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A Model of the Effect of Incremental Increases in Sport Fishing on Population Structure of Arctic Grayling above Devil Canyon

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INTRODUCTION

The opening of access roads into the proposed impoundment area can be expected to create a substantial Arctic grayling sport fishery in this previously seldom fished drainage. This study was initiated to examine the effects of increased mortality rates (due to fishing pressure) on the age structure and abundance of the Arctic grayling populations in the clear water tributaries studied to date. The results of the analysis can suggest management strategies and should be useful in the impact analysis. The predicted increased access and corresponding fishing pressure can be used with this data set to predict the cnanges that may be expected in these unexploited populations of grayling.

METHODS

Hook and line sampling methods were used to collect grayling for mark and recapture and age/length data over two open water seasons at eight major clear water tributaries to the Susitna River in the proposed impoundment. Field collection methods and data summaries are presented in ADF&G (1981) and ADF&G (1983) and are not reported here. Because hook and line methods were used to collect the data, the effects of fishing pressure can be projected from these catch records and population estimates.

The theoretical analysis of the data was developed using equations described by Ricker (1975). The equations used show the relationships between mortality, population size and age structure. The Arctic

grayling population structure in the proposed impoundment is presently assumed to be unexploited and to have natural mortality rates in a state of equilibrium.

The following equations were used to project population changes:

- (1) $N_{t+1} = N_t \times S_{tn}$ where: $N_{t+1} = Population number of age class t plus one year.$
 - Nt = Population number of age class t fish
 - S_{tn} = Natural survival rate of age t fish

 N_t and N_{t+1} are known for each age class and give estimates for S_{tn} for each age class.

In an exploited fishery then,

(2) N_{t+1} = N_t X S_{tn+F} where: S_{tn+F} = Survival rate of age t
fish after combined
natural and fishing
mortalities.

The annual total mortality rate, A, is related to S, as:

(3) $A_{tn+F} = 1 - S_{tn+F}$ and,

(4) $S_{tn+F} = e^{-Z_t}$ and, where: $Z_t = Instantaneous rate of total mortalities of age t fish.$

(5) $Z_t = F_t + M_t$ and,	where:	Ft	=	Instantaneous rate of fishing mortality of age class t fish.
(6) M _t = -1n S _{tn}	where:	M _t	=	Instantaneous rate of natural mortalities of age class t fish

Since M_t is available from N_t and N_{t+1} data, it is possible to substitute (model) values of F_t for a hypothetical fishery and predict the resulting age structure of the population with time. To do this, the following assumptions are made. (1) The rate of catch for each age class of fish per unit of fishing effort experienced by ADF&G will hold true for the general public. (2) Only grayling of age III and older are subject to increased mortality by (hook and line) fishing. (3) Recruitment of age II class fish is constant.

In an exploited system then, F_t is viewed as:

f = fishing effort, (98.25 hrs or 6.05 hrs/mile stream).

and q_{+} is estimated from:

(8) $q_t = -\ln (1-u_t)$ using,

The term u_t is called the rate of exploitation and was calculated from the mark-recapture fishing data found in ADF&G (1983).

Calculation of the annual total mortality rate (A_{tn+F}) n equation (3) thus allows calculation of predicted catch at different levels of exploitation.

(10) $A_{tF} = A_{tn+F} - (1-S_{tn})$ where: $A_{tF} = annual fishing mortality$ $A_{tn} = 1-S_{tn} = annual natural mortality$

(11)
$$C_t = \sum_{t = III}^{t = VIII} A_{tF} X N_t$$
 $C_t = total catch$

A model of the maximum sustained yield of Arctic grayling at various levels of fishing effort was constructed. The analytical formula and data were manipulated using a microcomputer and a commercial spreadsheet software entitled $SuperCalc^R$.

