Skagit Chinook Habitat Monitoring Status and Trends: Change in Skagit Tidal Delta Habitat Extent, 2004 – 2013

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This report presents 2013 results from GIS census polygon data of the vegetated Skagit tidal data. GIS polygons were created using methods described in Beamer et al. (2015) from high resolution orthophotos flown in 2013. Tidal delta extent results from 2013 are compared to results from other time periods, including the desired future conditions identified in the Skagit Chinook Recovery Plan (SRSC and WDFW 2005).

Results

Between 2004 and 2013 the net change in the Skagit River's tidal footprint is an increase of 83 hectares of intertidal footprint (Table 1, Figure 1).

Human and natural causes of habitat change were detected over the nine-year period, with restoration outpacing both natural and human causes of lost tidal delta extent. We are not losing tidal delta habitat faster than we are gaining it. Completed restoration projects are the primary reason for a net increase in tidal delta extent (Table 2). A total of 122 hectares was restored over the nine-year period, an average of 13.6 hectares restored per year.

Two unique habitat changes were detected. The first is a 15-hectare gain in habitat from a passive failure of a levee on WDFW lands, which was not repaired. The site is located along West Pass (Figure 1). The second is a 36-hectare loss also located along West Pass, in an area of extensive spartina marsh removal (Beamer et al. 2009). Spartina is an invasive plant in west coast estuaries that colonizes mudflat. In 2004 this area was mapped as (unnatural) marsh and in 2013 as unvegetated, thus showing a loss per our reporting methods.

Direct human causes of lost tidal delta extent were minor (Table 1). Only two incidents of lost habitat due to human cause were detected: 1) a loss of a third of a hectare due to levee repair along the North Fork Skagit River near the Forks; and 2) a 0.04-hectare filled channel as part of the Fisher Slough Restoration Project which helped re-meander Fisher Creek and create a blind channel lobe. Overall, direct human-caused losses of tidal delta extent were less than 0.04 hectares per year.

Natural changes in tidal delta extent occurred over the nine-year period with a net loss in tidal delta extent, primarily along the bay front (Figure 1), resulting in 12.6 hectares gained but 29.9 hectares lost. Overall, natural-caused change of tidal delta extent was a loss of 1.9 hectares per year.

Table 1. Gains and losses of Skagit tidal delta extent by cause for the period 2004 through 2013.

Cause of change		Gain (ha)	Loss (ha)	Net change (ha)
General	**Specific**			
human	channel filled in		0.041	-0.041
	levee repair		0.354	-0.354
	restoration	121.917		121.917
	invasive sp. (spartina) removal		36.295	-36.295
natural	passive dike breach	15.071		15.071
	erosion and progradation	12.621	29.889	-17.269
	Total	**149.608**	**66.580**	**83.028**

Table 2. Gains and losses of Skagit tidal delta extent by restoration project for the period 2004 through 2013.

Restoration project (year completed)	Gain (ha)	Loss (ha)	Net change (ha)
Fisher Sl restoration (2011)	18.657	0.041	18.615
SF Dike Setback restoration (2007)	8.369		8.369
Smokehouse restoration (2008)	26.902		26.902
Swinomish Channel fill removal (2008)	3.366		3.366
Wiley Sl restoration (2009)	64.623		64.623
Total	**121.917**	**0.041**	**121.876**

