IMPACTS ON SURF SMELT FROM DREDGE DISPOSAL FINAL REPORT

QUILLAYUTE RIVER NAVIGATION PROJECT

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January 2010

ICF International. 2010. Impacts on Surf Smelt from Dredge Disposal – Final Report. Quillayute River Navigation Project. January. (ICF 00421.09.) Seattle, WA. Prepared for U.S. Army Corps of Engineers, Seattle District, Seattle, WA. Contract No.: W912DW-07-D-1002 Task Order 15.

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Acronyms and Abbreviations

ANOVA	analysis of variance
Corps	U.S. Army Corps of Engineers
EPA	U.S. Environmental Protection Agency
GPS	global positioning system
MLLW	mean lower low water
NOAA	National Oceanic and Atmospheric Administration
OHWM	ordinary high water mark
p	probability
USCG	U.S. Coast Guard
WDFW	Washington Department of Fish and Wildlife
χ^2	chi-square

Project Summary

The mouth of the Quillayute River is periodically dredged to maintain the Quillayute River Navigation Channel, a federal navigation channel with a U.S. Coast Guard station located in La Push, Washington (Figure 1). This dredge disposal study was conducted under contract with the U.S. Army Corps of Engineers (Corps) (Contract W912DW-07-D-1002 Task Order 15) to determine the effects of dredged material disposal on surf smelt habitat at Rialto Beach in La Push, Washington. The study was designed to provide data concerning the suitability of habitat for smelt spawning to inform future decisions related to sediment disposal during Quillayute River dredging. In particular, the timing of dredge disposal has been limited in the past based on presumed timing of surf smelt spawning.

This report documents the results of biweekly habitat and surf smelt sampling conducted from July 8 through November 12, 2009. Study components include beach profile data, sediment characteristics, adult surf smelt sampling, and egg density and distribution. During this study, no dredge disposal occurred within the study area (Figure 2). Surf smelt use of the area was very low; few eggs and no adult fish were collected. The beach profile proved to be quite dynamic over the course of the study, shifting considerably between sampling events. Although the substrate generally contained a large fraction of pea gravel and sand that are considered to be in the suitable size range, sand was often lacking and the large substrate size and mobility of substrate may limit spawning habitat in the study area.

Introduction

The Corps is responsible for maintaining the Quillayute River Navigation Channel, a federal navigation channel with a U.S. Coast Guard (USCG) station located in La Push, Washington. La Push is located on the northwest corner of the Olympic Peninsula in Clallam County, Washington (Figure 1). This harbor is a dredged basin originally constructed in 1932. The basin provides a harbor of refuge, a USCG station, transient and permanent moorage in a marina, and a boat launch. Shoaling of the entrance channel requires maintenance dredging approximately every 2 years to ensure safe navigation. Maintenance dredging last occurred in 2007.

In 2009, the Corps was authorized to dredge the navigation channel to a depth of -10 feet mean lower low water (MLLW) plus 2 feet of overdredge to -12 feet (MLLW). Typically, the approved work windows for protection of fish species limit the available time for dredging to September 16 through February 28 of any year. Dredged sand and gravel may be disposed of at four separate locations: Site A (a 1-acre site on Quileute tribal reservation land), Site 2A (1.61 acres) and Site 1 (1.11 acres) are on the westward spit south of Rialto Beach. The fourth site (0.56 acre) is located at the south end of the James Island sea dike. Through negotiation with the Quileute Tribe, the National Park Service, the Environmental Protection Agency (EPA), and the Washington State Department of Fish and Wildlife (WDFW), the Corps was allowed to begin dredging as soon as September 1, 2009, provided that it investigate the impacts of disposal of dredged material at Site 2A on the spawning surf smelt population (EPA 2009). Site 2A is the disposal site of concern for this study. Dredging began in November 2009 and was estimated to take approximately 60 days. No dredging will occur beyond the closure of the fish window on March 1, 2010.

Surf smelt habitat monitoring was conducted at Rialto Beach monthly from May to September 1997, semi-monthly between October 1997 and March 1998, and monthly between March and September in 1998 through 2000; the monitoring was summarized in a National Park Service Environmental Study (Fradkin 2001). In that report, surf smelt spawning dynamics and spawning gravel composition were evaluated at the beach from the end of the Quillayute River Jetty north to Ellen Creek. The report recommended further surf smelt monitoring as well as studying nearshore sediment transport. Fradkin (2001) recommended that if regular dredge material deposition is instituted on the ocean side of the revetment, the Corps should provide periodic monitoring to ensure that gravel-size composition of Rialto Beach is not being significantly altered in a manner that would reduce surf smelt spawning habitat.

The Corps contracted ICF Jones & Stokes\HDR Joint Venture to prepare a study plan and conduct this investigation. The study plan was reviewed by the Corps and the Quileute Tribe and finalized in June 2009 (ICF Jones & Stokes 2009). Fieldwork was conducted every other week from July 8 through November 12, 2009.

This report documents the methods and results of beach characteristics and the surf smelt spawning study at the Quillayute spit dredged material disposal site. The purpose of this study is to characterize the baseline conditions of the area potentially vulnerable to impacts associated with dredged material disposal. Initially, the study was designed to include the period before and during dredge disposal. Although dredge disposal did not commence until after the surf smelt spawning season was past and the field studies were completed, the study provides an in-depth description of the habitat and the range of natural variability that occurs throughout the area during the study period. This baseline provides a valuable tool in assessing the habitat value and vulnerability of the area with regard to sediment characteristics and beach configuration.

The study area for the project includes three zones: dredged material disposal site 2A (Zone 2A) located on the west side of the boulder dominated Quillayute Jetty, the zone of influence where conditions change from those of the jetty to those of the beach (Zone N), and the gravel-dominated beach of control area (Zone C) located north of Zone N.

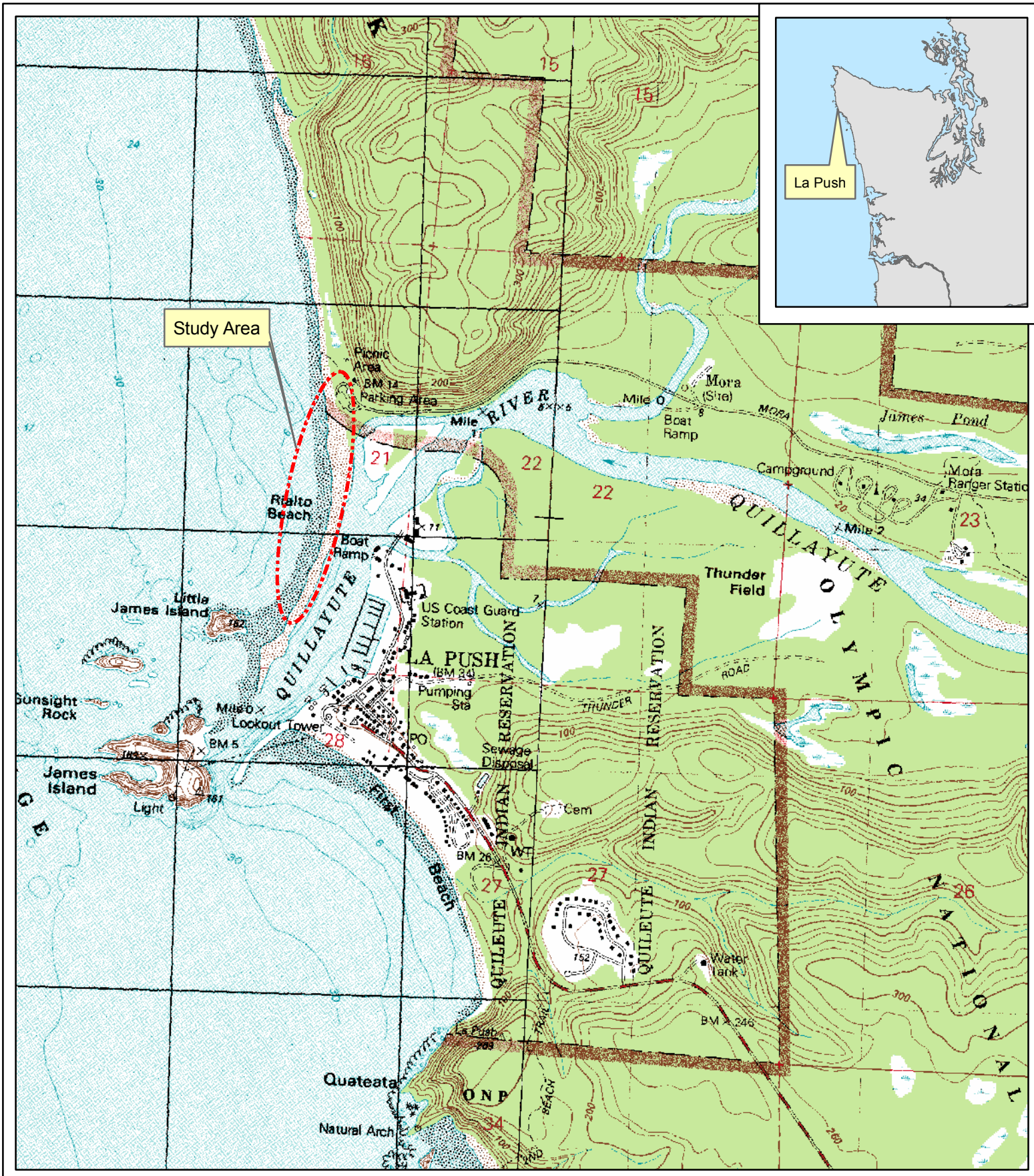

Figure 1. Project Vicinity

0 20 40 80 120 160 Miles

Study Objective

The objective of the study is to monitor gravel composition and surf smelt egg distribution and abundance to determine the effects of potential changes in beach sediment composition associated with dredge material deposition.

Specific questions related to dredge material placement to be evaluated include the following:

1. Are there measurable changes in beach morphology (slope and elevation) in the vicinity of Zone 2A?
2. Are there measurable changes in beach substrate composition in surf smelt spawning habitat?
3. Are surf smelt spawning in Zone N?
4. Are surf smelt eggs incubating successfully in Zone N?

Study Methods

Study methods for addressing the questions above included measuring the beach profile, sediment composition, adult surf smelt presence, and density of surf smelt eggs in beach substrate within Zone 2A. All components of the study were conducted during each of ten biweekly field visits between July 8 and November 12, 2009.

Study Area

The study area was delineated to include Zone 2A and areas that were estimated to potentially show a change in elevation or sediment composition through sediment transport (i.e., Zone N, the zone of influence), and an adjacent control area beyond the portion of beach that would be affected, but with similar orientation and exposure.

Once deposited in Zone 2A, dredged material is transported along the beach by wave action and currents, and eventually spreads out until no change is detectable. Dispersion of dredged material occurs both laterally (alongshore) and onshore/offshore (cross-shore). Cross-shore sediment transport is a function of the wave climate and the beach fill characteristics. In high energy climates such as the study area, fines tend to migrate offshore, while coarser materials will tend to stay in the upper beach profile. Therefore, the area that may experience a measurable change in sediment can be estimated from the quantity and type of material deposited.

During 2009, the Corps planned to deposit up to 1,500 cubic yards of dredge material during a single day at Zone 2A, a 100-foot-by-700-foot area. This material could include a large proportion of sand. Assuming equal cross-shore and alongshore transport, we estimated that the material would thin out to approximately 0.05 inch deep on top of existing sediment over a 6.2-acre area 520 feet out from the disposal area. However, since alongshore transport could exceed cross-shore transport, we assumed that the zone of influence may extend somewhat beyond this 520 foot distance laterally along the beach to the north. Therefore, the zone of influence was assumed to include up to 800 feet laterally north of Zone 2A. The vertical extent of the zone of influence was assumed to include the area from the ordinary high water mark (OHWM) down to the MLLW elevation. The OHWM elevation was estimated during the first site visit based on the best available indicators including beach morphology, extent of vegetation, and highest extent of drift material.

For reference, an 800-foot-long control area located north of the zone of influence was also sampled. The extent of the study area, including Zone 2A, the Zone N, and Zone C, is shown in Figure 2. Zone 2a and the southern half of Zone N include the boulders that make up the Jetty above about the +2 elevation (MLLW), and sand below about +2 (MLLW). The northern half of Zone N and Zone C are west facing gravel dominated beaches.

Beach Slope Profiles

Beach slope profiles were measured along four transects in the zone of influence and four transects in the control area to address study question 1:

- Are there measurable changes in beach morphology (slope and elevation) in the vicinity of Zone 2A?

Proposed transect locations are shown on Figure 2. Transects were spaced approximately 200 feet apart, and included four transects in dredge disposal Site 2A, the zone of influence north of the disposal area, and four locations in the control area. The starting point of each transect was mapped using differentially corrected global positioning system (GPS) on the first site visit. GPS with real-time correction allowing sub-meter accuracy was used on repeat visits to relocate the transect start points.

Beach profile elevations were measured using a measuring tape, surveyor's level, and stadia rod. Elevations were measured at 10-foot intervals along each transect. Elevations referenced vertically stable benchmarks that were measured relative to the known elevation of a National Oceanic and Atmospheric Administration (NOAA) Tide Station (Station ID: 9442396) Bench Mark in La Push (Bench Mark Stamping: 2396 A 2002, located in the concrete seawall at the south end of the Quileute Marina 4.6 feet (1.41 meters) east-northeast of the northeast corner of an aboveground 8,000-gallon concrete fuel tank (NOAA 2003). Beach elevations were taken at the sediment surface, not on wood or other debris. The shoreward terminus of each transect was also marked with a wooden stake from which a distance and bearing were measured.

Beach profile elevations are presented in tabular and graphic form. The slope of the beach at potential surf smelt spawning elevations was compared by a one-way analysis of variance (ANOVA) test of the beach slope measurements at the +7 elevation (MLLW). Measurements were compared for each individual biweekly observation.

Sediment Grain Size Distribution

Sediment grain size is an important component of surf smelt spawning habitat. Sediment grain size distribution was analyzed to address study question 2:

- Are there measurable changes in beach substrate composition in surf smelt spawning habitat?

Surf smelt typically spawn in sediment dominated by mixed sand and small gravel (Moulton and Pentilla 2006). Dredged material may be finer than this optimal size range, so the sediment grain size distribution could be an important factor in determining the extent and intensity of sediment effects in the zone of influence. Sediment grain size description included a visual observation and classification by dominant and subdominant size fractions, and a quantitative size fraction analysis of samples taken at selected locations.

Source: USDA 2006 (Clallam County NAIP Aerial photo)

Legend

- Sediment Sample Locations
- NOAA Benchmark
- Disposal_Area_2A
- Egg Sampling Zones

Study Transects

- Control Zone
- North Zone of Influence
- Spoil Disposal Area 2A

0 100 200 400 600 800 1,000 Feet

Figure 2. Quillayute Surf Smelt Study

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The visual observation and classification by dominant and subdominant size fractions was made at each 10-foot measurement interval along each beach profile transect (at approximately 1-vertical-foot intervals). Representative photos of each classified sediment type were taken to document the described sediment and to provide consistency between observers (Appendix A). Sediment size fractions that were used in the visual description are shown in Table 1.

Table 1. Sediment Size Classes

Class	Description	Size Range (inches)	Size Range (mm)
Bedrock	Bigger than a car	>160	>4,096
Boulder	Volleyball to car	10–15	256–4,000
Cobble	Golf ball to volleyball	2.5–10	64–256
Coarse gravel	Penny to golf ball	0.63–2.5	16–64
Medium gravel	Pea to penny	0.31–0.63	8–16
Pea gravel	bb to pea	0.08–0.31	2–8
Sand	Coarse to touch but smaller than a bb	0.0025–0.08	0.0625–2
Silt	Smooth to touch	0.00015–0.0025	0.0039–0.0625
Clay	Slick to touch, cohesive	<0.00015	<0.0039

The quantitative analysis of grain size distribution was completed at two elevations along the two transects closest to the disposal site in Zone N and along two randomly selected transects in the control area. The elevation of samples was selected to sample visually distinct sediment types identified during the first site visit. One-liter sediment samples of the upper 20 centimeters of sediment were collected with a hand trowel. Each sample was analyzed for size fraction distribution by a volumetric processing method using a standard sieve series.

Size fraction distribution was reported for each sample. The proportion of sediment that is suitable surf smelt spawning substrate (greater than 0.85 to less than 8 millimeters [Fradkin 2001]) was compared to control values. An ANOVA F-test was used to determine the significance (p) of the difference in proportion of optimal spawning substrate between zone of influence and control samples.

Adult Surf Smelt

We attempted to collect adult surf smelt to address study question 3:

- Are surf smelt spawning in Zone N?

However, no smelt were observed on any visit. If any adult fish had been collected, fish sampling would have been used to determine the following:

- relative abundance of adult surf smelt in Zone N and Zone C relative to season and location in the study area,
- sex ratio of surf smelt in the study area, and
- average size of surf smelt in the study area.

During each biweekly site visit, biologists fished for surf smelt in the zone of influence and control areas using handheld dip nets. In Washington State, recreational smelt fishing may be conducted using a dip net with no greater than a 36-inch opening. This type of gear was used to provide a catch-per-unit effort comparable to what might be expected for recreational smelt fishing. Seine

netting was considered for this study, but found to be impossible in the heavy surf that occurred in the study area. Dip netting was conducted by two biologists for 1 person-hour in Zone N and in Zone C.

Egg Density and Distribution

Surf smelt spawning and successful incubation can be determined by examining suitable habitat for the presence of surf smelt eggs and determining the developmental stage of the eggs found. This was conducted to address study questions 3 and 4:

- Are surf smelt spawning in the vicinity of Zone 2A?
- Are adult surf smelt eggs incubating in the vicinity of Zone 2A?

It is assumed that surf smelt spawned where surf smelt eggs were found. If successful incubation is occurring, eggs at varying developmental stages should also be present at some time during the study. The surf smelt egg sampling procedure was based on WDFW guidelines for collecting bulk beach samples (Moulton and Pentilla 2006) with a few modifications specific to this open-coast zone and the objectives of this study. The procedure consisted of:

5. Obtain bulk samples of mixed sand and gravel from the intertidal region of the beach.,
6. Condense the bulk samples to manageable volumes.
7. Examine condensed samples under a dissecting microscope to determine the presence or absence of eggs.

Sample Site Selection

The beach was visually assessed for appropriate substrate (i.e., sand and pea gravel, possibly with shell fragments mixed in) in the upper intertidal zone. In Puget Sound, surf smelt spawning and incubation areas are normally found in the +7 to +9 foot (MLLW) elevation zone (Moulton and Pentilla 2006). However, at this open coastal zone with significant wave action, it is likely that smelt might spawn at lower elevations as well (Pentilla pers. comm.), and wave action may bring spawning smelt or recently deposited eggs up well beyond the predicted high tide elevation. Therefore, zone selection targeted the most suitable substrate in the +5 to +10 foot elevation (MLLW) zone. Elevations were estimated relative to the most recent high water line, and/or the beach profile transects. Each composite sample area was 100 feet long taken between the beach-profile transects. The approximate locations of the composite egg samples are shown in Figure 2. No sampling for eggs was conducted in Zone 2A because this area is predominantly riprap at the upper elevation and, therefore, not suitable spawning habitat.

Bulk Substrate Collection

Bulk substrate collection for determining egg density followed the procedures described by Moulton and Pentilla (2006). The procedures for bulk sample collection are listed as follows:

1. Identify a 100-foot-long transect to sample. Prior to collecting composite egg samples, a biologist visually assessed the sample area to see if any eggs or spawning depressions were visible. Photographs were taken of beach conditions in each zone.
2. Map the bulk sample transect on a large-scale, aerial photo. The locations were always between the beach profile transects and are shown on Figure 2.

