Merrill, Hannah

From: zSMPC
Sent: Thursday, January 31, 2013 1:00 PM
To: zSMP
Subject: FW: OEC & FMPSP comments on SMP Draft
Attachments: DYNAMICS OF THE NORTH BEACH OF DUNGENESS SPIT.doc; 12_12 ClCoSMP Draft comments.doc

-----Original Message-----
From: Darlene Schanfald [redacted]
Sent: Thursday, January 31, 2013 12:05 AM
To: zSMPC
Subject: OEC & FMPSP comments on SMP Draft

Please let me know if you can open and read the attachments.

I want to look more at Chapter 2's permitted and prohibited use chart, so may submit some additional comments.

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Darlene Schanfald
Olympic Environmental Council Coalition
and Friends of Miller Peninsula State Park

From: Darlene Schanfald
January 31, 2013

Compliments to Margaret, Steve, Hannah and all other staff that have kept the Advisory Committee functioning and redrafting the SMP for the County. The quality of the work and effort is well recognized and appreciated.

GENERAL COMMENTS

• Please clarify where in the language when the Administrator is, by law, charged with determining CUPs, variances, etc., and when it is recommended. Where it is not set in law by WACs, please remove. It leaves too much discretion to one person. Perhaps these should come to the Planning Commission or, even before, to a committee set up for such considerations and recommendations to staff.

• The document lacks specific information about what can/cannot be sited, other than homes, aquaculture and general sweeping statements when it comes to recreational and commercial; seemingly unrestricted construction. E.G., 2.3.3.a. 'new structures…water-dependent uses." Should more specifics be included in the SMP as to what structures can be built and for what use?

Some Chapter 2 examples of lack of clarity—2.2---what commercial and industrial developments will be allowed? How many in any one area? Why allow golf courses if they use pesticides, or will golf courses have to be maintained without chemicals?

• Floating through the document are such terms as "discourage" and "encourage" siting developments, etc. (E.g., 1.2.6 and 1.2.12; 3.3.2.4; 3.8.2.3etc.) Insert, instead, "disallow" or "prohibit."

• I would like to see language that addresses the land spreading of municipal/industrial wastes, euphemistically called 'biosolids." These are sold as soil amenities/fertilizer/compost with mostly untested for, untreated and unlisted content constituents, which include dioxins, viruses, bad bacteria, pharmaceuticals, personal care products, radiation, hospital wastes, and more and whatever industries are allowed to send to waste water treatment plants. When spread, these toxic wastes run or blow off of residential, farm and forest lands, into nearby water bodies and out into the large marine bodies. The CWA, meant to stop the dumping of such wastes into open water bodies, is violated by the land spreading of these toxic wastes. I recommend we include language informing users of fertilizer on what to look for when purchasing them, in order to further protect salmon and our shorelines. Limiting the use of these toxins and their runoff would be beneficial to eel grass, as well and other in water habitats and wetlands.

* Judy Larson suggested starting each chapter with the general remarks, then moving to specifics. This would be a good format to follow.

CLIMATER CHANGE, SEA LEVEL RISE, MORE FORCEFUL WAVE ACTION, SETBACKS

The real driver of what will occur on the County shorelines, true of all world shorelines, are the conditions creating global warming and the connected change in weather and sea patterns. That is the main story line when asked to project 75 years into the future. All else follows.

The WA State Legislature and Ecology recognized this a few years back:
RCW 43.21M.040 Incorporation of adaptation plans of action by state agencies.

State agencies shall strive to incorporate adaptation plans of action as priority ***activities when planning or designing agency policies and programs****. Agencies shall consider: The integrated climate change response* *strategy when designing, planning, and funding infrastructure projects; and incorporating natural resource adaptation actions and alternative energy sources when designing and planning infrastructure projects.*

[2009 c 519 § 13.]

EO 09-05 Washington's Leadership on Climate Change: This order, signed in May 2009, **requires the state to: .....**
Prepare for rising sea levels and the risks to water supplies caused by climate change impacts.
(Emphasis is mine.)

Therefore, Ecology must do this and so must we. Hence, a statement on climate change-sea level rise affects Planners, other decision makers and the public should be kept aware of this at the initial entry into the document at the beginning of the document. While we read about what the shorelines will look like in 2200, **remember** that the changes towards the next century are now occurring, and will be nearly, if not totally reached within the 75 years for which we are being asked to plan. The public, investors in private and in our commons properties, should realize this up front. So, let's acknowledge this from the outset, in the beginning of the Plan and repeat it in Chapter 2, the chapter on setbacks.

Each beach is different. Existing developed beachfronts such as Diamond Pt and 4 Seasons Ranch have already been flooded from the marine side. Flood damage will increase with changing weather-water patterns and will always be worse when at high tide than at low tide.

Don Wilkin, Ph.D. retired Associate Professor from the University of AZ, measured sea level rise on 2005-6 at the U.S. Fish and Wildlife Dungeness Refuge. His "beach dynamic" results from three transect locations –both east and west of the where the trail meets the beach, and where the trail intersects with the beach -- are attached.

He believes that the increased bluff erosion to be expected from rising water levels and stronger storm surges will be more than undone by the increased occurrence of breaching of the spit by stronger winter storms. The net result will be spit degradation and possibly disappearance altogether.

As you know, to the west of the Refuge Trail are significant feeder bluffs which drop small particles all the way up to boulders. Wilkins took one more year worth of bluff recession measurements along the Dungeness County Park bluff trail, completed a little over a year ago. An earlier measurement gave an average recession for the year of about 9 inches. His re-measure two years later averaged 1 foot a year.

Some area bluffs will release streams of fine dirt over the years while other areas may release huge boulders or a hillside. Thus, 150' setback may be insufficient for 75 years, 200 or more feet may be appropriate in some areas. As well, the eco functions, the habitat importance of each beach needs to be taken into account when considering setbacks.

