Project Completion Report:

Project Title: Partnership for Monitoring and Assessment of NPS Bacterial Contamination of South Coast Beaches. Part B. Sunset Bay State Park

Rationale: Sunset Bay State Park is one of the most popular recreational sites on the southern coast of Oregon. However, the beach and surf zone at Sunset Bay have been subject to frequent water contact advisories over the past several years due to detection of elevated levels of indicator *Enterococcus* bacteria in the marine waters and in freshwater drainage system that empties into Sunset Bay through Big Creek. For example, 20% of the 112 water samples collected from Sunset Bay State Park in 2006 exceeded the state of Oregon single-sample maximum *Enterococcus* standard of 158 colony forming units (cfu) per 100 ml. Local area residents and natural resource managers have speculated broadly about the likely sources of elevated bacteria counts, and the possible sources of fecal bacteria include failed septic systems, elk, deer, and geese in the upstream wetlands, seagulls and dogs on the beach, and fecal material contributed by marine mammals that haul out in the marine zone on nearby rocks and headlands. As a starting point, it is a fundamental issue to determine whether the sources of bacterial contaminants in Sunset Bay are marine or terrestrial in origin.

Project Summary: South Slough NERR staff members Ben Grupe and Steve Rumrill completed a collaborative research project titled *"Partnership for Monitoring and Assessment of NPS Bacterial Contamination of South Coast Beaches."* This project was conducted over 2007 in cooperation with Oregon State University (Oregon Sea Grant-Extension) with grant funds provided by the Oregon Department of Environmental Quality (Non-Point Source Pollution Control Program). The primary goals of the project were to: (1) identify whether the sources of elevated *Enterococcus* numbers in the surf zone of Sunset Bay are terrestrial or marine in origin; (2) determine the extent and duration of bacteria levels that exceed USEPA and state of Oregon water quality standards; and (3) describe the range of ambient environmental variables (*i.e.*, rainfall, tidal height) that are correlated with elevated bacteria levels.

A series of 13 sample collection sites were established within the Big Creek watershed and within Sunset Bay. The sample collection sites were selected to encompass several different points along the freshwater drainage system of Big Creek, near the confluence of Big Creek and Sunset Bay, and several points located laterally along the surf zone of Sunset Bay. A total of 244 water samples were collected on 26 sampling dates over the period from November 2006 to October 2007. These water samples were collected from throughout the series of 13 sample sites and they were used to address the various objectives and tasks for the project. The primary findings from the investigation are that *Enterococcus* concentrations are consistently greater in the lower region of Big Creek than in the mixed estuarine-marine waters of Sunset Bay, indicating that the primary source of fecal indicator bacteria is delivery via Big Creek. Water samples collected in Big Creek and Sunset Bay are more likely to contain high counts of *Enterococcus* bacteria after significant rain events, but tidal flushing typically leads to reduced bacteria

levels within 72 hrs. High counts of *Enterococcus* bacteria were also observed in the shoreline sediments.

Variability among Replicate Water Samples: The assessment of inherent variability among replicate water samples indicates that although the MPN counts of *Enterococcus* bacteria can vary considerably from sample to sample, the single-sample density technique that is currently in use by the Oregon Department of Environmental Quality to trigger water contact advisories appears to be generally conservative and cost- effective. Only in one case (3/20/07; site #6c; replicate 4; MPN 134 cfu/100 ml) out of eight possible cases did the single-sample density MPN count of *Enterococcus* bacteria fall below the state of Oregon standard of 158 cfu/100 ml when the combined average from five replicate samples (243 $\pm$ 117 cfu/100 ml) exceeded the minimum standard of 158 cfu/100 ml. These findings suggest that there is a 12.5% chance that the single-sample maximum test would indicate no water contact advisory when more extensive testing with multiple replicates would reveal a higher level of bacterial contamination and issuance of a water contact advisory.

Monthly Monitoring within Big Creek and Sunset Bay: Aggregate analysis of the monthly water samples revealed a consistent spatial pattern in the concentrations of *Enterococcus* bacteria within the Big Creek drainage system, the surf zone at Sunset Bay, and in two adjacent ephemeral drainage ditches. The greatest geometric mean concentrations of *Enterococcus* bacteria were observed within the freshwater drainage system of Big Creek, and lower concentrations of bacteria were consistently observed in Sunset Bay and in the drainage ditches. This spatial pattern of bacteria concentrations provides strong evidence of bacteria loading primarily from watershed sources rather than marine sources.

The monthly time-series of *Enterococcus* bacteria MPN counts (cfu/100 mL) revealed several temporal trends in the intensity of contamination by fecal indicator bacteria. First, bacteria counts were higher within water samples collected from the surf zone at Sunset Bay (sites #6, 6b, 6c, 6d) and lower at the mouth of Big Creek (collection site #1) only during the wet season (January to March, 2007). However, bacteria counts were consistently greater within water samples collected at the mouth of Big Creek (collection site #1) in comparison with water samples collected from the surf zone (sites #6, 6b, 6c, 6d) over the period from April through November, 2007. The greatest MPN counts of *Enterococcus* bacteria occurred at the mouth of Big Creek during the driest months from mid July to October, 2007. Second, bacteria counts within the mouth of Big Creek exhibited a general increase over the dry season. In contrast, with the exception of one elevated sample in October, the counts of bacteria within water samples collected from Sunset Bay either decreased or remained about the same over the dry period from May to November. Third, the counts of *Enterococcus* bacteria approached or exceeded the ODHS single-maximum density standard of 158 cfu/100 ML only on two dates within the marine waters of Sunset Bay (22 May and 30 September, 2007). In contrast, the MPN counts of *Enterococcus* bacteria frequently exceeded the ODHS standard for water samples collected at the mouth of Big Creek

