Puget Sound Shoreline Science Review

by

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To Whom It May Concern:

Bringing critical area ordinances and shoreline master programs up to date has been a major venture for planners in the Puget Sound region, with immense potential consequences. With a background in and close to forest and stream research and with a special interest in buffering I noticed several problems with guidance laid out by state agencies and executed locally:

- Some stream research was being applied inappropriately to wetlands and tidewater
- Some forest science was being ignored or misapplied
- Buffering was being offered as a uniform cure-all, without consideration of alternatives
- Some Puget Sound conditions appeared to render some buffering ineffective
- The complexity of natural systems was being ignored in some instances, producing simplistic A-causes-B assumptions
- Because monitoring of earlier prescriptions had not been done, “did it work?” and “what’s broke” remained obscure
- Bromides, dogma and conjecture were being accepted as “science”
- Little research to remedy these problems, much of it easily undertaken, is either underway or contemplated.

Those issues plus curiosity underlie the enclosed analyses, which were written for planners and non-technical audiences.

My considerable respect goes to those who collected the data used in some of these papers. Often alone, with cumbersome gear, in waters rough above and murky below, or schlucking along muddy shores, these people comprise the whole foundation of research in aquatic places and the salt chuck. Their shoulders carry the quantitative analyses of ecosystem dynamics, where kinds of organisms can be manifold while key species are scant or elusive. I salute those who dig the data wells, secure the traps, count and measure, and organize the data.

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BS from University of Washington in Forestry and Geology. MS and PhD from Yale in Forestry. 40-years research experience in the natural sciences. Researcher-in-Charge of several forestry research laboratories in Northwest, Oregon and Alaska. Former technical editor, Journal of Forestry. Former head of National Fire Danger Rating System Research. Former head, National Timber Harvest Issues Program. Former affiliate professor, University of Washington. Former Director of Keep Washington Green Association (forest fire prevention), and 80-year family history and experience of Puget Sound shoreline ownership and stewardship. Current area of study involves the review of 3,500+ research papers on buffers, riparian zones, beach functions, and fisheries.

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Revision Notes:

- *Challenges to the science in a “guide” for protecting nearshore habitat.*
  added Rev 1, 05/21/10
- Formatting changes only: page breaks, page numbers, etc.

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A perspective on
Shoreline policy, technical issues, studies at hand, and the research void.

Existing and proposed Shoreline Master Programs carry sweeping policy implications. Yet, in none of the policy areas reviewed here is there a body of research-based measurements showing harm from existing residential shoreline uses, nor quantified estimates of beneficial change from required practices.

Sweeping statements of harm and alarm are floating about like wind-blown wrack. This because much of the “science” being offered in various syntheses and literature citations is conjecture-, not data-based.

Discussed here are some policy areas whose resolution obviously warrants the indicated research on benefits, harm, and options. The subjects are **shore protection, dock policies, and buffering**. Some existing studies are mentioned, as are some clearly needed investigations. I have probably overlooked a number of both kinds.

It is interesting that so little research links upshores, backshores, beaches, nearshores, and their marine-related life. In 2004 a group of marine shoreline experts concurred that “It was felt that no good science currently exists to recommend vegetation buffer widths in the [marine riparian zone] at this time.” And, “Scientifically defensible recommendations for vegetated buffers were felt to be limited to the recommendation of vegetation presence over absence when a choice implicated.”[1] In that year the Battelle team “assessing” Bainbridge shoreline “threats” said, ...little guidance currently exists for biotic indicators of habitat quality in Puget Sound nearshore marine systems.

So measures, even indicators, of bayside biologic badness and benefit tied to inshore and upland activity are largely absent.

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[1] Lemieux, J. P., et al, eds. 2004. *Proceedings of the DFO/PSAT Sponsored Marine Riparian Experts Workshop, Tsawwassen, BC, February 17-18, 2004.* Canadian Manuscript Report of Fisheries and Aquatic Sciences 2680. Vancouver BC: Fisheries and Oceans Canada.

Shore Protection Policy

Almost 40 percent of easterly Kitsap County shores support bulkheads, presumably to preclude wave-driven erosion leading to bank and bluff collapse.[2] The figure is about 58 percent on Bainbridge Island.[3]

Shore defense is frequently assumed to be harmful to beaches and their inhabitants. For some impacts, a two-stage mechanism is implied in the literature: First, physical effects on beaches, then the consequences of those effects on biota.

Distinction should be made between beach-intruding bulkheads and those meeting current placement (snug-against-the-bank) rules.

Recent work in Thurston County suggests a no-harm hypothesis is appropriate. A county-wide comparison of shores with and without protection found no significant beach changes from bulkheads.[4]

Hugh Shipman, a well-known coastal geologist who chaired a 2009 workshop on shoreline armoring, has remarked:

One wonders why the workshop was focused on managing shoreline armoring given the limited scientific research that has been done on the impacts of armoring on either geologic or ecologic processes, and the difficulty of applying the science that has been done elsewhere to Puget Sound given the unique aspects of our system.

One can wonder, but that's exactly what local planners and the state ... are doing throughout the Puget Sound region. They are focused on eliminating bulkheads that protect people's homes without scientifically valid proof of harm.[5]

Pertinent research areas would include:

Bulkhead success. A systematic tally of protection experience under various conditions of exposure and upshore geometry, including durability and cost-effectiveness. The flip side is bulkhead failure experience. This would include expansion of Shipman's published experience with 'soft' bulkheads. 'Protection' includes toe erosion, (presumably subsequent) bluff failures and shoreward beach progression.

Sediment 'starvation'. That shore protection reduces sediment additions to beaches is generally agreed. The reduction may or may not be small. There is no research-based evidence that bulkhead restraint of bluff colluvium has stripped beaches to their (rock or hardpan) substrate. In fact the Thurston County study (above) shows quite otherwise. Elsewhere studies

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[2] Borde, Amy B., et al. 2009. East Kitsap County nearshore habitat assessment and restoration prioritization framework. Sequim: Battelle Memorial Institute.

[3] Williams, Gregory D., et al. 2004. Bainbridge Island nearshore habitat characterization & assessment, management strategy prioritization, and monitoring recommendations. Sequim: Battelle Memorial Institute.

[4] Herrera Environmental Consultants. 2005. Marine shoreline sediment survey and assessment, Thurston County, Washington. Seattle.

[5] Shipman, Hugh. 2009. August 14 e-mail to Puget Sound Shoreline Planners.

are needed that quantify the sediment dynamics from bluff to beach plop to migration rates waterward and along beaches, with and without bulkheads. Obvious predictive variables are frequency and volume of colluvium arrival at the beach, fetch, beach length and steepness, storm parameters, a seasonality indicator, sediment size, et al. The work would expand on a 1989 Puget Sound shore-drift study by Schwartz et al[6] and one-site modeling by Finlayson.[7]

Beach profile effects below and laterally from bulkheads, including shrinkage and expansion of spits. This is extension of the ‘starvation’ with-and-without-bulkheads studies to cumulative effects and net gain or loss along whole drift cells. Given the long time frames involved in longshore change, these studies may require similarly long-duration studies and/or retrospective work.

Beach ‘coarsening’. The concern here is that bulkheads hasten the departure of fine sediments, leaving (fist-sized) cobbles, and this is bad. Battelle’s East Kitsap shoreline assessment found that half the beaches are ‘mixed coarse’ or cobble. This is consistent with early Sound-wide assessments that found, for instance, “... much of Puget Sound’s shoreline is a narrow beach fronting steep shore bluffs...The high tide beach has a steep face and is composed of coarse sediment.”[8] Cobbled upper beaches can readily be found in front of bulkheads, and in front of unprotected shores as well.

As with beach erosion generally, cobble exposure can be increased by wave energy diverted downward at a bulkhead’s face, *if* the bulkhead is reflective and below the high-tide line. Cobble can be seen as a distinct ecosystem (as is riprap, by the way), replacing some other ecotype. The research issues include “How much?” and “So what?” I know of no studies measuring cobble volumes relative to the many factors involved, nor gauging the positive and negative environmental effects.

Pollution impairment. If shore protection reduces bluff failure and consequent sediment movement beach-ward, it presumably restrains pollutants that attach themselves to sediment. Phosphorus from septic and fertilizer sources are examples. This matter has not been examined, at least for Puget Sound.

Upper-beach habitat occupation. The recent reconnaissance of easterly Kitsap County beaches concluded that 84 percent of bulkheads there encroach onto beaches. How far is not indicated; however numbers this large attract conjecture (often expressed as fact) that bulkheads overtop habitat, notably forage-fish spawning areas. The survey of Bainbridge beaches has shown that about half of the habitat suitable for sandlance spawning is <u>in front of</u> bulkheads. The figure for surf smelt is almost three-fourths. This does not mean that bulkheads are good for spawning. However given that many bulkheads have been in place for decades, and some beaches heavily protected for more than a century, it suggests an hypothesis that shore protection has no impact on forage-fish spawning.

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[6] Schwartz, M. L., et al. 1989. Net shore-drift in Puget Sound. Technical Res. Bull. 78. Olympia: Washington Department of Natural Resources.

[7] Finlayson, David. 2006. *The geomorphology of Puget Sound beaches*. Puget Sound Nearshore Partnership Report 2006-02. Seattle: Washington Sea Grant.

[8] Macdonald, Keith, et al. 1994. *Shoreline armoring effects on physical coastal processes in Puget Sound, Washington.* Seattle: CH2M Hill. Distributed by Washington Dept of Ecology, Olympia.

Two studies purport to show the effects of bulkheads on surf smelt egg survival.[9] In fact they compare treeless (and bulkheaded) unshaded shores with treed (non-bulkhead) shaded places. And yes, shade matters.

An obvious line of inquiry is whether overtopping by bulkheads is more troublesome than smothering by beach plops from unprotected bluffs, given that about 60 percent of the Sound's shore is bluffs.[10] Another query is the extent to which bulkheads actually intrude into habitat.

Lower-beach habitat degradation. This issue starts with the presumption that a bulkhead will effectively forestall beach plops to a wave-active beach, and that this will cause a decline in the beach profile, perhaps to a hardpan layer. First, this is unlikely at the accretion end of the drift zone and of course isn't relevant to non-drift reaches. Second, there is no documented reason to believe that, even on *unprotected* beaches, sediment contributions from banks and bluffs keep up with their sweeping away by storms and currents. Third, even hardpan has its biota, suggesting that this is an issue of habitat change rather than obliteration.

Clay substrates were mapped in a recent shoreline assessment of easterly Kitsap County. Assuming 'clay' includes hardpan (till), there is almost none along the beaches, with and without bulkheads. The Thurston County study found no beach degradation from shore protection. In any case, the research issue is the actual extent of such exposure, its causes, and its implications, if any, for biologic diversity and density.

Two studies[11] have shown no difference in subsurface fauna in front of bulkheaded versus unprotected shores, so this part of the habitat issue also seems moot.

A claim has been made that shoreline protection may *increase* sediment flows onto the beach by removing vegetation, thereby submerging eelgrass in silt.[12] Yet the Bainbridge survey showed that the mileage of eelgrass exceeds by half the extent of herring spawning, a key function of eelgrass. Half the Island's eelgrass and 83 percent of herring spawning is in front of bulkheads. There is no evidence that these linkages are either causal or adversarial.

Wrack is another biota issue. The wayward, aimless debris along the high-tide swash line provides transient shelter to some amphipods (beachhoppers) and insects. Far-projecting

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[9] Rice, Casimir A. 2006. Effects of shoreline modification on a northern Puget Sound beach: Microclimate and embryo mortality in surf smelt. Estuaries and Coasts 29(1):63-71; The same single-site 5-day comparison appears as a chapter in his University of Washington PhD thesis.

Tonnes, Daniel M. 2008. Ecological functions of marine riparian areas and driftwood along north Puget Sound shorelines. Master's thesis, School of Marine Affairs, University of Washington.

[10] Johannessen, Jim and Andrea MacLennan. 2007. Beaches and bluffs of Puget Sound. Puget Sound Nearshore Partnership Technical Report 2007-04. Seattle: US Army Corps of Engineers. The authors draw this figure from two citations.

[11] Sobocinski, Kathryn L. 2003. The impact of shoreline armoring on supratidal beach fauna of central Puget Sound. Master's thesis, School of Aquatic and Fishery Sciences, University of Washington.

Tonnes, 2008, above.

[12] Envirovision, Herrera Environmental, and Aquatic Habitat Guidelines Working Group. 2007. Protecting nearshore habitat and functions in Puget Sound, an interim guide. Publisher unk; probably Washington Department of Fish and Wildlife.

bulkheads displace shoreline wrack collection to more open beaches. Because wrack is a mix of (mostly) dead seaweeds and shore-contributed leaves and twigs, there are three factors to examine: The importance of wrack-embraced biota in the plankton-to-fish food chain, the (seasonal) quantitative relations with upland vegetation and offshore algae, and the amounts by which bulkheads in various postures affect those sources.

Upshore vegetation. Trees overhanging upper beaches have been considered a habitat asset. Their mention here reflects several analysts' incorrect assumptions that bulkheads are somehow hostile to trees and their shade. Relative to exposed banks, bulkheads may be the salvation of trees. Inspection of shorelines reveals many instances of trees leaning out from behind bulkheads. The Easterly Kitsap shore inventory found vegetation overhanging at least 25 percent of the shore's length within 31 percent of the shore segments, out to at least the ordinary high water mark. On Bainbridge 27 percent of the shoreline was found to have overhanging veg. Curiously neither survey reports the proportion of bulkheads that support overhanging trees or shrubs, nor is that fraction compared with unprotected shores.

The merits of overhanging trees are often advanced, with mention of shade for passing fish, shade for surf smelt eggs on the upper beach, and insects falling from trees to feed juvenile salmon. All appear to be false premises, and as a minimum should be considered hypotheses to test. Migrating fish are observed to traverse long expanses of open water in areas where nearshore approaches are feasible. Shade, important to those smelt that spawn in summer, is largely irrelevant in easterly Kitsap, where most spawning is non-summer, and the small amount of active summer spawning occurs on an unshaded beach despite an abundance of apparently available habitat.[13] Tree-obligate insects provide an average of only 1 to 2 percent of biomass consumed by migrating juvenile salmon, while adults and forage fish eat virtually none.[14] Expanded work on these subjects is certainly warranted; meanwhile these appear to be the best numeric findings to date.

A conclusion about shore-protection research: Conjecture is rampant, research is scant, harm is neither demonstrated nor quantified.

Policies On Residential Docks

Dock policies, current and/or proposed, include structural requirements, size parameters, numbers of craft allowed, and even numbers of docks and floats allowed in certain shoreline areas.

There is a considerable history of dock emplacements on the Sound, and much less history of research on their impacts on marine life.

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[13] Penttila, Daniel E. 2001. Effects of shading upland vegetation on egg survival for summer-spawning surf smelt on upper intertidal beaches in Puget Sound. 2001 Puget Sound Research. Olympia: Puget Sound Water Quality Action Team.

[14] Flora, D. F. 2007. A perspective on insects eaten by juvenile Puget Sound salmon. Available from the author.

Docks as ecosystems. The under surfaces of docks and floats are cited as important biomes in shoreline texts.[15] Their productivity in terms of diversity of species and numbers of individuals is well known to be immense.

Creosoted piling has returned as an issue because of a curious and expensive program of removing old piles. Dr. Kenneth Brooks is clearly the grand master of treated-piling research. He has said, "Because of [its color, odor, and irritation to skin], there is a perception that creosote must be harmful to aquatic life. But empirical evidence shows that those perceptions are not the reality." Brooks[16] notes a study that found, on creosoted piling, 124 species of invertebrates with over 31,000 animals per square meter.

Squashing marine life. Floating docks that rest on the beach at low tide can, twice daily, impair immobile organisms. If significant, this should create a low-tide stench of decaying tissue. It appears more likely that the dead biota are consumed by grazing predators (fish, sea stars, and many others). Whether there is a net loss of productivity is not clear.

Attenuating light. A number of studies of industrial and ferry docks have raised concerns about eelgrass beds lost to shade and turbulence. Such docks are typically 100-200 feet wide supporting buildings and tight decks. Light matters.

A mid-'90s study examined the negative effects of small docks, with and without central gratings, on performance of eelgrass beds.[17] Eelgrass impact was found. (This was not a fish-behavior study.)

Interrupting fish migration.[18] Ferry-dock studies have shown that shore-hugging migrating juvenile salmon pause at such docks because of the contrast with sunlight. Dark matters. Those studies are increasingly sophisticated. With the ability to track individual fish it has been found tentatively that fish pause at the edge of darkness, then about half go on under the dock while the rest go around. What they do at night and on cloudy days was not studied. Clearly this is a high-tide issue whose magnitude is still unknown.

Informal field observations suggest that residential docks less than eight feet wide are hospitable to transiting fish, including salmon. "...docks less than 8 feet wide allow substantial light penetration underneath them, especially during periods of low sun angles."[19]

I have seen schools of fingerlings take refuge in shade under floats and docks. Marine biologist Jon Houghton says, "If [floats or floating docks] are relatively narrow, e.g., 6 feet wide or less, fish would ultimately pass under or around them with little delay....juvenile salmonids have been observed to move freely along floating structures, ultimately passing under them in

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[15] For instance, Kozloff, Eugene. 1993. *Seashore Life of the Northern Pacific Coast.* Seattle: University of Washington Press. Also,Ricketts, Edward, et al. 1985. *Between Pacific Tides.* Stanford University Press.

[16] Brooks, Kenneth M. [n.d.] Creosote treated piling - perceptions versus reality. Creosote Council. www.creosotecouncil.com/PugetSoundCreosoteReport.pdf

[17] Fresh, K. L., et al. 1995. Overwater structures and impacts on eelgrass in Puget Sound, Washington. Proceedings, Puget Sound Research 1995. Vol 2 p. 537-43.

[18] A larger discussion is in Flora, D. F. 2008. Pressing on: Do residential docks really impede passing salmon? Available from the author.

[19] Houghton, Jon, 2006. Best available science review of proposed overwater structure restrictions in Blakely Harbor, Bainbridge Island, Washington. Edmonds, Washington: Pentec Environmental.

response to uncertain stimuli, or through gaps between floating sections, e.g., spaces between segments of a log boom."[20]

Refuge for juvenile fish. Such hesitation at (narrow) residential docks has not been quantified nor even studied. Casual observations show that small fish, singly and in schools, retreat beneath floats. Even children fishing observe this, to their dismay.

Hideouts for piscine predators. Houghton has pointed out that while frequent claims are made and searches are done for concentrations of fishes' predators beneath docks, they have not been found.[21]

The barnacle threat. There is a claim that "...barnacles and other organisms that colonize the piling result in formation of a different beach substrate than normal, changing the character of the habitat."[22] Implying that the change is bad, but is it?

A conclusion about dock-related research: Speculation has been embraced; there has been virtually no research on residential docks in Puget Sound; and harm is undiscovered.

Buffer Policies

For vaporous reasons no-touch belts of vegetation, in some cases over a hundred feet wide, are imposed or proposed along upshore residential edges.

A first analytical question is, what shoreline attributes are impaired or lie in harm's way? Next, what are the drivers? Then, what are the rectifying or preventive options?

Research has not played a proud role in answering these questions for Puget Sound. Conjecture underlies most of these claims:

Bank slippage and the beneficial role of upland trees. There are two contradictory arguments here. One is that tree roots grasp the bank's edge, keeping it in place. The other is that tree roots don't grasp but rather fail, abandoning trees to the beach where marine life will be helped.

If roots are tenacious they work against the argument that bluff failures benefit beach conditions.

DOE publications warn about the risks of trees at the brinks of banks: They fall.[23] No data is presented one way or the other. Given that all trees ultimately fall, a considerable literature has developed about the importance of large woody debris to *streams*. The primary benefit is creation of pools and riffles. Environmental engineers have even written prescriptions for log

[20] Houghton, Jon, 2006, above.

[21] Houghton, Jon, 2006, above.

[22] EnviroVision et al. 2007. Protecting nearshore habitat and functions in Puget Sound - An interim guide. Olympia (?) Washington Dept of Fish and Wildlife p. II-11.

[23] Myers Biodynamics, Inc. 1993. Slope stabilization and erosion control using vegetation, a manual of practice for coastal property owners. Publication 93-20. Olympia: Washington Department of Ecology.

sizes, spacing, orientation, and anchoring. And horror stories are abundant about resultant log jams and deaths of kayakers.

This is one of several issues for which stream science cannot be extrapolated to tidewater. Others will be mentioned directly.

Often claimed but yet to be shown with data is the role of tidewater driftwood in supporting invertebrates which then support fish or other parts of the food chain. A diet study has found ants and termites in the guts of juvenile salmon, though their importance biomass-wise has been questioned.[24] Carbon dating has shown drift logs over 200 years old in the north Sound, implying that any internal biota has been slow to digest the woody tissues.[25]

Buffer trees and shade. This issue was covered with bulkheads. Briefly, shade can be important along streams, and studies have shown it can help surf smelt eggs survive in some places. No research has shown the dependence of inshore saltwater fauna on shade, which can only happen at low tide (benthic fauna) or high tide (mobile critters), in daylight on hot days sans clouds.[26]

That overhanging trees dribble insects onto tidewater for fish consumption has been shown by me to be trivial, based on Puget Sound salmon diet studies. There is no other research directed to this subject.

Buffers, rainwater, and stormwater-borne pollutants. First, buffers offer no defense against pipe-borne pollutants. No buffer research needed for that.

Second, surface-water aspects of buffering have been studied much, relative to erosion, watershed protection, streamflow moderation, and nutrient dynamics. For reasons unknown to me, most of the buffer studies cited in research syntheses here are from croplands, pastures and feedlots in the Midwest and East.[27] Another body of studies, less cited here, is from forests where the issue is leaving buffers rather than creating them.[28] Not cited at all is any study of residential buffering, nor of buffering along residential vs undeveloped waterfront.

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[24] "The importance of wood-eating aquatic invertebrates is limited...The three most important wood-processing invertebrates in Oregon streams consume about 2 percent of the available woody debris per year..." Sedell, J. R., et al. Chap. 3 in Maser, C., et al. 1988. From the forest to the sea. Gen. Tech. Rpt. 229. Portland, OR: US Forest Service, Pacific Northwest Research Sta.

[25] Tonnes, 2008, above.

[26] At the summer solstice a 40-foot tree 10 feet from the bank casts a shadow only 10 feet onto the beach. Montgomery, D. R., et al, eds. Restoration of Puget Sound Rivers. University of Washington Press, p. 256.

[27] For example, Sheldon, D. T., et al. 2005. Wetlands in Washington State, Volume 1: A synthesis of the science - final. Washington State Department of Ecology Publication 05-06-006.

May, Christopher W. 2001 and 2003. Protection of stream-riparian ecosystems: a review of best available science. Prepared for Kitsap County Department of Natural Resources.

Desbonnet, Alan, et al. 1994. Vegetated buffers in the coastal zone, a summary review and bibliography. Coastal Resources Center Technical Report 2064. Narragansett, RI: Rhode Island Sea Grant and University of Rhode Island Graduate School of Oceanography.

[28] See, for example, notes 31 through 33, below.

Third, the farm studies yield disparate conclusions, mainly because some of the explanatory variables are not measured, or aren't reported. Kenneth Brooks has done much to untangle the cause-effect webs of buffer behavior relative to stormwater.[29] He amplified and corrected a number of buffer judgements made by the state Department of Ecology.[30]

Fourth, much of Puget Sound's stormwater is unique ecologically. This because of hardpan (glacial till) soils, hard or prolonged winter rains, absence of summer precipitation, and winter-dormant vegetation. These conditions warrant lines of buffer research here that, for reasons unclear, are not done. For example, the role of till in restricting infiltration from within buffers is surely a factor in buffer effectiveness regardless of width. Seasonal dormancy means buffer vegetation undoubtedly plays a trivial role in removing stormwater and its pollution baggage via ingestion and transpiration. How trivial hasn't been gauged.

Fifth, stormwater buffering is typically justified by removal of (arguably unimportant) pollutants: sediment, nitrogen, and phosphorus. Brooks has summarized a number of pasture studies showing that these stormwater-tainting ingredients "were effectively filtered in the first 2 to 15 feet of vegetated filter strip", though some pesticides needed more decomposition time or restraint.[31] Sediment is virtually a non-issue around the Sound because of our irrepressible vegetation.[32] Nitrogen from septic systems and alder trees are an issue in some places, although a recent study of septic discharge into Hood Canal has produced results that range from startling to ho-hum.[33] Research on streams entering Lakes Washington and Sammamish shows urban streams carrying no more sediment and P than forest streams.[34] Meanwhile alder trees, native and unstoppable along shores, are famous nitrogen fixers and dischargers. And of course the ocean trumps all in nutrient contributions to the Sound. Overall, it is interesting that site-specific studies of drainfield-sourced nutrients, with and without buffering, are largely absent here.[35] Concerning biologic wastes, a Scripps Institution professor has remarked,

"...a major part of the adaptation and activity of the creatures of the sea is directed to the conversion of waste particulates into new organisms; ...most of the sea is starving and

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[29] Brooks, Kenneth M. 2006. Supplemental best available science supporting recommendations for buffer widths in Jefferson County, Washington. Port Townsend: Aquatic Environmental Sciences.

Brooks, Kenneth M. 2007. Response to the Department of Ecology Critique of Brooks (2006) Dated March 9, 2007.

[30] Sheldon, 2005, above.

Granger, T., et al. 2005. Wetlands in Washington State, Volume 2: Guidance for protecting and managing wetlands - final. Washington State Department of Ecology Publication 05-06-008.

[31] Brooks, 2007, above.

[32] Provided that a significant share of the veg is ground cover, notably grass, about which Kenneth Brooks and I have, separately, had a lot to say. See his 2007 "Supplemental Best Available Science..."

[33] Atieh, Bryan G., et al. 2008. Hood Canal onsite sewage system nitrogen loading project: Year 2 final report. Seattle: University of Washington Dept of Civil Engineering.

[34] Brett, Michael T., et al. 2005. Non-point-source impacts on stream nutrient concentrations along a forest to urban gradient. Environmental Management 35(3):330-342.

[35] An exception is the Atieh et al study of drainfields adjacent to Hood Canal beaches, which yielded very mixed results.

particularly deficient in just those sorts of materials that are introduced by domestic waste, ...seawater is a toxic material to most land organisms and highly inimical to their survival (apparently including wastewater pathogens)...”[36]

Sixth, buffering of yard and other chemicals is another area lacking research, everywhere. What applications of herbicides and insecticides, on what slopes, above what kinds of buffers, make a difference at the shore? Road-related chemicals are a current concern. To what extent do they occur in overland stormwater flows moving toward buffers? And in what seasons, to what extent, do buffers work? There are at least two lines of research beckoning here, one involving sediment-bound chemicals and the other dealing with pollutant that remain in solution. There is almost no site-specific buffer-efficacy information in either case.

Buffers and habitat. Wide buffers have been indicated for ‘wildlife’ around wetlands and along shorelines. A number of monitoring and research questions curiously remain unanswered.

There are four broad interactions to consider. One is downhill effects of upland (buffer and non-buffer) habitat on marine habitat. A second, of particular reference to sea birds, is the link between upland habitat and marine wildlife. A third may be uphill effects of marine habitats on upland wildlife. And a fourth may be links between upland shore-fringe (buffer and non-buffer) habitat and dependent terrestrial wildlife.

And along the way, what are the site-specific, quantitative effects? The cumulative effects and diminishing returns? And when wildlife are considered, are analysts keying to the important difference between ‘obligate’ and ‘primary association’? Discussions of important species and their principal habitats tend to obscure that difference.

Okay, the first domain of inquiry, the effects of buffering versus non-buffering on inshore habitats down below. This seems to embrace bank failures, stormwater, and toxic substances, all discussed earlier. The absence of Puget Sound site-specific research on these subjects is unfortunate.

The second area is upland habitats’ direct effects on marine wildlife. Sea creatures are vastly different from those on land. “It is not in the terrestrial experience continuously to inhale the young, eggs, sperm, food, and excreta of all of our fellow creatures, as do essentially all marine organisms.”[37]

In *stream* riparian zones water, insects and animals move readily between land and water. Whether shoreline wildlife is affected by a shorn environment along streams has been studied in western Washington. Aquatic creatures are remarkably insensitive to vegetation above the backshore. A study of 62 Olympic Peninsula streams and associated riparian zones concluded that the characteristics and even the presence of the riparian forest had no influence on the persistence of fishes and stream-related birds and mammals.[38] Research on 18 Washington Cascades streams found that total abundance and species richness of birds and small

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[36] Isaacs, John D. 1978. Testimony on modification of secondary treatment requirements for discharges into marine water. In: Hearings before the Subcommittee on Water Resources of the Committee on Public Works and Transportation, House of Representatives, 95th Congress, May 24-5, 1978. Washington DC: GPO.

[37] Isaacs, above.

[38] Research by Peter Bisson and Martin Raphael, summarized in: Duncan, Sally. 2003. Science Findings 53 (May). Portland: US Forest Service, Pacific Northwest Research Station.

mammals using areas close to streams before any timber harvest were comparable to the number and kinds after harvest.[39] This research has direct application to Puget Sound streams and wetlands, and implications for tidal shores. Corresponding results have been found in research in Oregon and British Columbia.[40]

The role of shoreland in supporting tidewater wildlife could be different, especially for tidewater birds. Washington's Department of Fish and Wildlife has listed "priority species" across the state.

Among the 51 priority marine birds, herons, waterfowl, shorebirds, hawks and falcons are 17 that visit Puget Sound. Most are passers-through, nesting in prairie country, Alaska and Canada, where they typically don't use trees. Four are nesters here on the Island; of those one is a 'maybe' and two are oriented to fresh water.[41]

Is habitat really a limiting factor for these birds? The Island (and probably the County) arguably has more trees now than at any time in the last 150 years. Many are small, but many are "late successional", around a hundred years old. Elsewhere, cavity-nesting birds seek out old trees whose branch stubs have decayed on into the trees. Here too, but apparently only non-marine wood ducks and (maybe) hooded mergansers.[42]

So perhaps the only two marine-related priority birds that nest on the Island are bald eagles and great blue herons. Do these birds need nesting sites? Certainly, and in significant trees. Within 200 feet of tidewater shores (the inland reach of the Shoreline Management Act)? No. On densely (70%) forested Bainbridge Island, heron rookeries are found far from the beach, as are eagle nests. Eagles appreciate high perches, along the shore and elsewhere as well. An

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[39] O'Connell, M. A., et al. 2000. Effectiveness of riparian management zones n providing habitat for wildlife. Final Report. Timber Fish & Wildlife Report 129. Olympia: Washington Department of Natural Resources.

[40] Meehan, William R. 1996. Influence of riparian canopy on macroinvertebrate composition and food habits of juvenile salmonids in several Oregon streams. Research Paper 496. Portland: US Forest Service, Pacific Northwest Research Station.

Hall, James D. And Richard L. Lantz. 1969. Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. In: Northcote, T. G., ed. *Symposium on Salmon and Trout in Streams.* H. R. MacMillan Lectures in Fisheries. Vancouver, BC: University of British Columbia, Institute of Fisheries.

Ward, Bruce R., Donald J. F. McCubbing, and Patrick A. Slaney. 2003. Evaluation of the addition of inorganic nutrients and stream habitat structures in the Keogh River watershed for steelhead trout and coho salmon. In: Stocker, John G., ed. *Nutrients in Salmonid Ecosystems: Sustaining Production and Biodiversity. Proceedings of the 2001 Nutrient Conference, Eugene*. Bethesda, MD: American Fisheries Society.

Beschta, R. L. Et al. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interactions. In: Salo, E. O. And T. W. Cundy, eds. *Streamside Management: Forestry and Fisheries Interactions.* Contribution No. 57. Seattle: University of Washington, College of Forest Resources, Institute of Forestry Research.

[41] Paulson, Ian and George Gerdts. 1996. "Checklist of Bainbridge Island Birds." Bainbridge Island Park and Recreation District. This is out of print; I can supply it.

[42] Paulson and Gerdts again.

interesting issue here is, How many? Well, eagles are said to nest about 3 miles apart. That doesn't seem to demand many perch trees.

Rapid human population growth has coincided with rapid expansion of eagle populations. This spring we had 11 eagles within 60 feet of our house. One was eviscerating a dead cat; the other ten were standing around watching. Does this signal a deficiency of cats?

I am told that herons are in decline, not for reasons of habitat nor food, but rather predation. Eagles are stealing eggs and chicks from heron nests, causing rookeries to be abandoned. Is this because cats are scarce? This is a big, serious problem of the sort that wildlifers don't discuss much: Competition, tradeoffs, and cumulative effects of wildlife and habitat expansion efforts.

Downhill linkage from upland to beach habitats is largely the erosive one, discussed with shore protection. There are two interesting aspects. One is the sudden descent of dirt and debris in landslides. The other is the cumulative effect, over centuries, of bank failures and weathering that lead to a landward regression of beaches.

False premises concerning overhanging upland trees have been discussed. They concern shade and a drizzle of insects. The role of upland vegetation in wrack production has not been studied.

The <u>third</u> area, effects of marine habitats on <u>upland</u> wildlife, might be important if upshore critters depend on beaches. Raptors and herons have been discussed. Crows and raccoons visit beaches but are hardly dependent on intertidal matters. In Alaska bears sometimes depend on tidal shores, though streams give easier access to fish carcasses. Beachly bears are not seen here. Nor are upland invertebrates dependent on tidewater, so this area may be irrelevant.

The literature does not seem to reveal a causal habitat chain from tidewater up into shorelands: Saltwater's upland effects are generally negative, including undercutting, erosion, and caustic effects on vegetation.

The <u>fourth</u> area, buffering for <u>upland</u> wildlife, may be moot. A marine biologist has said, "...the legal intent of [nearshore] buffers is to protect functions in adjacent shorelines or critical areas, not to provide upland habitat for terrestrial species."[43] Too, it is not established that upland buffers are better habitat, in terms of creature diversity and numbers, than residential uses of the land. This point is certainly researchable, as are tradeoffs among, say, eagles, herons, cats and coyotes.

Bainbridge research biologist Conrad Mahnken has remarked lately on the absence of an overall habitat restoration plan for Eagle Harbor.[44] One might reasonably expect a folio of such plans, considering the diversity and abundance of landscapes, wetlands, and shorelines on the Island and around the Sound. There is none, partly because the intricate network of predator-prey relations hasn't been quantified. Somewhere among the food chains are critical links that might be enlarged; others may be more than adequate. Or nutrition may not be an issue; limiting factors may be dispersion (bears) or crowding (crows). In the end there need to be

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[43] Houghton, Jonathan. 2003. Review of incorporation of best available science in proposed City of Bainbridge Island shoreline rules. Edmonds, WA: PENTEC Environmental.

[44] Mahnken, Conrad. June 25, 2009. Testimony before the City of Bainbridge Island Hearing Examiner, concerning the City's proposed Strawberry Cannery Park Project.

justified targets for wildlife numbers, thence habitat, thence cover, thence vegetative structure and area estimates. This is far different from dartboard decisions about buffers snaking along shorelines.

In his critique of DOE's wetland buffer guidance, mentioned earlier, Brooks[45] found that DOE had provided no information useful to determining minimum wildlife habitat buffer widths necessary for sustaining viability of non-listed species. Brooks pointed out research showing that wildlife welfare depends on the total amount of habitat, not habitat fragmentation nor connective corridors. He asked:

> What degree of wildlife protection is required?
> On what scale is protection required?
> Which habitats require protection?
> What restrictions on private property are necessary to sustain wildlife?
> Do different species require different restrictions?

These questions seem relevant to tidewater margins as well as wetlands. In any case DOE did not answer them.

Brooks also challenged DOE to produce response curves, reflecting diminishing returns from widened buffers, and associated performance standards.

So where is the research on the performance of Puget Sound buffers in achieving any of these presumably worthy goals? Formal tidewater shore buffering has been in place since at least 1989 when Jefferson County's mandatory buffering began, and perhaps even earlier (the Shoreline Management Act occurred in 1971). If opportunities have been sought and used to gauge the effectiveness of buffering here their results are not apparent. So we seemingly have no Puget Sound performance record for buffers nor their alternatives.

No research supports making the Sound's shore buffers wider. Lacking baseline information on the efficacy of narrow buffers we can hardly quantify the gains from broadening

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[45] Brooks, 2006 and 2007, above.

them. However I assembled a mostly-obvious 24-item list of functions that wider buffers will **not** perform.[46] Documentation of them is in another paper.[47]

Considering the dubious usefulness of buffers, are there alternative ways to relieve whatever stresses and strains impinge on nearshore ecosystems? Yes. Water-borne pollutants can be stopped at their sources. Erratic, ravaging slope failures can be reduced by corralling and infiltrating upland stormwater.

Several conclusions about tidewater-buffer research: Some buffer basics are well-known; their application to Puget Sound shores is virtually unstudied; for most protection goals here vegetative buffering is likely ineffective; the goals themselves are not quantified; biologic harm in the absence of buffers is vaguely stated and unmeasured; widening buffers will not improve matters; buffers are more conscriptive than other routes to the same ends; these policy implications are widely ignored.

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[46] Twenty-four functions that wider buffers will **not** perform:

Better protect the Sound against stormwater-borne pollutants
Improve shade for surf smelt spawning
Provide more insects for salmon diets
Improve nutrient flows to tidewater prey organisms
Speed the dynamics of intertidal drift zones
Slow the loss of backshore to the sea
Provide more sediment to drift zones
Regulate tidewater temperatures to reduce plankton blooms or increase benthic invertebrate production
Improve the nutrition of passing salmon
Increase eelgrass production
Increase the abundance of juvenile nor adult salmon
Protect ocean-bound fish from predators
Increase marine habitat diversity
Restore marine conditions to beckon lost cod and herring
Increase diversity of upland landscapes
Enhance the attributes of native plant species
Discourage invasive animal species
Provide a better home for small mammals
Enlarge depleted habitat for cavity-nesting birds
Provide more shoreside perches for eagles, kingfishers
Conserve water for infiltration to aquifers
Protect aquifers from water-borne pollutants
Preserve play space for children
Nor perform better than a number of alternatives

[47] Flora, D. F. 2008. Bigger beach buffers for fun and profit. 16 p. Available from the author; also on line at several sites.

Challenges to the science in a “guide” for protecting nearshore habitat.

Local jurisdictions will shortly propose revisions to the Shoreline Master Program. It is likely that the state will encourage their attention, for associated science, to:

> Envirovision, Herrera Environmental, and Aquatic Habitat Guidelines Working Group. 2007. *Protecting Nearshore Habitat and Functions in Puget Sound, An Interim Guide*. Publisher unk; probably Washington Department of Fish and Wildlife.

This “guide” is flawed in a number of places, discussed below. To Bainbridge Island’s City Council I’ve described the “guide” as semi-science. In a number of instances it is doctrinaire, unsupported by any research.

The “guide” recommends buffers, and much wider buffers than currently imposed in Kitsap County (p. III-42). In another report I have assessed the consequences of wider buffers and presented results in terms of 24 things that wide buffers will **not** do for salmon, other creatures, nor the beach itself. My conclusions implicitly contradict a number of statements made in the abovementioned “guide”. The issues are discussed here briefly, roughly in the order they appear in the “guide”.

Two recurrent, troubling themes.

Appearing intermittently are two questionable premises. One is that the *structure* of near-tidewater ecosystems is like that of freshwater riparian systems. The second is that their *functions* are the same.

The structure theme ignores the immense diversity of freshwater regimes, with tens of thousands of miles of streams in western Washington alone. “Riparian” connotes interaction between fresh water and its surround, with water and biota moving into and out from the neighborhood. It also implies a gradient that, depending on adjacent slopes and soils, may reach far from the stream. The tidewater situation is abrupt. The influence of the marine environment (p. II-9) is in fact toxic. So-called marine riparian zones are more akin to ecologic edges than to aquatic riparian reaches (p. II-39, 41, 42, 44). Even estuaries, with constantly varying salinity, bear little resemblance to nearby upland, backshore and beach plant communities. The portrayal of a smooth transition from beach to upland (e.g. p. II-41) contradicts the concept of pages I-9 and II-44:

> “Puget Sound’s nearshore zone also represents three critical ‘edge’ habitats; the edge between upland and aquatic environments, the edge between the shallow productive zone and deep water, and the edge between fresh and marine waters.”
>
> “These zones are characterized by sharp environmental gradients...”

Amplifying the separation is the fact that 60 percent of Puget Sound shores are bluffs.

A number of the plant species listed at p. II-40 are specific to near-tidal places. Madrone, for instance, is uncommon along streams, favoring dry sites, while willows and cottonwoods are freshwater riparianites.

Functions differ too. Aquatic insects are indispensable in their environment. Any insect venturing over or into tidewater (save water striders) is a goner. Stream riparia support animals not seen at the sea shore: amphibians and beavers are examples.

Much is made in the paper of the special roles of vegetation close above the tidal shore (p. II-38ff). I'll make specific comments later. Generally, shade is important along streams (although recent studies indicate otherwise); it can hardly affect much of the beach. (In mid-summer a 40-foot tree 20 feet behind the beach shades non of the beach.) Because soils and climate differ between back-country forest streams and Puget Sound lowlands, "filtering" surface runoff is important up-country, little seen nor needed along the Sound. Lethal to vegetation if some of the toxics mentioned at p. II-42 are carried along. The "filtering" claim, by the way, contradicts the emphasis on feeder bluffs among some folks. Nutrients are needed in headwater streams, frowned on beside the Sound. Large woody debris is needed for stream-structure reasons but not for shaping the Sound. Leaf litter is important up-stream; it has never been shown as important to marine biota.

One commonality, interestingly, is that a number of large cross-sectional research projects have shown that wildlife in its various forms is indifferent to the presence or absence of forest vegetation along streams here in western Washington. That may well be true for the trees vs yards issue along the Sound. I can provide the studies.

Claiming the littoral is equivalent to aquatic riparian areas ignores the immense differences within both categories. High-country streams, for instance, have far different form and function from Puget Lowland streams.

Even with the tremendous variability in both aquatic riparian zones and marine littoral there is some overlap. However the difference is like that between oranges (small) and grapefruit (large). Despite the wide within-species variance in size, a series of randomized paired comparisons will always reveal an interspecies difference.

The Guide's Section II Nearshore Habitats.

Guide: "Bluff erosion is the primary source of material that replenishes beach substrate (p. II-2, 3 and 10). Response: This does not account for the immense amount of material carried onto beach alluvial fans by myriad small streams, not to mention rivers.

Guide: "Riparian vegetation alteration...can result in increased erosion and an increase...in landslides" (p. II-12). Response: DOE says that too much heavy, leaning veg is more likely to produce slides than is too little.

The left photo on p. II-44 purports to show "unaltered riparian vegetation". In fact this is a fractured ecosystem or an adulterated ecotone. Vegetation above the bluff is surely the second or third invasive, native, pioneer ecosystem following landscape 'alteration' by logging, then probably fire, then farming. In the far background appears a late-successional remnant stand, again the undoubted product of 'alteration'. The photo contradicts a statement in the previous paragraph about invasive plants not being native. I suspect the site in the right photo is very different now than when the picture was taken.

Guide: The sliding "...can result in an oversupply of substrate to the beach..." (P. II-12). Response: I challenge the authors to quantify 'oversupply' of beach plops or even provide the criteria for knowing 'oversupply'.

This is a contradictory section, in one part applauding feeder bluffs and in another part deploring their erosion.

Guide: "Activities that alter...shoreline substrates...can adversely affect...spawning habitats for forage fish" (p. II-13). Response: Yes, but there is excess habitat for surf smelt and candlefish. There is no indication that beach plops nor legally placed bulkheads have reduced the supply of forage fish.

Guide: "Removal of marine riparian vegetation can alter the temperature and nutrient regime of the nearshore environment. (p. II-36). Response: Hardly, if this alludes to beaches. Incoming tides erase the temperature effects, which is perhaps unfortunate for certain marine organisms including planktonic larvae.

If it applies to the upland, please identify instances where such alteration has been unfavorable to the beach and beyond. Even for riparian zones along streams effects on temperature and nutrients and the impacts of such changes have been shown to be dubious in a number of West Side studies, in some of which I was involved. The guide's authors have a burden of proof here.

The abundant inclusions of 'may', 'can', 'might', et al are vacuous.

Guide: "Riparian vegetation...influences the marine nearshore environment in ways similar to its function in freshwater environments - by stabilizing bluffs, filtering surface runoff, and providing shade, organic litter, and large wood debris" (p. II-39, 42). This theme is repeated later in the "guide": "the ecological functions provided by marine riparian areas are similar to freshwater riparian areas" (p. III-42). Response: First, in the Puget Sound area, riparian vegetation does little to 'filter surface runoff' nor even to stop it. Filtering presumably pertains to sediment flows, of which there are few beyond construction sites. It is doubtful that the authors have ever seen, much less measured, sediment filtering in vegetated buffers nor behind shoreline bulkheads. Second, organic litter is the repository of the nutrients that are important in streams but spurned in tidewater because of eutrophication tendencies. Except for a minor contribution to wrack, organic litter is brief seasonally and trivial on marine beaches. Third, the writers are invited to describe, much less quantify, the usefulness of large woody debris in a near-marine context. This dogma is borrowed from stream research about riffles and pools for stream biota. Intertidal riffles and pools are ephemeral with the tides. Too, the supply of drift logs died with log-raft towage; the ecologic impact of that loss, on site or cumulative, has not been shown.

In a July 2008 report and its annexes for Bainbridge Island's city council I dealt at length with bluff stabilizing, shade claims, and runoff filtering. That packet is available from me.

Guide: "Maintaining the diversity of these communities and continuity between them is critical to species that depend on these areas" (p. II-39). Response: Diversity yes; continuity impossible.

Again, Guide: "...highly modified areas lose habitat diversity" (p. II-44). Response: Requiring long, deep strips of native vegetation is a sure way to sameness. Meanwhile residential landscaping is sure to be diverse.

Guide: "Prior to European colonization, the Puget Sound lowlands and riparian forest communities were largely dense coniferous forests..." (p. II-40). Response: Only about 40 percent was dense (oldgrowth) coniferous forests. Burns accounted for the sparseness, and bracken ferns, not sword ferns, were the more prevalent ferns.