By lack of covering the obvious in this document, there is denial about current and near future climate change/global warming impacts. It begs the question why development, at taxpayer and natural resource expenses, in shorelines would be allowed. The County SMP must address these obvious current and not far distant future changes that will impact the shoreline. This would be in line with the very few statements in the DRAFT SMP, such as 4.2.2.

This plan is focused on a 75 yr time frame (acknowledge this Plan will be revisited before that), yet structures will be allowed to be constructed in areas that will be under water within the 75 year period. This makes no sense. A mitigation should include that the builder carry insurance due to loss by any natural disaster and pay for environmental damage, for even if such insurance were available and purchased, building and other debris would be added to the open waters should a disaster occur.

It is the obligation of the County to warn potential shoreline builders that already own land of the risks. No new properties on the shoreline should be approved. The County should develop a “risk map” and post it in the hallway, so that the public can easily see where not to build. Further, staff should have to tell prospective persons wanting to build in the shoreline of the risks. Buy backs, if money could be found, should be an option in order to avoid future problems that will occur.

Regarding the removal of brush from bluff properties for views, to do so can create destabilization of the bluff. Keeping the full bank vegetated is essential

It also seems contradictory to allow over water structures, at least of a type that would need to be anchored to the beach or in the sediment.

AQUACULTURE

<u>Fish raised in floating pens</u> are not water dependent, but they are very polluting and can be disease ridden and infectious to wild life, as scientific data worldwide has shown. As written, the section is pro industry, but is not protective of our waters, ecology and public health. This is out of compliance of the goals of the shoreline management act. Floating pens will not give financial or aesthetic protection of shoreline oriented private residences and could interfere with siting private boat ramps and decrease housing values. If No Net Loss is a SMP Act goal and Cumulative Affect is to be acknowledged, you could not search for a better example of what to avoid.

The proposed language has not listed the dire problems of finfish aquaculture—pollution, diseases escapement, interbreeding, loss of wild salmon redds to escapees. It has not listed the impacts from this industry elsewhere in the world.

<u>Types of aquaculture are not delineated.</u> The prevalence of aquaculture sitings is not spelled out. How many can there be on our near our shorelines? How close can they be to one another? How will cumulative affects be known?
In 3.2.2, for example, define “significant adverse effects.” “Mitigation” in order to have “adverse effects”!!! How will a project “demonstrate that the use/development will not meet 3.a-c requirements? The SMP should not promote a lottery system; a gamble of our natural resources.

The SMP Act is not to promote business, but rather to focus protections for salmon, recreation and home owners. Polluting our waters, bottomlands and food is not protective of our shorelines. The world over, be it Italy, Germany, Chile, Scotland, some of the Nordic countries, British Columbia, and on and on have unfortunately seen their waters and habitat ruined. This has impacted whale migratory paths and other marine animals problems. This has impacted the livelihoods of fisher men and women.

As well said by some in our last meeting, the federal and state governments (See 3.2.2.3) will do as they will, but we at the local level must work to protect our area. The farmed fish industry does not meet No Net Loss standards. Too, with sea level rise and worsening wave action all around, this would be problematic to siting these pens. The Clallam County SMP should list finfish aquaculture as PROHIBITED.

The newly introduced WA State Legislative HB 1599 would allow us to do just hat.

SPECIFIC COMMENTS

1.2.8 should be at the top of the goal list.

2.4.1 and 2.5.1 "Figure 3-2" is cited, where you mean Figure 2-2.

2.4.4.b This conflicts with 2.4.1. Importantly, how many residences and low intensity rec uses can be allowed in natural environment areas? Address cumulative impacts through the number and size of allowable structures and usage impacts at any one site.

2.4.4.e. New lots must not be allowed within Natural environments. This could deplete the natural designation by allowing numbers of structures to be placed in such areas. Too many loopholes; too many CUPs.

3.1.2.3.a. Manure spreading affects groundwater, and unintentionally air and surface waters via drift and runoff. Animals receiving medications and certain feeds will have contaminated manure. Is there a loading limit?

3.8.2.3. New residential development must not be allowed in flood and other sensitive areas. Don't "discourage;" rather, don't allow. Obviously, to just "discourage," would violate the SMP by putting people in harm's way and potentially harming the shoreline and salmon.

In both the text and in the Definitions, explain stream designation changes from number to Types.

3.11.3.4.c. Explain why culverts would be used given the trend is to remove culverts for salmon passages to be replaced with safer, friendlier passageways.

3.11.3.8 Railroads in Clallam County?

3.12.3.1 &3.12.5. Dams create upstream and downstream ecological hazards. These should not be permitted.

3.12.5.4 should be .2
The "criteria" could be spelled out, or a reference to where it is in another document/regulation.

3.12.8 Please cite laws allowing off-shore wind energy in WA State waters.

3.12.9.1 end the sentence at "…will not be permitted." Delete the rest of the sentence.

3.12.10.1. It is environmentally risky to site sewage disposal systems in shorelines and critical area buffers. This should be disallowed. Leakage, breakage, flooding will be problematic to such systems in shoreline areas.

3.12.10.3 How far off shore? "At a distance" is indefinite.

3.12.12.f should be 3.12.12.a. This is the direction of PSP and Ecology. As to 3.12.12.a within 75 years, 75' back could mean these are under water.

3.18.6.3. Typo. "seal" should be "sea." What is meant by "take into account?" Is the intent to perhaps not stabilize, or is the intent to try to stabilize to a degree to hopefully retard damage from sea level rise, etc.? I 3.18.9 the answer? (You likely fixed this already.)

4.5.3 Allowing fill if not natural systems will not be beneficial to shoreline systems. Structures built on them risk destabilization, and liquefaction from quakes.

Though your definitions include *Geologically hazardous areas means areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events are not suited to the siting of commercial,* *residential, or industrial development consistent with public health or safety concerns,* please provide information on where these sites are, inclusive of the known fault lines exist, including those between British Columbia and the Strait.

5.1.1.e should be 5.1.1.a. That order is better.