Fishing pressure, f, and the exploitation coefficient, $u_{(t)}$, were taken from R/M' values limited to the July and August 1982 samplings. This restriction most closely fulfills the "closed system assumption" (no inor outmigration) because there is little migration occurring in July and August, thus improving the level of certainty in the model.

Appendix Table I-1 summarizes the July catch and effort. The fishing pressure (f) value, which was varied to calculate C_t in the model, was taken as multiples of the mean effort (mean hours fished per mile = 6.05) reported during this period. An f value of 1.0 was set equal to an effort of 6.05 hours/mile per year.

The effects of exploitation on recruitment was also examined briefly in a separate analysis. This analysis assumed no effect of spawner reduction on recruitment of Age II grayling until the population of spawners is reduced to 10 percent of the unexploited population in year 1982. Two generations after the population of spawners is reduced to this level, the decrease in the Age II population is reduced linearly as a function of the remaining proportion of spawners.

RESULTS

Appendix Table I-2 presents the calculated maximum sustained catches resulting from differing levels of fishing pressure (f). Appendix Figure I-1 graphically illustrates these calculations. The calculated rate of fishing pressure for maximum sustained catch (of all age classes greater than II) is less than 1,000 fish/year.

Impoundment River <u>Fished</u>	Miles of River Fished	Hours Fished	Catch	CPUE	Hours Fished Per Mile	Fish Per <u>Mile</u>
Oshetna	2.2	21.25	288	13.6	9.66	1103
Goose	1.2	6.75	91	13.5	5.63	791
Jay	3.5	12.00	130	1C 3	3.43	455
Kosina	4.5	31.50	491	15.6	7.00	1232
Watana	4.0	18.00	175	9.7	4.50	324
Deadman	0.3	4.50	51	11.3	15.0	1835
Tsusena	0.4	3.00	29	9.7	7.5	
Fog	0.2	1.25	5	4.0	6.25	440
Total	16.3	98.25	1260			
Mean				12.8	6.05	665

Appendix Table I-1. Summary of catch and effort made during the July 1982 proposed impoundment grayling tag and recapture sampling program. -

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		Re	lative fish	ing pressu	re (f) = .	00		Total Population	Population of	Spawners
				Age Class	Age III	Spawners	Percent			
	11		1V	v	VI	V11	V111	and Older Fish	(Age V & Older)	of Tota Population
Natural Instantaneous Mortality (M)		.90	.46	. 27	. 77	.78	1.06			
Natural Survival (S)		.41	.63	.85	.46	.46	.35			
Fishing Mortality (F)		.00	.00	.00	.00	.00	.00			
Mark/Recapture (R/M') Ratio		.04	.09	.14	. 24	. 20	.26			
Total Instantaneous Mortality (Z)		.90	.46	.17	.77	.78	1.06			
Total Mortality (A_{n+F})		.59	.37	.15	. 54	. 54	.65			
Total Survival (S _{n+F})		.41	.63	.85	.46	.46	.35			
Numbers of Fish Year										
1982 1983 1984 1985 1986 1987 1988 1989 1990 1991	11363 11363 11363 11363 11363 11363 11363 11363 11363 11363	4602 4602 4602 4602 4602 4602 4602 4602	2904 2904 2904 2904 2904 2904 2904 2904	2454 2454 2454 2454 2454 2454 2454 2454	1134 1134 1134 1134 1134 1134 1134 1134	521 521 521 521 521 521 521 521 521 521	180 180 180 180 180 180 180 180 180 180	11795 11795 11795 11795 11795 11795 11795 11795 11795 11795 11795	4289 4289 4289 4289 4289 4289 4289 4289	36 36 36 36 36 36 36 36 36 36 36

Appendix Table I-2. Results of age class and total population calculations at variable levels of fishing pressure.

