

EVALUATION OF STREAM CROSSING STRUCTURES FOR PROVIDING FISH PASSAGE IN A TUNDRA STREAM; FISH SAMPLING OF FAWN CREEK, PRUDHOE BAY, ALASKA, 2004.

by **William Morris**
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Photo by William Morris ADNR, OHMP

December 2004

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**Evaluation of Stream Crossing Structures for Providing Fish
Passage in a Tundra Stream;
Fish Sampling of Fawn Creek, Prudhoe Bay, Alaska, 2004.**

Technical Report No. 04-05

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and Permitting
Alaska Department of Natural Resources**

Submitted to

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December 2004

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Abstract:

Fyke nets were set throughout Fawn Creek during summer 2004 to investigate the effectiveness of crossing structures for fish passage. In July, nets were fished upstream and downstream from the four lowest stream crossings of Fawn Creek and upstream from the upstream-most crossing. During August, only 3 crossings were sampled. We also fished a net in D Pad Lake at the headwaters of the Fawn Creek system in August. During July we expended over 1000 net-hours of effort and over 325 net-hours were fished in August. Fish were captured above and below most crossings; however, catch rates were highest in the lower portion of the system and generally highest downstream from crossings. Only one, exceptionally large, fish was captured above the Spine Road crossing and no fish were captured above the fifth (upstream most) crossing or in D Pad Lake. The stream crossings of Fawn Creek appear to be reducing the upstream extent of use in the system by fish, but the Spine Road crossing presents the most complete blockage to fish passage. Additional sampling and a system wide effort evaluating the potential for rehabilitation of the five crossings is recommended with emphasis on the Spine Road and upstream-most crossings.

Introduction:

Fawn Creek is a 20+ km tundra stream/lake system flowing north from D Pad Lake through an extensive wetlands complex to the Beaufort Sea (Figure 1). The stream is crossed by five roads and is first crossed by an oilfield road approximately 13 km upstream from the Beaufort Sea where the F Pad to E Pad road crosses the creek. Upstream from the F Pad to E Pad road crossing, the stream is crossed by the F Pad to GC-1 road, an access road from the Spine Road to F Pad and to the GC-1 road, the Spine Road, and by the GC-1 to GC-2 road. The creek was first sampled for fish in mid-July 2003. A fyke net was set downstream of the F-Pad to E-Pad road for one overnight period and seven broad whitefish (*Coregonus nasus*) were captured (Morris and Winters, 2003). In response to the presence of anadromous fish in the drainage, the Office of Habitat Management and Permitting (OHMP) designed a sampling program to investigate the potential impacts to fish and fish passage as a result of the numerous road crossings of the creek. All crossings were constructed prior to knowledge of fish presence in the system and as a result probably were not built with fish passage as a design criterion.

Methods:

In July 2004 each of the five crossings were inspected and velocity data were collected with a Global Water FP101 Flow Probe at each of the culverts or pipes. Fyke nets were set upstream and downstream from each crossing to help assess each crossing's ability to provide efficient fish passage. Nets were fished from 5 July through 11 July, expending over 1000 net-hours of effort; nets were checked once each day. Appendix I provides complete descriptions of each crossing, Appendix II provides photographs of each crossing and associated net sites with net set descriptions, and Figure 2 shows all fyke net locations. Fyke net sites are individually identified by their associated crossing and either upstream or downstream location. For example, Fawn Crossing 1 upstream is identified as FC1us and is the upstream net associated with the northernmost or downstream-most crossing. During August 2004 nets were set upstream and downstream from the 1st, 3rd and 4th (FC1, FC3, and FC4) road crossings and one net was set in

D-Pad Lake. Nets were fished from 3 August through 5 August expending over 325 net-hours of effort; nets were checked at the end of the approximate 48-hr set.