3. Prepare a sample label identifying the beach, transect, time, and date of sample, and drop it into the sample bag.
4. Starting at one end of the transect, scoop a sample (approximately 1 pint [500 milliliters]) of substrate from the top 1 to 2 inches along a 3- to 4-foot-long area.
5. Move 20 feet (measured by pacing off the distance) along the transect, obtain another scoop and combine with the previous scoop in the sample bag.
6. Repeat steps 4 and 5 until four scoops have been obtained and combined. This constitutes one bulk sample for the chosen transect.
7. Seal the bag and place in a cool location to ensure that the sample is not damaged during transport.
8. Photograph the transect from both ends, pointing parallel to the beach. Include the high tide line and distinguishing landmarks in the photo.

Condensing Bulk Samples

The bulk egg samples were processed in the field to remove most of the sand and reduce the volume of the sample. This was done by washing the eggs from the sand and discarding the barren sediment. Because eggs are lighter than sand and gravel, they will move upward during the washing process and will be removed from the surface of the material. Washing was conducted as follows:

1. Assemble 4–millimeter, 2-millimeter, and 0.5-millimeter screens on top of a drain bucket with the 4-millimeter screen on top and the 0.5-millimeter screen on the bottom.
2. Remove label from sample bag and place it in a 16-ounce sample jar.
3. Mark sample number and date on outside of sample jar with fine-tip permanent marker pen.
4. Add a portion of the sample to the top screen; thoroughly wash sediment through the screen set with fresh or salt water.
5. Discard the sediment in the top screens, and retain the sediment on the 0.5-millimeter screen.
6. Transfer the sediment from the 0.5-millimeter screen to a dishpan.
7. Add water until material is covered by 1 to 2 inches of water.
8. Swirl the pan, adding rocking and bouncing motions to allow the eggs to migrate to the surface of the sediment.
9. After swirling for 1 to 2 minutes, work the lighter fraction to the corner of the pan.
10. Carefully drain the lighter fraction by tipping the pan so the water drains away.
11. Skim the lighter fraction with the sample jar.
12. Repeat steps 6 through 11 two more times.
13. Process the remainder of the sample by steps 4 through 12, each time retaining the lightest fraction in the sample jar.

14. Fill the sample jar with Stockard's Solution to preserve the eggs. Seal the jar securely; invert carefully several times to ensure that the preservative reaches all of the eggs.
15. Tape the sample jar with electrician's tape to prevent lid loosening or evaporation of preservative during storage.

Laboratory Examination

Laboratory examination further condensed the sample and identified and counted the eggs. The winnowing process conducted in the field was repeated in a shallow tray to separate eggs from sand, when the volume of sand was large enough. Final separation was conducted under a dissecting microscope at 10-20 X, where surf smelt and other forage fish eggs are readily visible. Pacific sand lance eggs are surrounded by sand grains, thus it is necessary to search for clumps of sand grains, then tease off the sand with fine tipped forceps or dissecting needles to reveal the egg. However, no sand lance eggs were found during this study.

Eggs were counted by species and the counts recorded. The lab data form was only be used by personnel trained in forage fish egg identification.

Eggs found were archived for confirmation of species and spawn age analyses. All eggs found were preserved in Stockard's Solution in a labeled vial. Relative abundance and ages of forage fish eggs in the samples were recorded to provide information on the relative frequency and density of spawning.

Analysis

This report includes the mean egg density (number per sample) for each area (zone of influence and control areas) pooled by date and for the entire study. Egg observations turned out to be too infrequent to allow a statistical comparison between zone of influence and control areas. Since no dredge disposal occurred at Zone 2A during the study, any difference would be because of differences in habitat or random differences.

Schedule

Dates of site visits were selected based on the most suitable tides predicted for the sampling period. Sampling dates were as follows:

- July 8–10,
- July 22–24,
- August 6–7,
- August 20–21,
- September 3–4,
- September 17–18,
- September 30–October 1,
- October 14–15,

- October 28–29, and
- November 11–12.

Results and Discussion

Beach Slope Profiles

Beach profile data (Appendix B) reveal the changing conditions that occurred in the study area throughout the study. The steepest gradient occurred in Zone 2A, where the boulders of the jetty formed a stable base on which gravel and sand was deposited and eroded. Changes in gravel and sand in Zone 2A were generally not readily apparent from one visit to the next, and difficulties in comparing measurements in a boulder field make it difficult to discern these changes. Transect N1, located 200 feet north of Zone 2A, was in the same boulder-dominated terrain and shared the same general profile as the Zone 2A transects. The boulders are more widely spaced to the north, and transect N2 showed a transitional profile, with a slope midway between that of transects 2A 1 through N1 to the south, and transects N3 through C4 to the north (see Figure 2).

Transects N3 through C4 showed considerable variation from one site visit to the next. At times, the beach had a cuspate morphology with alternating areas of erosion and deposition forming cusps perpendicular to shore roughly 50 to 100 feet apart. At other times, the beach had an extremely even profile. This even profile was most evident during the second sampling event on July 24, and all of the profiles N3 through C4 line show very little variation. At times (July 9, August 7, August 21, September 3, October 1, October 14, and November 12) a high-tide bench formed, where waves during the highest tides deposited sediment.

Some differences in sediment and beach morphology occurred from one day to the next. The day-to-day difference in morphology observed on August 20 and August 21 on transect N2 can be seen in Figure 3. This difference represents a loss of about 0.5 foot (15 centimeters) of sediment in the elevations where surf smelt spawning is expected (+5 to +10 MLLW) between one day and the next. This instability could conceivably be detrimental to surf smelt incubation since the eggs are deposited at the sediment surface and the eggs are more buoyant than mineral sediment.

Changes in beach profile that occurred between biweekly visits, generally showed localized erosion and deposition, while a relatively consistent beach slope was maintained. There was no consistent change in beach configuration that could be attributed to seasons as some transects showed erosion, and others deposition throughout the study (Figures 4–9).

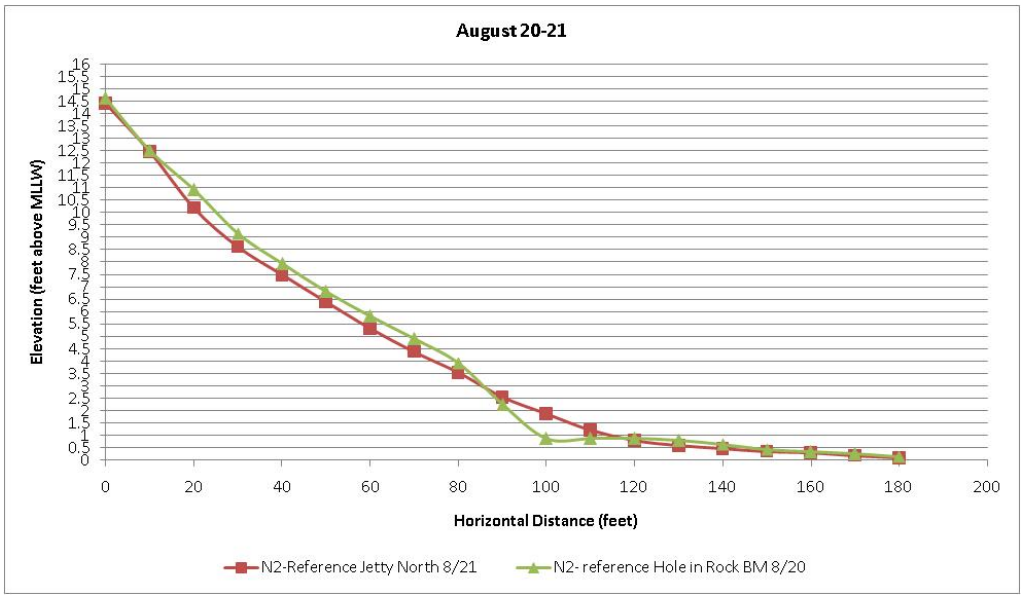

Figure 3. Beach Profile of Transect N2—August 20 and August 21, 2009

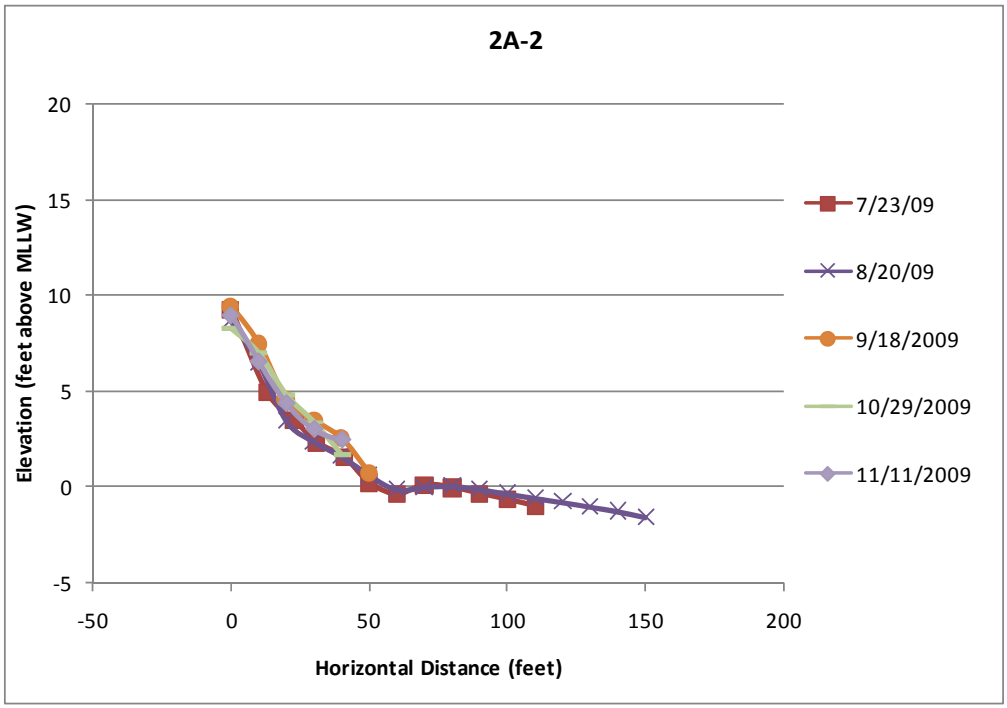

Figure 4. Example Beach Profiles at Transect 2A-2.

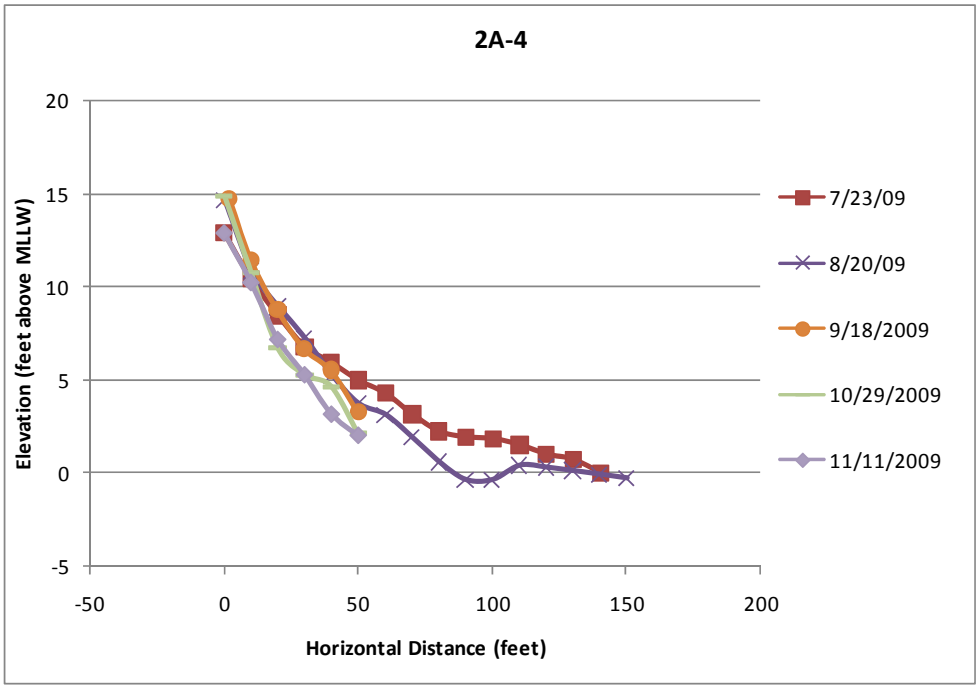

Figure 5. Example Beach Profiles at Transect 2A-4.

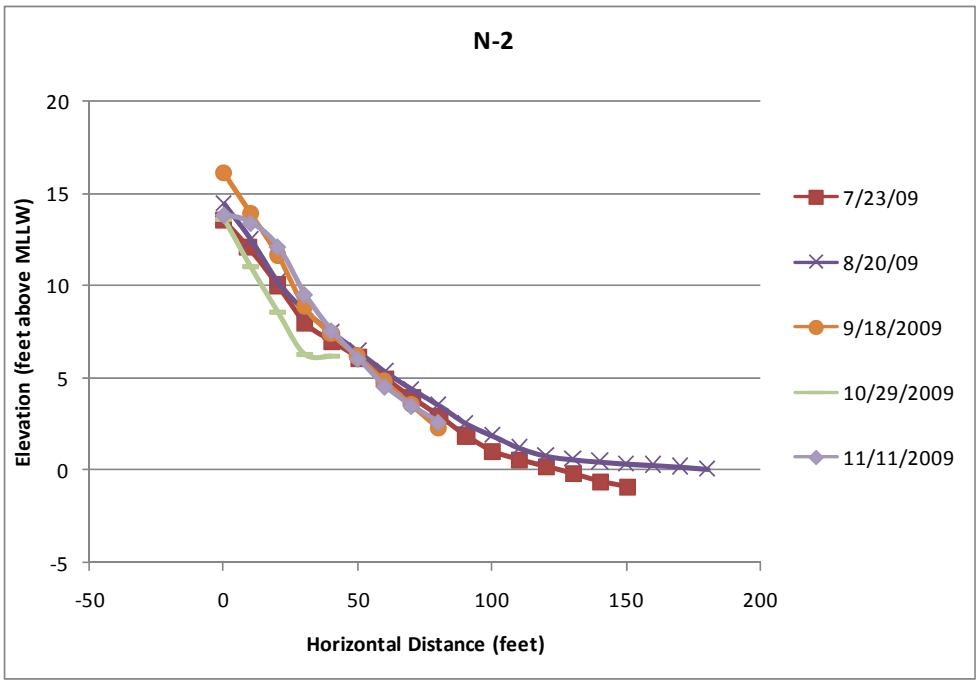

Figure 6. Example Beach Profiles at Transect N-2.

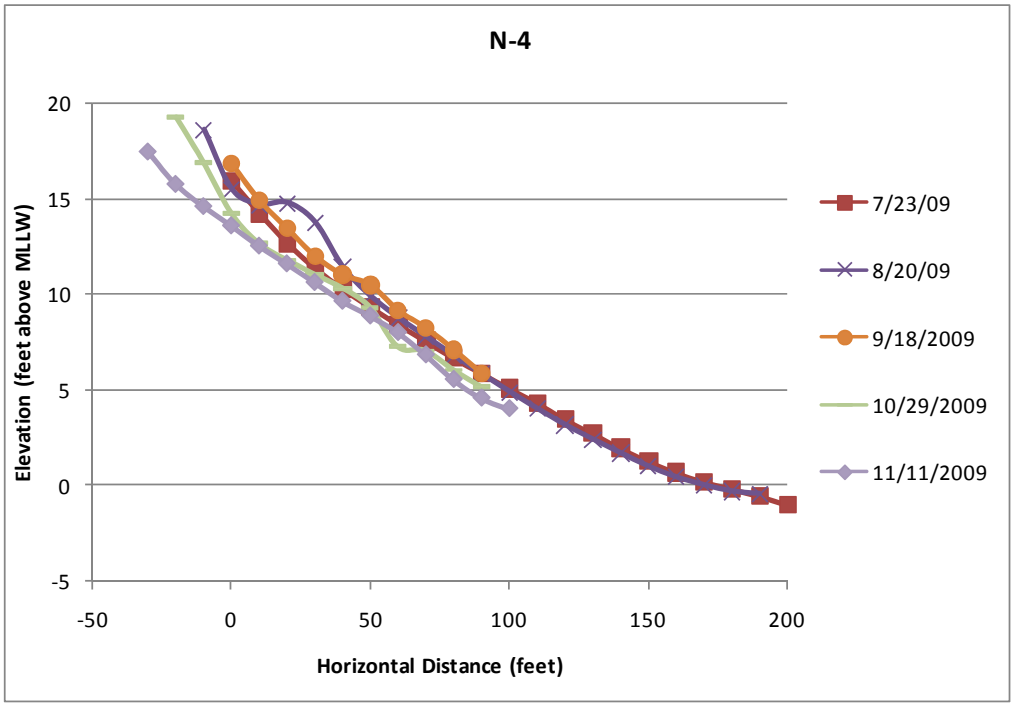

Figure 7. Example Beach Profiles at Transect N-4.

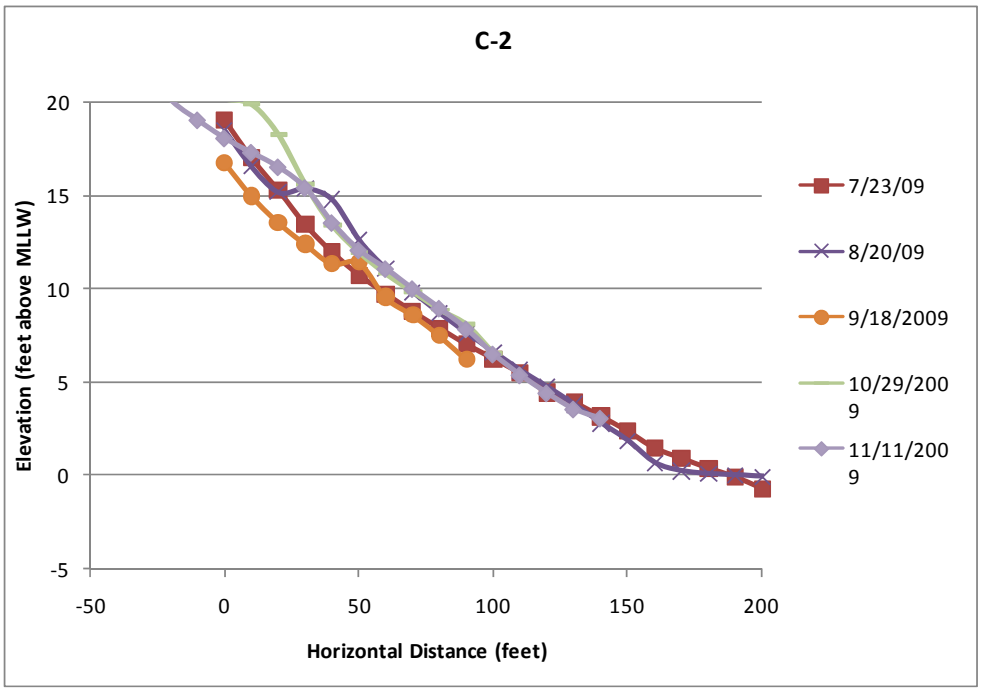

Figure 8. Example Beach Profiles at Transect C-2.