		Re	lative fish	ning pressu	ire (f) = .	50		Total	Population	Spawner
	-	Relative fishing pressure (f) = .50 Age Class 11 111 V VI N .90 .46 .17 .77 .3 .41 .63 .85 .46 .4 .02 .05 .07 .13 .3 .04 .09 .14 .24 .3 .04 .09 .14 .24 .3 .04 .09 .14 .24 .3 .04 .09 .14 .24 .3 .40 .60 .79 .40 .4 .60 .40 .21 .60 .5 .40 .60 .79 .40 .4 .40 .60 .79 .40 .4						Age III	Spawners	as a Percent
	11	_111_	_IV_	_ <u>v</u>	VI		VIII	and Older Fish	(Age V & Older)	of Total Population
Natural Instantaneous Mortality (M)		.90	.46	.17	.77	.78	1.06			
Natural Survival (S)		.41	.63	.85	.46	.46	.35			
Fishing Mortality (F)		.02	.05	.07	.13	.11	.15			
Mark/Recapture (R/M') Ratio		.04	.09	. 14	. 24	. 20	. 26			
Total Instantaneous Mortality (Z)		.93	.51	.24	. 91	. 89	1.21			
Total Mortality (A _{n+F})		.60	.40	.21	.60	.59	.70			
Total Survival (S _{n+F})		.40	.60	.79	.40	.41	.30			
Numbers of Fish Year										
1982 1983 1984 1985 1986 1987 1988 1989 1990 1991	11363 11363 11363 11363 11363 11363 11363 11363 11363 11363	4602 4500 4500 4500 4500 4500 4500 4500 45	2904 2773 2712 2712 2712 2712 2712 2712 2712	2454 2280 2177 2129 2129 2129 2129 2129 2129 2129	1134 992 921 880 860 860 860 860 860 860	521 467 408 379 362 354 354 354 354 354 354	180 155 139 122 113 108 105 105 105	11795 11166 10857 10720 10675 10662 10660 10660 10660 10660	4289 3893 3646 3509 3464 3451 3448 3448 3448 3448 3448	36 35 34 32 32 32 32 32 32 32

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		Re	lative fish	Total	Population	Spawner				
				Age Class		Age III	Spawners	as a Percent		
		111	<u>IV</u>	_v_	VI	VII	V111	Fish	(Age V & Older)	Population
Natural Instantaneous Mortality (M)		. 90	.46	.17	.77	.78	1.06			
Natural Survival (S)		. 41	.63	.85	.46	.46	.35			
Fishing Mortality (F)		. 04	.09	.15	. 27	.22	.30			
Mark/Recapture (R/M') Patio		.04	.09	.14	.24	.20	. 26			
Total Instantaneous Mortality (Z)		. 95	.55	.32	1.04	1.00	1.36			
Total Mortality (A _{n+F})		.61	.42	.27	.65	.63	.74			
Total Survival (S _{n+F})		. 39	.58	.73	.35	.37	. 26			
Numbers of Fish Year										
1982 1983 1984 1985 1986 1987 1988 1989 1989 1990 1991	11363 11363 11363 11363 11363 11363 11363 11363 11363 11363	4602 4400 4400 4400 4400 4400 4400 4400	2904 2648 2532 2532 2532 2532 2532 2532 2532 253	2454 2118 1931 1846 1846 1846 1846 1846 1846 1846	1134 868 749 683 653 653 653 653 653 653	521 418 320 276 252 241 241 241 241 241	180 134 107 82 71 65 62 62 62 62 62	11795 10585 10038 9819 9753 9736 9733 9733 9733 9733	4289 3537 3107 2887 2822 2804 2801 2801 2801 2801	36 33 29 29 29 29 29 29