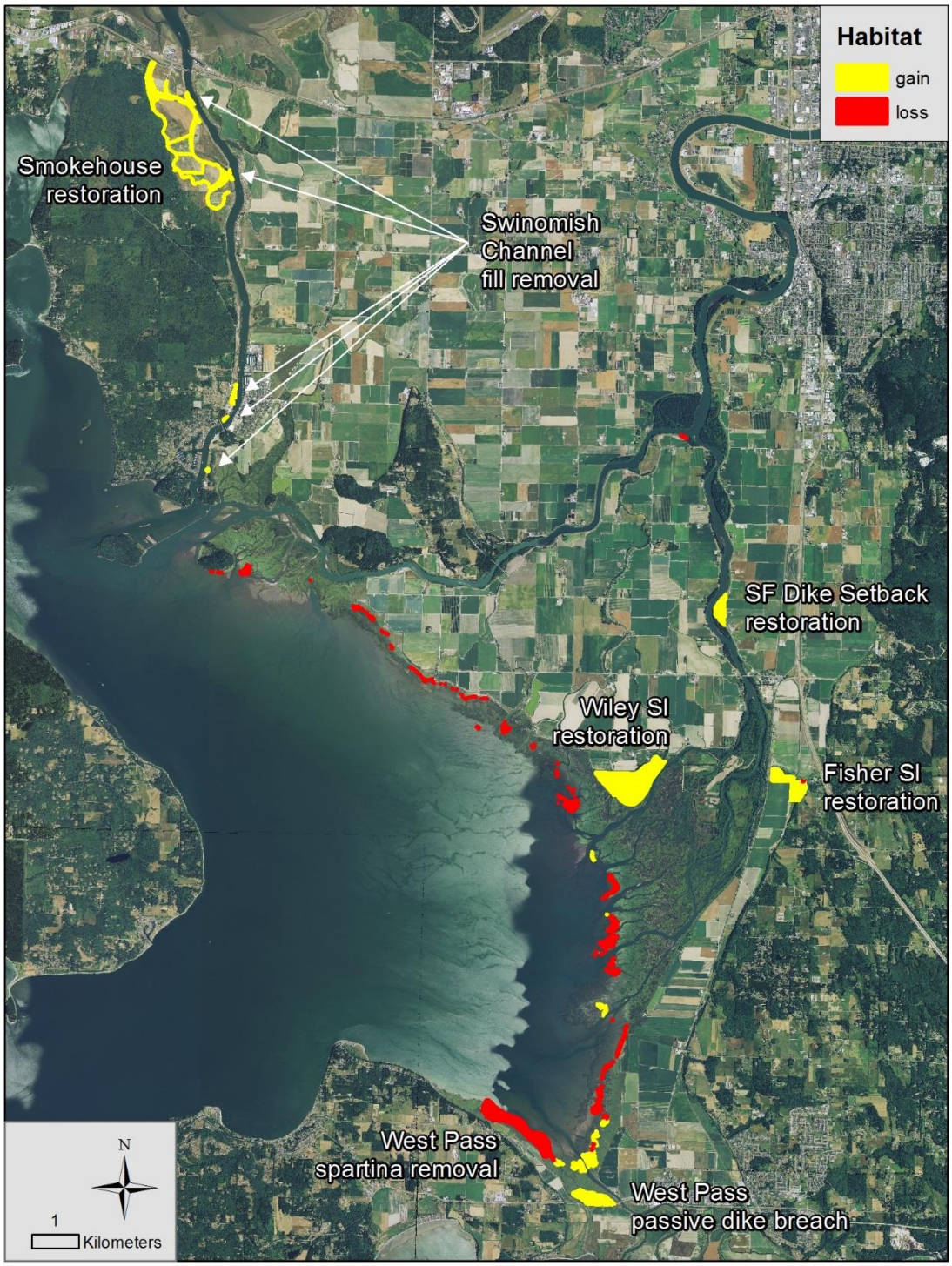

Figure 1. Map of gains and losses of Skagit tidal delta extent for the vegetated delta for the period 2004 through 2013.

What is the pace of tidal delta restoration since Chinook Recovery Plan implementation began?

We have data more current than 2013 for restoration because the 52-hectare Fir Island Farms restoration project was completed in the summer of 2016 (Figure 2, top panel). Adding Fir Island Farms to the restoration results shown in Table 1, a total of 174 hectares was restored between 2004 and 2016, averaging 14.5 hectares restored per year. However, the pace of restoration has slowed in recent years (Figure 2, bottom panel). During the first four years of Chinook Recovery Plan implementation (i.e., since 2005) 103.3 hectares of tidal delta extent were restored, an averae of 25.8 hectares per year. Since 2009, another 71.2 hectares has been restored, an average of 10.2 hectares per year.

