Preassessment Data Report #1

Assessment of Potential Injuries to Nearshore Vegetation Communities on Unalaska Island following the M/V *Selendang Ayu* Oil Spill

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Cover Photo:
Shoreline vegetation in Kashega Bay, Unalaska Island, Alaska (photo taken by G. Erickson).

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ABSTRACT

Vegetation surveys were conducted to assess potential impacts to nearshore vegetation communities as part of the pre-assessment phase of response to the M/V *Selendang Ayu* oil spill off the coast of Unalaska Island, Alaska. Nine paired plots (oiled and control) were selected in the spill zone for the survey. The control plots had significantly greater total plant abundance than the oiled plots, but when unknown species were removed from the analysis there was no significant difference in total plant abundance between oiled and control plots. These differences may have been due to factors other than oiling or cleaning, however, including the microhabitat differences between plots.

INTRODUCTION

On 8 December 2004 the M/V *Selendang Ayu* ran aground and broke in half in rough seas off Unalaska Island, Alaska (53°38'N, 167° 07'W). An estimated 354,218 gallons of oil (339,538 gallons of bunker oil [IFO 380] and 14,680 gallons of marine diesel and miscellaneous oils) were discharged. In addition to impacting shorelines, oil was also distributed onto wetland, riparian, and terrestrial vegetation on Unalaska Island. Oil deposition and subsequent cleanup efforts may result in injuries to vegetation communities in affected areas. We assessed potential injuries to native nearshore vegetation communities and habitats, and collected baseline measurements for possible future assessments of vegetation recovery.

The vegetative communities not only contribute to the natural biological diversity on Unalaska Island, but are also important as fish and wildlife habitat (*e.g.*, fish nurseries, spawning areas, and bird nesting areas). Several passerines, such as the Sanak song sparrow (*Melospiza melodia*), a regional endemic, utilize the upland vegetation for nesting habitat and substrate and waterfowl nest near and forage in streams (Gibson and Byrd 2006). Loss of vegetation or changes in vegetative species composition may have adverse impacts on these and other avian species. Native vegetation is also important for erosion control and bank stabilization. This area of Unalaska Island is also a refugium for numerous species of rare plants (Dickson 1956, Morgan 1980). The U. S. Fish and Wildlife Service, on behalf of the *Selendang Ayu* Natural Resource Trustees, and Polaris Applied Sciences (representing the Responsible Party) assessed potential injuries to native vegetation on Alaska Maritime National Wildlife Refuge lands using quantitative vegetation measurement and qualitative rankings of oiling and cleanup activity damage.

Little is known about the natural rate of recovery of plant communities on Unalaska Island from injuries related to oil spills and cleanup activities. While some information on relative sensitivity to hydrocarbons and disturbance is available for a few species, these data were often determined for other climatic regions of the plant species range (i.e., North Slope or Prince William Sound). The Aleutian climate may change a plant’s recovery time as compared to other areas.

METHODS

On July 19 to 24, 2005, representatives of the U.S. Fish and Wildlife Service (USFWS) and Polaris Applied Sciences, and a local botanist conducted a nearshore vegetation survey at nine locations in the Makushin and Skan Bay areas on Unalaska Island (Fig. 1).

General study areas were selected from available Shoreline Cleanup Assessment Technique (SCAT) maps (including cleanup locations) and resource maps, but specific plots were selected in the field because available data were too coarse-scaled for this project. Likely survey areas were visited by skiff and nine study locations were selected for the survey (Fig. 1). Lack of uncleaned but oiled areas, and inclement weather during the survey, limited the number of plots surveyed during this study to nine pairs of oiled and control plots (18 total plots), which are described in Appendix 1.

At each of the nine selected locations, two 5 x 10 meter plots were delineated using rebar stakes and nylon line. Plot corners were marked with nylon survey whiskers to enable repeat surveys at the same location. The two plots consisted of an oiled plot, located in areas of oiled nearshore vegetation, and a control plot located in areas of un-oiled vegetation. To the extent possible, given the physical constraints of the sites, the plots were located at similar beach elevations, wind and wave exposures and on similar substrata. This was to avoid floristic differences attributable to storm surges and salt-water incursions occurring in some areas.

However, due to the nearly continuous band of oiling along the seaward edge of the vegetation at the nine locations sampled, it was necessary in most cases to move control plots back away from the vegetation edge on the beaches to avoid oiled areas. This resulted in most of the control plots being located in more landward areas (away from the wave and salt spray zone) and at somewhat higher elevations than the oiled plots. See Table 1 for descriptions of the relative locations of the plots. See also Appendix 1 showing plot photos at all areas except those at segments SKS-18 and CNB-17.

Within the two paired plots at each of the nine locations, plant abundance and species diversity (number of species) were quantified using the point intercept sampling method. Each 5 x 10 meter plot was subdivided using nylon lines into a grid containing 50 interstices per plot. At each of the 50 sample points, a downward-pointing laser provided an intercept point. The laser was mounted on a tripod to minimize movement and therefore experimental error. Each plant stem or leaf that the laser beam intercepted was counted and recorded to species (where possible) with the exception of most grasses, sedges, bryoids (mosses and liverworts) and lichens. Unknown grasses and sedges were tallied using letters for species. Bryoids were recorded as “moss” or “lichen” regardless of species. Litter and bare soil were recorded only when there was no intervening plant cover.