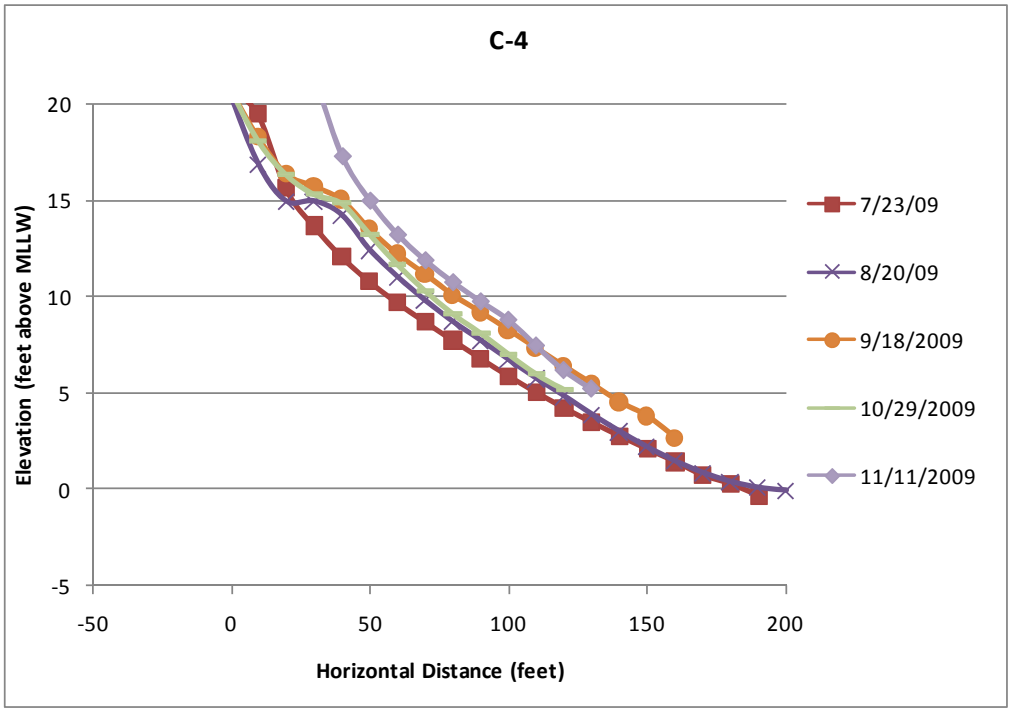

Figure 9. Example Beach Profiles at Transect C-4.

Between the October 15 and November 12 sampling events, very large waves hit the Washington Coast and relatively large changes to the beach were evident. Large logs that had been stable during all of the previous visits were moved in all three zones, portions of the beach were eroded and other portions of the beach were built up in Zones N and C. Logs were deposited along the upper portion of transect C4, and several feet of sediment built up around them at the shoreward end of transect C4 (Figure 9).

Beach slope measurements are shown in Table 2. The slope of transects N1 and N2 were typically closer to those in Zone 2A than in Zone C, while the slope of transects N3 and N4 were typically closer to the slope of the control transects. The one-way ANOVA indicated a significant (α=0.05) difference between Zone 2A and Zone C during seven of the ten visits, and no significant difference between Zones N and C on any of the ten visits. The 2009 data presented here represent a baseline range that can be used in the future if it is desirable to conduct a before\after analysis when dredge material is deposited at Zone 2A, or if other changes to the jetty occur.

Table 2. Comparison of Beach Slope Measurements

	Average % Slope at +7 foot elevation (MLLW)			One-way ANOVA p-values	
Date	**Zone 2A**	**Zone N**	**Zone C**	**Zone 2A vs. Zone C**	**Zone N vs. Zone C**
7/9/2009	19	11	12	0.051	0.478
7/23/2009	19	9	13	0.086	0.315
8/7/2009	24	12	20	**0.002**	0.409
8/20/2009	17	10	13	**0.016**	0.351
9/3/2009	19	11	11	**0.011**	0.989
9/18/2009	21	12	14	**0.035**	0.381
10/1/2009	26	10	14	**0.006**	0.134
10/15/2009	25	12	22	**0.018**	0.259
10/29/2009	22	11	15	0.135	0.274
11/12/2009	20	13	18	**0.006**	0.445
Minimum	17	9	11		
Maximum	26	13	22		
Average	21	11	15		

Note: ANOVA p-values in bold indicates a significant (α=0.05) difference.

Sediment Grain Size Distribution

Visual Assessment

During each site visit, the dominant and subdominant substrates were recorded at each measurement point along the 12 beach profile transects. Examples of the different substrate types are shown in Appendix A. Optimal substrate for spawning would be a mixture of sand and pea gravel. Surf smelt eggs typically adhere to sand grains and the egg sampling protocol specifies sampling the 0.5 to 2 millimeters fraction (coarse sand). Therefore, locations that were between +5 and +10 feet elevation (MLLW), and contained sand as either dominant or subdominant substrate were assessed as having potential surf smelt spawning habitat. The results of the visual assessment are summarized in Table 3. During the first site visit on July 8, all Zone N and C transects contained some potential spawning substrate. However, on all other sampling events, no sand was found at elevations above +3 feet (MLLW). On August 20, September 3, and November 11, sand was found at all Zone N and C transects except for transect N1. Transect C2 was the only transect that included sand at appropriate spawning elevations during every sampling event.

Table 3. Visually Determined Potential Spawning Substrate Summary by Transect and Date

	Zone\Transects											
	Disposal Site 2A				Zone of Influence North of Site 2A				Control Area			
Date	2A-1	2A-2	2A-3	2A-4	N1	N2	N3	N4	C1	C2	C3	C4
7/8/2009	<5	<3	<2	<1, 3–**8**	**<7**	**<12**	**<10**	**<10**	**< 13**	**<11**	**<10**	**<11**
7/23/2009	<	<0	<1	<4, **5–7**	<2	< 2, **4–14**	< 1	< 2	< 2	**<12**	**<17**	**<21**
8/6/2009	<4	<+3	<0	<	<3	**<10**	< 1, 9-12	**<8**	**<11**	**<12**	**<13**	**<8**
8/20/2009	<	<+1	<1, **5–7**	< 0	<1	<1, **6–8**	**<11**	**<14**	**<11**	**<11**	**<12**	**<11**
9/3/2009	<1	no sand	<1	<2	<2	**<9**	**< 0**	**<9**	**<6**	**<8**	**7–10**	**<12**
9/17/2009	<2	no sand	no sand	no sand	no sand	**<9**	11-20	no sand	no sand	**<8**	<4, **6–8**	**5-7**
10/1/2009	<	no sand	no sand	**<6**	no sand	no sand	**<11**	**<10**	no sand	**<6**	< 5	no sand
10/14/2009	no sand	<0	<1	<0	<2	**<9**	**<11**	**<12**	**< 8**	**<10**	no sand	**<6**
10/28/2009	**5–8**	<4	no sand	no sand	no sand	no sand	<5	**<10**	no sand	**<8**	**<7**	**<8**
11/11/2009	no sand	no sand	no sand	no sand	no sand	<4	**<16**	**<7**	**<10**	<4, **5–11**	**<5**	**<6**

Note: **Bold text** indicates sand in ranges that include appropriate spawning elevations (+5 to +9 [MLLW]).

Volumetric Assessment

The volumetric sediment grain size distribution assessment provides a more detailed description of the sediment characteristics in each zone. Upper and lower elevation sediment samples were taken on each transect in Zones N and C. These locations were chosen to include differences in sediment that occurred within the potential spawning elevation range (~+5 to +9 feet [MLLW]). When no differences in substrate were visible, upper and lower sediment samples were taken toward the upper and lower ends of this elevation range. Volumetric sediment size fraction data are shown in Appendix C, and summarized in Table 4. The proportion of sediment within the suitable size range for spawning (>0.85 and <8.0 millimeters [Fradkin 2001]) was greater in Zone N than in Zone C during seven of the ten sampling events, although only significantly greater during the first and last sampling events (July 8 and November 11). The steeper gradient located in the southern half of Zone N confines potential habitat to lower elevations, this and pockets of relative shelter between boulders may result in the larger proportion of sand found in Zone N.

Table 4. Percentage of Sediment Volume Suitable for Surf Smelt Spawning (>0.85 and <8.0 millimeters)

Date	N-Upper (%)	N-Lower (%)	N-Average (%)	C-Upper (%)	C-Lower (%)	C-Average (%)	ANOVA F-probability
7/8/2009	70	64	67	23	10	17	**4.0E-05**
7/23/2009	26	7	17	26	40	33	0.380
8/6/2009	20	31	25	21	42	32	0.573
8/20/2009	60	54	57	33	60	46	0.540
9/3/2009	62	27	45	42	78	60	0.465
9/17/2009	59	87	73	40	38	39	0.192
10/1/2009	51	83	67	18	51	34	0.190
10/14/2009	73	76	74	75	54	64	0.613
10/28/2009	85	97	91	38	77	57	0.054
11/11/2009	90	81	85	28	39	34	**0.009**

Note: p-value indicates probability of a greater difference in the proportion of optimal-sized sediment between zones (C vs. N) than between samples within a zone. Significant (α=0.05) p-values in **bold type**.

Adult Surf Smelt

No adult surf smelt were collected. Because of the heavy wave action at Rialto Beach in general and at the study area specifically, adult smelt may only be present in the wave zone for brief periods of spawning, if at all. Therefore, the absence of adult surf smelt during the site visits does not indicate that they do not use the study area, but rather that they were not spawning or present during the site visits. During each visit, the nearshore water surface was scanned for seabird activity that might indicate a concentration of forage fish. Harbor seals, pelicans, gulls, and surf scoters were commonly seen in the study area, but were never observed focusing in on a particular area as would be expected if a concentration of forage fish were present.

Smelt Egg Presence

One to two smelt eggs were found in three out of four samples in both Zones N and C taken on August 6. Based on the developmental stage of the eggs found on August 6, it is likely that spawning occurred between about July 31 and August 2. Two of the Zone C samples taken on August 20 contained smelt egg shells (hatched), and one Zone C sample contained a single dead surf smelt egg. One unidentified dead egg (~0.5 millimeters with no visible embryo and no peduncle or attached sand grains [possibly rock sole]) was found in sample N3 (located between transects N2 and N3 - See Figure 2) taken on July 23. No other eggs were found in any of the samples taken. Fradkin (2001) documented surf smelt spawning at Rialto beach in and north of the study area. Fradkin (2001) found higher egg density to the north than in the study area for this project. On October 14th the beach to the north appeared to have a lower slope, and a greater proportion of sand substrate than in the study area. Logs that run perpendicular to the beach are present in the beach north of the study area and these may influence sediment stability and slope. The steeper beach profile in the study area compared to that further north may result in poor spawning habitat and poor sediment stability, resulting in relatively little spawning and/or egg retention in the study area. The difference

in beach characteristics can be seen in the following photographs of Zone N (Figure 3), Zone C (Figure 4), and Rialto Beach just south of Ellen Creek in Zone 4 (Figure 5) (Fradkin 2001).

Figure 10. Zone N from Transect N4 Looking South—October 14, 2009.

Figure 11. Zone C from Transect C4 Looking South—October 14, 2009.

Figure 12. Rialto Beach from just South of Ellen Creek—October 15, 2009.

Beach photos taken from each profile transect start point (Appendix D) show the character of the beach during each sampling event.

Conclusions

Since no dredge disposal occurred during the study, the specific study questions put forward in the Introduction section cannot be answered in terms of the effects of a specific disposal event. Instead, the questions are addressed in terms of the potential for effects, assuming similar conditions in the future as follows:

- Are there measurable changes in beach morphology (slope and elevation) in the vicinity of the dredge disposal site?

The average beach slope in the middle of the potential spawning elevation range (+7 feet) varied by up to 7% in the control zone and by up to 3% in Zone N over a 2-week interval. Beach profiles also shifted throughout the study area on a daily time scale. In addition to changes in slope, the elevation of the beach at a given location shifted by up to 0.5 foot in one day, and by up to several feet over a two week period.

- Are there measurable changes in beach substrate composition in surf smelt spawning habitat?

As with beach slope, changes in substrate were visible on daily as well as two-week time scales. The average proportion of sediment that was suitable for surf smelt spawning and incubation was higher in Zone N than in Zone C during 7 of 10 occasions, although the difference was only significant (α=0.05) on two occasions (July 8 and November 11). Gravel generally dominated the beach substrate, with sand comprising a relatively small proportion of the whole. Although much of the gravel was in the suitable range (>0.85 to <8 millimeters), the lack of coarse sand (0.5 to 2millimeters) may limit suitability of substrate. Puget Sound surf smelt populations typically spawn

in a mixture of sand and gravel; for example, Middaugh et al. (1987) found that surf smelt spawning substrate at three Washington surf smelt spawning sites all included more than 30 % sand. The prevalence of coarse substrate may also cause smelt eggs to be buried deeper in the substrate than at lower energy sites. If this is the case, it may be necessary to excavate to a greater depth to sample efficiently.

- Are surf smelt spawning in the dredge disposal site zone of influence?

No adult fish were observed in the study area and very few eggs were collected. Spawning appears to have been very limited in the study area in 2009. Fradkin (2001) sampled Rialto Beach in and north of the study area from 1997 through 2000 and found that surf smelt eggs were present from May to September, but that egg density varied considerably between years. In 1999, Fradkin (2001) collected an average of less than 2 surf smelt eggs per liter in samples taken in May through August; no eggs were present in samples taken in September. This demonstrated a large variation from 1997 and 1998 when July average egg densities were about 30 and 10 eggs/liter, respectively. During 2009, smelt use was quite low, and eggs were only collected in August, and only in small numbers.

During this study, gravel substrate dominated the beach in Zones N and C, and substrate suitability may limit use. In addition, 2009 may also have had low spawning for reasons unrelated to habitat suitability. Natural inter-annual variation in population size may have reduced use of the study area in 2009. In addition, it is also possible that spawning may have occurred earlier in the year.

- Are surf smelt eggs incubating successfully in Zone N?

The few intact smelt eggs that were found in Zone N appeared to have been viable at the time of collection. Egg shells were also found indicating that some smelt may have incubated successfully in the vicinity. However, the dynamic nature and large size of the beach substrate seem to be contrary to good incubation habitat. If more eggs had been present, it might have been possible to surmise from the relative numbers of eggs at differing developmental stages whether eggs typically incubated successfully at the site. However, the lack of any eggs in most samples prohibits a definitive conclusion regarding egg incubation success.

Recommendations

1. Repeat this study during a minimum of two years during placement of dredged material. This study provides a baseline of beach profile and sediment conditions occurring without disposal. In order to determine the effect of dredged material disposal, it should be repeated when dredged material is disposed of.

2. Deposit dredged material during summer months to test the hypothesis that disposal does not substantially alter beach profile or grain size distribution.

3. Sample substrate at subtidal, intertidal, and supra tidal elevations to determine grain size distribution at these different elevations. This would help determine the optimal elevations for dredged material disposal.

4. In future studies, sample substrate for eggs at a greater number of elevations and sediment depths. Compositing a larger volume of sediment is recommended to keep the number of samples manageable.

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Appendix A. Sediment Photos

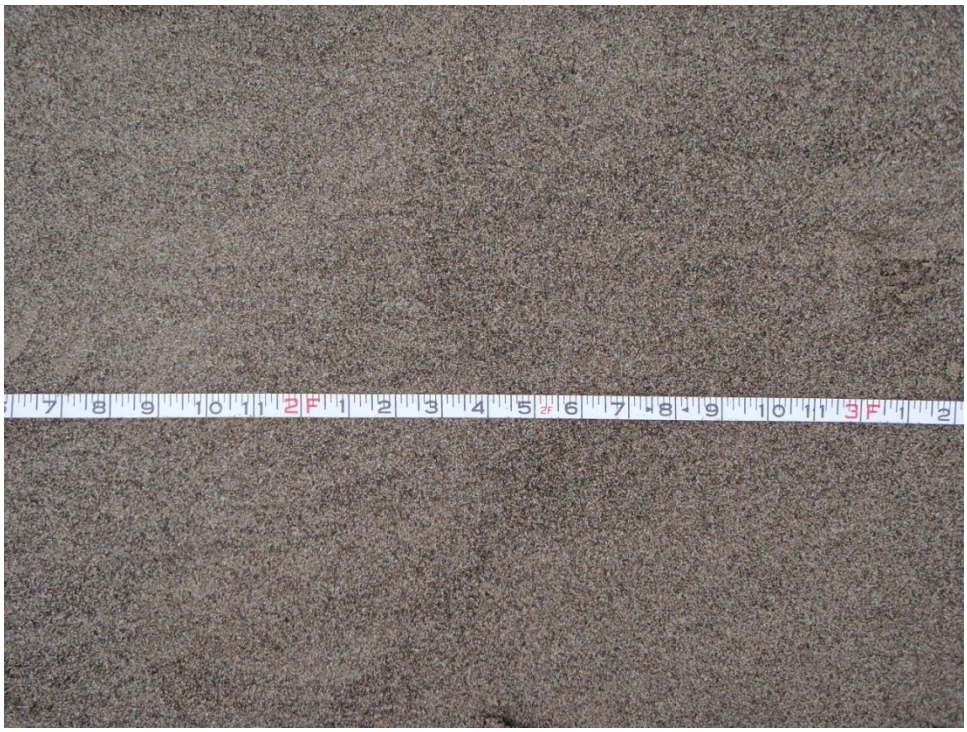


Photo 1. July 7, 2009 Dominant: Sand, Subdominant: Sand

Photo 2. July 9, 2009 Dominant: Sand, Subdominant: Gravel

Photo 3. July 9, 2009 Dominant: Gravel, Subdominant: Sand

Photo 4. July 9, 2009 Dominant: Boulder, Subdominant: Sand

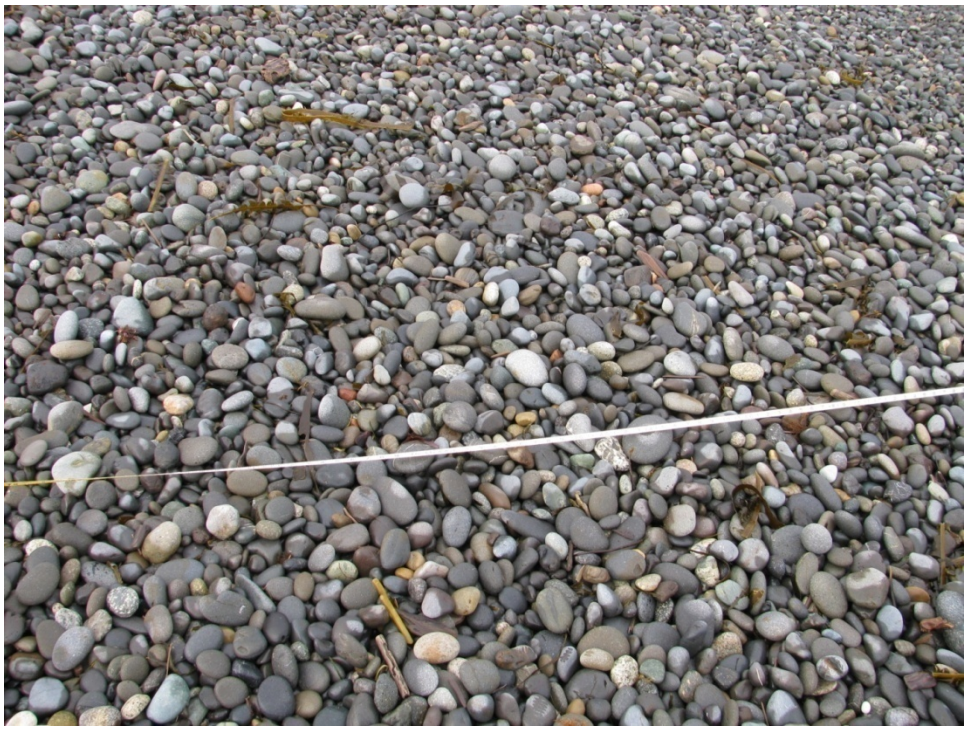


Photo 5. July 9, 2009 Dominant: Gravel, Subdominant: Gravel

Photo 6. July 23, 2009 Dominant: Sand, Subdominant: Gravel

Photo 7. July 23, 2009 Dominant: Gravel, Subdominant: Gravel

Photo 8. July 23, 2009 Seaward (left) - Dominant: Sand, Subdominant: Gravel, Shoreward (right) - Dominant: Gravel, Subdominant: Sand

