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McDonald Lake: Stock Status and Escapement Goal Recommendations

by

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Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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The Division of Sport Fish Fishery Manuscript series was established in 1987 for the publication of technically-oriented results of several years' work undertaken on a project to address common objectives, provide an overview of work undertaken through multiple projects to address specific research or management goal(s), or new and/or highly technical methods. Since 2004, the Division of Commercial Fisheries has also used the Fishery Manuscripts series. Fishery Manuscripts are intended for fishery and other technical professionals. Fishery Manuscripts are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

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ABSTRACT

McDonald Lake is one of the largest sockeye salmon (*Oncorhynchus nerka*) producing system in southern Southeast Alaska, and there has been no summary of the status of this stock in 25 years. The modern stock assessment history evolved from studies in support of a large-scale lake fertilization project. Fertilization of the lake occurred from 1982 to 2004, and there is a substantial base of limnological measurements associated with that effort. Escapement was measured with a counting weir from 1981 to 1984. During 1983 and 1984, the biologists studying McDonald Lake developed a systematic series of foot surveys as an inexpensive way to maintain a meaningful escapement measure. We assume the sum of these foot-survey counts represent about 75% of the total escapement, based on only two years of calibration. We developed three hypothetical series, or cases, of harvest statistics, using various assumptions. Because all three of these harvest cases require escapement estimates in their calculation, our total stock assessment picture for this lake is somewhat murky. Even so, these data show a pattern of generally stable escapements until 1993 and lower escapements later in the 1990s, when returning adults projected to be in excess of escapement goal were harvested in a directed terminal fishery in west Behm Canal. Since 2001, escapements generally fell further, as did harvest. We recommend revising the escapement goal for this system from the current range of 65,000 to 85,000 to a new range of 70,000 to 100,000 adult spawners, and recommend that this goal be classified as a *sustainable escapement goal*. Although the stock does seem to be in a period of persistent lowered recruitment, the performance of this system does not yet meet any of the criteria of a *stock of concern*, as defined in Alaska's Sustainable Salmon Fisheries Policy (5 AAC 39.222).

Key words: escapement, escapement goal, escapement goal ranges, fry stocking, harvest, hydroacoustics, lake fertilization, limnology, McDonald Lake, *Oncorhynchus nerka*, sockeye salmon, stock status

INTRODUCTION

McDonald Lake, located on the Southeast Alaska mainland, approximately 70 km north of Ketchikan (Figure 1), has been considered the largest sockeye salmon (*Oncorhynchus nerka*) producing system in southern Southeast Alaska (Geiger et al. 2004). Like most other major sockeye salmon systems in Southeast Alaska, the McDonald Lake run has a history of commercial exploitation and hatchery operation during the late 19th and early 20th centuries (Roppel 1982). More recently, McDonald Lake was the target of a long-term enhancement project initiated by the Alaska Department of Fish and Game (ADF&G) in the late 1970s, and carried out via lake fertilization from 1982 to 2004. Over most of the enhancement period, runs of sockeye salmon to McDonald Lake were strong, with estimated escapements averaging over 90,000 fish per year. An undocumented escapement goal of 65,000–85,000 sockeye salmon was established in 1993, and this goal was adopted as a *biological escapement goal*[1] in 2003 (Geiger et al. 2004). The stock was actively managed during the 1990s, and fish that were expected to be in excess of the escapement goal were harvested in near terminal purse seine fisheries in upper west Behm Canal. Peak harvests were 150 thousand sockeye salmon in 1993, worth an exvessel value of $0.75 million, and 250 thousand sockeye salmon in 1996, worth an exvessel value of $1.5 million. The McDonald Lake stock has supported the largest personal-use fisheries in southern Southeast Alaska, with a maximum reported harvest of more than 10,000 fish in 1994. McDonald Lake sockeye salmon were also used as a brood source for stocking projects at a number of other sites in southern Southeast Alaska. Over the past five years, however, the sockeye salmon run to McDonald Lake has declined, and estimated escapements were below the escapement goal in 4 of the last 5 years, 2001–2005.

Our first goal is to review the information we have on the recent management and enhancement efforts, which as far as we know, has not been published or reviewed in the last 25 years. This review will include a description of the stock assessment measures for the system, a description and listing of enhancement activities, including fish stocking, lake fertilization, and fish transport.

[1] That is a goal with the intent of maintaining the maximum sustainable catch for the system.

Our second goal is to recommend an escapement level for this system, and document our methods and rationale. Because we were unable to develop a reasonable and statistically defendable stock-recruit relationship for this system, suitable for forecasting the benefits of altering the escapement level, we will recommend a *sustainable escapement goal*[2].

Our third goal is to comment on the performance of the stock and report on this stock's status as a fishery resource, as required under Alaska's Sustainable Salmon Fisheries Policy (5 AAC 39.222). As a part of that review, we will recommend a more focused stock assessment effort, and a more extensive effort to measure escapement into the system.

