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Prioritizing sea level rise vulnerability across Puget Sound

- ***New study highlights parcels at highest risk of coastal flooding and erosion.***

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A new research study ranked over 111,000 land parcels in Puget Sound based on their vulnerability to coastal flooding and erosion that accompanies rising sea levels. Conducted by Pacific Northwest environmental design and engineering firm Natural Systems Design and Coastal Geologic Services, with the research institute Washington Sea Grant and the National Centers for Coastal Ocean Science (NCCOS), the study provides insight for landowners and government officials as they seek to minimize and mitigate the effects of sea level rise (SLR) on coastal property.

QUANTIFYING VULNERABILITY

The National Oceanic and Atmospheric Administration (NOAA) says the Washington shoreline could see as much sea level rise — 4 to 6 inches — in the next three decades as it did in the previous century. This will have cascading effects of accelerated coastal erosion, habitat loss, and other negative impacts. Prior studies focused on sections of shoreline, but updated and localized SLR projections and high-resolution elevation data for the Puget Sound region enabled this study to analyze hazards at the finer scale of individual parcels.

This quantitative study defines vulnerability as a function of exposure and sensitivity. The exposure index, which incorporates flooding and erosion, was coupled with the sensitivity index, which integrates infrastructure and coastal habitats into a total vulnerability index. As an example of how the research team determined index scores, it evaluated the parcel infrastructure score by measuring the amount of a structure's footprint that would be inundated in an SLR scenario above 6 inches. The calculation added a 10% premium to parcels that include hospitals, police stations, schools, and other critical facilities, and then adjusted for flooding on adjacent roads and in agricultural areas.



Photo by Jim Johannessen [\[enlarge\]](#)

Homes along Birch Bay after a January 2022 storm event.

The team employed four sea level rise scenarios out to the year 2100 to assess parcel vulnerability. These scenarios were chosen based on input from a project advisory group that included representatives from federal (e.g., U.S. Army Corps of Engineers, NOAA) and state agencies (e.g., Washington Department of Fish & Wildlife, Washington Department of Energy), as well as higher education institutions (e.g., University of Washington, Oregon State University).

The results were coupled with a social vulnerability index developed by a team at NCCOS for ZIP code areas within the Puget Sound watershed. This index considered 50 variables, including

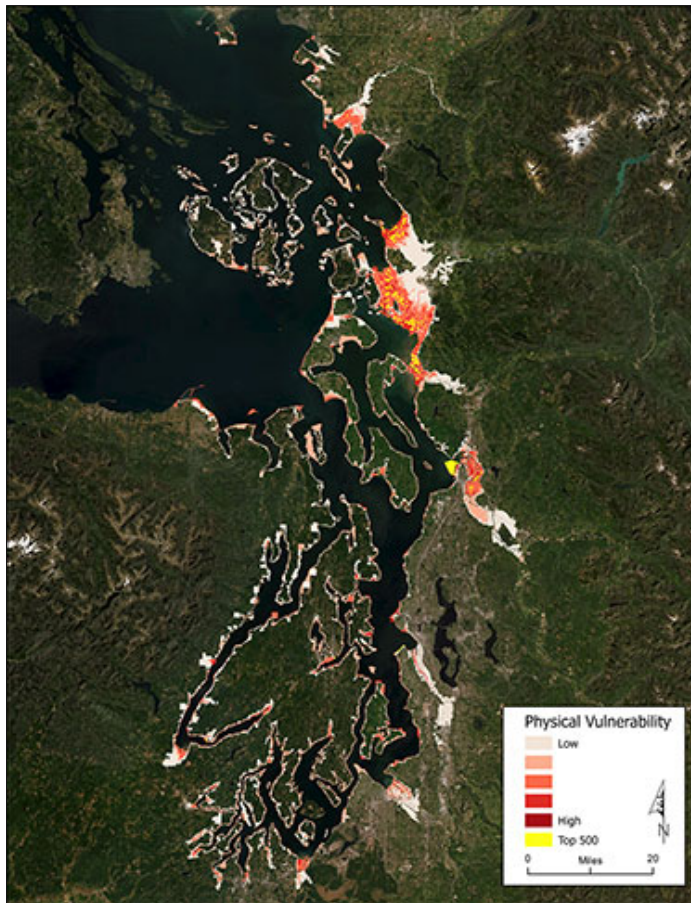
median income, average family size, and percentage of households without access to a vehicle. It also assessed seven components contributing to social vulnerability, such as diversity, housing data, and life satisfaction. The team weighted social vulnerability equally with exposure and sensitivity.

THE MOST VULNERABLE PARCELS

The exposure index indicates that parcels in North Sound, West Whidbey, on the Strait of Juan de Fuca, and on shorelines north of Seattle have the greatest relative exposure. The highest scores — and thereby the most exposed parcels — are generally associated with places that are both low-lying and have a high erosion potential. As anticipated, the study found a cluster of high scores where wind-generated waves are highest.

Clallam, Mason, and Island counties encompass a greater fraction of highly exposed parcels. San Juan County has the smallest percentage of top scoring parcels due to the prevalence of bedrock and high elevation parcels.

The study generally found greater sensitivity in larger river deltas such as Skagit and Snohomish. These tend to be heavily developed and low-lying, where agricultural lands are concentrated, and where the marsh migration layers suggest sea level rise would drive significant landward habitat migration.



[\[enlarge\]](#)

When the team combined exposure and sensitivity, it found clusters of vulnerability in the low-lying large river deltas. Fewer than 2,000 parcels scored in the upper 25% of the scoring range, suggesting that directing efforts to a relatively small number of parcels, region-wide, can decrease overall vulnerability.

Adding the socially modified vulnerability score into the framework shifts the parcels of highest vulnerability into different areas, including to urban zones near the South Sound. In this case, eastern Clallam, Snohomish, Mason, and Skagit counties contain a greater fraction of highly vulnerable parcels. In contrast, San Juan County shows very few highly vulnerable parcels when accounting for social vulnerability.

CONCLUSIONS AND VALIDATION

Despite some limitations in project capacity and datasets, this study incorporated present and future flooding conditions using the newest SLR projections and elevation data. It also updated and expanded erosion potential metrics, assessed the sensitivity of infrastructure on individual parcels, quantified the change in habitat area on parcels with rising seas, and integrated social vulnerability into the equation.

The research findings were validated to some degree on Dec. 27, 2022, when the region was hit by the type of significant coastal flooding event that is expected to become more frequent as sea levels rise. The storm resulted in five of the six continuously operating NOAA tide gauges surpassing their record-high water level. This included Seattle, which has records dating back 125 years.

John Lovie of Habitat Strategic Initiative, interested to see how our study results held up to an actual coastal flooding event, compared the flooding in Island County with the project results for the top 500 most vulnerable parcels in the county. He said, “All the flooding in the recent storm occurred within those (most vulnerable) areas, and virtually all of them had some flooding.”

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