Fawn Creek System

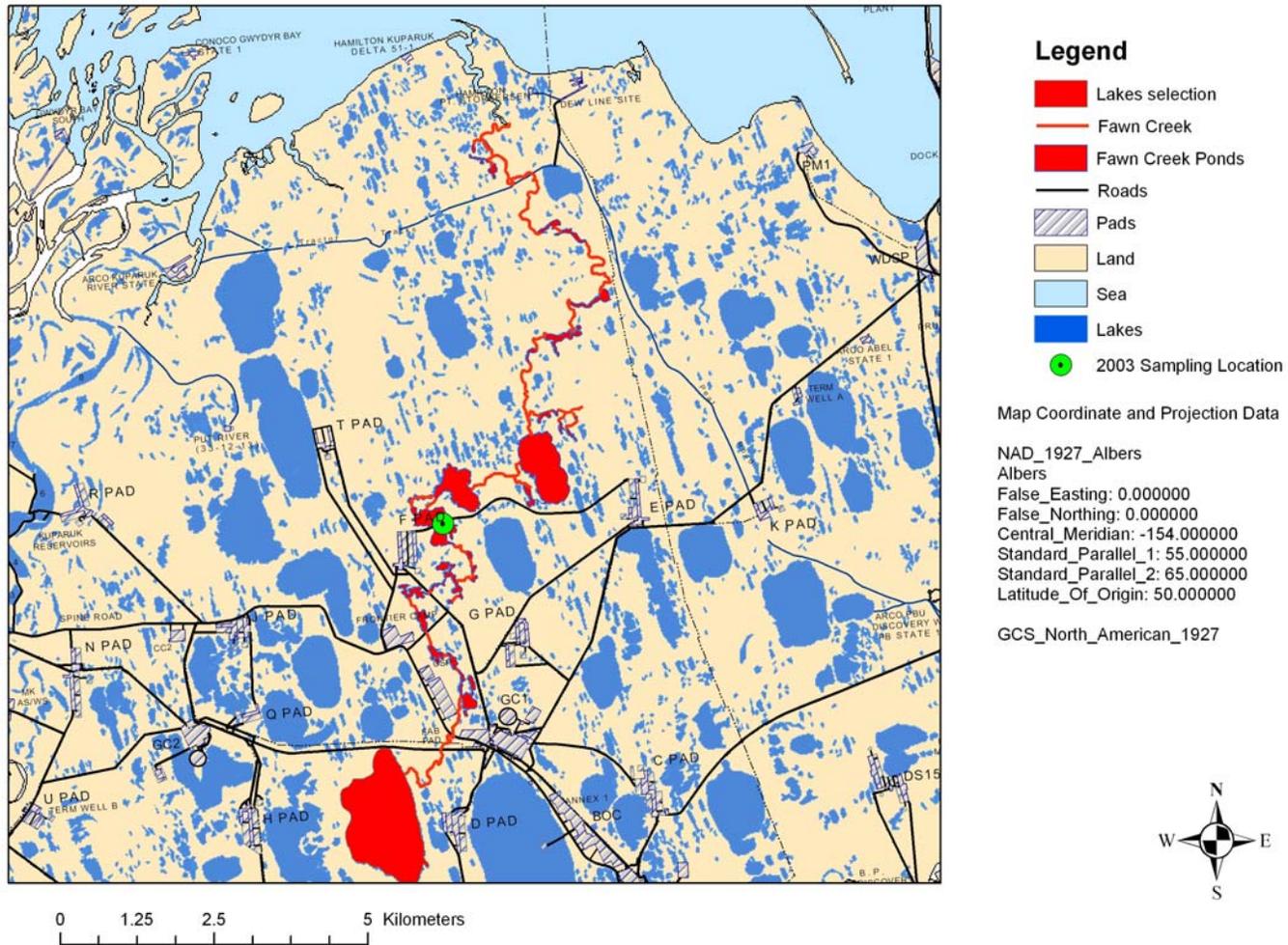


Figure 1. Fawn Creek is a 20 Km tundra stream/lake system flowing north through the Prudhoe Bay Oilfield to the Beaufort Sea. The 2003 fish sampling location is shown (green bull's-eye).

