Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2680

2004

PROCEEDINGS OF THE DFO/PSAT SPONSORED MARINE RIPARIAN EXPERTS WORKSHOP, TSAWWASSEN, BC, FEBRUARY 17-18, 2004

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Likely Scaling of Basin Area with some Marine Riparian Zone Functions

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The marine riparian zone (MRZ) provides a variety of ecological functions (Levings and Jamieson 2001). Many of them involve movement of material from the terrestrial system to the marine system, and much of this movement is mediated through the flow of either surface water or groundwater. Consequently, consideration of drainage basin area is essential to understanding the amount and spatial pattern of material flows through the MRZ.

To explore spatial variation in basin area for drainages terminating in the coastline, I used a routine GIS watershed delineation program to analyze 10-m USGS DEMs (U.S. Geological Survey digital elevation models) of Whidbey and Camano Islands. I also examined current USGS topographic maps and historical USGS T-sheets to delineate coastal wetlands (including stream delta marshes and lagoons). Regression analysis was used to examine relationships between marsh area and basin area. Additionally, basin areas were calculated for various coastline forms, i.e., cove, point, or straight coastline, and analysis of variance (ANOVA) was used to determine whether basin area standardized by coastline length varied with coastline form.

The results indicated that basin area was a strong predictor of stream delta marsh area ($r^2 = 0.70$, $p < 0.05$) and of lagoon area ($r^2 = 0.71$, $p < 0.05$) when power functions were fitted to the data ($y = 0.015x^{1.18}$ for delta marshes, $y = 0.056x^{1.41}$ for lagoons, where x = basin area and y = coastal wetland area). The results were not surprising for delta marshes, because similar scaling of marsh area with basin area can be shown for much larger scaled landscapes (Simenstad et al. 1982, Walker 1998). However, the relationship between basin area and lagoon area was surprising because lagoons are coastal wetlands partially or completely enclosed by sandy spits, and spit formation is thought to result from patterns in coastal erosion and sediment transport by tidal currents and waves. However, the results indicate that terrestrial drainages influence lagoon size. This could be due to basin influences on nearshore topography and bathymetry, or to inputs of basin sediments and water whose influence on lagoon morphology has not been previously recognized.

The results also illustrate the degree to which coastal spits facilitate the formation of coastal marshes. The smallest basin that was associated with a delta marsh was 53 ha, while the smallest basin associated with a lagoon was 2 ha. For a given area of costal wetland, basins were about seven times smaller for lagoons than for delta marshes.

Comparison of basin area, standardized for coastline length, between coves, points, and staight coastlines showed that standardized basin areas varied significantly between categories ($F_{2,22}$ = 11.13, $p < 0.0005$) and post hoc comparisons indicated significant pair-wise differences between coves versus points ($p < 0.01$) and straight coastlines versus points ($p < 0.02$) with a suggestive difference ($p < 0.09$) between coves and straight coastlines. Standardized basin areas averaged approximately 790 m^2 per meter of coastline for coves, 480 m^2 for straight coastlines, and 140 m^2 for points. These results suggest that inputs of freshwater and suspended and dissolved materials to the MR and nearshore will vary substantially with coastline form. In addition to influencing terrestrial inputs to the MR, coastline form likely influences the ability of marine currents, wind, and tide to disperse or concentrate these terrestrial inputs, with coves being sheltered, depostional environments and points being exposed, erosive environments.

Spatially variable input of freshwater, sediments, nutrients, pollutants and other similar materials to the MR has clear expression in the development of coastal lagoons and delta marshes of various sizes, and their associated geomorphology and biology. Similar ecological consequences of variation in basin size between coves, points, and straight shorelines could likewise be elucidated for these areas.

From a management perspective, the results indicate that the MR is not independent of terrestrial basins. Human activities in areas distant from the MR may have significant impacts (e.g., changes in freshwater inputs, nutrient inputs, sediment inputs, or pollution) on ecological processes and structures in the MR. Additionally, sensitivity to basin disturbance likely varies with coastline form. From the perspective of basin size, coves could be considered the most sensitive coastline form and points the least sensitive. However, there may be other considerations, not addressed in this exploratory analysis, which may vary with coastline form or basin size, e.g., basin slope and geology, which also may affect sensitivity to human disturbance.

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