Photo 9. July 23, 2009 Dominant: Sand, Subdominant: Gravel

Photo 10. July 23, 2009 Dominant: Sand, Subdominant: Gravel

Photo 11. August 7, 2009 Dominant: Boulder, Subdominant: Boulder

Photo 12. August 7, 2009 Dominant: Boulder, Subdominant: Cobble

Photo 13. August 7, 2009 Dominant: Boulder, Subdominant: Sand

Photo 14. August 7, 2009 Dominant: Sand, Subdominant Sand

Photo 15. August 7, 2009 Dominant: Sand, Subdominant: Gravel

Photo 16. August 7, 2009 Dominant: Gravel, Subdominant: Sand

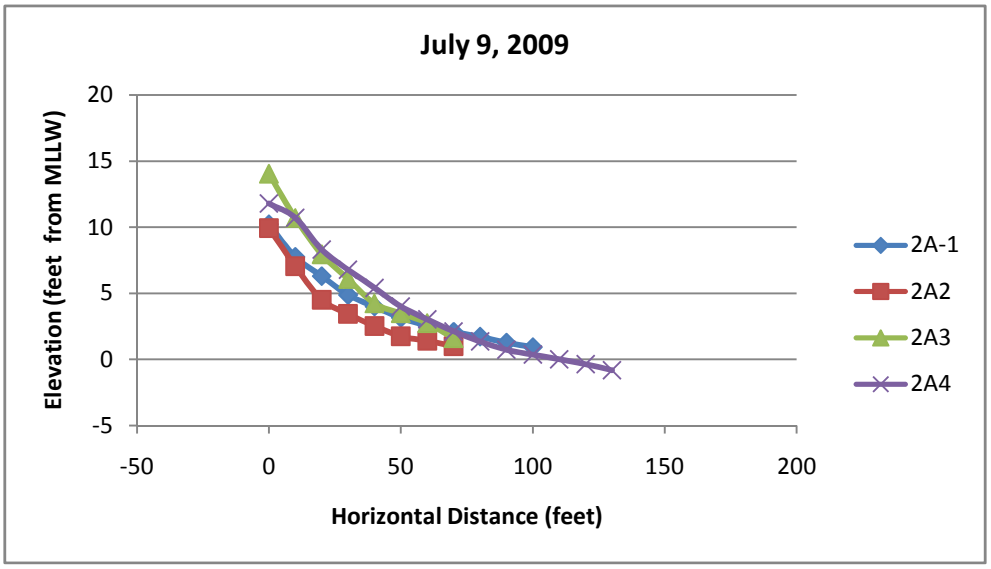
Photo 17. August 7, 2009 Dominant: Gravel, Subdominant: Gravel