5.12.9.b. No CUP no mater the expansion size? Example, expanding from 4Kto 5K sq ft. That is a 25% expansion, but it is very sizeable.

5.12.11.a. This expansion should be disallowed.

6.3.h. Expand description on the type of commercial shellfish beds to which this applies. There are those that are hand seeded; there are those that scrape, lay mats and plastic tube over acres, such as with planting geoduck farms. What does this passage relate to?

6.3.i. h. and i. can be one of the same. If there is the potential to cause significant erosion and sedimentation, such activities must be disallowed rather that “strictly regulated,” since enforcement often proves to be non existent. Mitigation/settlements…the damage is done. Wiser to disallow.

DYNAMICS OF THE STRAIT-FACING BEACH OF DUNGENESS SPIT

A report to the staff of the Dungeness National Wildlife Refuge
Submitted May 22, 2006 by

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ABSTRACT

This report covers the first year of a program to develop a long-term geophysical data base that will support management of the refuge as well as provide additional information for interpretive purposes.

The surface of the beach facing the Strait of Juan de Fuca fluctuated up and down, on average, in excess of sixteen inches through the year of May, 2005 through April, 2006. The largest vertical fluctuation was more than two feet, near the base of the bluff. A small amount of fluctuation was seasonal, with a slightly eroded, more rocky surface in winter, on average, and a slightly aggraded, less rocky surface in the summer. Much of the surface fluctuation is the result of rocks from the littoral zone being thrown up on the beach by periodic high-energy wave events. It is also likely that standing ground waves are being induced on the intertidal beach surface by a strong eastward littoral flood tide current. These ground waves appear to migrate slowly eastward, on average, and are eroded during ebb tides to form repeating crescents along the shoreline, or cusps, a characteristic somewhat particular to the Dungeness Spit.

A suspended clay or silt particle in the littoral flow could cover the 5.5-mile distance from the visitor's trail to the lighthouse in as little as 36 hours. In contrast, rocks and sand migrate eastward along the spit at very different rates. Sand requires a minimum of around two years to make the entire journey, while 6-inch cobbles require hundreds of years, at a minimum. The trip is made longer by the amount of time spent stranded on the beach. The movement of woody debris has yet to be studied.

Wave runup events with the potential to breach the spit occurred principally between mid-December, 2005 and early February, 2006. This was a result of the highest tides of the year combining with the most energetic wave runup. Current predictions are that ocean levels could rise between half a meter and a meter by the end of this century due to

global climate change, and that storm frequency and intensity will increase substantially. These data suggest that, even without a change in storm intensity or frequency, the minimal half-meter sea level rise would more than triple the rate of breaching of the spit, with potentially dire implications for its ability to repair itself.

INTRODUCTION

Anyone visiting the Dungeness Spit on a regular basis becomes aware of the dynamic nature of its north beach facing the Strait of Juan de Fuca. Quite obviously, the beach surface regularly changes profile and particle size, from steeply cusped to very flat, and from pure sand to pure cobbles, sometimes dramatically, sometimes overnight.

Understanding the nature and extent of those changes, the processes that cause them, and what implications they have for the future of the spit, have provided the impetus for this research – arising more out of the author's personal curiosity than any other, though nagging concerns about the implications of global climate change have also played a role.

This is the end of the first year of our systematic "monitoring" of the spit beach. Despite the crude methods and equipment employed, the data already show sufficient consistency and precision to suggest their potential usefulness in long-term monitoring and forecasting of the spit's condition. Repeated over years, this information may allow us to assess, and in some cases project, the effects of such influences on the spit as climate change, dam removal, McDonnell River watershed modification, watershed development, and drift cell modification. Should useful methods be developed this coming year to monitor the large woody debris (LWD), both on the beach and the crest of the spit, the fate of the spit over time should become significantly more predictable.

This first year, beginning in May of 2005, involved experimenting with measurement protocols and establishing permanent transects. While we have learned a great deal about the dynamics of the beach already, we are left with as many questions as answers. We are apparently beginning to learn how much we didn't know.

MEASUREMENT PROTOCOLS

Surveying the Transects. Three permanent thirty-meter transects were established on the strait-facing beach, perpendicular to the shore, to monitor the beach profile over time. The first transect, arbitrarily designated as "BEACH," is about 110 meters east of where the visitor trail reaches the spit. A second transect was established under the bluff about 55 meters west of the trail, designated "BLUFF". These were first measured in May, 2005. A third transect was added in late October, 2005, immediately east of where the public access trail reaches the beach, designated "TRAIL."

Each transect is thirty meters long with the zero station at the upslope end, nearest the large woody debris or the bluff, at an average elevation of approximately 14.15 feet mean sea level (MSL), and the thirty-meter station at the downslope end, nearest the water, at an average elevation of approximately 5.12 feet MSL. The transect zero stations have all been horizontally located with GPS. Each transect has a pair of permanent metal pins buried in the ground aligned with the transect, but shoreward several meters and hidden from public access. In case the zero stations are ever washed or blown away, the horizontal position of each transect can be reestablished quite precisely.

While each transect has its own relatively permanent monument from which measurements are taken, elevations for all transects are relative to a fixed feature on the ground unlikely to wash or blow away even under extreme conditions, in this case the easternmost corner of the bottom concrete stair of the trash pad at the bottom of the trail coming down the hill. This corner is defined as the "zero" elevation, and all transect measurements are stated in centimeters (about half an inch) below this zero elevation. Thus, as one moves down the beach toward the water, the surface elevation measurements increase from about 211 centimeters below the zero elevation at the upslope end or the zero station of any transect, to 486 centimeters below zero at the thirty-meter station, nearest the water. These elevations, of course, vary as the beach surface fluctuates up and down around an average elevation. For reference purposes, mean sea level, or the zero tide height, is estimated to be 642 centimeters below the zero elevation and would fall at about the 45-meter station on all transects in a perfectly still strait with no waves. The zero elevation at the trash pad is, thereby, an estimated 21.06 feet mean sea level (MSL).