		Re	lative fish	ing pressu	ire (f) = 2	2.00		Total	Population	Spawners
				Age Class		Population Age III	of Spawners	as a Percent		
	11	_111_	<u></u>		_ <u>vi</u>	VII	V111	and Older Fish	(Age V & Older)	of Total Population
Natural Instantaneous Mortality (M)		.90	.46	.17	.77	.78	1.06			
Natural Survival (S)		.41	.63	.85	.46	.46	.35			
Fishing Mortality (F)		.09	.18	. 29	.54	.44	. 59			
Mark/Recapture (R/M') Ratio		.04	.09	.14	.24	.20	.26			
Total Instantaneous Mortality (Z)		.99	. 64	.46	1.31	1.22	1.66			
Total Mortality (A _{n+F})		.63	.48	.37	.73	.70	.81			
Total Survival (S _{n+F})		.37	.52	.63	. 27	.30	. 19			
Numbers of Fish Year										
1982 1983 1984 1985 1986 1987 1988 1989 1990 1991	11363 11363 11363 11363 11363 11363 11363 11363 11363 11363	4602 4206 4206 4206 4206 4206 4206 4206	2904 2415 2208 2208 2208 2208 2208 2208 2208 220	2454 1828 1520 1389 1389 1389 1389 1389 1389 1389 1389	1134 664 494 411 376 376 376 376 376 376 376	521 335 196 146 121 111 111 111 111 111	180 99 64 37 28 23 21 21 21 21 21	11795 9547 8688 8397 8328 8313 8311 8311 8311 8311	4289 2926 2274 1984 1914 1899 1897 1897 1897 1897	36 31 26 24 23 23 23 23 23 23 23

		Re	lative fish	ing pressu	ire (f) = 4	.0		Total	Population	Spawners
				Population Age III	of Spawners	as a Percent				
	11		<u> </u>	V	VI	<u></u>	V111	Fish	& Older)	Population
Natural Instantaneous Mortality (M)		.90	.46	.17	.77	.78	1.06			
Natural Survival (S)		.41	.63	.85	.46	.46	.35			
Fishing Mortality (F)		.18	.37	. 59	1.07	.88	1.19			
Mark/Recapture (R/M') Ratio		.04	.09	.14	.24	.20	.26			
Total Instantaneous Mortality (Z)		1.08	.83	.76	1.84	1.66	2.25			
Total Mortality (A _{n+F})		.66	.56	.53	.84	.81	.89			
Total Survival (S _{n+F})		.34	. 44	.47	.16	.19	.11			
Numbers of Fish Year										
1982 1983 1984 1985 1986 1987 1988 1989 1990 1991	11363 11363 11363 11363 11363 11363 11363 11363 11363 11363	4602 3844 3844 3844 3844 3844 3844 3844 384	2904 2009 1678 1678 1678 1678 1678 1678 1678 1678	2454 1361 942 787 787 787 787 787 787 787 787	1134 388 215 149 124 124 124 124 124	521 216 74 41 28 24 24 24 24 24 24 24	180 55 23 8 4 3 2 2 2 2 2	11795 7873 6776 6506 6466 6460 6459 6459 6459 6459	4289 2020 1254 984 938 937 937 937 937	36 26 19 15 15 15 15 15 15

		Re	lative fish	ning pressu	ire (f) = 6	5.0		Total	Population	Spawners
				Age Class		-		Age III	Spawners	as a Percent
	11	_111	11	v	VI	VII	VIII	and Older Fish	(Age V & Older)	Population
Natural Instantaneous Mortality (M)		.90	.46	.17	.77	.78	1.06			
Natural Survival (S)		.41	.63	.85	.46	.46	.35			
Fishing Mortality (F)		.27	.55	.88	1.61	1.32	1.78			
Mark/Recapture (R/M') Ratio		.04	.09	.14	. 24	.20	. 26			
Total Instantaneous Mortality (Z)		1.17	1.01	1.05	2,38	2.10	2.85			
Total Mortality (A _{n+F})		.69	. 64	.65	.91	.88	. 94			
Total Survival (S _{n+F})		.31	.36	.34	.09	.12	.06			
Numbers of Fish Year										
1982 1983 1984 1985 1986 1987 1988 1989 1990 1991	11363 11363 11363 11363 11363 11363 11363 11363 11363 11363	4602 3513 3513 3513 3513 3513 3513 3513 351	2904 1671 1276 1276 1276 1276 1276 1276 1276	2454 1014 583 445 445 445 445 445 445	1134 227 94 54 41 41 41 41 41	521 139 28 11 7 5 5 5 5 5 5	180 30 8 2 1 0 0 0 0	11795 6594 5502 5301 5283 5281 5281 5281 5281 5281	4298 1410 713 512 494 492 492 492 492 492	36 21 13 10 9 9 9 9 9