STUDY SITE

McDonald Lake is located in the Tongass National Forest, approximately 70 km north of Ketchikan, Southeast Alaska, on the Cleveland peninsula (Figure 1; 55^o 55' 59" N Lat., 131^o 47' 48" W Long.). The lake is situated within a heavily forested watershed of 118 km^2 (Olson 1989), and has a surface are of 420 ha, a mean depth of 45.6 m, and a maximum depth of 110 m (Zadina and Heinl 1999). The lake is organically stained with a volume of 197 x 10^6 m^3 with a residence time of approximately 0.67 years (Zadina and Heinl 1999; Olson 1989). The primary inlet stream and spawning grounds, Hatchery Creek (ADF&G stream number 101-80-10680-2030; also know as Walker Creek), flows south west 9.6 km to the head of the lake. Movement of salmon into Hatchery Creek is blocked by a barrier falls approximately 1.5 km upstream of the lake. The outlet stream, Wolverine Creek (ADF&G stream number 101-80-10680), flows south 2.4 km to Yes Bay, in West Behm Canal.

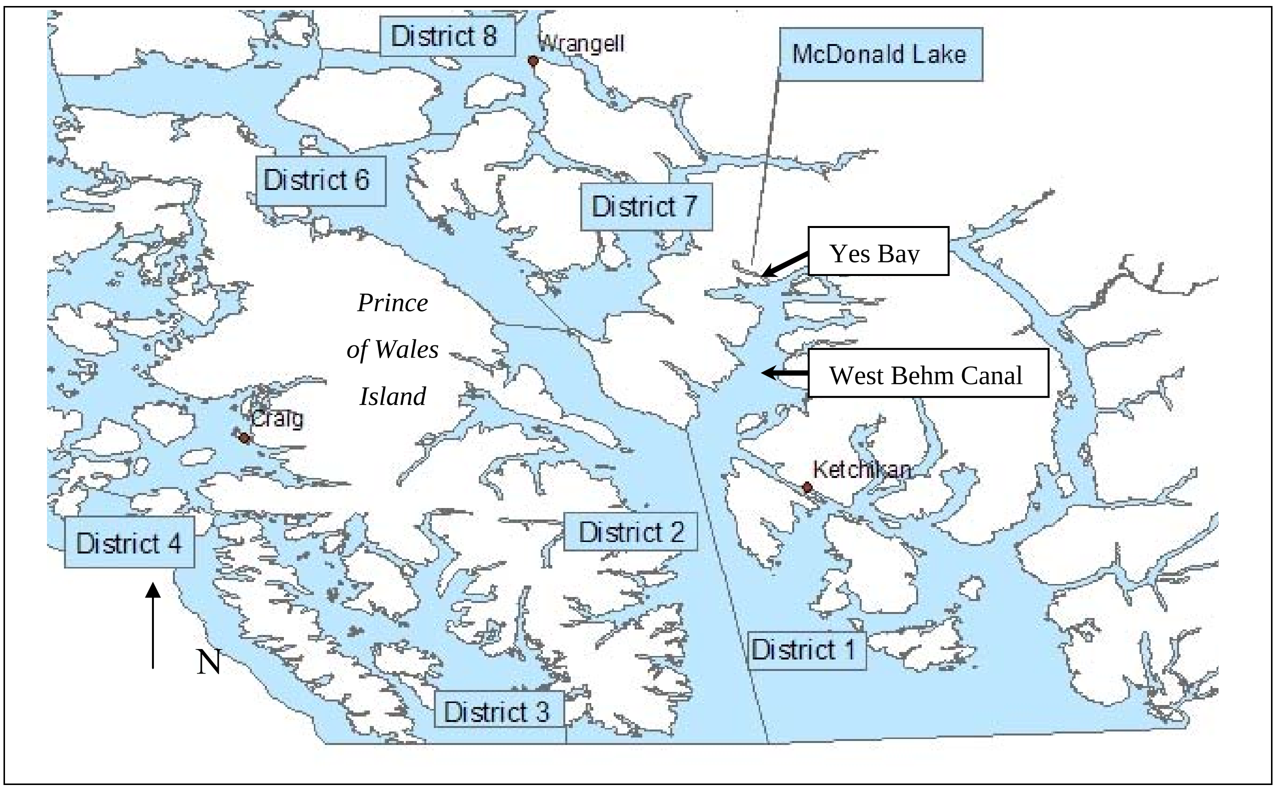

Figure 1.–Southern Southeast Alaska, showing ADF&G management districts and the location of McDonald Lake.

[2] Essentially a range of escapements that have been shown to be sustainable in the past.