Transects have been surveyed approximately twice a month, normally corresponding with the bi-monthly lowest tides during daylight hours, with spot elevations taken every two meters along each transect.

Beach Surface Characterization. At the same time the beach profile is surveyed, the beach surface is also characterized at each two-meter sampling point using a visual estimating frame that allows one to estimate the percent of beach at that location covered by sand, small gravel, medium gravel, large gravel, and cobbles. A metric classification scale is used with sand being any particle whose major diameter is under two millimeters, small gravel is two to twenty-five millimeters, medium gravel is twenty-five to fifty millimeters, large gravel is fifty to seventy-five millimeters, and cobbles are anything over seventy-five millimeters.

To generate a composite index, termed the Surface Index, the percent of sand is added to percent of small gravel multiplied by two, plus the percent of medium gravel multiplied by three, plus the percent of large gravel multiplied by four, plus the percent of cobble multiplied by five. A pure sand beach would have a surface index of 100 while a pure cobble beach would have a surface index of 500.

Daily Runup Measurements. Approximately daily, typically twenty to twenty-five times each month, the runup of waves on the beach is recorded for each transect. This involves scratching a line on the beach along each transect line near the highest runup point at that hour, waiting about ten minutes for the waves to leave runup marks on the scratch lines and then measuring the transect locations of each high runup mark as well as recording the time to the minute. A computer program is used, based on the recorded time of measurement for each transect (measurements are separated by the four or five minutes it takes to walk from one transect to the next), to translate the existing tidal height to a hypothetical static tide location on the transect. The difference between the static tidal station and the actual runup station is defined as the runup in meters and is taken as a measure of the energy being imposed on the beach by the surf.

Since, on average, any individual wave is running up to the same height above mean sea level at each transect location, a large number of these measurements over time, compared to one another, will show if there are any discrepancies among vertical transect station locations on the beach surface. To date, these stations are registered to one another to an accuracy of plus or minus three centimeters horizontally, perpendicular to the shore, and less than three millimeters vertically.

Sound Intensity Measurements. It has been observed that the sound intensity levels of the surf on the beach is strongly correlated with levels of runup and, it is assumed, with the energy being imposed on the beach by the surf. At the same time that runup measurements are taken each day, sound intensity levels are also recorded. This consists of using a sound meter with a C response scale, a flatter response curve more sensitive to both high and low frequencies than the human ear. The meter is set to a fast response time, updating every 1/10 of a second. Decibel readings (dBC) are recorded by hand approximately every three seconds until sixty readings are taken. These readings are taken from the lower lookout on the bluff trail which overlooks the section of beach containing the three transects. Interruptions in the recording of sound levels are regularly necessary because of conversations with passersby, the sounds of passing ships, passing airplanes, and winds through the surrounding trees. The fast response time of the meter makes this not a significant problem.

Littoral Drift Measurements. Littoral drift measurements are crude, but enlightening. They consist of chucking a stick big enough to be seen from the shore as far out into the surf as possible (given the advanced age, physical deterioration and failing eyesight of the present "chucker"), and measuring its lateral movement along the beach for three minutes. On more than ninety-five percent of the days, it is possible to follow its movement, which is normally parallel to the shore, unless a breaking wave front catches it and drives it onto the beach. On days of exceptionally high waves, the stick is regularly lost from sight and no measurement is possible. Eastward drift is defined as positive, westward as negative.

RESULTS

BEACH Profile. The average profiles, for the BEACH and the TRAIL transects are very similar. The statistical "best-fit" linear slope averages nine percent from the zero through ten meter stations, eight percent for the ten- through twenty-four-meter stations, and ten percent for the twenty-four-meter through the thirty-meter stations. The average

BLUFF transect, because of the seasonal accumulation of colluvium at the base of the bluff, differs from BEACH and TRAIL only in that it averages twelve percent slope in the upper ten meters, but otherwise mirrors the other two from ten meters through thirty.

That the beach surface goes up and down has been adequately documented this past year. Indeed, of the 48 permanent transect stations, the least variation during the year was the thirty-meter station of the BLUFF transect, the seaward end, which varied by only 24 centimeters (just over nine inches) in elevation. The largest variation was the zero station for the BLUFF transect of 77 centimeters (over 30 inches), just under the bluff. This resulted from a large amount of colluvium accumulating at the base of the bluff during the summer of 2005. In mid-October, a high overnight tide with unusually high runup washed the colluvium away and abruptly removed 42 centimeters (over 16 inches) of material from the first two meters of the transect.

Average variation of all individual stations monitored for the entire year, i.e. the difference between the highest elevation observed and the lowest, was 41.84 centimeters (16.47 inches). The greatest variation was concentrated in two characteristic locations on all transects: the zero meter station, i.e. the upper end, and between stations 10 through 16, which is the zone where the majority of high-energy high-tide waves deposit sand and gravel. Why the zero stations would vary so greatly, relative to stations two and lower, remains to be determined. Obviously, the upper stations are submerged far less than the lower stations, and typically not at all other than in exceptionally high winter tidal runup events. On the other hand, events with enough energy to affect this upper end of the beach have the potential to move an unusual amount of material, even if it only happens a few times a year. The typical breach of the spit finds erosion concentrated at the crest of the beach.

Even between sampling dates, which averaged every two weeks, great variation in beach elevation could occur. The zero station for the BEACH transect dropped 53 centimeters between successive measurements on December 26 and January 9. A very large log four meters upslope of the zero station, which was used as a base for measurements, was dislodged by a high-tide, high energy event during that period, the highest tide of the year combined with the highest runup of the year, helping explain the erosion at the zero meter station. This resulted in one of the more anomalous beach profiles. On January 9, the top ten meters of the BEACH transect averaged only six percent slope instead of the normal nine percent, the ten- through twenty-four-meter station steepened to ten percent and the remainder of the transect was unmeasurable because of high tides.