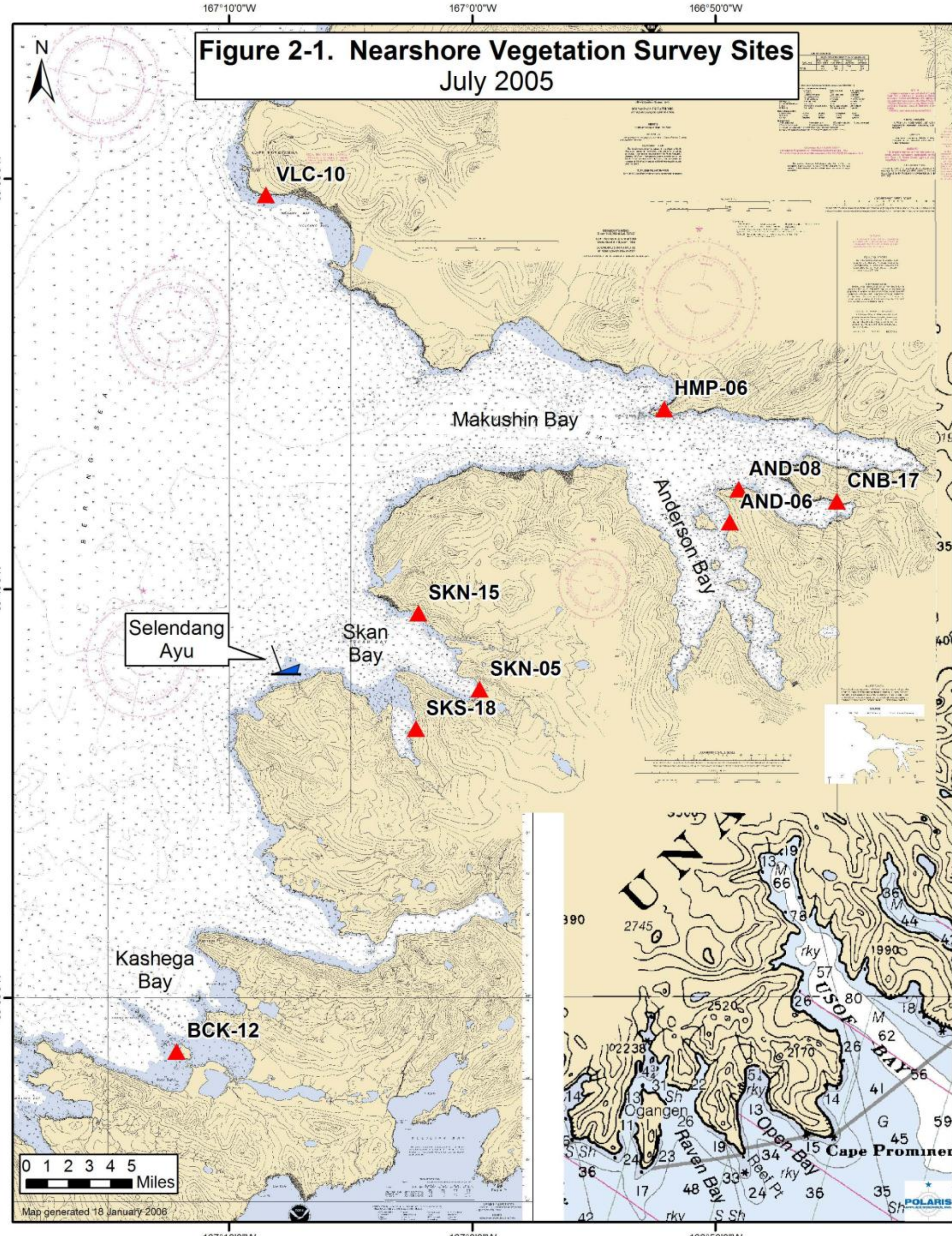

Figure 2-1. Nearshore Vegetation Survey Sites
July 2005
N
VLC-10
HMP-06
Makushin Bay
AND-08
AND-06
CNB-17
Anderson Bay
SKN-15
Selendang Ayu
Skan Bay
SKN-05
SKS-18
Kashega Bay
BCK-12
0 1 2 3 4 5 Miles
Map generated 18 January 2006
167°10'0"W
167°0'0"W
166°50'0"W
53°50'0"N
53°40'0"N
53°30'0"N
Ogangen
Raven Bay
Reef Pt
Open Bay
Cape Prominent
USOF BAY

Table 1. Description of relative vegetative plot locations used to assess injury to plant communities from *Selendang Ayu* oil on Unalaska Island, Alaska during the July 2005 survey.

Survey location	Relative plot locations
VLC-10	Both oiled and control plots up to seaward edge of ryegrass zone; plots are on a moderate slope
SKN-15	Oiled and control plots are adjacent, but seaward edge of control plot is landward of seaward edge of oiled plot; plots are on a moderate slope
SKN-05	The seaward edge of both oiled and control plots are at the same beach elevation; plots are on a relatively flat terrace
SKS-18	Oiled and control plots are adjacent, but seaward edge of control plot is landward of seaward edge of oiled plot; plots are on a moderate slope; back corner of control plot near a freshwater seep
AND-06	Oiled and control plots are adjacent, but seaward edge of control plot is landward of seaward edge of oiled plot by about 1.5 m; plots on a flatter slope
AND-08	Oiled and control plots are adjacent, but seaward edge of control plot is landward of seaward edge of oiled plot; plots are on a moderate slope
CNB-17	Oiled and control plots are adjacent, but seaward edge of control plot is landward of seaward edge of oiled plot; both plots are on a moderate slope; control plot on a steeper slope – appeared to include a more diverse community in the landward half of the plot
BCK-12	Control plot on a small flat terrace just above the oiled plot
HMP-06	Control plot located just above the oiled plot; plots are on a moderate slope

Data from each plot were used to calculate biodiversity and plant abundance by species. Biodiversity was represented by the total number of different species in each plot. Plant abundance was measured by counting the total (top plus multiple) number of laser beam hits on the leaves and stems of various plant species encountered in the 5 x 10 meter plots. Additionally, the degree of oiling was calculated by the number of times the laser encountered oil in a plot (sum of sample point encounters).