Guide: “Probably the most common activity that has directly impacted riparian vegetation along the shoreline is clearing” (p. II-43,44). Response: The great epoch of clearing is long gone. In the days of logging, burning, re-burning, row crops, haying, and dairying on the Island, clearing was rampant and nearly universal. Now is a time of recovery despite residential development. A trip along any shoreline reveals a horizon of treetops.

Clearing is invariably followed by vegetation here, wanted or otherwise. Bare earth is an unusual substance in these parts; witness the furor over excavation near Lynwood on the Island.

Guide: “Forest and prairie communities have developed in the rain shadow...” (p. II-40). Response: The prairie actually predated all else, part of the oak-grass savanna that remains in many places, our most native upland ecotype.

Guide: “By slowing erosion and retaining sediment, vegetation reduces pollutants...” (p. II-42). Response: Among vegetation regimes, grass will indeed slow stormwater, hence erosion and related sediment movement. But pollutants are not reduced, just retained for later disposition.

Guide: “...vegetation overhanging the intertidal zone covers less than 18% of the shoreline” (p. II-45). Response: So what?

Guide: Bluffs are vital to the presence of kelp forests and eelgrass (p. II-10). Response: There is no documented correlation between bluff geometry and kelp/eelgrass holdfasts/presence. Such an armchair analysis would be easy to conduct.

Guide: Bulkheads deter colluvium from being transported (p. II-11). Response: A study of 1308 historic landslides in Seattle indicates that slides on significant bluffs ride over bulkheads.

Guide: Shoreline armoring [bulkheads] affects the size, shape, and substrate character of the down-drift beach (p. II-11, 51). Response: A Thurston County study involving 29 pairs of bulkhead/barehead beach profile transects found no significant difference in profiles nor beach texture.

Guide: Piling attracts barnacles that “result in formation of a different beach substrate than normal, changing the character of the habitat (p. II-11). This is truly a stretch. Barnacles are vastly present in all but the highest-energy or smallest-sediment beaches. The presence of these and other organisms on piling earns them recognition as special habitats by people from Ricketts to Kozloff.

Guide: “Groins and jetties can alter...species composition” (p. II-11). Response: Where is there enduring scouring after 150 years of beach protection? Lincoln Park, West Point, and ? None was found in the Thurston County study of bulkheads, where scouring was a particular issue. Jetties are rare, and there is no showing that species have changed harmfully because of groins.

Guide: “Erosion caused by shoreline armoring...can be accelerated when the bluffs supplying sediment to that beach are armored even though those bluffs may be miles away” (p. II-13). Where is the with/without or time series data? Is there really a tradeoff between bluff erosion and beach erosion? None was found in the Thurston County study.

Guide: Sea level rise will expose more beach and bluff area to wave energy; landward migration of beaches will result (p. II-13). Response: So? How does "exposed bluff area" increase?

Guide: Forage fish are a critical prey resource for a number of species (p. II-17, 20ff). Response: I find no study showing that surf smelt are consumed by salmon. Don't know why.

Guide: "For summer spawning fish, the presence of over-hanging trees along the upper beach is important for moderating wind and sun exposure which can kill eggs" (p. II-21). Response: Only two places in the central Sound have summer spawning. Both have been bare of overhanging trees for a century yet summer-spawning fish return there, despite abundant, apparently suitable, habitat elsewhere.

Guide: "Local observations indicate that the physical extent of kelp and eelgrass beds in the Puget Sound region is in decline" (p. II-36). Response: Puget Sound Action Team says otherwise: "On a Soundwide scale, there has been no evidence of a trend in eelgrass area" and "Despite high year-to-year variability, significant [upward] trends in floating kelp are apparent..." (*2007 Puget Sound Update).*

Guide: "Shoreline modification activities (e.g., shoreline armoring, placement of over-water structures, and riparian vegetation alteration) can...[reduce] the quantity and quality of habitat available" (p. II-47, also 50). Response: It is not clear how modification degrades "food, refuge from predation, a shallow water migration corridor..." (P. II-48). Concerning the latter, I have estimated that residential docks add, on average, less than 100 feet to the 55-mile outbound trip of juvenile salmon from Sinclair Inlet to the Strait of Juan de Fuca.

Section III Regulating Shoreline Modification.

Section III is a considerable essay on the badness of overwater structures (docks mainly) (p. III-3 to 19), bulkheads (p. III-20 to 33), and riparian vegetation alteration (p. III-34 to 49), collectively termed 'shoreline modification'.

The general points are:

> Fish are prone to swim around docks and this is bad
>
> Waves bouncing off bulkheads can stir up sediments (the guide ignores the abovementioned Thurston County study)
>
> Buffers are needed to deal with shade, driftwood, wildlife, stormwater filtering, and bluff stability.

Docks

Guide: Juvenile salmon are forced into deeper waters (Table III.1 on p. III-5 and 6). Response:

In 2001, Nightingale and Simenstad wrote:

> "...findings have demonstrated that fishes responses to piers are ambiguous with some individuals passing under the dock, some pausing and going around the dock, schools breaking up upon encountering docks, and some pausing and eventually going under the dock."

Five years later Battelle, in a 10-site ferry terminal study, wrote:

> About half of the tagged fish were able to transit under the ferry terminal and were not prevented from following normal shoreline movement patterns...We cannot conclude whether fish moved under the dock or around the dock consistently during periods when light-dark contrast was not inhibiting movement;" and:
>
> "In general, greater numbers of juvenile salmonids tended to be observed adjacent to ferry terminals than under or away from the terminal although no differences in densities specific to each site were statistically significant."

Ferry-terminal fish-passage studies abound. None considers what may be a key factor in fish behavior: The rumbling of traffic across the apron, with vibrations telegraphed downward through the piling.

The badness of fish detouring around docks is ascribed either to reducing their fitness for further travel or their risk of being eaten by bigger fish. Relative to the energy expended in random crossing of Puget Sound and finally proceeding to sea, dock dodging has not been shown to be significant. See my conclusion on the previous page. Too, since a key diet item of maturing salmon is younger salmon, it is not clear that deep-water predation represents a net loss.

Guide: "...the shaded, deep-water environment under piers can create a favorable habitat for predatory fish" (p. III-3). Response: Jon Houghton, marine biologist with PENTEC, has written:

> "...there is no evidence, despite many efforts to find it, that [docks and floats] in marine waters lead to a concentration of predators on juvenile salmonids or increased vulnerability to those predators that may be present. On the other hand, areas around docks and floats are frequently used as cover or as a source of prey by schools of juvenile salmonids..."

Nightingale and Simenstad have pointed out that there is no evidence of predatory birds, marine animals, nor piscivorous fishes gathering in dock-darkened recesses awaiting prey.

Too, one can readily see schools of fingerlings scurrying, when startled, into the shelter of floats and log booms.
Guide: "Table III.1 provides a summary of the impacts of overwater structures..." (p. III-3). Response: Most of the material in this table is conjectural and in fact is not being studied except for large piers.

There are ferry-terminal studies galore. These structures are 50 to 170 feet wide and hundreds of feet long. The number of fish-impact studies of residential docks on Puget Sound appears to have been zero. We have no quantified knowledge of effects of typically narrow private docks on passing salmon nor on any other fish species.

Guide: "Docks and piers should not be located on shallowly sloped beach areas because of the large footprint required..." (p. III-9). Response: The whole point of piers is to reduce the footprint. Floats and piers support an ecosystem so remarkable that texts recognize them as special habitats.

Bulkheads

This part of Section III echoes Section II. The concerns expressed in, say, Table III.4 (p. III-23 to 24) seem to assume bulkhead types no longer emplaced: Smooth vertical concrete slabs, offset away from the bank. Riprap bulkheads, now required to be snug against the shore, are not creating the impacts recited here, and even the old kinds aren't creating mischief, at least in the studied Thurston County area. There, bulkheads haven't coarsened the beach and beach profiles haven't changed, nor is 'aquatic vegetation' distressed.

Riparian-area Vegetation (p. III-37ff)

Much of this is a reprise of part of Section II. However tables of buffer data from other studies appear on Pages III-39, 40, and 41. There is much to be said about buffers, and I've said some of it in another submission.

I've done statistical analysis on sone of May's tables that underlie page 39. There is not significant gain in effectiveness as buffers are broadened. Further, his recitations on microclimate, LWD recruitment, and water temperature are relevant only to certain freshwater habitats, not tidewater.
The same problem comes with Knutson and Naef (p. III-40). Microclimate, water temp, and LWD aren't relevant along tidewater.

In both tables, wildlife habitat does not correspond to the nesting habitat required by WDFW's priority bird species. For animals, most of Kitsap County is occupied habitat and probably always will be. We all need to get beyond 'primary association' to really critical 'obligatory' habitat.

The FEMAT Site Potential Tree Height table (p. III-40, 41) was contrived in panic fashion to meet Congressional demands for spotted-owl attention. For things like shade and microclimate there is no relevance to tidewater, and LWD is driven by other factors. We want dead trees standing, not falling. Similarly, bank stabilization is different beside tidewater from that beside streams. And the wildlife is different. There is no adjustment in the table for soil type, hence not for runoff. In any case, the FEMAT stuff is under revision.

Noncompliance and local resistance.

Page III-37 to 38 has a discussion of problems with local resistance and noncompliance, and how to sidestep the matter with 'marine riparian protected areas'. The nexus between such areas and marine habitat protection is not explained in the document despite references to Chris May, Knutson and Naef, and FEMAT. None of these reflect any tidewater studies nor a quantitative protection statement indicating how much protection is actually needed for, say, bank stabilization.

Unmentioned information.

Some nearshore problems emphasized in the "guide" may be unwarranted:

> Dependence of juvenile salmon on insects is seen as a problem in the absence of shoreside trees from which insects are said to drop. However diet studies have shown

that insects dependent on trees comprise only about 1.5 percent of those fishes' intake. One of the underlying studies was headed by Sea Grant's Jim Brennan.

Several effects of bulkheads are presumed to occur and to be problematic. These include scouring, beach lowering, steepening of the beach, and coarsening of the substrate. None of these things occurred in a 29-site study in Thurston County.

Docks are said to interfere with the out-migration of salmon. An analysis of residential docks indicates that salmon traveling 55 miles from the Gorst Creek hatchery near Bremerton to the Strait of Juan de Fuca add, on average, less than 100 feet to the journey by encountering and swimming around such docks.

Drainfields are recited as a problem by providing nitrogen to tidewater, leading to deaths of bottom fish, notably in Hood Canal. Analyses have shown that the ocean puts 400 times as much nitrogen into the Canal as could be inserted by all the septic systems there. "Corrected" septic systems will be trumped by the ocean.

An estimated 15,000 dogs in Kitsap County generate about 10,000 pounds of feces daily. Dogs are a bigger problem, apparently, than stormwater in CSOs and out-of-whack septic systems, yet the "guide" offers no solution.

The 15-year-old FEMAT recommendations are being revised. The SPTH figures for LWD recruitment along streams are clearly calling for too large a buffer: Research has shown that 70 percent of large wood in headwater streams comes from within 20 m of the stream. There are similar problems with other elements of SPTH.

Buffers along the Sound's littoral are based mostly on agricultural buffering in the Midwest and East. Feedlots and row-cropped farmland offer poor guidance to use here, where soil and climate issues raise special problems with buffers. Yet the "guide" offers no local science on the subject, no call for research here, and no call for monitoring the efficacy of existing buffers.

Unsupported proposals.

The last pages of the "guide" contain sweeping calls for regulations that are unsupported by research:

A requirement for 'vegetation conservation plans' (there is ample evidence that vegetation here is irrepressible, none that it is scant).

Off-site mitigation (presumably for imagined ecologic 'loss')

No-touch buffering (precluding owners' use of their places).

If there is consensus on buffering matters it was expressed at a Tsawwassen meeting of marine specialists, as Jim Brennan will recall. That consensus was that there is no relevant science on these subjects. This was not a call for "a precautionary approach" (p. III-42). Such an approach requires quantification of the risk and the cost of being wrong. With buffers we scarcely know the benefits, much less the range of outcomes nor their consequences, if any. Given this situation, a better approach is quite different – adaptive management. We're already down that pike with buffering in a variety of circumstances and dimensions. It remains to determine what they were for, how well they worked, and whether alternatives do better at less cost.

April 2008
November 2009

Some notes on surf smelt, their protection and role.

Surf smelt have special status in some shoreline regulations because these fish spawn on upper beaches, vulnerable there to certain kinds of structures as well as to predators and, in some times and places, to sun and wind. Their importance lies in the nearby passage of predatory salmon that, it is assumed, consume surf smelt as well as other "forage fish".

Examined here are six issues, relying on studies cited later. The questions and their short answers are:

Are surf smelt affected by shoreline conditions? *Yes. It is well established that their spawning can be vulnerable to bulkhead placement, landslides, or, in the North Sound, to sunburn.*

Are surf smelt unique among "forage fish"? *Yes, because of their beach-top spawning, their abstention from seaward migration, and their excess habitat.*

Are surf smelt important to salmon? *Probably not; when present in salmon diets they are a small share.*

Is this because there aren't enough surf smelt? *Unknown.*

Would doubling the amount of shading above nearby beaches be significant for surf smelt survival? *No. Summer spawning is rare in Kitsap County. More shade might be useful elsewhere, at specific sites not yet identified.*

Would doubling the amount of their habitat make a difference for surf smelt production? *No. There already is excess habitat. Habitat is evidently not a limiting factor.*

It is not clear that habitat in front of modern bulkheads may be eroded away.

Bulkhead opponents rather frequently state that, by discouraging low-bank erosion, bulkheads starve waterward beaches of sediments and thus of spawning substrate. A forage-fish habitat specialist has said, "...there's a lot of research yet that has to be done to prove that the beaches are deflating...It's a presumption I think that the beaches are deflated, we have some certain sites that look like they have deflated but we need more work in that region..."[1]

[1] Penttila, Daniel E. 2001. Verbal response to a question following Penttila's presentation at *2001 Puget Sound Research*, Session 2A, Fish Ecology and Biology. Proceedings published by Puget Sound Water Quality Action Team.

In Thurston County 29 pairs of transects were used to compare bulkkheaded with natural beaches.[2] Beach slopes were not significantly different between natural and bulkheaded beaches. These were relatively low-energy beaches. Concrete bulkheads were an average of 8.5 feet out from the bank, thereby occupying habitat that may or may not have been relevant to surf smelt. Whether outward placement of these bulkheads conflicts with the abovementioned rules was not stated. Only a few riprap bulkheads were sampled; they tended to be snug against the bank.

A California hydrologist, after eight years' monitoring, found "A comparison of summer and winter beach profiles on beaches with seawalls and on adjacent control beaches reveals no significant long-term effects or impacts of seawalls..." The study period included two severe winter storms.[3] The cross-shore beach profile did change and restore itself seasonally.

Hugh Shipman, a well-known coastal geologist who chaired a 2009 workshop on shoreline armoring, has remarked:

One wonders why the workshop was focused on managing shoreline armoring given the limited scientific research that has been done on the impacts of armoring on either geologic or ecologic processes, and the difficulty of applying the science that has been done elsewhere to Puget Sound given the unique aspects of our system.

One can wonder, but that's exactly what local planners and the state ... are doing throughout the Puget Sound region. They are focused on eliminating bulkheads that protect people's homes without scientifically valid proof of harm.[4]

Prof. David Finlayson has said[5], "...there has been almost no research on surface armoring of beaches under oscillatory flow, so determining what effect armoring might have on beach morphodynamics is difficult." Whether this is an issue for surf smelt is probably best gauged by whether the spawners return; apparently they do.

Bluffs may smother high-beach habitat.

Bluffs face 60 percent of Puget Sound beaches[6], of which half are called unstable[7]. With or without a bulkhead a bluff's collapse may blanket the upper beach with stones and clay for

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[2] Herrera Environmental Consultants, Inc. 2005. Herrera Environmental Consultants, Inc. 2005. Marine shoreline sediment survey and assessment - Thurston County, Washington. Seattle.

[3] Griggs, Gary B., et al. 1997. Interaction of seawalls and beaches: Eight years of field monitoring, Monterey Bay, California. University of California at Santa Cruz. Contract Report CHL-97-1. Prepared for U.S. Army Corps of Engineers. Available from U.S. Defense Technical Information Center.

[4] Shipman, Hugh. 2009. August 14 e-mail to Puget Sound Shoreline Planners.

[5] Finlayson, David. 2006. The geomorphology of Puget Sound beaches. Puget Sound Nearshore Partnership Technical Report 2006-02. Seattle: University of Washington Sea Grant Program.

[6] Johannessen, Jim and Andrea MacLennan. 2007. Beaches and bluffs of Puget Sound. Puget Sound Nearshore Partnership Technical Report 2007-04. Seattle: US Army Corps of Engineers. The authors draw this figure from two citations.

[7] Finlayson 2006, above, citing Shipman's 2004 USGS professional paper.

decades until the fallen “colluvium” disperses.[8] Even without leaning trees or stormwater saturation at the bluff’s top, natural forces like erosion and frost-heave gradually transport the aboveshore to the beachtop.[9] Without waves undercutting the slope this disintegration is a slow process. In any case, the shores of Puget Sound have been drawing back, with beach habitat in tow, since the glaciers left.[10]

Sunlight can be hard on surf smelt eggs, but it is largely a non-issue in the Central Sound, for three reasons.

Laid on or close to the surface of pea-gravel beaches, surf smelt eggs are presumably highly vulnerable during their 2-to 8-week incubation period. Predators may include crows, gulls, strolling and diving ducks, raccoons, even backshore ants. Of the eggs that remain, Penttila[11] found (in summer, across 37 study sites) average mortality of 36% on shaded habitat. A single-site study of summer spawning by Rice[12] found 50% mortality in the shade. Smelts’ are perilous pre-natal periods; these high figures occurred even though, in that season, eggs mature and larvae are out and away within a couple of weeks.

In these studies, still higher mortality occurred on unshaded beaches. The average on 37 sites was 60%; 75% in the latter 1-site study. This impact is offset, of course, or surf smelt might disappear from certain beaches. The offset factor is that each female produces between 15,000 and 20,000 eggs.[13]

One reason the shading issue has little relevance in the mid-Sound is that summer spawning was found at only two sites here: Ross Point in Sinclair Inlet and a shoreline segment in Bainbridge Island’s Eagle Harbor. Elsewhere in this area spawning happens in other seasons.[14]

Surf smelt keep right on using those high-mortality beaches...

A second reason is that surf smelt persist in spawning on beaches that are ostensibly high-mortality. For instance both Kitsap sites are largely bare of shade; both have been ‘altered’ for more than a century. Despite its exposure to natural mortality, Ross Point has supported a

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[8] I have seen such “beach plops”, in a high-energy inlet, persist for over 60 years.

[9] Johannessen, Jim and Andrea MacLennan. 2007. Above.

[10] Johannessen & MacLennan 2007 and Finlayson 2006, both above.

[11] Penttila, Daniel E. 2001. Effects of shading upland vegetation on egg survival for summer-spawning surf smelt on upper intertidal beaches in Puget Sound. 2001 Puget Sound Research. Olympia: Puget Sound Water Quality Action Team.

[12] Rice, Casimir A. 2006. Effects of shoreline modification on a northern Puget Sound beach: Microclimate and embryo mortality in surf smelt (*Hypomesus pretiosus)*. Estuaries and Coasts 29(1): 63-71.

[13] Therriault, T. W. et al. 2002. Review of surf smelt (*Hypomesus pretiosus*) biology and fisheries, with suggested management options for British Columbia. Research Document 2002-115. Nanaimo: Fisheries and Oceans Canada.

[14] Penttila 2001, above.

major smelt fishery for decades.[15] Seemingly impaired beaches are not discouraging procreating smelt.

...despite an apparent surplus of smelt spawning habitat...

A third reason for reduced concern about shade, and about surf smelt habitat welfare generally, is that, in a situation odd for gravel-spawning fish, more suitable habitat has been found in surveys than smelt have put to use. "Approximately 10 percent of the shoreline of the Puget Sound Basin is used by surf smelt for spawning habitat. Most of [the] beaches on the Puget Sound shoreline that appear outwardly suitable for surf smelt spawning habitat are apparently not used by the fish, at least to a degree where spawn can be detected by current forage fish spawning habitat survey protocols."[16] The reason is unknown.

...perhaps because a warm substrate is useful to surviving embryos.

The classroom image of green boughs, dappled shade, and cool waters soothing grateful salmon is imperiled by western-Oregon research. It shows that sun-exposed creeks can indeed kill fish when the sun is high. However the day-long warmth raises the overall net biomass of fish because (1) the fish mature faster, and size defeats many predators as well as rigors of the regime, while (2) warmth enhances production of the microorganisms on which juvenile fish feed.[17]

Whether the new paradigm applies to tidewater spawning beds is not known, although it is clear that a beach, hot at mid-day, warms the incoming tide of afternoon, and that warm weather reduces incubation time by as much as 75 percent.[18] Optimum shade has not been quantified for tidewater beaches, all of which are open to low-angle and reflected sunlight. Nor has research yet linked degrees of shade to degrees of temperature for various compass orientations of the beach.

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[15] Penttila (?) No date. Washington State surf smelt fact sheet. LaConner: Forage Fish Unit, Washington Department of Fish and Wildlife.

[16] Penttila 2007, above.

[17] For example,

Murphy, Michael L. And James D. Hall. 1982. Varied effects of clear-cut logging on predators and their haitat in small streams of the Cascade Mountains, Oregon. Canadian Jour. Of Fisheries and Aquatic Sciences

Gregory, S. V., et al. 1987. Influence of forest practices on aquatic production. In: Salo, E. O. and T. W. Cundy, eds. *Streamside management: Forestry and fishery interactions. Contribution No. 57. Seattle: University of Washington Institute of Forest Resources.*

Beschta, Robert L., et al. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interactions. In: Salo and Cundy, above.

Berg, Dean R., et al. Restoring floodplain forests . In: Montgomery, David R., et al. 2003. *Restoration of Puget Sound rivers.* Seattle: University of Washington Press.

[18] Penttila 2007, above.

Historically bulkheads have probably precluded surf smelt spawning.

Surf smelt competed badly with bulkheads for space on tidewater beaches, because spawning occurs downhill from above mean high water to about the seven-foot tidal level.[19] However, since 1974 the state Department of Fisheries has issued bulkhead placement and construction-scheduling criteria to protect surf smelt spawning zones.[20] There is no compromise with expedience in the regs. It follows that, for more than 30 years, new bulkheads have not invaded spawning places.

But not by eliminating shade.

In two recent North Sound small-scale studies, summer surf smelt egg mortality on a bulkheaded beaches was compared with mortality on an unprotected beaches.[21] In both studies bulkheaded places had higher mortality. Ignored was the fact that, in both studies, the bulkheaded places had no shoreside trees, while the unprotected places had tree-provided shade. Obviously the bulkheads were not intrusive enough to prevent spawning, and just as obviously it was the trees, not the shore protection, that mattered for shade and thus mortality.

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[19] Penttila, Dan. 2007. Marine forage fishes in Puget Sound. Puget Sound Nearshore Partnership Technical Report No. 2007-03. Seattle: Seattle District, US Army Corps of Engineers.

[20] Washington Department of Fisheries. 1974. Bulkhead criteria for surf smelt (*Hypomesus pretiosus*) spawning beaches in Puget Sound, Hood Canal, Strait of Juan de Fuca, San Juan Islands, and the Strait of Georgia. Olympia. WDF (now WDFW) had been regulating bulkhead placement since at least 1971; the 1974 rule moved bulkheads uphill.

This paper places the upper edge of spawning between MHW and MHHW, at 8 to 14 feet above MLLW, depending on location. It is given as 11 feet in the central Sound.

[21] Rice, Casimir A. 2006. Effects of shoreline modification on a northern Puget Sound beach: Microclimate and embryo mortality in surf smelt. Estuaries and Coasts 29(1):63-71; The same single-site 5-day comparison appears as a chapter in his University of Washington PhD thesis.

Tonnes, Daniel M. 2008. Ecological functions of marine riparian areas and driftwood along north Puget Sound shorelines. Master's thesis, School of Marine Affairs, University of Washington.

Is the abundance of surf smelt too great, too little, or just right?

For surf smelt, as for other forage fish, the companion question is, “For what?”

The trend in Puget Sound’s annual recreational catch of surf smelt is upward, to about 3 million pounds by 2002,[22] besides an uncertain commercial take of perhaps 100,000 pounds (about the same level as in 1995).[23] Overall about 60 million fish are caught each year.

Attention these days is mainly on the needs of salmon. Curiously, surf smelt do not appear significant in studies of salmon diets.[24] The main shore-spawning prey species of maturing and adult salmon are herring and sand lance (candlefish). Off the coast anchovies are a large factor. Why surf smelt are largely off the edge of the page is not clear.

It is equally puzzling that sand lance loom so large, given their similarity to surf smelt in size, spawning habits and prey. It has been estimated that 60 percent of juvenile Chinook diets and

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[22] Washington Department of Fish and Wildlife, reported in Puget Sound Action Team’s *2007 Puget Sound Update*. Olympia: [now Puget Sound Partnership].

[23] Washington Department of Fish and Wildlife, reported in:

Therriault, T. W. et al. 2002. Review of surf smelt (*Hypomesus pretiosus*) biology and fisheries, with suggested management options for British Columbia. Research Document 2002/115. Nanaimo: Canadian Science Advisory Secretariat, Fisheries and Oceans Canada.

Lemberg, Norm A., et al. 1997. Washington Department of Fish and Wildlife 1996 forage fish stock status report. Olympia.

[24] These reports were examined:

Fresh, Kurt L., et al. 2006. Juvenile salmon use of Sinclair Inlet, Washington in 2001 and 2002. Technical Report No. FPT 05-08. Olympia: Washington Department of Fish and Wildlife. The study included 258 inshore Chinook, 77 offshore Chinook, 41 inshore chum and 34 inshore cutthroat.

Brennan, James S., et al. 2004. Juvenile salmon composition, timing, distribution, and diet in marine nearshore waters of central Puget Sound in 2001-2002. Seattle: King County Dept of Natural Resources and Parks. A 2- season catch of 819 Chinooks, 89 cohos, and 56 cutthroat trout.

Fresh, Kurt L., et al. 1981. Food habits of Pacific salmon, baitfish, and their potential competitors and predators in the marine waters of Washington, August 1978 to September 1979. Progress Report No. 145. Olympia: Washington Department of Fisheries. 210 Chinook, 166 coho, and 287 chum were examined from nearshore habitats less than 20m deep. They ran studies elsewhere as well, and covered other fish species.

Duffy, Elisabeth J. 2003. Early marine distribution and trophic interactions of juvenile salmon in Puget Sound. Master of Science thesis. Seattle: University of Washington, School of Aquatic and Fishery Sciences. This study involved 697 Chinook, 195 coho, 292 chum, and 156 pink salmon. These figures include juveniles from nearshore and offshore (surface) captures. Her report did not include biomass findings.

Groot, C. and L. Margolis. 1991. Pacific salmon life histories. Vancouver, BC: UBC Press. A 445-page compilation of salmon science, including diets in various places and life stages.

35 percent of overall juvenile salmon diets (presumably by weight) are sand lance.[25] Perhaps it is their tendency, like herring, to ball up when attacked, making them safer individually but vulnerable in their togetherness. Perhaps there is more yield per acre of habitat. Much more, because the mileage of surf smelt habitat is almost twice as great as that of sand lance.[26]

In short, sufficiency is unclear.

[25] Washington Department of Fish and Wildlife. 1999. Washington State forage fish - sand lance. Olympia.

[26] Penttila, Daniel E. 1999. Spawning areas of the Pacific herring (*Clupea*), surf smelt (*Hypomesus*), and the Pacific sand lance (*Ammodytes*) in central Puget Sound, Washington. Manuscript report. Olympia(?): Washington Department of Fish and Wildlife.

A perspective on
Insects eaten by juvenile Puget Sound salmon.

Commonly listed among the functions and values of tidewater buffers are insects, said to fall from overhanging shoreline trees, to be eaten by young salmon and forage fish swimming close to shore. Whether that nutrition mechanism is significant or trivial relative to other sources is the general question addressed here.

Examined specifically are four issues, relying on research publications cited later. The questions and their short answers are:

Do young salmon ingest insects?

Yes. Puget Sound studies indicate that insects account for about 12 percent of juvenile salmon biomass intake. For adult salmon and forage fish the figure is near zero.

Where does the insect biomass come from?

Mostly from aquatic sources (freshwater streams and wetlands) and estuaries. Some derives from tidewater beaches. Some comes from upland vegetation. Little comes from trees.

What share of salmons' diets comes from insects dependent on trees?

Between 1 and 2 percent.

Would doubling the number of shoreside trees make a difference for young salmon?

Given the several local studies of salmon diets, a considerable science on aquatic and near-tidal insects, and clear knowledge of the insect inhabitants of marine riparian tree species, the answer appears to be 'nearly none'.

Juvenile salmon practice predation across a broad spectrum of prey.

Young salmon are avid consumers (as are many other predators) of aquatic insects as the fish hatch upstream and, growing along the way, the salmon move down toward estuaries and tidewater. In Puget Sound their diet shifts toward marine organisms and smaller fish. By adulthood, cruising in deep water, their menu comprises mostly fish, notably herring. Until then, insects will have played a steadily declining role in salmons' intake.

In a recent Sinclair Inlet study[1] kinds[2] of prey, all from the animal (versus plant) kingdom, were compiled from juvenile salmon stomachs. Over a hundred kinds were marine creatures, either connected to the bay's bottom or drifting or moving under their own power. Typical were fish eggs, shrimps and tiny shrimp-like creatures, sand fleas, pileworms, young crabs, and barnacle larvae. Remarkably, Chinook salmon ate juvenile octopuses and squid. Not surprisingly they also ate perch, bottom fish and (smaller) chum salmon.

Insects have been found in all tidewater juvenile-salmon diet studies.

Perhaps more surprising is that insects, few of which survive in saltwater, are present in the salt chuck. Yet, in Sinclair Inlet and other studied places, insects have not been rare in the fare of juvenile salmon. Arriving from various places beyond the tidal reach, they have ranged from tiny mites to hulking wasps. Rather a let-down after an octopus presumably, though some of the insects' quantities were large.

Three other Puget Sound studies have yielded published results in sufficient detail to analyze biomass consumption, a better measure of salmon welfare than numbers of creatures consumed. Biomass is what drives both energy and growth of fish.

Brennan et al (2004)[3] worked off Snohomish and King County shores, including Vashon and Maury Islands. Fresh et al (1981)[4] worked near Anderson Island in the South Sound and off Bainbridge Island. Duffy (2003)[5] collected in the Whidbey basin and the Fox Island-Steilacoom area south of the Tacoma Narrows.

In all four studies the capture sites were close to shore because the emphasis was on juveniles.[6]

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[1] Fresh, Kurt L., et al. 2006. Juvenile salmon use of Sinclair Inlet, Washington in 2001 and 2002. Technical Report No. FPT 05-08. Olympia: Washington Department of Fish and Wildlife. The study included 258 inshore Chinook, 77 offshore Chinook, 41 inshore chum and 34 inshore cutthroat.

[2] "Kinds" is meant as the biologist's "taxa". Anna Jones, James Jones, and Other Joneses comprise three taxa.

[3] Brennan, James S., et al. 2004. Juvenile salmon composition, timing, distribution, and diet in marine nearshore waters of central Puget Sound in 2001-2002. Seattle: King County Dept of Natural Resources and Parks. A 2-season catch of 819 Chinooks, 89 cohos, and 56 cutthroat trout.

[4] Fresh, Kurt L., et al. 1981. Food habits of Pacific salmon, baitfish, and their potential competitors and predators in the marine waters of Washington, August 1978 to September 1979. Progress Report No. 145. Olympia: Washington Department of Fisheries. 210 Chinook, 166 coho, and 287 chum were examined from nearshore habitats less than 20m deep. They ran studies elsewhere as well, and covered other fish species.

[5] Duffy, Elisabeth J. 2003. Early marine distribution and trophic interactions of juvenile salmon in Puget Sound. Master of Science thesis. Seattle: University of Washington, School of Aquatic and Fishery Sciences. This study involved 697 Chinook, 195 coho, 292 chum, and 156 pink salmon. These figures include juveniles from nearshore and offshore (surface) captures. Her report did not include biomass findings.

[6] Excluded from the figures are adult salmon tallied in the 1981 Fresh study. No insects were found in adults.

The weighted-average[7] insect-biomass share of the stomach biota of all young salmon examined (Chinook, coho, chum and pink) in these four studies was about 12 percent. That share ranged widely, from 0 (frequently) to 50 percent (rarely) in particular times and places.

A few kinds account for most of insects' dietary contribution.

Although 61 biologic types of insects were recognized by the analysts, and several were numerous, few of them carried much heft biomass-wise.

The significant groups are described here, including their general habitats. Together these five groups accounted for over 85 percent of the insect biomass consumed by salmon:

Ants and termites (Members of Hymenoptera and Isoptera) –- These may seem unlikely visitors to saltwater, but they outweighed every other eaten group by far, contributing 58 of the 85 percent just mentioned. Ants were prominent in Sinclair Inlet and along central Puget Sound shores.

Carpenter ants live in dead and rotted wood. Winged adults emerge from nests yearly in swarms to mate in the air; males then die. Aerial swarming echoes the mating behavior of many aquatic insects and, if trees don't interfere with wind, may explain the presence of ants afloat on tidewater.

Most ants, the workers, don't have wings. These versions are common in shoreline wrack, dissecting plant tissues and other invertebrates live and dead. Anthills and portals to underground nests are common along Puget Sound backshores. A single nest's hunting ground can reach out hundreds of yards. So unwinged ants may well come to salmon, accidentally, from the marine margin.

Brennan's group published monthly diet detail. Ants were found in Chinook taken throughout the two summers studied. This suggests wandering surface ants rather than episodic flyers.

Dampwood termites, found in Sinclair Inlet, occupy dead wood including snags, stranded drift logs, and branches in the wrack. They parallel ants with their unwinged workers and winged flyers. The winged ones emerge to fly annually at mating time. As with ants, annual swarming may bring them to the shore. Termites do not tumble from trees; in fact they have no use whatever for live trees.

Curiously, in the first of two years' assessment, the Fresh team in Sinclair Inlet found a considerable biomass of termites – more than any other prey organism except fish and worms. The next year virtually none. Yet, like ants, termites swarm every year, in late summer. Perhaps birds got'em.

Flies (Dipterans) –- Three kinds of flies were found in numbers great enough to be worth tallying, all of them well-known to fly fishermen and stream biologists.[8] They were midges, dance flies, and fungus gnats. The analysts concluded that the flies had floated downstream

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[7] Weighted by numbers of salmon examined in each study/species group.

[8] To be acknowledged, a species or group had to occur in more than 1 percent of stomachs (Fresh et al 1981) or more than .1 percent (Fresh et al 2006), or exceed occurrence, count, and biomass thresholds (Brennan et al).

into tidewater. Fungus gnats and midges are found in marine settings as well. They were about 13 percent of the insect biomass.

Saltmarsh leafhoppers and aphids (Among the Homoptera) –- Most leafhoppers, planthoppers and their cousins live and dine on land plants. Enough are aquatic that they are mentioned in texts on aquatic invertebrates. Several families were found in Sinclair Inlet. Some species are specific to streamsides and salt marshes, where they live along the margins. Others hang out on grasses just above the wrack line along marine beaches. A popular fishing fly is tied to mimic leafhoppers.

Every rose gardener deplores the earthly habits of aphids (plant lice), that suck juices from the leaves of shrubs, annuals, perennials, and trees like birches that have succulent leaves. Some are winged and may be blown about. Some live on emergent vegetation in fresh water. And some live on bay-side plants.

Aphids are one of the two groups significant to this review that are likely to have come, in mating swarms, from non-aquatic vegetation. About 3 percent of the insect biomass came from aphids.

Bark lice (Part of Psocoptera) -- Aphid-like and winged, these insects are vegetation-dependent, living on the surfaces of shrubs and trees. They feed on lichens and fungi. They were found in significant numbers and biomass in Puget Sound studies, apparently at swarm-and-mate time.[9] They are the second group that probably came from non-aquatic vegetation. About 8 percent of the insect biomass was bark lice.

Some moths and aquatic caterpillars (Lepidopterans) –- This group is huge across the Northwest. The analysts weren't able to report whether terrestrial or aquatic species were found, and there are many possibilities of both. Those found were presumably winged adults. Their larvae are famous miners and shredders of foliage, from trees to shrubs to stream vegetation. About 4 percent of the insect biomass was of these kinds.

An example of tree-based caterpillars in salmonid stomachs occurred during the 2001-03 tent caterpillar outbreak. I collected 2000 larvae (caterpillars) from one birch tree and estimated that 6000 more were too high to reach. Billions
of adults must have flown from trees and shrubs around the Sound. A handful were found in salmonid stomachs by the Brennan team. Clearly most of these terrestrial moths had business away from tidewater.

Diet proportions recited here should be considered rather general, for three reasons. They are based on biologic and environmental conditions that vary immensely over space and time. Identification of partly-digested invertebrates is not easy. And many of the numbers were reported in charts rather than tables, so some crude scaling was required.

Stream deltas, estuaries, and their marshlands may have much to do with insect supplies.

Many kinds of aquatic insects, well-known to fish, were consumed by these studies' salmon, though in small numbers in the central and lower Sound. Examples not discussed above

[9] Brennan et al 2004, and Fresh et al 2006, both above.

include many other freshwater fly families, diving wasps, water bugs, aquatic beetles, fishing spiders, and water mites.

The Sinclair Inlet analysts wondered at the low occurrence of aquatic insects, especially midges, in their part of the Sound. They reasoned that such insects favor deltas and salt marshes, scant in the Inlet.

Duffy, on the other hand, found that prey comprised mostly insects in the deltas of the Whidbey Basin, fed by three rivers carrying 60 percent of the freshwater entering Puget Sound. The combination of down-river drift and a mosaic of deltaic estuaries and marshes there may deliver multitudes of aquatic insects and board lingering salmon nicely. The researchers seem to agree that aquatic insects loom much larger than this summary suggests.

Most of the salmonids’ insect prey groups have links to fresh water...

Of 61 insect kinds found in the several studies (albeit sparsely in most cases) 42 are strongly represented among freshwater obligates: Some parts of their lives depend absolutely on streams or standing water.[10]

...While a few have ties to trees.

These are bark lice, some aphids, and certain moths. The source of bark lice is puzzling, as they are not associated with alders, firs, cedars nor our other common shoreline trees.[11] Aphids, on the other hand, are ubiquitous and could be coming from many terrestrial plants.

Moths, too, were mentioned earlier. Alders (our most abundant shoreline trees) host (rarely) a leafroller, a webworm, and a tussock moth plus (every few years) those rascally, cyclic caterpillars. Cedars attract tussock moths and a leaf tier. That’s about it for our nearshore tree-dependent moths, and moths of all venues were minor in salmon stomachs. Of the tree-related moths, only the tent caterpillar was identified in the studies.

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[10] This is a tighter criterion than the “primary association” test commonly used by naturalists. It was applied presumptively to studies’ listed taxonomic families when a family includes some non-aquatic members but the family is well-known for its aquatic siblings, as determined from the taxonomic literature. References included:

McCafferty, W. Patrick. 1998. *Aquatic Entomology*. Boston: Jones and Bartlett.

Merritt, R. W. and K. W. Cummins. 1996. *An Introduction to the Aquatic Insects of North America.* Dubuque: Kendall Hunt.

Thorp, James H. and Alan P. Covich, eds. 2001. *Ecology and Classification of North American Freshwater Invertebrates.* New York: Academic Press.

Furniss, R. L. and V. M. Carolin. 1977. *Western Forest Insects*. Miscellaneous Publication No. 1339. US Forest Service. Washington, DC: Superintendent of Documents.

[11] Furniss and Carolin, above.

Those insects most likely to be dependent on trees, aphids and bark lice, accounted for about 1½ percent of the total invertebrate biomass found in salmon stomachs.

All other eaten insects were heavily related to non-tree upland vegetation or to freshwater environments.

Herring and similar fish eaten by salmon are not insect consumers.

Predators all, salmon start young at eating other fish, even other salmon. Herring, sand lance, and surf smelt, collectively called baitfish or forage fish, up to half the lengths of attacking salmon, were found in salmon stomachs.

If insects were consumed by forage fish they would be contributing to the greater welfare of salmon. However Fresh's 1981 team netted and examined nearly 400 forage fish and reported no insects in their diets.

The key insect groups described here all have and use wings.

All these fulsome contributors to salmon nutrition have legs, which they use continually for local motion across leaf and beach surfaces and through dead-wood tunnels. With certain exceptions they also have wings, reserved for major migration, meeting and mating.

Aside from downstream drifting, aerial swarming may be insects' prime route to tidewater.

Mating and migration flights, and related swarming, may account for the seemingly spontaneous, irregular appearance of many insects, controlled by temperature and other environmental factors. That they arrive upon tidewater is presumably nocturnal mischance.

Tidewater trees do little to assist beach-related insects.

Freshwater biologists often report seeing insects falling from trees into streams or ponds below. These are mainly aquatic insects that have emerged from puberty in the water to mate in flight or on any nearby surface. Males then typically die at once, dropping back into the water. Females usually expire post-partum, in the water. Thus both sexes can be seen heading waterward.

There are some intertidal and near-tidal insects that may follow the fly-and-die protocol, including some midges, certain flies, springtails and a beetle, but none needs trees to copulate. Some of these are numerous along the shore though none provides significant biomass to salmon.

In addition to swarm-and-die there is a presumed accidental, incidental drizzle of insects from saltwater shoreline trees' foliage, or with leaves as they fall. However insects commonly associated with Puget Sound trees do not lose their grips easily.[12] And leaf fall comes in later months than salmon feeding.

Elsewhere, trees have not been essential conduits for tidewater insects.

The salmon-diet studies reviewed here do not identify specific vectors for the observed insects. However other studies have noted insect swarms blown out to sea, and the abundance of woodland insects arriving in streams adjacent to pastures and forest clearcuts. From western Oregon to southeast Alaska research has shown that clearcuts can generate more invertebrate supply in adjacent streams than does oldgrowth.

In all places where insects have been trapped beside tidal beaches, there has been a baseline catch of insects regardless of inshore vegetation. An example is an unvegetated condominium site in the Georgia Basin of B.C., which provided a low but significant census of aquatic flies.[13] In Puget Sound Sobocinski captured large numbers of insects on shorelines encumbered by bulkheads and scant vegetation.[14]

Shoreside trees may be an impediment to inshore insects heading salmon-ward.

A line of shoreside trees may be a barrier to insect swarms, trapping them inshore. The windbreak stops or slows air currents whose ability to carry insects varies with windspeed. The insects won't really care: They have no affinity for saltwater, and most die after mating in any case.

Doubling the extent of shoreside trees probably would not materially affect diets of juvenile salmon in saltwater.

The key reason for this surmise is the very low fraction of tree-obligate insects in tidewater salmonid diets. That percentage is estimated at between one and two.

This low ingestion rate occurs despite the relative abundance of wooded shores. For instance 21 percent of the shore in Sinclair Inlet, a seemingly industrial inlet, is wooded,[15] and most of the juveniles found there came down a woodland stream. Around nearby Bainbridge Island, past which Sinclair Inlet salmon swim, 27 percent of the shoreline has overhanging

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[12] Furniss and Carolin, above.

[13] Romanuk, T. N. and C. D. Levings. 2003. Associations between arthropods and the supralittoral ecotone: Dependence of aquatic and terrestrial taxa on riparian vegetation. Environmental Entomology 32(6):1343-53.

[14] Sobocinski, Kathryn L. 2003. The impact of shoreline armoring on supratidal beach fauna of central Puget Sound. Master of Science thesis. Seattle: University of Washington, School of Aquatic and Fishery Sciences.

[15] Fresh et al 2006, above, p. 70.

vegetation.[16] Yet tree insects made up only 12 percent of the insect biomass consumed by fish examined in the inlet and only about 1.7 percent of their total biomass intake.

These disparate numbers - over 20 percent of the shoreline providing only 1.7 percent of diet - suggest that trees are intrinsically low yielders of salmon welfare relative to other insect sources and other shores. An example is given by insect trap studies in Howe and Puget Sounds, the former in British Columbia.[17] Tree-dependent aphids and other Homopterans trapped were found almost exclusively along wooded shores, but they were minor in number and minuscule in biomass relative to other insects.

Further, the invertebrate beach trap studies mentioned earlier typically captured significant numbers of insects at sites close to permanent or seasonal fresh water. This was true for all insects - tree obligates, dependents on other vegetation, and of course the aquatic sorts. Curiously, freshwater presence has not been analyzed statistically as a predictive variable, but it appears to be more relevant than presence or absence of trees. If this is so, adding to the mileage of overhanging trees may do little to expand insect abundance because freshwater presence, not verdure, is likely the limiting factor.

Conclusions and Implication

While marine invertebrates and fish generally figure large in the nutrition of juvenile salmon after they reach the Sound, insects comprise a wide-ranging but overall minor share, about 12 percent. Forage fish, on which salmon rely, apparently do not eat insects. Adult salmon largely forego insects. About 88 percent of the insects consumed by young salmon apparently come from non-tree sources, mainly aquatic (stream, estuary). Of salmons' total invert biomass content, about 1 1/2 percent appears to be tree-sourced.

Several factors suggest that adding shoreline trees will not make life better for juvenile salmon. (1) the forage fish on which salmon depend ingest few if any insects; (2) juvenile salmon eat few tree-obligate insects, perhaps because, while (3) trees are already rather abundant, (4) few kinds of insects require the presence of Puget Sound's backshore trees; and in any case (5) streams and standing water rather than trees may govern the supply of insects at shoreside.

These conclusions support a statement made to Bainbridge Island's Planning Commission by a city-hired expert.[18] He said that he could not predict an increase in fishery welfare significantly greater than zero if the mileage of shoreline vegetation were doubled.

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[16] Williams, G.D., et al. 2004. Bainbridge Island nearshore habitat characterization & assessment, management strategy prioritization, and monitoring recommendations. Sequim: Battelle Memorial Institute. Table A-2.

[17] Romanuk and Levings 2003, and Sobocinski 2003, both above.

[18] Gregory D. Williams, Battelle Memorial Institute's Marine Sciences Laboratory.

Some notes on creosote and the pickled-piling paradox.