Photo 18. August 7, 2009 Dominant: Gravel, Subdominant: Cobble

Photo 19. August 7, 2009 Dominant: Cobble, Subdominant: Boulder

Photo 20. October 1, 2009 Dominant: Gravel, Subdominant: Gravel

Appendix B. Beach Profile Data


July 9, 2009
Elevation (feet from MLLW)
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15
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200
Horizontal Distance (feet)
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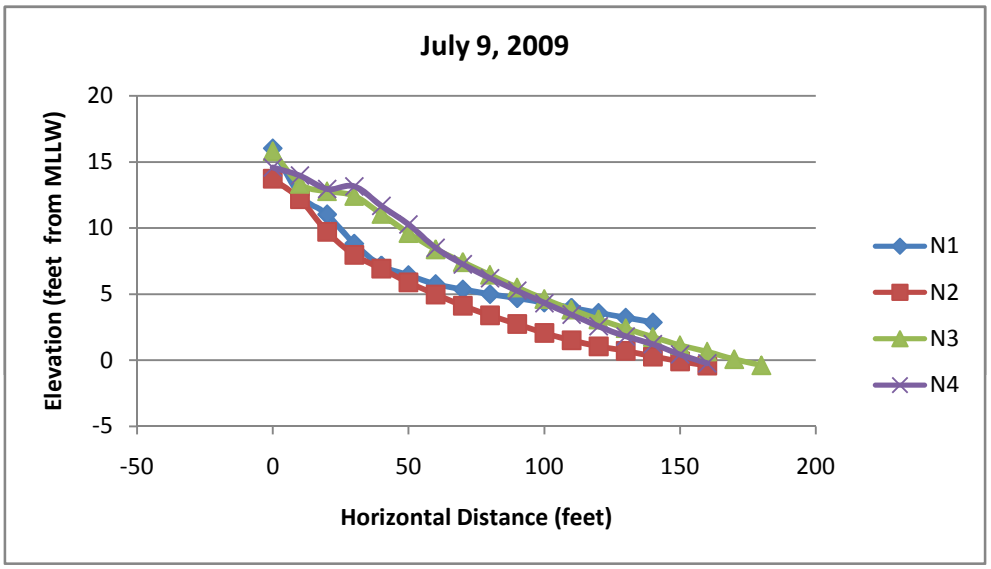
2A2
2A3
2A4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Horizontal Distance (feet)
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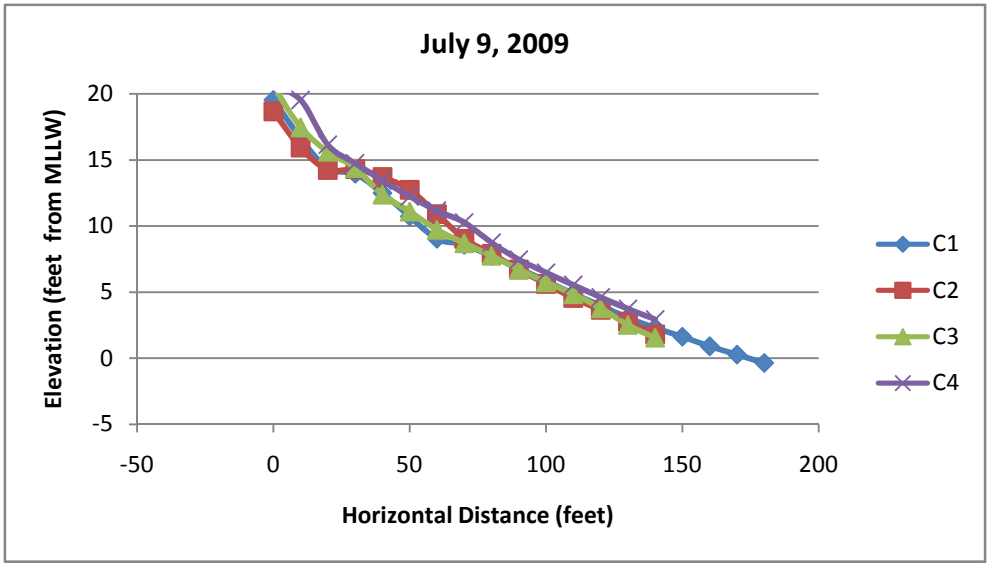
N2
N3
N4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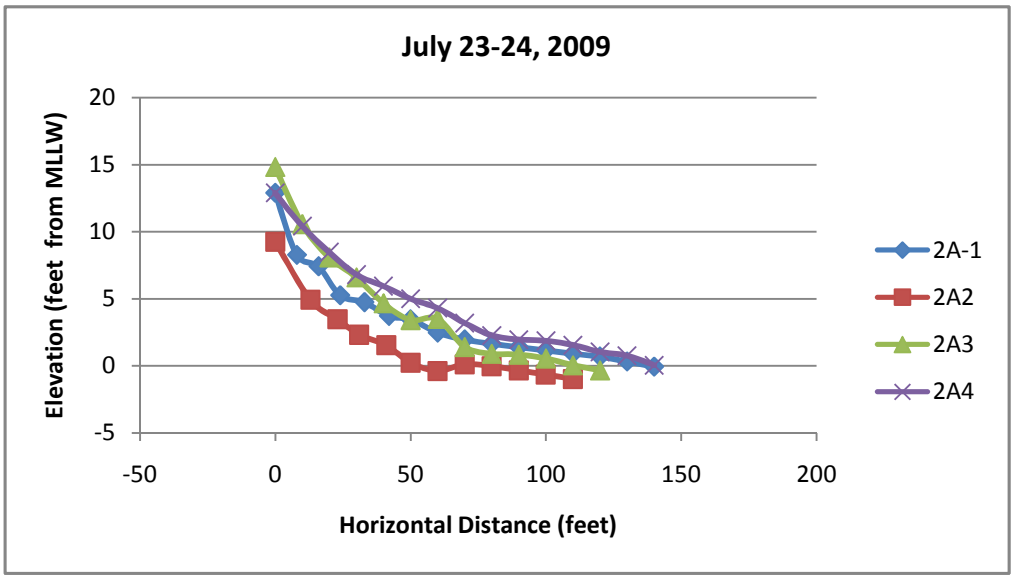
Horizontal Distance (feet)
C1
C2
C3
C4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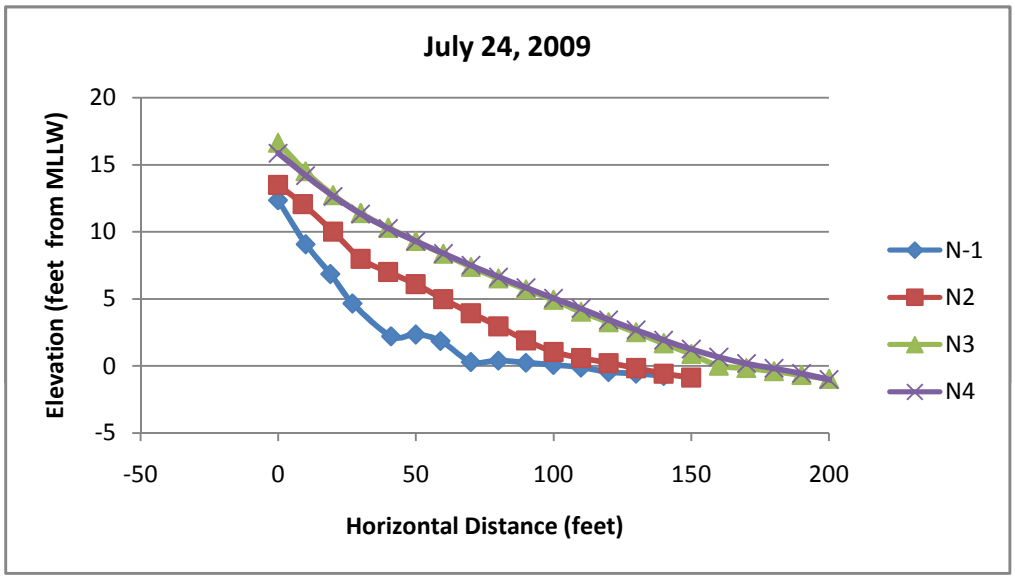
2A3
2A4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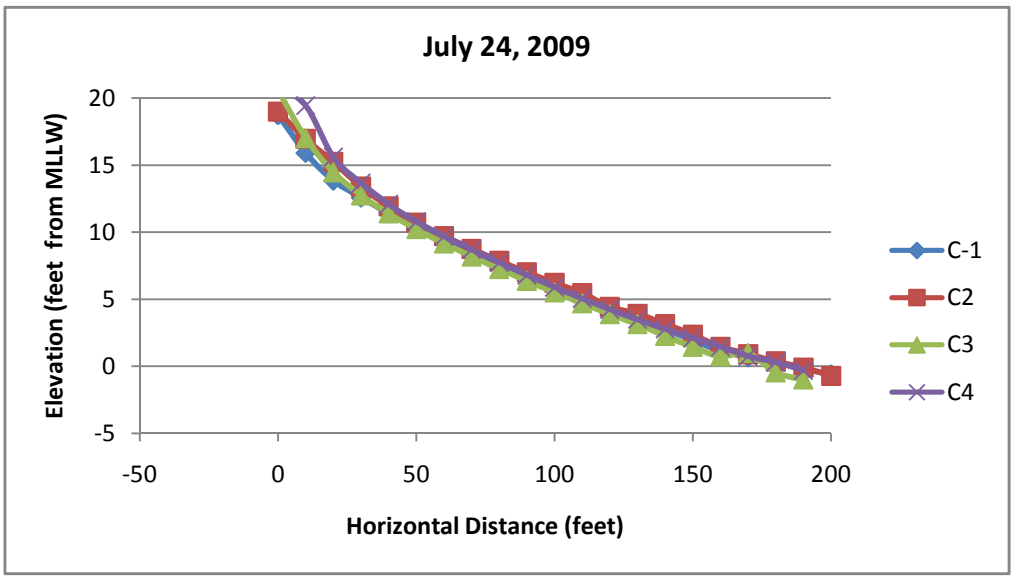
N2
N3
N4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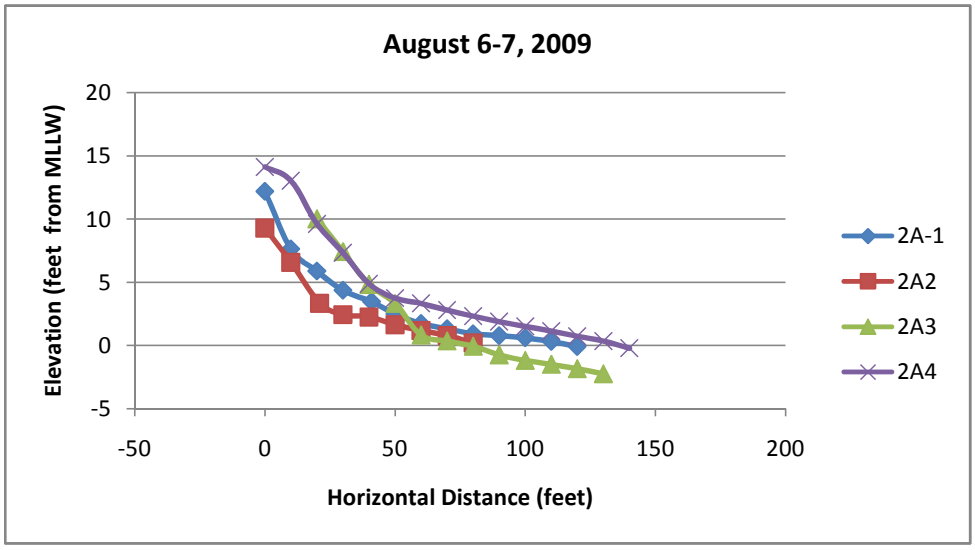
C2
C3
C4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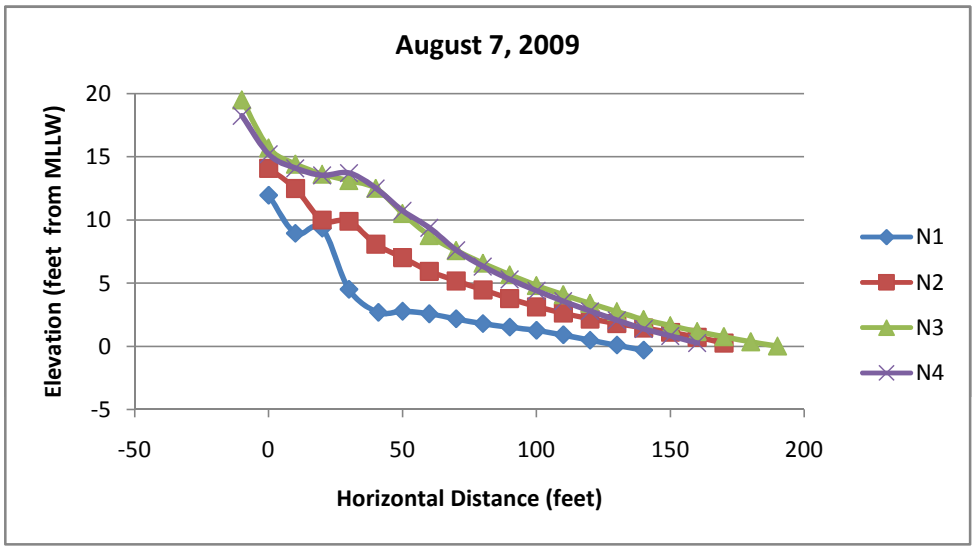
2A2
2A3
2A4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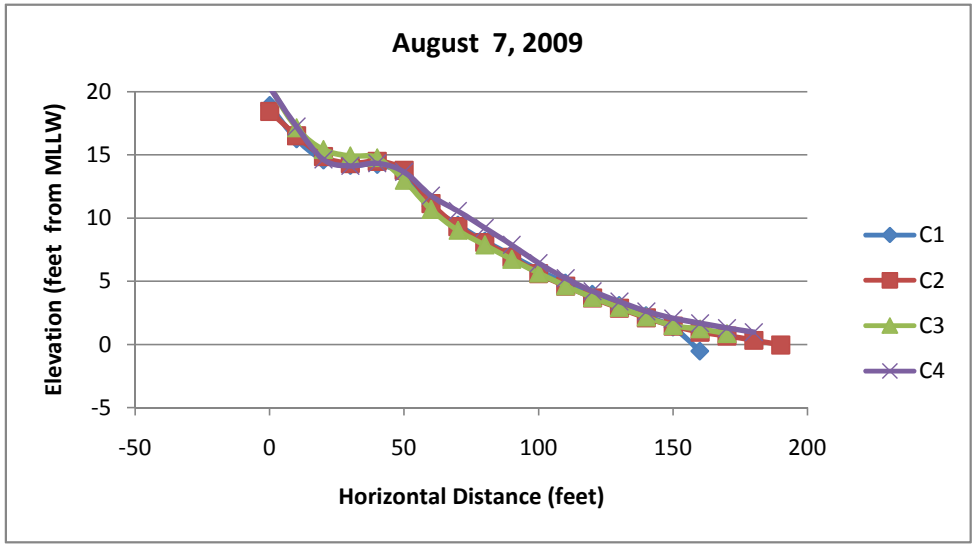
100
150
200
Horizontal Distance (feet)
N1
N2
N3
N4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150
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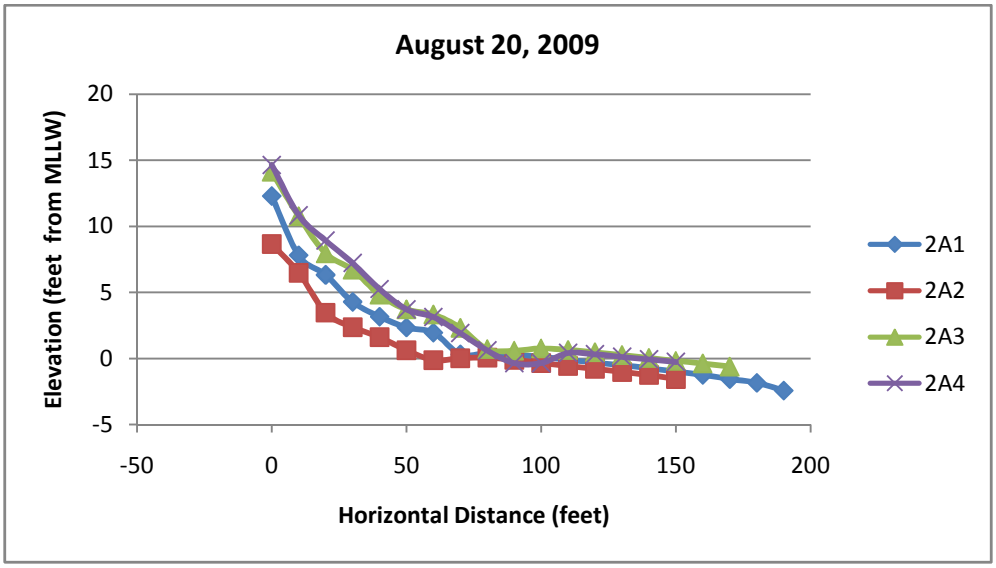
Horizontal Distance (feet)
C1
C2
C3
C4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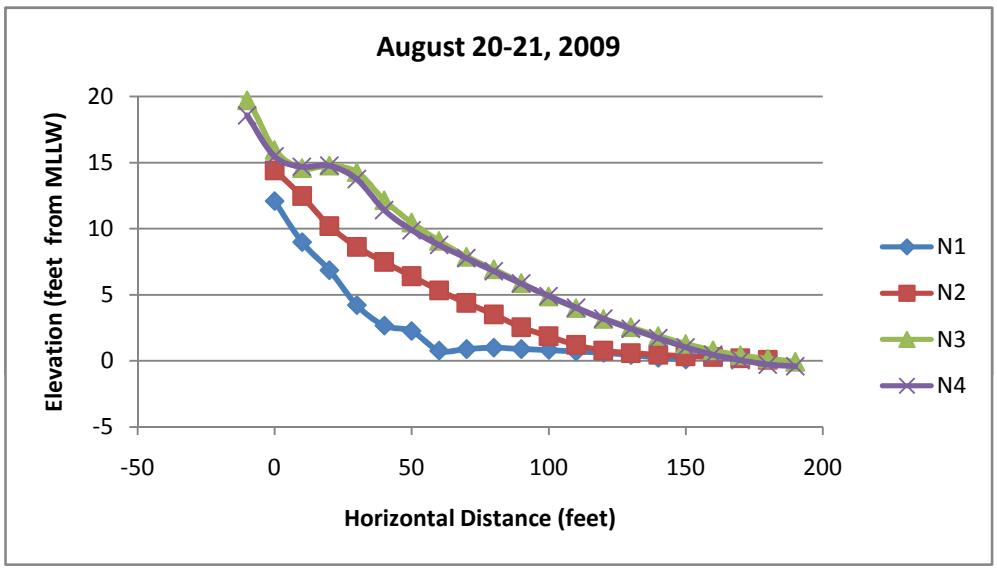
2A2
2A3
2A4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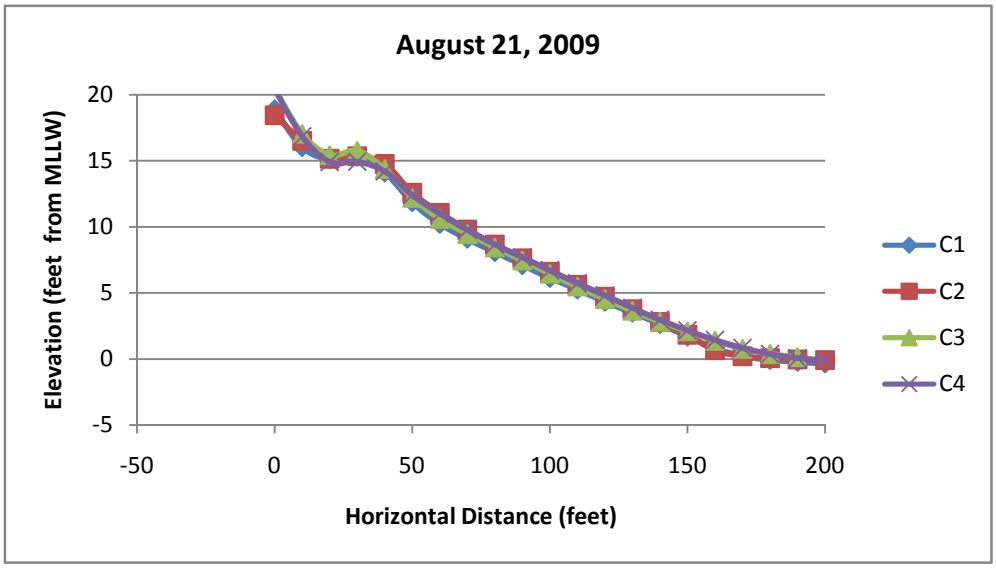
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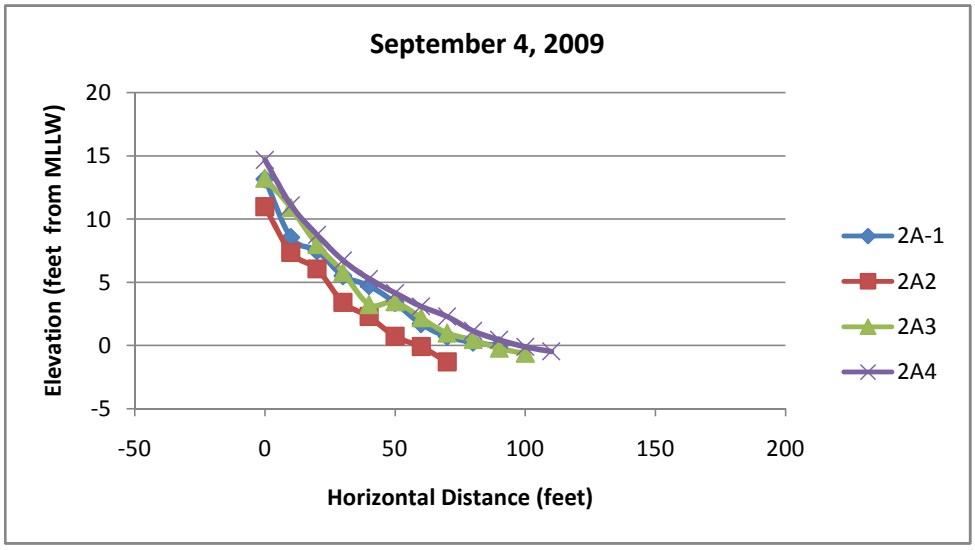
C3
C4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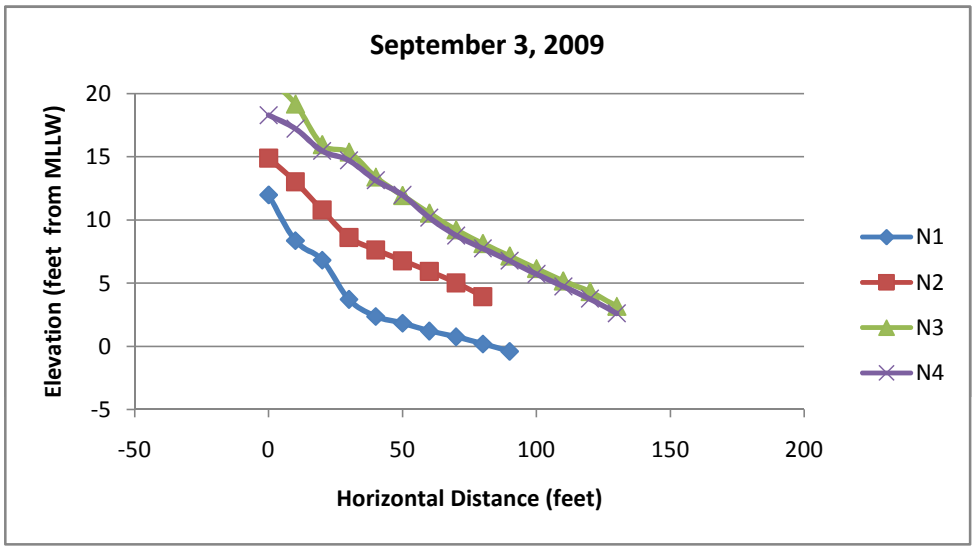
2A3
2A4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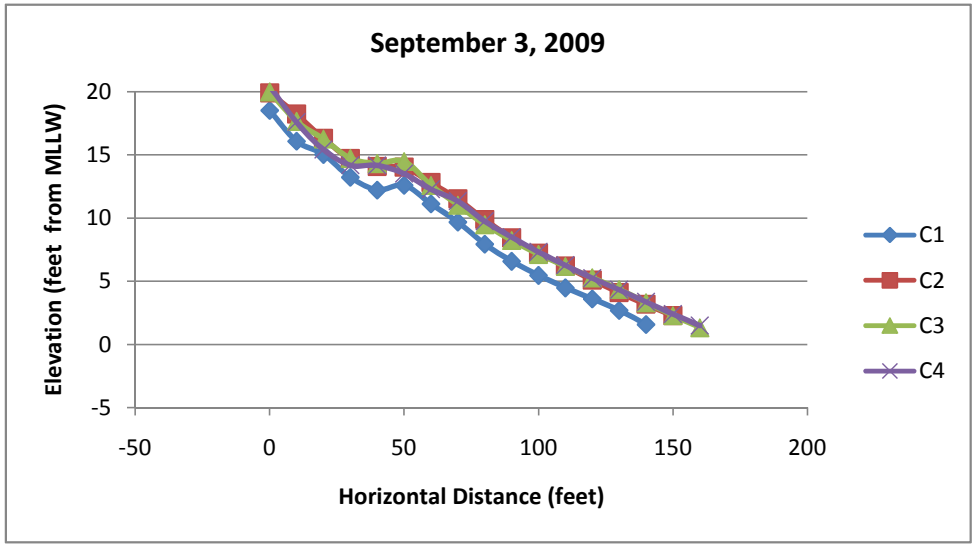
N3
N4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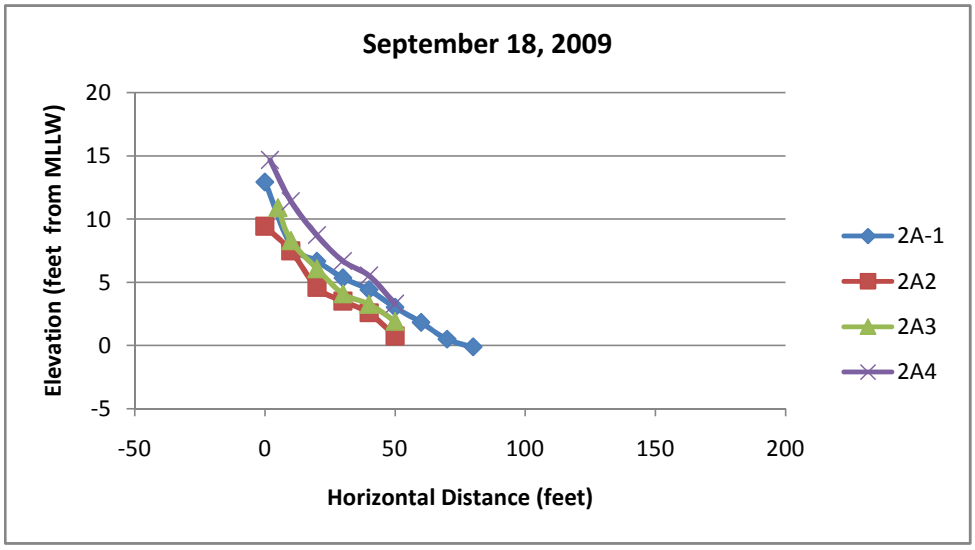
200
Horizontal Distance (feet)
C1
C2
C3
C4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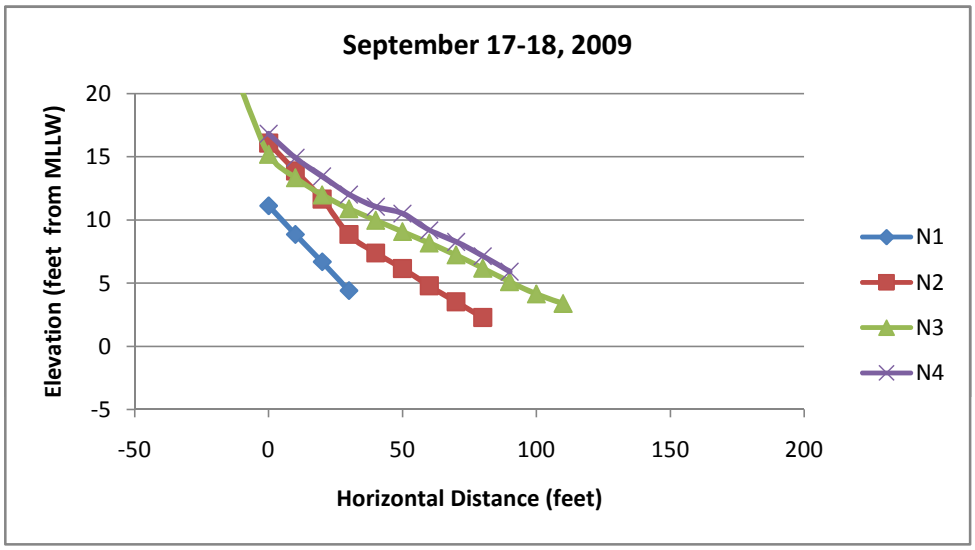
2A2
2A3
2A4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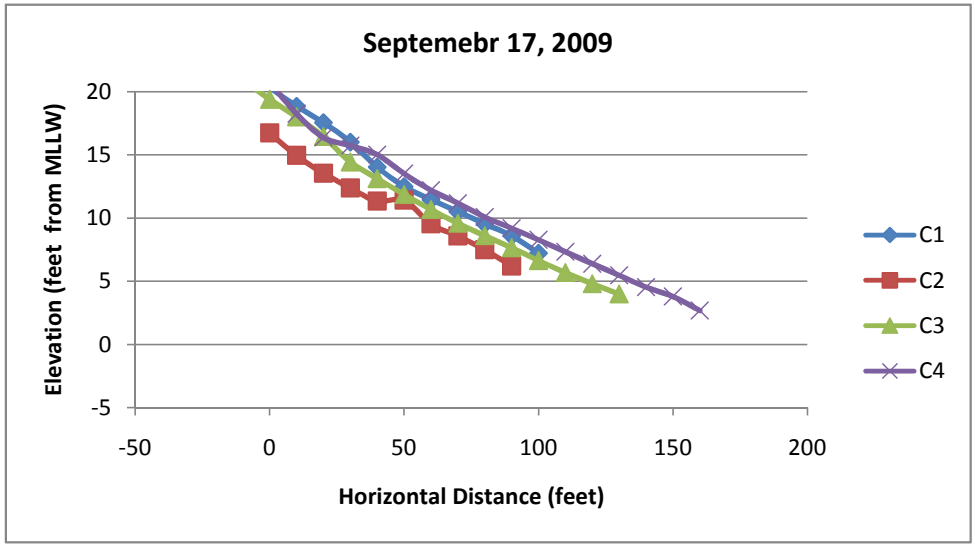
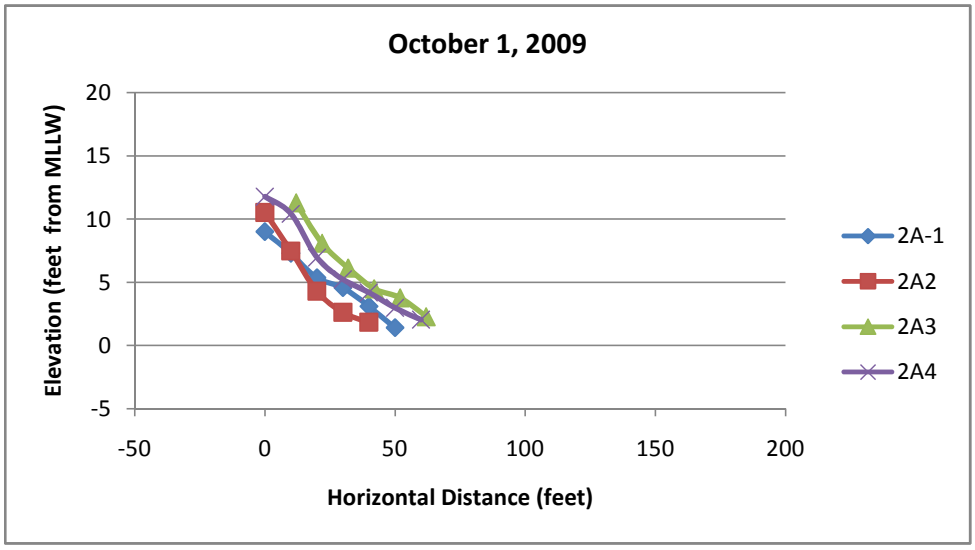
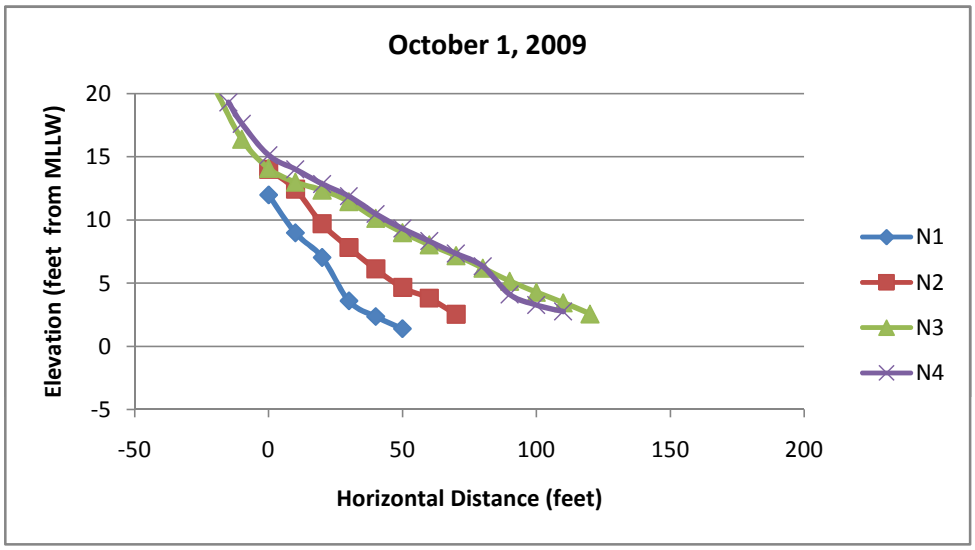
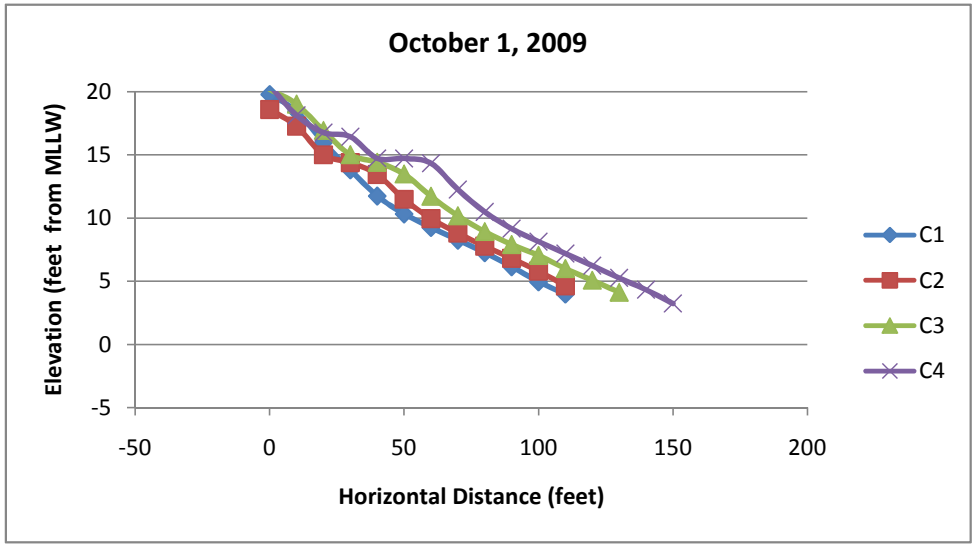
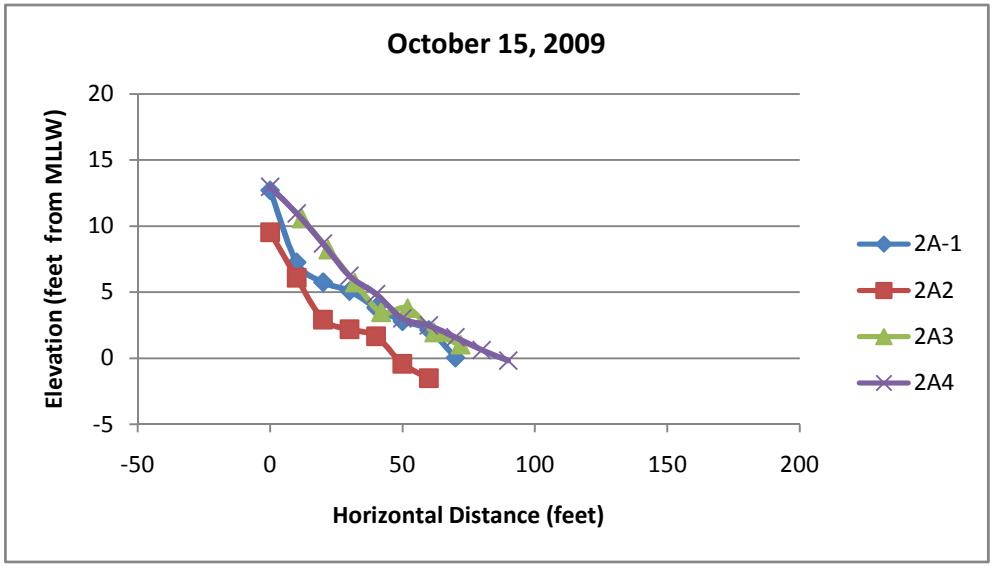
100
150
200
Horizontal Distance (feet)
N1
N2
N3
N4