Statistical comparisons were made between control and oiled plots of nearshore vegetation at the nine surveyed locations. The hypothesis tested was that oiling would result in significantly less plant abundance and species diversity in the oiled plots versus the control plots.

Since the control and oiled plots were adjacent (paired) at each of the nine locations, a paired two-sample t-test ($p = 0.05$) was utilized to test the one-tailed hypothesis. The data analysis tool: ‘t-Test: Paired Two Sample for Means’ in the MS Excel program was used.

RESULTS AND DISCUSSION

Oiling

The average degree of oiling (total hits on oil/plot) on oiled sites was 25.9 (± 18.6 standard deviation). Oil was encountered only once on control sites. The amount of oiling varied among oiled plots and was heaviest on the ocean edge of the plot. Because vegetation nearest the ocean's edge was oiled, control plots were usually set back at least one meter from the beach/vegetation interface, whereas the seaward edges of the oiled plots were located at the interface.

There were many beach segments where oiled vegetation had been recently removed or was being removed during the survey. Removal of vegetation in these areas occurred after the growing season and vegetation had not recovered during our survey. Because we were not able to locate adequate numbers of these plots associated with adjacent (paired) control areas, we were unable to survey them. It is unknown whether these areas will re-vegetate naturally. However, the most oiled vegetation in the spill area had been removed last winter, before the growing season. In these areas, we observed lush re-growth of predominantly ryegrass (e.g., SKN 14).

Vegetation

The results of the statistical comparisons for selected plant species are summarized in Table 2. There was no significant difference in total plant abundance (total hits/plot) between oiled and control plots ($t_{0.05(1),8} = 1.86$, $p = 0.05$), except when unknown species (almost all grasses) were added to the analysis. When unknown species are included, the control plots had significantly greater total plant abundance than the oiled plots ($t_{0.05(1),8} = 1.86$, $p = 0.01$).

In the field, both the oiled and control plots looked visually very similar, as they were almost all dominated by tall (4-5 feet high), dense stands of Aleutian ryegrass (*Leymus mollis*) (see photo in Appendix 1). This is demonstrated by the fact that there was no significant difference in ryegrass abundance between the oiled and control plots ($t_{0.05(1),8} = 1.86$, $p = 0.43$) (Table 2). However, upon examining all the data after the survey fieldwork, it became apparent that despite the similar abundance of ryegrass, most of the control plots sampled a more diverse community of plants than the oiled plots, as shown by the significantly greater number of species present in the control plots. Notes on habitats of surveyed plants are found in Table 2, with more detailed information in Table 3 from Golodoff (2003).

Taxa present on both oiled and control plots include seacoast angelica (*Angelica lucida),* Siberian spring beauty (*Claytonia sibirica),* western hemlock parsley (*Conioselinum chinense),* sea beach senecio (*Senecio pseudo-arnica*), scurvy weed (*Honckenya peploides*), and petruski (*Ligusticum scoticum).* No significant difference in plant abundance between plots was found for western hemlock parsley ($t_{0.05(1),8} = 1.86$, $p = 0.04$) or petruski ($t_{0.05(1),8} = 1.86$, $p = 0.24$. These plants appear to prefer habitats that include both nearshore and meadow areas (Tables 2 and 3). However, seacoast angelica is found in significantly greater abundance in control plots ($t_{0.05(1),8} = 1.86$, $p = 0.04$). Sea beach senecio and scurvy weed are hardy, salt tolerant coastal plants found on sand or gravel shorelines (Tables 2 and 3; Golodoff, 2003). Supporting this observation, sea beach senecio was found in greater abundance in the oiled plots ($t_{0.05(1),8} = 1.86$, $p = 0.02$), whereas, scurvy weed had no significant difference in abundance between plots ($t_{0.05(1),8} = 1.86$, $p = 0.07$). However, this statistical result appears to be a result of the fact that scurvy weed was found in similar large numbers in both control and oiled plots at SKN-05. The beach at SKN-05 was one of the only sites where both plots were located at the same beach elevation.

Several taxa were present only in the control plots, but not in the oiled plots, including monkshood (*Aconitum maximum),* may flower *(Anemone narcissiflora)*, artemesia (*Artemesia unalaskensis)*, cow parsnip (*Heracleum lanatum),* and salmonberry (*Rubus spectabilis*). In addition, the control sites had more laser hits on unknown grasses than the oiled sites (312 versus 13, respectively; Appendix 2). The preferred habitats of all these plants are meadows and hillsides (Tables 2 and 3; Golodoff, 2003). Cow parsnip is used by sparrows, finches, wrens and eagles for perching and for nesting material (Golodoff, 2003). These species differences largely accounted for significantly greater species diversity (number of species) in the control plots versus oiled plots ($t_{0.05(1),8} = 1.86$, $p = 0.0003$).

Due to the fact that most of the control plots were located in more landward areas at somewhat higher elevations in order to avoid oiled areas, they tended to sample more diverse plant communities found in upland and meadow habitats. This is in contrast to the oiled plots, which sampled less diverse, more salt-tolerant plant communities. The relative composition of the nearshore plant communities in the plots shown in Table 2 reflects a gradient of underlying habitat types, which are preferred by different species. The more stressed environment near the seaward vegetation edge, subject to wave action, salt spray and poor soil retention, supports a less diverse community than the more protected areas just inland and upland from the seaward edge.