Background

Removing old creosoted piling from Puget Sound has been a State (Department of Natural Resources) program for some time. It is now a part of the “Shared Strategy for Puget Sound” administered by the “Puget Sound Partnership”. By 2007 some 2600 tons have been removed and shipped to eastern Washington at a cost of $400 to $1000 per ton.[1] The high cost of removal and the aesthetic and historic values of remnant driven piling became issues on the Island.

The creosote we know and love

Patented in 1838 for ‘pickling’ timber, creosote in the early years was heavy oil left after distilling off illuminating gas and carbolic oil (remember Lysol and carbolic acid)from coal.[2] Nowadays the resulting coal tar is re-distilled to separate lighter ‘creosote’ from heavy ‘coal tar pitch’. Like coal itself, creosote is a mix of over two hundred chemical compounds, and the mixture can be adjusted during manufacture.[3] The oily product smells bad, burns bare skin, and famously protects piling for decades from marine borers (gribbles and shipworms, aka *Limnoria* and *Bankia*).

The creosote we love to hate

Treating pilings, railroad ties, and other ground-contact wood with creosote began here in Port Madison in 1904, moving to Eagle Harbor the next year. It was written that “Large tankers arrive...with creosote oil and steamships come to load the processed piles, ties, and lumber”.[4]

Douglas fir was generally the timber of choice for piling because it resists shattering when being pounded by piledrivers. However fir is relatively hard to treat. Pressure treating results in several inches of creosote penetration into (debarked) logs, with the core unsaturated. Standards for tidewater piling treatment typically call for 10 to 20 pounds of creosote per cubic

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[1] Kaufman, Lisa. 2007. Puget Sound Initiative creosote removal. Presentation at 15th Conference for Shellfish Growers, Shelton, WA. Sponsored by Washington Sea Grant. [No proceedings]. A single treated pile could easily weigh 3/4 ton.

[2] Encyclopaedia Britannica 11th edition. 1911.

[3] From the Creosote Council’s Web site: www.creosotecouncil.com.

[4] Marriott, Elsie Frankland. 1941. *Bainbridge through bifocals*. Seattle: Gateway Printing Co.

foot of wood, which weighs 30-40 pounds pre-treatment.[5] I've estimated that 40 to 110 gallons of creosote were used per treated pile, and hundreds of thousands of poles, piling and planks were treated yearly for over 70 years. Perhaps a half-billion gallons of creosote went into the retorts. A million gallons of 'loss' may have seemed trivial at the time.

Trivial then perhaps but looming large now. It is interesting, though, that Eagle Harbor supports sensitive sea birds and, across the narrow channel from the creosote emporium, a summer spawning bed for surf smelt. Salmon spawners are seen and more are forecast in the harbor.

Creosote and cancer

Even the Creosote Council says, "The weight of evidence for creosote carcinogenicity shows that creosote and related coal tar products are clearly carcinogenic in animal skin when applied at high doses for prolonged periods of time".[6] Sixty to 80 percent of creosote is PAHs, a chemical group of which at least 8 members are EPA Priority Pollutants.[7]

However creosote plant-worker studies, some involving hundreds of people and many years of follow-up, have uncovered little cancer attributable to wood treatment with creosote. For instance, "...over the course of a working lifetime, wood treatment workers exposed to coal tar creosote as a consequence of their employment will experience no more than one additional cancer per 10,000 workers exposed, probably less, and maybe zero."[8] Nonetheless, creosote is not benign: The workers wear special clothing and creosote can be vicious to exposed skin (my personal experience).

Piling as a marine menace

Immersed in water, treated piling gives up some of its creosote. Some vaporizes from sections exposed to the sun, some sinks, some appears as a floating sheen, and some probably is consumed by bacteria. Most remains in the wood, occupying the pore spaces in wood fibers, for many years.

Meanwhile marine life intensely occupies the piles' surfaces, often within a year or two. The density of these organisms is amazing –- Brooks[9] remarks a study that found, on creosoted

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[5] Forest Products Laboratory. 1987. *Wood Handbook: Wood as an Engineering Material.* Agriculture Handbook 72. USDA Forest Service, Forest Products Laboratory.

Western Wood Products Assn. 1958. *Douglas Fir Use Book, Structural Data and Design Tables.* Portland, OR: Daily Journal of Commerce.

[6] From their Web site, above. 16 September 2007.

[7] Sinnott, Timothy J. 2000. Assessment of the risks to aquatic life from the use of pressure treated wood in water. Albany(?): New York State Department of Environmental Conservation.

[8] Creosote Council, above, "Creosote and health".

[9] Brooks, Kenneth M. [n.d.] Creosote treated piling - perceptions versus reality. Creosote Council. www.creosotecouncil.com/PugetSoundCreosoteReport.pdf

piling, 124 species of invertebrates with over 31,000 animals per square meter. So common is the invert coverage that piling has been recognized as a distinct marine ecosystem.[10]

The sheen

Sinnott[11] says, “A thin film or sheen frequently appears on the surface of the water around a creosote-treated wood structure immediately after the structure is put in place. The sheen results from low quantities of volatile PAHs leaching from the wood....The presence of a sheen, however, is not indicative of the presence of contaminants from creosote treated wood in the water column under the sheen...Because the PAHs are volatile they evaporate from the water quickly and are degraded in the atmosphere.” For example, the half-life of naphthalene, a major component of the sheen, is about 5 hours in the heat of summer.[12]

Creosote in the water column

There is no question that some creosote PAH leaches from piling, for some months after installation. Little of it remains sloshing about in the water, for several related reasons. Creosote products don’t dissolve easily in saltwater, creosote is slightly heavier than saltwater, the lighter (low molecular weight) components evaporate, and the heavier fractions settle to the bottom as particles.[13] A joint USDA/EPA team said, “no documented reports of environmental harm from creosote treated wood used in water could be found.”[14] This because “...very small quantities of PAHs were released, and those same quantities were rapidly removed from the water column.”

“The major source of PAHs in water is atmospheric deposition of particulates from combustion sources, including natural sources such as forest fires, and urban runoff.”[15] Brooks[16] concurs, adding that “Petroleum spills overwhelm all other sources in magnitude...”

In San Diego Bay, with its warm water, low current speeds and high water density, PAHs were found to persist in the water column, at least long enough to reveal measurable trends upward

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[10] Ricketts, Edward F., et al. 1939, 1985. *Between Pacific Tides*. Stanford, CA: Stanford University Press.

Kozloff, Eugene N. 1973, 1993. *Seashore Life of the Northern Pacific Coast.* Seattle: University of Washington Press.

[11] Assessments of the risks..., above.

[12] Sinnott 2000, above.

[13] Sinnott 2000, above.

[14] USDA 1980. *The Biologic and Economic Assessment of Pentachlorophenol, Inorganic Arsenicals, and Creosote, Vol 1: Wood Preservatives.* Technical Bulletin 165 8-1. US Department of Agriculture. Cited in Sinnott 2000, above.

[15] Sinnott 2000 again, citing two research compilations.

[16] Brooks, Kenneth M. 1997. Literature review, computer model and assessment of the potential environmental risks associated with creosote treated wood products used in aquatic environments. Port Townsend, WA: Aquatic Environmental Sciences. Also at www.wwpinstitute.org.

then downward during the 1990s. The reduction was attributed to bilge water capture and removal of half the piling at a naval station.[17]

The sediment situation

That some fraction of some members of the PAHs bleed from newly treated piles for awhile and descend to the beach is known. How much, for how long, how far, and so what are key questions. This discussion is based on Sinnott and the two Brooks papers.

The 'so what' appears to be that, whatever their source, those heavy PAHs are indubitably acutely toxic to bay bottom life. In and on the sediments around treated piles, whether close together as at the old Fort Ward pier or widely spaced, studies have found PAHs close to the piles, mostly within a foot. Their amount depends mostly on currents and the sediments' oxygen content (which meters the rate of PAH's breakdown). In conditions typical of Puget Sound and the Georgia Basin, the near-piling level of PAHs can be expected to peak 700 to 1000 days after installation, followed by decline. In a low-current situation PAH levels can be expect to drop to nil within 5 to 10 meters. All this from Brooks' model, based on data assembled from many sources.[18]

The pickled-piling paradox

The work by Brooks, a long-time analyst of such things, shows that marine animals crowd onto and around treated piling. The piles teem with barnacles, mussels, anemones, worms, and seastars. Crabs and fish cruise the perimeter. Worms, amphipods, and other invertebrates live on and next to the piling. At Forts Ward and Worden "the density of life was nearly eight times that found in pristine Pacific Northwest sediments."[19]

How can this be? First, all those creatures settle in aboard the piles as, fairly quickly, the outer quarter-inch or so of creosote is shed. Next, these animals flourish, producing new and crowding out old members of the community. Third, waste products from the living animals and carcasses of the old sink to the sediments below where, fourth, they are dined upon by the benthic bunch. For them there is an abundant free lunch.

As Brooks told Islanders years ago, reality differs from perceptions.[20]

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[17] Katz, C. N. 1998. Seawater polynuclear aromatic hydrocarbons and copper in San Diego Bay. Technical Report 1768. San Diego: U.S. Navy Space and Naval Warfare Systems Center.

[18] Brooks 1997, above.

[19] Brooks n.d., above.

[20] Elfendahl, Jerry. 2007. Questions that we ought to ask about creosote. *Bainbridge Review* 15 September 2007.

September 2009

A (long) perspective on bulkheads.

In Summary:

The present state of Puget Sound's shore is the sum of myriad small biologic and physical disasters across several millennia. Beaches and their biota have washed away, waves and currents have etched the banks, backshores have collapsed, burying intertidal habitats and carrying upshore habitats to oblivion. Every shoreline reach has been pummeled.

People and their defenses are numerous beside Puget Sound. Repeating practices from around the world, many shore residents have installed protective shields against bank erosion.

Nine persistent apprehensions about residential bulkheads are examined. For most there remains a dearth of impact discovery and measurement. Of the nine concerns eight appear to be resolved by current rules and practice that put shore protection tightly against banks. Harm from the other matter, retarded downdrift sediment, (a, below) is strangely unsupported by quantitative research.

Puget Sound's beach history is short geologically.

5000 years ago, "...much of [Puget Sound's] coastal terrain was probably smooth and rounded like the present upland areas of the central Puget lowlands."[1] Shoreline erosion, and beaches as we know them, were just beginning. Sandspits and other tidewater erosion artifacts were yet to come.

The great change agent is erosion that in time will move whole hills and mountains into the ever-shallower Sound. Downing[2] indicates that major rivers yield about 3.5 million tons of sediment to the Sound annually, while about 3 million tons comes from beach and bluff erosion. He mentions an estimate that 90 percent of the river sediments don't linger on beaches, presumably going directly to the depths. Unstated are the share of bluff sediments that also proceed directly to the deep, and the role of the Sound's myriad small ravine-fed creeks[3] with their seasonal discharge.

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[1] Downing, John. 1983. *The Coast of Puget Sound, Its Processes and development*. Washington Sea Grant. p. 53.

[2] Downing, 1983, above, p. 54.

[3] Finlayson, David. 2006. *The geomorphology of Puget Sound beaches*. Puget Sound Nearshore Partnership Report 2006-02. Seattle: Washington Sea Grant. p. 5, 7.

There are nearly 300 in Kitsap County alone and over 2000 around the Sound that have 'natural outfalls'. In: Carmichael, Robyn, et al. (Date unk) Public stormwater outfalls to Puget Sound. Seattle: People for Puget Sound. http://pugetsound.org/programs/policy/stormwater.

Erosion next to the Sound is more than a gentle shedding of weathered strata. Collapse of tall shores is profound and largely unpredictable as to specific site and timing. Bluff failure is typically caused by joint action of saturated upper slopes and undercutting of the toe.[4] Erosion at the toe sets up a bank for collapse, with rain saturation at the top a common trigger. A 2007 analysis of 1308 Seattle landslides, spanning a century, confirms this observation.[5] Over five millennia, 60 percent of Puget Sound's margin has been converted to bluffs from gentle slopes.[6] Concurrently at least that many beaches have been dismantled by natural forces and rebuilt shoreward.

Stormwater management policies address the saturation problem and are not mentioned here, beyond remarking that shore-top vegetative buffering is not a palliative for saturation here for several reasons.[7]

The other great force affecting bluffs and beaches is wind, especially storm winds that drive waves against the shore. Hence toe erosion. Thence bulkheads.

Shoreline defense has been around for those five millennia.

But not here. Shoreline protection has been installed along rivers and tidal shores for several thousand years. Some of the great engineering feats in Mesopotamia and Egypt related to guiding waters and securing shores, as much as 5000 years ago.

150 years largely bracket the time of shoreline alteration and protection around the Sound. Shoreline alteration of some kind has come to most beaches, even parks. Even in my memory every shoreline cabin or farm had a boat and a backshore place to put it. Trails and stairs to the beach let folks cut up drift logs for firewood and gather shellfish. Livestock grazed as close to the beach as they could get. Miles of dikes were installed to support oyster culture. Fish canneries, docks and mills were supported on piles but tied to bulkheads.

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[4] As do:

Terich, Thomas A. 1987. *Living with the shore of Puget Sound and the Georgia Strait.* Durham, NC: Duke University Press. p. 8 et al.

Burns, Robert. 1985. *The shape and form of Puget Sound.* Seattle: Washington Sea Grant. p. 77.

Shipman, Hugh. 2001. *Coastal landsliding on Puget Sound: A review of landslides occurring between 1996 and 1999*. p. 6 ff.

Johannessen, Jim and Andrea MacLennan. 2007. *Beaches and bluffs of Puget Sound.* Puget Sound Nearshore Partnership Report 2007-04. Seattle: US Army Corps of Engineers. p. 10.

[5] Schulz, William H. Landslide susceptibility revealed by LIDAR imagery and historical records, Seattle, Washington. Engineering Geology 89:67-87.

[6] Johannessen and MacLennan, 2007, p. 8, citing two sources.

[7] The reasons include hard and/or prolonged winter rains, winter dormancy of vegetation that precludes evapotranspiration, summers that are rainless when the vegetation is ready, glacial tills (hardpan soils) that trap water above the hardpan and channel it toward the shore, and root systems that are dense above those soils and further saturate the buffer. I can provide papers on these subjects.

It is said that about a third of Puget Sound currently has bulkheads.[8] On Bainbridge Island the fraction is estimated at one half.[9] Whether this is too many — or too few — is hard to perceive.

Shoreline residents do not install bulkheads casually. They are expensive and not so charming as to be shown off obliquely at garden parties. Still, the one-storm capture of several feet of a low-bank yard can be as ominous as a voluminous beach plop caused by undercutting of a high bank's toe. A 10-foot bank seems far less likely to cause mischief than a 40-foot bank. But over decades toe erosion of, say, 6 inches per year on any exposed beach will do the same horizontal gnawing of the upland.

Bulkheads are the common protection against toe erosion (and sweeping away of whole low banks in extreme storms). In times past some bulkheads were placed well out on the beach to create dry upland. That practice is now outlawed; bulkheads are placed above the high-water line.[10]

Experience has also shown that landslides descending upon an inshore bulkhead can override the barrier and plop onto the beach.[11] Remarkably, success rates for bulkheads in various circumstances have not been reported. However occasional failures of (mostly undermined concrete) bulkheads have been given wide notice.[12]

Nine Concerns Have Been Raised About Bulkheads

These have appeared singly or in groups in the popular ecology press. They were displayed together in a 1994 review of their validity[13] and can be seen in even the Puget Sound Partnership's presumably learned Action Agenda[14]. So they deserve review in light of whatever new research has emerged.

(a) By eliminating undercutting of the bank and discouraging collapse of 'feeder bluffs', bulkheads rob down-drift beaches of sediments, which

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[8] State of Washington, Puget Sound Action Team. 2008. *Puget Sound Action Agenda*. Olympia. p. 21.

[9] Williams, Gregory D., et al. 2004. *Bainbridge Island Nearshore Habitat Characterization & Assessment...* Sequim: Battelle Memorial Institute. p. 1.

[10] In the State's hydraulic code: WAC 220-10-050. The code uses "ordinary high water line", defined in RCW 90.58.030(2)(b) as either the line of vegetation or the line of mean higher high tide. This is discussed by Macdonald et al, 1994, below, at p. 2-2.

[11] Shipman, Hugh, 2004. Coastal bluffs and sea cliffs on Puget Sound, Washington. In: Hampton, M. A. And G. B. Griggs, eds. *Formation, Evolution, and Stability of Coastal Cliffs - Status and Trends.* Professional Paper 1693. Denver: US Geological Survey, p. 92.

[12] Macdonald et al, 1994, below, Sec. 4; Terich, 1987, above.

[13] Macdonald, Keith, et al. 1994. *Shoreline armoring effects on physical coastal processes in Puget Sound, Washington.* Seattle: CH2M Hill. Distributed by Washington Dept of Ecology, Olympia, as Report 94-78, Coastal Erosion Management Studies Volume 5, p. 3-2.

Paired with Downing, above, the pub remains an excellent non-mathematical source on beach dynamics.

[14] Puget Sound Partnership, 2008.

(b) Lowers the level of the beach,

(c) Leaving behind only bigger rocks, thus 'coarsening' the beach,

(d) Increasing turbidity and thus releasing sediment-tied nutrients and pollutants,

(e) By occupying beach space bulkheads preempt *lebensraum* for passing fish and upper-beach marine life,

(f) While altering lower-beach habitat,

(g) And displacing washed-in algae and its companions (wrack),

(h) After the beach is disrupted by equipment access,

(i) Meanwhile hindering backshore and above-bank vegetation.

Some of these concerns relate to early bulkheads placed in the intertidal zone to increase upland area. As mentioned earlier, modern bulkheads, by law, are installed snug against the bank, above MHHW.

Concern (a) Downdrift sediment reduction and its impacts

Although bulkheads are interesting ecosystems, the key reason for their existence is to absorb and diminish wave energy that drives substrate flux. Read erosion of banks' toes. Deflected waves move sediment; more without than with bulkheads of course.

The surfaces of about 4/5 of Puget Sound beaches, with and without bulkheads, are moving slowly, carried by currents and wind-driven waves.[15] Some sands and small gravels move outward to deep water; some move laterally. Lateral movement has received the most attention. Its speed varies mostly with 'fetch' (wind exposure) and beach length. It is considered good for bringing sediments to 'sinks' and for covering areas shorn of sediments; and bad for generating the shorn places. These beaches have a low donor end and a high sink end.

Drift reaches have been mapped. There are at least 230 Puget Sound transit-neutral beaches that have not budged for decades. However there are 860 places where sediment is clearly in motion along the beach.[16] Like bluff failures and toe erosion, drift is mostly a storm-driven winter activity. It is a slow business and untidy. The insertion of bluff sediments into the beach procession is rather like hippopotami mating - episodic, impulsive, ponderous, with thumps, bumps, and scattered piles of detritus.

Downwind drift takes decades to make a difference in most settings, depending on the beach's profile, fetch (the distance over which waves build up), the length of the beach, its composition,

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[15] Johannessen & McLennan, 2007, p. 5.

[16] Ibid, p. 5, citing Schwartz, M. I., et al. 1981. *Net shore-drift in Washington State: Shorelands and Coastal Zone Management Program.* Olympia: Dept of Ecology.

the sink's buildup, and of course the donor bluffs' height and fragility.[17] I have estimated that 60 percent of the variance in alongshore sediment movement rates is explained by fetch and drift-cell length.[18] That leaves only 40 percent to be explained by bulkhead existence or placement, bluff geometry, sediment sizes, beach profiles and other known drivers of beach dynamics. Individually these factors, including bulkheads, may be relatively unimportant in the greater scheme of things.

There is a rather simple concept of (unprotected) bluffs distributed above the beach contributing sediments at a steady rate, replacing intertidal sands and gravels in a proper proportion to maintain stable beach profiles and magically maintaining the right texture and depth for intertidal biota without burying creature comforts. The biota include beach hoppers, forage-fish spawners, and the multitudes of tiny creatures (hundreds of species with thousands of members per square foot) just below the surface of sandy and muddy beaches.

With or without bulkheads, most Puget Sound beaches do not conform to the model. For one thing, descent of the "right" sizes and amounts of sediments from banks and bluffs depends of course on what's up there, how much comes down, and when. Too much sediment buries beach habitat, often for scores of years.[19]

In general, incoming sediments do not keep up with drift. The result is steeper, less-sandy beaches than would occur with abundant supply.[20]

The research literature does not reveal the 'right' sediment yield, nor the best schedule for bluff failures, nor how to achieve them. Angst focuses on protected sediment-source banks and bluffs, implying that there is never a problem with *too much* sediment. Yet, "Human impacts on kelps probably consist largely of processes that increase sedimentation in shallow waters."[21] Too, there can be too much sediment for eelgrass welfare.[22]

Clearly bulkheads succeed in their primary mission of impeding toe erosion and thus sediment mobility from behind and above. It is clear also that high bluffs round down over time, ravelling or careening over shore protection and plopping onto the beach. However there seem to be no numbers whatever on the effect of bank protection on beach sediment supplies and longshore beach dynamics. And no data is reported on the shrinkage of down-drift spits or other features affected by residential shore protection.
A recent synthesis report says, "Although the cumulative impacts to the coastal geomorphic system and nearshore habitats resulting from severe anthropogenic loss of sediment supply

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[17] Macdonald, et al. 1994, Sections 2 and 4.

[18] Using data in Macdonald et al, 1994, at p. 3-25; he cites:

Schwartz, Maurice L., et al. 1989. Net shore-drift in Puget Sound. *Engineering Geology in Washington, Volume II.* Bulletin 78. Washington Division of Geology and Earth Resources, pp. 1137-46.

[19] Author's observations over 60 years.

[20] Macdonald et al, 1994, p. 2-4; 2-13.

[21] Mumford, Thomas F, Jr. 2007. Kelp and eelgrass in Puget Sound. Puget Sound Nearshore Partnership Technical Report 2007-05. Seattle: US Army Corps of Engineers. pp. v, 21.

[22] Mumford, 2007, p. 13.

are unknown, impacts are likely to be substantial and pervasive."[23] In other words, "There must be a problem here somewhere. We looked but couldn't find it."

About (b) beach profile impacts,

During at least recent centuries the Sound has been swashing its way into the land at rates between 2 and 8 inches per year.[24]

Virtually all Puget Sound beaches are concave upward: They are steeper at the top than farther down.[25] This regardless of their position on the drift zone. These separate slopes vary considerably. A study of 23 beaches found upper beaches' slopes varying by a factor of ten; the same for lower slopes.[26] Of course slope is irrelevant for isolated beach plops whose bulges on the beach may endure for years.

No geologist has suggested the 'right' nor 'best' beach profile. Nor the 'appropriate' beach elevation; interesting questions considering that an active drift beach has both high and low ends. In any case, the beach migrates inland as bluffs and banks recede. On an actively eroding, unprotected shoreline a place that is a foot underwater at high tide will be farther under eventually. If, for example, over a decade a bluff recedes 4 inches annually and the slope of the upper beach is .10, the beach profile will have moved 40 inches and dropped 4 inches. At that rate, on a natural beach, any spawning patches for forage fish will have been swept away every year.[27] Perhaps their salvation lies in some of the spawning gravels being pushed uphill rather than rolled away in the longshore drift. The literature doesn't help here.

Do unprotected *low*-bank beaches move inland faster than those with *high* banks? Perhaps. Over time, assuming the same amount of wave energy, low banks drop less material to interrupt toe erosion. However faster landward movement of the beach face means more material moves off the lower parts of the beach profile, offshore or longshore. This narrows the difference in dispersal of dislodged sediments and exposure of the banks' toes. Visual evidence is complicated by the possibility that jutting, tall headlands may be the remnants of

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[23] Johannessen and MacLennan, 2007, p. 14.

[24] Macdonald, 1994, p. 2-26 and 27, citing Keeler, R. F. Map showing coastal erosion...in the Port Townsend...Quadrangle, Puget Sound Region, Map 1199-E. Reston, VA: US Geological Survey (4 inches per year in central Puget Sound); quoting Shipman, Hugh, 1993. Shoreline erosion rates. Coastal Erosion Bulletin No. 2, p. 3. Olympia: Dept of Ecology ("on less exposed shorelines,...much less than 4 inches per year). Also:

Jones, Leland B. 2003. Puget Sound shoreline erosion and erosion control. [Report to City of Bainbridge Island.] Bainbridge Island. (6 inches per year on the east side of Bainbridge Island).

Shipman, Hugh, 2004, above. ("...a few centimeters a year, or less, in most areas"). The basis for this latter estimate is not given.

[25] Finlayson, 2006, p. 29ff.

[26] Finlayson, 2006, p. 32.

[27] Surf smelt spawn directly onto the surface, with some eggs jogged by currents into spaces among the fine gravels; candlefish (sand lance) leave their eggs in shallow surface depressions. Penttila, Dan. 2007. Marine forage fish in Puget Sound. Technical Report 2007-03. Published for Puget Sound Nearshore Partnership in Seattle by US Army Corps of Engineers.

tall ridges of millennia ago, with low banks between having always curved inland. It is even more interesting considering the many (300-plus) beaches where sediment does not move. The Puget Sound literature seems silent on this whole matter.

With bulkheads landward of MHHW "...the structure will in general not cause narrowing of the fronting beach."[28] This in places where the water table is not elevated in front of the bulkhead, a condition that seems unlikely on our relatively steep Puget Sound beaches.

Also, "Only armoring that continually interacts with waves and sediment can cause permanent profile lowering. In areas of coarse beach material (not capable of maintaining an elevated water table) armoring must be positioned waterward of OHW [≈MHHW] to influence the beach in that way."[29] Many Puget Sound beaches are coarse; see (c).

Scouring connotes turbulence-caused scooping of the beach at any beach level but usually refers to wave momentum reflected downward at the face of a bulkhead or bank. It also alludes to the beach-top washing away of just smaller sediments, leaving cobbles. The common dynamic here is erosion at the toe of the bank or bulkhead.[30]

A recent study of bulkhead effects on Thurston County beaches[31] involved 29 paired comparisons of bulkheaded with unprotected shores. No scouring was found, and no statistically significant difference in beach profiles in front of bulkheaded versus bareheaded shores.

The most recent assessment may be by Finlayson[32], "...there has been almost no research on surface armoring of beaches under oscillatory flow, so determining what effect armoring might have on beach morphodynamics is difficult."

The effects of even massive bulkhead projects on beach levels are apparently uncertain, as at Steilacoom's Sunnyside Beach and Seattle's Lincoln Park; both have miles of offshore exposure (fetch).[33] A researcher seems to cap the shoreline-geometry discussion with, "The 'anything-that's-not-natural-is-not-good' argument of some geomorphologists is inconsistent with the historical and philosophical basis that drives humans to improve their living conditions."[34]

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[28] Macdonald et al, 1994, p. 4-17.

[29] Macdonald et al, 1994, p. 4-28. The paper explains that OHW (Ordinary High Water) tends to be used interchangeably with MHHW (Mean Higher High Water), which is not to be confused with MHW (Mean High Water). Helpful, eh?

[30] Downing, 1983, p. 108.

[31] Herrera Environmental Consultants. 2005. Marine shoreline sediment survey and assessment, Thurston County, Washington. Seattle.

[32] Finlayson, 2006, p. vi.

[33] Macdonald et al, 1994, pp. 5-12 and 5-24,31.

[34] Macdonald et al, 1994, p. 4-19.

Coarse beaches (c) are commonly seen around the Sound. 26 years ago, Downing[35] said, “The most prevalent coastal landforms to evolve from the last glaciation are the coarse sand and gravel beaches and high bluffs so common along the shores of Puget Sound.” Macdonald echoed that: “The morphology of much of Puget Sound’s shoreline is that of a narrow beach fronting steep shore bluffs...The high tide beach has a steep face and is composed of coarse sediment.”[36] “Coarse” generally refers to cobble, i.e. stones of about fist size,[37] known for spraining the ankles of beach walkers while harboring some key intertidal inhabitants.

Cobbled upper beaches can readily be found in front of bulkheads, and in front of unprotected shores as well. Their development is fairly clear: The interplay of waves and currents carries away smaller sediments but isn’t strong enough to make the bigger stones travel.[38] There are variations on this theme, with some cobble moving sometimes but not as actively as smaller stuff. There are places where, by some mechanism, large round cobbles have been pushed into piles without any apparent sorting away of smaller sediments.[39] The upper beach is especially susceptible because there are more high tides than low, and because the uprush of waves is stronger than the downrush.[40] “The most important ramification of this...is the definition of a narrow high-tide corridor where wave energy is concentrated and sediment transport is most active.”[41] One can interpret the literature as saying that cobble drives beach steepness, while steepness uncovers the cobble.

Do bulkheads encourage cobble? As with beach erosion generally, it can be increased by wave energy diverted downward at a bulkhead’s face, *if* the bulkhead is reflective and below the high-tide line. I know of no studies measuring cobble volumes relative to the many factors involved. Is cobble bad? It can be seen as a distinct ecosystem (as is riprap, by the way), neither good nor bad in the large scheme of things. However, once exposed, cobble helps capture and hold smaller sediments.[42]

Turbidity (d) is the constant companion of waves crossing the beach.

Turbidity (suspended sediment) is essential to beach nourishment and longshore beach movement, considered desirable. The choices presumed by this issue are at the beach’s top, between a bank and a bulkhead, either of which generates turbulence, hence sediment erosion, hence transport of nutrients and pollutants if they are attached to sediment. Phosphorus, a nutrient, is an example.

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[35] Downing, 1983, p. 4.

[36] Macdonald et al, 1994, p. 2-20.

[37] Downing, 1983, puts cobble in the diameter range of 2.5 to 10 inches, at p. 55.

[38] Finlayson, 2006, p. 40.

[39] Some sites are near the mouths of the Skokomish and Nisqually Rivers and at Rolling Bay on Bainbridge Island.

[40] Finlayson, 2006, p. 24.

[41] Finlayson, 2006, p. 42.

[42] Finlayson, 2006, p. 41; Downing, 1983, p. 57.

Bulkhead observations have shown that riprap reflects less energy downward than smooth concrete bulkheads, and any bulkhead above the high-tide line is fairly harmless relative to the beach.[43] So, if sediment-borne nutrients and/or pollutants are an on-site concern, a beach-top riprap bulkhead will presumably restrain upshore sediments with, relative to a vertical shore, tamed turbidity.

Occupation of upper-beach habitat (e) is an issue readily surmised from aerial images of beaches with bulkheads imposed well out from the backshore. These are from another time, and they tend to fail sooner than bank-hugging structures.

How many, how far, how soon, and so what are interesting questions.

The concern for upper-beach habitat centers mostly on spawning places for forage fish, particularly sand lance and surf smelt. However, for surf smelt, there is said to be a surplus of habitat. This means that many beach reaches with characteristics seemingly right for the fish are unused.[44] The reason is unknown.

Removing protruding bulkheads is sometimes touted. This seems to beg the question of beach smothering by subsequent bluff failures. And most Puget Sound beaches are below steep slopes.

An inventory of beach habitats on Bainbridge Island has shown that about half of the habitat suitable for sandlance spawning is in front of bulkheads. The figure for surf smelt is almost three-fourths.[45] This does not mean that bulkheads are good for spawning. However given that many bulkheads have been in place for decades, and some beaches heavily protected for more than a century, it suggests that bulkheads may not be vile.

Lower-beach habitat degradation (f) associated with bulkheads is more likely habitat change. This issue starts with the presumption that a bulkhead will effectively forestall beach plops to a wave-active beach, and that this will cause a decline in the beach profile, perhaps to a hardpan layer. First, this is unlikely at the accretion end of the drift zone and of course isn't relevant to non-drift reaches. Second, there is no documented reason to believe that, on *unprotected* beaches, sediment contributions from banks and bluffs keep up with their sweeping away by storms and currents. Third, even hardpan has its biota.[46]

Open sand would erode to mixed-course sand, gravel, hardpan, and finally, bedrock. This would mean a shift from an assemblage dominated by small crustacea (harpacticoid copepods, amphipods) at higher elevations and eelgrass...in the lower intertidal zone; through

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[43] Macdonald again, p. 4-36 et al.

[44] Penttila, Dan. 2007. Marine forage fishes in Puget Sound. Puget Sound Nearshore Partnership Technical Report 2007-03. Seattle: US Army Corps of Engineers, p. 8 ff.

[45] Williams, Gregory D., et al. 2004. *Bainbridge Island Nearshore Habitat Characterization & Assessment, Management Strategy Prioritization, and Monitoring Recommendations.* Sequim: Battelle Memorial Institute. Various maps.

[46] Thom, Ronald M. and David K. Shreffler. 1994. *Shoreline armoring effects on coastal ecology and biological resources in Puget Sound, Washington*, Volume 7 in Coastal Erosion Management Studies. Olympia: Dept of Ecology. p. 2-3.

an *Ulva* [sea lettuce]-hardshell bivalve habitat; to one containing primarily crustaceans such as isopods and larger amphipods; to barnacles and rock-boring bivalves; and finally to barnacles and seaweed.[47]

...a mix of sand and gravel would change from an assemblage of small crustacea, bivalves, and eelgrass to rocky/hardpan communities composed of barnacles, seaweed, and other associated flora and fauna.[48]

So there is certainly a change in the ecosystem at those sites. Its extent is, curiously, not estimated in the King County shoreline assessment mentioned nor in a Thurston County study of bulkhead effects[49]. Hardpan exposure is not even mentioned among 36 kinds of data in a shoreline assessment for Bainbridge Island.[50] It is a local change in a perennial landscape of change as bluffs retreat and beaches slide landward. And the replacement organisms all are useful prey for other marine creatures.

Bulkheads were indicted in two studies in which traps were set to catch insects and other arthropods on upper beaches that have, versus have not, bulkheads.[51] Bulkheaded sites had no trees, and produced fewer invertebrates. However in one study the results were compromised by differential placement of the traps relative to the shore, and in both studies findings were confounded by the presence of standing and flowing fresh water in the non-bulkhead places; water and riparian vegetation were sure to produce inverts.[52] It was interesting too that even the bulkheaded sites received substantial numbers of insects and their cousins.

Another study[53] looked at benthic fauna (critters within the beach) in the intertidal area below bulkheads set above mean high water, comparing them with sites at the same level on beaches lacking bulkheads. 52 samples were taken around Puget Sound, with varied vegetation situations. There was no significant difference in biota between bulkheaded and bareheaded

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[47] Thom and Shreffler, 1994, p. 4-7.

[48] Williams, Thom, Brennan, et al. 2001. *State of the nearshore ecosystem: Eastern shore of central Puget Sound, including Vashon and Maury Islands.* Prepared for King County Department of Natural Resources. p. 10-4.

[49] Herrera Environmental Consultants, 2005, above.

[50] Williams et al, 2004, above, p. 10ff.

[51] Sobocinski, Kathryn L. 2003. The impact of shoreline armoring on supratidal beach fauna of central Puget Sound. Master's thesis, School of Aquatic and Fishery Sciences, University of Washington.

Romanuk, Tamara N. and Colin D. Levings. 2003. Associations between arthropods and the supralittoral ecotone: Dependence of aquatic and terrestrial taxa on riparian vegetation. Environmental Entomology 32(6):1343-1353.

[52] See my 2007 analytical paper, "A perspective on insects eaten by juvenile Puget Sound salmon", 10 p.

[53] Conducted and reported by Sobocinski in her 2003 MS thesis, above.

beaches.[54] This was confirmed in a study mentioned earlier,[55] in which there was no difference in the number of subsurface macroinvertebrates (worms, beetles, beachhoppers, et al) between ‘altered’ and ‘natural’ beaches’.

Sediment displacement, or lack of it, to the benefit of kelp, eelgrass, and other seaweeds may be a zero-sum exchange, depending on how the matter of the right amount of substrate needed is resolved someday.[56] Shellfish endure the same uncontrollable variance in substrate conditions. Bluff failure can cause major sediment overload problems where shellfish is farmed or growing naturally.[57]

And there is no way to adjust ‘feeder bluffs’ to feed just the right amount to drift in the right direction in the right amounts at the right tides during the right winds to suitably succor eelgrass substrate without overdoing it. Too, recent research indicates that water temperature can be more critical to eelgrass than sediment flows in some venues.[58]

On Bainbridge Island the mileage of eelgrass exceeds by half the extent of herring spawning. Given that herring prefer eelgrass as egg-laying sites, is this a case of too much eelgrass, too few herring, or something else? The literature does not say. It does not seem to signal a scarcity of eelgrass, a conclusion supported by surveys elsewhere in the Sound.[59]

About wrack (g), the upper-beach line of decaying seaweed, leaves, kelp, and general drift debris, smelly at times, is haven to certain amphipods (beachhoppers)[60] consumed occasionally by passing fish[61].

Whether there is a need for or sufficiency of leaves in the leaf-shedding season is unknown and unexamined. Fall may not be a needful time for more soggy plant tissue considering this is also

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[54] Sobocinski, 2003, above, p. 59.

[55] Tonnes, Daniel M. 2008. Ecological functions of marine riparian areas and driftwood along north Puget Sound shorelines. Master’s thesis, School of Marine Affairs, University of Washington. pp. 11, 24-5, Fig. 1.8.

[56] Thom and Shreffler, 1994, above, p. 6-16.

[57] Personal experiences.

[58] Schanz, Anja, et al. 2009. Identifying eelgrass stressors in Puget Sound, Washington (USA) - A case study in the San Juan Island Archipelago. 2009 Puget Sound Georgia Basin Ecosystem Conference Abstracts, p. 113-14.

[59] “On a Soundwide scale, there has been no evidence of a trend in eelgrass area”. Puget Sound Action Team. 2007. *2007 Puget Sound Update*. Olympia, p. 26, citing: Dowty, P., et al. 2005. Puget Sound submerged vegetation monitoring project: 2003-2004 monitoring report. Habitat Program, Washington Department of Natural Resources. Olympia.

[60] Kozloff, Eugene. 1993. *Seashore Life of the Northern Pacific Coast.* Seattle: University of Washington Press. p. 280. Also,

Ricketts, Edward, et al. 1985. *Between Pacific Tides.* Stanford University Press. p. 22.

[61] There are several, including Fresh, Kurt L., et al. 2006. *Juvenile Salmon Use of Sinclair Inlet, Washington in 2001 and 2002.* Technical Report FPT 05-08. Washington Department of Fish and Wildlife.

the time of kelp and other seaweed demise. The whole wrack matter may be irrelevant to bulkhead policy: an above-mentioned study found no difference in wrack invertebrates between bulkheaded and bareheaded beaches.[62]

Here again, bulkhead placement makes a difference. Although invertebrates may feed on seaweeds wherever they wash, including riprap fissures, prone and wet is the popular posture for wrack. Beach space clearly counts.

Construction disruption (h) is controllable. Rules already limit the seasons for bulkhead work. When I raised this issue with the DNR piling pullers, their head said that the barge never touches the beach. A barge on the beach would certainly crush some benthic biota, including clams and small invertebrates, whose recovery volume and time are on the order of millions and months. Assuming two barge visits per century, This may not be a ponderous problem. Particularly considering the alternative: bluff collapse with beach-plop burial of these biota, in some cases for decades[63].

Backshore vegetation and diversity (i) may or may not be affected by bulkheads, depending again on how close the protection is to the bank, the character of the backshore, and the propensity of the upper bluff to descend, with and without the bulkhead. As Grandma said, “Bluffs will be bluffs,” unpredictable and driven by seeping demons.

Trees overhanging upper beaches have been considered a habitat asset. Their mention here reflects several analysts’ incorrect assumptions that bulkheads are somehow hostile to trees and their shade.[64] Relative to exposed banks, bulkheads may be the salvation of trees. Inspection of shorelines reveals many instances of trees leaning out from behind bulkheads.[65]

The no-tree presumption has led to scholarly mischief. Two recent studies purport to find bulkheads at fault in the (summer) heating of upper beaches, leading to surf-smelt egg mortality.[66] Their results are confounded by the authors’ decisions to compare no-tree bulkheaded sites with treed no-bulkhead beaches. Sure enough, beach temperatures and egg mortality were higher in front of the bulkheads. But “shoreline modification” was not the cause. ‘Twas shade’s absence.

Another artifact of the bulkheads-discourage-shoreline-trees dogma is that without trees, insects will not fall from the foliage to nourish passing juvenile salmon. Diet studies have shown

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[62] Tonnes, 2008, above, p. 24.

[63] Personal experience.

[64] For instance, Puget Sound Partnership. December 2008. *Action agenda*. Olympia, p. 161, pertaining to north central Puget Sound action area. Also Johannessen & MacLennan, 2007, pp 15 ff.

[65] Herrera Environmental Consultants, 2005, above, pp 5-26, 29, 31.

[66] Rice, Casimir A. 2006. Effects of shoreline modification on a northern Puget Sound beach: Microclimate and embryo mortality in surf smelt. Estuaries and Coasts 29(1):63-71; and

Tonnes, 2008, above.

that insects make up about 12 percent of young salmons' diets. However tree-dependent insects account for only about 1.5 percent of diets.[67]

Two more arguments, both lacking any research basis, about shoreline trees. On is that shade is important to passing fish. This is relevant to streams, but hardly to salmon that travel long distances, in many directions, in open water. Too, shade for them is relevant only at highest tides, in daytime, on sunny days, in sun-exposed reaches.

The second point is that leaves from trees, especially alders, contribute nutrients, especially nitrogen, to the salt chuck. Research in Hood Canal is showing that more nutrients are hardly welcome, with nitrogen in excess in a number of places.[68]

The bottom line seems to be that where bulkheads keep bank and upslope vegetation from collapsing, upshore habitat is helpfully maintained. A no-net-loss situation.

Some conclusions about the issues.

(a) Surface sediments are pushed along most but not all beaches, with and without bulkheads. The speed is slow; the volumes may or may not be large depending on a half-dozen factors.

Sediment reduction is an almost certain product of bulkheading plus whatever protection measures are taken at the tops of tidal shores. However the 'right' volume of sediment plops is elusive, partly because equilibrium beach levels are typically decades long in development, with interruptions by storms and slides that are erratic in timing and size. The effect of residential bulkheads is much proclaimed but little measured. However a Thurston County study showed no significant sediment-related effects from protected relative to unprotected beaches.

(b) Beach profiles (at right angles to the shore) migrate shoreward as beaches invade banks. Beach plops slow this process, and bulkheads largely stop it. A Thurston County study found no significant profile effects of residential shore protection. That study should be replicated northward. However the literature indicates that bulkheads placed above ordinary high water (≈mean higher high water) will not, in general, cause narrowing of the beach.

(c) Coarse upper beaches (gravels and cobbles) is the common condition on Puget Sound, with and without bank protection. So are concave-upward beach profiles, for the same reason: wave action. Again, bulkheads beyond waves' reach are blameless (if coarseness is a problem, which is debatable).

(d) Turbidity may be generated by waves hitting the beach, a bulkhead or bank, whichever waves attack. Whether turbidity occurs depends on fines in the beach and bank.

(e) Putting bulkheads on upper-beach habitat is illegal.

(f) Beach-habitat "degradation" is more like habitat change. Much depends on whether sediment on site is a lot, a little, or 'just right' for a particular array of beach life. Those arrays

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[67] Flora, 2007, above.

[68] This is the Hood Canal Dissolved Oxygen Program, with a strong link to the Applied Physics Laboratory at University of Washington.

vary among sediment situations. Research has found no difference in benthic (beach surface and just below) fauna between protected and bareheaded beaches.

(g) Wrack's presence clearly depends on unfettered upper beaches, as well as abundant seaweed and backshore contributions. Tree (especially alder) leaves are acquiring displeasure because of their nitrogen content. Ditto for lawn clippings. Yet wrack residents (beach hoppers et al) depend on these and other nutrient sources. In any case, a legally placed bulkhead does not block wrack's arrival.

(h) A third of Puget Sound beaches are bulkheaded. There is no evidence that their construction has affected the present nor past welfare of beach life. Equipment disruption covers so little of the Sound at a time, so briefly, that it must be trivial relative to, say, the impacts of a single major storm.

(i) Backshore and upshore vegetation differ. Active beaches typically have no backshore (a terrace just above the reach of most tides). Accretion (sediment-receiving) beaches may have. Sea grasses, some shrubs, and even trees may reside there. Removing that area to site a bulkhead is presumably illegal.

The upshore (above the bank or bluff) is, after all, protected by bulkheads to the extent that they forestall landslides. Trees in this zone are risky and discouraged. Other vegetation may include lawn grass and landscaping; the former is the best cover for discouraging surface erosion. In any case, a premier reason for toe protection is to guard this area.

A perspecitve on bulkhead research.

Hugh Shipman, a well-known coastal geologist who chaired a 2009 workshop on shoreline armoring, has remarked:

One wonders why the workshop was focused on managing shoreline armoring given the limited scientific research that has been done on the impacts of armoring on either geologic or ecologic processes, and the difficulty of applying the science that has been done elsewhere to Puget Sound given the unique aspects of our system.

One can wonder, but that's exactly what local planners and the state ... are doing throughout the Puget Sound region. They are focused on eliminating bulkheads that protect people's homes without scientifically valid proof of harm.[69]

Some implications for restoration.

Given a desire by some people — the natural world manifests no preferences — for a shoreline world of another time, a first question is, "What shall we mimic?" Perhaps the most interesting and different environment would be that of 5000 years ago, when shoreline slopes were fluted but gentle, the climate was warm, an oak-grass savannah prevailed, and our more familiar shrub-conifer environ waited in the foothills.

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[69] Shipman, Hugh. 2009. August 14 e-mail to Puget Sound Shoreline Planners.

Relative to that time, natural forces have totally destroyed 60 percent of Puget Sound shores by converting them to bluffs. Beaches have been dismantled and rebuilt landward, from original shapes that we know not.

A more recent setting would be that of the “Medieval Warming” period of 1400-1650, when conifers came down to the low lands. This might be more consistent with the global-warming epoch that some perceive or expect. By then, perhaps only half of Puget Sounds edges had been shorn away.[70]

Another target for the Puget Sound’s edges might be the “pre-settlement” surround of, say, 150 years ago, though it ignores the earlier Native-supporting woodland backdrop, frequently afire and thus a patchwork of vegetative and habitat types in proportions largely unknown today but apparently only partly ancient forest. One estimate is that only 30 to 70 percent of old-growth stands were really old: The rest had burned or was otherwise destroyed.[71]

Cutting through these visions of olden times has been the inexorable storm-driven episodic erosion of shores, landslides, and landward invasion of beaches. Were it not for invasiveness, these local catastrophes would have meant extinction by geocalamity for most intertidal biota. Is that our preferred shoreline dynamic?