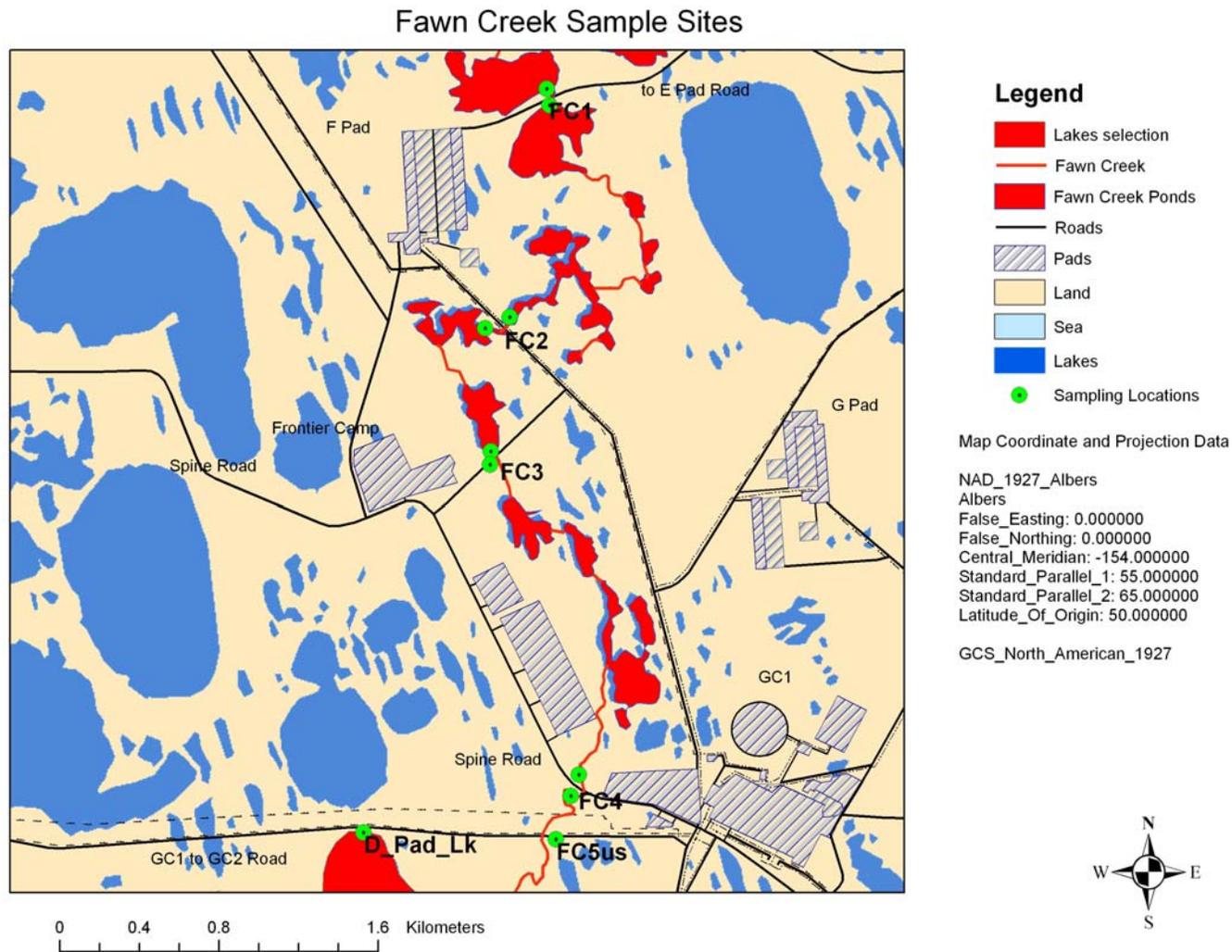


Figure 2. Fyke nets were set above and below each road crossing of Fawn Creek (green bull's-eyes); with the exception of the upstream most crossing where one net was fished upstream from the GC1 to GC2 road and one net was set in D-Pad Lake. From north to south (downstream to upstream) road crossings are Fawn Creek 1 (FC1) through Fawn Creek 5 (FC5); D Pad Lake was the upstream most net site.

Results:

Broad whitefish, least cisco (*Coregonus sardinella*), Arctic grayling (*Thymallus arcticus*), and ninespine stickleback (*Pungitius pungitius*) were captured in fyke nets set in Fawn Creek in July. All fish over 200 mm long from the tip of the snout to the fork in the tail were tagged with a unique numbered T-bar anchor tag. One tagged fish moved upstream through two lower culvert batteries during the week of sampling in July, but most recaptured fish were captured either downstream from or at the next upstream culvert from their tagging location. Of the 63 individual fish large enough to be tagged, 41% were tagged below the first crossing and only six were recaptured after being tagged.

Standardized catches from July sampling (fish per 24 hour period) generally were highest downstream from the first road crossing and lowest at the upstream-most locations (Figure 3). Non-parametric analysis of variance between the ranked catch rates at all sites sampled in July indicate that non-stickleback species were not distributed equally throughout the sample area and that capture rates were highest downstream in the system (KW=16.3434, $p = 0.0377$, Appendix III). Highest catch rates for all species tended to be higher downstream from culverts than upstream (Figure 3); however, statistical analysis suggests that catch rates were not significantly different up or downstream from individual stream crossings when considering the entire sampling area and only non-stickleback species (Wilcoxin Rank Sum, U downstream = 354, U upstream = 221, $p = 0.1375$, Appendix III). Only one, exceptionally large broad whitefish was captured above the Spine Road at net site FC4us in roughly 137 hours of effort; no fish were captured above FC4us. Analysis of stickleback catch rates strongly indicates that the species is unevenly distributed throughout the drainage, and that sticklebacks were concentrated downstream from road crossings (KW = 29.2088, $p = 0.0003$; Wilcoxin Rank Sum, U downstream = 415, U upstream = 160, $p = 0.0055$, Appendix III). No sticklebacks were captured upstream from the Spine Road.

August sampling was limited to three of the crossings and a net was added in D Pad Lake. Arctic grayling, least cisco, ninespine stickleback, and threespine stickleback (*Gasterosteus*

aculeatus) were captured during August sampling. Only 7 non-stickleback fish were captured in August; however, over 700 ninespine sticklebacks were captured. Too few non-stickleback fish were captured to allow for statistical analysis; however, similar to July catches, more fish were captured downstream in the system than upstream (Figure 4).