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		Re	lative fist	ning pressu	ire (f) = 8	.0		Total	Population	Spawners
				Age Class				Population Age 111	of Spawners	as a Percent
	11	_111	1V	v	VI	VII	VI11	Fish	(Age V & Older)	Population
Natural Instantaneous Mortality (M)		.90	.46	. 17	.77	.78	1.06			
Natural Survival (S)		.41	.63	.85	.46	.46	.35			
Fishing Mortality (F)		.36	.74	1.18	2.14	1.77	2.38			
Mark/Recapture (R/M') Ratio		.04	.09	.14	.24	.20	. 26			
Total Instantaneous Mortality (Z)		1.26	1.20	1.35	2.92	2.54	3.44			
Total Mortality (A _{n+F})		.72	.70	.74	.95	.92	.97			
Total Survival (S _{n+F})		.28	.30	. 26	.05	.08	.03			
Numbers of Fish Year										
1982 1983	11363 11353	4602 3211	2904 1390	2454 755	1134 133	521 89	180 17	11795 5595	4289 994	36 1
1984 1985 1986 1987	11363 11363 11363	3211 3211 3211	970 970 970	252 252 252	20 14 14	3 2	0	4556 4448 4447	275 267 267	6 6 6
1988 1989 1990	11363 11363 11363	3211 3211 3211	970 970 970	252 252 252	14 14 14	1	000	4447 4447 4447	267 267 267	666
1991	11363	3211	970	252	14	1	0	4447	267	6

		Re	lative fish	ing pressu	ire (f) = 1	0.		Total	Population	Spawners
	-	Age Class			Population Age III	of Spawners	as a Percent			
	<u> </u>	_111_	1V	_ <u>v</u> _		VII	VIII	and Older Fish	(Age V & Older)	of lotal Population
Natural Instantaneous Mortality (M)		.90	.46	.17	.77	.78	1.06			
Natural Survival (S)		.41	.63	.85	.46	.46	.35			
Fishing Mortality (F)		.45	.92	1.47	2.68	2.21	2.97			
Mark/Recapture (R/M') Ratio		.04	.09	. 14	.24	.20	. 26			
Total Instantaneous Hortality (Z)		1.35	1.38	1.64	3.45	2.98	4.03			
Total Mortality (A _{n+F})		.74	.75	.81	.97	.95	.98			
Total Survival (S _{n+F})		.26	.25	. 19	.03	.05	.02			
Numbers of Fish Year										
1982 1983 1984 1985 1986 1987 1988 1989 1989 1990	11363 11363 11363 11363 11363 11363 11363 11363 11363 11363	4602 2934 2934 2934 2934 2934 2934 2934 293	2904 1156 737 737 737 737 737 737 737 737	2454 562 224 143 143 143 143 143 143 143	1134 78 18 7 5 5 5 5 5 5 5 5	521 57 4 1 0 0 0 0 0 0	180 9 1 0 0 0 0 0 0	11795 4797 3918 3822 3819 3819 3819 3819 3819 3819	4289 707 247 151 148 147 147 147 147 147	36 15 6 4 4 4 4 4 4 4



Appendix Figure I-1. Sustained yield of Arctic grayling for different levels of fishing pressure. The f value represents multiples of 6.05 hrs per mile of hook and line sport fishing per year.