Table 2. Statistical differences of plant abundance and diversity in surveyed plots that were oiled and control by the *Selendang Ayu* on Unalaska, Alaska, July 2005.

Plant species / Parameter	**Statistical comparison results**	**Comments***
Aleutian ryegrass (*Leymus mollis*)	No significant difference in abundance between plots [p = 0.43]	This result confirmed our visual impression of the similarity of the plots in the field. Almost all plots were dominated by tall dense stands of ryegrass. [Grasses not included in Golodoff]
Seacoast angelica (*Angelica lucida*)	Control plots significantly greater in abundance than oiled plots [p = 0.04]	No habitat preferences given in Golodoff (2003)
Western hemlock parsley (*Conioselinum chinense*)	No significant difference in abundance between plots [p = 0.13]	Preferred habitat includes both coastal and meadow habitats
Fireweed (*Epilobium angustifolium*)	Control plots significantly greater in abundance than oiled plots [p = 0.02]	No habitat preferences given in Golodoff (2003), but other sources indicate fireweed is found in more meadow habitats
Cow parsnip; Putchki (*Heracleum lanatum*)	Control plots significantly greater in abundance than oiled plots [p = 0.005]; No cow parsnip plants found in oiled plots	Prefers grassy hillsides and meadows Used by sparrows, finches, wrens, eagles for perching and nesting material
Scurvy weed (*Honckenya peploides*)	No significant difference in abundance between plots [p = 0.07] [at locations other than SKN-05, scurvy weed is almost always found only in the oiled plots]	Scurvy weed is found on sandy and gravel beaches and in dune areas Statistical result was strongly influenced by similar large numbers of scurvy weed plants in both oiled and control plots at SKN-05 – one of the only areas with both plots at the same elevation

Table 2 (cont).

Petruski (*Ligusticum scoticum*)	No significant difference in abundance between plots [p = 0.24]	Favors dry, rocky, sandy areas; near seashores and cliffs; seems to be salt tolerant
Sea beach senecio (*Senecio pseudo-arnica*)	Oiled plots significantly greater in abundance than control plots [p = 0.02]	Hardy coastal plant; salt tolerant on sand or gravel shores
Unknown grasses	Control plots significantly greater in abundance than oiled plots [p = 0.02]	Unknown species of grass found almost all found in control plots; consistent with a more meadow habitat
All species plus unknowns	Control plots significantly greater in abundance than oiled plots [p = 0.001]	Almost all unknown species were grasses found in control plots; consistent with a more meadow habitat
All species without unknowns	No significant difference in abundance between plots [p = 0.05]	
Species diversity (No. of species) plus unknowns	Control plots significantly greater in diversity than oiled plots [p = 0.000]	Control plots sampled more diverse meadow type habitats; most unknowns are grasses
Species diversity (No. of species) without unknowns	Control plots significantly greater in diversity than oiled plots [p = 0.000]	Control plots sampled more diverse meadow type habitats

- Habitat notes taken from information presented in Golodoff (2003).

Table 3. Habitats of plants documented during the Unalaska vegetation survey July 2005, from Golodoff (2003).

Common name	Scientific name	Habitat*
Kamchatka lily	*Fritillaria camschatcensis*	"Kamchatka lilies bloom in the meadows and hillsides in early to mid summer."
Bog orchid	*Platanthera convallariaefoia*	"Bog orchids bloom in the marshy meadows in early to mid summer."
Bistort	*Polygonum viviparum*	"Bistort is a common and early bloomer in the meadows and hillsides."
Siberian spring beauty	*Claytonia sibirica*	"Spring beauty favors damp ground and grows abundantly in low patches in open areas as well as shady places, such as under salmonberry (*Rubus spectabilis*) bushes."
Beach greens, Scurvy weed	*Honckenya peploides*	"Beach greens grow abundantly on sandy and gravel beaches and over sand dunes, often in loose extensive mats. The plant withstands salt spray, and occasionally gets washed over and covered in sand during storms and high tides."
Monkshood	*Aconitum maximum*	"Monkshood is common in grassy meadows and hillsides, among ferns, putchki (*Heracleum lanatum*) and fireweed (*Epilobium* spp.)."
May flower	*Anemone narcissiflora*	"…they begin to bloom in mid-May on south-facing hillsides."
Buttercup	*Ranunculus bongardii*	"Both buttercups share the same habitat of fields and meadows."
Salmonberry	*Rubus spectabilis*	"Salmonberries grow in abundance in Unalaska's hills and ravines."
Sitka great burnet	*Sanguisorba stipulata*	"Burnet favors meadows, marshes, and wet hillsides and often grows among yarrow (*Achillea borealis*), fleabane (*Erigeron peregrinus*), and pyrola (*Pyrola* spp.)."
Lupine	*Lupinus nootkatensis*	"Lupines often grow in stands on dry slopes, in gravel and sandy places, and along cliffs and coastal areas."
Beach pea	*Lathyrus maritimus*	"The blossoms of the beach pea bejewel the sandy shores and dunes where it thrives."
Seacoast angelica	*Angelica lucida*	[habitat preference not given]

Table 3 (cont).