If not, at what point do we want to stop the clock of paleohistory? Perhaps the aim is not to stop the clock at all, but rather to perpetuate a rate of change. On Puget Sound that presumably means some momentum toward a flatter earth, shallower tidewater, and bluffs all round. Is the present rate about right? If not, how does one rationalize a different dynamic?

Meanwhile, the shoreline environment — upshore, backshore, beaches — probably does not care. Shore life will ebb and flow, always occupying our irrepressible biome.

Some implications for equilibrium.

This paper has painted a picture of constant small ecologic disturbance along wave-pressed shores. But in all that turmoil there can be composure. Those 230 transit-neutral beaches are examples, on which sediment arrives from bluffs and creek-supplied sediment fans at the same rate as it disperses.[72] This is dynamic equilibrium, like an engine purring along at a constant speed, fed by a constant flow of gas.

The concept is applied as well to up-down sediment movement across the beach, with waves’ energy just enough to preserve the beach’s profile without scouring into the bank for new material.[73] Sediment moves, but the amount pushed uphill equals the amount washed down. This is most likely where storm winds come straight into the beach. Equilibrium may not occur

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[70] My estimate.

[71] Spies, Thomas A., et al. 2002. Summary of workshop on development of old-growth Douglas-fir forests along the Pacific Coast of North America: a regional perspective. Corvallis, OR: US Forest Service, Pacific Northwest Research Station.

[72] Macdonald et al, 1994, above, p. 2-4.

[73] Ibid, p. 2-6.

until fine sediments have mostly been bounced down the beach, leaving cobbles too heavy for the surf to budge.[74]

Another longshore case of equilibrium occurs when the receiving end of reach ‘fills up’ with sediment. By this I mean that the longshore gradient (steepness) of the bank has increased enough that storm waves exhaust their energy against that slope. How often this occurs I know not.

Equilibrium also occurs when sediment inputs to a drift reach are zero, with wave energy dispersed across bedrock or cemented hardpan.
Over time the downdrift end of the beach may depress from its previous fulsome level, while the intermediate beach may or may not change depending on wave behavior. Habitat implications of such drift cells are “species assemblage shifts”[75] (changes in the arrays of species). See the discussion of habitat change (f) earlier.

Some implications for research.

Interactions of wave, current, and sediment dynamics remain elusive even at a conceptual (model) level, because most research has come from vastly wide water bodies with wide-sloped, largely sandy beaches.

Not yet quantified are such basic dynamics as the steepness of beaches relative to natural circumstances; destinations of colluvium (offshore versus lateral) and time frames relative to bluff geometry; temporal changes in down-drift beach profiles; relative effects of seawalls, riprap protection, and left-alone shores; joint relationships of toe exposure and bluff-top hydrology in activating failure of key geomorphic structures; the tendency of colluvium to override bulkheads; nor even the relative importance of small streams in delivering sediments to the shore. Concerning beach coarsening, it is not clear whether steep beaches encourage big stones, or the reverse. Nor, apparently, is there much evidence as to whether beach changes trigger protection decisions or the reverse. Nor, in much of Puget Sound, whether shoreline protection has much effect at all on marine life.

Research on these subjects continues to be sparse, and the outlook is not bright considering fiscal circumstances and the determination of leadership at the state level to place action well above science.

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[74] Ibid, p. 2-13.

[75] Thom, et al, 1994, above, p. 2-3, 4-7.

Pressing on:
Do residential docks really impede passing salmon?

There are studies showing that docks' shadows affect the welfare of juvenile salmon headed toward the sea. Wide docks (ships' piers and ferry terminals) create sharp breaks between sunlight and deep shade.

One effect, shading-out of eelgrass, is observed but the impacts on salmon have not been measured and aren't discussed here.

It has been supposed that predator fish, lurking in the darkness, will dash out to consume the passing salmon. Shade-based predation has been discounted, as discussed later.

Abrupt light-to-dark transitions, on sunny days under large docks, cause some salmon to detour around the discontinuity. Shade-driven diversion has been reported.

But not under narrow residential docks.

If residential docks are making a difference to emigrating juvenile salmon, how large might that impact be? Small, according to calculations shown here. An average of 93 feet are added to the 55-mile swim from Kitsap County's Sinclair Inlet to Puget Sound's exit.

Docks have been crucial, stable platforms on capricious waters

Docks and wharves, piers and floats have reached out into the world's tidewater, lakes and rivers for four thousand years at least. People of Puget Sound received their first piano and their first steam engine across docks. Without docks the essentials of civilized life would have been lowered with ships' tackle into longboats, and struggled across beaches one bit at a time. The cumbersome alternative was scows, hauled back and forth with ropes and grounded on the shore.

Yesterday's mosquito-fleet docks with their freight sheds are gone, replaced by light-duty piers and floats as shoreline use has become largely residential and recreational. Most residential docks are tucked into protected bays. On Bainbridge Island, for example, two-thirds of all docks are on the two-fifths of the shore that is sheltered.[1] One of Puget Sound life's great pleasures is standing quietly on a float, watching schools of 'shiners' move past and beneath.

[1] Williams, Gregory D., et al. 2004. Bainbridge Island nearshore habitat characterization & assessment, management strategy prioritization, and monitoring recommendations. Sequim: Battelle Memorial Institute, Marine Sciences Laboratory, p. 32.

Lately docks have been criticized for their ecologic effects.

There is a considerable literature on the badness of docks for eelgrass and passing salmon. Eelgrass, with its various contradictions,[2] isn't treated here. The fish matter is mainly one of deep shade beneath large docks, and the related research derives almost entirely from ferry terminals[3] and industrial wharves.

Out-migrating salmon pay attention to sun/shade 'edges'.

Research on salmons' eyesight has shown that fishes' size correlates inversely with ultraviolet-light acuity; the latter helps find inshore planktonic prey, which reflect UV light. Too, the time required for fry eyes to adapt back and forth between light and dark is 20 to 40 minutes.[4]

It is assumed that fish are reluctant to go where they cannot see.[5] "Findings have demonstrated that fishes' responses to piers are ambiguous with some individuals passing

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[2] For instance, eelgrass is said to be in decline, yet it is increasing in Puget Sound. It is said to nurture juvenile fish yet it lies downhill from their preferred cruising routes. It is said to be unique habitat yet kelp provides the same functions. It is said to defy culture yet planting works.

Eelgrass, pocket estuaries, and shallow tidewater are considered three key legs supporting emigration of young salmon. Yet estimates of the proportional uses of these habitats were not found.

[3] At least ten terminals have been studied, with the sophistication of tallying fish impacts improving steadily. Recent state Department of Transportation studies of terminal biology include:

Olson, A. M., S. D. Visconty and C. M. Sweeney. 1997. Modeling the shade cast by overwater [ferry] structures. University of Washington School of Marine Affairs. For Washington Department of Transportation.

Simenstad, Charles A., et al. 1999. Impacts of ferry terminals on juvenile salmon migrating along Puget Sound shorelines. Phase I: Synthesis of state of knowledge. Seattle: Washington State Transportation Center.

Shreffler, D. K. And R. Moursund. 1999. Impacts of ferry terminals on migrating juvenile salmon along Puget Sound shorelines: Phase II: Field studies at Port Townsend Ferry Terminal.

Haas, Melora Elizabeth, et al. 2002. Effects of large overwater structures on epibenthic juvenile salmon prey assemblages in Puget Sound, Washington. University of Washington School of Aquatic and Fishery Sciences and Washington State Transportation Center.

Williams, G. D., et al. 2003. Assessing overwater structure-related predation risk on juvenile salmon: Field observations and recommended protocols. Battelle, for Washington Department of Transportation.

Southard, S. L., et al. 2006. Impacts of ferry terminals on juvenile salmon movement along Puget Sound shorelines. Battelle for Washington State Department of Transportation.

[4] Nightingale, Barbara and Charles Simenstad. 2001. White paper: Overwater structures: marine issues. University of Washington School of Aquatic and Fishery Sciences. A literature compilation.

[5] A discussion of all this is in Nightingale and Simenstad 2001, above, p. 39ff.

under the dock, some pausing and going around the dock, schools breaking up upon encountering docks, and some pausing and eventually going under the dock...”[6]

Some numbers have been put on that reluctance. Acoustic tracking of a (small) number of fish at the Port Townsend ferry terminal (120 feet wide) found that half crossed under the terminal, with the rest going around (adding perhaps 650 feet to their longshore trip).[7]

The same analysts also watched school of fish gather adjacent to terminals, suggesting they queue up before pressing on, at least in daylight when confronted with sharp shade lines under the docks.

None of the studies considered the acoustic effects of dock traffic.

A number of factors have been suggested to explain whatever outgoing salmon do around docks. State of the tide, currents, brightness and angle of the sun, height of the dock and width of the terminal, and predator presence have been mentioned. Unmentioned is sound and vibration from vehicles, the latter telegraphed to tidewater through piling. A ferry terminal supporting an hourly schedule may have a nearly continuous series of vehicles arriving in the dock-borne queue and departing the vessel.

Contrary to received dock doctrine, increased loss of young salmon to predators has never been documented.

“Such a move [around the end of a dock] to deeper waters likely increases the risk of predation by larger predators occupying pelagic waters”[8] and “...the shaded, deep-water environment under piers can create a favorable habitat for predatory fish”[9]. A marine biologist notes, “...there is no evidence, despite many efforts to find it, that such structures in marine waters lead to a concentration of predators on juvenile salmonids or increase vulnerability of juvenile salmonids to those predators that may be present.”[10]

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[6] Nightingale and Simenstad 2001, above, p. 43.

[7] Southard, S. L., et al. 2006, above. P. 42.

[8] Nightingale and Simenstad 2001, above, p. 43.

[9] Envirovision, Herrera Environmental, and Aquatic Habitat Guidelines Working Group. 2007. Protecting nearshore habitat and functions in Puget Sound, an interim guide. Olympia: Washington Department of Fish and Wildlife, p. III-3. Contrary to the associated Table III.1, most of the ‘impacts’ of overwater structures are unsupported by quantified research.

[10] Houghton, Jon. 2006. Best available science review of proposed overwater structure restrictions in Blakely Harbor, Bainbridge Island, Washington. Edmonds, Washington: Pentec Environmental, p. 15.

There have been virtually no impact studies of residential (small) docks on Puget Sound.

A mid-‘90s study examined the effects of small docks, with and without central gratings, on performance of eelgrass beds.[11] This was not a fish-behavior study.
Informal field observations suggest that residential docks less than eight feet wide are hospitable to transiting fish, including salmon. “...docks less than 8 feet wide allow substantial light penetration underneath them, especially during periods of low sun angles.”[12]

I have seen schools of fingerlings take refuge in shade under floats and docks. Houghton says, “If [floats or floating docks] are relatively narrow, e.g., 6 feet wide or less, fish would ultimately pass under or around them with little delay....juvenile salmonids have been observed to move freely along floating structures, ultimately passing under them in response to uncertain stimuli, or through gaps between floating sections, e.g., spaces between segments of a log boom.”[13]

Requiring mid-dock grating to bring daylight to the depths is an untested mandate.

If the research base is as limited as this, it is surprising that jurisdictions seem to be routinely requiring gratings on residential docks unrelated to eelgrass. It is even more surprising that research agencies are not studying migrant-fish behavior in the presence of narrow docks.

In any case, the likelihood that salmon suffer from residential docks, is apparently small.

This statement is based on more estimates (less data) than I would like. We begin with the number of docks encountered between the salmon’s natal stream and the ocean. We consider the distances around them and the proportion of fish that will use the roundabout option.

A small salmon leaving the Gorst Creek hatchery west of Bremerton and taking the express route, the “inside passage” to the sea, encounters 55 residential docks. This route passes Dyes Inlet at Bremerton, the mainland west of Bainbridge, past the openings to Liberty and Miller Bays, circles through Appletree Cove at Kingston, rounds Point No Point and crosses the entrance to Hood Canal en route to Marrowstone Island and Point Wilson, there leaving the Sound heading west.[14] Along this 55-mile tidewater route twenty of the residential docks are 30 feet long or shorter, no impediment to salmon even at highest tides.[15]

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[11] Fresh, K. L., et al. 1995. Overwater structures and impacts on eelgrass in Puget Sound, Washington. Proceedings, Puget Sound Research 1995. Vol 2 p. 537-43.

[12] Houghton, Jon, 2006, above, p. 7.

[13] Houghton, Jon, 2006, above, p. 4.

[14] This route is conjectural; given the tendency of salmon to ‘stray’, Gorst Creek may be sending salmon to the far corners of the Sound. In time, acoustic tagging and other techniques will surely answer the route question.

[15] Assuming that juvenile salmon migrating inshore want at least 3-1/2 feet of water, and there is a 1:10 beach profile gradient.

The average length of the other 35 residential docks is 81 feet.[16] Salmon are unlikely to be swimming within 35 feet of the shore.[17] What is the probability of their swimming around a dock? It happens in daylight, on sunny days, when the water is deep enough to invite visits inboard from the end of the dock. The probability of this joint event is about .035.[18]

Multiplication does the rest, suggesting that residential docks add an average of about 93 feet or .032 percent to salmons' travel from the central Sound to the Strait of Juan de Fuca.[19] Considering that few residential docks will be encountered thereafter, the burden of diversion adds only about .012 percent to the fishes' 150-mile swimming distance to the ocean.

There remains the possibility, mentioned earlier, that residential docks do not matter at all to salmon.

Residential docks are:

> Few in number,
> Narrow, offering diffused shade,
> Relatively short, and
> Quiet, creating little disturbance by carrying little traffic, all pedestrian.

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[16] The dock counts and lengths are taken from Google Maps satellite images.

[17] Given the assumptions in note 15.

[18] On average, 26 of the 92 days of the May-July migration season are clear (28%). Assume 12 hours of bright sunlight on those clear days (50% of the day). The joint probability of arriving at a dock in bright daylight is thus (.28 x .5) = .14.

Now consider the tide. Assume the landward end of the dock is at MHHW, 11.4 feet above MLLW [tidal data from NOAA for Seattle datum]. MHW is at 10.5 feet. MTL is at 6.7 feet, 47 feet [(11.4-6.7) x 10] out from the bank. MTL is 34 feet [81-47] from the average dock's outer end, where the water is 3.4 feet deep at Mean Tide. At this tide level and below, which is the status half of the time, the low water pushes approaching salmon farther out than the average dock reaches. In fact, at mean low tide the 3.5-foot depth threshold for salmon is 39 feet beyond the dock; at mean tide level that threshold is still a foot beyond the dock.

The other half of the time, when the tide is higher than its overall average level, its mean level is 3.8 feet higher than MTL. As the water comes inland it brings the 3.5-foot threshold closer to the upland by 38 feet.

Thus half the time they would swim past without pause; the other half they would confront the dock at an average distance of 38 feet from its outer end.

[19] The added swimming distance averages 38 x 2 = 76 feet. The expected value of swimming-around distance at any long dock is .035 x 76 = 2.66 feet.

There are 35 docks with which to deal, so the probable added swimming distance for each fish is 2.66 x 35 = 93 feet. This in a journey of 55 miles.

Evidence of impact-neutral bulkheads, floats and other shoreline modifications.

With the help of a shoreline inventory and modeling by a major consultancy[1], I've shown that bulkheads have little relationship to the welfare of eelgrass, forage fish spawning areas, and other nearshore habitats. This is important because of the tremendous amount of energy that has gone into berating bulkheads. It's important to you because shoreline reach-oriented inventories are about the best data sets we have concerning nearshore stress.

In support of its coming Shoreline Master Program update, Bainbridge Island did a shoreline inventory of human-installed 'stressors' and habitats. Fifty miles of shoreline were divided into 201 'reaches', with data collected and reported from each reach.

The structure scores included measures of

- bulkhead extent
- encroaching bulkhead extent
- floating structures, ramps
- outfall density
- marina/fish farm presence
- upshore vegetation extent
- artificial shade
- sediment sources
- upshore impervious area

The habitat scores included measures of

- eelgrass welfare
- overhanging vegetation
- surf smelt spawning beaches
- candlefish spawning beaches
- herring spawning sites
- geoduck beds
- salt marsh presence
- seaweed and kelp beds

Analysts for the city combined the structure scores into a composite stressor score for each reach. A composite habitat score was also compiled for each reach.

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[1] Williams, G. D., et al. 2004. Bainbridge Island Nearshore Habitat Characterization & Assessment, Management Strategy Prioritization, and Monitoring Recommendations. Sequim: Battelle Marine Sciences Laboratory.

Figure 1, plots composite habitat-density scores against composite scores for all the human-installed stressors. Each dot reflects a single reach.

Notice (1) the wide scatter of the dots, indicating little if any correlation between the basket of stressors and basket of habitats.

And (2) the absence of a trend downward from left to right. If present that trend would indicate that an increase in stressor levels is associated with a decrease in habitat abundance.

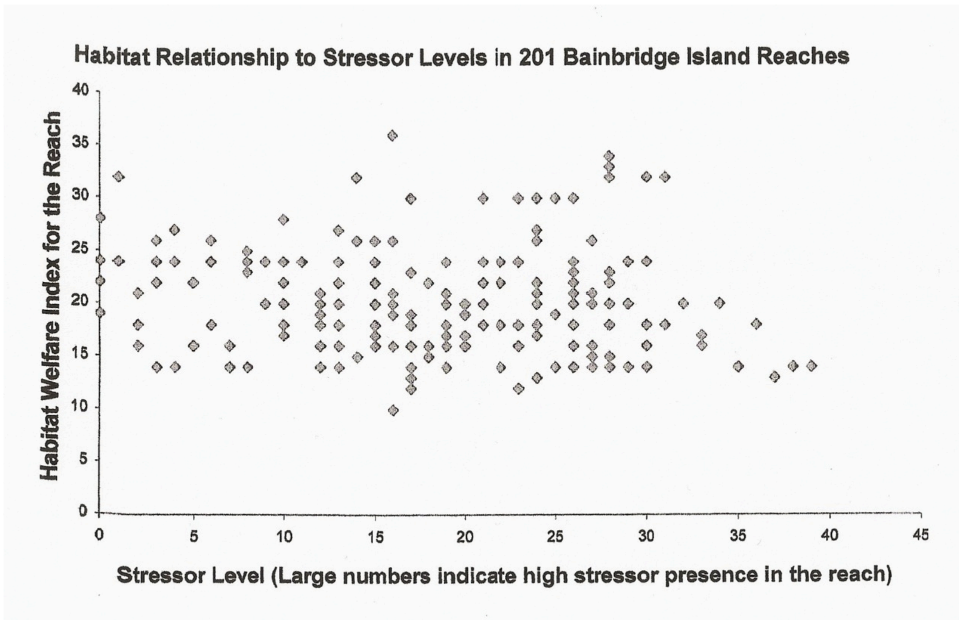

Figure 1

It is possible that composite scores obscure the effects of individual stressors. Bulkhead intensity is of special interest because the analysts clearly assumed the badness of shore protection.

Figure 2 plots reaches' habitat indexes on reaches' bulkhead footage. Again there is no correlation and no trend.

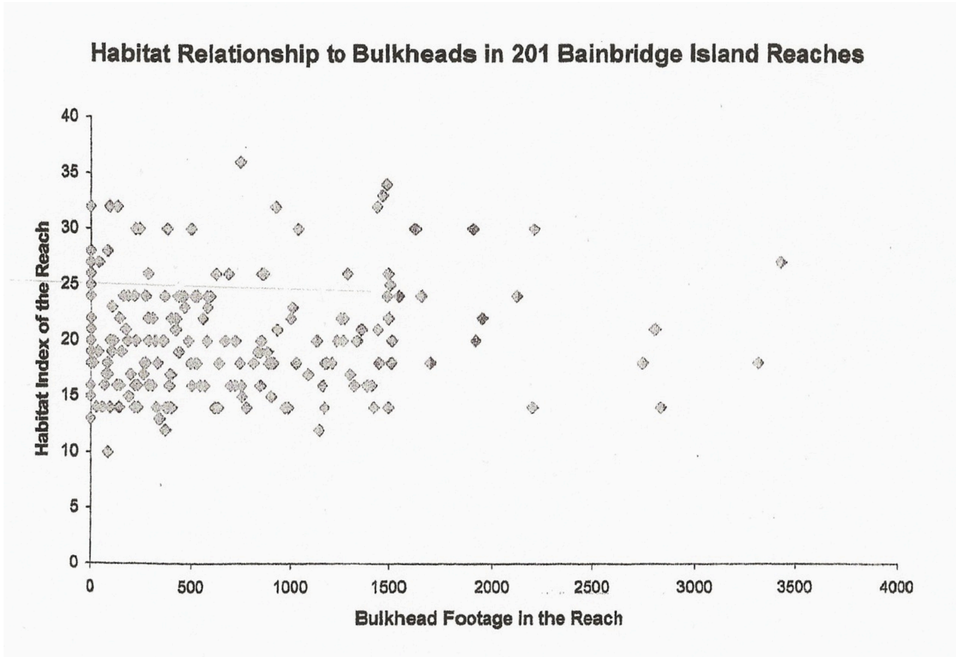

Figure 2

Because bulkheads that encroach out onto beaches are considered more harmful than those snug against the bank, in Figure 3 I repeated the bulkhead plot of Figure 2 but with encroaching bulkheads. Still no indictment of bulkheads.

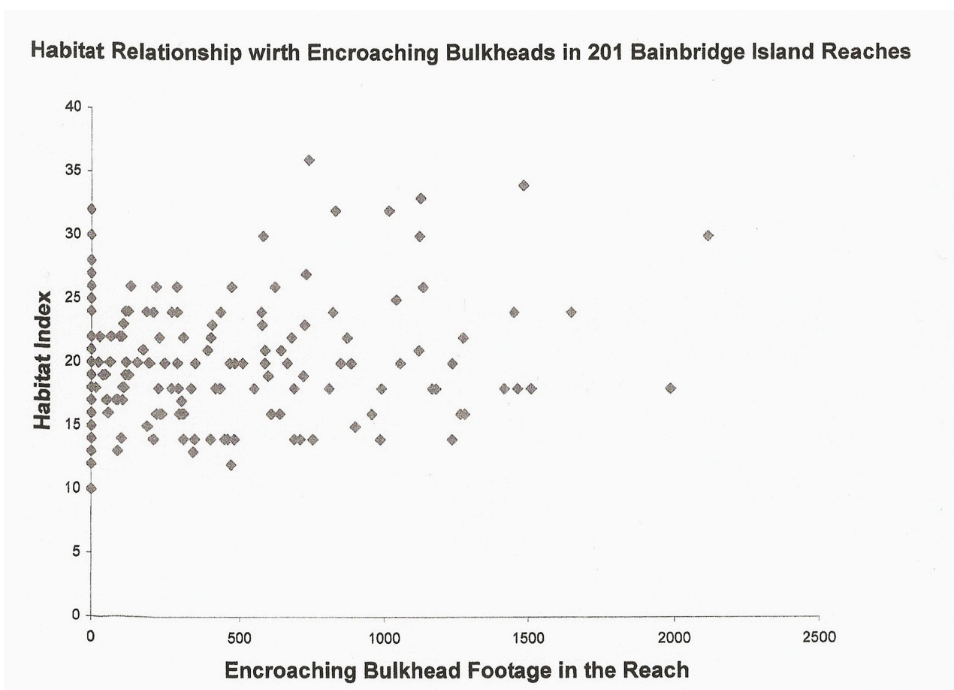

Figure 3

These figures are obviously only a few of the stressor ---> habitat relations that can be charted.

It is time to explain that the plotting was accompanied by statistical analyses of the data showing that, in each case, neither the correlation nor the trend is significantly different from zero.

A Conclusion — The simplest conclusion is that habitat welfare around Bainbridge Island cannot be shown to be dependent on constructed features along the shore. Variations in human-imposed “stressors”, whatever their bulk and intensity, are not associated, singly nor collectively, with variations in nearshore habitats.

This for Bainbridge Island. What about elsewhere? Virtually the same results emerged from easterly Kitsap County, where “stressor” data was collected on 500-plus reaches.[2] However fewer than a score were assessed for habitat welfare, so this conclusion is not firm.

The results are consistent with a similar cross-sectional study of bulkhead effects in Thurston County.[3] It remains to be seen whether multi-year monitoring with repeated measurements at same sites will alter the conclusions.

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2. Borde, A. B., et al. 2009. East Kitsap County Nearshore Habitat Assessment and Restoration Prioritization Framework. Sequim: Battelle Marine Sciences Laboratory.

3. Herrera Environmental Consultants. 2005. Marine shoreline sediment survey and assessment, Thurston County, Washington. Seattle.

December 2008

Bigger beach buffers for fun and profit.

Well, no.

Current shoreline doctrine emphasizes selected bits of ecology, mostly salmon-centric. So this paper deals with some nearshore ecologic issues, including what is to be protected and how it is done.

My thesis is that wider buffering will not increase the welfare of salmon, other creatures, nor the beach itself. There are better ways.

I mention but dwell not on the social costs of conscripting thousands of front yards from children; fear and hassles are not my province.

Rather, with a considerable background in riparian research management, I challenge a crucial share of tidal nearshore doctrine.

For openers, **no tidewater research supports 200-foot, nor 100-foot shore-top vegetated buffers.** (Explained below.)

Here is a list of things that 100- and 200-foot buffers will not do for Kitsap County. Many are rather obvious.

Wider buffers will **not** do these things: (see the explanations below)

- Better protect the Sound against stormwater-borne pollutants
- Improve shade for surf smelt spawning
- Provide more insects for salmon diets
- Improve nutrient flows to tidewater prey organisms
- Speed the dynamics of intertidal drift zones
- Slow the loss of backshore to the sea
- Provide more sediment to drift zones
- Regulate tidewater temperatures to reduce plankton blooms or increase benthic invertebrate production
- Improve the nutrition of passing salmon
- Increase eelgrass production
- Increase the abundance of juvenile nor adult salmon
- Protect ocean-bound fish from predators
- Increase marine habitat diversity
- Restore marine conditions to beckon lost cod and herring
- Increase diversity of upland landscapes
- Enhance the attributes of native plant species
- Discourage invasive animal species
- Provide a better home for small mammals

- Enlarge depleted habitat for cavity-nesting birds
- Provide more shoreside perches for eagles, kingfishers
- Conserve water for infiltration to aquifers
- Protect aquifers from water-borne pollutants
- Preserve play space for children
- Nor perform better than a number of alternatives

Costly, 'best', and available it may be... but little of the County's science comes from research.

This is not the County's fault, nor their advisors'. There simply is not a supply of quantitative studies relating upland Puget Sound conditions to the welfare of the beach and beyond. This is a major concern among marine biologists, oceanographers, et al.[1]

There is a vast literature on buffers. It has concentrated mainly on riverine risks.

Because buffers are pertinent to non-point-source pollutants, river issues have typically pertained to agriculture, with overland flows across pastures, feedlots, and croplands, the latter two usually involving bare soil. Slopes are not great and soils are relatively deep and porous. Most U.S. studies have been in the Midwest and East, where summer rainfall is significant.[2] In many cases abrupt snow melt is a factor. None of these facets is prominent along Puget Sound.

Recent decades have brought stream buffer studies into the Northwest forestry sphere.

These have dealt mostly with concerns about sediment and debris flows, provision of woody debris to salmon streams, and habitat protection where clearcutting would otherwise sharply change the ecosystem. Research findings have been surprising for all three issues, discussed a bit later.

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[1] Lemieux, J. P., et al, eds. 2004. Proceedings of the DFO/PSAT sponsored marine riparian experts workshop, Tsawwassen, BC, February 17-18, 2004. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2680. Vancouver BC: Fisheries and Oceans Canada.

Some progress during the subsequent four years is mentioned here later.

[2] Perhaps the publication most widely read in Puget Sound planning circles is intended to guide tidewater buffering, yet it relies almost entirely on inland ag and stream studies:

Desbonnet, Alan, et al. 1994. Vegetated buffers in the coastal zone, a summary review and bibliography. Coastal Resources Center Technical Report 2064. Narragansett, RI: Rhode Island Sea Grant and University of Rhode Island Graduate School of Oceanography.

Data on buffer efficacy has ranged widely.

It is easy to cite contradictory research findings; however differences are more apparent than real. They lie in incomplete reporting (especially in research surveys and compilations) of the many factors, natural and manipulated, that bear on a buffer and its burden. One can read that over 50 percent of received nitrate can be removed by a buffer six feet wide. Or that only 4 percent was removed in a 30-foot buffer.[3]

So-called syntheses are not much help in resolving the variance. Most of these publications focus on a narrow perception of relevant landscapes and threats. In trekking through 3500 abstracts and papers related to buffers I did not find an efficacy model that would accommodate Puget Sound conditions.

The literature is clear on three things.

One, manure 'juice' sinks quickly into deep soils. Two, users of buffers to capture sediment and pollutants face rapidly diminishing increments of protection as buffers are widened.[4] Gary Tripp has shown, from the literature, that the first 30 feet are the most effective at removing nutrients.[5] And third, statistical analysis shows there is no real increase in protection inherent in widened buffers.[6] 200 feet is no better than 30 feet.

Kitsap County's manure juice does not sink forthwith.

We call it stormwater; the issue is the same. Our sloping shores, underlain in most places by hardpan (glacial till), hard or prolonged rains, absence of summer precipitation, and winter-dormant vegetation combine to thwart buffer effectiveness.

Typically close to the surface, with very low permeability, hardpan serves as a cement floor above which flow whatever fluids infiltrate surface soils. Tills account for our remarkable abundance of wetlands, which are generally cups in the till.

The second element is our rainfall's concentration in winter months and its abundance. In much of North America (but not here) summer rain is common. This is a factor in vectoring chemicals, applied during the growing season, into buffers. Here, rain's abundance in multi-day events and occasional downpours (as in early December, 2007) tends to flood even well-

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[3] Both are found in Desbonnet et al, above.

[4] Desbonnet, again, shows this clearly, as do others.

[5] Tripp, Gary. 2004. Questions about buffers. Bainbridge Island: Bainbridge Citizens United.

[6] Regression analyses applied to:

May, Christopher W. 2001 and 2003. Protection of stream-riparian ecosystems: a review of best available science. Prepared for Kitsap County Department of Natural Resources.

And to Desbonnet, 1994, above.

vegetated buffers. Since at least the 1880s, almost all of the hundreds of landslides in Seattle have been preceded by winter storms.[7]

A third element is our irrepressible vegetation, which spares us much erosion. However an unintended consequence of many prescribed buffers is their porousness at the surface: Overhead shrubs and trees suppress with shade the dense ground cover needed to halt stormwater in its stride.

The fourth factor is the dormancy of most of our vegetation in the season of our tempests. Trees along the shores are expected to capture large amounts of stormwater and send it off to the sky via evapotranspiration. But that is a spring-summer affair. For hardwoods and softwoods alike, winter absorption of water is as little as one percent of that in summer.[8]

Together, these conditions conspire to pass stormwater on through buffers, or, underground above the till, create dams of roots that saturate the substrate with obvious effects on the buffer, stormwater, and whatever the water carries.

All of which is exacerbated by buffering on steep slopes. Bluffs aside, Puget Sound shores are not famously steep. Still, shorelines do not slope *uphill* toward the bay.

Obviously, where stormwater flows through pipes all this is a non-issue. However some beach outfalls are showing human and animal bacteria, and other pollutants may be there too. Stopping pollutants at their sources is clearly the best chance.

This matters for many pollutants.

The buffer literature concentrates on sediments and nutrients. Sediments are important because they can carry attached pollutants like phosphates, metals, and a number of organics. (Other stormwater-borne pollutants don't depend on sediment attachment; they move in solution or as particles.)

In any case, it is unlikely that present or wider buffers will effectively filter/absorb pollutants, excess nutrients, nor filter sediment if such materials are presented steadily to the buffers.

Long-lasting toxic chemicals are mainly a problem of urban harbors.[9] Shoreline 'heavy' industries are mostly gone, with shoreline use becoming largely residential and recreational. Examples are Bellingham, Edmonds, Olympia, Port Townsend, Port Gamble, Port Discovery, Port Ludlow, Port Orchard, Gig Harbor, Eagle Harbor and Port Blakely, even Bremerton.

"The available scientific evidence...does not generally support a conclusion that the freshwater streams and lakes of Puget Sound or the marine waters are universally contaminated from pollutants for which there are established standards.

"Most impairment of existing water quality standards for marine waters in the main Puget Sound basin are for fecal coliform and low dissolved oxygen.

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[7] Schulz, William H. 2007. Landslide susceptibility revealed by LIDAR imagery and historical records, Seattle, Washington. Engineering Geology 89: 67-87.

[8] Baker, Frederick S. 1950. *Principles of silviculture*. New York: McGraw-Hill.

[9] Puget Sound Action Team. 2007. State of the Sound 2007. Olympia. p. 26.

“Only 8 sites out of 639 where dissolved metals and mercury results were reported exceeded 2006 Washington water quality standards...and none were in the Puget Sound basins.[10]

Nonetheless there are long lists of toxic chemicals, including persistent bioaccumulative toxins, many of them tucked into the Sound.[11] The proportion of toxic pollutants that enter the Sound in stormwater is open to question; and of stormwater the share that comes in pipes rather than surface flows is not clear. As mentioned earlier, a sustained discharge of toxics into surface-riding stormwater will scarcely be deterred by buffers in the long term.

Shade for beach-using fish will not increase

This relates mostly to ‘forage fish’ (surf smelt and candlefish), all of which spawn on upper beaches and some of which spawn in summer. Overhanging vegetation is applauded for keeping thinly buried fish eggs from dessication, and it works to some extent (mortality is still high, but for other reasons). However most summer spawning occurs in the north Sound. Only two spawning sites in the County are used in summer. They have not had shade for at least a century, and the spawners have not faded away despite much unused suitable habitat elsewhere. I’ve enclosed a paper, ***Some Notes on Surf Smelt, Their Protection and Role***.

In any case, thickening buffers will not increase the amount of overhanging vegetation.

Wider buffers will not enhance salmon diets. Here’s why.

Much is made in local marine riparian literature of the supposed supply of insects from overhanging vegetation to salmon lingering below. I went to Puget Sound studies of juvenile-salmon diets (there are four). About 12 percent of the biomass found in young Sound-traveling salmons’ stomachs was insects. Only about 1-1/2 percent was insects dependent on tree species associated with tidewater shores. Yep, another paper, ***A Perspective on Insects Eaten by Juvenile Puget Sound Salmon***.

Broader buffers would, if anything, provide a denser screen shielding the Sound from flying, mostly aquatic, insects inland.

Nutrient flows to tidewater prey organisms have little to do with buffers, wide or narrow.

Studies of nutrients entering Hood Canal point to a partial role of streamside alders in supplying nitrogen that produces surges in plankton supply. This is bad to the extent that dying plankton encourages bacteria that use oxygen, to the detriment of bottom-dwelling fish and

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[10] Puget Sound Partnership. 2008. Draft forum paper on water quality. pp. 5, 10, 12.

[11] For instance, WAC chapter 173-333.

invertebrates. It is also trivial relative to the immense volume of nitrogen coming into the Sound from the ocean.[12]

Nutrient inputs from leaf litter are important in streams in supporting bacteria and tiny insects that in turn feed the freshwater plankton that support salmon there. This is not a factor in Puget Sound because of the immense dilution by arriving ocean and fresh water. In any case, only buffer vegetation overhanging the beach provides leaves, twigs, and other swash elements.

Widening buffers would have no effect.

Longshore drift would not be helped by deeper buffers.

A key argument against bulkheads has been their retention of sediment that would otherwise slump onto the beach, ultimately, over decades, sustaining the beach profile and nourishing spits.[13] Problems with this doctrine (indeed, dogma) include an abundance of sediments that come from hundreds of small streams, a consequent lack of correlation of beach 'needs' with backslope geometry[14], endurance of beach conditions in the face of infrequent beach plops, and the absence of proven beach degradation by bulkheads in recently studied reaches.[15]

If bulkheads don't make a difference in beach erosion, widening the belt of protective upshore vegetation can hardly matter.

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[12] For instance, the ocean provides 400 times as much nitrogen to Hood Canal as do all the septic tanks near the shore. This per:

Paulson, Anthony J., et al. 2006. Freshwater and saline loads of dissolved inorganic nitrogen to Hood Canal and Lynch Cove, Western Washington. US Geological Survey Scientific Investigation Report 2006-5106. Tacoma: USGS Publishing Service Center.

[13] For instance, the sole exposition cited by the City in framing the Marine Critical Areas ordinance:

EnviroVision, Herrera Environmental, and Aquatic Habitat Guidelines Working Group. 2007. Protecting nearshore habitat and functions in Puget Sound, an interim guide. Publisher not identified; may be Washington Dept of Fish and Wildlife.

[14] In a statistical analysis on the correlation of beach drift volumes with driving factors I found that about 60 percent of the variance in sediment drift rates was accounted for by fetch (exposure) and drift-zone lengths. This leaves only 40 percent of variance to be shared by bulkheads, feeder-bluff geometry, rates of slumping, sediment character, stratigraphy and saturation.

[15] Herrera Environmental Consultants. 2005. Marine shoreline sediment survey and assessment, Thurston County, Washington. Seattle. In 29 paired comparisons of bulkheaded with unprotected shores, no scouring was found, and no statistically significant difference in beach profiles in front of bulkheaded versus bareheaded shores. Nor did bulkheads 'coarsen' the beach sediments.

Nor would landslides above the backshore.

It is well understood that bluff slumps are triggered by saturation of the upper slope, at times of intense or long-enduring rain, as in December 2007 or 1996-7 respectively. Studies of 1308 historical landslides in Seattle support that perception.[16] Losses of upland to the sea would not be reduced by more trees, farther from the bank, gripping with all their might.

This is contrary to received doctrine, based partly on observations that logged-over areas slide more readily into streams. They do. However recent studies confirm that such slides are associated with logging roads at slope tops that concentrate water during storms, mainly because of clogged or absent culverts. Resulting debris flows charge right on through buffers.

On the Sound's hardpan, adding tree roots carries potential for damming seepage through soils above the till, raising risk of a 'blowout'. This probability has not been quantified, mainly because with/without studies are difficult at the scale and with replications needed. However the risk is present with any treed buffer above tills that slope downward toward the beach. I've enclosed a literature survey: ***Tidewater Trees: A Risk Analysis of Trees Above, On, and Near the Shore***.

Widening buffers to conform to some notion of adding more woody debris to the shore would have no basis in quantitative estimates of 'need' and 'supply', nor a reckoning of how a tree, falling from the far side of a 100-foot buffer, would ever reach the beach.

Trees don't help get the 'right' temperature at the beach nor beyond.

Whatever the very temporary (at highest tide, in hot weather) benefit of overhanging trees elsewhere around the Sound, a treed buffer will not influence water temperatures. That it might is a hangover from stream studies.

This is a good place to point out the massive equalizing effects of a massive Sound and the ever-present ocean. Billions of gallons move to and fro, often swirling and mixing, within the Sound. Meanwhile the ocean continually puts even more billions in every day. Much of which then leaves, melded variously into the fresh water. If it were not so, the Sound would lose its salinity. For every gallon of fresh water in the central Sound there are nine gallons of ocean water.[17]

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[16] Schulz, William H. 2007. Landslide susceptibility revealed by LIDAR imagery and historical records, Seattle, Washington. Engineering Geology 89:67-87.

[17] Ebbesmeyer, Curtis C., verified by Flora with data from:

Salinity – Puget Sound Action Team. 2007. Puget Sound Update. Olympia. p. 241.

Per capita sewerage and King County flow – King County Wastewater Treatment Div. 2003. Fact sheet: King County wastewater flow projections.

Extrapolation of sewerage to the central and south Sound: Flora

Runoff including rivers entering central and south Sound – Hart Crowser, Inc. 2007. Control of toxic chemicals in Puget Sound, Phase 1. Dept of Ecology publication 07-10-079, Table 3.

So the ocean trumps all, including temperature. Also nitrogen (mentioned earlier), other nutrients, probably oxygen, and myriad organisms. No amount of upshore vegetation will alter tidewater temperatures hence invertebrate production, which in many cases responds to temperature.

It has been supposed that hot sand is hard on beach-residing invertebrates, the most common of which is talitrids (beach-hoppers aka sand fleas). Summer-bare beaches can indeed get lethally hot (there's data on this), yet a North Sound study found that subsurface talitrid densities were the same with and without overhead shade and drift wrack.[18]

From these findings it is clear that wider buffers are unlikely to affect the nutrition of passing salmon, for better or worse.

Juvenile salmon traversing the Sound, predators all, feed mostly on marine creatures, of course, including small fish. In a Sinclair Inlet study a hundred kinds of marine organisms were found in stomachs of young salmon, including fish eggs, shrimps and tiny shrimp-like creatures, sand fleas, pileworms, young crabs, and barnacle larvae. Remarkably, Chinook salmon ate juvenile octopuses and squid.

Most of these animals start life as swimming or drifting larvae. Some become stuck in place as adults. And as adults they depend on plankton for sustenance. The plankton depends on nutrients. Around the Sound, as explained earlier, some nutrients leak right on through buffers, regardless of size. That probably doesn't matter: as mentioned, the ocean has a corner on the nutrient business.

Salmon may be grateful that buffering, regardless of width, is not saving the Sound from nutrients.

Eelgrass may need help. It won't come from wider buffers.

Like most plants, eelgrass is invasive. Given right conditions and an absence of competitors, its range expands. "On a Soundwide scale, there has been no evidence of a trend in eelgrass area....In Central Puget Sound, eelgrass area declined over the last two years [2005-6], but these declines were not statistically significant."[19]

An Eagle Harbor project aims at encouraging eelgrass by decreasing shade by reducing shade-causing plankton by installing oysters to consume or kill the plankton, or consume the nitrogen on which plankton depend. The latter goal is probably negated by main-Sound nitrogen working its way into the harbor.[20]

Yet there are calls for more eelgrass, for fish habitat generally and herring in particular. Do buffers help or hurt? The literature does not suggest an eelgrass-buffer tie beyond whatever eelgrass-using nutrients come into reach from falling leaves (if the leaves don't blanket the bottom, cutting off sunlight).

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[18] Tonnes, Daniel M. 2008. Ecological functions of marine riparian areas and driftwood along North Puget Sound shorelines. MS thesis, School of Marine Affairs, University of Washington.

[19] Puget Sound Action Team. 2007. 2007 Puget Sound Update. Olympia. p. 26.

[20] Yes, I've done a paper on that, 6 pages long, not enclosed.

Wider buffers can't increase tidewater's input of leaves. Grass clippings might be better, with their finer structure.

Bigger buffers and greater salmon production.

Not likely, especially given the wide buffers already assigned to (pocket) estuaries. The number of salmon passing leaving the County is determined mostly by hatchery production, somewhat by local stream conditions.

Wider buffers will hardly shield migrating salmon from predators.

The number of salmon leaving our waters for the Strait depends mainly on predation, of course. Predators include the mighty eaters - seals, sea lions and killer whales - plus eagles, cormorants, other marine birds, and other salmon.

Wider buffers may have a mixed effect, by encouraging some nesting predators but also other creatures that attack those predators, like falcons, cats, raccoons, and coyotes. Eagles, already provided with buffer-content trees and a nearshore richly supplied with trees, while often choosing to perch on dock railings and idle on the beach, may not care. There is no evidence that herons are in decline nor, for that matter, increasing. Perhaps eagles, predatory on herons and growing in numbers, will be a limiting factor in herons' welfare, rather than habitat.

More on the bird matter in a later section.

Diversity of marine habitats would not gain an iota via wider upland buffering.

And not just diversity. Buffering against residential uses will hardly pluck upward the general welfare of shore ecosystems.

Herring and cod have been fisher-friendly neighbors.

Cod are gone from Agate Pass, a famous fishing site. The herring situation is interesting. Some people are ready to bemoan its passing, yet thousands of tons (millions of fish) are taken every year from the Sound.

Adding another strip of upland buffers in front of homes has not been shown to benefit these fish. Indeed the linkage is hard to imagine.

Other penalties come with nativeness wrapped in a wide buffer.

A fixation on native species seems to have a two-part rationale. One is that exotics may be invasive to the extent of crowding out natives, and this is bad. The other is that natives are more durable: resistant to weather, insects and disease. The latter argument is specious. Non-natives are often brought aboard because they are less subject to native pests, frosts, drought, et al. That because they are slightly different genetically. Native pests have evolved to fit native opportunities. The trick is to get exotics lacking exotic problems. That is commonly achieved.

Perhaps our most noxious non-native species are feral cats, discussed later. Anyhow, attached is ***Notes on Vegetation Nativeness*.**

The diversity of near-marine habitat would freeze in place.

This for three reasons. One is the emphasis on native or similar vegetation. Second is the uniform one-size character of buffering as proposed. Third is the driving out of creatively wrought landscaping.

The potential for problems with long, continuous or intermittent stretches of near-monoculture is considerable. Not only are such arrays drab, they may expire simultaneously.

Discouraging invasive animal species is an issue with wide-buffer implications.

Include feral cats. In fact they will probably determine and largely dominate the wildlife mix. A wider swath may bring some more predatory birds anesting; it will surely see our perennial favorites - squirrels, deer, coyotes, crows, rats, raccoons, opossums. However species richness may not equal that of landscaped yards, and it may be less evident until the garbage can goes over or the cat disappears.

Whether abundance (the total number of animals) will increase may depend on whether habitat acreage is a critical factor for any of these species. Food may be more important than *lebensraum,* in which case wide buffers may not change populations of some species. For others, such as deer, a wider vegetated buffer might exacerbate our overpopulation.

Small mammals and some birds might do well with wider buffers.

Or maybe not, depending on the predator situation and the number of cats. Cats are a well-recognized scourge of birds and small mammals, killing several per night if the victims are available.[21] The cats don't know why, they just do it.

Assuming even distribution of small mammals through the buffer, upland homes would face twice as many presumably troublesome rodents with a 100-foot buffer as with the present 50 feet. The critters won't be better off individually, in fact they would be confronting twice as many of their own kind.

State-listed cavity-nesting birds might find more residences.

