constructing and managing stormwater ponds to serve a dual, simultaneous purpose as habitat for native species. We surveyed amphibians, fish, birds, and beavers across nearly 200 stormwater ponds in Puget Sound. We found consistent negative associations between urban impervious landcover and signs of beaver, as well as the presence of certain bird and amphibian species. Pond size was also strongly tied to beavers and bird community composition. Further, size was linked to hydroperiod, which likely influenced presence of predatory invasive fish and bullfrogs, and therefore native amphibian diversity. Riparian tree cover and aquatic vegetation - sometimes associated with the intentional "renaturing" of stormwater ponds - had variable, species-dependent relationships with wildlife presence. Some species, such as the northern red-legged frog, were particularly sensitive to a variety of pond characteristics, from landcover to invasive species, to vegetation, and therefore might be good proxies for habitat quality. Finally, impervious surface was also negatively associated with human environmental health disparities in communities surrounding our study sites. Thus, our work has social implications for the equitable accessibility of more biodiverse stormwater ponds with higher potential for ecosystem services.

S42026-23

## Elemental Properties of Scotch Broom-Derived Biochar

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Biochar can be produced from a wide variety of feedstocks and has been studied extensively since 2010. There are a variety of applications for biochar, including soil improvement and remediation, carbon sequestration, and pollutant removal. Scotch broom is an invasive plant found worldwide and extensively in the Puget Sound region, but there has been little study into its use as a biochar feedstock. Scotch broom is difficult to remove, with currently little incentive to do so, making removal slow and limited. Scotch broom damages the soil for native plants, with these negative effects increasing upon removal, harming biodiversity while also serving as a potential fire risk. After removal, Scotch broom is often burned, releasing greenhouse gases, air pollutants, and potentially damaging the soil underneath. By processing Scotch broom into biochar, this waste could instead be put to use sequestering carbon and restoring soil. This study's objective was to determine the elemental and chemical properties of Scotch broom-derived biochar produced through slow pyrolysis at 400, 500, and 600 °C using a muffle furnace. The experimental results showed that Scotch broom is a viable feedstock for biochar production and that temperature was an important factor in SBDB's final properties. Specifically, the percent carbon increased from  $68.5 \pm 0.9\%$  to  $77.6 \pm 0.4\%$  as temperature increased. Similarly, pH increased from  $8.2 \pm 0.1$  to  $10.0 \pm 0.1$  as temperature increased. Conductivity and nitrogen levels were relatively low. Weight also decreased as pyrolysis temperature increased. Further study is warranted for Scotch broom-derived biochar, especially its potential to restore soils previously damaged by Scotch broom removal. Turning Scotch broom into biochar may increase incentives to remove it.

S42026-24

## Kelp Community Changes and Variations Across South Puget Sound

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Puget Sound has seen an 63% decrease in Bull Kelp (*Nereocystis luetkeana*) compared to the earliest baseline in 1878, with individual sub-basins showing up to 96% loss. Much less is known about the status of understory kelp species and associated communities across the region. To address this data gap and leverage recreational divers for community science, Reef Check's kelp forest monitoring expanded into Washington in 2022. Since the inception of the Washington program, four years of monitoring data has been collected at kelp beds across Puget Sound to track the health of kelp communities across the region and its changes over time. South Puget Sound has seen some of the largest bull kelp bed declines in the Sound but much less was known about the understory kelp species and invertebrate communities. Here we present kelp and invertebrate density data from six survey sites in South Puget Sound. Kelp and invertebrate diversity varied greatly across these sites. Species composition ranged from bull kelp and rich understory community at Salmon Beach to acid weed (*Desmarestia ligulata*) and the invasive wire weed (*Sargassum muticum*) at Squaxin Island. Devils Head where kelp densities were already low compared to other sites showed greater than 50% decline in all kelp species in 2025. Substrates at sites with large declines or changes in species composition had 75% or greater percentages of aggregate substrate of less than 5 cm in size . Reef Check will continue long-term monitoring of these sites and, in collaboration with the Seattle Aquarium, develop an Understory Kelp Abundance and Condition Indicator for the Puget Sound Vital Signs framework to make information on these distribution and trends of subtidal kelps available to managers and the public in a standardized and digestible way. .