Influence of Tidal Exchange on Bacteria in Sunset Bay: Intensive field sampling was carried out four times during the project to assess the importance of tidal flushing on levels of *Enterococcus* bacteria in the surf zone of Sunset Bay. The initial time-series dataset illustrated the spatial and temporal pattern of bacteria concentrations during a relatively simple single-input (pulse) event. The datasets indicate that bacteria counts in the surf zone of Sunset Bay dropped below the state standard after a period of about 48 hrs (or 4 tidal flushing cycles) following the first substantial input of bacteria from Big Creek, and after about 27 hrs (or 2 tidal flushing events) after the final inputs of substantial concentrations of *Enterococcus* bacteria. The second time-series dataset illustrated the spatial and temporal pattern of bacteria concentrations during a more complicated multiple-input (press) event at the end of the wet season (May 2007) when lower concentrations of bacteria were delivered into Sunset Bay over a longer period of time by the flowing waters of Big Creek. The third time-series dataset illustrated the spatial and temporal pattern of bacteria concentrations during a prolonged press-input event during the summer (July) dry season when moderately high concentrations of bacteria were delivered into Sunset Bay over a longer period of time by the flowing waters of Big Creek. In this third case, the counts of *Enterococcus* bacteria at the mouth of Big Creek were continuously elevated over a period of >24 hrs, and bacteria concentrations in the surf zone fluctuated due to the daily cycle of flushing by the semi-diurnal tides. The fourth time-series dataset illustrated the spatial and temporal pattern of bacteria concentrations during a prolonged press-pulse-input event during the fall season when the first substantial storms deliver rains that flush out the bacteria that have accumulated over the summer months throughout the Big Creek drainage system. During the fall season press-pulse-input event the counts of *Enterococcus* bacteria at the mouth of Big Creek were continuously elevated at levels 3X to 100X above the state of Oregon standard over a period of >120 hrs, and bacteria concentrations in the surf zone were also highly elevated directly in response to the loading of bacteria by the discharges of Big Creek

Relationship between Rainfall and Bacteria in Sunset Bay: About 49% of the variability in *Enterococcus* counts in the surf zone of Sunset Bay can be attributed to variability in the intensity of local rainfall over the previous 12 hrs. The correlation between precipitation rate and bacterial contamination is weakened somewhat because substantial bacteria inputs are still detected in Sunset Bay during summer when the intensity of rainfall is near zero. The greatest concentrations of *Enterococcus* were detected during periods when the rainfall was delivered at a rate of 15 to 23 mm over the prior 12 hrs. The non-linear relationship between precipitation and bacteria concentration indicates that local rainfall (measured in Charleston) can be used as a moderately effective predictive tool to anticipate periods when the counts of *Enterococcus* bacteria are expected to be elevated within the surf zone at Sunset Bay.

Relationship between Salinity and Bacteria in Sunset Bay: We observed a strong negative relationship between salinity of the water samples and the MPN counts of *Enterococcus* bacteria collected from the surf zone at Sunset Bay. For example, when the salinity measurement at the time of collection was very low (in the range of 0 to 5 psu) the *Enterococcus* counts were also low. When the salinity measurement of the water

sample was in the range of 5 to 13 psu the *Enterococcus* counts were highly elevated (between 1000 and 2000 cfu/100 mL). In contrast, when salinity values were higher (24 to 33 psu) in the more marine waters that were typical within the surf zone during periods of flooding and/or high tides, the MPN counts of *Enterococcus* bacteria were generally low (100 to 700 cfu/100 mL) or near zero.

Calculation of Hydrodynamic Retention Time and Flushing Rate: Staff members from the South Slough NERR used existing topographic maps, nautical charts, and conducted new topographic and bathymetric sonar surveys to develop a digital 3-D computer model of the Sunset Bay tidal basin. The digital computer model was then used to estimate the volume of the tidal basin at high and low stages of the semi-diurnal tides, and a series of additional parameters were incorporated into equations to determine the retention time and hydrodynamic flushing of tidal and fresh waters within Sunset Bay. A Global Water WL-16U datalogger was deployed within the flowing waters of Big Creek beginning in February 2007. Changes in the measurements of water level within the creek were coupled with measurements of the cross-sectional profile of the Big Creek streambed and corresponding measurements of streamflow velocities to obtain volumetric estimates of the discharge of freshwater through the Big Creek drainage system. Residence time of a tidal basin describes the average time that freshwater spends in a bay or estuary before it is transported or flushed out of the system. Our volumetric estimates of the bathymetry of the Sunset Bay tidal basin allow us to make a very rough estimate of the residence time of freshwater (and fecal indicator bacteria) within Sunset Bay. The retention time for water within Sunset Bay is estimated at 2-3 days in the winter season, and about 3-6 days in the summer season. These calculations allow for a greater understanding of the residence time of *Enterococcus* and *E. coli* bacterial contaminants after they are transported by the flowing waters of Big Creek into the semi-enclosed tidal embayment.

Technical Report: A technical report to summarize and describe the results from the project was generated during February, and the final report is titled "*Partnership for Monitoring and Assessment of NPS Bacterial Contamination of South Coast Beaches. Part B. Spatial and Temporal Pattern of Bacterial Contamination within Sunset Bay.*" The technical report describes the rationale and design for the sampling program, and results generated by the collection and processing of water samples to address the study objectives for evaluation of water sample variability, seasonal monitoring in Big Creek and the surf zone, tidal exchange dynamics, storm events, and calculation of the hydrodynamic retention time and flushing rate for Sunset Bay. The report also contains a series of recommendations for future research to address the problem of chronic contamination and frequent water contact advisories within Sunset Bay State Park.