Common name	Scientific name	Habitat preference
Cranesbill	*Geranium erianthum*	"Cranesbill blooms midsummer and is very abundant on hillsides and meadows, often growing among fleabane (*Erigeron peregrinus*), ferns and grasses."
Fireweed	*Epilobium angustifolium*	[habitat preference not given]
Willow-herbs	*Epilobium* spp.	Habitat for *E. glandulosum*: "This willow herb is common in both grassy fields and damp meadows, and often grows among fireweed (*E. angustifolium*), putchki (*Heracleum lanatum*), and artemisia (*Artemisia* spp.)."
Petruski	*Ligusticum scoticum*	"Petruski favors dry rocky and sandy areas. It often grows near seashores and cliffs and seems to be salt tolerant."
Western hemlock parsley	*Conioselinum chinense*	"Hemlock parsley often grows in tall grass, and favors meadows, sandy shores, and banks."
Putchki	*Heracleum lanatum*	"Putchki favors grassy hillsides and meadows, often growing near beaches and old village sites, among monkshood (*Aconitum* spp.), fireweed (*Epilobium* spp.), and buttercups (*Ranunculus* spp.)."
Arctic starflower	*Trientalis europaea*	"Starflower grows among the moss and crowberry heath of hillsides and meadows where the ground cover is low."
Bedstraw	*Galium aparine* *G. triflorum*	"Bedstraw is a spindly, spreading beach plant that is springy underfoot, and burry to the touch." "It favors damp inland places, whereas *G. aparine* is strictly a coastal plant."
Fleabane	*Erigeron peregrinus*	"Fleabane is abundant in Unalaska's meadows and hillsides."
Yarrow	*Achillea borealis*	"The plant grows in dry areas, in sandy or rocky soil, from sea level to upper elevations."
Artemisia	*Artemisia unalaskensis*	"A hardy plant, often shoulder high, this artemisia grows in stands from sea level upwards."
Seabeach senecio	*Senecio pseudo-arnica*	"Seabeach senecio is a hardy coastal plant. Salt tolerant, it thrives along sand or gravel shores among the grasses and beach greens (*Honckenya peploides*)."

* Grasses are not included in Golodoff (2003).

CONCLUSIONS

We found significant differences in species diversity and plant abundance between oiled (oiled and cleaned) and control plots in this single survey. These differences may have been due to factors other than oiling or cleaning, however, including the microhabitat differences between plots discussed in the results. These microhabitat factors, rather than any effects of the oiling, appear to be the most likely explanation of the statistical results presented above. The *Selendang Ayu* Natural Resource Trustees may consider repeating these surveys in subsequent growing seasons to better document the extent of damage and recovery of plant communities on Unalaska Island from the *Selendang Ayu* oil spill.

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Appendix 1. Photos and description of vegetation plots surveyed on Unalaska Island, Alaska in the area of the *Selendang Ayu* oil spill, July 2005.

SKS 18 – N53.61010 W167.03925
This site was a very small pocket cove with short, steep boulder beach. Vegetation edge was just beyond boulder beach and had northwest exposure. Vegetation was a tall rye grass community with dominant vegetation of *Leymus mollis*, *Angelica lucida*, *Ligusticum scoticum*, and *Claytonia sibirica*. Beach was heavily oiled and partially cleaned in places.

Photo credit: J. Stout (USFWS)

BCK 12 – N53.47895 W167.20015
Beach on Buck Island with north-northwest exposure. Sites were above small cobble and shell beach. Heavily oiled shoreline, with oil extending approximately 5 meters into ryegrass community. Dominant vegetation consisted of *Leymus mollis, Senecio pseudo-arnica, Heracleum lanatum, Honckenya peploides,* and *Conioselinum chinense*. Cows had disturbed much of the area behind the plots.


Photo credit: J. Stout (USFWS)

Oiled plot P1 (left) seaward of control plot P2 (right) at BCK-12 (Photo 179).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

Setting up oiled plot P1 at BCK-12 (Photo 176).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

Control plot P2 at BCK-12 (Photo 177).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

CNB 17 – N53.70269 W166.74806
Beach with south-southwest exposure near the head of Cannery Bay. Base of slope along rocky shoreline with a vegetation community comprised of a mix of coastal meadow species and a beach line rye grass community. Sedges and legumes also present.

Photo credit: J. Stout (USFWS)

AND 8 – N53.70807 W166.81514

Boulder beach at base of steep rock scree slope inside small cove. Northern exposure with rocks underlying entire plots. Vegetation community dominant vegetation was *Leymus mollis, Senecio pseudo-arnica, Honckenya peploides,* and *Conioselinum chinense.* Oiled plot oiled at tide-line into fringe.

Photo credit: J. Stout (USFWS)

View into control plot P2 at AND-08 (Photo 119; No photo of oiled plot).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

SKN 15 – N53.65728 W167.03490

Beach is a narrow cobble-boulder beach with south-southwest exposure. Oiled plot was partially cleaned and was below slope on beach. Dominant vegetation consisted of *Leymus mollis, Epilobium angustifolium, Rubus spectabilis, Honckenya peploides,* and *Conioselinum chinense.*

Photo credit: J. Stout (USFWS)

Oiled vegetation at SKN-15; edge of oiled plot P1 (Photo 58).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

Left seaward corner of control plot P2 at SKN-15 (Photo 55).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

HMP 06 – N53.74068 W166.86748

Boulder beach between two bluffs. Sloping berm with northwest exposure. Vegetation primarily *Leymus mollis*, *Senecio pseudo-arnica*, and *Conioselinum chinense*. Shoreline heavily oiled.

Photo credit: J. Stout (USFWS)

Surveying oiled plot P2 at HMP-06 (Photo 310).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

Control plot P2 at HMP-06 (Photo 309).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

AND06 – N53.69450 W166.82150

Protected arm at Makushin Bay. Cobble, boulder beach with western exposure. Vegetated below rolling hills with *Leymus mollis, Senecio pseudo-arnica, Chamerion angustifolim, Geranium erianthum, Galium aparine,* and *Conioselinum chinense*.