A slight seasonality in average surface levels was observed. The beach surface was about two centimeters higher than average in spring, six centimeters higher than average in summer, one centimeter lower in fall, and two and a half centimeters lower in winter. This past April of 2006 averaged over eight centimeters below average, so several years data may be necessary to get some sort of true seasonal behavior.

Explaining *why* the beach goes up and down as it does is an entirely different matter. It is assumed that the energy imposed by the surf on the beach is of substantial importance in determining these dynamics. Correlating runup energy with changes in average beach elevation across all transects, however, yields a feeble 0.28 correlation. This is not entirely surprising given that energy measurements have been taken for just over half a year, added to the fact that the transects show a very weak correlation with one another in terms of their vertical movement, as do comparable stations across different transects.

In a very real sense, the beach can be broadly thought of as undulating somewhat randomly around a mean profile with land waves perpendicular to the shoreline whose periods are on the order of only ten or fifteen meters. These are commonly manifested as a succession of cusps, particularly obvious when viewed from the bluff overhead.

The TRAIL and the BLUFF transects are physically nearest to one another, about 55 meters apart. They show a correlation in overall vertical movement of 0.59. The TRAIL and the BEACH transects are about twice as far apart, 110 meters. Their movement correlates at the 0.28 level. The BEACH and the BLUFF are, obviously, 155 meters apart and their movement correlates at only the 0.17 level.

Justification for locating the three transects was that the BLUFF had a large sediment source upslope, while the BEACH did not. We assumed the TRAIL might prove to be intermediate, being close to the bluff, but not directly underneath it. Interestingly, the top three stations of both the BEACH and the TRAIL transects, stations zero, two and four meters, correlate unusually highly, 0.77, 0.67, and 0.62 respectively in their vertical movement, meaning that the top three stations on these two transects are going up and down almost in unison, presumably subject to similar dynamics. There is, however, virtually no correlation among the top three stations – zero, two and four - of the TRAIL and the BLUFF, and only a slightly positive, but statistically insignificant, correlation between the BEACH and the BLUFF for the top three stations. Our data show that, presumably because of sediment eroded from the bluff, the upper end of the BLUFF transect behaves substantially differently from the other two, varying with less frequency but greater magnitude than the other two.

Conversely, the bottom three stations of the TRAIL and BLUFF transects, stations 26, 28, and 30 meters, correlate unusually highly in vertical movement, 0.86, 0.86, and 0.72 respectively, meaning that these stations are, likewise, going up and down very much in synchrony. On the other hand, there is virtually no correlation between the TRAIL and the BEACH for the bottom three stations. The TRAIL/BLUFF synchrony may be due to the eroded bluff sediment sheeting, in effect, obliquely northeastward down and across the beach, affecting the lower stations of TRAIL and BLUFF transects but not affecting the lower BEACH transect, which is farther away and undoubtedly shows more typical drift cell behavior for the spit, receiving its sediment entirely from the littoral drift.

It is logical that the eroded bluff colluvium would have no impact on the upper ends of the TRAIL and BEACH transects, but the existence of a slightly positive correlation between the lower stations of BEACH AND BLUFF while there is none between BEACH and TRAIL is baffling. Presumably they are all being affected by the same coastal drift cell. Figure that one out and I'll give you a cigar. Another year's data, at a minimum, will be necessary to shed further light on this relationship.

Lest the data be considered suspect, there is a comfortingly strong and consistent relationship between the vertical movement of adjacent stations on the same transect, as well as how far the adjacent station elevation ends up above or below the average elevation. This correlation drops off as one moves from comparing adjacent stations to comparing those that are two stations apart, three stations apart, and so on.

Below are the Pearson product-moment correlation coefficients for both vertical change and for resulting surface elevations comparing stations on the same transect:

	Correlation Coefficients for Cm Vertical Change	**Correlation Coefficients for Cm Above or Below Annual Average Elevation**
Adjacent Stations	0.90	0.85
Two Stations Apart	0.75	0.69
Three Stations Apart	0.62	0.55
Four Stations Apart	0.51	0.45
Five Stations Apart	0.43	0.38
Six Stations Apart	0.37	0.30
Seven Stations Apart	0.30	0.25

If one cannot adequately predict vertical change using energy data from the waves on the beach, what possible variable can predict change of the beach elevation? It turns out that, looking station by station, knowing what elevation the previous measurement was relative to the annual average elevation is the best predictor of vertical change in the next sample. That is, if a particular station is significantly below its annual average elevation in one sample, the next time it is likely to have risen substantially, and obviously the reverse is true. For all stations on all transects, there is a minus 0.68 correlation between elevations relative to average in the prior sample and change in the current sample. This suggests a beach that is undulating around an average elevation, further evidence for slowly migrating standing waves on the beach surface induced by the littoral current. This is discussed further in a later section.

Clearly extreme energy events reshape the beach strongly and characteristically across transects. The two-week sampling interval, however, doesn't reveal enough details of these dynamics, certainly not with only a year's physical data, and not with only partial energy data for the year. Another year of sampling will, it is hoped, begin to provide clearer insights and better-defined patterns. We see these patterns on the ground. Now we need to improve our study so they emerge from the data as well.

Beach Surface. Surface index is a convenient simplification that adequately reflects the average grain size of particles on the beach surface. To derive surface index, at each monitoring station along the transect a sampling frame is used to determine the percent of beach covered by sand, small gravel, medium gravel, large gravel, and cobbles. Percent sand is added to percent small gravel multiplied by two, plus percent medium gravel multiplied by three, plus percent large gravel multiplied by four, plus percent cobble multiplied by five. A pure sand beach would have a surface index of 100, and a pure cobble beach would index at 500.

The table below presents the surface index for each station averaged across all transects and all sampling dates. These data show a slight tendency for the average upper half of the beach to be somewhat stonier than the average lower half, though sand normally provides the most cover in the majority of sampling locations. Still, all sizes of cobble, gravel and sand in almost all combinations have been found in all transect locations.