S42026-25

## Mapping Eelgrass Meadows at ANeMoNe Monitoring Sites using Single-beam Sonar: Examples from South and Central Puget Sound

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Eelgrass (*Zostera marina*) meadows provide important habitat and ecosystem services throughout the Puget Sound, but their spatial extent and distribution can be difficult to characterize using field-based methods alone. The Washington Department of Natural Resources' Acidification Nearshore Monitoring Network (ANeMoNe) has been monitoring eelgrass health and water quality throughout Washington State since 2015, providing long-term information on environmental and ecosystem conditions at established monitoring sites. To complement this field-based monitoring, we evaluated the use of sonar surveys to characterize eelgrass meadow extent and detect changes through time across ANeMoNe sites, using on Central and two South Sound sites (Casey Inlet, Nisqually Reach, and Maury Island) as case studies. We conducted repeated surveys using a single-beam sonar system to collect spatially continuous bathymetry and eelgrass distribution data across each site. Meadow area differed among sites, with Maury Island supporting the largest meadow and Case Inlet the smallest in 2025. Temporal changes also varied among sites, with a 93% decline in meadow extent at Case Inlet between 2015 and 2025, while Maury Island and Nisqually Reach remained relatively stable. Surveys also provided spatial information on eelgrass distribution within the broader bathymetric context of each meadow, sometimes extending beyond or occurring outside of the area of field-based monitoring. These results demonstrate the that repeated sonar surveys can provide valuable spatial and temporal information for characterizing eelgrass meadow extent and detecting changes in meadow distribution through time. Integrating sonar surveys with existing field-based methods can improve our ability to monitor changes in eelgrass meadows and generate information that could support future monitoring, conservation and management efforts.

S42026-26

## Persistent organic pollutants in South and Central Puget Sound herring stocks remain of concern despite long-term declines

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Pacific herring (*Clupea pallasii*) are widespread in coastal areas throughout the northern Pacific Ocean and critical components of a complex, pelagic ecosystem. They serve as an important resource for a wide range of fish, marine mammals, seabirds, and humans. The Toxics Biological Observation System has monitored four herring stocks within Puget Sound since 1999 to evaluate spatial and temporal trends of persistent organic pollutants (POPs) in the pelagic food web. These stocks were chosen to represent the status and trends of herring across three broad regions of Puget Sound that coincide with a gradient of urban-industrial influence and hydrology: the North Basin (Semiahmoo and Cherry Point), the Central Basin (Port Orchard-Port Madison), and the South Basin (Squaxin Pass). We found that concentrations of both PCB and PBDE in Pacific herring residing in Puget Sound have declined over the last 20 years. The average annual percent decline in PCB and PBDE concentrations in these stocks ranged between 2.0 - 3.1% and 7.2 - 9.3% per year, respectively. While estimated rates of decline were similar across regions and chemicals, concentrations of PCB and PBDE in Central and South Basin stocks were roughly two-times greater than the most northern stocks. Despite declining exposure and accumulation, concentrations of POPs in Central and South Basin herring exceed health effects thresholds, indicating current exposure could be negatively impacting these stocks and the broader food web. Levels of PCB and PBDE in herring from Squaxin Pass and Port Orchard-Port Madison have the potential to reduce growth and increase susceptibility to disease, respectively. Because these contaminants bioaccumulate, higher trophic predators, such as Chinook salmon and Southern Resident Killer Whales that rely directly or indirectly on these stocks for food, are likely to accumulate even greater concentrations of these chemicals. While POPs remain a concern for the pelagic food web in South and Central Basins, sustained long-term declines in exposure and accumulation highlight that the health of Puget Sound's pelagic food web continues to improve with respect to these contaminants.