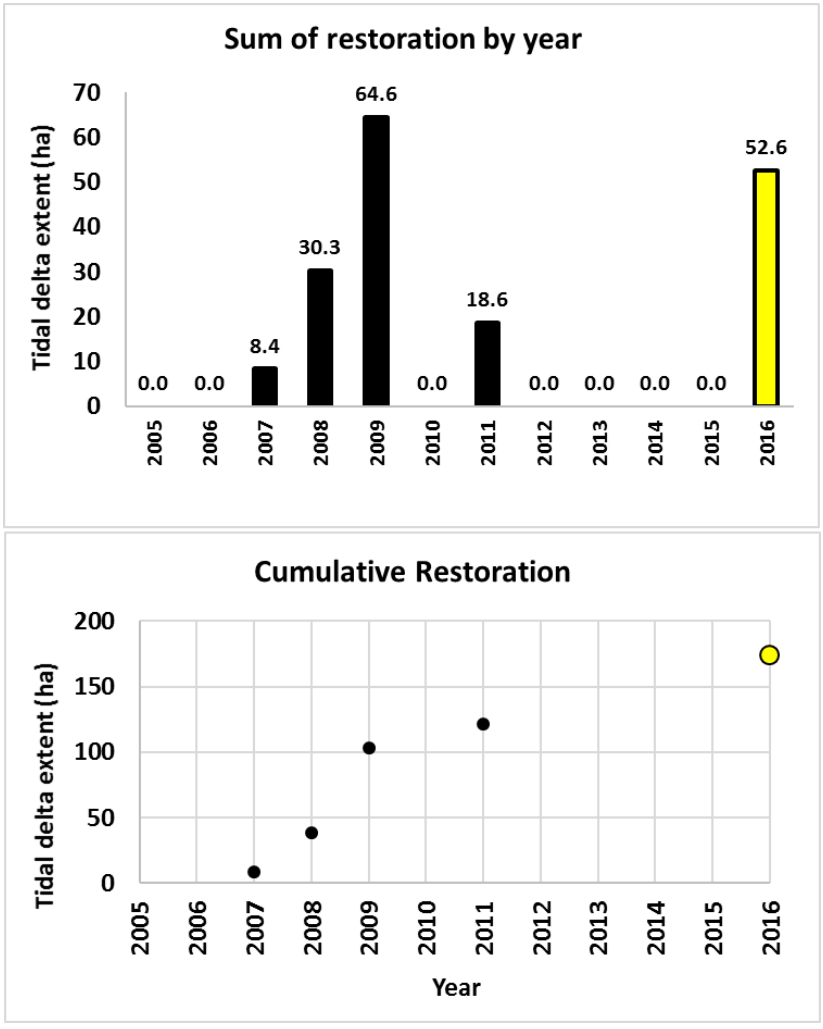

Figure 2. Annual (top panel) and cumulative (bottom panel) restoration influence on Skagit tidal extent. The solid black bars and circles reflect results from restoration projects shown in Table 2 and were detected in the 2013 tidal delta GIS polygon layer. The yellow bar and circle includes Fir Island Farms, which was completed in 2016 and helps inform the recent pace of restoration.

How are the results adding up compared to goals?

Table 3 shows recent Skagit tidal delta extent results (2000, 2004, and 2013) compared to the Skagit Chinook Recovery Plan's desired future condition (DFC) and historic condition. The Skagit's DFC is 37.0% of the tidal delta's historic extent. At the beginning phase of Chinook Recovery Plan implementation (reflected by the 2004 result) the Skagit's tidal delta extent was 29.6% of its historic condition and already 80.0% of the DFC. In 2013 the Skagit's tidal extent was 30.3% of its historic condition and 81.9% of DFC.

Table 3. Skagit tidal delta extent indicator results compared to historic and Skagit Chinook recovery plan desired future conditions (DFC).

Source	Year	Status	DFC	Historic condition
Skagit Phase I (source[1])	2000	3,118 ha (73.7% of DFC)	4,232.6 ha (37.0% of Historic)	11,438 ha
Skagit Monitoring Pilot[2]	2004	3,384.65 ha (80.0% of DFC)		
SRSC Habitat Status & Trends Program	2013	3,467.68 ha (81.9% of DFC)		

[1]Page 7 (historic, Year 2000) & page 41 (DFC) of Beamer et al. 2005; Note: DFC = year 2000 conditions + restoration goal of 1,114.6 ha

[2] Beamer et al. 2015

How long will it take to reach Skagit tidal delta desired future condition?

Our monitoring results demonstrate it will be the net sum of natural- and human- caused gains and losses of delta habitat over time that will achieve the Skagit tidal delta's DFC of 4,232.6 hectares.