If they seek such. Four of the five species of cavity nesters designated priority species by WDFW and seen on Bainbridge Island nest elsewhere, and the fifth, wood ducks, are fresh-water diners and denizens. Wood ducks seek wetlands and ponds. With perhaps thousands of wetlands in the County these ducks have little need for tidewater buffers. Helping them nest leads to nest boxes because trees with large-enough cavities are generally older than those

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[21] King County Critical Areas Ordinance Best Available Science, 2003, p. 9-38. Also Zimmerman, Mary Lou. 2007. Cats and wildlife don't mix. Bainbridge Island Broom, winter issue.

found along our shores.[22] The County has a maturing woodland cover, some of which is already late-successional. Stag-topped trees favoring eagles are with us; branch cavities for wood ducks are not far behind.

Eagles and kingfishers would gain little from expanded buffers.

This because kingfishers are regularly seen peering from bulkhead tops, floats and docks, as well as lower tree branches, while eagles find treetop perches closest to the bay in the present buffers.

Widening the buffers will not make the perch trees taller.

Getting stormwater into aquifers would be an unlikely role for expanded buffers.

Buffers sit above hardpan on much of the County. That substrate dictates a very slow rate of infiltration, especially on slopes. A likely scenario would be saturation of the buffer farther inland than otherwise, extending then to the bank's top.

Widening buffers usually means more trees, which increase the summer burden on groundwater. Water use by individual mature trees has been measured at 100-150 gallons per day. There is no controlling this flow: The trees turn the tap.

Nonetheless stormwater-borne pollutants accumulate in any buffer as the water's transit slows.

Even with diminishing returns, a wider buffer would presumably accumulate more pollutants, especially those carried on sediments. Without active absorption by vegetation, the pollutants will either decompose or sink slowly toward aquifers. In winter, as mentioned earlier, the sopping up by vegetation is near zero.

Aquifer users do not thank us for buffer-provided pollutants.

Meanwhile a children's place would be further conscripted.

The number of shoreline home places that can comfortably forego a hundred feet or more of yard space is near zero, whether next to the water or behind the house. Yet that is what may happen, with access limited to a trail.

Children pay the social price, in space lost as the yard is inundated by regulation. Parents would be in the odd position of telling their children they can't go beyond the sign or through the fence.

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[22] Discussion with George Gerdts, Island ornithologist, and material in:

Larsen, Eric M., et al. 2004. Management recommendations for Washington's priority species. Volume IV: Birds. Olympia: Washington Department of Fish and Wildlife.

Officials with clipboards and boots could wander through any time. But not children. Forget sand boxes, swing sets, inflatable pools, scooters, basketball and badminton courts.

It would not happen at once. Buffers would come sliding in as residents make changes.

Not the least consequence would be creation of competition for what space remains, raising prices and leading to smaller homes sandwiched into denser spaces. So much for the extra bedroom. So much for kids.

There are alternatives that perform better yet carry lower social and private costs

Shoreline and wetland buffering is immensely costly, turning whole regions of the County instantly into nonconforming uses. Not the least of these is uses foregone. Yard space for children is only one.

However grass is one of the better alternatives to vegetative buffering that requires shrubs and trees. Its ability to corral stormwater and grasp pollutants has no equal among plant communities. Attached is an 11-page background paper, ***Lawns of Grass, An Assessment***.

Other options for stormwater include ponds, furrows, berms, and in some cases even paved routes. A large body of literature supports 'low impact development' aimed principally at better disposition of stormwater. LID measures have three important benefits. They capture rainwater close to where it falls, thwarting entrainment of pollutants. They offer routes into the soil and on to groundwater and aquifers. Third, they offer a chance to sprinkle small effective measures among many places comfortably, safely, and often economically.

For sediment there are grassy swales and fields.

For waterborne pesticides and toxic chemicals there are lawns and above all forbearance, which mightily trumps buffers.

For bacteria and some nutrients, septic systems. A system at work (most do) removes 99.9 percent of coliform bacteria.[23]

For wildlife, the same yards and verges that serve as children's places, plus parks, meadows, and the vast network of existing wetland buffers.

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[23] U.S. Environmental Protection Agency. 2002. Onsite wastewater treatment systems manual.

October 2005

The passing of a children's place.

Families who move to Kitsap County look forward to the extra bedroom they can now afford, a garden in a friendly climate, and an outdoor place for children.

Little do they know that, sooner or later, a shadow will probably fall across the back yard — the fence that guards a buffer around some "critical area".

It's rather probable — the County has perhaps 5000 wetlands, maybe 800 or more streams.

Some 50 square miles — 1/8 of the county — faces recruitment into wetland buffers alone. That doesn't include special wildlife habitat conservation areas and corridors, tidewater buffers, stream buffers, nor hillside setbacks.

Kids pay the price, in space lost. This because it's typically the back yard that is inundated. Not by water but by regulation.

Parents will be in the odd position of telling their children they can't go beyond the sign, although officials with clipboards and boots can wander through any time, with volunteer groups "saving" the environment and admonishing residents for too much ivy or too few shrubs.

Meanwhile the conscripted space must be allowed to sprout brush, drop limbs, and host a remarkable array of rodents, raccoons, opossums, and the like.

But not children. Forget sand boxes, swing sets, friendly paths, scooters, basketball and badminton courts.

It won't happen at once. Buffers will come sliding in as neighborhoods develop.

Not the least consequence will be creation of competition for what space remains, raising prices and leading to smaller homes sandwiched into denser spaces. So much for the extra bedroom. So much for kids.

May 2008
December 2008

Shoreline vegetated buffers, good and bad for Puget Sound.

There is a plethora of literature on buffering along watered places. Little of it applies directly to Puget Sound. This is a brief discussion of why that is, the functions and values we expect from buffers, whether buffers can be expected to function well here, and some of the alternatives. In summary:

Buffer studies around the world have focused largely on streams winding through farmland. Thus data on buffer effectiveness comes mostly from short-duration studies on deep, well-drained soils beneath pastures, feedlots, or bare-soil row-crop agriculture.

Recent decades have brought buffer research to forest settings along back-country streams in the Northwest's West Side. Some of those are mentioned here.

Literature compilations portray wide differences in effective buffer widths, reflecting not faulty research but rather compilers' failure to indicate the field conditions that varied among studies. There is no 'best' buffer science.

In any case, buffering beside Puget Sound has had much advocacy but little study. In particular before/after research is seemingly absent altogether and with/without comparisons are few and somewhat confounded.

Buffers' primary role is stopping or slowing overland and near-surface stormwater. This is important where nutrients, pathogens and toxics aren't otherwise stopped.

Buffers work here: They slow or even stop sediments, which carry certain pollutants. By slowing stormwater they encourage infiltration to aquifers, which is either good or bad.

Buffers don't work here: They don't stop stormwater in places with combinations of steep slopes, hardpan (glacial till) soils, hard or prolonged rains, winter-dormant vegetation, limited low groundcover (as in shrub landscaping and woodlands). Dissolved pollutants travel on.

On balance, updated SMPs might well include (1) checking the performance of existing buffers and (2) considering the cost and effectiveness of alternatives, including halting pollutants at their sources.

There is a vast literature on buffers. It has concentrated mainly on riverine risks.

Because buffers are pertinent to non-point-source pollutants, river issues have typically pertained to agriculture, with overland flows across pastures, feedlots, and croplands, the latter two usually involving bare soil. Slopes are not great and soils are relatively deep and porous. Most U.S. studies have been in the Midwest and East, where summer rainfall is significant.[1] In may cases abrupt snow melt is a factor. None of these facets is prominent along Puget Sound.

Recent decades have brought stream buffer studies in the Northwest forestry sphere.

These have dealt mostly with concerns about sediment and debris flows, provision of woody debris to salmon streams, and habitat protection where clearcutting would otherwise sharply change the ecosystem. Research findings have been surprising for all three issues, discussed a bit later.

Data on buffer efficacy has ranged widely.

It is easy to cite contradictory research findings; however differences are more apparent than real. They lie in incomplete reporting (especially in research surveys and compilations) of the many factors, natural and manipulated, that bear on a buffer and its burden. One can read that over 50 percent of received nitrate can be removed by a buffer six feet wide. Or that only 4 percent was removed in a 30-foot buffer.[2]

So-called syntheses are not much help in resolving the variance. Most of these publications focus on a narrow perception of relevant landscapes and threats. In trekking through 3500 abstracts and papers related to buffers I did not find an efficacy model that would accommodate Puget Sound conditions.

For buffering, Puget Sound is unfavorable to say the least.

This statement applies to places underlain by glacial tills (hardpan), left by continental ice sheets or their outflow rivers.[3] Typically close to the surface, with very low permeability, they serve as a cement floor above which flow whatever fluids infiltrate surface soils. Tills account for our remarkable abundance of wetlands, which are generally cups in the till.

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[1] A buffer publication widely read in Puget Sound planning circles is intended to guide tidewater buffering, yet it relies almost entirely on inland ag and stream studies: Desbonnet, Alan, et al. 1994. Vegetated buffers in the coastal zone, a summary review and bibliography. Coastal Resources Center Technical Report 2064. Narragansett, RI: Rhode Island Sea Grand and University of Rhode Island Graduate School of Oceanography.

[2] Both are found in Desbonnet et al 1994, above.

[3] Till's nature and origin are well described in Puget Sound Nearshore Partnership publications:

2006-02 The geomorphology of Puget Sound Beaches

2007-04 Beaches and bluffs of Puget Sound.

The second element is our rainfall's concentration in winter months and its abundance. In much of North America (but not here) summer rain is common. This is a factor in vectoring chemicals, applied during the growing season, into buffers. Here, rain's abundance in multi-day events and occasional downpours (as in early December, 2007) tends to flood even well-vegetated buffers. Since at least the 1880s, almost all of the hundreds of landslides in Seattle have been preceded by winter storms.[4]

A third element is our irrepressible vegetation, which spares us much erosion. However an unintended consequence of many prescribed buffers is their porousness at the surface: Overhead shrubs and trees suppress with shade the dense ground cover needed to halt stormwater in its stride.

The fourth factor is the winter dormancy of most of our vegetation. Trees along the shores are expected to capture large amounts of stormwater and send it off to the sky via evapotranspiration. But that is a spring-summer affair. For hardwoods and softwood alike, winter absorption of water is a little as one percent of that in summer.[5]

Together these conditions conspire to pass stormwater on through buffers or, underground above the till, create dams of roots that saturate the substrate with obvious effects on the buffer, stormwater, and whatever the water carries.

All of which is exacerbated by buffering on steep slopes. Bluffs aside, Puget Sound shores are not famously steep. Still, shorelines do not slope *uphill* toward the bay.

So, do we need vegetated buffers? If yes, how many miles of them? How wide? With what within them? And if not, what would be on all those miles and acres?

The last question first. Even in downtown Seattle, the principal land uses facing the Sound are residential and recreational. Industrial use is fading, as in Bremerton, Olympia, Bellingham, Tacoma, and on Bainbridge's bays. There is general agreement that, in both our urban core and suburban areas, the shorelines of Kitsap County will retain their residential domain, with shoreline vegetation comprising grass, shrubs, and trees.

Whether formal buffering is needed is largely unknown. Marine shoreline experts, meeting in 2004, concurred that "It was felt that no good science currently exists to recommend vegetation buffer widths in the [marine riparian zone] at this time." And, "Scientifically defensible recommendations for vegetated buffers were felt to be limited to the recommendation of vegetation presence over absence when a choice implicated."[6]

From such a sturdy knowledge foundation it is a bit hard to justify, much less write specifications for, bank-top buffers.

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[4] Schulz, William H. 2007. Landslide susceptibility revealed by LIDAR imagery and historical records, Seattle, Washington. Engineering Geology 89:67-87.

[5] Baker, Frederick S. 1950. *Principles of Silviculture*. New York: McGraw-Hill.

[6] Lemieux, J. P., et al, eds. 2004. *Proceedings of the DFO/PSAT Sponsored Marine Riparian Experts Workshop, Tsawwassen, BC, February 17-18, 2004.* Canadian Manuscript Report of Fisheries and Aquatic Sciences 2680. Vancouver BC: Fisheries and Oceans Canada.

There is nearby stream science relative to buffers.

Riparian research in forestry has included with/without studies of clearcutting versus buffering next to streams. Examples are mentioned here.

Buffering to control stream temperatures with trees' shade has been common, because high water temps are known to cause mortality in salmon eggs. It is also known that higher temperatures increase productivity of the ecosystem, including the biomass of young salmons' prey and the rate of growth of those salmon.

The obvious tradeoff has gradually been quantified. Across western Washington, on nine pairs of logged and unlogged sites, total salmonid biomass averaged 1.5 times greater after streamside logging than in adjacent unlogged sections.[7] In southwest Oregon, despite its warmer climate, on eight streams where 102,000 macroinvertebrates were counted and identified, the organisms were more numerous in reaches lacking any canopy.[8] Again in Oregon, in three watersheds, there was no salmonid mortality in clearcuts despite higher temperatures.[9] On Vancouver Island two whole watersheds were committed to salmon recovery studies. Both areas were clearcut; one was restored, including streamside vegetation. The barren watershed greatly outproduced the revamped watershed.[10]

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[7] Bisson, Peter A. And James R. Sedell. 1984. Salmonid populations in streams in clearcut vs old-growth forests of western Washington. In: Meehan, William R., et al, eds. *Fish and wildlife relationships in old-growth forests, proceedings of a symposium, April 1982.* American Institute of Fishery Research Biologists.

[8] Meehan, William R. 1996. Influence of riparian canopy on macroinvertebrate composition and food habits of juvenile salmonids in several Oregon streams. Research Paper 496. Portland: US Forest Service, Pacific Northwest Research Station.

[9] Hall, James D. and Richard L. Lantz. 1969. Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. In: Northcote, T. G., ed. *Symposium on Salmon and Trout in Streams.* H. R. MacMillan Lectures in Fisheries. Vancouver, BC: University of British Columbia, Institute of Fisheries.

[10] Ward, Bruce R., Donald J. F. McCubbing, and Patrick A. Slaney. 2003. Evaluation of the addition of inorganic nutrients and stream habitat structures in the Keogh River watershed for steelhead trout and coho salmon. In: Stocker, John G., ed. *Nutrients in Salmonid Ecosystems: Sustaining Production and Biodiversity. Proceedings of the 2001 Nutrient Conference, Eugene*. Bethesda, MD: American Fisheries Society.

In a review of such studies, researchers have said:

Increased temperatures following logging, together with increased light levels and increased nutrient concentrations, often lead to general increases in productivity in the trophic levels that form the basis of fish production. Increased temperatures, light, and nutrients all play a role. Temperature directly affects development rates of fish; in some systems, the temperature increases lead to earlier emergence, longer growing seasons, and increased survivals at critical times in the life histories of fish.[11]

A book has been written about large woody debris (driftwood) in streams[12]; there is lengthy discussion in another[13]; and much journal literature that tends to deify driftwood. Meanwhile the 'right' amount of woody debris, presumably differing greatly among sites, has not been determined. In fact a 'let disturbance alone' view is growing.[14] In natural conifer forests a 39-stream study showed that more than 70 percent of the woody debris originated within 65 feet of the stream.[15]

Whether wildlife habitat is affected by a shorn environment along streams has been studied in western Washington. Aquatic creatures are remarkably insensitive to vegetation above the backshore. A study of 62 Olympic Peninsula streams and associated riparian zones concluded that the characteristics and even the presence of the riparian forest had no influence on the persistence of fishes and stream-related birds and mammals.[16] Research on 18 Washington Cascades streams found that total abundance and species richness of birds and small mammals using areas close to streams before any timber harvest were comparable to the number and kinds after harvest.[17]

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[11] Beschta, R. L. Et al. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interactions. In: Salo, E. O. And T. W. Cundy, eds. *Streamside Management: Forestry and Fisheries Interactions.* Contribution No. 57. Seattle: University of Washington, College of Forest Resources, Institute of Forestry Research.

Quoted in Buell, J. W. 2000. Review of Kitsap County draft "Land use & development policies, Critical Areas Ordinance, and supporting documentation". Memorandum 21 January 2000. Portland, OR: Buell & Associates, Inc., Consulting Biologists.

[12] Maser, C., et al. 1989. *From the Forest to the Sea, the Story of a Fallen Tree.* General Technical Report PNW-GTR-229. Portland: US Forest Service, Pacific Northwest Research Station.

[13] Montgomery, David R., et al., eds. 2003 *Restoration of Puget Sound Rivers*. Seattle: Center for Water and Watershed Studies, University of Washington Press.

[14] Tappeiner, J. C. II, et al. 2002. Silviculture of Oregon Coast Range forests. In: Hobbs, Stephen D., et al, eds. *Forest and Stream Management in the Oregon Coast Range.* Corvallis: Oregon State University Press.

[15] McDade, M. H., et al. 1990. Source distances for coarse woody debris entering small streams in western Oregon and Washington. Canadian Journal of Forestry Research 20(3):326-30.

[16] Research by Peter Bisson and Martin Raphael, summarized in: Duncan, Sally. 2003. Science Findings 53 (May). Portland: US Forest Service, Pacific Northwest Research Station.

[17] O'Connell, M. A., et al. 2000. Effectiveness of riparian management zones n providing habitat for wildlife. Final Report. Timber Fish & Wildlife Report 129. Olympia: Washington Department of Natural Resources.

Most residential shoreline buffers are manufactured habitat.

With much of the County's shores developed, including 80 percent of Bainbridge's, mostly for homes, buffers clearly are and will be created, insular habitat.

A University of Washington ornithologist has found that the array of bird species is broader in urbanizing (suburban) areas than in forests. This in the Seattle-Snoqualmie Pass corridor.[18] The reason is the greater range of habitats in developing areas. By extension, birds are more varied in the present diverse landscapes along shores than would live in a uniform buffer perimeter.

Elsewhere, cavity-nesting birds seek out old trees whose branch stubs have decayed on into the trees. But not many here. Four of the five species of cavity nesters designated priority species by WDFW and seen on Bainbridge Island nest elsewhere. The fifth, wood ducks, hang around fresh water. Our marine birds are mostly passers-through, nesting in Alaska and Canada, where they typically don't use trees.

Fisheries ands riparian scientists are skeptical about the permanence and effectiveness of contrived habitats.[19] For one thing, they may have unintended inhabitants: feral cats, crows, coyotes and rats, et al, all of whom we seem to have in sufficient abundance, to the consternation of other wildlife.

Finally, there may be a heads-up in a consultant's statement, "...the legal intent of [nearshore] buffers is to protect functions in adjacent shorelines or critical areas, not to provide upland habitat for terrestrial species."[20]

Everywhere, buffer-width research has shown 'diminishing returns to scale'.

Buffer compilations from across the country do not apply well to the Puget Sound lowland. However in their provinces they consistently show that gain in buffer effectiveness is not proportional to increases in width. A 20-foot buffer is not twice as effective as one 10 feet wide. This is counter-intuitive if one assumes that twice as many trees or twice as much space means twice the absorptive capacity, but there it is. It appears that for sediments and nutrients, in farm country, buffer efficacy is largely 'used up' within 100 feet.

A reason is that natural systems depend on many factors. Assume, for instance, that for winter survival of a species there must be shelter, solar warmth, and prey. Doubling the amount of shelter is unlikely to double survival unless the other factors expand too. However more shelter may make some difference. But only if it is a limiting factor. If shelter is generously abundant there isn't much point in adding more. This is called 'declining returns to scale', and it can apply to buffering.

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[18] Marzluff, John. 2003. Data presented at a seminar on urban ecology, November 7, University of Washington, College of Forest Resources, Seattle.

[19] For instance, Simenstad, Charles A. and Jeffrey R. Cordell. 2000. Ecological assessment criteria for restoring anadromous salmonid habitat in Pacific Northwest estuaries. Ecological Engineering 15:283-302.

[20] Houghton, Jonathan. 2003. Review of incorporation of best available science in proposed City of Bainbridge Island shoreline rules. Edmonds, WA: PENTEC Environmental.

There is an important difference between ‘obligate’ and ‘primary association’.

Lists of important species and their principal habitats tend to obscure that difference.

> *Deermouse droppings and wood duck doo*
> *Critter evidence it’s true*
> *But I don’t know and nor do you:*
> *Do they here reside or just pass through?*

If buffering is the order of the day, grass probably trumps all other vegetation.

Lawns have been scorned as an unsuitable land use, particularly along the shore. It is said that lawns contribute fertilizer nutrients, herbicides, insecticides, and grass clippings to the Sound and all of these are bad. In addition grassy yards use water that otherwise would not be drawn from aquifers.

Grass outranks trees by more than two to one in nutrient absorption and is especially effective in poorly drained soils like our hardpan.[21]

“Oils, most metals and pesticides will generally not be effectively removed by vegetated buffers once they have entered [the ground].”[22] These chemicals typically attach themselves to sediment, so much depends on whether sediment moves along.

Relative to trees and shrubs, grass can be best for erosion control. The reason is the tendency for water moving over a bare surface to draw itself into small channels. The channels lead to rill erosion, and grass prevents the rills. Rills are not prevented by woodland vegetation.[23] Around Puget Sound construction sites, overgrazed pastures, and row-crop farms may be our rather few erosion sites.

Grass uses less water than, say, trees. In summer trees use multiple inches of water per month. Lawn watering of an inch a week is sometimes recommended during droughty weather, though few yards appear to get that much. An advantage of yards is that water use can be controlled; with trees only the tree turns the tap.

Grass is biologically more productive than trees. The primary productivity of yards is greater than that of woods.[24]

“Native” vegetation is a provincial prescription.

It isn’t a technical matter except for the question of whether non-native vegetation is more susceptible to stressors than native kinds.

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[21] Desbonnet et al, 1994, above.

[22] Desbonnet et al, 1994, above.

[23] Desbonnet et al again, above.

[24] Falk, John H. 1980. The primary productivity of lawns in a temperate environment. Journal of Applied Ecology 17:689-696.

‘Non-native’ materials may be cultivars of natives rather than truly foreign. In either case they may have been bred or selected not only for their appearance, scent, or other utility but also for durability. Non-native plant materials may be the rational response to a non-native pest or disease. And many non-native variants have been introduced here because of native diseases and insects.

It seems unlikely that thousands of homeowners, landscapers, and growers will gladly forego showy rhododendrons, roses, and scarlet maples for homely native rhodies, wild roses, and Northwest drab maples.[25]

Listed here are 14 benefits that have been claimed for buffers if placed where now they do not exist.

They are all fairly readily refuted:

- Trees planted along the shore would eventually fall with sediment to the beach, helping marine life without smothering it,
- Trees planted along the shore would stabilize the bank,
- Upland vegetation would everywhere slow and absorb stormwater,
- Buffer vegetation would contribute useful nutrients to tidewater,
- Vegetation zones would serve as barriers to harmful chemicals,
- Insects from buffer trees are an important food source for marine fish,
- Vegetated buffers would displace grass, a good thing,
- An ancient-forest tidewater shoreline would be restored,
- Prescribed buffers are charming,
- Vegetation strips would impose little cost on the community,
- Requiring buffers would not be conscription: It carries little value reduction nor out-of-pocket costs to owners,
- Owners would lose little benefit of the property,
- Children would enjoy no-touch buffers more than lawns, and
- Buffers are generally great places for people.

Refutation is in a separate group of papers.[26]

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[25] More on this subject is in Flora, D. F. 2008. Notes on vegetation nativeness. Available from the author.

[26] Available from the author:

Flora. 2004. On buffers around Kitsap County’s watered places

Flora. 2006. Analyses supporting buffer widths of 50 feet or less

Flora. 2007. A perspective on insects eaten by Puget Sound salmon

Flora. 2008. Tidewater trees: A risk analysis

Flora. 2008. Lawns of grass, an assessment.

Given existing buffering, wider buffers will not:

- Improve shade for surf smelt eggs
- Increase water temperatures to enhance invertebrate production
- Increase large woody debris (driftwood)
- Drop more leaf litter (wrack) onto beaches
- Provide more woodland insects for fishes' diets
- Conserve water for infiltration to aquifers
- Increase eelgrass production
- Increase the abundance of juvenile nor adult salmon
- Improve shoreline habitat functions for salmonids or other resources
- Increase marine habitat diversity
- Broaden the diversity of nearshore vegetation
- Enhance the attributes of resident plant species
- Draw enthusiasm from landscape architects
- Speed the dynamics of intertidal drift zones
- Slow the loss of backshore to the sea
- Provide useful perches for eagles
- Encourage outdoor play by children
- Raise property values and taxes
- Reduce site-specific problems.

Expansion of these points is in Flora, D. F. 2008. Bigger beach buffers for fun and profit.

There are alternatives to buffers that may be cost-effective

Buffers are clearly not a panacea. In fact lawns of grass appear to be a better baseline against which to gauge alternatives:

- For stormwater - ponds, furrows, berms, Low Impact Development, and (according to King County) even paved routes in some places.
- For sediment - grassy swales
- For insecticides and herbicides - using short-half-life materials
- For toxic chemicals - abstinence and abatement
- For bacteria - functioning septic systems
- For wildlife - existing designated open space: leafy verges, parks, meadows, beaches, and inland woodlands that also serve as children's places.

Some notes on vegetation and nativeness.

Vegetation is native if it's from Puget Sound.

The County CAO's definition of native vegetation refers to species that are indigenous to the Puget Sound lowlands. This presumably includes recent arrivals like Douglas fir that has been here only 3-4 thousand years, at most eight fir-tree generations. It certainly includes Oregon white oak, which has been here longer. And Oregon grape, Oregon ash, Oregon crabapple, Oregon tea-tree, California rose-bay, all 'natives'.

'Indigenous' includes plants that arrived here before and after a cooling of the climate several millennia ago. Clearly 'native' is a relative term, especially since none were here ten millennia ago. In short, nativeness is an elastic matter.

The Growth Management Act points out that the worth of vegetation depends on its 'functions and values'.

These aren't listed but presumably functions include protection of the ground, control of stormwater movements, stabilizing slopes, and along the shore, providing habitat for shoreline-inhabiting wildlife. Wildlife nurture may be considered a value, albeit both good and bad. Other values are aesthetics and protection of property rights, the latter specifically mentioned in GMA.

Structural functions do not depend on species nativeness.

Stormwater streaming toward the Sound, rolling overland or riding about hardpan soils, is of course indifferent to nativeness. What matters is physical barriers in the form of stems, roots, and grass blades. Native shrubs and grasses do this as well as others presumably. None do it well; this is the subject of another paper.

Stabilizing the shore, attributed to root wads, is either good or bad depending upon whether the occasional failure of 'feeder bluffs' (i.e., all banks and bluffs) is preferred. Some of our better grippers are exotic, e.g. Scotch broom. Others, like Cascara, are regional natives. Unfortunately good grippers, with their dense root networks, also encourage saturation of shore-top soils, leading to slope failures. An advantage of Scotch broom and other shrubs is that they never grow tall, heavy trunks that lever trees and their rootwads over the side.

Nor are Kitsap wildlife very discriminating.

Wildlife depend on native plants. We wish. Like non-native roses, non-native raspberries, and non-native geraniums.

Density, vertical structure, succulence and bugginess seem to favor wildlife, almost regardless of nativity. A ground cover of ivy is seemingly more useful to ground-abiding birds and animals than the alternative, which appears often to be bracken ferns and weeds. True firs from afar attract raccoons, small birds, eagles, and more, as well as native firs.

But landscapers certainly are.

With miles of buffers under discussion, many of those buffers would be in places that would otherwise be landscaped. The prospect of Puget Sound's rather narrow array of species, repeated endlessly, is an affront to homeowners who take pride in designing and maintaining their surrounds. The popularity of diversity is clear during tours of homes and visits to nurseries. Indeed, nurseries would be sorely affected by a nativeness constraint.

Aesthetically many people prefer, say, red maples over native maples; scarlet oaks to native Oregon white oaks; non-native, showy cultivars of rhododendrons over the rather uninteresting native species; tasty and productive apples over the native crabapples; the same argument for non-native plums and cherries relative to natives; redwoods relative to firs; mountain ferns relative to lowland natives, weeping birches over locals, cultivated roses over thorny natives, alien daffodils over native ditchgrass, and so on. Few Kitsap yards have wholly native species. While, with a stretch, one may point to hundreds of native Puget lowland plant species, "exotics" offer us thousands.

The usual arguments against non-natives are these:

Durability. Non-natives aren't attuned to our climate. Generally untrue; meanwhile some of our natives, including oaks and dogwoods, are fading. Many non-natives come from climates similar to ours, and our climate is clearly favorable for plant growth. Owners seem willing to give extra care to seemingly fragile plants, and replace those that fail. That means extra effort and expense, but it is an option that owners should have.

Durability relative to insects and diseases. Actually a concentration of any species invites attack. Native forest trees are having a rough time because of beetles. Gypsy moths are sweeping toward us, attacking all broadleaf species. Native dogwoods are dying. Native bracken ferns are less evident. Counterpart species from elsewhere are chosen, in some cases, for their resistance to pests and pestilence.

Native apples, cherries, and plums have been bred away from their susceptibility to insects and disease. We've been glad to see varieties other than native crabapples, Indian plums, and wild cherries. Aside from appearance and durability, the alternative species save us from having to search T&C's produce bins for worm-free produce and give us a broader array of varieties, while making fruit more economic for both grower and consumer.

Invasiveness Native plant and animal species are here because of their invasiveness over recent centuries. Indeed, every species on earth is invasive. And every native species is invasive within its province or it is displaced. 3000 years ago the prevailing plant species here were oaks and grasses. Even within its shady domain, the shy trillium presses outward against all comers, and obviously wins with some frequency. Salal and salmonberry, natives both, have become invasive nuisances west of the mountains and especially toward the coast. So using 'invasiveness' as an argument against non-natives seems ironic.

All organisms are invasive, constantly probing, intruding, occupying, or retreating. This has been widely seen in salmon (good) and spartina (bad).

Local nurseries are replete with invasives--plants that, given pleasant environments, enlarge their garden presence.

All native species are invasive in their provinces, or they would not be here. Salal and salmonberry, both natives, have become invasive nuisances along the coasts of Washington and Oregon. Even within its shady domain, the shy trillium presses outward against all comers, and obviously wins with some frequency.

Invasion includes movement across bare ground. Without invasiveness vegetation would not spread across disturbed areas. By ruling out invasive exotics we foreclose most perennials. And indeed most useful exotics. Landscapers will not be pleased.

Nor will they be pleased if we prohibit invasive natives. Yet the ecologic effect, such as saving mosses from fescues or vice versa, would be comparable.

Meanwhile the State has compiled lists of aggressive plants that are actually harmful. Perhaps citing this list is more useful than forbidding all exotic species.

Lawns of grass, an assessment.

Kitsap County's charm flows partly from its lawns. Grassed lawns have played an admirable environmental role. Readers are reminded that, for other reasons too, lawns are and have ever been immensely important places.

These pages report research showing that replacing lawns with non-grass vegetation will not likely reduce alleged potential problems with excess nutrients nor 'pollutants'. Certain heavy-duty chemicals, released steadily and copiously, are likely to sluice through vegetation, regardless of its kind. This because of our stormwater's habits. However no kind of vegetation surpasses lawn grass in absorbing pollutants of all kinds.

Vistas, meadows, and lawns are hallmarks of pleasant lifestyles in every developed region of the world. They are celebrated in centuries of art, poetry and prose. Provincially they are implicit in the state's Growth Management Act and the Smart Growth agenda.

Locally questions have been raised about the laudability of lawns and the goodness of grass. Some have proposed that the City endorse and commit resources to replacement of lawns.1

It appears that issues about lawns devolve largely into concerns about what comes from, goes across or flows under lawns. Here are some of those issues with findings from the technical literature. Overall, as with other Island natural systems, lawns are complex places to which simple assumptions may not apply.

Yards, Lawns, and A Children's Place

Why is all this important? Because families coming here look forward to an outdoor place for children.

However, in land-use planning, a children's place is becoming an afterthought. Sad that, with buffering and the condo flood, yards are fading. Without yards and grassy home places what refuge is there for kids? Where will be the places to romp? Where will be the backyard swing sets, sandboxes, Radio Flyer wagons, croquet layouts, tent pitches, and private places to run and dream?

[1] CAO Non-Regulatory Citizens Working Group. 2004. Matrix of recommendations for Land Use Committee [of Bainbridge Island City Council] re: Critical Areas Ordinance non-regulatory options. April 27, 2004. On file at Bainbridge Island Department of Planning and Community Development.

Presumably they'll be wedged among the requisite shrubs, 'native' groundcovers and Astroturf-like surfaces. Because all chemicals are very bad and lawns are surfeited with them.[2] However these underlying declarations of danger are largely false.

Hardpan, Climate, Vegetation, and the Stormwater Story

Across northern states the continental glaciers left a rich legacy of lakes and wetlands, and a belt of farm-poverty-producing soils: bedrock, gravels, and compressed hardpan. Bainbridge got some of all three: 350-plus wetlands, areas of hard rock and gravels, and a heavy harvest of hardpan. Which says much about *where* our stormwater goes.[3]

Our peculiar climate says it all about *when* surface water flows. In contrast to most other U.S. regions we have scant summer rainfall. We lack the brief but intense local "convectional" storms that provide summer runoff.[4] And our prolonged winter rain events add other unusual regional dimensions, not the least of which are leaky buffers and saturated soils.

Our vegetation is special too. It's irrepressible, providing a useful rain softener in almost all places and seasons, in some combination of surface veg, shrubs, and trees. Bare ground is an oddity. However a key fact is that most vegetation goes dormant in winter. For hardwoods and softwoods alike, winter transpiration is as little as one percent of that in summer.[5]

Together these three factors - soils, climate and vegetation profile - make us different relative to stormwater.

Why tell this stormwater story? Because stormwater is the prime mover of nutrients and pollutants, for better or worse, across the landscape including lawns and all other vegetation.

Prolonged (winter) rains soak into upper soil horizons as far as the hardpan, which can be a matter of only inches. The glacier-compacted subsoil accepts water very slowly, perhaps an equivalent of .06 rainfall inches per hour.[6] At that rate, after a week the hardpan is wetted downward only 1-2 feet. Meanwhile rainwater (and other fluids) drain downhill on the hardpan's surface, toward surface seeps at wetlands, ponds, and creeks. This subsurface flow diverts water from aquifers but it is critical to streams.

Vegetation matters. Roots have trouble invading the hardpan, but they impede water sliding along through the surface soil. The root-soil combination can be an effective dam, saturating the soil on the uphill side.

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[2] For example, Cruickshank, Cara. 2002. "Get your lawn off drugs:" the natural landscapes project. Scotch Broom. Autumn.

[3] There is a soil-type survey done by the U.S. Department of Agriculture covering all of Kitsap County.

[4] Hornbeck, James W., et al. 1984. Forest hydrology and watershed management. In: Wenger, Karl F., ed. Forestry Handbook (Society of American Foresters). New York: Wiley.

Hewlett, J. D. 1982. Principles of forest hydrology. Athens, GA: University of Georgia Press.

[5] Baker, Frederick S. 1950. Principles of Silviculture. New York: McGraw-Hill.

[6] A calculation based on equations and data in: Washington Department of Ecology. 1992, 2000. Stormwater management manual for the Puget Sound basin [with amendments], Section III. Soil type D.

Vegetation aboveground helps in three ways. One is physical obstruction of moving water, typical of grass. Another is absorption, by the settled leaf litter under vegetation, including grass clippings. The third is uptake of water in the course of photosynthesis, a growing-season-only factor.

Lawns and Erosion

Sediment is widely cited as a threat to wetlands and streams[7], going back decades to times of rampant logging, land clearing and farming across America. An active construction area is said to produce about 2000 times as much sediment as a fully vegetated area.[8]

However the erosion concern may be beating a dead horse. I suspect there were three periods in Kitsap history when erosion was prevalent. One was the 1870s and 80s, when logging and burning reached almost everywhere. Another was the era of stump ranching when everybody had livestock and overgrazed pastures were the norm. The third was the time of strawberry farms when much of the island was kept clear for berry culture, with long rows of bare soil exposed to winter rains.

Our present era of abundant vegetation and a cultural aversion to bare dirt mitigate against surface erosion. A few pastures are still with us, but given sensible animal management the Island's risk of rill erosion, the main source of sediment outside construction sites, is probably nil. Certainly woods and subdivision lawns don't carry that risk.

Stormwater in Flood Mode

However, overland flow of the waters not retained by vegetation or floodwater restrainers can wash away the accumulated dead leaves and twigs that make up forest duff, stripping the ground back to the underlying hardpan. Grass bends its head and lets the water flow over[9], but the woodland detritus has almost no capacity to cling.

[7] Desbonnet, Alan, et al. 1994. Vegetated buffers in the coastal zone, a summary review and bibliography. Coastal Resources Center Technical Report No. 2064. Narragansett, RI: University of Rhode Island Sea Grant.

[8] U.S. Environmental Protection Agency. 1976. Erosion and sediment control in surface mining in the eastern U.S., Volume 1, Planning. EPA Technology Transfer Seminar Publication EPA 625/3-76-006. Cited in: Barfield, B. J., et al. 1977. Prediction of sediment transport in a grassed media. Paper No. 77-2023. St. Joseph, MI: American Society of Agricultural Engineers.

[9] Ree, W. O. 1949. Hydraulic characteristic of vegetation for vegetated waterways. Agricultural Engineering 30(4):184-9. Cited in: Barfield, et al, above.

These sluices through the bushes are junior versions of the woodland debris flows that Northwest scientists have been studying for decades.[10] Such flows are narrow, sudden, and sodden. They surge through wooded buffers into streams. Scoured out along the way are surface vegetative litter and duff and their algae, fungi, and fauna. A legacy is the woody debris that shelters fish and kills kayakers. Small versions of these flows are common in ravines all around Puget Sound.

Aside from trenching against the torrent or routing water into closed conduits, the best protection against erosion is stormwater capture at the top of the slope. No matter what the groundcover, water moving across the ground tends to concentrate, carving out tiny rills that merge into bigger channels. This can be seen in gardens in which shrubs are open-spaced. "...naturally occurring vegetated buffers are generally incapable of inducing sheet flow from storm water runoff ..." and "The natural tendency of water to move in discrete channels may be one of the greatest impediments to successful buffer implementation for nonpoint source pollution control..."[11] Up-slope capture leads to ways to encourage infiltration, mentioned next.

Aquifer Recharge and Yard Vegetation

How best to enhance infiltration of (presumably clean) stormwater? In a land of extremely dense glacial tills, adjusting vegetation would seem to have little merit, unless the till sill is narrow enough that tree roots can break through. Unless the roots block the breakthrough. I know of no Puget Basin research on this matter.

One objective is to delay stormwater long enough to allow it to infiltrate downward. Our winter storms are long enough that stormwater tends to roll over grass, run across bare ground around shrubs, and right on through woodland duff. Especially on steep ground. An option that works, although site-specific and generally expensive, is 'low impact development' (LID), which embraces water gardens, permeable pavements, small structural and roadway footprints, rain barrels – a landscape reminiscent of the 1930s.[12]

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[10] For example (there are scores of relevant pubs):

Swanson, F. J. Et al. 1982. Material transfer in a western Oregon forested watershed. In: R. L. Edmonds. Analysis of Coniferous Forest Ecosystems in the Western United States. Stroudsberg, PA: Hutchinson Ross Publishing Co.

Swanson, F. J. et al. 1987. Mass failures and other processes of sediment production in Pacific Northwest forest landscapes. In: Salo, E. O. And T. W. Cundy, eds. Streamside management: Forestry-fishery interactions. Seattle: University of Washington.

Swanson, F. J. et al 1998. Flood disturbance in a forested landscape. BioScience 48(9):681-9.

Skaugset, A. E. Et al. 2002. Landslides, surface erosion, and forest operations in the Oregon Coast Range. In: Hobbs, S. D., et al, eds. Forest and Stream Management in the Oregon Coast Range. Corvallis: Oregon State University Press.

[11] Desbonnet et al, above, p. 10.

[12] An array of such treatments is in:

Hinman, Curtis. 2005. Low impact development – Technical guidance manual for Puget Sound. Olympia and Tacoma respectively: Puget Sound Action Team and Washington State University's Pierce County Extension.

A King County analysis concluded that "...if a forested area is replaced with a paved surface for which runoff is collected in a recharge pond, net recharge may be greater than under the original condition in which much of the precipitation is lost to interception and evapotranspiration."[13]

This says little about lawns, except that infiltration (retention) ponds are typically lined with grass and other vegetation is excluded.

Given that our residential open space is invariably covered by some kind of vegetation, and all veg draws water from below, choosing least-thirsty plants has appeal. A woodsy setting transpires perhaps 2,000 to 4,000 tons of water per acre per summer.[14] During that time, a watered lawn might use 1800 tons over four months.[15]

A further advantage of a managed lawn is that water use can be controlled by the turn of a spigot. Trees, those great water conduits to the sky, keep right on doing their thing.

Septic Output and Lawns

Septic systems discharge whatever goes into them, of course, if one includes periodic pumping. Around Puget Sound two septic products, both involving drainfields, generate special concerns. These are coliform bacteria and nitrogen.

Fecal Coliform is a goner in a standard, maintained septic system (tank plus field). EPA reports that 99-99.99 percent removal is common.[16] Recently the Kitsap County Health District surveyed some 50 miles of shoreline along Hood Canal, finding only 13 septic systems needing attention.

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[13] King County Department of Natural Resources and Parks et al. 2004. Best available science, Volume 1. P. 6-20, citing:

Bidlake, W. R. And K. L. Payne. 2001. Estimating recharge to ground water from precipitation at Naval Submarine Base Bangor and vicinity, Kitsap County, Washington. Water-Resources Investigation Report 01-4110. U.S. Geological Survey. [Place of publication unk.]

King County also says (same report, p. 6-17), "The routing of storm water into infiltration systems is the preferred method for storm water management in Washington..."

[14] 2,000 tons is based on research by Prof. Leo Fritschen at the University of Washington. He measured transpiration for a second-growth Douglas-fir by putting an adult forest tree into a very large pot, called a lysimeter, which measured how much water the tree took up. It corresponded to about 20 inches of rain per year. This in the Cedar River watershed.

4,000 comes from Buell, Jesse H. 1949. The community of trees. In: Trees, the Yearbook of Agriculture.

[15] This is based on the common Puget Sound prescription of one inch of water per week. I doubt that most people use that much.

[16] U.S. Environmental Protection Agency. 2002. Onsite wastewater treatment systems manual. EPA/625/R-00/008. Cincinnati: National Risk Management Research Laboratory.

A key factor in septic-system success is, of course, free flow of fluids through the drainfield's dispersal pipes. Which accounts for regulators' insistence on grass rather than deeper-rooted plant covers.

Nitrogen, essential to all proteins and thus to all animals and plants, is both nuisance and necessity in the Puget Sound country. Nuisance because in some wild waters nitrogen is a limiting factor to the reproduction of algae. Adding nitrogen can support explosive growth of these marine and freshwater plants that are at the bottoms of many food chains as well as adding oxygen. That's good, but excess algae die, decompose, and the decay organisms use up oxygen, a process to which fish deaths in Hood Canal have been attributed.[17] Some lakes, and probably some West Side wetlands, have been oversupplied with nitrogen, creating an excess of algae in a process called eutrophication.

The necessity side relates to dry-land plants all around, from lawns to forests, and famously to fish, in freshwater streams. So deficient that adding fertilizer to streams has markedly increased invertebrate populations and the numbers and sizes of juvenile salmon.[18] Volunteers have been carrying salmon carcasses from hatcheries to backcountry streams.[19] Wipfli, Mark S. et al. 2003. Marine subsidies in freshwater ecosystems: salmon carcasses increase the growth rates of stream-resident salmonids. Transactions of the American Fisheries Society 132:371-381. [Results in Southeast Alaska]

Elsewhere, nitrogen abounds. There is four times as much nitrogen as oxygen in air. Ocean upwelling brings huge amounts into Puget Sound.[20] Animal doo and decaying vegetation may be the main sources of nuisance nitrogen on the Island. Alder trees are great nitrogen-fixers,

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[17] Fagergren, Duane, et al. 2004. Hood Canal low dissolved oxygen - Preliminary assessment and corrective action plan. Puget Sound Action Team and Hood Canal Coordinating Council. [Processed. Place of publication unknown.]

Paulson, Anthony J., G. L. Turney, et al. 2004. An analysis of nitrogen loading to Hood Canal. Preliminary results, subject to revision. Tacoma: U.S. Geological Survey. Two papers at http://wa.water.usgs/projects/hoodcanal.

[18] Ward, Bruce R., Donald J. F. McCubbing, and Patrick A. Slaney. 2003. Evaluation of the addition of inorganic nutrients and stream habitat structures in the Keogh River watershed for steelhead trout and coho salmon. In: Stocker, John G., ed. Nutrients in salmonid ecosystems: Sustaining production and biodiversity. Proceedings of the 2001 Nutrient Conference, Eugene. Bethesda: American Fisheries Society.

[19] Bilby, Robert E., et al. 1998. Response of juvenile coho salmon (*Oncorhynchus kisutch)* and steelhead (*Oncorhynchus mykiss*) to the addition of salmon carcasses to two streams in southwestern Washington, U.S.A. Canadian Journal of Fisheries and Aquatic Science 55:1909-1918.

[20] Harrison, P. J., D. L. Mackas, B. W. Frost, et al. 1994. An assessment of nutrients, plankton, and some pollutants in the water column of Juan de Fuca Strait, Strait of Georgia and Puget Sound, and their transboundary transport. In: Proceedings of the BC/Washington Symposium on the Marine Environment, January 13 & 14, 1994. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1948. Ottawa [?]: Fisheries and Oceans Canada.

using nodules on their roots.[21] Drainfields are probably trivial troublemakers given recent estimates along Hood Canal.[22]

Septic nitrogen is not well-processed inside a septic tank. Its return to the atmosphere involves a change from ammonia to nitrite, then nitrate, then (via bacterial action) to gas. This needs to happen in the "vadose" (porous, unsaturated) zone in and around the drainfield. So it's no surprise that grass outperforms woodlands by 2 to 1 in protecting aquifers and water places from nitrogen.[23]

Phosphorus Plus Some of the Really Bad Stuff

These are chemicals that cling to sediments. As goes surface erosion so go these things. Some, including phosphorus and many organic chemicals, move from the sediments to roots and up into plants. This assuming the plants are actively taking up water. We are fortunate here in having a long growing season and ground covers that stay green. The bad bit can be saturation. Saturation with the chemicals, harming the plants. Or saturation by stormwater that carries the soil particles on down the hill.