An additional calculation was made at this point to estimate the maximum sustained yield if catch (mortalities) are limited to individuals VI and older (approximately 350 mm and greater in length). The maximum sustained yield under these conditions occurs at f = 1.5 and is estimated to be less than 100 fish per year. The total harvest of all size classes of fish older than age II is about 650 fish per year at the same level of f. By comparison, the maximum sustained yield is 950 fish per year (which occurs at f = 4.5) when all age classes are harvested.

These values assume equal distribution of effort and success levels similar to those experienced in the field by the ADF&G crews while collecting this data. If access is not limiting, the distribution of fishermen will probably parallel the relative densities of fish.

Possible effects of higher levels of exploitation on recruitment are presented in Appendix Table I-3 and illustrated in Appendix Figure I-2. Under baseline conditions, 36% of the age III and older fish are spawners. At the higher rates of exploitation, this number drops off rather rapidly. Although recruitment is probably in excess of what is required under the current conditions, the projected decrease in the number of the spawners at the high rates of exploitation is probably sufficient to affect recruitment. Using the assumptions of the model and assuming a linear decrease in recruitment following a decrease of spawning aged fish to 10% of the non-exploited population, the number of fish caught annually rapidly decreases when f = 8 (48.8 hrs/mile of river).

	Total Number Spawn				
	Total Number of	of Age VI and	Total Catch All Age	as a Percent of	
Year	Spawners (Age V & Older)	Older Fish Caught	Classes (Age III & Older)	Total Population	
1982	4289	646	3083	36	
1983	1410	139	1427	21	
1984	713	46	1014	13	
1985	512	24	924	10	
1986	494	18	917	9	
1987	492	17	916	9	
1988	492	17	916	9	
1989	492	17	916	9	
1990	492	17	916	9	
1991	492	17	916	9	
1992	492	17	916	9	
1993	492	17	916	9	
1994	492	17	916	9	
1995	492	17	916	9	
1996	492	17	916	9	
1997	492	17	916	9	
1998	492	17	916	9	
1999	492	17	916	9	
2000	492	17	916	9	
2001	492	17	916	9	
2002	492	17	916	9	

Appendix Table 1-3. Results of analysis of effects of decreasing spawner populations caused by fishing pressure on twenty year catch rates.

		Total Number		Spawners
	Total Number of	of Age VI and	Total Catch All Age	as a Percent of
Year	Spawners (Age V & Older)	Older Fish Caught	Classes (Age III & Older)	Total Population
1982	4289	668	3244	36
1983	1291	127	1424	20
1984	622	39	999	12
1985	438	19	912	9
1986	423	14	906	8
1987	421	13	906	8
1988	421	13	906	8
1989	421	13	901	8
1990	421	13	894	8
1991	415	13	890	8
1992	414	13	885	8
1993	414	13	889	8
1994	414	13	885	8
1995	414	13	879	8
1996	408	13	875	8
1997	406	13	874	8
1998	406	13	873	8
1999	406	13	869	8
2000	406	13	863	3
2001	401	13	859	8
2002	399	13	858	8

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Year	Total Number of Spawners (Age V & Older)	Total Number of Age VI and Older Fish Caught	Total Catch All Age Classes (Age III & Older)	Spawners as a Percent of Total Populatio
1982	4289	686	3395	36
1983	1182	115	1415	19
1984	543	32	983	11
1985	374	15	898	8
1986	362	11	894	7
1987	361	10	893	7
1988	361	10	847	8
1989	361	10	794	9
1990	319	10	760	8
1991	306	9	753	8
1992	304	9	753	7
1993	304	9	716	8
1994	304	9	672	9
1995	271	9	643	8
1996	259	8	635	8
1997	257	7	634	7
1998	256	7	605	8
1999	256	7	569	9
2000	230	7	543	8
2001	219	6	536	8
2002	216	6	534	7