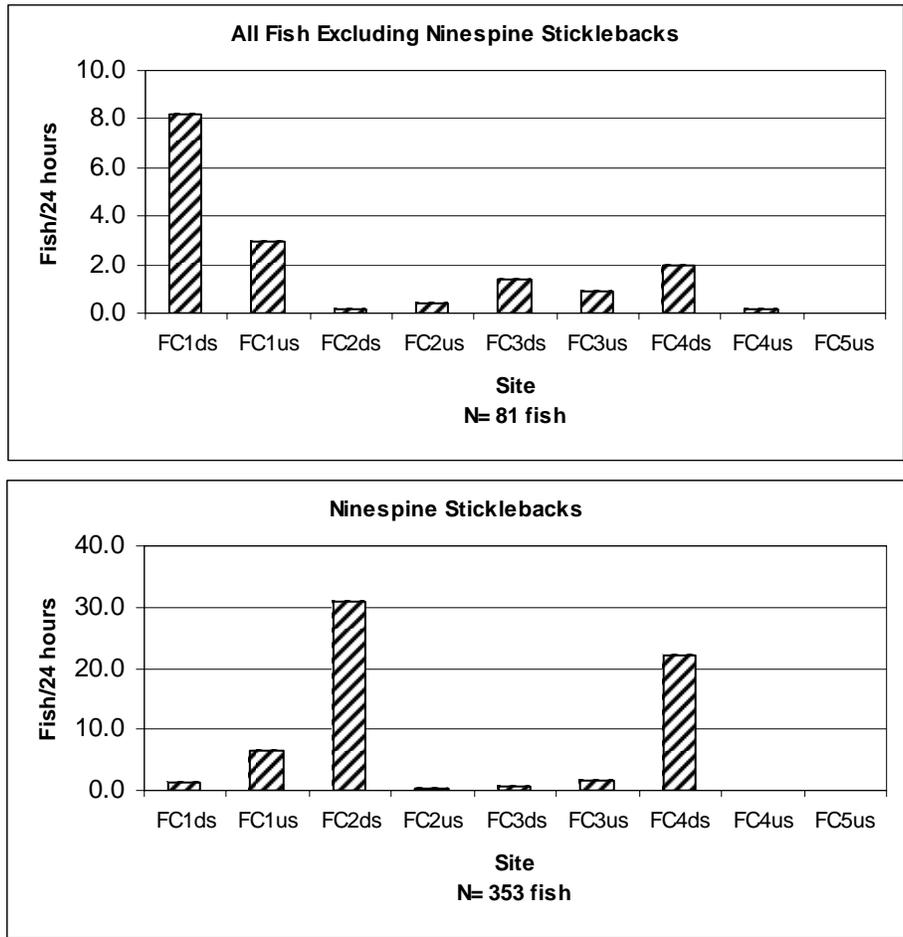


Figure 3. Fyke net catch summary in fish per 24 hour period for all net sites, Fawn Creek, July 2004.

Ninespine stickleback numbers were relatively high in August, with highest catch rates downstream from culvert batteries (Figure 4). Highest catch rates occurred below the Spine Road at FC4ds which appears to be the upper limit of fish use in the system. High catch rates of sticklebacks in August are common in drainages on the arctic coastal plain as fish begin to congregate and move to wintering areas. In this case, it appears that sticklebacks were

concentrating near pools associated with culvert scour for wintering or attempting to move towards upstream water bodies for wintering.

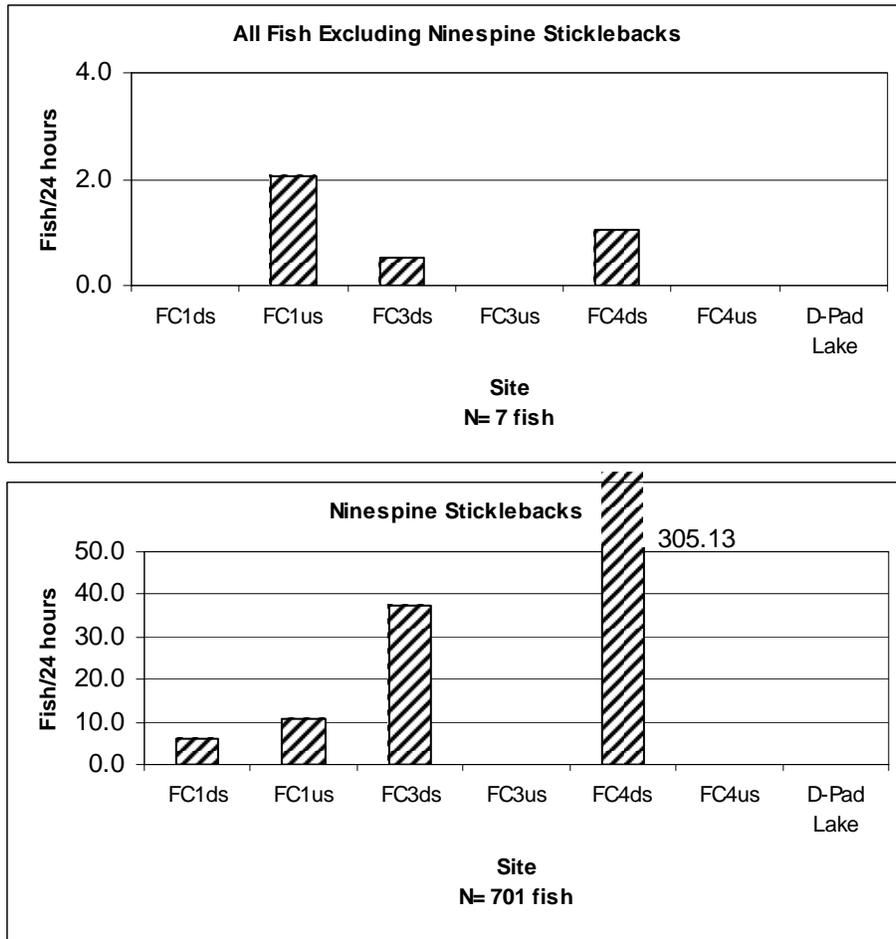


Figure 4. Fyke net catch summary in fish per 24 hour period for all sites, August 2004.

While catch rates appear to be influenced by the stream crossings, fish passage is occurring through the lower three stream crossings (FC1 through FC3). Fish size distribution in the pool below the Spine Road crossing is similar to the size distribution observed in the lower drainage, indicating that crossings are not differentially excluding any particular size class of fish (Wilcoxin Rank Sum, U all downstream fish = 426.50, U FC4ds fish = 401.50, $p = 0.8732$) (Figure 5, Appendix III). It is likely that at particular flow levels in the system, different culvert

batteries provide some velocity regime that allows for some level of passage for most size classes. The Spine Road crossing largely is an exception to this as shown by the capture of only one broad whitefish and no sticklebacks.