An asset of wetlands here is their abundance of clay-sized bottom sediments. By adsorption these gather phosphates, toxics and metals. Our wetlands' typical low (acid) pH helps too. This may seem a strange function for wetlands, but DOE has said that a function of wetlands is to trap and transform chemicals and improve water quality in the watershed.[24]

You may well disagree. Be of cheer. There's a consensus that, overall, grasses "...are generally able to respond rapidly to increased concentrations of nutrients, grow rapidly and densely, and typically grow well in nearly all climates. Thickly planted, clipped grasses provide a dense, obstructive barrier to horizontally flowing water. This increases the roughness of the terrain, which reduces flow velocity, promotes sheet flow, and increases sediment and adsorbed pollutant removal efficiency."[25]

Too, grasses have an advantage over other vegetation in their greater capacity (per square foot) to absorb otherwise unwanted chemicals. This because of their higher "primary productivity".[26]

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[21] Bollen, W. B. And K. C. Lu. 1968. Nitrogen transformation in soils beneath red alder and conifers. In: Trappe, J. M., et al., eds. Biology of alder. Portland: USDA Forest Service, Pacific Northwest Research Station.

Edmonds, R. L. 1980. Litter decomposition and nutrient release in Douglas-fir, red alder, western hemlock, and Pacific silver fir ecosystems in western Washington. Canadian Journal of Forestry Research 10:327-337.

[22] Flora, D. F. 2005. An ocean view from the foot of Hood Canal: A different perspective on the dead zone. Bainbridge Is.[processed].

[23] Desbonnet et al, above.

[24] Paraphrased from : Sheldon, Dyanne et al. 2003. Freshwater Wetlands in Washington State, Vol. 1: A Synthesis of the Science (Draft, August 2003). Olympia: Department of Ecology. P. 2-5.

[25] Desbonnet et al, above.

[26] Falk, John H. 1980. The primary productivity of lawns in a temperate environment. Journal of Applied Ecology 17:689-696.

Fertilizers and Yard Chemicals Generally

Farmers, foresters and landscapers are economically and biologically shrewd. They have a strong incentive to minimize the use of expensive chemical treatments, so most operators do soil testing as part of site- and time-specific fertilizing. Some homeowners resort to soil analyses, but most can readily judge when grass and shrubs have gotten greener and taller and trees are adding new growth.

As with fertilizers, the extent of use of herbicides and insecticides here is unknown. Insecticide use may increase as we see an influx of gypsy moths to decimate flower and vegetable gardens and deciduous trees, perhaps followed by the Asian gypsy moth that will take conifers. Not to mention rusts, wilts, mildews, galls, chewers, girdlers, and wasps. Native plants will presumably be especially susceptible as these (and most other harmful) insects come from abroad. Another challenge to creative chemistry will be mosquito-borne West Nile disease and, with regional warming, malaria.

Grass has advantage over less-dense plantings like shrubs because of its structural integrity. Invaders like Scotch broom, laurel, poison oak and blackberries are better repelled by lawns. And grass establishes that tight cover in weeks rather than the years required by even broadleafed-tree litter.

Concern about yard chemicals should be moderated by the fact that chemicals are applied mostly in seasons in which stormwater will not wash them away before they decompose.

There are yard and buffer chemicals that meet these environmental standards:[27]

Persistence. A half-life of less than 30 days is a recommended objective.

Adsorptivity. The tendency of a chemical to adhere to soil particles rather than passing through to groundwater or horizontally to streams. The coefficient is K, preferably above 300.[28]

Solubility in water. Less than 30 mg/L is considered desirable, especially if persistence is high and adsorptivity is low.

Petroleum Products and Industrial Chemicals

There are heavy-duty chemicals, including organics and heavy metals, in Puget Sound. Familiar names are zinc, lead, mercury, copper, PAHs, PCBs, dioxins, and furans. Most of the Sound's contaminated sediments are associated with industrial areas, and the great majority lie in Elliott Bay.[29]

The weakness of buffers, including lawns, applies also to petroleum products and heavy metals. It is argued that vegetation, by capturing rainwater, also absorbs the chemicals. It does,

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[27] Mulla, David J. Et al. 1996. Clean water for Washington - Pesticide movement in soils - Groundwater protection. Extension Bulletin 1543. Pullman: Washington State University Cooperative Extension.

[28] K is the 'partition coefficient', the ratio of adsorbed to dissolved pesticide concentrations per 1% of soil organic carbon content. Knew you'd wonder.

[29] Map in Puget Sound's Health 2002, published by Puget Sound Action Team [formerly Puget Sound Water Quality Action Team].

but only in the growing season and only up to a point: plants have a limited capacity for the chemicals they don't need.

Even woodlands become overwhelmed, especially where soils are dense and slow to absorb water, as on much of the County. The hardpan helps keep chemicals out of aquifers but speeds the chemistry downhill to wetlands and creeks. So pervious are woods that a research compilation points out that 300-foot wooded buffers are no more effective than 6-foot buffers.[30]

Stormwater dilutes these chemicals but they don't dissolve; they just ride the wave of water to wherever they settle. As lawns and other buffers become saturated with water they can also be saturated with the bad stuff.

The primary enduring solution to chemical pollution is cutting off chemicals at the source. This is not an indictment of septic systems, lawns, nor suburban life. Snohomish County, in an assessment of their many lowland lakes, found that the quality of lake water is better where shores are lined with homes than where they are not.[31]

Lawns, Grass, and Native Vegetation

Lawns preserve a heritage of native grass. The key lawn grass species here are fescues, descendants of the grass that predated fir trees in the Puget Lowland. Remnants of the grass-oak savannas remain from Victoria south into California.[32] It is ironic that restoration of those grass-based environments is a key element of conservation these days, while some folks would have grasses diminished.

If Not Grass, What?

Presumably some other vegetative child-friendly groundcover. Ideally, one that provides all the functions and values of grassed lawns with less expense or hassle. A challenge indeed.

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[30] Desbonnet et al, above.

[31] Williams, Gene and Heidi Reynolds. 2003. State of the lakes report. Everett: Snohomish County Public Works, Surface Water Management.

Tidewater trees:
A risk analysis of trees above, on, and near the shore.

Recent shoreline planning has typically called for vegetated buffers, including trees. An underlying presumption is that, where trees are absent, they can be established and will endure. Addressed here is their falldown potential.

Examined specifically are vintage outlier trees, trees that have slid to the beach, and arboreal buffers. Specific questions and their short answers are:

Might old outlier trees outlive us all? Yes, but their risk of blowdown or collapse-after-decay is high.

Are trees on the backshore, having arrived in a landslide, apt to survive? Yes, if most of the roots are still embedded above saltwater's reach.

Can a narrow corridor of trees above the shore be safe and thrive? Yes, but many will die of crowding, and some windblown trees along the back and fore sides can be expected to fall, unexpectedly.

What risk factors can we alter? Wind, diseases, pests largely elude us. Ground saturation by stormwater can be reduced, by well-known methods.

Does edge-tree mortality argue for wider buffers? That's beyond the scope of this paper, involving protection alternatives, land uses foregone, and creating a broader field of risk, including adjacent residences.

In the main, trees in the Puget Sound country are irrepressible. So is change in natural forest cover. Several thousand years ago the Puget lowland was an oak-grass savanna. A dozen tree generations later the pioneering success of Douglas firs and bracken fern is obvious.

In 1792, George Vancouver saw an unbroken distant skyline of trees above Hood Canal. But the nearshore view was broken, presumably because of forest fires. It has been estimated that old growth forests occupied about 40 percent of the land; the rest was old burns slowly regenerating.[1]

A century later all of Puget Sound's islands had been logged and cutting had reached 1 to 2 miles inland from tidewater elsewhere.[2] Many of today's old shoreline remnant trees were seedlings then. 100-year-old fir and cedar trees are now called 'late successional', and for

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[1] Pacific Northwest Research Station. 2003. *Science Update.* Issue 4. Portland, OR: USDA Forest Service.

[2] U.S. Geological Survey. 1898. 19th annual report, Part V. Washington DC.

many people they have come to be as inspiring as ‘ancient-forest’ old growth. Today’s ‘second growth’ is more probably third or even fourth growth. Any of those generations could have spawned the relict shore-top trees of today.

After being denuded by logging, burning and farming, Bainbridge Island has regained nearly a million trees, an average of about 60 trees per acre. That may be typical of Puget Sound’s other exurban areas.[3]

Bluff-top isolated trees are at risk.

Shaggy old trees standing tall can frame views and support raptors surveying the neighborhood. A solitary tree on a shoreline bluff can have considerable aesthetic appeal.

It can also be a target. Field experience suggests that a 30-mile wind will pull of twigs and some minor branches; a 40-mile wind will take a number of large branches; and a 50-mile wind can break or even topple many trees. 50-mile winds occur, on average, every 7 years.[4]

Most shoreside trees lean toward the beach because they have had more light-seeking branches on that side, and because the bank may be creeping. Related is the steady upward and outward growth of trees, especially those in sunny, well-watered places. Regardless of lean, trees are heavy (30-40 pounds per cubic foot)[5], which makes their places along bluffs especially prone to collapse. Unnoticed as years go by, size can become apparent suddenly.

If stubs of previously broken branches have admitted decay organisms the situation is not improved.[6] And the posture of isolated trees can be destroyed by their being rocked in ordinary winds, especially at the edges of slopes where wind speeds are highest.[7] This says nothing about the effects of saturated soils, discussed later.

Legacy trees may be several species. Around the Sound each species, native or otherwise, has its ecologic niche, and the niches overlap. Firs, cedars and madrones are durable and common. Oaks are admired in the north Sound. Alders are uncommon as loners, brittle, and relatively short-lived. Birches are vulnerable. Shore pines are picturesque but not statuesque.

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[3] There is an abundant literature now on urban forestry, much of it applicable to the welfare of Puget Sound, but not arrayed here.

[4] Finlayson, David. 2206. The geomorphology of Puget Sound Beaches. Puget Sound Nearshore Report 2006-02. Seattle: University of Washington Sea Grant Program. The experience figure applies to West Point in Seattle.

[5] Forest Products Laboratory. 1987. *Wood Handbook.* Agriculture Handbook 521. Washington DC: US Forest Service.

[6] Scharpf, Robert F. 1993. *Diseases of Pacific Coast Conifers.* Agriculture Handbook 521. Washington DC: US Forest Service.

[7] Jones, Leland B. 2003. Puget Sound shoreline erosion and erosion control. Bainbridge Island [processed].

With our soil-climate combination, ground saturation is an issue for trees.

Glacial-till (hardpan) soils that constrain water infiltration[8] and heavy winter rains conspire to saturate soils at the intersections of upland slopes and backshore scarps.

Saturated upshore soils are common in the central Sound. In a study of 1308 historic landslides in Seattle, a geologist estimated that nearly all of Seattle's slides are triggered by heavy winter precipitation.[9]

Across much of the continent, deeply bedded tree roots help hold soil in place. But there are important exceptions. One is on forest slopes where road-related debris torrents tear down steep slopes. Research shows that in these places, surface erosion is otherwise minor, despite clearcutting.[10]

The other place is here, where rootwads are pan-shaped because of the near-surface glacial tills. The root concentrations dam near-surface water; hence saturation. Along streams, roots may help hold soil in place. Beside the Sound soggy soil aids the departure of many root systems.

Shoreside trees below bluffs are common.

The problem is compounded by shallow-rootedness caused by the hardpan. A famous observer in 1903 said, "Much of this windfall occurs among shallow-rooted trees, or where the ground is soft because soaked with water..."[11] In 1909 a forest scientist pointed out that wind causes damage "By breakage of crowns or branches, thus allowing access to fungi and to insects; and by breakage of stems at their point of least resistance; and by uprooting trees singly."[12] And a half-century later, "Shallow-rooted trees are always likely to be uprooted and thrown down by heavy winds, especially when they are growing in moist soils containing little rock."[13] Nothing has changed in the isolated-tree department.

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[8] Shipman, Hugh. 2004. Coastal bluffs and sea cliffs on Puget Sound, Washington. In: Hampton, M. A. And G. B. Griggs, eds. *Formation, Evolution, and Stability of Coastal Cliffs - Status and Trends.* U.S. Geological Survey Professional Paper 1693. Washington DC: US Department of the Interior.

[9] Schulz, William H. 2007. Landslide susceptibility revealed by LIDAR imagery and historical records, Seattle, Washington. Engineering Geology 89:67-87.

[10] Skaugset, Arne E., et al. 2002. Landslides, surface erosion, and forest operations in the Oregon Coast Range. In: Hobbs, S. E., et al, eds. *Forest and Stream Management in the Oregon Coast Range.* Corvallis: Oregon State University Press.

[11] Pinchot, Gifford. 1903. *A Primer of Forestry Part I - The Forest*. Division of Forestry Bulletin 24. Washington DC: US Department of Agriculture.

[12] Schenck, Carl A. 1909. *Forest Protection - Guide to Lectures Delivered at the Biltmore Forest School.* Asheville, NC: The Inland Press.

[13] Baker, Frederick S. 1950. *Principles of Silviculture.* New York: McGraw-Hill.

Some of them survive.

A dislodged tree may fall head-first to the beach, but many are carried down with slumping earth, down but not necessarily out. Their need is to keep some roots and foliage above the reach of saltwater. The minimum proportion has not been established. Here the advantage of a bulkhead at the base of the slope is obvious - it can keep much of the tree aloft.

Perhaps the worst case is a tree lying prone on the beach, head outward. If the bole is directly on the beach it creates a groin, bad for transient beach sediments. If the tree is elevated a bit by remaining branches it may create a hard shadow line that deters passing juvenile fish.[14]

In any case, falling bluffs are not a well-organized way to establish verdure behind bulkheads nor put woody debris on the beach.

Trees at the top are discouraged by experts:

“New major trees should not generally be established on the face of coastal slopes...Large trees should be used on the face of slopes sparingly and with caution. Should these trees collapse because of undermining of the root system by erosion or by windthrow, large volumes of earth can be disturbed by the tree roots when they pull from the slope. The resulting large, bare areas are opened to further erosion, which may endanger adjacent land and vegetation.”[15]

“Any process that adds weight to the top of a potentially unstable slope can increase the risk of sliding....Vegetation growth increases weathering of soils and root action can, particularly in compact units like glacial till, loosen natural fractures and joints in the material, leading to failure. Movement of trees by wind stress may loosen soils, enhancing infiltration and, in some cases, may impart significant loads to the slope itself that may trigger failure.”[16]

“For [glacial till] bluffs to become and remain stable they should be planted with shrubs and trees not more than 15 feet high, and no tall trees should be allowed to grow landward of and close to the top of the slope...Large tees, especially firs, are at greatest risk of failure from high wind velocities. The wind velocities cause the trees to fail by rocking back and forth, and are especially susceptible to failure near the brows of the slope where wind velocities are highest.”[17]

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[14] Southard, S. L., et al. 2006. Impacts of ferry terminals on juvenile salmon movement along Puget Sound shorelines. Sequim: Battelle Memorial Institute. Also Flora, D. F. 2008. Pressing on... (in this packet).

[15] Myers Biodynamics, Inc. 1993. Slope stabilization and erosion control using vegetation, a manual of practice for coastal property owners. Publication 93-20. Olympia: Washington Department of Ecology.

[16] Shipman, Hugh. 2001. Coastal landsliding on Puget Sound: A review of landslides occurring between 1996 and 1999. Report 01-06-019. Olympia: Washington Department of Ecology.

[17] Jones, Leland, 2003, above.

No matter what, all buffer trees fall.

Some fall sooner than others, because of crowding. It is common to plant trees 6 to 10 feet apart. Six-by-six yields 1200 trees per acre; 10 by 10 is 430. In either case by age 30 perhaps 250 will remain (about 16 feet apart), the others shaded out.[18] The causes are small genetic differences and minor variations at the site. Douglas-firs are great crowders-out; so are alders. Certain pines rise together in tight tolerance of each others' presence; these stands are called dog hair. Their high densities have led to catastrophic forest fires.

Is crowding mortality a problem? Yes and no. It changes the ecosystem because different organisms benefit or are bereft. More sunlight enters the wooded bit, encouraging ground covers and shrubs that may or may not be welcome. The tree cluster can be more park-like if the dead material is removed along with intrusive vegetation. It will be more natural and woods-like otherwise. (Because of the early, irregular mortality a planted-tree place loses its row-crop look within a couple of decades.)

Buffers present special, contrived situations:

- They usually are narrow relative to their overall area, presenting linear edges, exposed to the elements
- They are often in precarious situations, simply because regulators have mandated that these places should have treed buffers
- These places may include saturated soils and/or steep slopes
- They typically comprise relict trees remaining after decades of blowdown, partial harvest, understory clearing, and the like
- Residual species are often native alders which are short-lived leaners
- Trees along buffer edges lean too, because branches grow more readily toward the light.

These things are well understood in the forestry community. There remain specific questions about the stability of buffer trees in particular places, although blowdown around clearcut and woodland edges is obvious. Less dramatic are seasonally soggy soils that impair buffer functions and exacerbate the blowdown problem.

Our Puget Sound problem with shallow-rootedness is recognized in, for instance, "The depth of root penetration is largely a function of soil depth and type, soil moisture, and the presence or absence of a dense layer of clay or till."[19]

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[18] These numbers are illustrative and easily disputed in particular cases.

[19] Menashe, Elliott. 1993. Vegetation management: A guide for Puget Sound bluff property owners. Publication 93-31. Olympia: Washington Department of Ecology.

Insects and diseases may change the lives of buffer trees.

Those triangular orange tent-like cardboards stapled to trees are there to catch gypsy moths, a scourge moving toward us that will decimate hardwood trees.[20] Its cousin is the Asian gypsy moth, truly fearsome, that eats all vegetation and has been found in ship cargoes. Largely ignored by land-use planners, these mortality threats will be monumental if they cannot be kept at bay.

Millions of acres of western Canadian trees are dead because of the mountain pine beetle, which attacks tree species that are native to the Northwest. Lodgepole pines there are not much different from lodgepole pines around the Sound.

Native dogwoods appear to be on their way out. A startling place to see this is in Victoria's Oak Bay neighborhood, which has had a famous population. And there seems to be something wrong with madrones here, though not uniformly.

Generally, insects and diseases are most virulent in crowded places, whether for people or plants. A long buffer of dense, similar vegetation could be a corridor to collapse of vegetated buffering.

Though not quite yet.

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[20] Furniss, R. L. And V. M. Carolin. 1977. *Western Forest Insects.* Miscellaneous Publication 1339. Washington DC: USDA Forest Service.

Cited buffer science: Its ecogeographic domains.

A number of regulatory and even technical treatments of buffering in the Puget Lowland have relied on research conducted in distant places, within ecosystems and land-use regimes rarely if ever found here. Planners and analysts are often unaware of this lack of congruence.

To illustrate the point, here is an assessment of the science papers cited by Christopher May in his report to Kitsap County.[1] Some observations on the applicability of the science follow.

The Christopher May collections

Aside from the Desbonnet summary paper mentioned later, May relied on 145 citations, of which about 50 were primary-research (non-synthesis) papers. Those specific to **pollutant buffering** (his table 5) were:

> Bingham, S. C., et al. 1980. Effect of grass buffer zone length in reducing the pollution from land application areas. Trans of Amer Soc of Agric Engineers 23(2):330-342. Poultry manure applied ‘regularly’ in a field. Bingham and Overcash (below) published together and probably studied the same site: **North Carolina**.
>
> Dillaha, T. A., et al. 1988. Evaluation of vegetative filter strips as a best management practice for feed lots. Jour Water Pollution Control Fed 60(7):1231-38. Trials of grass and low vegetation for buffering in feedlots using artificial rainfall. 11-16% slopes. Study was in **Virginia**.
>
> Doyle, R. C., et al. 1977. Effectiveness of forest and grass buffer strips in improving the water quality of manure polluted runoff. ASAE Paper 77-2501. This study involved placement of livestock manures (dairy waste) close to buffers, 86 tons per acre, in **Maryland**. May’s pollutant table misrepresents this pub as 1997.
>
> Hubbard, R. K. and R. R. Lowrance. 1992. Solute transport through a riparian forest buffer system. Agron. Abstr. 43-4. Similar material in: Spatial and temporal patterns of solute transport through a riparian forest. Pp 403-11 in: Riparian ecosystems in the humid U.S., functions, values and management. 1994. Washington DC: Natl Assoc Conserv Districts. **Georgia coastal plain**.
>
> Jacobs, T. C. And J. W. Gilliam. 1985. Riparian losses of nitrate from agricultural drainage waters. Jour Envir Quality 14:472-8. **North Carolina coastal plain** cultivated fields.
>
> Jones, J. J., et al. 1988. The identification and management of significant fish and wildlife resources in **southern coastal Maine**. Augusta: Maine Dept of Inland Fish and Wildlife. Not primary research on pollutants.

[1] May, Christopher W. 2000 and 2003. Protection of stream-riparian ecosystems: a review of best available science. Report to Kitsap County Natural Resources Coordinator. 38 p.

Lowrance, R. R. 1992. Jour Envir Quality 21(3):401-5. May's cited-literature section does not include this entry, which he used in his nutrient table. The study was done along a transect from **Georgia coastal plain** crop land through woodland to a stream.

Lynch, J. A., et al. 1985. Best management practices for controlling nonpoint source pollution on forested watersheds. Jour Soil & Water Conserv 40:164-7. Compared cut and uncut forest pollution control performance with and without buffers. **Central Pennsylvania**.

Madison, et al 1992 This citation is mostly missing from May's literature list. It is assumed to be Madison, C. E. 1992, at page 331 in Agronomy Abstracts. UW's collection of this journal ends with 1991. Presumably this paper reflects Madison's 1992 MSc thesis at the University of Kentucky, for which he did work on vegetated filter strips in **Wisconsin**.

Magette, W. L., et al. 1989. Nutrient and sediment removal by vegetated filter strips. Transactions of Amer Soc of Agric Engineers 32(2):663-7. Experiments with grass plots and rainfall simulator, near the Chesapeake in **Maryland or Virginia**.

Mander, U., et al. 1997. Efficiency and dimensioning of riparian buffer zones in agricultural catchments. Ecol Engineering 8:299-324. Relating mostly to his grey-alder research in **Estonia**, this report mentions two deciduous riparian woodlands near the Rhode River in **Massachusetts** and Little River, **Georgia**.

Osborne, L. L. And D. A. Kovacic. 1993. Riparian vegetated buffer strips in water-quality restoration and stream management. Freshwater Biology 29:243-58. They followed N and P in groundwater moving from row crops through grass, cropped, and forested buffers, in **central Illinois**.

Overcash, M. R., et al. 1981. Predicting runoff pollutant reduction in buffer zones adjacent to land treatment sites. Trans of Amer Soc of Agric Engineers 24(2): 430-435. On the eastern Piedmont in **North Carolina**. See Bingham above.

Peterjohn, W. T. And D. L. Correll. 1984. Nutrient dynamics in an agricultural watershed: observations on the role of a riparian forest. Ecology 65(5):1466-1475. Followed sediments, N and P, from a corn field through a deciduous woodland in **Maryland, in the coastal plain**.

Petersen, R. C., et al. 1992. A building-block model for stream restoration. In: P. J. Boon et al, eds, *River conservation and management* New York: Wiley. Not primary science: A literature review and suggested concepts of stream dynamics and ecology.

SCS [USDA Soil Conservation Service, now Natural Resources Conservation Service]. 1982. Filter Strip 393. Apparently related to fecal coliform removal in vegetative filter strips. However this is not a valid literature citation.

Schultz, R. C. et al. 1995. Design and placement of a multi-species riparian buffer strip system. Agroforestry Systems 29:201-26. Description of a riparian buffer restoration project in **Iowa** and some data on effectiveness. Farmland is row-cropped with corn, soybeans. The buffer is grass-shrub-trees.

Shisler, J. K. et al. 1987. Coastal wetland buffer delineation. Trenton: New Jersey Dept of Environmental Protection, Div of Coastal Resources. 327 p. 100 **New Jersey coast**al sites were studied for interactions of disturbance, buffers, wetlands.

Terrell, C. R. And P. B. Perfetti. 1989. Water quality indicators guide: surface waters. Technical paper SCS-TP-161. Washington, DC: US Soil Conservation Service. 129 p. Used in May's pollutant table three times for buffer widths: Herbaceous or cropland vegetative filter strips for nutrients, wooded buffers for nutrients, and pesticide/coliform removal. Rating sheets "to determine by means of an indicators approach whether farm-generated materials are a problem". Intended to be applied nationally. Not primary research.

Vanderholm , D. H. And E. C. Dickey. 1978. ASAE Technical Paper No. 78-2570, presented at ASAE 1978 winter meeting. No title is given by May, yet this paper is cited twice, for flat and 4-percent slopes. Its title is "Design of vegetative filters for feedlot runoff treatment in humid areas". It was mentioned but not published in ASAE's *Transactions*, which are in UW library. Vanderholm's related papers deal with manure handling and storage in feedlots. Vanderholm was at U of Illinois and research was almost certainly in central and northern **Illinois**.

Vought, L. B., et al. 1994. Nutrient retention in riparian ecotones. Ambio 23(6):343-8. A review article with "some new data from Sweden" on changes in nutrients in surface and groundwaters with distance of travel through riparian vegetation zones. This is a Swedish journal, in English.

Xu, L., et al. 1992. Nitrate movement and loss in riparian buffer areas. Agronomy Abstracts p. 342. This is based on a MS thesis at North Carolina State. Nitrate and chloride were inserted in soil trenches between croplands and riparian buffers; the distance they had moved was measured after 530 days. In the **Piedmont region of NC**.

Young, R. S., et al. 1980. Effectiveness of vegetated buffer strips in controlling pollution from feedlot runoff. Jour Environ Quality 9:483-97. Studied cropped fields in **Minnesota** for nutrient capture by buffer strips.

May's science on **buffering for fine sediment removal** (his table 4) comes from:

Belt, G. H., et al. 1992. Design of forest riparian buffer strips for the protection of water quality: analysis of scientific literature. A 30-some page science summary, produced by Idaho Forest, Wildlife and Range Policy Analysis Group at University of Idaho. Not primary research.

Broderson, J. M. 1973. Sizing buffers strips to maintain water quality. MS thesis, University of Washington. A literature review, oriented mainly to Northwest West Side logging. Not primary research.

Cederholm, C. J. 1994. A suggested landscape approach for salmon and wildlife habitat protection in western Washington riparian ecosystems. In: Carey, A. B. and C. Elliott. 1994. Washington forest landscape management project, report no. 1. Olympia: Dept of Natural Resources. P. 78-90 Not primary research.

Cooper, J. R., et al. 1987. Riparian areas as filters for agricultural sediment. Soil Science Society of America Journal 51:16-20. Cultivated land and woods draining to a flood plain swamp, in the **Atlantic coastal plain**.

Davies, P. E. And M. Nelson. 1994. Relationships between riparian buffer widths and the effects of logging on stream habitat, invertebrate community composition and fish abundance. Australian Jour of Marine and Freshwater Resources 45:1289-1305. Eucalyptus forests in **Tasmania**.

Desbonnet, Alan, et al. 1994. Vegetated buffers in the coastal zone, a summary review and bibliography. Coastal resources technical report 2064. Narragansett, RI: University of Rhode Island Sea Grant and School of Oceanography. It is curious that May double-counted sediment-control buffer widths by including numbers from this pub, in that he also pulled data from five of Desbonnet's nine selected authors on sediment. In any case this is not primary research.

Dillaha, T. A., et al. 1988. Evaluation of vegetative filter strips as a best management practice for feedlots. A **Virginia** study; see above.

Erman, (Not Eman, as in May's table), D. C., et al. 1977. Evaluation of streamside bufferstrips for protecting aquatic organisms. Contribution 165 (not 16 as in May's citation), Technical Completion Report, Center for Water Resources, University of California at Davis. Not accessible via Google, not in UW collection.

Ghaffarzadeh, M., et al. 1992. Vegetative filter strip effects on sediment deposition from overland flow. Agronomy Abstracts p. 324. Not accessible via Google. Agron Abstr is in UW library but only through 1991.

Gilliam, J. W. And R. W. Skaggs. 1988. Natural buffer areas and drainage control to remove pollutants from agricultural drainage waters. Pages 145-8 in: Kusler, J. A, et al, editors. Proceedings of the National Wetland Symposium. Several sponsors. Not yet seen; in UW stacks.

Horner, R. R. And B. W. Mar. 1982. Guide for water quality impact assessment of highway operations and maintenance, FHWA WA-RD-39.14. Report to Washington State Dept of Transportation. Dept of Civil Engineering, Univ of Washington. Not primary research.

Karr, J. R. And I. J. Schlosser. 1977. Impact of near stream vegetation and stream morphology on water quality and stream biota. EPA 600-3-77-097. Not found in EPA on-line catalog, nor in UW catalog. A 1978 *Science* paper may be related. Also Schlosser and Karr published jointly later, which may locate the work.

Lowrance, R., et al. 1986. Long-term sediment deposition in the riparian zone of a coastal plain watershed. Jour of Soil and Water Conserv 41(4):266-71. Estimated erosion and deposition downslope from field to forest in the **southeastern coastal plain**, probably in Georgia.

Lowrance et al. 1988. Erosion and deposition in a field/forest system estimated using cesium-137 activity. Jour of Soil and Water Conserv 43:195-9. Same objective as in 1986, but used a cesium tracer with very different results. **Same region**, probably same site.

Lynch, J. A., et al. 1985. Best management practices for controlling nonpoint source pollution on forested watershed. Jour of Soil and Water Conservation 40:164-7. **Central Pennsylvania**, see above.

Magette, W. L., et al. 1989. Nutrient and sediment removal by vegetated filter strips. Grass plots and rainfall simulator, possibly in **Maryland**. See above.

Moring, J. R. 1982. Decrease in stream gravel permeability after clear-cut logging: An indication of intragravel conditions for developing salmonid eggs and alevins. Hydrobiologia 88:295-8. On the Alsea River in **Oregon** Coast Range.

Peterjohn, W. T. and D. L. Correll. 1984. Nutrient dynamics in an agricultural watershed: observations on the role of a riparian forest. Ecology 65(5):1466-75. **Coastal plain of Maryland**, see above.

Raleigh, R. F., et al. 1986. Habitat suitability index models: Chinook salmon. FWS/OBS-82/10.122. US Dept of Interior, Fish and Wildlife Service. For rating stream habitats according to temperatures, velocities, etc judged important to Chinook. Data taken from many sources. Not primary science.

Terrell, C. R. And P. B. Perfetti. 1989. Water quality indicators guide: surface waters. SCS-TP-161. Washington, DC: US Soil Conservation Service. 129 p. Listed twice in May's sediment table. A rating guide for application nationally, see above. Not primary research.

USDA Soil Conservation Service. 1982. The SCS item of unknown content, listed above in the nutrient table.

Wilson, L. G. 1967. Sediment removal from flood water by grass filtration. Transactions of Amer Soc of Agricultural Engineers (ASAE) p. 35-7. Research done near Safford, **Arizona**

Wong, S. L. And R. H. McCuen. 1982. The design of vegetative buffer strips for runoff and sediment control. Civil Engineering Dept of Univ of Maryland, for the **Maryland** Coastal Zone Management Program. This may have involved modeling, implying sponging up others' data rather than doing primary research. UW library says only U of Maryland library has this.

Young, R. S., et al. 1980. Effectiveness of vegetated buffer strips in controlling pollution from feedlot runoff. Jour of Environmental Quality 9:483-97. Studied cropped fields in **Minnesota**. Also in nutrients table.

Some Observations

May's cited primary-science studies on buffering for **nutrients** and **sediment** involve mostly:

- The Midwest and East Coast
- Manure (nutrient studies) and cropland (sediment research)

May's suggestions for stream-buffer widths have been extrapolated to all fresh water, apparently, by some consultants.[2] His compilation is sadly small, considering the plethora of buffer studies.

He fails to identify the soil, seasonality, climate, vegetative composition and density, upstream and landscape features, of upland and buffers pertinent to the studies he cites. Similarly rainfall

[2] Envirovison, Herrera Environmental, and Aquatic Habitat Guidelines Working Group. 2007. Protecting nearshore habitat and functions in Puget Sound: An interim guide. [Place of publication and publisher unknown. May be Washington Dept of Fish and Wildlife]

intensity and duration, snow cover and melt, soil saturation, and overland vs subsurface flow circumstances. This problem is compounded by his considerable use of others' compilations.

Given the known, vast differences between conditions in the Puget Sound lowland and those elsewhere in North America, one cannot perceive how May drew his inferences about buffering here.

Nor does he identify particular problems here with nutrients or sediment, their locations and intensities, nor whether buffering can be expected to be best or even salubrious practices.

October 2004
September 2005

On buffers around Kitsap County's watered places.

THE ISSUE

Hundreds of miles of buffers (untouchable native vegetation zones) are imposed on the County's stream, wetland, and tidal shores, plus lands around "wildlife habitat conservation areas". Thousands of acres are included, and their area is being expanded via revision of the Critical Areas Ordinance. Yet a rationale for the existence of buffers is virtually nonexistent; their impact on people is completely ignored, their private and social costs are similarly disregarded, and alternative means to the same ends are not explored by the County.

Recent science points to the limited usefulness of buffers, and even the federal government is moving away from buffers in its land stewardship.

Why Buffers?

The only, though sweeping, arguments for buffers are that (1) any land use, however gentle, is a threat to the welfare of a "critical area" if the touched land lies alongside the critical area; and (2) it is necessary, in every case, to separate touched land from critical areas by an unblemished zone of native vegetation.

And What Are "Critical Areas"?

By state statute, "wetlands; areas with a critical recharging effect on aquifers used for potable water; fish and wildlife conservation areas; frequently flooded areas; and geologically hazardous areas" [RCW 36.70A.030].

All of these five categories have attracted buffers. Planners have turned buffer expansion into a minor industry, with jurisdictions seemingly competing to be 'out in front' in this matter.

Buffering On Puget Sound Is Different

At least three things make our conditions distinct from those in much of North America.

One, our plant biota flourishes. We can scarcely keep it from growing. With or without designated buffers the land is typically covered with one, perhaps even three, horizontal tiers of vegetation. Rarely is the earth bare, exposed to erosive loss of sediments. Our rapid-response vegetation also means that, absent buffers, vegetation surrounds our wetlands anyway.

Two, our rainfall occurs mainly in winter, in contrast to much of the nation. One implication is that little Puget Sound stormwater is taken up by vegetation, because plants are largely dormant then.

Three, our hardpan (glacial till) soils, close to the surface and present in much of the County, provide a nearly impermeable barrier to infiltration of stormwater and a floor over which water moves downhill. That floor is so dense that tree roots typically fan out above it.

Our rather unusual combination of winter rain and dense soils is not good for key buffer functions. Saturated buffers are a common mode here, with water moving through "by displacement", meaning that water behind pushes the water ahead. The buffer quickly loses most of its delaying power. Meanwhile, ironically, created buffers with planted veg on bare or mulched ground invite erosion because of wide spaces between plants and an absence of tight groundcover.

So our buffers leak. Most of whatever comes in, goes out. This applies to stormwater, to sediments and sediment-borne chemicals, and to water-borne pollutants and nutrients. Vegetation is largely unable to adsorb and transpire stormwater and its cargoes during our long wet season.

spurs the need to identify alternatives to buffers, at least as we currently think of them. This point has also been made by Chris May, a Kitsap County biologist.[1]

Science and the Puget Sound Country

For several reasons, relevant science has had little influence on buffering and buffer widths here. Research pertinent to Puget Sound is scant. In addition to irrepressible vegetative cover, dry summers, and shallow hardpan soils we have a broad array of animal and plant species, a general absence of agriculture; and a deeply incised drainage pattern. Studies elsewhere must be viewed skeptically.

There is statutory guidance requiring 'best available science', offering latitude making it easy to mix opinion with research findings, from first-rate to truly dubious. Actually there is no question about what comprises acceptable science. It involves hypothesis testing, replications and control groups, multiple variables considered, statistical analysis, peer review (preferably blind) and publication. In addition, for Kitsap County's use, research should be conducted in the Northwest's west-side ecoregion, in land-use settings typical of the area. Thus, for example, research from farm ponds and eroding pastures is not very relevant here.

Economic Analysis and Critical Area Buffers

GMA does not appear to require economic analyses of prospective buffer requirements, neither in the aggregate nor at the project level. However *SEPA (State Environmental Protection Act) mandates economic evaluations of 'significant' projects and policy changes.* Surely the impacts of potentially huge land set-asides for various buffer types warrant economic impact studies.

There are two relevant economic perspectives. One is 'mesoeconomic', dealing with community and county-level impacts. The other is 'microeconomic', at the project level. It does not appear that either approach has been employed in Kitsap County for critical-area and/or buffer designations and management.

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[1] May, Christopher W. 2003. Stream-riparian ecosystems in the Puget Sound lowland eco-region - a review of best available science. [Place unknown] Watershed Ecology LLC.

WETLANDS AND BUFFERS

Wetlands and Their Science

The 1972 Clean Water Act, which gave life to wetlands with a capital W, has led to a flood of curious federal and local rules and decisions.[2] Kitsap County's definition of a wetland includes areas as small as 2500 square feet (equivalent to a 50-foot square) that support certain kinds of vegetation. Standing water is not required. A requirement for perennial wetness would sharply reduce the County's thousands of classified wetlands.

The intended results of County wetland regulation are to "preserve flood control, storm water storage and drainage or stream flow patterns; and prevent turbidity and pollution of wetlands and fish or shellfish-bearing waters, and to maintain the wildlife habitat". Not by accident, these are roughly the same functions set out by the state's Department of Ecology in its recent compilation of wetland research[3], which are:

- Trap and transform chemicals and improve water quality in the watershed,
- Maintaining the water regime in a watershed, including reducing flooding, and
- Food web and habitat functions.

You will notice that there are no quantitative objectives here. Also, the first two categories imply concern, not for the wetland, but rather for the presumed stream below it. DOE perceives wetlands as sumps and surge tanks.

In any case, the County may or may not have an inventory of wetlands that lays out the physical parameters of each one. They almost certainly don't portray the functions of each wetland, with the degree to which each one performs. Bainbridge Island has 359 documented wetlands on its 28 square miles. If similarly equipped, the County must have over 5000 wetlands.

Wetland 'science' appears on every hand. Compilations abound. Perhaps the largest is DOE's book-length coverage, cited above, with about a thousand references. That summary was written for state-wide application, so only a fraction is applicable here, partly because pre-1990 research is generally not included, but especially because forest wetland research is omitted, deferring to a 250-item compilation by another agency, which wasn't ready. However even that tentative work overlooks key material.

Moreover many collections of abstracts, and the reports they summarize, fail to portray fully the conditions to which they do and don't apply. In short, the County does not know at all well the conditions and benefits, if any, of an immense and immensely diverse inventory of wetlands. They have neither comprehensive data nor a trustworthy research foundation toward which to turn. Whether wetlands comprise a County treasure, or a general pain, can hardly be supported by the County at this point.

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[2] For example, see a recent *Wall Street Journal* editorial, August 23, 2004. A landowner faces prison for tending ditches in a cornfield, put there by the county's drain commission. The property is 10 miles from a river and thus, at worst, is an exempted, isolated wetland. It took a federal judge to get him off the hook, but the case may go to the Supreme Court.

[3] Paraphrased from: Sheldon, Dyanne et al. 2003. Freshwater Wetlands in Washington State, Vol. 1: A Synthesis of the Science (Draft, August 2003. Olympia: Department of Ecology. P. 2-5.

Wetland Buffers and Buffer Science

Given the abundance of wetlands (probably over 5000 in the County), an early and major question is whether wrapping them in buffers is needed at all. This is a matter of what functions the wetland actually performs; what the immediate landscape is and will be like, absent the buffer; and whether any of those functions is impaired or compromised in the absence of a buffer.

DOE, in its rather brief consideration of buffers, notes that most research bears on agricultural sites, therefore on sediment filtering and nutrients (fertilizers). Few studies, they point out, deal with stormwater, wildlife, nor long-term effects of buffers on any presumably bad agents.[4] Listed next are thirteen claimed benefits from wetland buffers, with a brief assessment of the validity of each in Kitsap County:

(a) Upland vegetation would slow and absorb stormwater,
(b) Buffers would capture sediments,
(c) Vegetation zones would serve as barriers to harmful chemicals,
(d) Buffer vegetation would contribute nutrients to wetlands,
(e) Trees planted along the shore would eventually fall into the wetland, helping aquatic life,
(f) Insects falling from trees onshore would be an important food source for wetland inhabitants,
(g) 'Longshore trees would provide shade for aquatic spawners and invertebrates,
(h) Vegetated buffers would displace grass, a good thing,
(i) Trees in vegetation buffers would provide perches for eagles and other raptors,
(j) The buffers would provide additional habitat for wildlife,
(k) Nativeness is necessary to achieve these listed benefits,
(l) An ancient-forest mystique would be restored, and
(m) Prescribed buffers would be charming.

The first three of the thirteen benefits are generally illusory here. Buffer saturation (which defeats a-c, above) is mentioned by Desbonnet[5], Chris May, the DOE science pub (p. 5-46), and others. Winter rains coinciding with dormant vegetation means that plants take up neither stormwater nor the bad things being carried along. Third, a federal judge has barred the use of 38 pesticides and herbicides in key areas, and required consultation between NOAA and EPA on a total of 54. The common denominator is salmon protection, but a logical extension would involve all fish-related streams and wetlands. Stopping pollution problems at the source makes far more sense than fiddling with buffers.

Trees' contribution of nutrients (d) may be a bit much, considering that buffers are prescribed for *stopping* nutrients before they reach the wetland. Too, as mentioned again later, salmon are credited with contributing nutrients to the buffers.

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[4] Sheldon et al, 2003 draft, p. 5-20ff.

[5] Desbonnet, Alan, Pamela Pogue, Virginia Lee, and Nicholas Wolff. 1994. Vegetated buffers in the coastal zone, a summary review and bibliography. Coastal Resources Center Technical Report No. 2064. Narragansett, RI: University of Rhode Island Graduate School of Oceanography.

If fallen trees are wanted (e), use narrow buffers versus wide. This finding is well-understood.[6]

Insects and shade (f and g) are sometimes worthwhile, provided the vegetation is directly above the waters. Alders host five insect species, none of which willingly fall. Trees aren't much as insect droppers; the great insect supply is aquatic insects, hatched in the water, emerging to mate, and returning. Ditto for other macroinvertebrates.

Displacing grass (h) is not a good thing. Relative to trees, grass is a premier cover for preventing rill erosion, containing chemicals and utilizing passing nutrients. I can speak to this at tedious length.

How many wetlands need more raptor perches (i)? I don't know, but alders are a common element of wetlands.

Buffers as habitat (j) may have unintended inhabitants:

Feral cats,
Coons and rats,
Crows and bats,

all of whom we seem to have in sufficient abundance. Onshore animals do just about nothing for the health of wetlands.

Barring non-native vegetation (k) imposes a real cost in monoculture and lost diversity. What fault is there in functional equivalents like rhododendron cultivars? None.

Is there a functional difference between scarlet oaks and native oaks, between red maples and native maples? No.

Buffer Research Compilations

DOE mentions 88 wetland buffer references, of which 29 are compilations rather than primary science, with the limitations mentioned earlier.

Compilations are especially hard to interpret because they repeat only a fraction of the information from each report cited, and the reports typically say little about salient factors that the investigator didn't measure. Thus, for instance, one of these compilations (Desbonnet et al) indicates that 6-foot buffers are every bit as effective as 300 footers.[7]

DOE concludes, and repeats 21 times, that there are no specific, definitive sets of buffer specs to support any or all specific wetland functions.

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[6] The DOE pub, foresters generally, and Pollock, Michael M. and Paul M. Kennard. 1998. A low-risk strategy for preserving riparian buffers needed to protect and restore salmon habitat in forested watersheds of Washington state. Bainbridge Island: 10,000 Years Institute.

[7] See the next two notes.

Diminishing Returns

Gary Tripp, a Kitsap County resident, has attempted to wring some reasonable conclusions from collected buffer research compilations, by noting threshold values below which a majority of recommended buffer widths, for particular protective functions, tend to be grouped.[8] He shows that, if one believes the semi-science on offer, and if a wetland or waterway requires protection from some intrusion, quite narrow buffers can suffice. In fact widening them produces little if any extra benefit.[9]

Tripp also points to the mischievous Wall Misconception, by which planners assume that buffers comprise a wall against upslope badness. A Wall corollary is that upslope lands make no positive contribution to the welfare of waters; another misconception. He also notes the court ruling taking certain lawn chemicals off the market, eliminating an upslope claimed threat.

Wetland Buffers and Land Commandeered

A quarter-acre wetland's diameter is about 120 feet. Adding, say, a 75-foot buffer multiplies the dedicated space by five!

If the number and size array of County wetlands is like that of Bainbridge, 32,000 County acres would be devoted to wetlands and their buffers. That's 50 square miles. Add that to 160 square miles of stream buffers discussed later, plus shoreline buffers and unestimated square miles of habitat conservation areas.

Conclusion about Wetland Buffers

The County's information about wetlands is insufficient to determine (1) what function(s) each wetland provides, (2) which of these needs support from buffers, (3) the social and owner cost of buffering there, (4) whether benefits justify these costs, and (5) alternatives to buffers at that site. In fact, a staff person has said that their wetland maps are about 60 percent correct, implying rather little knowledge about the County's array of wetland circumstances.

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[8] Science and observations supporting the current or smaller buffer widths at http://www.bainbridge.cc.

[9] The Desbonnet data for sediments is in Figure 1 of this document. The proportion of sediment removed by buffers is along the vertical axis; their widths is along the bottom. Triangles are the data points, drawn from various studies (mostly in the East). The curve has been fitted mathematically and serves as a summary of the data's information.

There are two stories here. One is that a large amount of sediment was stopped, during the studies' terms, by rather small buffers; typically buffers 16 feet wide or less removed 50 percent; over 70 percent was halted by buffers less than 50 feet wide, and even 6-foot buffers were highly successful. The second story is in the flatness of the curve. Beyond about 20 meters (about 60 feet), there was little gain in protection as buffers widened. This is the diminishing-return story.