Photo credit: J. Stout (USFWS)

View into oiled plot P1 at AND-06 (Photo 90).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

Left seaward corner of control plot P2 at AND-06 (Photo 91).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

VLC 10 – N53.82705 W167.14128

Plot located on north end of boulder beach at base of steep densely vegetated slope. Southeast facing just above sea level and just within reach of high and storm tides. Dominant vegetation includes *Leymus mollis, Senecio pseudo-arnica, Lupinus nootkatensis*, *Conioselinum chinense*, *Honckenya peploides*, and *Angelica lucida*.

Photo credit: J. Stout (USFWS)

Oiled plot P1 at VLC-10 (Photo 27).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

Left seaward corner of control plot P2 at VLC-10 (Photo 33).
Photo credit: G.M. Erickson (Polaris Applied Sciences)

SKN 05 – N53.62561 W166.99181

Plot located at northern head of Skan Bay on top of steep, narrow, small gravel beach. Beach is heavily oiled and surrounded by steep cliffs. Typical ryegrass, *Senecio*, *Honckenya* community. Northwest exposure.

Photo credit: J. Stout (USFWS)

Left seaward corner of control plot P2 at SKN-05 (Photo 76; No photo of oiled plot). Photo credit: G.M. Erickson (Polaris Applied Sciences)

Appendix 2. Site vegetation data. Shown are the number of hits on oil or plant species of a stationary laser beam over 100 points/plot.

Segment	Type	Hit Type	Oil	*Leymus mollis*	*Aconitum maximum*	*Achillea borealis*	*Anemone narcissiflora*
SKS18 P1	Oiled	Top Hits		37			
SKS18 P1	Oiled	Multiple Hits	32	76			
BCK12 P1	Oiled	Top Hits		47			
BCK12 P1	Oiled	Multiple Hits	47	115			
CNB17 P1	Oiled	Top Hits		10			
CNB17 P1	Oiled	Multiple Hits	12	20		1	
AND8 P1	Oiled	Top Hits		36			
AND8 P1	Oiled	Multiple Hits	8	66			
SKN15 P1	Oiled	Top Hits		30			
SKN15 P1	Oiled	Multiple Hits	38	35			
HMP6 P1	Oiled	Top Hits		42			
HMP6 P1	Oiled	Multiple Hits	42	113			
AND06 P1	Oiled	Top Hits		30			
AND06 P1	Oiled	Multiple Hits	4	77			
VLC10 P1	Oiled	Top Hits		28			
VLC10 P1	Oiled	Multiple Hits	4	43			
SKN05 P1	Oiled	Top Hits		24			
SKN05 P1	Oiled	Multiple Hits	46	66			
SKS18 P2	Control	Top Hits		10			
SKS18 P2	Control	Multiple Hits		9			
BCK12 P2	Control	Top Hits		27			
BCK12 P2	Control	Multiple Hits		89			
CNB17 P2	Control	Top Hits		6			1
CNB17 P2	Control	Multiple Hits		15		7	5
AND8 P2	Control	Top Hits		30			
AND8 P2	Control	Multiple Hits		89	1		
SKN15 P2	Control	Top Hits		30			
SKN15 P2	Control	Multiple Hits	1	63			
HMP6 P2	Control	Top Hits		28			
HMP6 P2	Control	Multiple Hits		91	4	7	
AND06 P2	Control	Top Hits		22			
AND06 P2	Control	Multiple Hits		94			
VLC10 P2	Control	Top Hits		38	0		
VLC10 P2	Control	Multiple Hits		137	1		
SKN05 P2	Control	Top Hits		35			
SKN05 P2	Control	Multiple Hits		53			

Appendix 2 (cont.)

Segment	Type	Hit Type	*Angelica lucida*	*Artemesia unalaskensis*	*Carex spp.*	*Claytonia sibirica*	*Conioselinum chinense*
SKS18 P1	Oiled	Top Hits	1				1
SKS18 P1	Oiled	Multiple Hits	5				1
BCK12 P1	Oiled	Top Hits	1				
BCK12 P1	Oiled	Multiple Hits	3				
CNB17 P1	Oiled	Top Hits	1		10		
CNB17 P1	Oiled	Multiple Hits	1		19		2
AND8 P1	Oiled	Top Hits	4				
AND8 P1	Oiled	Multiple Hits	15				1
SKN15 P1	Oiled	Top Hits	5			3	
SKN15 P1	Oiled	Multiple Hits	3			2	
HMP6 P1	Oiled	Top Hits					1
HMP6 P1	Oiled	Multiple Hits					3
AND06 P1	Oiled	Top Hits					5
AND06 P1	Oiled	Multiple Hits	2			2	9
VLC10 P1	Oiled	Top Hits					1
VLC10 P1	Oiled	Multiple Hits	1			3	
SKN05 P1	Oiled	Top Hits					
SKN05 P1	Oiled	Multiple Hits					
SKS18 P2	Control	Top Hits	4				
SKS18 P2	Control	Multiple Hits	1			6	6
BCK12 P2	Control	Top Hits	1				13
BCK12 P2	Control	Multiple Hits	3				23
CNB17 P2	Control	Top Hits	4				2
CNB17 P2	Control	Multiple Hits	7			1	2
AND8 P2	Control	Top Hits	3				
AND8 P2	Control	Multiple Hits	5			1	
SKN15 P2	Control	Top Hits	8	2			
SKN15 P2	Control	Multiple Hits	9	5		6	
HMP6 P2	Control	Top Hits	2				
HMP6 P2	Control	Multiple Hits	9			1	4
AND06 P2	Control	Top Hits	2				3
AND06 P2	Control	Multiple Hits	8	3		2	6
VLC10 P2	Control	Top Hits	4				2
VLC10 P2	Control	Multiple Hits	21	1		21	7

SKN05 P2	Control	Top Hits	2
SKN05 P2	Control	Multiple Hits	6

Appendix 2 (cont.)