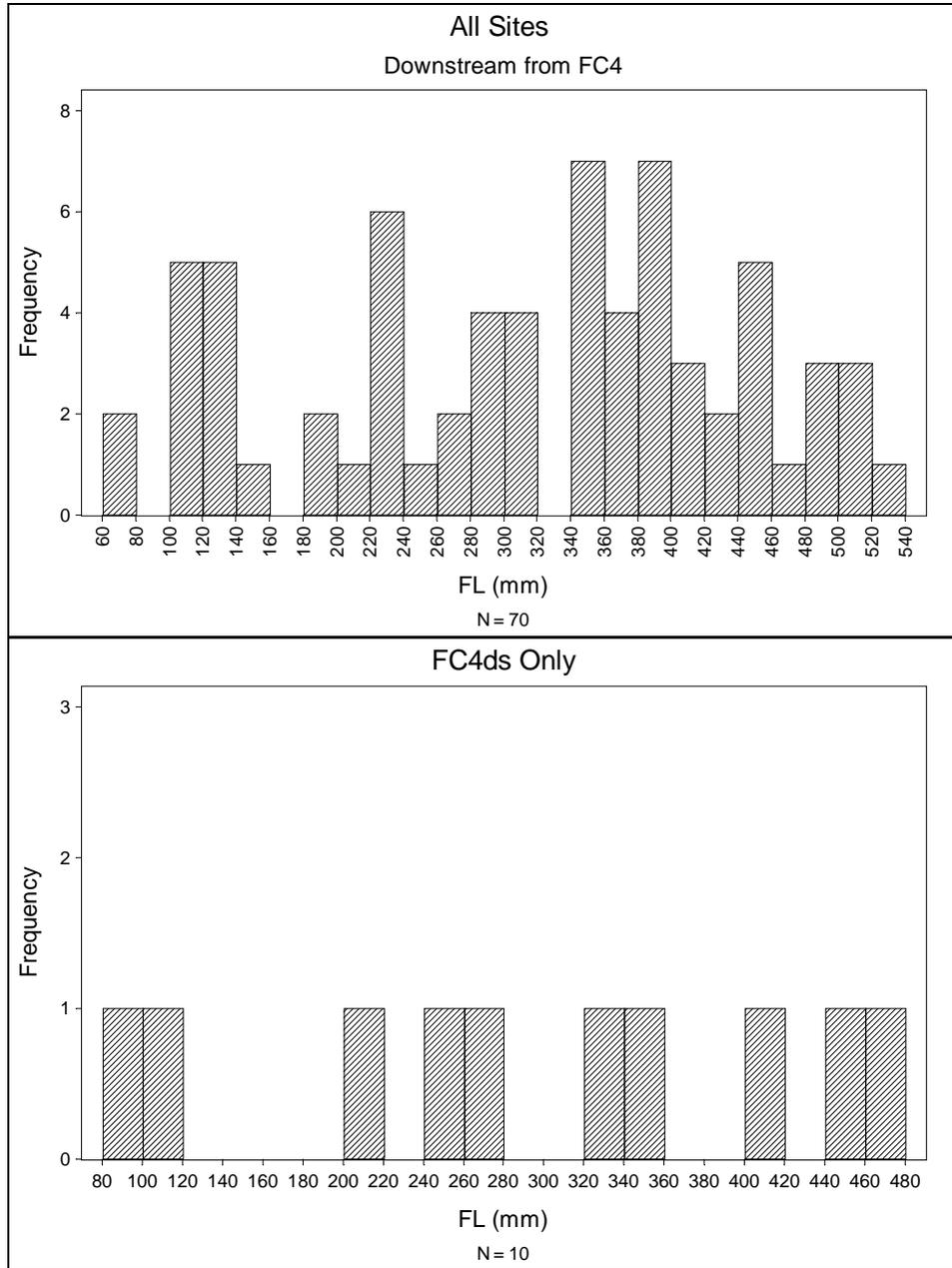


Figure 5. Length frequency distributions of the catch at FC4ds and all downstream sites (excluding FC4ds) suggests that all age/size classes of non-stickleback fish present in the system are reaching as far as upstream as just below the Spine Road.

Discussion:

Road crossing inspections indicate that most crossings of Fawn Creek present a partial barrier to fish at some or most flows (Appendix I). The Spine Road crossing, which is perched at most flows, presents the most complete barrier to fish passage. Water velocities were relatively high during July and marginal for fish passage. However, early July velocities do not represent the highest velocities/flows that would be expected in the system during and immediately after break-up when fish distribute throughout systems on the North Slope. Higher velocities would also be expected during the annual fall floods. Physical inspection of the crossings indicates that water is being impounded upstream from several of the crossings and creating wetland habitat, potentially productive habitat for both fish and waterfowl. However, the Fawn Creek complex, perhaps with the exception of D Pad Lake, is too shallow to winter fish. Artificial wetlands could attract and hold fish during fall by mitigating the effects of cold temperature cues that help initiate fall migrations to wintering areas. Fish that stay too late in the season could ultimately become trapped in the system and die during winter, an occurrence documented in systems with and without road crossings (Morris 2003, Morris 2000). No attempt was made to quantify the number of fish potentially impacted by remaining in the system over winter.