There is a third story, one of statistical relevance. The second term in the equation is not significantly different from zero, which means that a horizontal line, hitting the left axis part-way up (actually at .77), is quite plausible. And that means that no buffer wider than a narrow fringe will enhance protection. Hence the remark in the text that 300-foot buffers are no better than 6-footers.

Current high-order buffer science raises serious questions about wetland buffers aside, perhaps, from narrow fringes for wildlife purposes. However, even fringes may be irrelevant, according to a researcher.[10] The issue is critical because of the huge acreage involved, on sites of particular appeal for active land uses.

STREAM AND TIDEWATER BUFFERS

Karl Duff has estimated that stream buffers under present rules occupy about 100 square miles. There is a proposed increase of 50 percent in the draft CAO. Together with wetlands and their buffers, 200 square miles would be conscripted. **That's half the County**, not counting presumably extensive Habitat Conservation Areas and shoreline buffers, though there would be some overlap.

An attention grabber is the remarkable widths proposed for certain stream buffers, and their considerable expansion during this round of replanning. The reasoning involved is not revealed.

Virtually any stream capable of supporting any kind of fish is given 150 feet of buffer on each side, plus 15-foot setbacks for most uses, creating a no-build strip 330 feet wide. Few people understand how far this is, especially in woodsy terrain.

Most Northwest west-side buffer research pertains to forest streams. It has become increasingly sophisticated, and some older conclusions have been reversed. For instance (mentioned earlier), the notion that young salmon need shade has given way to the realization that higher temperatures favor invertebrates on which juvenile salmon feed; the tradeoff seems to favor non-shade (hence non-buffer) situations north of California. It is now known that forest buffers leak copiously but intermittently; this was mentioned earlier. It has also been found lately that, on some streams, salmon contribute nutrients to the riparian shore, rather than the reverse.[11]

In Kitsap County tidewater shorelines get buffers of 50 to 115 feet depending on the shore's zoning and (perhaps) whether there is a Habitat Conservation Area designation. On the upper beach these would include shellfish areas, and forage fish spawning areas. That about wraps up the whole shore, it seems, and additional areas can be included with an HCA based on "species of local importance" (starfish and sand dollars?). The CAO also includes "waters of the state" (see below), for which no definition is offered but which probably includes all of Puget Sound.

It was 50-foot shoreline buffers that caused the Bainbridge uprising. Record crowds pressed into planning commission meetings. One wonders whether the HCA approach is the County's backdoor route to tideline buffers. The County has perhaps 3 times as much shoreline as the island.

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[10] Adamus, P. R. [date unk.] Personal communication cited in King County Best Available Science draft, October 2003, at page 9-6: "Not all wetland species benefit from buffers that are wooded. Most shorebirds, for example, shun small wetlands surrounded by trees."

[11] Bilby, Robert E., et al. 2003. Transfer of nutrients from spawning salmon to riparian vegetation in western Washington. Transactions of the American Fisheries Society 132:733.

HABITAT CONSERVATION AREAS AND BUFFERS

HCAs, Some Background

Fish and Wildlife Conservation Areas reflect a federal concept adopted for Endangered Species Act species presumed to be in trouble. Thus large wetlands along flyways have been designated HCAs.

GMA doesn't define 'fish & wildlife conservation areas', but 'fish and wildlife habitat' is defined in the draft CAO as

> ...those areas identified as being of critical importance to the maintenance of fish, wildlife, and plant species, including: areas with which endangered, threatened, and sensitive species have a primary association; *habitats and species of local importance*; commercial and recreational shellfish areas; kelp and eelgrass beds, forage fish spawning areas; naturally occurring ponds and their submerged aquatic beds that provide fish or wildlife habitat; *waters of the State*; lakes, ponds, streams or rivers planted with game fish by a government or tribal entity, or private organization; State natural area preserves and natural resource conservation areas. [italics added]

'Habitat of local importance' means

> A seasonal range or habitat element with which a given species has a primary association and which, if altered, may include areas of high relative density or species richness, breeding habitat, winter range, and movement corridors. These might also include habitats that are of limited availability or areas of high vulnerability to alteration, such as cliffs, talus, and wetlands.

The key point here is that habitats can be very broadly defined, for many species, embracing nearly the whole of the County if, say, coyotes or woodpeckers are selected as species of local importance, or if tall trees are chosen as habitats of local import.

The Habitat Inventory

Recently the state's DF&W did a remote-sensing overhead survey of the County. Their aim was to locate and quantify habitat for at least some wild animal species. With LIDAR it is possible to get greater resolution (detail) than with most photo systems, and with less technical hassle. Another advantage is that LIDAR can, to some extent, portray understory vegetation in addition to overhead trees. There are limitations, though. For instance, salmonberry (native) cannot be distinguished from blackberries (foreign).

A more significant limitation of the inventory is its emphasis on upper vegetation, which is not the same as 'cover'. And cover falls far short of habitat. Further, habitat implies the presence of critters in some but unknown numbers, because there is no field-checking program, and the critters may not be there. Or they may be spread unevenly within the habitat, for reasons not detected in the assessment. Too, the system seems unlikely to pinpoint key, but small and scattered, forage and hiding places. It also says nothing about home ranges across the landscape.

Deermouse droppings and wood duck doo
Critter evidence it's true
But I don't know and nor do you:
Do they here reside or just pass through?

These are serious shortcomings given an objective of identifying key habitat for the greater welfare of selected wildlife.

Wildlife Habitat and Buffers

Further, there is a temptation to declare green patches of a certain character as habitat, find several hundred such patches, and put a buffer around each of them. As shown above for small wetlands, this can blanket the County with protective buffers (and protective covenants).

The draft CAO hedges on the widths of such buffers, calling for their determination in Habitat Plans. However a perimeter planning space around HCA's is widened from 200 to 250 feet; without apparent justification for either figure. This is clearly an open-door mandate, given the lack of specific species' identities, their assumed spatial needs, population targets, species priorities in inevitable cases of conflict, and even the larger question of whether habitat is to be defined in terms of green patches, whole home ranges, regional wanderings, predator-prey communities, preferred forage vegetation, etc.

That buffers may reach 200 feet is demonstrated in the draft CAO, in which that width is assigned to certain streams, doubling the former belt for no reason presented in the CAO. Advocates for wildlife buffers are inconsistent to say the least in declaring how wide a buffer a species 'needs'. Speakers for such buffers should be held to relating the specific role of the buffer, the consequence of no buffer at all as well as various buffer widths, with quantitative estimates and statements about the kind of dependency that is involved.

Consistency in Rules and Restraints

"Functions" typically listed for HCAs are different from those for wetlands, yet they often lie on the same ground. So there will be conflicts in management and buffering that aren't recognized in the critical areas ordinance. For instance, which takes precedence, wetland isolation or habitat enhancement? Suppose geese must be killed to preserve water quality, but geese meet a density criterion that puts them in a high habitat class? Suppose beavers appear and alter a key wetland? There is no mention of priorities among mutually exclusive functions in the CAO.

The No-Buffer Alternative

Indeed there is serious question as to why a buffer is needed at all if the Habitat Conservation Area is reasonably chosen. It is especially disturbing when the criteria stated for the HCA are described differently from those for the buffer, while both are expected to provide the same function(s).

Nor is it clear that any buffer can deliver the same quality of life to critters as does the HCA; this because of diminishing returns. Adding acres can be pointless when other factors than space are constraining.

In a separate letter to the Commission I summarize seven large-scale northwest buffer studies that point away from buffering for wildlife. These are among the most comprehensive stream studies ever done.

For Kitsap County there is no showing that residential yards and already-required open spaces, the latter quite numerous, will not provide habitat benefits for most species. Research in King County has shown, for instance, that species diversity of birds is higher in exurban areas than in woodlands. Species richness has also been found to be greater in Cascade Mountain clearcuts than in adjacent old-growth.

The Federal Position on HCAs and Buffers

The federal government has subscribed to the no-buffer argument. The federal Fish and Wildlife Service will no longer pursue critical habitat designations for wildlife they administer under the ESA. They say, "The [Clinton] administration found that designation was "not prudent" for the vast majority of species as critical habitat would not provide a benefit to the species", and again, "Designation of critical habitat provides little additional protection to species."[12]

Clearly, if the federal government finds no utility in HCAs for premier listed species of national import, the rationale for state and local designations fades.

And if the HCA is irrelevant, so of course is its buffer.

Unfortunately NOAA Fisheries has just decreed critical habitat for 2376 miles of tidewater shores in Puget Sound and the strait, for salmonid welfare. The decree applies to federal actions only.

GEOLOGICALLY HAZARDOUS AREAS

Buffers here have a different orientation: protecting things above as well as below the buffer.

Can they do this? Maybe. Are they infallible? Certainly not. Do planners know how wide a buffer is needed here? No. Are there attractive alternatives? Yes.

Why Are Some Puget Sound Slopes "Critical Areas"?

The answer is not clear. Cascade ski slopes, Seattle's Counterbalance, and North Kitsap's Bond Road are probably more dangerous than slopes generally found on the Kitsap Peninsula.

There is no apparent public purpose here, though public health is mentioned. Prevention of collapse is not a public venue here either. In short, a County role is unneeded and, as mentioned below, ineffective.

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[12] Wire-service report, *The Oregonian*, May 29, 2003; and a press release from Fish & Wildlife Service, May 28, 2003, authored by Megan Durham.

The principal focus of planners is shoreline bluffs. The mechanism for deciding which are tricky is by seeing which have fallen before, an after-the-cow-is-out process. Landowners are themselves surely able to understand high, steep places with rubble at the bottom.

Slope Stability and Native Vegetation

The County wants buffering for the whole slope, with native vegetation up the slope and 25 feet inland. This for slopes of even ten vertical feet if they've been nibbled lately by, say, storm water.

It is a comfort to know that vegetation is expected to save slopes, and that native plants will do that best. Trilliums are well-known for their superiority over ivy, local maples over eastern scarlet maples, Olympic rhodies over showy California cultivars, and shore pines over red pines. Aren't they?

Owners will be prudent to avoid trees in their buffers, as thinning, pruning, and topping are sharply limited.

Buffers for Niggling Slopes

Beyond this, setbacks are required from the top of the slope: above slopes of 30 percent, if tipped by LIDAR as unstable (observed in motion?), the County requires that buildings be as far back from the edge as the slope is high plus another third of the slope height (or another 25 feet if the slope is under 75 feet high). My front yard is 30 percent (17 degrees) and perfectly stable. It may be hard to find a 30-percent slope showing signs of slumping.

If not bulkheaded, a 10-foot bank pushes activity back 35 feet.

If one's bank is 15 percent (8 degrees) or more, with that raw-looking bank, the setback from the 'edge' is 40 feet, almost always. There may be an interesting contradiction here.

Government Knows Best

Mandated setbacks depend on a perception that local government and its advisors (1) know what's best for landowners and (2) have the perfect knowledge of nature and engineering required to forestall land stability problems.

Where Buffering Wouldn't Work

Two recent major landslips illustrate the inability to predict, at a neighborhood scale, pending slumps. One is at Carlyon Beach, west of Olympia, where an entire recumbent hillside moved, displacing scores of homes. It was not anticipated by deduction, designation, data, detection, nor, of course, decree.

Another was the Rolling Bay Walk (Bainbridge Island) fatalities, where a row of houses sits below a bluff.

Neither of these events could have been prevented by buffers, partly because decades-old houses preempted spaces close to the shore, as is now the case in places like Rockaway Beach on Bainbridge Island and Salmon Beach in Tacoma. People know the risks and take their chances.

Is Kitsap County in deep water?

This leads into protection philosophy. Back to landslides, are they wanting to flag every slope that **might** someday move, those that seem **certain** to move within some time frame, or something in between? Use of the Coastal Zone Atlas, and probably any other predictive mechanism, involves inevitable errors of timing, location, and scope.

Which suggests also a legalistic perspective. Why set the County up for landowners' reactions to error? Why not leave it to landowners to look around their properties, seek advice and local knowledge, and draw their own conclusions?

BUFFERS AND FREQUENTLY FLOODED AREAS

The County's CAO says little about potential flooding. Inland, these designated areas correspond to 100-year flood forecasts, whose breadth is typically covered by buffers laid in for other purposes. Along tidewater shores a 10-foot anomaly above mean sea level is floated. The related map was prepared, the flood damage ordinance says, in 1978. Current County documents dance around the tidewater question. The CAO technical committee discussed tsunamis briefly, shrugged, and moved on.

As with landslides, a practical issue is why, if owners are willing to forego flood insurance, is the County requiring people to build a certain number of feet above some assumed flood lines? Is this not another intrusion on private rights, unnecessary in terms of public welfare?

BUFFERS AND 'CRITICAL' AQUIFER RECHARGE AREAS

Point-Source Protection

State regs (perhaps law) require buffers around Group A water systems, which have over 15 hookups. The County proposes to expand these buffers from one- to five-year horizontal travel times. How these are estimated on the ground is not explained, but an effect is to increase reserve areas 400 percent. Many wells will have their buffers redrawn from a five to a ten-year travel-time circle. These are in gravelly soils above shallow aquifers.

Typical sizes of these circles have not been presented.

Bigger Chunks of Country

Well heads aside, protected recharge areas will target flat terrain, highly permeable soils, "more permeable surficial geology", and shallow water tables, according to the draft CAO. Perceptions of where these areas are and which should be delineated appear to vary greatly among hydrogeologists. For instance, currently no account is taken of rainfall, yet that varies greatly within the County.

There is also a matter of water quality versus quantity as water is recharged into the ground. Should septic systems be encouraged relative to sewer take-away systems? Currently, it is said, sewer availability is more of a constraint to County development than is water availability. Should deep wells be encouraged relative to shallow ones, to bypass tainted aquifers and give shallow lenses a chance to refill? Should water-collecting blacktop be joined with recharge ponds to maximize infiltration? That would certainly be more effective than any sort of buffering.

Imprecision in Recharge-Area and Related Buffer Planning

The CAO technical committee was told that mapping of porous soils is done from the air, with an error expectation of 20 percent.

The Runoff Tradeoff

A key rationale for wetlands has been their presumed ability to gather and then slowly infiltrate stormwater. This, too, is more effective on a per-acre basis than buffering, and the County has many wetlands. Perhaps some should be dammed to increase retention, or beavers be allowed to do their thing.

Interference with runoff has implications for storm surges down spawning creeks. Wetlands not only meter out the flows but also reduce them. The role of buffers here is equally ambivalent--to the small extent that buffers slow water movement.

The Folly of Old Science

King County, in its analysis of this subject, says that problems of the past have in many instances already been dealt with by new regulations, and that "Reliance on old data will generally overstate current risks"[13].

Speaking to keeping bad substances away from aquifers they say, "...many pesticides have a high adsorption potential and low solubility in water, making them less of a contamination risk to groundwater"[14]. Adsorption relates to clinging to clay particles rather than being carried down to the aquifer. It has been suggested to Kitsap County that they gather a list of such chemicals; the list is not yet apparent.

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[13] King County. October 2003. Best available science, Chapter 6: Critical aquifer recharge areas, p. 9.

[14] Same source, p. 15.

PROBLEMS WITH BUFFERS, EVERYWHERE

Buffers are indeed problematic, wherever they are used. In general,

- It is doubtful that they will perform as expected, for any of the functions listed earlier;
- The acreages expropriated are immense;
- The cost, in lost public and private uses of that land, are correspondingly high, not only because of buffers' extent but also because the land involved is typically premier landscapes;
- Property values, especially for home places, will drop substantially in many places;
- This will occur now as well as later, in anticipation of announced requisitions;
- Further value losses come with the expectation that buffers will be enlarged in future rounds of replanning, a reasonable outlook given recent trends;
- Vegetation would be a thicket. Vegetation belts would typically not be open yard space nor simple setbacks. They would be barricades; in fact imposing impenetrable plant species has been discussed;
- A children's place would be conscripted. Even in rural areas the dark shroud of buffers would compromise traditional play places;
- Not only would vegetation be mandated, but property rights of many kinds would be extinguished;
- Buffers are not innately friendly places; wildlife habitat and tall trees can be a mixed blessing;
- Perhaps most significant, there are cost-effective alternatives for providing every function claimed for buffers.

WHY BUFFERING WILL FAIL

If imposed according to current plans, in due course buffering will surely be counted as failure. Of course by the time of the next CAO some planners will be gone and many of the old dogmas will have been scorned or forgotten. Meanwhile buffers will not have met expectations, first because there are conflicting expectations and second because nobody is keeping score. There will be no systematic record of what problems were perceived and whether they were solved by buffers or by alternatives to buffers. Indeed, many 'problems' will have lost their urgency or even evaporated. Estimates of cost effectiveness will not have been made nor corrected later. The total public and private costs of buffering will not have been reckoned. This will be sad failure indeed.

Protecting Kitsap waters: Alternatives to buffers.

Protect the wetland and you protect its functions. Mostly true. Buffering is prudent protection. Mostly false.

How can this be so? Why is it important? What other protection options are there?

In summary,

Uses foregone make buffers an extravagant land conscription

Options include

for stormwater - ponds, furrows, berms, and even paved routes; Low Impact Development

for sediment - grassy swales and fields

for pesticides and herbicides - lawns, forbearance, and Integrated Pest Management

for toxic chemicals - grass and abstinence

for bacteria - septic systems

for wildlife - yards and their verges, parks, meadows, beaches, and woodlands that also serve as children's places

allowing wetlands to perform functions without encumbering buffers

BUFFERING IS EXTREMELY COSTLY.

Land is fixed in supply and is arguably our scarcest Kitsap resource. As one attorney has noted, buffers instantly turn whole regions of the community into nonconforming uses.[1] And premier landscapes are involved. So conscripting buffer space here carries uncommonly high community and private costs. Too, buffers are land-intensive—if a Port Blakely-area inventory is representative, in the County one is almost everywhere within 350 feet of a wetland buffer.[2]

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[1] Mackie, Alexander W. 2004. Protection of critical areas and the mythology of buffers. Olympia: Perkins Coie. Present at "Growth management in Washington" seminar, Seattle, November 15-16, 2004

[2] January 14, 2005, memo to Land Use Committee from Larry Frazier and Steve Morse, p. 2. On Port Blakely property of 1200 acres 46 wetlands were found, implying an average inter-wetland spacing of 812 feet. 50-foot buffers are assumed.

Wetlands are regularly being rediscovered, having been lost in back corners, or where small seeps and wet spots have been newly designated as regulated wetlands. There are thousands of wetlands in the County.[3] Their encircling buffers typically double and can even triple the no-touch area. Proposed wetland buffers may cover 13 percent of the County. Dr. Karl Duff has estimated that proposed stream buffers may occupy 15 to 27 percent of the County, depending on location.[4] Even wider buffers are proposed for wildlife habitat areas and a network of 100-foot buffer-like corridors is proposed between wetlands and priority habitats.

THERE ARE USEFUL OPTIONS, AND MOST ARE BETTER THAN BUFFERS.

STORMWATER has been the principal purveyor of water to wetlands since the glaciers left, either by overland flow or underground seepage. There are concerns about too much and too little. Most Kitsap wetlands are probably seasonal,[5] with many dry much of the year. Keeping them wet longer has been the object of some damming.

'Hydroperiod adjustment' is seen as an important role for wetlands; this is the surge-tank role applauded by the state Department of Ecology (DOE)[6], mostly to keep stormwater away from streams below the wetland. **Stormwater collection and dispersal** is a well-developed branch of engineering, well understood and practiced here.

Given buffers' leakage problem[7] **retention ponds,** to capture water before it reaches the wetland, are in wide use. The captured water dissipates by evaporation and infiltration. **Detention ponds** are a variation, with water released to the wetland, but slowly. Dispersion of hillside water above the wetland, using **small furrows**, works. Even better is **grass**, which keeps stormwater from forming into rills. Grass filter strips, a proven technique, are said to be superior to buffers,[8] and are in common use.[9] **Berms and barriers** like curtain drains, laid horizontally above the wetland, divert and delay waters. These features can direct surface and ground water into channels or underground conduits that bypass the wetland. King County

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[3] Duff, Karl. 2005. *Facts and views presented to the Kitsap County Planning Commission regarding the proposed updated critical areas ordinance (CAO).* Port Orchard, WA: September 23, 2005.

[4] Duff, Karl. 2005. *Facts and views presented to the Kitsap County Planning Commission regarding the proposed updated critical areas ordinance (CAO).* Port Orchard, WA: September 23, 2005.

[5] My estimate.

[6] Department of Ecology's draft publication, *Freshwater wetlands in Washington State, A synthesid of the science* (August 2003), p. 2-5.

[7] A problem confirmed by Chris May in "Stream-riparian ecosystems in the Puget Sound lowland eco-region - a review of best available science", 2003.

[8] Desbonnet, Alan, et al. 1994. Vegetated buffers in the coastal zone, a summary review and bibliography. Coastal Resources Center Technical Report No. 2064. Narragansett, RI: University of Rhode Island and Rhode Island Sea Grant.

[9] Barfield, B. J., et al. 1977. Prediction of sediment transport in a grassed media. Paper No. 77-2023. American Society of Agricultural Engineers.

says that a **paved surface with a recharge pond** can do more for aquifers than a forest on the same area.[10]

Recently devised is a whole program of practices called **Low Impact Development**. LID strategies "focus on evaporating, transpiring, and infiltrating stormwater on-site..."[11]

SEDIMENT, a common problem in farm areas, does not concern us here.
If it did, **grass** would be twice as effective as woodland at retaining sediment.[12]

If **NUTRIENTS** are a problem in Kitsap wetlands it has never been shown. Nutrients, primarily nitrates and phosphates, are an issue downhill from pastures and especially feedlots. Dogs, deer, and yard care are probably the main Kitsap sources, with septic systems a source in some places. Phosphates may be the lesser issue here because they tend to bind themselves to soil particles. Nitrates go with the flow. Here again, **grass** is the solution of choice, if there is a problem. Its success with septic-source nitrates is a given.[13] Grass is twice as effective as forest buffers in corralling nitrogen.[14] As with most other vegetation, grass takes up nitrates best during the growing season. This is good timing considering that fertilizing is a growing-season activity. In the rainy season, anything that retards or diverts stormwater is good, and **grass** is a winner here as well. "Thickly planted, clipped grasses provide a dense, obstructive barrier to horizontally flowing water. This ... reduces flow velocity, promotes sheet flow, and increases sediment and adsorbed pollutant removal efficiency."[15]

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[10] King County. October 2003. *Best available science.* p. 6-20.

[11] Hinman, Curtis. 2005. Low impact development -- Technical guidance manual for Puget Sound. Olympia and Tacoma: Puget Sound Action Team and Washington State University Pierce County Extension. P. 11.

[12] Desbonnet et al, above.

[13] "Under proper site and operating conditions [septic systems] can achieve significant removal rates (i.e., greater than 95 percent) for biodegradable organic compounds and suspended solids." "The percent removal of subsurface wastewater infiltration system [drainfield] percolate at 3 to 5 ft depth was found to be over 99.99%." U.S. Environmental Protection Agency. 2002. Onsite wastewater treatment systems manual. EPA/625/R-00/008. p. 3-28, 3-29.

[14] Desbonnet et al, p. 17.

[15] Desbonnet et al, p. 18.

PESTICIDES AND HERBICIDES are yet to be reported in Kitsap wetlands. Vegetation control chemicals are the more likely, from control work along roads and in yards, mostly in summer when stormwater to carry them toward mischief is scant. Research has shown that a 20-30 foot band of grass can stop 70-100 percent of herbicides.[16] **Lawns** work.

Forbearance in application, including following label instructions, and using chemicals specific to the problem, are known solutions. Modern chemicals are designed to lose their potency quickly. Choosing chemicals with a half-life less than three weeks has been recommended. **Physical control of vegetation**, rather than spraying, has been adopted by Bainbridge Island's road staff.

Integrated pest management, adapted from farming, boils down to using plants adapted to the site, keeping them well nourished, avoiding treatments that harm predators of the pests, mowing instead of spraying unwanted vegetation, and using chemicals sparingly and only when really needed.

PERSISTENT TOXIC CHEMICALS, including metals like lead, typically from industrial activity, generally elude capture as they move in pulses of stormwater, or adhere to sediments above and below ground. The Island has had upland experience with such chemicals, in addition to our famous waterfront creosote site.

If the sediments are free to travel (e.g. zinc and copper)[17] they are prone to saturate buffers, residing there with their toxic passengers until dislodged by pulses of surface water.[18] The ability of vegetation to draw in and use these chemicals is very small and generally fatal to the plants. Not to mention effects on living things in wetlands and streams and all along the food chain. The upshot is that, where wetlands accumulate sediments they correspondingly warehouse chemicals.[19] This is the sump role of wetlands.[20]

So, for some persistent toxics, buffers work temporarily where sediment is the vector, and **grass**, mentioned above, is the best
filter. But industrial chemicals tend to arrive in the landscape continuously, racing downhill past sediments, saturating everything including Puget Sound.[21] Against these enemies of nature the obvious weapon is **control at the source**. Heavy metals and industrial chemicals don't belong in Kitsap buffers; for them buffering is not a solution.

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[16] Cited in King County's *Best Available Science*:

Arora, K. S. et al. 1996. Herbicide retention by vegetative buffer strips from runoff under natural rainfall. Transactions 39:2155. American Society of Agricultural Engineers.

Mickelson, S. K., et al. 1995. A summary report: the effectiveness of buffer strips in reducing herbicide losses. Annual meeting proceedings. Soil and Water Conservation Society.

[17] DOE above, p. 3-29.

[18] Desbonnet et al, above.

[19] DOE above, p. 2-37.

[20] DOE above, pp 2-5, 2-39.

[21] Puget Sound Water Quality Action Team. 2002. Puget Sound Update 2002. p. 49 ff.

The simplest sort of source suppression is **abstinence and prohibition**, and there are lists of target industries. However the problems and their solutions lie with individual processes and are often place- and stage-specific. A solution may be as simple as installing and servicing a filter. Industrial engineering is the expertise of choice here, not wetland command.

BACTERIA emerging from septic systems are a non-issue assuming reasonable design and care (and crippled systems declare themselves loudly, via odors). "Normal operation of **septic tank**/subsurface infiltration systems [**drainfields**] results in retention and die-off of most, if not all, observed pathogenic bacterial indicators within 2 to 3 feet of the infiltrative surface....most bacteria are removed within the first 1 foot vertically or horizontally from the trench-soil interface."[22]

WILDLIFE WELFARE is not specific to wetlands nor their buffers. No bird or animal is solely dependent on a wetland and its close surround. Rather, larger landscapes are involved and available. Which is why wildlife habitats are treated separately from other 'critical areas'.

Kitsap wetlands are breeding places for amphibians, and certain Puget Sound birds depend on adjacent shrubs for nesting.[23] For both groups there is a larger world, far beyond wetlands and their margins. It has not been shown that widening a bordering vegetation belt beyond a few meters leads to more amphibians or birds. Nor even that wetland quantities are limiting factors in the abundance of these species. If wetlands and buffers were costless, present buffer policy, now being applied without any attempt to answer these habitat-need questions, might be harmless. But buffers are not free.

For other wildlife, repeated studies along Northwest forest streams have shown that birds, small mammals, invertebrates and fish prosper in the absence of buffers. And **Kitsap back yards and verges** are surely far more hospitable than streamside forest clearcuts.

There is also an issue of how many wildlife-usable wetlands we actually have--those that hold water year-round. Too, besides **knowing more about our wetlands** we need to **estimate the County's Prudent Carrying Capacity (PCC)** for wanted wildlife species. Not only don't we know the numbers, we don't know what the limiting factors are--predators, food chain, cold winters, etc., with the possibility that wetlands don't really make a controlling difference.

People see the County, its institutions and its landscape, as an environment for families. Countryside **treatment as a children's place** is not much different from ensuring habitat for wild things. **Lawns, parks, meadows, beaches, and woodlands** are serving wildlife well.

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[22] US Environmental Protection Agency. 2002. *Onsite wastewater treatment systems manual*. EPA/625/R-00/008. p.3-33.

[23] The bird statement based on information from Prof. John Marzluff, University of Washington.

In its effort to tutor the provinces, DOE has identified three wetland functions, services that Kitsap wetlands have been providing across centuries of human habitation and disturbance:

Trapping and transforming chemicals and improving water quality in the watershed,

Steadying water flows, including reducing flooding, and

Food web and habitat functions.[24]

DOE is saying that **the best substitute for a buffer in protecting watersheds is the wetland itself**. Yet, DOE points out, these wetland functions are the very roles that planners want to shift to buffers. Frugality in land use is being discarded.

[24] Paraphrased from DOE above, p. 2-5.

May 2008
December 2008

Notes and sources from a Puget Sound debate.

PUGET SOUND'S HEALTH IS DETERIORATING

Yes Fish are dying in Hood Canal. Nitrogen from septic tanks is a major cause.

No Fish mortality there has occurred intermittently for at least 50 years. This corresponds to a cycle in ocean upwelling, which brings low-oxygen water into the Canal. The ocean brings 400 times a much nitrogen into Hood Canal as do all the septic systems along the Canal.[1]

Yes Dissolved oxygen, essential to marine life, is low in some areas.

No This is mostly an ocean-water issue, plus sunlight that encourages phytoplankton (microscopic marine plants) which generate oxygen, followed by decay of the dead plankton that uses oxygen. Rivers and wind play roles too. This is all natural and possibly cyclic.

Yes 140 million gallons of household discharge a day go into the Sound from King County (formerly Metro) treatment plants.[2] Bainbridge Island puts almost a million gallons per day into the Sound.

No Sewage gets secondary treatment.

Ocean water flushes the central Sound: for every gallon of river and treatment water going in, nine arrive from the ocean (along the bottom of the Sound) and together ten

[1] Paulson, Anthony J., et al. 2006. Freshwater and saline loads of dissolved inorganic nitrogen to Hood Canal and Lynch Cove, Washington. Scientific Investigations Report 2006-5106. Reston, VA: USDI Geological Survey.

[2] West Point plus Renton: Hart Crowser et al. 2007. Control of toxic chemicals in Puget Sound. Appendix D, Table D-1. Earlier version of this paper used: 60 gallons per person per day, per EPA report in file. King County data (note 3) shows 2.3 million people connected to sewer systems in 2000. 60 x 2.3 = 140 million gallons/day.

gallons leave (along the top). 90 percent of the water in the central Sound, on average through the year, is oceanic.[3]

Yes Population close to the Sound has gone from 2.2 million in 1974 to 3.8 million in 2008.[4] Employment has grown similarly, implying growing industrial discharges to the Sound.

No Shoreline 'heavy' industries are mostly gone. Shoreline use has become largely residential and recreational. Examples are Bellingham, Edmonds, Olympia, Port Townsend, Port Gamble, Port Discovery, Port Ludlow, Port Orchard, Gig Harbor, even Bremerton and our own Eagle Harbor and Port Blakely.

Trees are returning after 150 years of logging, burning, farming. Bainbridge Island has about a million trees, an average of about 60 per acre.

TIDEWATER ORGANISMS ARE THEREFORE IN DISTRESS

Yes Non-salmon fish are in trouble. Herring are in decline. Cod are largely gone.

No Eelgrass, on which herring spawn, is leaving some areas, though without an overall trend up nor down. Herring also spawn on various kelps, which are increasing.[5] Some 1/4 billion herring (8 million pounds) are caught every year in the Sound.

Codfish have diminished here and in B.C., for reasons unclear. Overfishing is suspected.

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[3] Ebbesmeyer, Curtis C.; verified by Flora with data from:

Salinity - Puget Sound Action Team. 2007. Puget Sound Update. Olympia. P. 241.

Per capita sewerage and King County flow - Keng County Wastewater Treatment Div. 2003. Fact sheet: King County wastewater flow projections.

Extrapolation of sewerage to the central and south Sound: Flora

Runoff including rivers entering central and south Sound - Hart Crowser, Inc. 2007. Control of toxic chemicals in Puget Sound, Phase 1. Dept of Ecology pub 07-10-079. Table 3.

[4] 3.8 million from p. 6 in 'Fresh Water' section of Puget Sound Partnership, 04/08 draft Water Quality Topic Forum Paper. Puget Sound Action Team, Office of the Governor, State of Washington (PSAT) "2007 Puget Sound Update" says 4.22 million in 2005. This probably includes Jefferson and Clallam Counties.

[5] Mumford, Thomas F., Jr. 2007. Kelp and eelgrass in Puget Sound. Puget Sound Nearshore Partnership Technical Report 2007-05. Seattle: U.S. Army Corps of Engineers.

Yes Spartina, an invasive marine grass, threatens the shellfish industry and shallow bays everywhere in the Sound.[6]

No Spartina eradication is underway, so successfully that complete eradication is expected by 2010.[7]

Yes Chinook and summer chum salmon are ‘threatened’. Puget Sound shorelines are ‘critical habitat’ for Chinook.

No All Puget Sound shores were designated ‘critical habitat’ by a federal agency because Chinook salmon swim past the beaches.[8] The designation was overturned in a federal court. There was and is no evidence that beaches are toxic or otherwise harmful to salmon, nor that beach conditions enhance salmons’ passage. Try estuaries.

Salmons’ declines are attributed by a state agency to overfishing, dams, and habitat degradation. Pacific Rim offshore overfishing is beyond our control.

Ocean conditions are often cited in a general way.[9] Too, Puget Sound and river water temperatures have risen since about 1970; this may benefit juvenile salmon.[10]

Billions of dollars are being spent on habitat, presumably successfully.

Yes Resident orca populations are fragile.

No Their numbers have trended upward since 1974.[11]

Yes Other marine mammals are in jeopardy.

No Numbers of seals and sea lions are at or near record levels and growing.[12]

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[6] Puget Sound Action Team. 2007 Puget Sound Update. Olympia: Office of the Governor. p. 84.

[7] Same source.

[8] National Marine Fisheries Service [aka NOAA Fisheries], in 2005.

[9] For example, 2007 Puget Sound Update p. 101, 105, 112.

[10] Same source, p. 101.

[11] Same source, p. 78.

[12] Same source, pp 75-6. Also Terich, Thomas A. 1987. Living with the shore of Puget Sound and the Georgia Strait. Durham, NC: Duke University Press. p. 13.

SHORELINES ARE BEING ABUSED BY BULKHEADS

Yes Bulkheads are being built on upper-beach forage-fish spawning areas.

No The state's hydraulic code requires that new bulkheads be built against the bank, not out on the beach.

Yes Bulkheads displace backshore trees.

No Half the bulkheaded sites visited in a Thurston County study[13] had overhanging trees. Trees or other vegetation are usually close to bulkheads on almost any shore.

Yes Bulkheads are turning beaches from sand to cobble.

No Most Puget Sound beaches have a cobble component.[14]

The along-shore substrate is typically sand and gravel, courtesy of the glaciers that left about 10,000 years ago.[15]

A beach in equilibrium usually has cobble at the top on a steep section, with pebbles and coarse sand on the gradual slope below; all in the intertidal area.[16]

Yes Bulkheads cause a lowered beach profile.

No 29 pairs of transects across Thurston County beaches, each with a bulkheaded and an unprotected beach, showed no statistically significant beach-profile change.[17]

Yes Bulkhead induce scouring along the foot of the bulkhead.

No None was found in the Thurston County Study.[18]

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[13] Herrera Environmental Consultants. 2005. Marine shoreline sediment survey and assessment, Thurston County, Washington. Seattle.

[14] Burns, Robert. 1985. The shape and form of Puget Sound. Seattle: Washington Sea Grant, p. 88. Also Downing, John. 1983. The coast of Puget Sound, its processes and development. Seattle: Washington Sea Grant, P 4, 53ff.

[15] Finlayson, D. 2006. The geomorphology of Puget Sound beaches. Puget Sound Nearshore Partnership Report 2006-02. Seattle: Washington Sea Grant.

[16] Finlayson, 2006, above, p. 29. Also Johannessen, Jim and Andrea MacLennan. 2007. Beaches and bluffs of Puget Sound. Puget Sound Nearshore Partnership Technical Report 2007-04. Seattle: US Army Corps of Engineers, p. 2-4.

[17] Herrera Environmental Consultants, 2005, above.

[18] Same source.

Yes Bulkheads deny beach ‘nourishment’ from ‘feeder bluffs’.

No Studies of 1308 historical landslides in Seattle showed that, after bluff undercutting was stopped with a bulkhead, the upper slopes continued to recede, with ‘colluvium’ riding over the bulkheads onto beaches.[19]

In almost all cases slides were triggered by prolonged rainfall.

Beach ‘nourishment’ and long-shore dispersal of beach-plop sediments is typically a multi-decade process, and ultimate stability of the upper bluffs may involve centuries.

Yes Sandspits and other accretion sites will disappear because sediments will not be available to be driven along drift zones by waves toward the spits.

No No studies were found in which sediment-drift impairment was measured, nor was it shown that sandspits have shrunk because of slope-toe protection.

Yes Bulkheads preclude collapse of trees from banks onto the beach, which benefit beach organisms.

No With bulkheads, trees continue to fall from above, due to soil saturation. This is apparent but its frequency is unreported in the literature.

Trees can be a detriment on the beach, acting as groins or, slightly elevated on remaining branches, providing hard shadows that passing fish are said to avoid.

Drift logs, the prime source of woody beach debris, are almost gone from the Sound as timber towing has nearly vanished. Yet no loss of beach health has been attributed to the change.

ABSENCE OF TREES FROM RESIDENTIAL SHORELINES IS COMMON AND THAT IS BAD

Yes Passing salmon consume insects that fall from shoreline trees.

No Only 1 to 2 percent of juvenile salmons’ diets comprise insects that are tree ‘obligates’. Adult salmon and forage fish (herring, surf smelt, candlefish) do not eat insects.[20]

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[19] Schulz, William H. 2007. Landslide susceptibility revealed by LIDAR imagery and historical records, Seattle, Washington. Engineering Geology 89:67-87.

[20] Flora, D. F. 2007. A perspective on insects eaten by juvenile Puget Sound salmon. 10-page background report available from the author.

Yes Shade from overhanging trees is important to spawning surf smelt, which use the upper beach.

No This is a summer-time issue. Only in two places in the central Sound do surf smelt spawn in summer. One is in Eagle Harbor, across from the creosote plant, on a beach that has lacked shade for a century. Surf smelt continue to spawn there, successfully.[21]

There is an excess supply of spawning beaches: Places with suitable substrate but no use by surf smelt.[22]

Yes Sand lance (candlefish) also spawn high on the beach.

No But not in summer.

Yes Passing salmon seek the uneven shade of overhanging trees, for reasons unclear.

No This is a benefit only at highest tides, in daytime.

This is a hiding mechanism in streams. Nobody has shown that it applies to tidewater fish (which are bigger).

Salmon, including juveniles regularly cross long open-water reaches, even wandering away from their routes to the ocean. This does not suggest dependence on shoreline shade.

Yes Trees along the shore fall to the beach, creating habitat for termites, wood-eating worms, and perhaps carpenter ants.

No Trees lying on the beach can be a problem, mentioned earlier. Nobody has shown that beach logs make a significant difference to fish nor to beach-dependent life; logs are not ‘critical habitat’.

Yes Trees shed leaves to the beach, which adds nutrients to the ecosystem.

No These are the same nutrients that are deplored because they encourage phytoplankton. Decay of the plankton and the leaves depletes oxygen, causing ‘hypoxia’.

Yes Trees frame views.

No Trees block views.

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[21] Flora, D. F. 2008. Some notes on surf smelt, their protection and role. 8-page background report available from the author. Also, Penttila, Dan. 2007. Marine forage fishes in Puget Sound. Puget Sound Nearshore Partnership Technical Report 2007-03. Seattle: US Army Corps of Engineers.

[22] Penttila, 2007, above.

Yes Trees' roots stabilize the bank.

No The Seattle study showed that virtually all landslides in Seattle have been triggered by saturation of the soil. Rootwads encourage saturation. Along streams, roots help against banks' scouring out; yet streams continue to meander. This could be a tidewater benefit only at the highest of high tides where the bank is low.

Yes Trees above the bank slow and capture stormwater and send it to the atmosphere; this is good.

No Those great conduits to the sky can each send away 100 gallons or more per day. That water is lost to the aquifer.

'Evapotranspiration' from trees is a spring-summer matter, when venting water away is unneeded and perhaps unwise.

Yes By stopping stormwater trees stop erosion.

No Trees stop underground water seeping along above hardpan ('glacial till') soils. They don't stop surface water, which collects into erosion rills and then gullies.

Yes By stopping erosion trees stop sediment movement, and many pollutants cling to sediments.

No But see the previous 'no' argument. Stormwater, with whatever sediment it carries, flows right on past trees. Sediment treatment needs grass or other tight groundcover.

Yes 'Raptors' like eagles and hawks watch for prey from high places, preferring dead-tree limbs. The Island's eagle population is growing.

No With a million trees, the Island has many perches. And despite all those trees, eagles are regularly seen on floats and dock railings.

Yes Lands next to tidewater have been called critical habitat, with trees encouraged.

No 'Critical habitat' does not correspond to obligate habitat.

The reality of woodsiness above the beach is its actual inhabitants: Raccoons, opossums, squirrels, rats, root rots, tent caterpillars, feral cats and pursuing coyotes, and many birds, all found in abundance all across the Island.

Four of the five species of cavity nesters designated priority species by WDFW and seen on the Island nest elsewhere and the fifth, wood ducks, are fresh-water diners and denizens. With hundreds of wetlands on the Island these ducks are well-served away from tidewater. Most marine birds nest northward (Canada mostly).[23]

Stream studies in western Washington have shown that diversity and abundance of wildlife have not differed between tree and no-tree situations.[24]

Yes Trees are a key element of shoreline 'restoration'.

No Pre-settlement forests were about 60 percent fire-caused clearings.

It is said by ecologists that Puget Sound shorelines have been altered beyond restoration.

Since the target restoration state of shore reaches cannot be known, 'restored' is in the eye of the beholder.

DOE guidelines for Shoreline Master Programs say, "Restoration does not imply a requirement for returning the shoreline area to aboriginal or pre-European settlement conditions."

Yes Trees are charming.

No Prescriptions for vegetated shorelines are so standardized as to preclude diversity, a major feature of natural ecosystems.

Companion calls for 'native' vegetation further truncate the options without demonstrably enhancing the welfare of the shore.

Yes Trees are great play places for children.

No The City's prescriptions for shoreline vegetated buffers preclude use except for narrow trails. Demolition of a shoreline tree house was required recently.

OVERWATER STRUCTURES (DOCKS) ARE BAD TOO

Yes Migrating salmon resist crossing beneath piers and ferry terminals. They go around, which exposes them to predators and uses energy.

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[23] Discussion with George Gerdts, Island ornithologist, and material in Larsen, Eric M., et al. 2004. Management recommendations for Washington's priority species. Volume IV: Birds. Olympia: Washington Department of Fish and Wildlife.

[24] There have been two such studies, involving scores of streams, in western Washington. Other studies in Oregon and British Columbia reached the same conclusion. Flora can provide background.

No Two recent outdoor studies in Puget Sound show that some do and some don't. Reasons for the difference are guessed but not demonstrated.[25]

"...there is no evidence, despite many efforts to find it, that [docks and floats] in marine waters lead to a concentration of predators on juvenile salmonids or increased vulnerability to those predators that may be present. On the other hand, areas around docks and floats are frequently used as cover or as a source of prey by schools of juvenile salmonids..."[26]

Yes The fish shy away from sharp changes in sunlight intensity.

No But many don't. "Juvenile coho and pink salmon appeared to prefer dark under pier habitats during their early marine life history."[27] One can readily see schools of fingerlings scurrying, when startled, into the shelter of floats and log booms.

Yes This surmise warrants costly rules requiring narrow docks with full-length light-penetrating gratings.

No An analysis has shown that residential docks add an average of 93 feet to the 55-mile trip of hatchery smolts headed to the Strait of Juan de Fuca from Sinclair Inlet.[28] Relative to the energy expended in leaving Puget Sound, the dock problem is clearly negligible.

PATHOGENS AND CHEMICALS ARE OUR GREATEST THREATS TO PUGET SOUND. THESE MUST BE CLEANED UP AT ANY COST.

Yes "Serious impairment to water quality and sediment does occur in localized sites in Puget Sound under existing standards and sampling methods."[29]

No That statement was dropped from the final Puget Sound Partnership paper on water quality, and no impairment data is given for the Sound.

"The available scientific evidence...does not generally support a conclusion that the freshwater streams and lakes of Puget Sound or the marine waters are universally

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[25] Southard, S. L., et al. 2006. Impacts of ferry terminals on juvenile salmon movement along Puget Sound shorelines. Sequim: Battelle Memorial Institute.

[26] Houghton, Jonathan. 2006. Best available science review of proposed overwater structure restrictions in Blakely Harbor, Bainbridge Island, Washington. Edmonds, WA: Pentec Environmental. P. 15.

[27] Same source, p. 4.

[28] Flora, D. F. 2008. Pressing on: Do residential docks really impede passing salmon? Available from the author.

[29] Puget Sound Partnership. 2008. Draft forum paper on Water Quality, p. 3.

contaminated from pollutants for which there are established standards."[30] This statement, too, was edited out.

Yes Fecal coliform bacteria is...one of the most ubiquitous pollutants [in Puget Sound].[31]

No Functioning septic systems remove 99.9 percent of fecal coliform.[32] "Although it is presumed in some locations that the presence of pathogens in water bodies is due to failing septic systems, this is not always the case and extensive testing is needed to identify sources."[33] Animal waste is a signficant source of fecal coliforms, including marine mammals, wild animals, pets.[34]

Yes Metals in stormwater come from many sources, including brake linings.[35]

No "Only 8 sites out of 639 where dissolved metals and mercury results were reported exceeded 2006 Washington water quality standards...and none were in the Puget Sound basins."[36]

"In 2000 Michelson found that measured dissolved metals were significantly below the relevant marine water quality criteria in samples collected at 5 and 50 meters below the the surface in several cross transects of the middle Puget Sound basin."[37]

Yes Herbicides and insecticides are major problems.

No These are typically applied in summer, when stormwater is not available to carry them to tidewater.

Modern pesticides are formulated to have short-duration effects. Half-lives of yard chemicals are public information.

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[30] Same source, p. 3.

[31] Puget Sound Partnership. 2008. Final forum paper on Water Quality, p. 18.

[32] EPA. 2002. Onsite wastewater treatment systems manual. EPA/625/R-00/008. Cincinnati: National Risk Management Research Laboratory.