The average beach surface index, averaging all sixteen stations over three transects, has been 144. The BEACH transect has averaged 148, TRAIL has averaged 139, and BLUFF has averaged 144. It is unlikely these differences are of any significance. The least stony, most sandy beach measured was a 103, and the most stony was 211. Regularly, individual station measurements are taken that are pure sand, as well as those that are pure gravel and cobble with no sand. While the figures below are averages for the entire year, a surface index of 174 is obtained when averaging only stations on all transects in the upper four meters of the intertidal zone and above (which varies from season to season). Individual station samples have ranged from pure sand at 100, a very common occurrence, to a high of 435, predominantly cobbles over 75 mm in diameter.

Station (all transects)	**Overall Average Surface Index**
0	153
2	147
4	148
6	148
8	150
10	150
12	147
14	145
16	142
18	140
20	138
22	137
24	136
26	137
28	138
30	136

Unfortunately, understanding when, where, and why the beach becomes either sandy or rocky remains largely a mystery. There is a small positive correlation between large positive changes in beach elevation and increases in “stoniness” averaged over the entire transect. On average, beaches rising in elevation between samples will be at the upper end of the observed range for surface indices, in the 175 to 200 range, i.e. somewhat stony (a beach whose surface is half sand and half medium gravel averages 200.) Beaches dropping in elevation tend to average in the lower range, somewhere between 110 and 140. There is, however, little consistency in this pattern and beaches that degrade sharply can often be very stony, while sand can accumulate significantly on beaches that are aggrading.

Careful daily measurements of surf energy, measured as magnitude of runup on the beach, have been taken since August 1, 2005. These data show no correlation with surface index. On the other hand, all beaches average slightly more stony in the winter (155) than in the summer (130), with the fall and spring intermediate (143). This mirrors a slight seasonality in the energy of waves on the beach, as will be presented in the next section.

It is obvious from daily observations that beach stoniness can change dramatically overnight, as was the case on the day this report was written. A particularly stony beach a day earlier, on May 16, 2006, was covered over by a blanket of sand during the overnight high tide, though whether the previous day’s stones were partly gone or just covered up is not known. These data suggest strongly that looking at surface stoniness on a daily basis will be necessary to shed light on the process. The erosion and deposition, sorting and mixing that goes on in the intertidal zone is unlikely to make much sense unless observed repeatedly between successive tidal floods. Eventually, tracer methods may need to be employed to follow the movement of sediment on these beaches. The best evidence for now is that the gravel and cobbles are generally rolled along the benthic surface by the littoral currents just offshore, the small ones rapidly and the big ones more slowly, and are occasionally picked up and washed onto the beach by high energy events, the size of the rocks depending on the energy of the event. How and when they get off the beach is a bigger mystery.

Daily Runup Measurements. Obviously, if there were no wave energy in the strait, the shoreline would move up and down the beach only to the extent the changing level of the tide dictated. Other than what movement was caused by the littoral current, there would be little in the way of sorting or mixing, eroding or depositing materials on the beach. Wind-driven waves and swells off the ocean constitute a substantial part of the energy imposed on the beach and are principal engines for change on the beach surface. Clearly, the vast majority of materials deposited on the upper reaches and crest of the spit are the result of extreme wave runup pushing them there.

This research assumes that the amount of energy imposed on the beach by waves, hence the amount of work that can be done in sorting, mixing, eroding and redepositing sediment by the surf, is directly related to the height the waves run up on the beach (termed “runup) as compared with the water’s static level at any time during the tidal cycle. If, for any given tidal height, the waves were only washing up fifteen meters higher than the static water level yesterday, but are washing up thirty meters today, we would expect about twice the potential for change on the beach today from surf action as yesterday, i.e. the waves could do twice as much work moving beach materials around.

These measurements didn't begin until around the middle of summer, 2005. Reliable and efficient measuring techniques took some experimentation. To determine the tidal height at any given time, the tide tables for Dungeness Bay, Sequim Washington, posted at the spit's trailhead, have been used. To estimate the tide for any time between high and low tides, a squared sine curve, which is symmetrical, is used to interpolate.

Almost daily, at a randomly convenient time during daylight hours, the author would scratch lines in the beach, extending from each transect down as far on the beach as wave action would allow. About ten minutes would pass, as the waves washed up and obliterated part of the scratch line. This leaves a very clear record of the maximum runup during that period of time. For each transect, that runup location would be measured in terms of transect meters, and the time recorded. Later, the runup measurement would be compared to the estimated static tide level and the amount of runup would be calculated.

Because the three transects go up and down during the interim between our bi-weekly profile measurements, we can only estimate where the static tide would fall on any given day. As a result, we average the three transects to generate a single runup measurement for each day.

It is obvious, given only these partial data, that the runup results are going to prove seasonal. The table below summarizes the full months of monitoring runup to the date of this report.

Month 2005/2006	**Avg Daily Runup (meters)**	**Max Daily Runup (meters)**	**Min Daily Runup (meters)**	**Std Dev of Daily Runup (meters)**
August	8.46	10.76	6.23	1.25
September	13.05	28.61	4.75	5.89
October	15.99	27.44	9.66	4.64
November	16.21	25.84	6.99	5.79
December	17.85	28.69	8.65	4.60
January	22.34	34.62	15.67	4.43
February	15.13	32.04	6.08	6.87
March	17.28	29.52	9.63	5.25

January runup figures were obviously extreme. Coupled with seasonally extreme high tides averaging over eight feet, the waves ran up extremely high on the beach. The table below shows how far up the beach the highest high tides were washing.