Year	Total Number of Spawners (Age V & Older)	Total Number of Age VI and Older Fish Caught	Total Catch All Age Classes (Age III & Older)	Spawners as a Percent of Total Population
1982	4289	717	3672	36
1983	994	93	1386	18
1984	416	22	945	9
1985	275	9	869	6
1986	267	6	866	6
1987	267	6	853	6
1988	267	6	715	8
1989	259	6	599	9
1990	176	6	544	6
1991	167	4	539	6
1992	166	4	531	6
1993	166	4	450	8
1994	161	4	377	9
1995	112	4	341	6
1996	104	3	336	6
1997	103	2	331	6
1998	103	2	283	8
1999	101	2	237	9
2000	72	2	213	7
2001	65	2	209	6
2002	64	1	206	6

	Total Number of	Total Number of Age VI and	Total Catch All Age	Spawners as a Percent of
Year	Spawners (Age V & Older)	Older Fish Caught	Classes (Age III & Older)	Total Population
1982	4289	741	3918	36
1983	837	75	1344	16
1984	3)	14	906	8
1985	203	6	838	5
1986	198	4	836	5
1987	198	4	730	6
1988	198	4	541	9
1989	150	4	425	8
1990	96	3	389	5
1991	92	2	386	5
1992	91	2	339	6
1993	91	2	254	9
1994	70	2	199	8
1995	46	1	180	5
1996	43	1	178	5
1997	42	1	144	7
1998	42	1	98	11
1999	26	1	71	8
2000	16	0	62	5
2001	15	õ	61	5
2002	15	0	50	7

		Total Number of	Total Number of Age VI and	Total Catch All Age	Spawners as a Percent of
Y	'ear	Spawners (Age V & Older)	Older Fish Caught	Classes (Age III & Older)	Total Population
1	982	4289	760	4137	36
1	983	707	60	1296	15
1	984	247	10	866	6
1	985	151	3	807	4
1	986	148	2	806	4
1	987	147	2	623	6
1	988	147	2	407	9
1	989	87	2	302	6
1	990	53	1	278	4
1	991	51	1	277	4
1	992	51	1	216	6
1	993	51	1	143	9
1	994	31	1	105	7
1	995	19	0	96	4
1	996	18	0	95	4
1	997	17	0	75	6
1	998	17	0	50	9
1	999	11	0	37	7
2	2000	7	0	33	4
2	2001	6	0	33	4
2	2002	6	0	29	5



Appendix Figure I-2. Effort of heavy fishing pressure on Arctic grayling catch rates assuming effort of harvest on recruitment. The f value represents multiples of 6.05 hrs per mile of hook and line sport fishing per year.

CONCLUSION

The model demonstrates that in a closed system fishery, where fisherman access is not limiting, modest levels of fishing pressure can drastically reduce grayling population. In reality, a reduction in the numbers of large fish would probably result in a decrease in fishing pressure before the population would be eliminated. The residual fishery, after such an event, would probably reflect recruitment by immigration of stock from other areas.

Although the data collected pertains to the streams that will be inundated by the impoundment, the similarity in age structure among the streams (ADF&G 1983, Table 5-3-8) suggests that this data base may be applicable to grayling fisheries in other tributaries of the upper Susitna basin. The modeling of the available data results in age/class population structures presently found in exploited grayling systems in other parts of interior Alaska (Armstrong 1982; Grabacki 1981).

The spreadsheet program used in the analysis allows very rapid changes in assumptions and output of usable information with relatively little programming effort. Projections can be made given any reasonable set of assumptions concerning harvest, recruitment, management strategies, and other aspects of the population dynamics of grayling, with minor adjustments to the model presented.

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Appendix I: A model of the Effect of Incremental Increases in Sport Fishing on Population Structure of Arctic Grayling above 545Devil Canyon # 185



SUSITNA HYDRO AQUATIC STUDIES PHASE II REPORT

Synopsis of the 1982 Aquatic Studies and Analysis of Fish and Habitat Relationships

- APPENDICES -

by

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