[33] Puget Sound Partnership. 2008. Draft forum paper on Water Quality, p. 10.

[34] Same source.

[35] Same source, p. 7; Final forum paper p. 12.

[36] Draft forum paper, p. 12. Cites a DOE 2007 statement.

[37] Final forum paper, p. 18. Quoting S. Michelson, King County Department of Natural Resources and Parks.

Yes Persistent bioaccumulative toxics (PBTs) have been found in fishes' food webs.[38]

No They are in bottom sediments, not the water column, in industrial bays.[39] "Although a few local examples... strongly suggest a linkage between urban runoff and sediment toxicity...opportunities to demonstrate a strong cause-and-effect relationship are too rare to draw many generalized conclusions."[40]

Yes This group includes PCBs, designed to resist degradation and highly toxic.[41]

No PCBs have been banned since the 1970s.[42]

Yes Another subset, PBDEs, flame retardants, behave the same but are still in use.[43]

No For this and other PBTs there is not yet a method for removing them from sediments, much less in a cost-effective manner.

Yes PAHs come from road asphalt and are a combustion product of gas and oil. Moving into bottom sediments, they cause liver lesions in sole.[44]

No PAHs are known to disintegrate over time. Those in creosote dissipate within hours when exposed to the atmosphere.[45] Effects on people, and their routes into the sole, are not explained.

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[38] Puget Sound Action Team. 2007 Puget Sound update. P. 140ff.

[39] Same source, p. 141.

[40] Puget Sound Partnership. 2008. Final forum paper on Water Quality, p. 14.

[41] Puget Sound Action Team. 2007. Puget Sound update. P. 149ff.

[42] Same source, p. 141 box.

[43] Same source, p. 142ff boxes, figs.

[44] Same source, p. 163ff.

[45] Flora, D. F. 2008. Some notes on creosote and the pickled-piling paradox. Available from the author.

Evidence on near-zero habitat harm from nearshore development.

A well-known Northwest contract-research firm has shown that a broad array of man-caused features along tidewater shores have no meaningful impact on "ecosystem functions".

Despite an obviously vigorous and fairly complex effort, a relationship between human-installed "stressors" and habitat factors was not found. Statistical analyses of the studies' data show that little of the variation in ecosystem (habitat) functions can be explained by a large basket of stressors. The correlation of multiple stressors with the welfare of nearshore habitats is not significantly different from zero (Bainbridge Island) or extremely low (East Kitsap County).

The link beyond habitats to nearshore-dependent creatures was not explored because, the analysts explained, science is not available to do so. Overall, then, no significant correlation was found between human-caused nearshore features and marine life on Puget Sound.

These results are consistent with other research that is summarized here.

The results are quite damaging for notions of the need for nearshore restoration and its prioritization.

These are results of nearshore assessments of Bainbridge Island[1] and easterly Kitsap County[2]. Some 700 shore segments were analyzed. More than 20 human-imposed "stressors" were rated, from buoys to bulkheads, from paths to piling, for each shore segment. Also rated were estimates of habitat extent and welfare, based on 3 to 16 factors.

[1] Williams, G. D., et al. 2004. *Bainbridge Island Nearshore Habitat Characterization & Assessment, Management Strategy Prioritization, and Monitoring Recommendations.* Sequim: Battelle Marine Sciences Laboratory.

[2] Borde, A. B., et al. 2009. *East Kitsap County Nearshore Habitat Assessment and Restoration Prioritization Framework*. Sequim: Battelle Marine Sciences Laboratory.

Bainbridge Island

Each of 201 beach segments ("reaches") was scored for both human-installed stressors' presence and their presumed effects. This was done by repackaging stressors as "Controlling Factors", wherein wave energy, sediment supply, hydrology, and six other nearshore phenomena were weighted by the extent and intensity of the stressors impacting each reach, as well as the natural character of the reach. An example is a Controlling Factor called physical disturbance, whose score was derived from stressor data on number of buoys (their dragging chains), floats, and boats upon the beach. Controlling Factor scores were then summed to yield a total Controlling Factor score for the reach.

A habitat rating ("Ecological Functions score") was also assigned to each reach based on its estimated utility for ten organisms including forage fish, seaweeds, eelgrass, and overhanging vegetation.

I calculated the "coefficient of determination" (r^2) between the Controlling Factors and Ecological Functions as a group, using data provided in the study for the 201 reaches. r^2 is the proportion of variability in Ecological Functions that is explained by Controlling Factors. **It is 0.016, virtually at the bottom of possible values between 0 and 1.**[3]

The authors displayed plots of the 201 values and also a subset of that data for 31 'low-bank' reaches. They are Figures B-72 and B-74, below. Because the low-bank plot suggests some correlation, I calculated r^2 for those reaches. **It is still extremely low.**

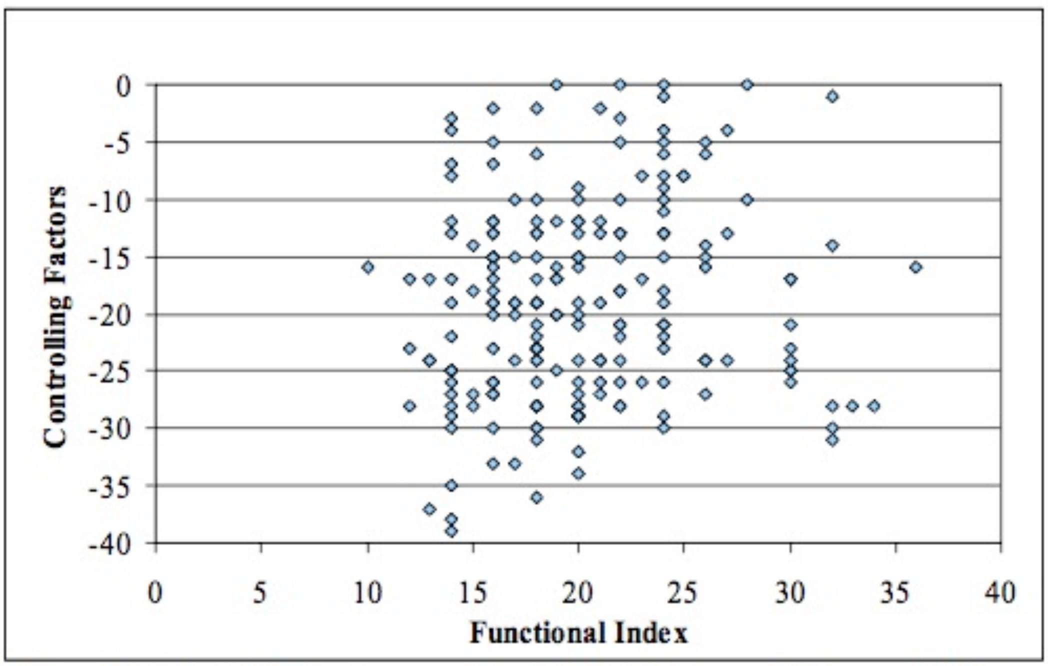

Figure B-72. Controlling Factors versus Functional Index Scores, All Geomorphic Types.

[3] Known to biostatisticians as r^2, the coefficient of determination is the percentage of variance of y explained by x, where y is drawn from a cluster of habitat factors and x is an amalgam of human-installed stressors.

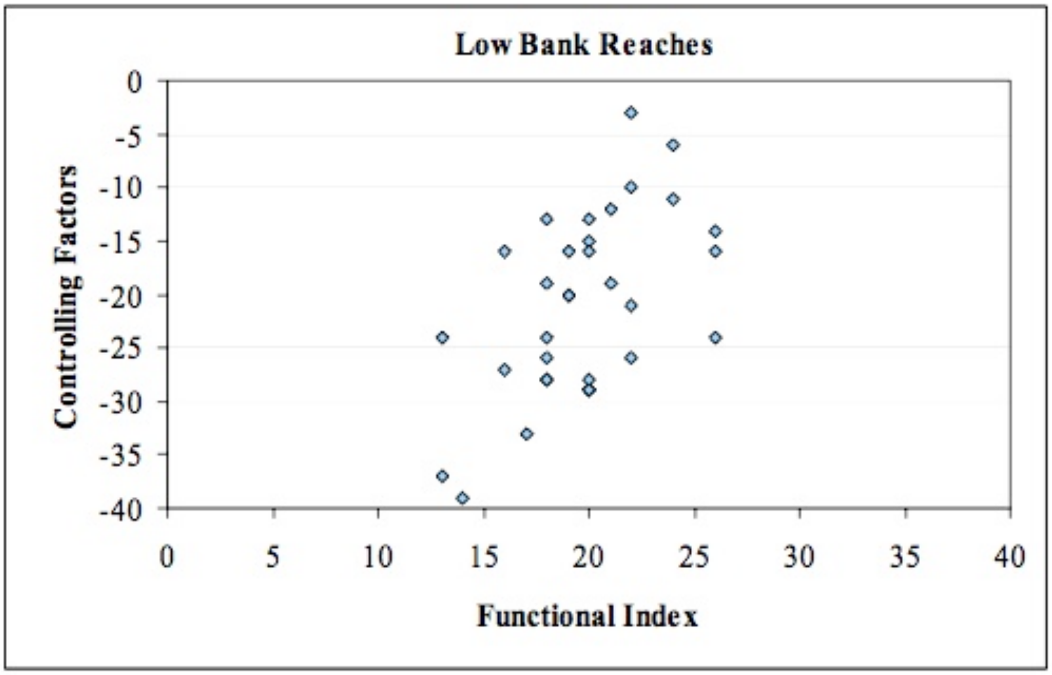

Figure B-74. Controlling Factors versus Functional Index Scores, Low Bank.

These figures do not demonstrate significant relationships. In general a coefficient of determination less than 0.66 is considered insignificant.

The Bainbridge report alludes repeatedly to causality between Controlling Factors and habitats, and correlation between Controlling Factors and Ecological Functions.[4] To examine further the correlations, which the analysts regarded as corresponding to causation, I calculated a number of regression equations using the report's data.[5]

The factors assumed to stress habitats explained only 0.06 percent of variation in Ecological Functions across the 201 reaches. That percentage is not significantly different from zero.[6]

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[4] For example, *Bainbridge Island Nearshore...* p. 30.

[5] If we want an equation showing how well Controlling Factors (X) explain Ecological Functions (Y), Controlling Factors is the explanatory variable. In an equation Y = 2 + 3X, X is the explanatory variable.

Reported here are "adjusted R-squareds" (values range between 0 and 1) and "F" values for the equations. R^2 (the "adjusted coefficient of determination" for the equation) is based on the ratio of X-explained variation (technically "variance") to total variation in Y.

F is based on the ratio of X-explained variation to as-yet-unexplained variation in Y. F relates to a "null" hypothesis that Controlling Factors have no incremental effect on Ecological Functions; the equation's slope coefficient is not significantly different from zero. That is, as Controlling Factors intensify, there is no significant change in Ecological Functions. For large data sets an F value over about 4 indicates less than a 5 percent probability that the null hypothesis should be accepted. Five percent is a customary level of acceptable probability.

[6] This because F is only 0.88.

What about the low-bank reaches by themselves? Controlling Factors explain only 0.14 percent of variation in Ecological Functions.

Easterly Kitsap County

In this shoreline assessment each of East Kitsap's 518 beach reaches ("sites") was scored for stressors. The rest of the analytical process was similar to the Island's, except that "Controlling Factors" were joined by a companion set of "Dominant Physical Processes", the latter having in common the results of water movement. For instance, wave energy and depth/ slope [profile change] are Controlling Factors, as with Bainbridge. Sediment transport and wave erosion are Dominant Physical Processes.

Habitat impacts were scored for reaches for which data was available. Impacts were based on the extent of eelgrass, wrack, driftwood, lower-beach flats, and the character of backshore vegetation including its overhang. Other factors were added for pocket estuaries.

I calculated, for those reaches, the correlation of stressor levels with habitats along East Kitsap beaches, as done above for Bainbridge. It appeared logical to merge the scores for Factors and Processes as the authors did in their graphics (Figure 15, below). There is a very low level of correlation, with only 12 percent of variability explained by Controlling Factors and Physical Processes combined.

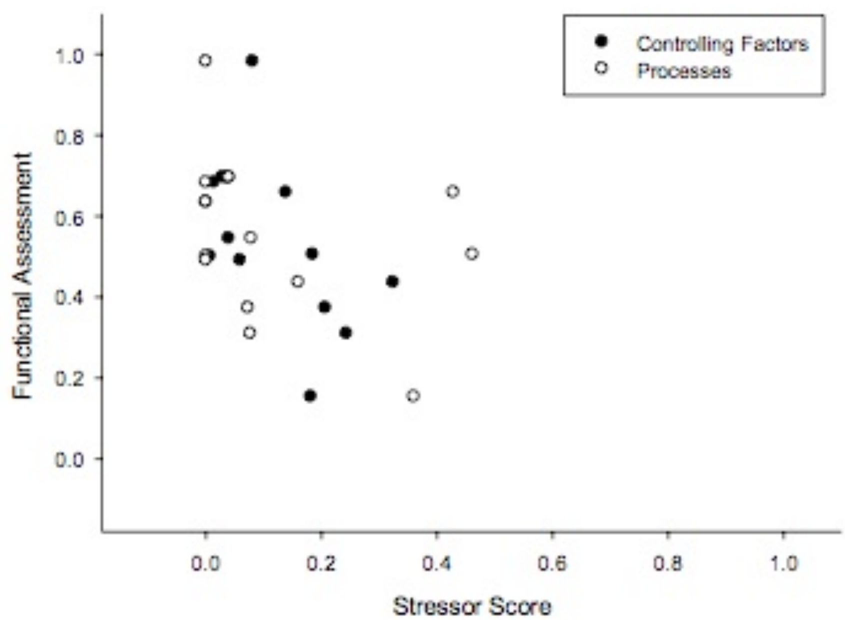

Figure 15. Functional assessment scores vs. GIS-based stressor scores for 14 NAUs.

In short, none of these supposed stressors has demonstrated a significant effect on habitats. The low correlation measures can only be construed as excusing the inventoried human-built stressors from the list of factors actually affecting habitats.

Harm May Be Wrongly Attributed to Bulkheads

As with many index-number systems, the use of Controlling Factor and Dominant Physical Process scores in policy-making requires decomposing them to determine specific effects of their many components.

The most pervasive input into these composite ratings was the presence and extent of bulkheads. Bulkheads appear as causal stressors in five of the nine factors affecting Bainbridge Island Controlling Factor scores; in two of five Controlling Factors and all of the six Physical Process factors applied to East Kitsap.
Not only did bulkheads enter frequently, the scores were “primarily affected” by ‘armoring’ in East Kitsap[7]; around Bainbridge “high rates of shoreline armoring..., armoring encroachment..., and point modifications...have significantly changed the historic composition of substrate and depth-slope contours along Bainbridge Island shorelines.”[8] Perhaps. At any rate, bulkheads stand large among the presumptive sources of nearshore harm, with no substantiating research demonstrating the tie.

What does ground truth tell us?

It is possible to separate out bulkhead scoring from the Bainbridge Island basket of stressors included in Controlling Factors. Likewise for components of the Ecological Function index.[9] In four regression equations bulkhead intensity was the explanatory variable of special interest. The dependent variables were eelgrass density, extent of overhanging vegetation, presence of sandlance spawning, and presence of surf smelt spawning[110], with these conclusions: **There is no evidence of a statistically valid relationship between reaches’ bulkhead lengths and eelgrass welfare, overhanging vegetation’s extent, nor forage-fish (surf smelt and candlefish) spawning-ground expanse.**[11]

The Bainbridge report deals as well with ‘encroaching’ bulkheads - those that are somewhere out on the beach. Their distances from the bank are not indicated, just the percentage of

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[7] *East Kitsap County Nearshore*... p. 27, 28.

[8] *Bainbridge Island Nearshore...* p. 32.

[9] Readers should understand that all the indexes involve heavy doses of conjecture and hence normative (arbitrary) structures and values.

[10] The report’s text is unclear as to whether spawning has happened in these places, or they only appear suitable for spawning. Sound-wide there is more seemingly suitable beach than is actually used.

[11] On Bainbridge Island
an increase in bulkhead length is
associated with no statistically
significant reduction in: Adjusted R^2 F

Eelgrass welfare 0.5 percent 0.009

Overhanging vegetation 0.6 percent 2.17

Sand lance spawning 0.5 percent 0.0001

Surf smelt spawning 0.4 percent 1.82

shoreline in each reach that has that condition. Briefly, encroaching bulkheads are no harder on eelgrass than bulkheads generally: statistically insignificant, with only 0.2 percent of variation explained. Results for sand lance and surf smelt spawning and for overhanging vegetation are similar.

The East Kitsap report also has an eelgrass component and a "vegetation" index in its Ecosystem Functions (habitat) basket, though for only 12 reaches. The vegetation index includes measures of the above-beach vegetation for 225 feet inland as well as overhanging veg.

Readers are reminded that the East Kitsap sites were selected by the analysts, not chosen randomly nor in some systematic fashion. Of the 14 validation sites, 6 do not have bulkheads at all and 2 of the others have no eelgrass, leaving only 6 sites out of 518 as thin gruel for estimating the incremental effects of bulkheads on eelgrass. In any case, **Bulkheads had a demonstrated significant effect on neither of these purported habitat factors.**[12]

Another set of numbers on bulkheads as stressors: All 201 Bainbridge reaches' bulkhead data were regressed against the aggregate index for the Ecological Functions (habitat) group. The adjusted R-squared was abysmal, 0.0008. For East Kitsap a similar regression was run: Ecosystem Functions (habitat) against bulkhead length, for the 14 follow-up reaches. The adjusted R-squared was very low, 0.06. **Bulkheads clearly play a statistically trivial role in nearshore habitat welfare.**

The authors clearly regard bulkheads as hostile to eelgrass. Yet Bainbridge Island shoreline maps reveal the considerable coexistence of eelgrass with bulkheads. About half the Island's eelgrass is in front of bulkheads; about two-fifths of bulkheads are fronted by eelgrass.

At a 2009 conference on bulkheads, a well-known researcher said, "it has not been confirmed in the field or the laboratory whether currents and sediment transport rates will increase or decrease in front of a hardened shoreline, as compared to a non-armored section of beach, and whether the sedimentary environment will be significantly modified.[13]

That the sedimentary environment was not affected was shown in a study of Thurston County beaches, where profiles of bulkheaded sections were compared with nearby non-bulkheaded

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[12] On East Kitsap reaches an increase in bulkhead length is associated with no statistically significant reduction in:

Eelgrass welfare 27 percent 5.07

Vegetation 17 percent 3.73

(The F significance threshold is 5 because of the small sample.)

[13] Ruggiero, Peter. 2009. Impacts of shoreline armoring on sediment dynamics. In: [Abstracts of] Puget Sound shorelines and the impacts of armoring: State of the science. Alderbrook Inn, 13 May 2009. US Geological Survey http://wa.water/usgs.gov/SAW/

profiles. Following adjustment of an analytical glitch, no statistically significant beach changes were shown.[14]

Two studies purport to show effects of bulkheads on surf smelt egg survival.[15] In fact they compare treeless (and bulkheaded) unshaded shores with treed (non-bulkhead) shaded places.

Two studies[16] have shown no difference in subsurface fauna in front of bulkheaded versus unprotected shores, so this part of the habitat issue also seems moot.

Not one of the 40-odd references cited in the Bainbridge analysis nor the score of fish-habitat citations in the East Kitsap report contain research showing ecosystem decline (much less ‘destruction’) caused by residential bulkheads in Puget Sound.

Other conjectural inclusions in the stressor indexes, such as the roles of piling, residential docks, stormwater outfalls, upshore impervious area, and upshore woodland coverage are seemingly dubious.

Three Conclusions

Singly and together these reports suggest no effect of the nearshore built environment on habitats.

The authors analyzed a broad array of *human-built* nearshore ‘stressors’ in their search for relevant nearshore habitat stressors. Investigators must now presumably look to *natural* factors not embraced in these two assessments. Natural drivers are known to include water temperatures, invertebrate dynamics, beach profiles’ shoreward migration, upland ecology, and the perennial conflicts and interplay of nearshore organisms among themselves and their environment.

Meanwhile the argument that habitats and their occupants require “restoration”, implying conversion of nearshore areas to some seemingly natural state, is not supported by these analyses. More discussion of restoration is below.

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[14] Herrera Environmental Consultants. 2005. Marine shoreline sediment survey and assessment, Thurston County, Washington. Seattle.

[15] Rice, Casimir A. 2006. Effects of shoreline modification on a northern Puget Sound beach: Microclimate and embryo mortality in surf smelt. Estuaries and Coasts 29(1):63-71; The same single-site 5-day comparison appears as a chapter in his University of Washington PhD thesis. Although this study was said to cover ‘shoreline modification’, the 2-site design recognized only a bulkhead and shade trees, and it was not possible to separate bulkhead effects, if any, from those of trees.

Tonnes, Daniel M., 2008. Ecological functions of marine riparian areas and driftwood along north Puget Sound shorelines. Master’s thesis, School of Marine Affairs, University of Washington.

[16] Sobocinski, Kathryn L. 2003. The impact of shoreline armoring on supratidal beach fauna of central Puget Sound. Master’s thesis, School of Aquatic and Fishery Sciences, University of Washington.

Tonnes, Daniel M. 2008, above.

About Harm

The low correlations also press forward the issue of *harm*. In these studies harm was presented in terms of effects on habitats, not their inhabitants, despite sidebar references to salmon and forage fish. Stopping short of trying to guess effects of various levels of habitat quality on classes of marine life was, I think, a good idea, given the authors' perception that "Biotic variables, such as fish abundance or benthic community composition, are not used as metrics...because scale-appropriate information of this type is currently lacking for the study region".[17]

So harm was gauged at the habitat level. And only harm, not benefits, despite the welfare gains to animals, plants, and people from some of the "stressors". Many of the "stressors" are themselves habitats; bulkheads may ease the rate of burial of upper-beach habitat, and, by slowing landward bank erosion, retard the downward-and-landward displacement of beach profiles. The recreational and economic benefits of docks and floats have been known and appreciated for thousands of years. Floats are shaded refuges for small fish. Culverts and outfalls will be indispensable unless stormwater routes to aquifers can somehow be devised. Meanwhile stairs to the beach seem unlikely stressors; beach access predated arrival of Europeans by more than a little.

The kinds of harm imputed by the analysts are not a strong basis for alarm, partly because of their dubious nature. Forage fish spawning beaches are listed, for instance, yet there are unused spawning beaches. Eelgrass is affected by a number of things, but their sensitivity to bulkheads has never been demonstrated for any of the 700+ reaches in these reports, nor at other Puget Sound residential places. Intertidal seaweed's importance and sensitivity to "stressors" have not been quantified. Certain reasons for encouraging overhanging vegetation are vacuous, as I have shown elsewhere. And so on. There is no scientific evidence that bulkheads, stairs, and other 'stressors' measurably harm nearshore habitats. Puget Sound's alleged peril surely does not reside in these matters.

About Conjecture

Most technical discussions of nearshore stressors and their impacts carefully include hedges such as "may", "might", or "in some places". These two reports treat linkage as near-absolute despite the widely deplored absence of research findings. Causality is generously presumed.[18] The analysts' models are "scientifically defensible"[19] (though they differ). Their normative estimates of degrees of impact are said to be based on best available science and best professional judgment.[20] The maps, inventories, and analytical process are intricate and interesting. But given the general paucity of relevant science (which the reports acknowledge), the burden on conjecture and hence credibility is considerable.

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[17] *Bainbridge Island Nearshore*... p. 20.

[18] As at page 99 in the Bainbridge report.

[19] *East Kitsap County Nearshore*... p. i; *Bainbridge Island Nearshore*... p. 17.

[20] *Bainbridge Island Nearshore*... p. 20, 22.

Implications for a Restoration Program

The reports are said to be driven partly by a need for “a method for prioritizing restoration projects”.[21] The authors cite an earlier paper, co-authored by the Bainbridge report’s senior writer, concluding that

> ”...the strategies of restoration, enhancement, and creation should be applied depending on the degree of disturbance of the site and the landscape. This theory assumes that historical conditions represent the optimal habitat conditions for a particular site.”[22]

A similar doctrine comes with the Bainbridge report:

> “...<u>restoration of controlling factors [is] the key to successful and long-term sustainability</u>.” [Underlining by the authors][23]

“Demolition” is nowhere mentioned, but it looms beyond. As when bulkhead removal is proposed as a “most obvious opportunity”.[24] However there is presented no case for restoration, no estimates of costs, and no array of alternatives toward the same ends.

The authors’ arguments for restoration are predicated on strong causal relations between stressors and habitats. Causation almost always generates high correlations. Correlations in these nearshore assessments are remarkably low. *QED*.

I have commented elsewhere on the formidable problems of knowing where we want to go in restoration and then getting there. The point here is that without a correlation between supposed stressors and presumed problems, any rationale for removing the human-installed stressors disappears.

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[21] *East Kitsap County Nearshore*... pp. I, ii, 2, 30. Also “Bainbridge Island Nearshore...” p. iii, 15

[22] *East Kitsap County Nearshore*... p. 29.

[23] *Bainbridge Nearshore*... p. E-6.

[24] *Bainbridge Nearshore*... p. 34

To whom it may concern.

As scientists who work in Puget Sound on shoreline issues, we are compelled to comment on a document recently circulated by Dr. D. F. Flora entitled **"Evidence of near-zero habitat harm from nearshore development."** Dr. Flora's document is presented as a rigorous scientific evaluation of the effects of human activity on the ecological condition of Puget Sound shorelines, but it falls well short of any reasonable standard for scientific rigor or credibility. While the document has many problems, we have identified four general categories.

First, the document is incomplete in many respects. Rigorous science presents a thorough and unbiased review of available information, but this work does not. It uses limited results from a few Puget Sound studies, ignoring much of the data and nearly all the context presented in those sources, as well as relevant studies from other, related ecosystems. Science from both Puget Sound and other parts of the world shows clear adverse effects from armoring and other forms of shoreline modification. A forthcoming proceedings of a workshop on armoring in Puget Sound and associated literature review will provide a much more comprehensive evaluation of the topic.

Second, Dr. Flora's description of his analytical methods and reporting of results are so incomplete that it is impossible to evaluate, reconstruct, or even understand them, all requirements for any sound scientific document. The statistical analyses he performed were methodologically flawed, incorrectly using linear regression analyses to analyze the data from a report by Williams et al. (2004). These data consisted of subjective assessments of shoreline conditions, variables that are unlikely to have followed a normal probability distribution. Thus the standard statistical tests used by Dr. Flora to seek relationships (or lack thereof) are not applicable. In addition, "peer review" of Dr. Flora's analysis was apparently done informally by "friends." True scientific peer review is carried out objectively (and usually anonymously) by experts on the specific topic at hand.

Third, the document is inconsistent in that it claims to make the case for conclusive evidence of "no harm" yet acknowledges that major information gaps exist, especially with respect to biological responses to human activity. In addition, the document includes no mention of cumulative effects, which is the focus of great concern by acknowledged experts in nearshore conditions. Specific habitat parameters at any given site challenge our attempts to measure potential impacts. In many ecosystems, scientists are working to find methods for effectively measuring both site-specific and cumulative impacts.

Finally, the document is factually incorrect in many places, especially in its use and interpretation of studies. It incorrectly describes regional science on the topic as a large, concerted effort when it is not. Local research was either mischaracterized by Dr. Flora (e.g., citations of Rice (2006), Sobocinski (2003), or completely incorrect (e.g., citation of Tonnes (2008). For example, Dr. Flora concluded from the work in Rice (2006) and Tonnes (2008): "*Two studies purport to show the effects of bulkheads on surf smelt egg survival. In fact they compare treeless (and bulkheaded) unshaded shores with treed (non-bulkhead) shaded places.*" The Rice (2006) study did not attribute observed differences in smelt eggs specifically to armoring but to shoreline modification, and the Tonnes (2008) study did not measure smelt embryo condition. Similarly, Flora's comment that *"Two studies have shown no difference in subsurface fauna in front of bulkheaded versus unprotected shores, so this part of the habitat issue also seems moot"* cites only part of one study (Sobocinski 2003) as support for this conclusion. In fact, other results from the Sobocinski work showed that natural beaches had higher invertebrate abundance and taxa richness in both fall-out traps and benthic cores than did armored beaches. Dr. Flora also claims that the beach profile analysis done by Herrera (2005) showed that the effects of armoring on beach slope are negligible. However, he fails to address the data in this report that clearly show evidence for lowering of beach profiles associated with bulkheads.

The management of Puget Sound's shorelines is complex, as is the problem of evaluating impacts of shoreline armoring. All acknowledge that more careful, well thought-out local research on this topic is necessary. However, the available research, which consists of a small number of studies in Puget Sound but a large number elsewhere, clearly supports the contention that armoring can have physical and biological impacts on beaches and their ecological functions, and that society should take a precautionary approach to shoreline management. While science and policy dialog on this topic is healthy, a document such as Dr. Flora's does little to advance this dialog. Science organizations and even the federal government are taking action to make the public more aware of the key role that science plays in informing policy, and of what needs to be done to prevent distortion of science from misinforming policy decisions (e.g., Sullivan et al. 2006, BPC 2009).

Signed by:

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Megan N. Dethier, UW, Friday Harbor Labs
Jason Toft, Wild Fish Conservancy
Steve Ralph, Stillwater Sciences
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Stephen C. Conroy, King Co. DOT
Wendy Gerstel, QWG Applied
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Rice, C. A. 2006. Effects of shoreline modification on a Northern Puget Sound beach: Microclimate and embryo mortality in surf smelt *(Hypomesus pretiosus)*. Estuaries and Coasts Vol. 29: 63-71.

Sobocinski, K. L. 2003. The impact of shoreline armoring on supratidal beach fauna of central Puget Sound. Master's thesis, School of Aquatic and Fishery Sciences, University of Washington.

Sullivan, P. J., J. M. Acheson, P. L. Angermeier, T. Faast, J. Flemma, C. M. Jones, E. E. Knudsen, T. J. Minello, D. H. Secor, R. Wunderlich, and B. A. Zanetell. 2006. Defining and implementing best available science for fisheries and environmental science, policy, and management. American Fisheries Society, Bethesda, Maryland, and Estuarine Research Federation, Port Republic, Maryland.

Tonnes, D.M. 2008. Ecological functions of marine riparian areas and driftwood along North Puget Sound shorelines. MS Thesis, University of Washington.

Williams, G. D., R.M. Thom, and N.R. Evans. 2004. Bainbridge Island Nearshore Habitat Characterization & Assessment, Management Strategy Prioritization, and Monitoring Recommendations. Prepared for City of Bainbridge. Battelle Memorial Institute.

February 2010

A response to clutch of detractors.

Re: Evidence on habitat neutral bulkheads, floats, and other installed "stressors".

Donald F. Flora, PhD[1]

Overview

With the help of two shoreline inventories and modeling by a major research consultancy, I've written a paper showing that bulkheads and other human-installed nearshore structures have little relationship to the welfare of eelgrass, forage fish spawning areas, and other nearshore habitats.[2]

Although results are specific to Bainbridge Island and eastern Kitsap County, they have triggered immediate alarm in a portion of the Puget Sound technical community because the findings run counter to common suppositions. A critical letter signed by a troupe of 14 technical people has been circulated widely. This is a response to that letter and other comments made by members of the troupe.

In general, the criticism is unfounded. I start with a summary of what I actually did and the results. Next I address our points of agreement; then the conjectured faults and incorrect statements presented by the troupe.

Background

As Washington shoreline jurisdictions update their shoreline plans they are prodded by the Department of Ecology to inventory their nearshores. Inventories are taking various forms. Bainbridge Island and Kitsap County divided their shorelines into 'reaches', with data collected for each reach on installed structures and other indicators of human occupation, and on measures of habitat presence and density.

The data was used and published by a well-known Northwest contract-research firm as they identified priorities for shoreline 'restoration'.[3]

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[1] 12877 Manzanita Road, Bainbridge Island, WA 98110. 206-842-0709.

[2] Flora, D. F. 2009. *Evidence of Near-Zero Habitat Harm from Nearshore Development*. Bainbridge Island.

[3] Williams, G. D., et al. 2004. Bainbridge Island Nearshore Habitat Characterization & Assessment, Management Strategy Prioritization, and Monitoring Recommendations. Sequim: Battelle Marine Sciences Laboratory.

Borde, A. B., et al. 2009. East Kitsap County Nearshore Habitat Assessment and Restoration Prioritization Framework. Sequim: Battelle Marine Sciences Laboratory.

The analysts also compiled composite indexes of what I will call ‘stressors’ (the human-installed things) and, separately, conditions I will call ‘habitat welfare’. These for each reach.

At the time of my analysis habitat data for Kitsap County was limited to less than a score of reaches, so the rest of this discussion relates to Bainbridge Island, although I got similar results for the small Kitsap data set.

What I Did

The consultants plotted the composite habitat scores against stressor scores, and I followed their lead. In Figure 1, each dot reflects a single reach. Notice (1) the wide scatter of the dots, indicating little if any correlation between the basket of stressors and basket of habitats. And (2) the absence of a trend downward from left to right. If present that trend would have indicated that an increase in stressor levels is associated with a decrease in habitat abundance. It wasn’t there, as you can see in the figure.

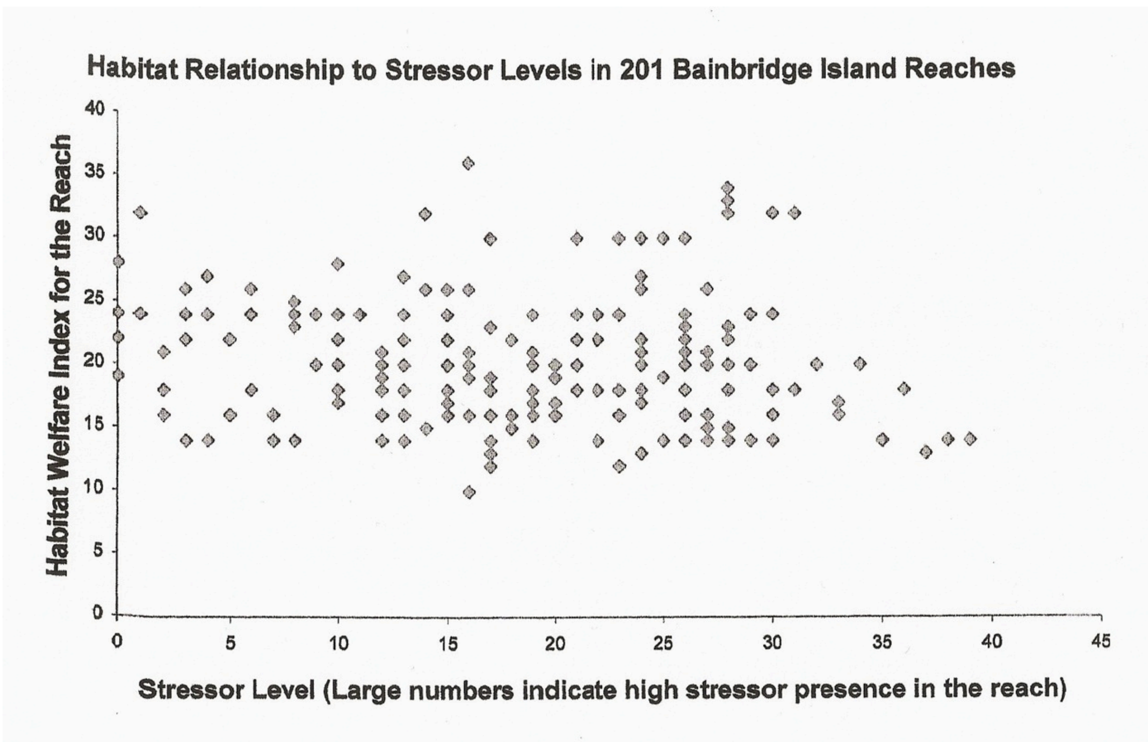

Figure 1

It is possible that composite scores obscure the effects of individual stressors. Bulkhead intensity is of special interest because the analysts clearly assumed the badness of shore protection. Figure 2 plots reaches’ habitat indexes on reaches’ bulkhead footage. Again there is no correlation and no trend.

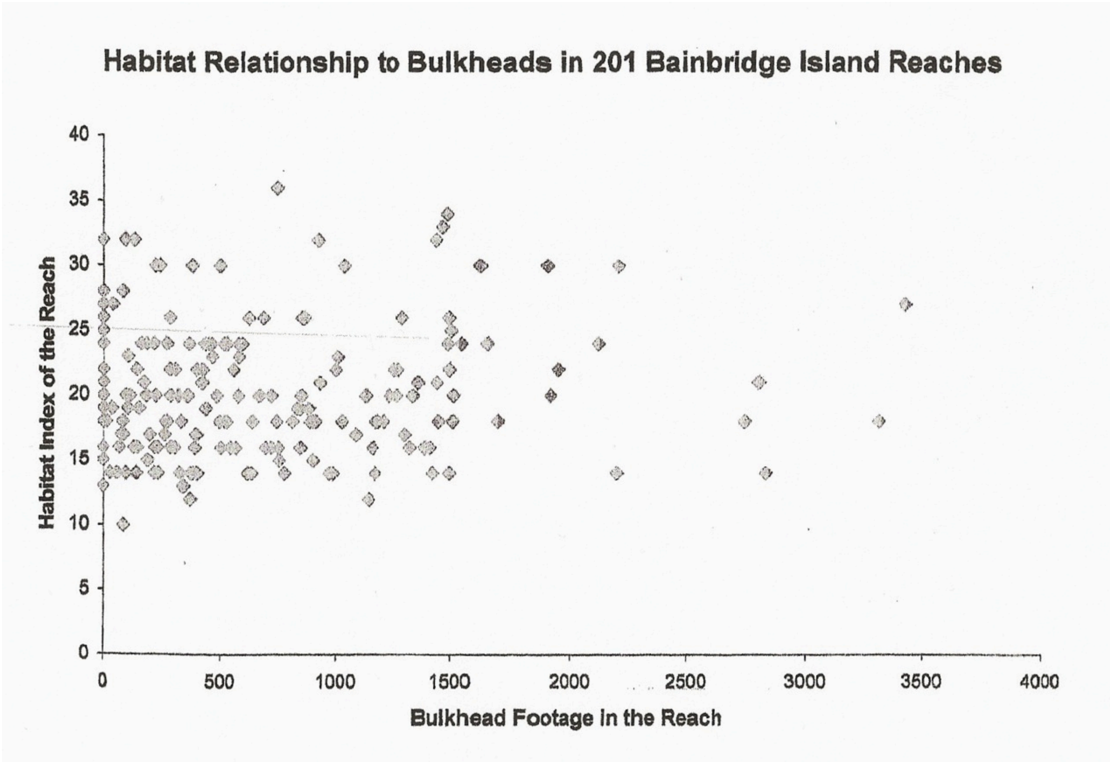

Figure 2

I plotted many combinations of individual habitats on individual stressors, as well as the composite habitat index on single stressors, with the same general result: no correlation and no trend.

Next, to add analytical rigor (the troupe's term, see below) I did a series of statistical analyses, addressing the hypothesis that there is no correlation between habitats and human-created supposed stressors, individually nor collectively. Almost invariably the conclusion was that the relationships are not significantly different from zero.[4]

This is not scientific opinion nor professional judgement. It is concrete analytical findings using impeccably sourced data and standard, basic statistical computations. The results have been peer reviewed and can be replicated readily by anybody with a basic technical degree.

[4] Contrary to the critique's claim, I examined the matters of normality and heteroscedasticity. However, again contrary to the troupe's complaint, normality is of little concern in correlation and regression analyses like these.

On Natural Stressors

An obvious question is, What other factors out there control the welfare of nearshore habitats? Presumably they are natural, not human-installed.

The troupe of fourteen who reviewed the study provided the answer: We don't know. The relevant Puget Sound science, they say, is limited. "All acknowledge that more careful, well thought-out local research...is necessary."[5] Their view was echoed at the recent Puget Sound conference on shore protection, mentioned by the troupe. A lead speaker said, "The workshop confirmed...the limited scientific research that has been done on the impacts of armoring on either geologic or ecologic processes, and ...the difficulty of applying the science that has been done elsewhere to Puget Sound given the unique aspects of our system."[6]

The relevance of "elsewhere" science from ocean nearshores has been questioned by a well-known shoreline geologist,[7] and I have explained that extrapolation from stream science is folly in a number of instances[8].

So the troupe of 14 plus a number of researchers and I agree completely that marine science is scant for the Sound, and that the Sound has unique features not likely represented by studies of the ocean, streams, and the "other parts of the world" that are mentioned vaguely by the troupe.[9]

By extension, we appear to agree that marine science relevant to Puget Sound is inadequate for intelligent nearshore policy making.

The Troupe's Derogation

Much of the troupe's criticism comes from their incorrect perception that I wrote for a technical audience. The paper was intended for an audience of nontechnical people including planners who may not have a marine science background.

The troupe says the work lacks "rigor". That word is straight from The Graduate Student's First Book of Phrases. The statement may be offensive to the 20-some people, including scientists, who conducted the overall enterprise with detailed study plans, data accession, modeling, calculations, and analyses of the results. My (subsequent) role was merely to expand the consultants' graphic analysis, form hypotheses, and examine correlations.

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[5] An undated "Comment on Evidence of near-zero habitat harm from nearshore development". This heading echoes the title of my November, 2009, analysis.

[6] Shipman, Hugh. 2009. From an email to Puget Sound Shoreline Planners, published 14 August, 2009 on Bainbridge Shoreline Homeowners web site.

[7] Finlayson, David. 2006. *The Geomorphology of Puget Sound Beaches.* Puget Sound Nearshore Partnership Report 2006-02. Seattle: Washington Sea Grant.

[8] Flora, Don. 2009. *A Perspective on Shoreline Policy, Technical Issues, Some Studies at Hand, and the Research Void.* Bainbridge Island. Available from the author.

[9] One wonders how many of the troupe are doing personal, quantified research on reaction of habitats or creatures to natural or imposed stressors in accord with peer-reviewed study plans.

The troupe wrongly claims that I pursued a case for “conclusive evidence of ‘no harm’”. They read what was not there. In fact I only made a case for a null hypothesis based on no correlation, which was not refuted.

The troupe noticed that I made no mention of cumulative effects. It is hard to conceive effects accumulating, within or among shoreline reaches, if there are no effects to put into the pile in the first place. And near-zero association of habitat welfare with stressors suggests that increasing, say, bulkheads won’t increase their effects. I made similar points relative to restoration and no net loss.

The troupe claims wrongly that the linear regression part of my statistical analyses was inappropriate because the “...variables are unlikely to have followed a normal probability distribution”. In fact that problem is of minor concern.10 Indeed, no alternative analytical approach was suggested by the troupe.

It is significant that the troupe mentions little of their own research, nor puts forward any “more-correct” analysis of the data I used; nor did they provide data from some other source that would refute (or support) what I did.

I invite readers to replicate my analysis; the data is in the public domain[11] and the methods are standard and well-known to those with even first-year knowledge of statistical analysis.[12] Even better would be analysis of data from a different part of Puget Sound. Meanwhile the Bainbridge 201-reach data set may be the best nearshore stressor-habitat array we have for Puget Sound.

Incidentally

Support for my no-harm hypothesis comes from the neighborhood of one of my analysis’ sharpest critics. Eelgrass has declined abruptly in formerly prolific Westcott Bay, 7 miles from the Friday Harbor university laboratory. An early hypothesis there, based apparently on doctrine and soon refuted, blamed installed fixtures, including bulkheads. No significant correlation was found between structures and eelgrass welfare. So the causation premise was replaced by a new hypothesis involving low-tide summer-time tidewater temperature, a wholly natural phenomenon.

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[10] See, for example, Zar, Jerrold H. 2003. *Biostatistical Analysis.* A more common concern is heteroscedasticity, which is not present in these data sets.

[11] The total data set that I used corresponds to a score of columns with just over 700 rows. The data are on the Web. In cover letters I have offered to help with data and their analysis.

[12] Some alternatives, if preferred by the reviewers, could be nonlinear or nonparametric analyses. However the relevant conclusions are apparent from the scatter plots: Habitat welfare varies widely for any stressor level, and increasing stressor levels does not increase impacts.

Elsewhere

The Thurston County (Herrera) study[13], about bulkhead effects on beach profiles, could well be repeated elsewhere. However a glitch developed in the indoor phase that resulted in greatly overstating the effects on profiles. I offer a flagon of Ivar's clam nectar, perhaps even lunch, to the first troupe member who can find the glitch.

The Rice study purported to estimate the effects of a bulkhead and tree shade on dessication of beach-laid surf smelt eggs. Guess which of these two factors actually caused the dessication.[14]

Tonnes did an excellent analysis of driftwood in the North Sound, that might lead to a book. I can suggest ten chapter titles. Contrary to the troupe's wrong assertion, Tonnes did conclude that surf-smelt egg mortality rose where beach temperatures were high, and that was where shade was reduced. His is one of the two sources I mentioned that show equality of subsurface fauna in front of bulkheaded versus unprotected shores.[15]

Unfortunately certain of the local studies mentioned by the troupe encountered confounding factors that I concluded, after visiting study sites, had compromised the studies' conclusions.

The Grand Slam

A troupe member has said that my report "would not be considered publishable by any journal". She may be surprised. She derided my peer reviews, which in fact were helpful. She warned that my paper must be "fought off". She said my report does not contain "facts". Perhaps graphics and statistical correlations are not "facts". The director of programs for People for Puget Sound has said that while my paper "is being cited at some local government meetings" it is too large [13 pages] for him to pass around. The troupe says it's too short. One blogger applauded my objectivity; another questioned it.

All because correlation is absent from 201 data sets.

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[13] Herrera Environmental Consultants. 2005. Marine shoreline sediment survey and assessment, Thurston County, Washington. Seattle.

[14] Rice, Casimir A. 2006. Effects of shoreline modification on a northern Puget Sound beach: Microclimate and embryo mortality in surf smelt. Estuaries and Coasts 29(1):63-71; The same single-site 5-day comparison appears as a chapter in his University of Washington thesis.

[15] Tonnes, Daniel M., 2008. Ecological functions of marine riparian areas and driftwood along north Puget Sound shorelines. Master's thesis, School of Marine Affairs, University of Washington.