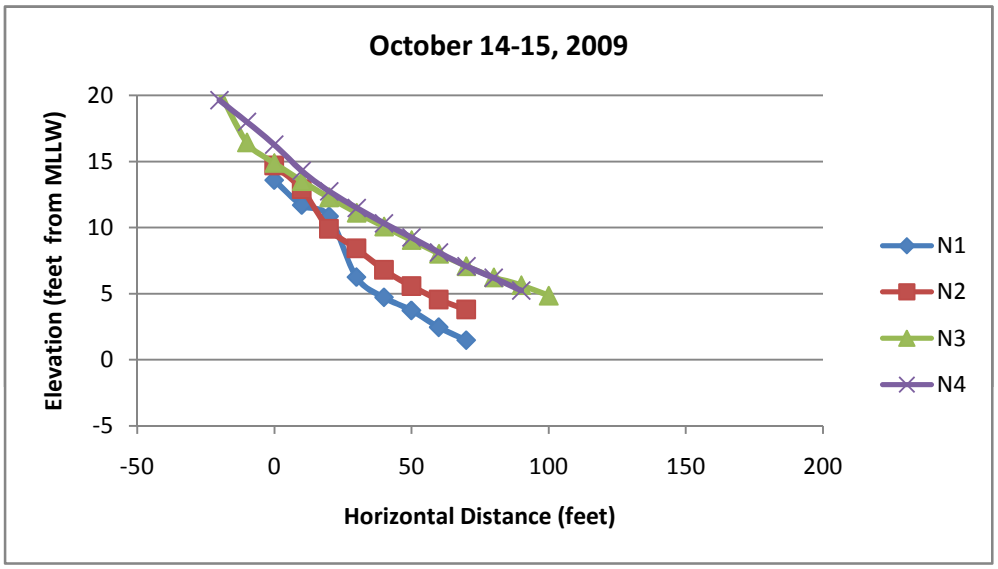

Septemebr 17, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
C1
C2
C3
C4

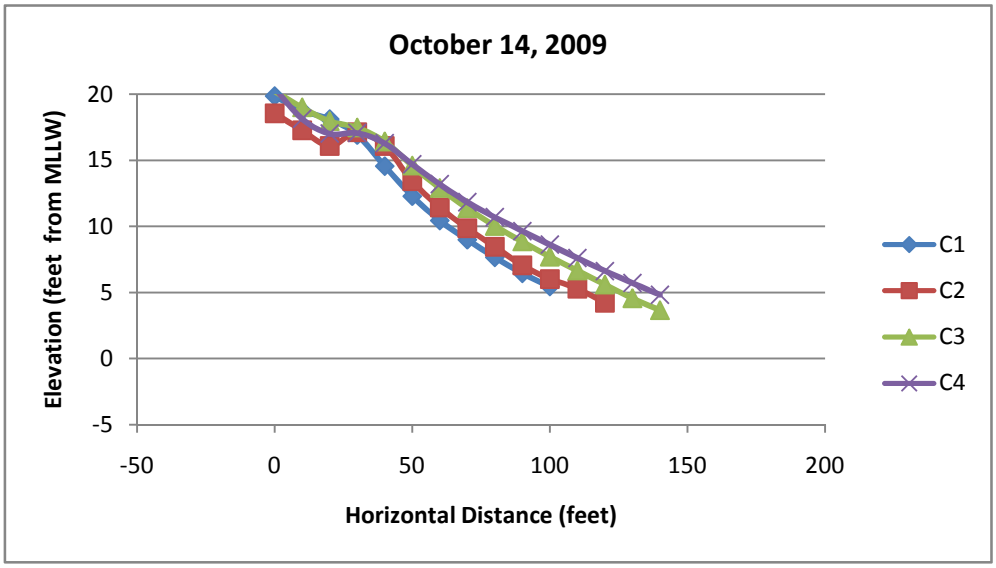

October 1, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
2A-1
2A2
2A3
2A4

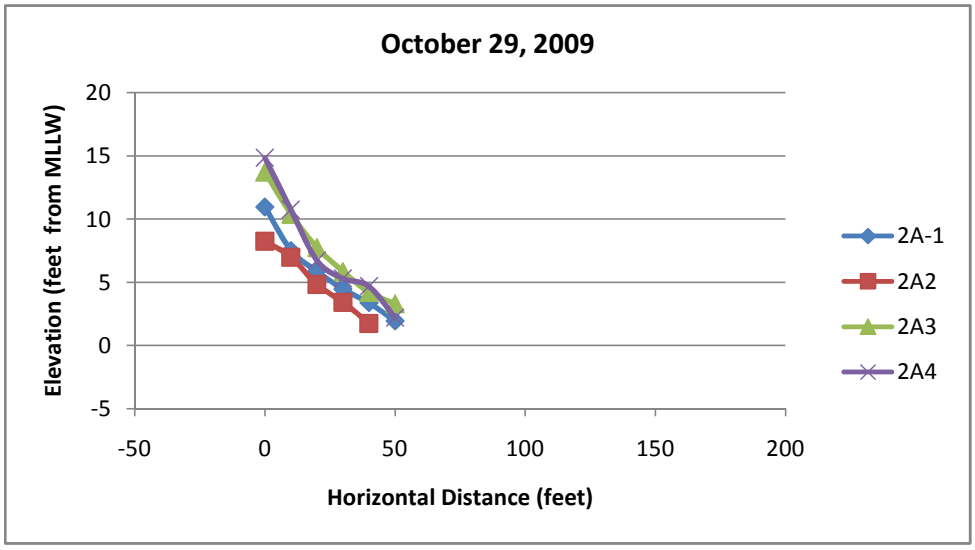

October 1, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
N1
N2
N3
N4

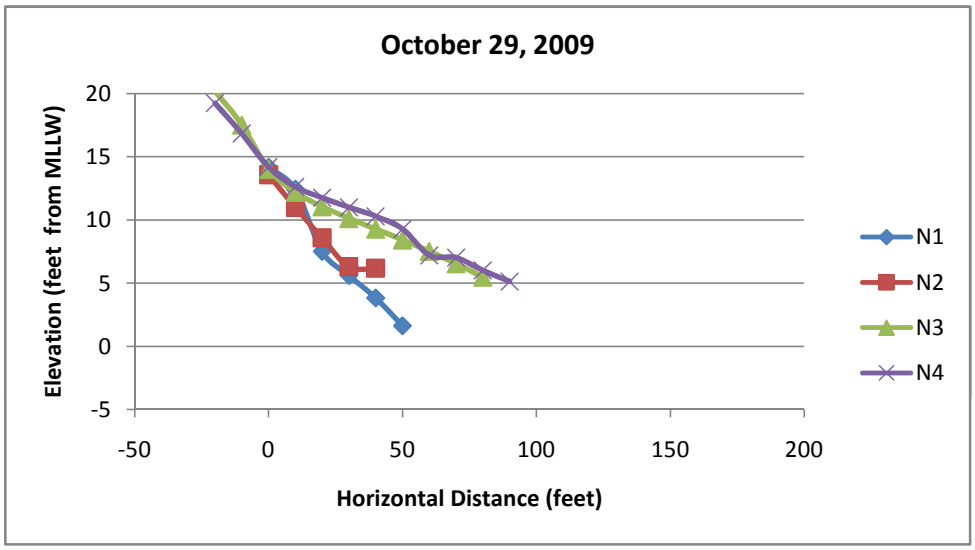

October 1, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
C1
C2
C3
C4

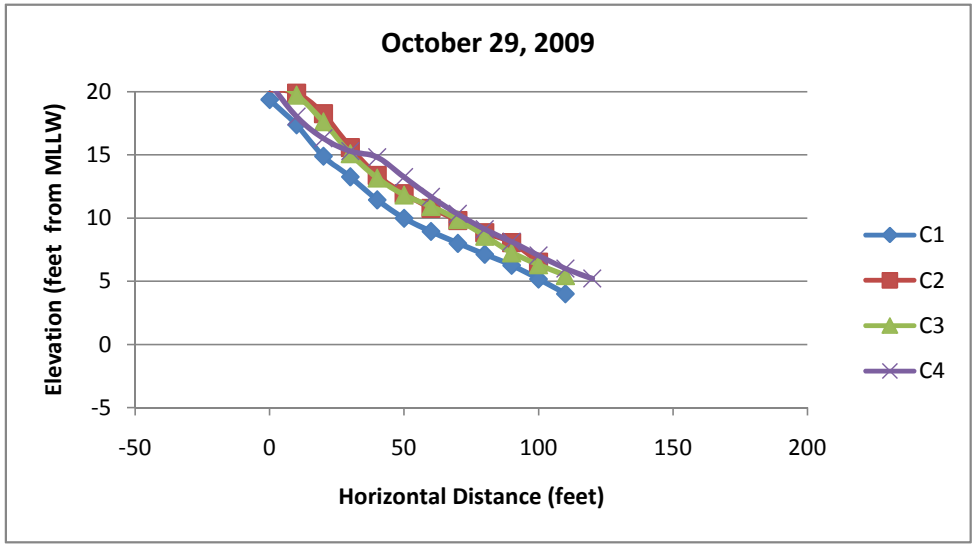

October 15, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
2A-1
2A2
2A3
2A4

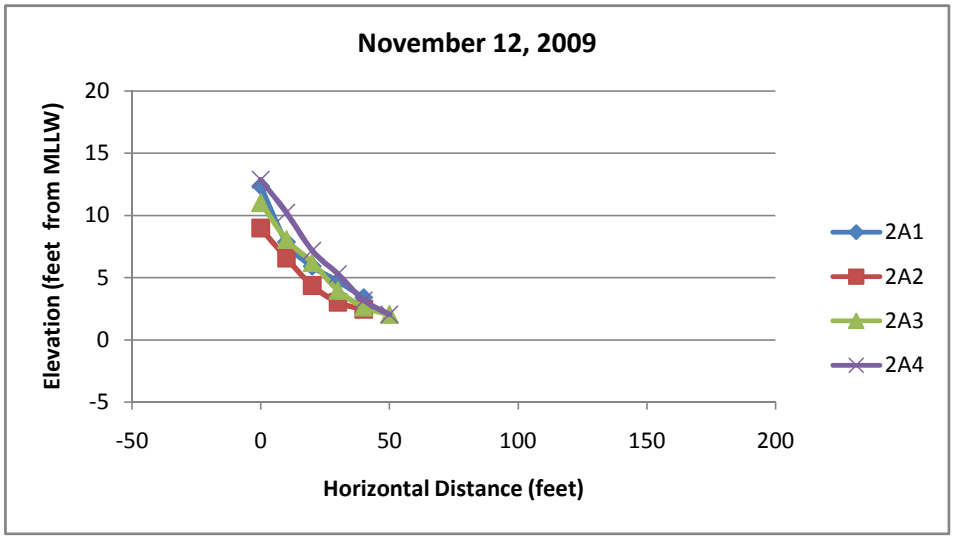

October 14-15, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
N1
N2
N3
N4

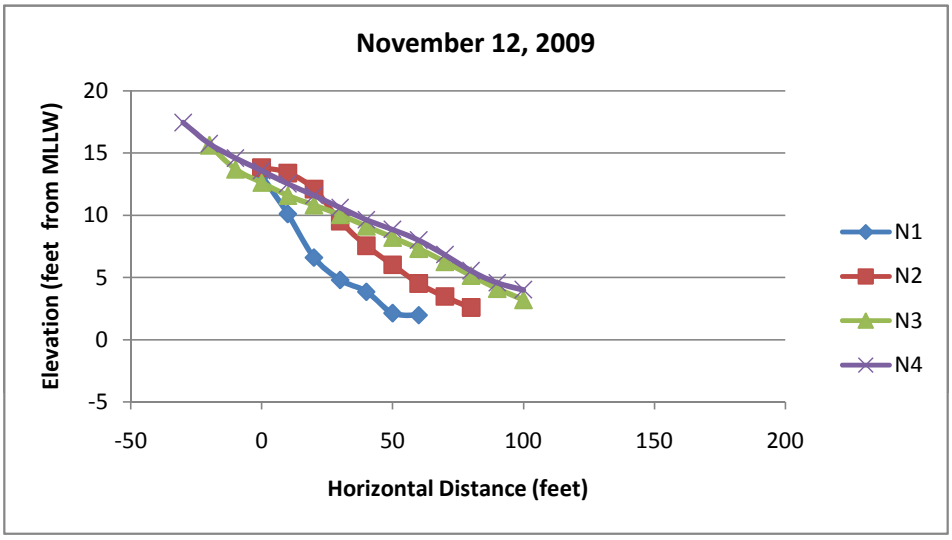

October 14, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
C1
C2
C3
C4

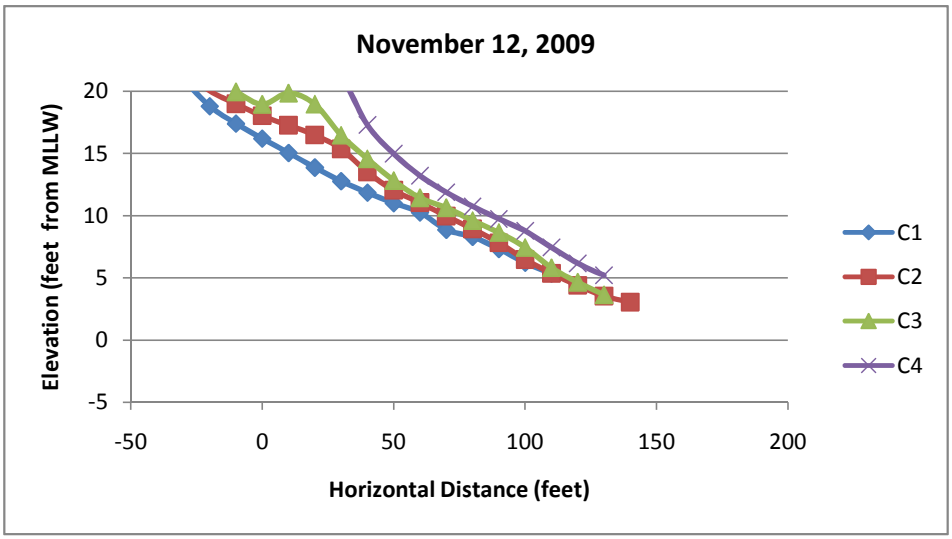

October 29, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
2A-1
2A2
2A3
2A4


October 29, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
N1
N2
N3
N4

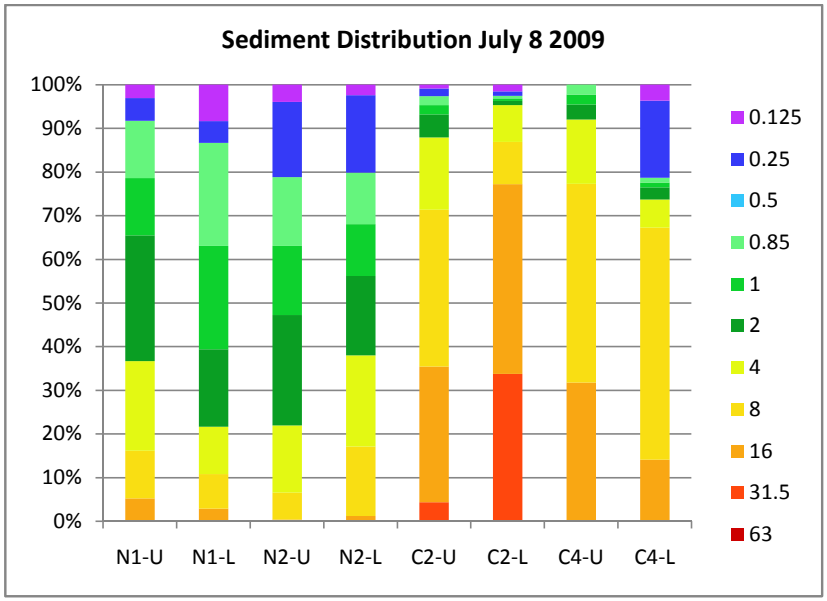

October 29, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
C1
C2
C3
C4

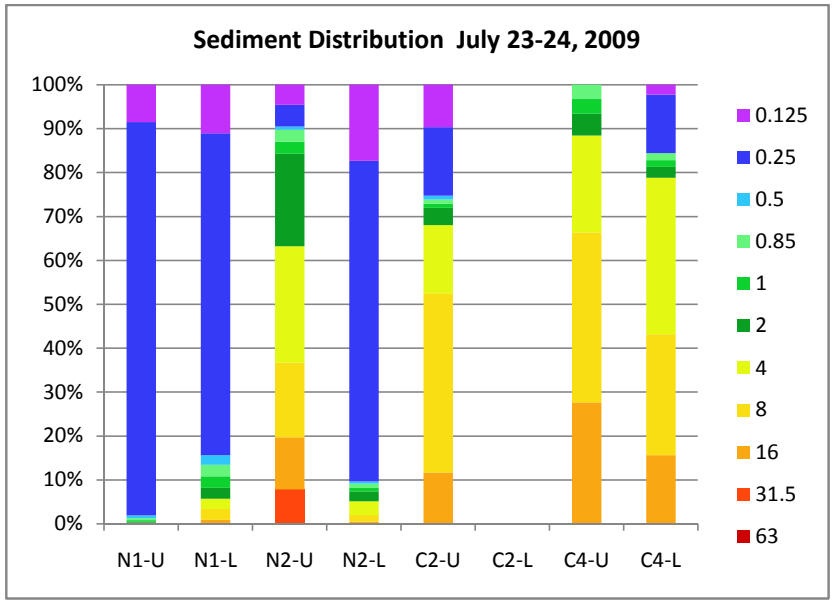

November 12, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
2A1
2A2
2A3
2A4