Fish catch rate data indicates that passage is occurring to some extent at all crossings with the exception of the sites above the Spine Road. Fish passage appears to be inhibited by the stream crossings downstream from the Spine Road as shown by the higher catch rates in the system below the first road crossing and generally higher catch rates of fish downstream from road crossings. The Spine Road crossing (FC4) blocks access to the FC5 area and D Pad Lake for nearly all fish. Catch rates immediately below the Spine Road were approximately 2 fish per day (24 hour), the third highest rate among all sites sampled, yet only one exceptionally large and robust broad whitefish was captured above the Spine Road crossing. Fyke net catches in D Pad Lake consisted of thousands of fairy and tadpole shrimp suggesting the lake could provide high quality fish feeding habitat. However, it appears that, because of the reduction in fish passage associated with the culvert batteries (particularly the Spine Road Crossing), the lake is not utilized by fish despite its direct connection to Fawn Creek.

Recommendations:

We recommend that at least one additional year of fyke-net data be collected at the crossings of Fawn Creek to confirm or refute the results of our 2004 effort and to further help prioritize crossings for rehabilitation. While it appears from the 2004 results that fish passage is hindered by the succession of culverted road crossings, and that highly productive upstream fish habitats are not accessed by fish, the number of fish potentially impacted lethally by being trapped in the system in winter was not quantified. However, depending on the age classes of fish impacted, the impact may be less significant than the reduction in productivity associated with reduced fish passage through the system. A combination of a large scale tagging and radio-telemetry program may help ascertain the significance of fish entrapment in the system.

Generally, we recommend that the crossings downstream from the Spine Road be critically evaluated for their need for continued use and that any crossings deemed non-critical for safety and access purposes be removed or fish passage improved. Crossings deemed critical should be evaluated and culvert batteries modified or replaced to ensure the efficient and durable passage of resident and anadromous fish. It is possible that any increase in conveyance will result in some loss of artificially created wetlands; however, with a restored drainage pattern, fish migration both to and from the remaining wetlands will be accommodated. During design and construction of any crossings that may require rehabilitation it may be possible to retain much of the artificial wetland characteristics of the drainage while simultaneously improving fish passage capabilities.

Fish habitat above the Spine Road appears to be quite productive, sustaining high numbers of fish food organisms, but the areas are nearly completely isolated from fish. Access to the food-rich wetlands above the two roads, including D Pad Lake, could provide appreciable benefits to anadromous fish using the Fawn Creek system. D Pad Lake may also have the capacity to provide a wintering area for fish that may gain access after rehabilitation of the FC4 and FC5 crossings. Our highest priority recommendation, based on 2004 sampling, is to rehabilitate and

restore fish passage at the Spine Road crossing as it represents a nearly complete obstacle to fish movement.

We recommend the first step to rehabilitation of the Fawn Creek crossings include field inspections with industry and OHMP representatives during summer or fall 2005. Pending 2005 sampling results, restoration work identified as most critical should be initiated. Performance monitoring should be conducted after any stream crossing rehabilitation work is completed to assess the effectiveness of the work in improving fish passage and in distributing fish to upstream habitats in the Fawn Creek system.

Works Cited:

- Morris, W.A. 2003. Seasonal movements and habitat use of Arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), and broad whitefish (*Coregonus nasus*) within the Fish Creek drainage of the National Petroleum Reserve-Alaska, 2001-2002. Technical Report No. 03-02. Alaska Department of Natural Resources, Office of Habitat Management and Permitting. Juneau. 110 pp.
- Morris, W.A. 2000. Seasonal movements of broad whitefish (*Coregonus nasus*) in the freshwater systems of the Prudhoe Bay oil field. Masters Thesis. University of Alaska Fairbanks. 71 pp.
- Morris, W.A., and J.F. Winters. 2003. Fish sampling of Fawn Creek and Mine Site B, trip report, July 2003. Alaska Department of Natural Resources, Office of Habitat Management and Permitting. Fairbanks. 8 pp.

APPENDIX I –Fawn Creek Stream Crossing Descriptions

FC1	July 11, 2004	N 70.33994 W -148.74840	NAD27		
Description:	<p>4 24" X 40' CMPs F to E Pad order = 1,2,3,4 Culverts draining large wetlands complex upstream in Fawn Creek water ponded upstream ~ 6"</p> <p>upstream culverts 1&2 level with water culverts 2&3 submerged ~ 3" all below stream bed</p> <p>downstream culverts roughly 1/2 full all below stream bed</p>				
Velocity Measurements					
	Upstream		Downstream		
	velocity (fps)	depth (ft)	velocity (fps)	depth (ft)	
1 bottom	1.2	1.6	1 bottom	1.2	0.9
1 mid-flow	1.1	0.8	1 mid-flow	2	0.45
2 bottom	1.7	1.9	2 bottom	2.1	1
2 mid-flow	1.6	1	2 mid-flow	3.4	0.5
3 bottom	0.7	1.9	3 bottom	2.1	0.9
3 mid-flow	1.7	1	3 mid-flow	3.3	0.5
4 bottom	0.3	2.2	4 bottom	2.2	0.8
4 mid-flow	1.3	1.1	4 mid-flow	3.3	0.5
Assessment:	Likely a barrier at some flows				

FC2	July 11, 2004	N 70.32960 W -148.75662	NAD27		
Description:	<p>1, 4' X 61' CMP Culverts draining large wetlands complex in Fawn Creek</p> <p>upstream inlet 1.2' above stream bed 0.7' hydraulic drop into pipe barrel</p> <p>downstream 2" off thalweg</p>				
Velocity Measurements					
	Upstream		Downstream		
	velocity (fps)	depth (ft)	velocity (fps)	depth (ft)	
1 bottom	1.5	1.8	1 bottom	1.4	2.5
1 mid-flow	4.3	0.9	1 mid-flow	2.2	1.25
Assessment:	Likely a barrier at some flows				

