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EVIDENCE OF NEAR-ZERO HABITAT HARM FROM NEARSHORE DEVELOPMENT

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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.

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 0.003, 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, attached. Because the low-bank plot suggests some correlation, I calculated r^2 for those reaches. **It is still extremely low.**

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]
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, attached). There is a very low level of correlation, with only 12 percent of variability explained by Controlling Factors and Physical Processes combined.

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[10], 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 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 profiles. Following adjustment of an analytical glitch, no statistically significant beach changes were shown.[14]

Two studies purport to show the 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.

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.

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:

> "...restoration of controlling factors [is] the key to successful and long-term sustainability." [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.**

NOTES

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.

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.

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.

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

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/

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.

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.

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.

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