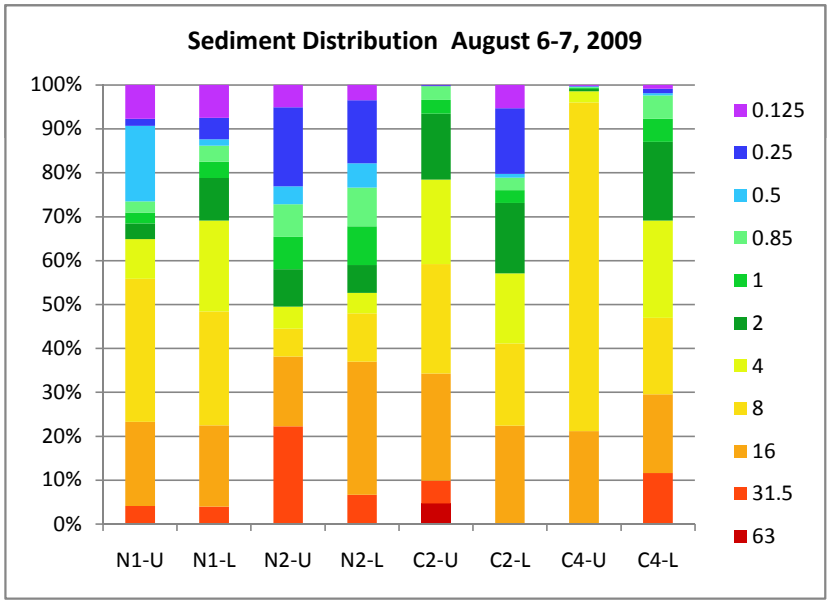

November 12, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
N1
N2
N3
N4

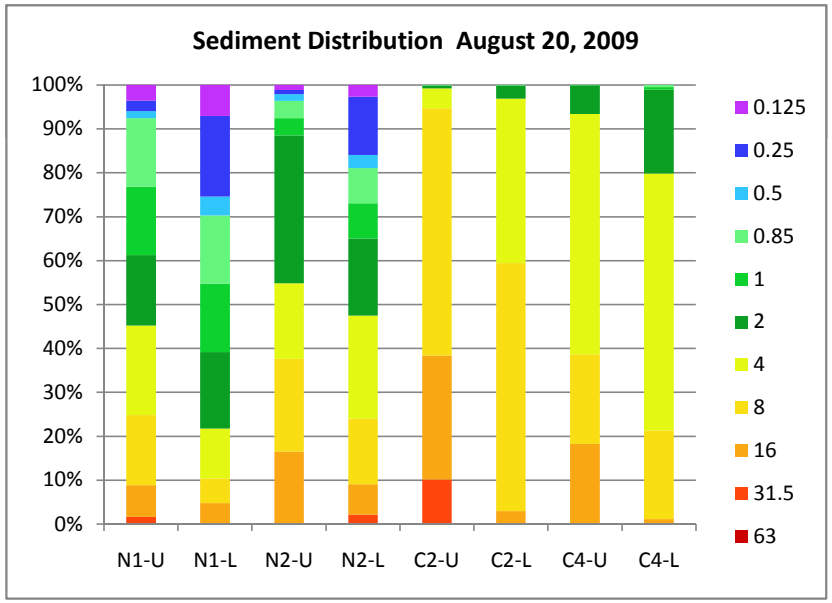

November 12, 2009
Elevation (feet from MLLW)
20
15
10
5
0
-5
-50
0
50
100
150
200
Horizontal Distance (feet)
C1
C2
C3
C4

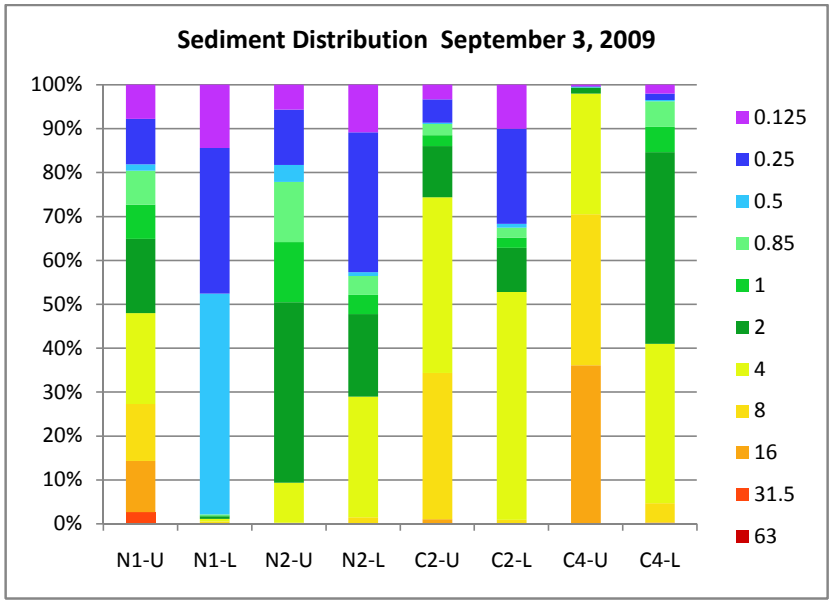
Appendix C. Volumetric Sediment Data

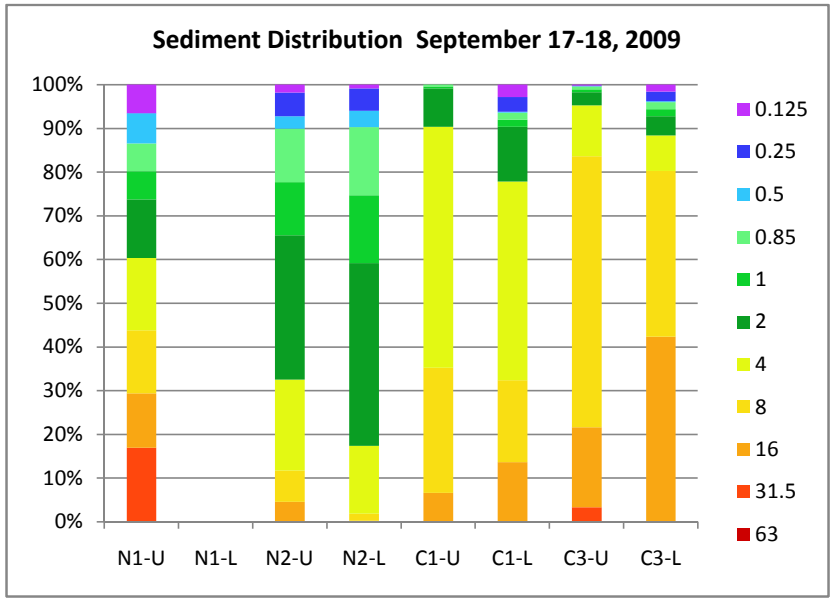

Sediment Distribution July 8 2009
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
N1-U
N1-L
N2-U
N2-L
C2-U
C2-L
C4-U
C4-L
0.125
0.25
0.5
0.85
1
2
4
8
16
31.5
63

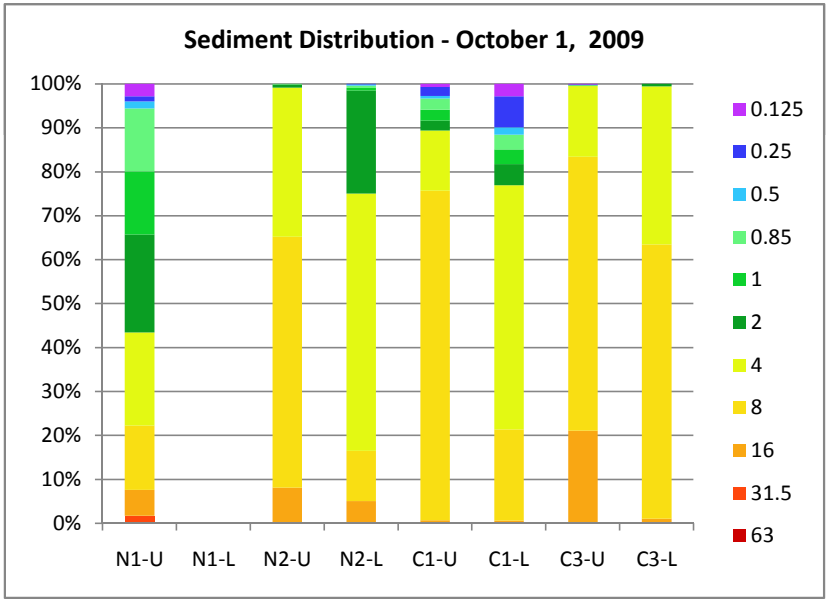

Sediment Distribution July 23-24, 2009
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
N1-U
N1-L
N2-U
N2-L
C2-U
C2-L
C4-U
C4-L
0.125
0.25
0.5
0.85
1
2
4
8
16
31.5
63

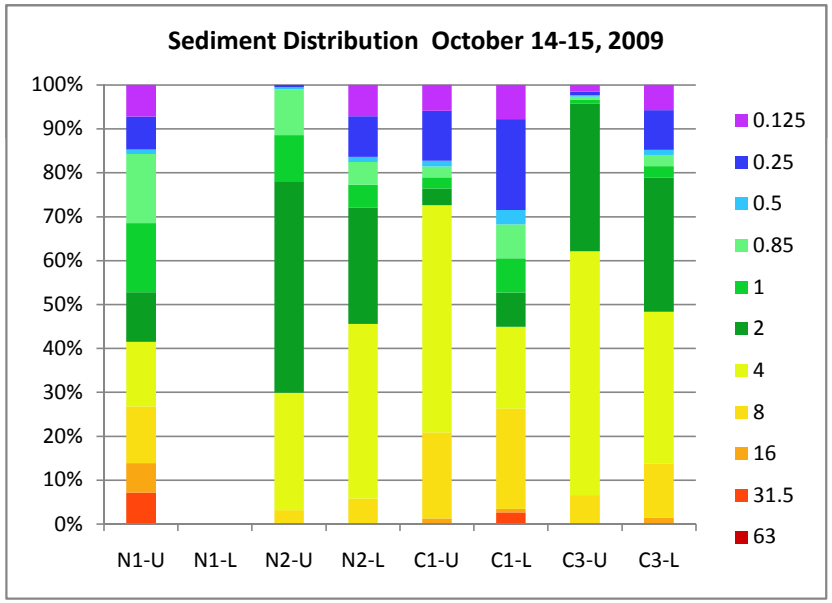

Sediment Distribution August 6-7, 2009
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
N1-U
N1-L
N2-U
N2-L
C2-U
C2-L
C4-U
C4-L
0.125
0.25
0.5
0.85
1
2
4
8
16
31.5
63

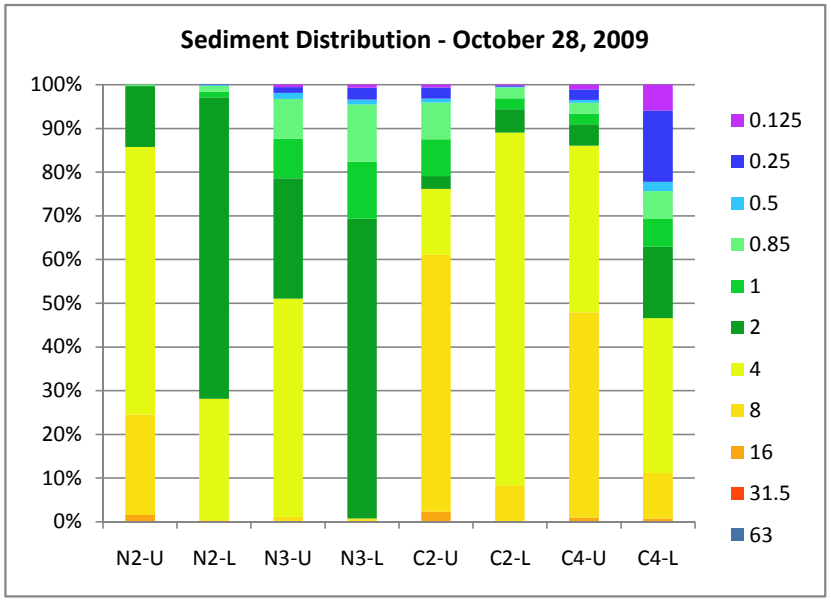

Sediment Distribution August 20, 2009
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
N1-U
N1-L
N2-U
N2-L
C2-U
C2-L
C4-U
C4-L
0.125
0.25
0.5
0.85
1
2
4
8
16
31.5
63

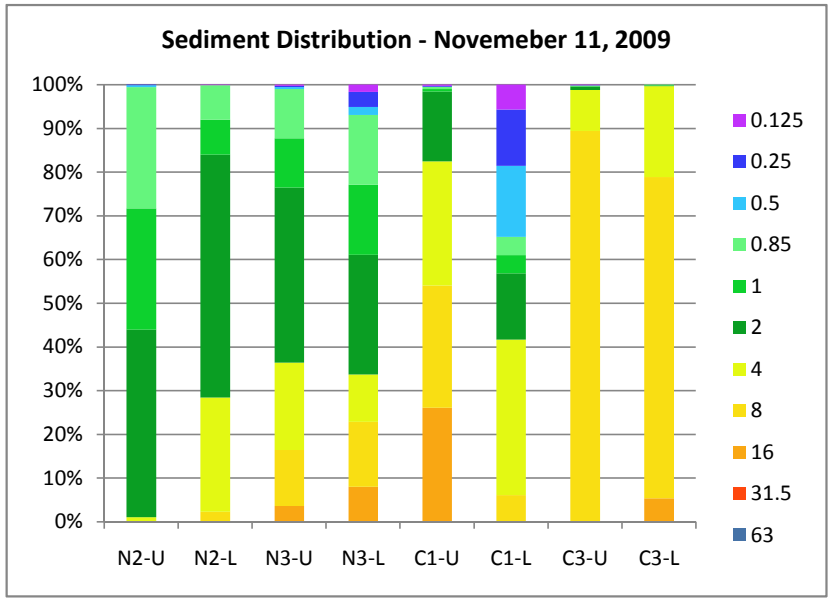

Sediment Distribution September 3, 2009
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
N1-U
N1-L
N2-U
N2-L
C2-U
C2-L
C4-U
C4-L
0.125
0.25
0.5
0.85
1
2
4
8
16
31.5
63


Sediment Distribution September 17-18, 2009
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
N1-U
N1-L
N2-U
N2-L
C1-U
C1-L
C3-U
C3-L
0.125
0.25
0.5
0.85
1
2
4
8
16
31.5
63


Sediment Distribution - October 1, 2009
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
N1-U
N1-L
N2-U
N2-L
C1-U
C1-L
C3-U
C3-L
0.125
0.25
0.5
0.85
1
2
4
8
16
31.5
63


Sediment Distribution October 14-15, 2009
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
N1-U
N1-L
N2-U
N2-L
C1-U
C1-L
C3-U
C3-L
0.125
0.25
0.5
0.85
1
2
4
8
16
31.5
63


Sediment Distribution - October 28, 2009
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
N2-U
N2-L
N3-U
N3-L
C2-U
C2-L
C4-U
C4-L
0.125
0.25
0.5
0.85
1
2
4
8
16
31.5
63


Sediment Distribution - Novemeber 11, 2009
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
N2-U
N2-L
N3-U
N3-L
C1-U
C1-L
C3-U
C3-L
0.125
0.25
0.5
0.85
1
2
4
8
16
31.5
63

Appendix D. Site Photograph Log

File name	Photo	Date	Location	View	Notes
P7080001	1	7/8/2009	N3	S	
P7080002	2	7/8/2009	Hole in Rock BM	E	G. Novak at Hole In Rock Benchmark
070909_0013	13	7/9/2009	C3	S	Note high tide bench & lots of seaweed
070909_0020	20	7/9/2009	Between N3 & N4	NE	Sand in low spots of beach cusps
072309_54	54	7/23/2009	C	W	
072309_55	55	7/23/2009	C	NE	
072309_56	56	7/23/2009	C	NE	
072309_57	57	7/23/2009	N3	E	
072309_58	58	7/23/2009	N3	E	
072309_59	59	7/23/2009	N3	E	
072309_67	67	7/23/2009	N	NE	
072309_68	68	7/23/2009	N	NE	
072309_69	69	7/23/2009	N	NE	
072309_70	70	7/23/2009	N2	S	
072309_71	71	7/23/2009	N4	E	
072309_72	72	7/23/2009	N4	E	
072309_73	73	7/23/2009	N4	E	
072309_74	74	7/23/2009	Between N4 & C1	NE	
072309_75	75	7/23/2009	C1	SW	
072309_76	76	7/23/2009	C1	NW	
072309_77	77	7/23/2009	C1	N	
072309_81	81	7/23/2009	C3	NE	Transect C4 in background
072309_86	86	7/23/2009	C	W	Sand & Gravel
072309_87	87	7/23/2009	C	W	Sand & Gravel
072309_92	92	7/23/2009	Between C2 & C3	N	
072309_93	93	7/23/2009	Between C2 & C3	N	
072309_94	94	7/23/2009	Between C2 & C3	N	
072309_95	95	7/23/2009	C3	SE	
072309_96	96	7/23/2009	C3	SE	
072309_97	97	7/23/2009	C3	SE	
P8060004	4	8/6/2009	C3	N	Pin flags at Sediment sampling locations
P8060005	5	8/6/2009	N4	N	
P8060006	6	8/6/2009	N4	S	
P8060007	7	8/6/2009	N3	N	
P8060008	8	8/6/2009	N3	S	
P8060009	9	8/6/2009	N2	N	
P8060010	10	8/6/2009	N2	S	
P8070029	29	8/7/2009	2A-2	N	From ~0 elevation, south of transect 2A-2
P8070030	30	8/7/2009	2A-2	N	From ~0 elevation, south of transect 2A-2
P8210010	10	8/21/2009	C4	N	
P8210011	11	8/21/2009	C4	S	
P8210012	12	8/21/2009	C3	N	
P8210013	13	8/21/2009	C3	S	
P8210014	14	8/21/2009	C2	N	
P8210015	15	8/21/2009	C2	S	
P8210016	16	8/21/2009	C1	N	
P8210017	17	8/21/2009	C1	S	
P8210018	18	8/21/2009	N4	N	
P8210019	19	8/21/2009	N4	S	
P8210020	20	8/21/2009	N3	N	
P8210021	21	8/21/2009	N3	S	
P8210024	24	8/21/2009	N2	N	
P8210025	25	8/21/2009	N2	S	