Segment	Type	Hit Type	*Epilobium angustifolium*	*Epilobium spp*	*Equisetum arvense*	*Erigeron peregrinus*	*Fritillaria camschatcensis*
SKS18 P1	Oiled	Top Hits					
SKS18 P1	Oiled	Multiple Hits					
BCK12 P1	Oiled	Top Hits					
BCK12 P1	Oiled	Multiple Hits					
CNB17 P1	Oiled	Top Hits	3				
CNB17 P1	Oiled	Multiple Hits	8			1	
AND8 P1	Oiled	Top Hits	1				
AND8 P1	Oiled	Multiple Hits	8				
SKN15 P1	Oiled	Top Hits					
SKN15 P1	Oiled	Multiple Hits					
HMP6 P1	Oiled	Top Hits					
HMP6 P1	Oiled	Multiple Hits					
AND06 P1	Oiled	Top Hits		7			
AND06 P1	Oiled	Multiple Hits		23	2		
VLC10 P1	Oiled	Top Hits					
VLC10 P1	Oiled	Multiple Hits					
SKN05 P1	Oiled	Top Hits					
SKN05 P1	Oiled	Multiple Hits					
SKS18 P2	Control	Top Hits			1		
SKS18 P2	Control	Multiple Hits	2		11		
BCK12 P2	Control	Top Hits	1	1			
BCK12 P2	Control	Multiple Hits	2	8	3		
CNB17 P2	Control	Top Hits	2		1		1
CNB17 P2	Control	Multiple Hits	13		14	7	
AND8 P2	Control	Top Hits	4				
AND8 P2	Control	Multiple Hits	10	2			
SKN15 P2	Control	Top Hits	3				
SKN15 P2	Control	Multiple Hits	3				
HMP6 P2	Control	Top Hits	6				
HMP6 P2	Control	Multiple Hits	13		28		
AND06 P2	Control	Top Hits	6		1		
AND06 P2	Control	Multiple Hits	14	1	41		
VLC10 P2	Control	Top Hits					

VLC10 P2	Control	Multiple Hits
SKN05 P2	Control	Top Hits
SKN05 P2	Control	Multiple Hits

Appendix 2 (cont.)

Segment	Type	Hit Type	*Galium aparine*	*Geranium erianthum*	*Heracleum lanatum*	*Honckenya peploides*	*Lathyrus maritimus*
SKS18 P1	Oiled	Top Hits					3
SKS18 P1	Oiled	Multiple Hits					6
BCK12 P1	Oiled	Top Hits				1	
BCK12 P1	Oiled	Multiple Hits	1			18	
CNB17 P1	Oiled	Top Hits		1			4
CNB17 P1	Oiled	Multiple Hits	2				6
AND8 P1	Oiled	Top Hits		2		2	
AND8 P1	Oiled	Multiple Hits		6		5	
SKN15 P1	Oiled	Top Hits					
SKN15 P1	Oiled	Multiple Hits				1	
HMP6 P1	Oiled	Top Hits	1				
HMP6 P1	Oiled	Multiple Hits	7			1	
AND06 P1	Oiled	Top Hits	3				
AND06 P1	Oiled	Multiple Hits	39			1	
VLC10 P1	Oiled	Top Hits				2	
VLC10 P1	Oiled	Multiple Hits				15	
SKN05 P1	Oiled	Top Hits				11	1
SKN05 P1	Oiled	Multiple Hits	4			63	1
SKS18 P2	Control	Top Hits			4	1	
SKS18 P2	Control	Multiple Hits			7	1	
BCK12 P2	Control	Top Hits	1		5		
BCK12 P2	Control	Multiple Hits	5		9		
CNB17 P2	Control	Top Hits		1	2		2
CNB17 P2	Control	Multiple Hits		14	4		3
AND8 P2	Control	Top Hits					
AND8 P2	Control	Multiple Hits	5	9	3		
SKN15 P2	Control	Top Hits					
SKN15 P2	Control	Multiple Hits	1	4			
HMP6 P2	Control	Top Hits			8		
HMP6 P2	Control	Multiple Hits	6	5	17		
AND06 P2	Control	Top Hits	1		4		
AND06 P2	Control	Multiple Hits	27	1	5		

VLC10 P2	Control	Top Hits			2		
VLC10 P2	Control	Multiple Hits	3		9		
SKN05 P2	Control	Top Hits	2			10	1
SKN05 P2	Control	Multiple Hits	14			67	13

Appendix 2 (cont.)