FC3	July 11, 2004	N 70.32362	NAD27	
		W -148.75857		
Description:	1, 36" X 84' smooth wall pipe 1, 20" X 64' smooth wall pipe gravel deposit downstream of scour pool Culverts draining large wetlands complex in Fawn Creek upstream 36" pipe 0.9' off thalweg 20" pipe on bed downstream 36" pipe protrudes into 3 to 6' deep scour pool 10', 3 to 6' off bed 20" pipe on gravel bench above large scour pool, submerged 2"			
Velocity Measurements				
	Upstream		Downstream	
	velocity (fps)	depth (ft)	velocity (fps)	depth (ft)
36" bottom	2.9	1.1	36" bottom	2.2
36" mid-flow	2.9	0.55	36" mid-flow	3.2
20" bottom	3.8	1.4	20" bottom	2.2
20" mid-flow	3.1	0.7	20" mid-flow	2.9
Assessment:	Likely a barrier at some flows			

FC4	July 11, 2004	N 70.30830	NAD27	
		W -148.75169		
Description:	1, 4.8' X 98' smooth wall pipe Culvert across Spine Road in Fawn Creek upstream 0.7' head at inlet 1' above bed, sand bags around inlet downstream 40' X 60' scour pool with 15' of pipe protruding into pool, pool ~ 8' deep or deeper outlet ~ 7' off bottom Bottom of pipe nearly perched at present flow (somewhat high for season)			
Velocity Measurements				
	Upstream		Downstream	
	velocity (fps)	depth (ft)	velocity (fps)	depth (ft)
bottom	3.2	2.6	bottom	2.8
mid-flow	3.2	1.3	mid-flow	3.7
inside trough	4.7	1		
Assessment:	Barrier at nearly all flows perched at normal summer water levels excessive velocity at high water			

FC5	July 11, 2004	N 70.30622	NAD27	
		W -148.75507		
Description:	1, 30" X 40' CMP			
	Culvert across pipe road draining wetlands that feed Fawn Creek			
upstream	submerged 3" on bottom of toe of road but above stream bed			
downstream	culvert on stream bed			
Velocity Measurements				
	Upstream		Downstream	
	velocity (fps)	depth (ft)	velocity (fps)	depth (ft)
bottom	3.2	2.6	bottom	2.8
mid-flow	3.2	1.3	mid-flow	3.7
Assessment:	Likely a barrier at some flows			

APPENDIX II – Fawn Creek Stream Crossing and Net Site Photographs



FC1 Crossing– View of downstream side of culvert battery, all culverts are more than 50% submerged.

Water surface elevation difference between upstream and downstream sides can be observed.



FC1 Crossing- View of culvert battery looking downstream from F Pad to E Pad Road.

FC1ds net is located off of the point at top center of the photograph.



FC1 Crossing- View of upstream side of culvert battery, culvert inlets are completely submerged.



FC1 Crossing- View of culvert battery looking upstream from F Pad to E Pad Road.



FC1ds Net Set– traditional set, full extension of lead from shore
Set on 7/6/2004 and pulled on 7/11/2004
Reset on 8/3/2004 and pulled on 8/5/2004

July Effort – 114.7 hours
August Effort – 46.5 hours



FC1us Net Set– traditional set, full extension of lead from shore
Set on 7/6/2004 and pulled on 7/11/2004
Reset on 8/3/2004 and pulled on 8/5/2004

July Effort – 114.8 hours
August Effort – 46.6 hours



FC2 Crossing– View of downstream side of culvert.



FC2 Crossing– View of culvert looking downstream from F-Pad to GC-1 Road.



FC2 Crossing– View of upstream side of culvert.



FC2 Crossing- View of culvert looking upstream from F-Pad to GC-1 Road.



FC2ds Net Set– bi-directional set, creek blocked, fishing up and down stream
Set on – 7/5/2004 and pulled on 7/11/2004

July Effort – 136.6 hours

Photograph has been digitally lightened.



FC2us Net Set– traditional set, full extension of lead from shore
Set on – 7/5/2004 and pulled on 7/11/2004

July Effort – 115 hours

Photograph has been digitally lightened.



FC3 Crossing– View of downstream side of culvert battery.

Gravel outwash present downstream from large scour pool.

Photograph has been digitally lightened.



FC3 Crossing- View of culvert battery looking downstream from Spine Road Access Road.

Small culvert is submerged.
Large culvert is suspended in large scour pool.

FC3ds net is located off of the point at top right of the photograph.



FC3 Crossing- View of upstream side of culvert battery, crossing creating significant head resulting in whirlpool effect as water drops into culverts inlets.

Significant road prism erosion was present on the upstream side of the crossing, indicating a severe restriction of flow at water and extreme head build-up.



FC3 Crossing- View of culvert battery looking upstream from Spine Road Access Road.



FC3ds Net Set– traditional set, full extension of lead from shore
Set on 7/5/2004 and pulled on 7/11/2004
Reset on 8/3/2004 and pulled on 8/5/2004

July Effort – 136.8 hours
August Effort – 46.7 hours



FC3us Net Set– traditional set, full extension of lead from shore
Set on 7/5/2004 and pulled on 7/11/2004
Reset on 8/3/2004 and pulled on 8/5/2004

July Effort – 136.8 hours
August Effort – 46.8 hours



FC4 Crossing– View of downstream side of culvert.