File name	Photo	Date	Location	View	Notes
P8210026	26	8/21/2009	N1	N	
P8210027	27	8/21/2009	N1	S	
P8210028	28	8/21/2009	2a4	N	
P8210029	29	8/21/2009	2a4	S	
P8210030	30	8/21/2009	2a3	N	
P8210031	31	8/21/2009	2a3	S	
P8210032	32	8/21/2009	2a2	N	
P8210033	33	8/21/2009	2a2	S	
P8210034	34	8/21/2009	2a1	N	
P8210035	35	8/21/2009	2a1	S	
P9040001	1	9/4/2009	Between C3 & C4	N	
P9040002	2	9/4/2009	Between C2 & C1	N	
P9040003	3	9/4/2009	Between C2 & C1	S	
P9040004	4	9/4/2009	Near C3	W	
P9040005	5	9/4/2009	Near C1	W	
P9040006	6	9/4/2009	Near C2	W	
P9040007	7	9/4/2009	Near N4	SW	
P9040008	8	9/4/2009	Near N4	NW	
P9040009	9	9/4/2009	Near N4	N	
P9040010	10	9/4/2009	Between N2 & N3	N	
P9040011	11	9/4/2009	Between N2 & N3	N	
P9040012	12	9/4/2009	Between N2 & N3	S	
P9040013	13	9/4/2009	Between N2 & N3	S	
P9040014	14	9/4/2009	2a1	S	
P9040015	15	9/4/2009	2a2	N	
P9170020	20	9/17/2009	C1	N	
P9170021	21	9/17/2009	C1	S	
P9170022	22	9/17/2009	N3	N	
P9170023	23	9/17/2009	N3	S	
P9170024	24	9/17/2009	N4	N	
P9170025	25	9/17/2009	N4	S	
P9170080	80	9/17/2009	2a1	S	
P9170081	81	9/17/2009	2a1	N	
P917082	82	9/17/2009	2a2	S	
P9170085	85	9/17/2009	2a4	N	
P9170086	86	9/17/2009	2a4	S	
P9170087	87	9/17/2009	2a3	N	
P9170088	88	9/17/2009	2a3	S	
P9170089	89	9/17/2009	N1	S	
P9170090	90	9/17/2009	N1	N	
P9180099	99	9/18/2009	C1	S	
P9180100	100	9/18/2009	C1	N	
P9180101	101	9/18/2009	C2	S	
P9180102	102	9/18/2009	C2	N	
P9180103	103	9/18/2009	C3	S	
P9180104	104	9/18/2009	C3	N	
P9180105	105	9/18/2009	C4	S	
P9180106	106	9/18/2009	C4	N	
PA010033	17	10/1/2009	C1	S	
PA010034	18	10/1/2009	C1	N	
PA010035	19	10/1/2009	N4	S	
PA010036	20	10/1/2009	N4	N	
PA010037	21	10/1/2009	N3	S	

File name	Photo	Date	Location	View	Notes
PA010038	22	10/1/2009	N3	N	
PA010039	23	10/1/2009	N2	S	
PA010040	24	10/1/2009	N2	N	
PA010041	25	10/1/2009	C2	S	
PA010042	26	10/1/2009	C2	N	
PA010043	27	10/1/2009	C3	S	
PA010044	28	10/1/2009	C3	N	
PA010045	29	10/1/2009	C4	S	
PA010046	30	10/1/2009	C4	N	
PA010049	33	10/1/2009	2a2	S	
PA010050	34	10/1/2009	2a2	N	
PA010051	35	10/1/2009	2a1	S	
PA010052	36	10/1/2009	2a1	N	
PA010053	37	10/1/2009	2a3	S	
PA010054	38	10/1/2009	2a3	N	
PA010055	39	10/1/2009	2a4	S	
PA010056	40	10/1/2009	2a4	N	
PA010057	41	10/1/2009	N1	S	
PA010058	42	10/1/2009	N1	N	
PA010059	49	10/1/2009	N4	S	
PA010060	50	10/1/2009	N4	N	
PA140001	1	10/14/2009	N3	S	
PA140002	2	10/14/2009	N3	N	
PA140003	3	10/14/2009	C1	S	
PA140004	4	10/14/2009	C1	N	
PA140005	5	10/14/2009	N4	S	
PA140006	6	10/14/2009	N4	N	
PA140007	7	10/14/2009	C2	S	
PA140008	8	10/14/2009	C2	N	
PA140009	9	10/14/2009	C2	NE	
PA140010	10	10/14/2009	C2	W	
PA140011	11	10/14/2009	C3	S	
PA140012	12	10/14/2009	C3	N	
PA140013	13	10/14/2009	C4	S	
PA140014	14	10/14/2009	C4	N	
PA150035	35	10/15/2009	N2	S	
PA150036	36	10/15/2009	N2	N	
PA150037	37	10/15/2009	N1	W	
PA150038	38	10/15/2009	N1	S	
PA150039	39	10/15/2009	N1	N	
PA150040	40	10/15/2009	Between 2a3 & 2a4	NW	
PA150041	41	10/15/2009	2a4	S	
PA150042	42	10/15/2009	2a4	N	
PA150043	43	10/15/2009	2a2	S	
PA150044	44	10/15/2009	2a2	N	
PA150045	45	10/15/2009	2a1	W	
PA150046	46	10/15/2009	2a1	S	
PA150047	47	10/15/2009	2a1	N	
PA280057	41	10/28/2009	N1	S	
PA280058	42	10/28/2009	N1	W	
PA280059	43	10/28/2009	N1	N	
PA280063	47	10/28/2009	N4	S	
PA280064	48	10/28/2009	N4	W	

File name	Photo	Date	Location	View	Notes
PA280065	49	10/28/2009	N4	N	
PA280066	50	10/28/2009	C1	S	
PA280067	51	10/28/2009	C1	W	
PA280068	52	10/28/2009	C1	N	
PA280069	53	10/28/2009	C2	S	
PA280070	54	10/28/2009	C2	W	
PA280071	55	10/28/2009	C2	N	
PA280072	56	10/28/2009	C3	S	
PA280073	57	10/28/2009	C3	W	
PA280074	58	10/28/2009	C3	N	
PA280075	59	10/28/2009	C4	S	
PA280076	60	10/28/2009	C4	W	
PA280077	61	10/28/2009	C4	N	
PA290078	62	10/29/2009	2a1	S	
PA290079	63	10/29/2009	2a1	W	
PA290080	64	10/29/2009	2a1	N	
PA290081	65	10/29/2009	2a2	S	
PA290082	66	10/29/2009	2a2	W	
PA290083	67	10/29/2009	2a2	N	
PA290084	68	10/29/2009	2a3	S	
PA290085	69	10/29/2009	2a3	W	
PA290086	70	10/29/2009	2a3	N	
PA290087	71	10/29/2009	2a4	S	
PA290088	72	10/29/2009	2a4	W	
PA290089	73	10/29/2009	2a4	N	
PA290090	74	10/29/2009	N2	S	
PA290091	75	10/29/2009	N2	W	
PA290092	76	10/29/2009	N2	N	
PB110018	2	11/11/2009	C4	S	
PB110019	3	11/11/2009	C4	W	
PB110020	4	11/11/2009	C4	N	
PB110021	5	11/11/2009	Bewteen C3 & C4	N	
PB110022	6	11/11/2009	C4	E	
PB110024	8	11/11/2009	C3	S	
PB110025	9	11/11/2009	C3	W	
PB110026	10	11/11/2009	C3	N	
PB110027	11	11/11/2009	C2	S	
PB110028	12	11/11/2009	C2	W	
PB110029	13	11/11/2009	C2	N	
PB110030	14	11/11/2009	C1	S	
PB110031	15	11/11/2009	C1	W	
PB110032	16	11/11/2009	C1	N	
PB110033	17	11/11/2009	N4	S	
PB110034	18	11/11/2009	N4	W	
PB110035	19	11/11/2009	N4	N	
PB110036	20	11/11/2009	N3	S	
PB110037	21	11/11/2009	N3	W	
PB110038	22	11/11/2009	N3	N	
PB110039	23	11/11/2009	N2	S	
PB110040	24	11/11/2009	N2	W	
PB110041	25	11/11/2009	N2	N	
PB120049	33	11/12/2009	2a1	S	
PB120050	34	11/12/2009	2a1	W	

File name	Photo	Date	Location	View	Notes
PB120051	35	11/12/2009	2a1	N	
PB120052	36	11/12/2009	2a2	S	
PB120053	37	11/12/2009	2a2	W	
PB120054	38	11/12/2009	2a2	N	
PB120055	39	11/12/2009	2a3	S	
PB120056	40	11/12/2009	2a3	W	
PB120057	41	11/12/2009	2a3	N	
PB120058	42	11/12/2009	2a4	S	
PB120059	43	11/12/2009	2a4	W	
PB120060	44	11/12/2009	2a4	N	
PB120064	48	11/12/2009	N2	S	
PB120065	49	11/12/2009	N2	W	
PB120066	50	11/12/2009	N2	N	
PB120067	51	11/12/2009	N3	S	
PB120068	52	11/12/2009	N3	W	
PB120069	53	11/12/2009	N3	N	
PB120070	54	11/12/2009	N3	NW	
PB120071	55	11/12/2009	N4	S	
PB120072	56	11/12/2009	N4	SW	
PB120073	57	11/12/2009	N4	W	
PB120074	58	11/12/2009	N4	N	
PB120075	59	11/12/2009	C1	S	
PB120076	60	11/12/2009	C1	W	
PB120077	61	11/12/2009	C1	N	
PB120078	62	11/12/2009	C2	S	
PB120079	63	11/12/2009	C2	SW	
PB120080	64	11/12/2009	C2	W	
PB120081	65	11/12/2009	C2	N	
PB120082	66	11/12/2009	C3	S	
PB120083	67	11/12/2009	C3	W	
PB120084	68	11/12/2009	C3	N	
PB120085	69	11/12/2009	C4	S	
PB120086	70	11/12/2009	C4	S	
PB120087	71	11/12/2009	C4	W	
PB120088	72	11/12/2009	C4	N	

File name	Photo	Date	Location	View	Notes
P7080009	9	7/8/2009			trace fraction of sediment (<1 ml)
P7080010	10	7/8/2009	South of 2a	SW	
P7080011	11	7/8/2009	South of 2a	SW	
P7080012	12	7/8/2009	South of 2a	W	C. Soncarty fishing
P7080013	13	7/8/2009	South of 2a	SW	C. Soncarty fishing
P7080014	14	7/8/2009	South of 2a	SW	C. Soncarty fishing
P7080015	15	7/8/2009	South of 2a	S	
P7080016	16	7/8/2009	South of 2a	S	
P7090021	21	7/8/2009	Quileute Lab		A. Wones processing sediment
P7090022	22	7/8/2009	Quileute Lab		Organic depris in sedimant sample
P7090023	23	7/8/2009	Quileute Lab		N. Gleason and J. Hagen processing sediment
072309_64	64	7/23/2009			G. Novak & D. Stratten
072309_84	84	7/23/2009			G. Novak on level
072309_85	85	7/23/2009			D. Stratten on rod
P8200003	3	8/20/2009	C4		Dead porpoise
P8200004	4	8/20/2009	C4		Dead porpoise
P8200005	5	8/20/2009	C4		Dead porpoise
P8200006	6	8/20/2009	2a	S	
P8200007	7	8/20/2009	2a	N	
P8210008	8	8/21/2009	N	SW	
P8210009	9	8/21/2009	N	W	
P8210022	22	8/21/2009	between N2 and N3		Dead dogfish
P8210023	23	8/21/2009	between N2 and N3		Dead dogfish
P8210036	36	8/21/2009	S4		
P8210037	37	8/21/2009	S4		
P8210038	38	8/21/2009	S3		
P8210039	39	8/21/2009	S3		
P8210040	40	8/21/2009	S2		
P8210041	41	8/21/2009	S2		
P8210042	42	8/21/2009	S1		
P8210043	43	8/21/2009	S1	S	Panorama, Left to Right
P8210044	44	8/21/2009	S1	SSW	Panorama, Left to Right
P8210045	45	8/21/2009	S1	SW	Panorama, Left to Right
P8210046	46	8/21/2009	South end of spit	S	Panorama, Left to Right from spit to James Island
P8210047	47	8/21/2009	South end of spit	SSW	Panorama, Left to Right from spit to James Island
P8210048	48	8/21/2009	South end of spit	SW	Panorama, Left to Right from spit to James Island
P8210049	49	8/21/2009	South end of spit	WSW	Panorama, Left to Right from spit to James Island
P8210050	50	8/21/2009	South end of spit	W	Panorama, Left to Right from spit to James Island
P8210051	51	8/21/2009	C4		Dead porpoise
P8210052	52	8/21/2009	C4		Dead porpoise
P8210053	53	8/21/2009	C4		Dead porpoise
P9170026	26	9/17/2009	Between N4 and C1		Dead surf scoter
P9170027	27	9/17/2009	Between N4 and C1		Dead surf scoter
P9170028	28	9/17/2009	Zone N		Cathy Robinson fishing for smelt
P9170029	29	9/17/2009	Zone N		Cathy Robinson fishing for smelt
P9170030	30	9/17/2009	Zone N		Cathy Robinson fishing for smelt
P9170031	31	9/17/2009	Zone N		Cathy Robinson fishing for smelt
P9170032	32	9/17/2009	Zone N	N	
P9170033	33	9/17/2009	Zone N	S	
P9170034	34	9/17/2009	Zone N	NW	
P9170035	35	9/17/2009	Zone N		
P9170036	36	9/17/2009	N4		Dead common murre

File name	Photo	Date	Location	View	Notes
P9170037	37	9/17/2009	Zone N		Cathy Robinson fishing for smelt
P9170038	38	9/17/2009	Zone N		Cathy Robinson fishing for smelt
P9170039	39	9/17/2009	Zone N		Cathy Robinson fishing for smelt
P9170040	40	9/17/2009	Zone N		Cathy Robinson fishing for smelt
P9170041	41	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170042	42	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170043	43	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170044	44	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170045	45	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170046	46	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170047	47	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170048	48	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170049	49	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170050	50	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170051	51	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170052	52	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170053	53	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170054	54	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170055	55	9/17/2009	Control - Zone C		Heavy foam in surf from phytoplankton
P9170056	56	9/17/2009	Control - Zone C		Andy Wones fishing for smelt
P9170057	57	9/17/2009	Control - Zone C		Heavy foam in surf from phytoplankton
P9170058	58	9/17/2009	Control - Zone C		Heavy foam in surf from phytoplankton
P9170059	59	9/17/2009	Between C3 and C4		Dead river otter
P9170060	60	9/17/2009	Between C3 and C4		Dead river otter
P9170061	61	9/17/2009	Between C3 and C4		Dead river otter
P9170062	62	9/17/2009	Between C3 and C4		Dead river otter
P9170063	63	9/17/2009	Between C3 and C4		Dead river otter
P9170064	64	9/17/2009	Between C3 and C4		Dead river otter
P9170065	65	9/17/2009	Between C3 and C4		Dead river otter
P9170066	66	9/17/2009	Between C3 and C4		Dead river otter
P9170067	67	9/17/2009	Between C3 and C4		Dead river otter
P9170068	68	9/17/2009			Pelicans
P9170069	69	9/17/2009			Dead petrel
P9170070	70	9/17/2009			Dead petrel
P9170071	71	9/17/2009	C4		Dead porpoise (> 1month on beach)
P9170072	72	9/17/2009	C4		Dead porpoise (> 1month on beach)
P9170073	73	9/17/2009	C4		Dead porpoise (> 1month on beach)
P9170074	74	9/17/2009	C4		Dead porpoise (> 1month on beach)
P9170075	75	9/17/2009	C4		Dead porpoise (> 1month on beach)
P9170076	76	9/17/2009	C4		Dead porpoise (> 1month on beach)
P9170077	77	9/17/2009	South of 2a	S	Beach at sunrise
P9170078	78	9/17/2009	South of 2a	N	Beach at sunrise
P9170079	79	9/17/2009	South of 2a	NW	Beach at sunrise
P9170083	83	9/17/2009	South of 2a	SW	Beach at sunrise
P9170084	84	9/17/2009	South of 2a	SW	Beach at sunrise
P9170093	93	9/17/2009	N3	NE	Recent erosion at high tide line
P9170094	94	9/17/2009	N4		Murre carcass
P9170095	95	9/17/2009	N4		Murre carcass
P9170096	96	9/17/2009	N4		Dead surf scoter
P9170097	97	9/17/2009	N4		Dead surf scoter
P9170098	98	9/17/2009	N4		Dead surf scoter
PA010047	31	10/1/2009	N		Otter Carcass (>2 weeks old)

File name	Photo	Date	Location	View	Notes
PA010061	43	10/1/2009	S1	S	
PA010062	44	10/1/2009	S1	N	
PA010063	45	10/1/2009	between S1 and S2		Tunicates
PA010064	46	10/1/2009	S2	S	
PA010065	47	10/1/2009	S2	N	
PA010066	48	10/1/2009	Between S2 & S3		Dogfish head
PA010067	49	10/1/2009	Between S2 & S3		Dogfish head
PA010068	50	10/1/2009	S3	S	
PA010069	51	10/1/2009	S3	N	
PA010070	52	10/1/2009	S4	S	
PA010071	53	10/1/2009	S4	N	
PA150015	15	10/15/2009	North of Study Area	N	
PA150016	16	10/15/2009	North of Study Area	S	
PA150017	17	10/15/2009	North of Study Area	E	
PA150018	18	10/15/2009	North of Study Area	SE	
PA150019	19	10/15/2009	North of Study Area	S	
PA150020	20	10/15/2009	North of Study Area	N	
PA150021	21	10/15/2009	Just S of Ellen Creek		Freshly dead coho salmon
PA150022	22	10/15/2009	Ellen Creek	N	Mouth of Ellen Creek
PA150023	23	10/15/2009	Ellen Creek	N	Pond above OHW
PA150024	24	10/15/2009	N of Ellen Creek	N	
PA150025	25	10/15/2009	N of Ellen Creek	NW	
PA150026	26	10/15/2009	N of Ellen Creek	W	
PA150027	27	10/15/2009	N of Ellen Creek		*Phyllospadix*
PA150028	28	10/15/2009	N of Ellen Creek		*Phyllospadix*
PA280044	28	10/28/2009	South of 2a		Marbled murrelet on beach
PA280045	29	10/28/2009	South of 2a		Marbled murrelet on beach
PA280046	30	10/28/2009	South of 2a		Marbled murrelet on beach
PA280047	31	10/28/2009	South of 2a		Marbled murrelet on beach
PA280048	32	10/28/2009	S1	S	
PA280049	33	10/28/2009	S1	N	
PA280050	34	10/28/2009	S2	S	
PA280051	35	10/28/2009	S2	W	
PA280052	36	10/28/2009	S2	N	
PA280053	37	10/28/2009	Between S2 & S3		Sandy flotsam at high water line
PA280054	38	10/28/2009	S3	S	
PA280055	39	10/28/2009	S3	N	
PA280056	40	10/28/2009	S3	W	
PA280060	44	10/28/2009	Between N4 and C1		Dead barred owl
PA280061	45	10/28/2009	Between N4 and C1		Dead barred owl
PA280062	46	10/28/2009	Between N4 and C1		Dead barred owl
PB120042	26	11/11/2009	Between C3 & C4	S	
PB120043	27	11/11/2009	Between C3 & C4	N	
PB120044	28	11/11/2009	Between C3 & C4	N	
PB120045	29	11/11/2009	Between C3 & C4	W	
PB120046	30	11/11/2009	Between C3 & C4	N	
PB120047	31	11/11/2009	Between C3 & C4	S	
PB120048	32	11/11/2009	C4		Video clip at C4 - Pan South to North