Segment	Type	Hit Type	*Ligusticum scoticum*	*Lupinus nootkatensis*	*Platanthera convallariaefolia*	*Polygonum viviparum*	*Ranunculus bongardii*
SKS18 P1	Oiled	Top Hits	1				
SKS18 P1	Oiled	Multiple Hits	7				
BCK12 P1	Oiled	Top Hits					
BCK12 P1	Oiled	Multiple Hits					
CNB17 P1	Oiled	Top Hits		4			
CNB17 P1	Oiled	Multiple Hits	2	4			
AND8 P1	Oiled	Top Hits					
AND8 P1	Oiled	Multiple Hits					
SKN15 P1	Oiled	Top Hits					
SKN15 P1	Oiled	Multiple Hits	5				
HMP6 P1	Oiled	Top Hits	2				
HMP6 P1	Oiled	Multiple Hits	3				
AND06 P1	Oiled	Top Hits					
AND06 P1	Oiled	Multiple Hits					
VLC10 P1	Oiled	Top Hits	3	2			
VLC10 P1	Oiled	Multiple Hits	8	5			
SKN05 P1	Oiled	Top Hits					
SKN05 P1	Oiled	Multiple Hits					
SKS18 P2	Control	Top Hits		1		1	
SKS18 P2	Control	Multiple Hits		6			
BCK12 P2	Control	Top Hits					
BCK12 P2	Control	Multiple Hits					
CNB17 P2	Control	Top Hits	1	2	1	1	
CNB17 P2	Control	Multiple Hits	3	3	2	1	
AND8 P2	Control	Top Hits					
AND8 P2	Control	Multiple Hits					
SKN15 P2	Control	Top Hits	1				
SKN15 P2	Control	Multiple Hits	6				1
HMP6 P2	Control	Top Hits					
HMP6 P2	Control	Multiple Hits					
AND06 P2	Control	Top Hits					

AND06 P2	Control	Multiple Hits	2
VLC10 P2	Control	Top Hits	
VLC10 P2	Control	Multiple Hits	
SKN05 P2	Control	Top Hits	
SKN05 P2	Control	Multiple Hits	6

Appendix 2 (cont.)

Segment	Type	Hit Type	*Rubus spectabilis*	*Sanguisorba stipulata*	*Senecio pseudo-arnica*	*Trientalis europaea*	*Viola langsdorffii*
SKS18 P1	Oiled	Top Hits			3		
SKS18 P1	Oiled	Multiple Hits			7		
BCK12 P1	Oiled	Top Hits					
BCK12 P1	Oiled	Multiple Hits			20		
CNB17 P1	Oiled	Top Hits					
CNB17 P1	Oiled	Multiple Hits		2		1	
AND8 P1	Oiled	Top Hits			2		
AND8 P1	Oiled	Multiple Hits			7		
SKN15 P1	Oiled	Top Hits					
SKN15 P1	Oiled	Multiple Hits					
HMP6 P1	Oiled	Top Hits			1		
HMP6 P1	Oiled	Multiple Hits			1		
AND06 P1	Oiled	Top Hits			4		
AND06 P1	Oiled	Multiple Hits			15		
VLC10 P1	Oiled	Top Hits			4		
VLC10 P1	Oiled	Multiple Hits			10		
SKN05 P1	Oiled	Top Hits			11		
SKN05 P1	Oiled	Multiple Hits			20		
SKS18 P2	Control	Top Hits				2	
SKS18 P2	Control	Multiple Hits					
BCK12 P2	Control	Top Hits					
BCK12 P2	Control	Multiple Hits					
CNB17 P2	Control	Top Hits		2			
CNB17 P2	Control	Multiple Hits		4			1
AND8 P2	Control	Top Hits	4		0		
AND8 P2	Control	Multiple Hits	34		1		
SKN15 P2	Control	Top Hits	4				
SKN15 P2	Control	Multiple Hits	12				
HMP6 P2	Control	Top Hits			0		
HMP6 P2	Control	Multiple Hits			3		

AND06 P2	Control	Top Hits		7
AND06 P2	Control	Multiple Hits	1	10
VLC10 P2	Control	Top Hits		4
VLC10 P2	Control	Multiple Hits		6
SKN05 P2	Control	Top Hits		0
SKN05 P2	Control	Multiple Hits		9

Appendix 2 (cont.)

Segment	Type	Hit Type	Unknown Grass	Unknown Trailing Plant	Fern	Soil	Litter	Cobble/Rock	Moss
SKS18 P1	Oiled	Top Hits				1			
SKS18 P1	Oiled	Multiple Hits							1
BCK12 P1	Oiled	Top Hits							
BCK12 P1	Oiled	Multiple Hits							
CNB17 P1	Oiled	Top Hits	3			1	8	4	
CNB17 P1	Oiled	Multiple Hits	1						3
AND8 P1	Oiled	Top Hits							
AND8 P1	Oiled	Multiple Hits							
SKN15 P1	Oiled	Top Hits	3				8	1	
SKN15 P1	Oiled	Multiple Hits	6						3
HMP6 P1	Oiled	Top Hits					2	1	
HMP6 P1	Oiled	Multiple Hits							
AND06 P1	Oiled	Top Hits					1		
AND06 P1	Oiled	Multiple Hits							
VLC10 P1	Oiled	Top Hits					1	5	4
VLC10 P1	Oiled	Multiple Hits							3
SKN05 P1	Oiled	Top Hits					1	2	
SKN05 P1	Oiled	Multiple Hits							
SKS18 P2	Control	Top Hits	25				4		
SKS18 P2	Control	Multiple Hits	97						
BCK12 P2	Control	Top Hits							1
BCK12 P2	Control	Multiple Hits		3					
CNB17 P2	Control	Top Hits	15		1		3	1	3
CNB17 P2	Control	Multiple Hits	54		37				
AND8 P2	Control	Top Hits	8					1	
AND8 P2	Control	Multiple Hits	27		4				2
SKN15 P2	Control	Top Hits	7				2		
SKN15 P2	Control	Multiple Hits	24						1
HMP6 P2	Control	Top Hits	4				2		

HMP6 P2	Control	Multiple Hits	33
AND06 P2	Control	Top Hits	3
AND06 P2	Control	Multiple Hits	8
VLC10 P2	Control	Top Hits	
VLC10 P2	Control	Multiple Hits	7
SKN05 P2	Control	Top Hits	