Photograph has been digitally lightened.

FC4 Crossing– Side view of downstream side of culvert. Pipe is nearly perched and water is plunging into pool.



FC4 Crossing– View of culvert looking downstream from Spine Road.

Culvert suspended in approximate 6' to 8' deep scour pool.



FC4 Crossing – View of upstream side of culvert.

Considerable water surface elevation drop occurs immediately inside culvert inlet, approximate head of 0.7'.



FC4 Crossing– View of culvert looking upstream from Spine Road.



FC4ds Net Set– bi-directional set, creek blocked, fishing up and down stream
 Set on 7/5/2004 and pulled on 7/11/2004
 Reset on 8/3/2004 and pulled on 8/5/2004

July Effort – 136.5 hours
 August Effort – 46.7 hours



FC4us Net Set– bi-directional set, creek blocked, fishing up and down stream
Set on 7/5/2004 and pulled on 7/11/2004
Reset on 8/3/2004 and pulled on 8/5/2004

July Effort – 137.2 hours
August Effort – 46.8 hours



FC5 Crossing– View of downstream side of culvert.

Culvert is 2/3 submerged and water velocity is accelerated at the outlet.



FC5 Crossing– View of culvert looking downstream from GC-1 to GC-2 Road.



FC5 Crossing– View of upstream side of culvert.

Culvert is 3” submerged and crossing is impounding water above the road. Road fill in the area was saturated with water.

Culvert inlet is located between the large and small clumps of vegetation at the toe of the road.



FC5 Crossing– View of upstream side of culvert from GC-1 to GC-2 Road. D Pad is visible in the background.

FC5us Net Set- traditional set, full extension of lead from shore
Set on 7/9/2004 and pulled on 7/11/2004
Reset on 8/3/2004 and pulled on 8/5/2004

July Effort – 46.5 hours

APPENDIX III – Statistical Analyses

Non-Stickleback Catch per Day (24 hour period) by Site, July 2004. Kruskal-Wallis One-Way Nonparametric Analysis of Variance

Site	Mean Rank	Sample Size
FC1ds	37.8	5
FC1us	32.2	5
FC2ds	16.3	6
FC2us	18.6	6
FC3ds	29.8	6
FC3us	25.2	6
FC4ds	27.4	6
FC4us	15.9	6
FC5us	13.5	2
Total	24.5	48

Kruskal-Wallis Statistic 16.3434
P-Value, Using Chi-Squared Approximation 0.0377

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	8	2694.23	336.779	2.60	0.0222
Within	39	5053.77	129.584		
Total	47	7748.00			

Total number of values that were tied 32
Max. diff. allowed between ties 0.00001

Cases Included 48 Missing Cases 0

Non-Stickleback Catch per Day (24 hour period) by Upstream vs. Downstream from Stream Crossings, July 2004. Wilcoxon Rank Sum Test

US/DS	Rank Sum	N	U Stat	Mean Rank
ds	630.00	23	354.00	27.4
us	546.00	25	221.00	21.8
Total	1176.0	48		

Normal Approximation with Corrections for Continuity and Ties 1.485
Two-tailed P-value for Normal Approximation 0.1375

Total number of values that were tied 32
Maximum difference allowed between ties 0.00001

Cases Included 48 Missing Cases 0

Stickleback Catch per Day (24 hour period) by Site, July 2004.
Kruskal-Wallis One-Way Nonparametric Analysis of Variance

Site	Mean Rank	Sample Size
FC1ds	20.0	5
FC1us	25.6	5
FC2ds	39.7	6
FC2us	16.6	6
FC3ds	17.7	6
FC3us	26.9	6
FC4ds	41.2	6
FC4us	12.0	6
FC5us	12.0	2
Total	24.5	48

Kruskal-Wallis Statistic 29.2088
P-Value, Using Chi-Squared Approximation 0.0003

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	8	5095.38	636.923	8.00	0.0000
Within	39	3103.62	79.580		
Total	47	8199.00			

Total number of values that were tied 27
Max. diff. allowed between ties 0.00001

Cases Included 48 Missing Cases 0

Stickleback Catch per Day (24 hour period) by Upstream vs. Downstream from Stream Crossings, July 2004
Wilcoxon Rank Sum Test

US/DS	Rank Sum	N	U Stat	Mean Rank
ds	691.00	23	415.00	30.0
us	485.00	25	160.00	19.4
Total	1176.0	48		

Normal Approximation with Corrections for Continuity and Ties 2.778
Two-tailed P-value for Normal Approximation 0.0055

Total number of values that were tied 27
Maximum difference allowed between ties 0.00001

Cases Included 48 Missing Cases 0

Comparison of non-Stickleback Species Length Frequency Distributions Between FC4ds and all Sites Downstream from FC4ds, July 2004.
Wilcoxon Rank Sum Test

Below_4	Rank Sum	N	U Stat	Mean Rank
1	2841.5	69	426.50	41.2
2	479.50	12	401.50	40.0
Total	3321.0	81		

Normal Approximation with Corrections for Continuity and Ties 0.160
 Two-tailed P-value for Normal Approximation 0.8732

Total number of values that were tied 17
 Maximum difference allowed between ties 0.00001

Cases Included 81 Missing Cases 53