Month 2005/2006	Avg High High Tide (feet MSL)	Avg High High Tide Static Station (transect meters)	Avg High High Runup Station (transect meters)	Max High High Tide (feet MSL)	Max High High Static Station (transect meters)	Max High High Runup Station (transect meters)
August	7.43	22.80	12.75	7.8	25.36	11.10
September	7.22	23.58	10.52	7.6	24.70	-4.56
October	7.38	22.99	7.00	7.7	24.37	-3.07
November	7.91	21.09	4.88	8.4	23.25	-5.43
December	8.41	19.28	1.43	8.8	20.77	-8.64
January	8.47	19.04	-3.29	9.0	20.41	-14.21
February	8.13	20.31	5.18	8.8	21.50	-13.47
March	7.65	22.01	4.72	8.4	23.70	-8.38

Remember that the station numbers grow smaller as one moves up the beach toward the crest. The zero station is below the crest but closest to it, and is higher on the beach than the 30-meter station, which is downslope toward the water. Negative numbers for stations are upslope of the zero station toward the crest and have different implications depending on the transect. Any negative runup number for the BLUFF transect means the base of the bluff is being actively eroded. For the BEACH transect, any number more negative than minus four meters is potentially overtopping the crest of the spit, though it may be deflected by woody debris. For the TRAIL transect, any number more negative than about minus nine meters is running down and over the private access road.

The data show that the tidal runup was high enough to overtop the spit at the BEACH transect 21 days between October of 2005 and March of 2006, though the crest was largely protected by large woody debris between the top of the transect and the crest.

Similarly, it was high enough to erode the base of the bluff on 42 days between October and March, and on six days it was high enough to run down the private access road.

Current predictions are that ocean levels will rise by at least half a meter by the end of this century and that storm frequency and intensity will increase substantially. These data suggest that, even without a change in storm intensity or frequency, the rise in ocean level alone will more than triple the rate of breaching on the spit and, in fact, could prevent it from repairing itself.

This coming year we intend that there be fewer gaps in the daily runup measurements. As with all measures, the more often they are taken, the more enlightening they will be.

Littoral Drift. Measurements for littoral drift began about the first of October. At first glance, these data don't seem to tell us anything remarkable. A more careful look now convinces the author otherwise.

Littoral drift to the east is considered positive, to the west is considered negative. The eastward drift since October 1 averages out to 9.14 meters per minute, while the westward drift averages -5.06 meters per minute. Wind does not seem to be affecting measurement since most of the sticks floated very low in the water and frequently would move counter to the prevailing wind, more in keeping with whether the tide was flooding or ebbing.

While many more measurements will be necessary over the coming years to have confidence in these numbers, assuming they are close to real values, this results in a net eastward drift of 4.08 meters per minute. If a perfectly suspended clay or silt particle began its journey from the trail location, it would take almost exactly 36 hours to reach the end of the spit, 5.5 miles away, assuming 6 hours for each flood tide and each ebb tide.

Particles in the littoral drift have a tendency to be moved in proportion to the square of their radius. They resist being moved, on the other hand, in inverse proportion to their mass which varies as the cube of the radius. Thus, as radius (or diameter) goes up, the particle requires a sronger current to move it.

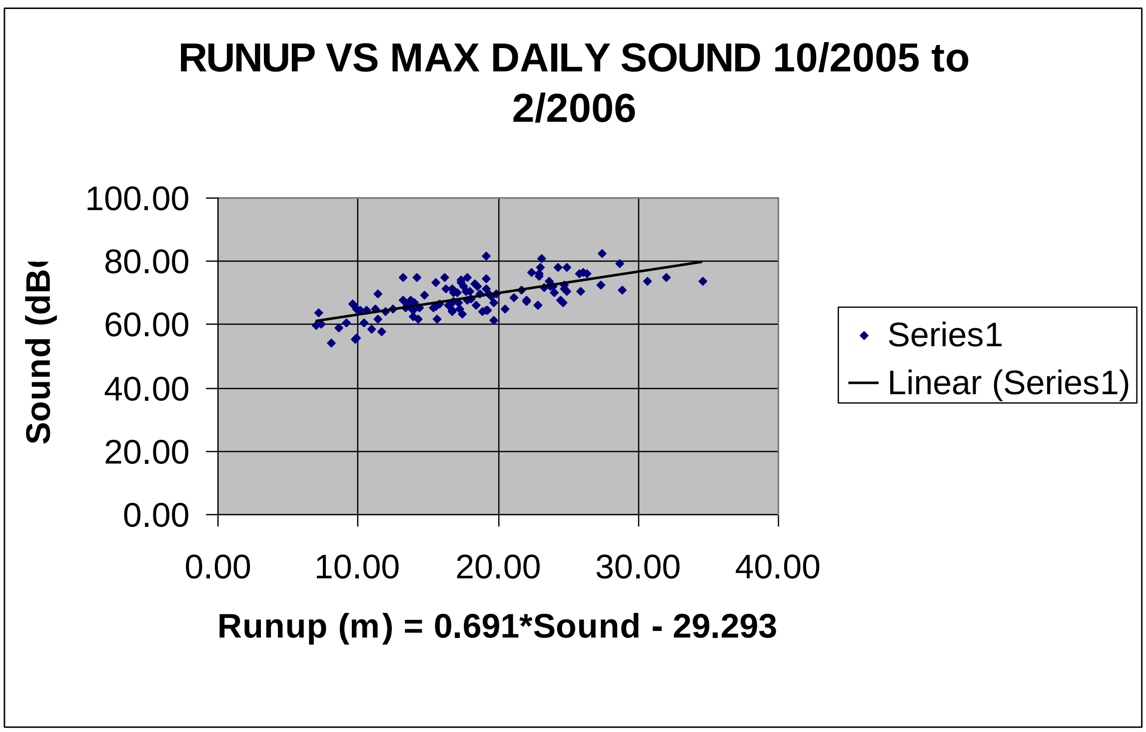
Assuming all particles were identical in mass density in a constantly fluctuating littoral current with these average velocities, the average sand particle would take a minimum of 2 years to travel the length of the spit from the trail, plus any time spent stranded on the beach. A typical small gravel particle, on the other hand, would take a minimum 28 years, a typical medium gravel particle would take at least 77 years, a typical large gravel particle would take at least 128 years, and a cobble averaging 165 mm in diameter would require no less than 340 years, again increased by any time spent stranded on the beach. As noted earlier, larger stones tend to be "hung out to dry" on the upper reaches of the beach and are removed only infrequently when events of an exceptional nature, like those that put them there, take them back off (it is assumed).