If overall gains and losses (i.e., net result of Table 1) continue at the same pace as observed between 2004 and 2013 – including the two unique habitat changes described above – the Skagit's DFC for tidal delta extent will not be achieved until year 2096, 91 years after Chinook Recovery Plan implementation started. Moreover, once DFC has been achieved, periodic tidal delta restoration, at the rate of 19 hectares per decade, will be required to maintain DFC assuming the observed rate of natural delta habitat loss remains the same.

However, large scale spartina infestation in the Skagit tidal delta has been eradicated and dike failures are usually repaired or become official restoration projects, so we excluded the effects from these two unique observations to more realistically estimate three scenarios of how long it could take to achieve Skagit tidal delta DFC. The scenarios are: 1) fastest observed restoration

pace, 2) slowest observed restoration pace, and 3) achieve DFC at the midpoint of a 50-year recovery plan. The rates used for restoration and natural habitat losses are shown in Table 4. All values, except the rate of restoration needed to achieve Scenario 3, are from observed data. Table 4 shows results for: (a) the year when DFC is achieved; (b) the amount of restoration required to achieve DFC; (c) the amount of additional restoration required to maintain DFC through year 2106; and (d) the total amount of restoration needed to achieve and maintain DFC through 2106. Year 2106 is the year when DFC is achieved by Scenario 2, the slowest of the three scenarios to achieve DFC.

Under Scenario 1 the Skagit's DFC for tidal delta extent is achieved in year 2045, 40 years after Chinook Recovery Plan implementation started (Table 4). Under Scenario 2, DFC is achieved in year 2106, over 100 years after Chinook Recovery Plan implementation started! Under Scenario 3 DFC is achieved in year 2030, but it takes an average of 47 hectares per year of restoration, nearly a doubling of the fastest observed restoration pace to date. Interestingly, achieving DFC sooner requires less total restoration to achieve and maintain DFC. Moreover, it is likely that costs for completing large capital projects such as tidal delta restoration will increase over time. Together these two issues suggest it is more cost effective overall to achieve DFC sooner rather than later.

Table 4. Summary of scenarios for achieving Skagit tidal delta extent DFC.

DFC scenario	DFC achieved (year)	Restoration amount needed (2014-DFC)	Additional restoration to maintain DFC though year 2106	Total restoration to achieve and maintain DFC
Scenario 1: Fastest observed restoration pace • Restoration pace = 25.8 ha/yr • Natural gain/loss rate = -1.9 ha/yr	2045	825.6 ha	117.1 ha	942.7 ha
Scenario 2: Slowest observed restoration pace • Restoration pace = 10.2 ha/yr • Natural gain/loss rate = -1.9 ha/yr	2106	948.6 ha	0.0 ha	948.6 ha
Scenario 3: DFC by mid-point of a 50 year recovery plan • Restoration pace = 47.0 ha/yr • Natural gain/loss rate = -1.9 ha/yr	2030	799.0 ha	145.9 ha	944.9 ha

What are the caveats to these results?

Spatial extent: These results apply to the Skagit indicator: *Tidal delta habitat extent* for the vegetated Skagit tidal delta, excluding any changes to low density marsh which cannot be reliably delineated through remote sensing. There is some future work needed to ensure all data layers used for status and trends analysis comparing historic, contemporary, and future time periods are using the exact same spatial extent. We found inconsistencies in mapping between 2004 and 2013 to occur primarily in southern Padilla Bay north of State Route Highway 20, and therefore excluded this area from results in this fact sheet. No restoration has occurred to date in this area north of the highway, and delta fringe erosion/progradation does not appear to be as acute as in Skagit Bay. The spatial extent for results shown in Figures 1 & 2 and Tables 1 & 2 is:

- northern border is State Route Highway 20;
- southwestern border is English Boom along Camano Island;
- southeastern border is West Passage's bifurcation with South Passage near Stanwood; and
- Skagit River upstream border is upstream of bifurcation of the North and South Forks and includes the dike setback floodplain areas of Cottonwood (west side) and Britt Slough (east side).

Reporting of unnatural marsh areas: The area of extensive spartina marsh removal near West Pass was mapped as marsh in 2004 and unvegetated in 2013, and thus shows as a loss in vegetated tidal delta extent per our reporting methods. For this fact sheet we did not apply to the results concepts of functioning or impairment to tidal delta habitat areas. Tidal delta habitat areas that are disturbed by dredging, a muted hydrology, and/or overwater structures are classified as 'impaired' or 'partially impaired' in estuarine habitat functions provided to juvenile salmon depending on the degree of disturbance (see chapter 4 of Beamer et al. 2015). Natural tidal habitats disturbed by invasive plants should also be added to the impairment list, and included in chapter 4 of our habitat status and trends methods (Beamer et al. 2015).

Reporting of habitat types within tidal delta extent: The results shown in this fact sheet only apply to the indicator: *Tidal delta habitat extent* and do not account for changes in specific habitat types (e.g., extent of blind and distributary channel) which have not been completely delineated yet in the 2013 data layer. It is important to complete delineation of the GIS data layer into habitat types especially to track the channel results because large changes in intertidal footprint by restoration projects can have downstream or 'outside the dikes' effects (Hood 2004) and restored habitat conditions within project areas do not necessarily remain the same over time as natural processes interact with the site. One completed restoration project accounted for in the 2013 result, Wiley Slough, is expected to create significant downstream or 'outside the dikes' increases in tidal channel extent. The approximately 52-hectare tidal footprint of the Fir Island Farms Restoration Project (not accounted for in the 2013 result because restoration occurred in summer 2016) is also expected to create significant downstream increases in tidal channel extent. The habitat effects of the built Milltown Island Restoration Project are not observable in our tidal delta extent results. Milltown Island, located in the South Fork Skagit tidal delta, had significant restoration activity between 2004 and 2013 but there was no change in overall tidal footprint. The project was designed

to increase river and tidal connectivity to the site, not restore isolated habitat due to diking. Thus, there is no gain/loss tidal extent polygon shown in Figure 1 for Milltown.

What are the lessons learned and recommendations for adaptive management?

The status and trends results for tidal delta extent provide several lessons related to implementation of the Skagit's tidal delta recovery strategy and its monitoring plan. Taken together, these lessons lead to three recommendations for adaptive management.

Monitoring plan related:

Good news: The GIS census methods work for measuring the indicator: *Tidal delta habitat extent*.

Recommendation: Continue monitoring tidal delta extent (and other habitat extent indicators) for the Skagit tidal delta with a maximum interval period for monitoring data layers of 5-7 years.

Recovery plan strategy related:

Good news: The fundamental habitat hypothesis of the Skagit Chinook Recovery Plan to protect and restore the tidal delta is supported by the actions implemented. Overall, the Skagit tidal delta is gaining habitat faster than it is losing it. Completed restoration projects are the primary reason for a net increase in tidal delta extent; direct human causes of lost tidal delta extent were minor.

Bad news: Natural changes in tidal delta extent resulted in a net loss in tidal delta extent, primarily along the Skagit bay front, further supporting findings that sea level rise is offsetting the delta's natural habitat formation processes (Hood et al. 2016). In addition, human-caused changes to sediment routing within the delta are likely inhibiting habitat formation by creating areas that are sheltered from sediment supply but not from sea level rise nor wind wave intensity (Hood et al. 2016).

More bad news: While restoration efforts are responsible for the net increase in Skagit tidal delta extent over our study period, the pace of restoration slowed mid-period from 25.8 to 10.2 hectares per year. If restoration gains and natural losses continue at the overall observed 2004 – 2013 pace, the Skagit's DFC for tidal delta extent will not be achieved until year 2096. The pace of restoration would need to be nearly double the fastest observed pace to achieve Skagit tidal delta DFC 25 years after the start of Chinook Recovery Plan implementation.

Recommendation: Increase the current pace and magnitude of tidal delta restoration to: (a) realistically achieve DFC near the midpoint of a 50-year recovery plan implementation period; and (b) maintain DFC over time. The current pace of restoration leads to DFC in 80-90 years from now. Periodic ongoing restoration will be needed to offset chronic natural loss of marsh.

Recommendation: Explicitly incorporate sea level, storm surge, and sediment routing within the Skagit tidal delta into an updated recovery strategy for the Skagit tidal delta. Projects that can improve sediment routing and deposition within the delta may offset chronic natural loss of marsh.

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