The more remarkable implications of these data, however, have to do with the formation of cusps, a characteristic somewhat particular to the Dungeness Spit. Flood currents have been measured as high as 38 meters per minute, and ebb currents have exceeded 25 meters per minute. Sustained currents, even very slow ones, will establish standing waves on the underwater beach surface, or ground waves, just as they would in the mud of a river bed. These standing ground waves typically form seaward of the twenty-meter stations during high tide events, during the few hours where the water is deep enough for sustained rapid flow in contact with the shallow intertidal bottom. These ground waves, which are about ten to fifteen meters between crests, tend to migrate toward the east very slowly under water during flood tide.

As the tide ebbs, however, these standing ground waves are progressively exposed and the seaward edges are eroded by the runup of waves. This eroded ground wave pattern deflects the water wave runup into the dips between the standing ground wave crests, where the subsequent runoff is sufficiently erosive to remove all but the coarsest of eroded materials. As the ebb tide progresses, this forms the characteristic cusps or repeating crescents with the points pointing seaward.

If this scenario is correct for explaining the formation of cusps, we would expect the strongest cusps to form at times of exceptional flow rates, usually during a strong flood tide, followed by high energy waves during the ebb. Observations will be made this next year to confirm or refute this scenario.

Sound Levels. Each day on which runup measurements were taken, sound intensity levels of the surf were recorded from the lower bluff lookout on the trail to the beach. The protocol eventually decided on was to record sixty readings from the sound level meter set on the C scale and a fast response time. Average, maximum, and minimum levels would be derived. After many months of recording, the daily maximum level turned out to correlate most strongly with the actual runup on that day. As a practical matter, these recordings should be taken for a ten-minute period to match the period spent waiting for the runup markings. While that may result in more representative maximum daily sound levels, the small improvement doesn't justify the extra time at this point. The principal value of this measurement is to provide a reasonably good estimate of runup when access to the beach is restricted due to exceptionally high runups.



The table above shows the relatively strong relationship between maximum daily sound intensity level and measured runup of surf on the beach. This can be used to estimate the runup on days when the beach isn't accessible. Work will continue with an emphasis on making the relationship at the higher end of the energy spectrum more precise.

DISCUSSION

The author has grown to think of the beach as a giant canvas whose artist works only under water and who has never been seen directly. Twice each day, a curtain of water drops over the beach, once totally and once only partially, and then pulls back, again once totally and once only partially, to reveal the latest of the artist's handiwork, so very different from day to day, even from tide to tide. It is our challenge to figure out not only what the artist has created each time, which is often very subtle, but by what means she has done it without ever having the opportunity to see her work.

It is important to try to put all this in perspective. The obvious first concern is the stability of the spit. Ignoring, for the moment, the implications of global climate change, probably no single factor will have more to do with the spit's long-term stability than its large woody debris (LWD). A program will have to be implemented, somehow, to begin monitoring and tracking this material. Repeat photography and/or tagging have been suggested.

The larger rocks that end up being tossed high up on the spit also provide a certain amount of armoring, though how effective they are in protecting the spit remains to be seen. Again, a way of tracking individual rocks would be ideal, but no obvious method suggests itself save for painting a bunch of them dayglo pink and releasing them to watch them move.

That the rocks occasionally strewn across the beach in such great numbers are normally sequestered and transported in the near offshore seems obvious. Many of the larger ones serve as attachments for the holdfasts of the kelp. Later in the year, when a large amount of kelp is washed up on the beach, it will be useful to inventory the beach-stranded holdfasts in terms of particle or grain size of the rocks to which they are attached. This past year, months after most of the kelp washed ashore, a single line of kelp remained fifty meters offshore. This year, if that happens again, we will try to find a diver to go down and look at the size of rocks that are holding that kelp in place. That may give us a clue to the fate of both smaller and larger rocks.

In general, most of the ups and downs of the beach surface appear to be undulations above and below an equilibrium surface. To date, the fall and winter months and April have averaged a few centimeters below the yearly average, while the late spring and summer months averaged a few centimeters above. There is, thus, a small seasonal effect. The dramatic excursions from average, however, seem to be more in the nature of transient "ripples" (except where colluvium is being washed from the base of the bluff.) This would be in keeping with the notions of slowly migrating benthic surface waves that form in the littoral flood currents.

One of the investigators has suggested we establish a fourth transect at the west end of the park property to monitor the effects of any beach hardening that is almost surely going to be installed to preserve the expensive homes on top of the bluff. This is a great idea but will require transportation for the measuring equipment. It will be necessary to have access to the “mule” for such an undertaking.

It would also be helpful for one-time permission to dig several pits on the beach, probably down no more than two feet and perhaps six feet in diameter, to see what is down there in terms of particle or grain size. These could be done anywhere, preferably far from where the public congregates, but it would be most useful to be able to do so both under the bluff and out on the spit.

Attempting to predict the implications of global climate change for the spit from these data is premature at this point. It is, however, an issue that must remain in our minds as we gain confidence in the data and what they are telling us about the dynamics of the spit.

Much more could be said. Another year’s measurements, however, will give us more assurance that we are saying something useful.

ACKNOWLEDGMENTS

Thanks to the staff of the Dungeness National Wildlife Refuge, particularly Pam, Annette, Colleen, Kathy, Debby and Leslie, for tolerating our relatively constant presence on the beach and for providing us occasional rides out on the spit to count dead birds and other fun things. It is hoped these findings will, in time, provide the refuge a valuable management tool as well as an interpretive resource.

My effusive personal thanks to my indomitable crew, fellow refuge volunteers and charter members of WSU’s Clallam County Beach Watchers, Ann Elliott and Jon Wendt, who have braved fog, wind, rain, blowing sand, and curious passersby to compile these data with such accuracy and fidelity. They show up to work when no one in their right minds would even think about it. That probably suggests they have larger problems than just their intrepid souls. I literally couldn’t have done it without them and hope never to have to.