HISTORICAL STATUS

Most of the historical information about McDonald Lake was provided by Roppel (1982), and the following is taken from her account. The McDonald Lake run supported a cannery located at Yes Bay during the late 19th and early 20th centuries. Between 1893 and 1904, sockeye harvests in the vicinity of Yes Bay ranged from 21,500 to 80,000 fish. The area around McDonald Lake was given a special status as a hatchery reserve by presidential proclamation, and a hatchery was built at McDonald Lake in 1905. The proclamation stated that fishing was permitted only when enough salmon had entered Yes Bay to supply the maximum number of eggs required for hatchery operations, as judged by the hatchery superintendent. The hatchery superintendent could stipulate the amount, type, and place fishing could take place, but this influence was restricted to the confines of Yes Bay (Roppel 1982). Catches attributed to McDonald Lake from 1906 to 1926 were highly variable and ranged from only 11 fish to 139,000 fish. The hatchery operation started in 1905 with an egg take of 7.4 million eggs. By 1909 the hatchery had been expanded to a capacity of 72 million eggs, and egg takes met capacity in 1909 through 1911 and in 1915. Roppel (1982) made the interesting observation that in 1910 the hatchery collected 72 million eggs, but the cannery also harvested 139,000 sockeye salmon (despite the closure of the fishery). This suggests to us that the run exceeded 200,000 sockeye salmon in that year. In 1909 and 1911 the cannery reported harvests of 86,000 and 82,000 sockeye salmon, and a collection of 72 million eggs. This suggests to us that these runs were in excess of 100,000 sockeye salmon in 1909 and 1911.

The hatchery ended operations in 1932, and in 1935, the presidential proclamation reserving the water and land for fish propagation was revoked (Roppel 1982). After the hatchery closed in 1932, this system was simply not monitored for nearly 50 years. Although McDonald Lake was known to be highly productive in the early 1900s, there was apparently little information collected or recorded regarding the sockeye salmon run between 1934 and the late 1970s. ADF&G began to focus attention on this system as part of a region-wide program to rehabilitate sockeye salmon runs in Southeast Alaska and as part of a joint U.S.-Canada salmon studies.

STOCK ASSESSMENT MEASURES

ESCAPEMENT ESTIMATION

For McDonald Lake, the first escapement measures after statehood were made in 1981 and were continued through 1984, when an adult counting weir was operated at the lake as part of the joint U.S.-Canada mark-recapture studies (Hoffman et al. 1983, 1984). Weir counts were over 120 thousand in 1981 and 1984, and 56 thousand in 1983. The weir was very large (45 bipods, plus 100s of feet of fencing that extended into the woods), and difficult to maintain. The weir was overtopped by floodwaters in several years, and was known to have been a poor barrier to fish passage in 1982. The 1982 weir count of 16 thousand was considered a gross undercount of the total escapement by biologists that worked at McDonald Lake during that year.

In 1983 and 1984, ADF&G conducted a systematic series of foot surveys of spawning sockeye salmon in Hatchery Creek, and compared the count of fish observed to the final weir counts in those years. The biologists working on the system at the time saw these foot surveys as a way to develop a long-term escapement series for this system, after they no longer had funding to operate the weir. Seven foot surveys were conducted at the spawning stream on designated survey dates in 1983 and 1984: 23 August, 31 August, 10 September, 20 September, 28 September, 10 October, and 20 October. The survey dates were chosen to correspond to surveys that had been conducted on or near those dates from 1979 to 1982. The study area was defined as 1.5 km of Hatchery Creek from just upstream of the mouth (GPS coordinates: 55.992° N, 131.844° W), to a location just downstream of the barrier falls (GPS coordinates: 56.002° N, 131.840° W), and included the old hatchery side channel on the lower section of the creek. Two observers conducted surveys simultaneously, and estimated the number of live sockeye salmon in the study area. The number of live fish present was estimated to be the average of the counts of both surveyors.

In 1983, the sum of the 7 foot surveys (41,010 sockeye salmon) accounted for approximately 73% of the fish passed through the weir (56,142 sockeye salmon). In 1984, the sum of the 7 foot surveys (92,800 sockeye salmon) accounted for approximately 77% of the fish passed through the weir (121,224 sockeye salmon). Thus, the sum of the foot surveys for 1983 to 1984 averaged 75% of the weir counts in those two years. From 1985 to 1993, the total escapement to McDonald Lake was estimated by dividing the sum of the 7 foot surveys by 75%. Back-cast estimates of the escapement to McDonald Lake were also made for 1979 to 1982.

In many years, one or two surveys were not conducted due to inclement weather or high water. Values for missing surveys were interpolated for the 1979 to 1993 escapement data, using an iterative EM algorithm (McLachlan and Krishnan 1997). Survey data were arranged in a matrix table with years in columns, and designated survey dates in rows (Table 1). We assumed that the expected count for a missing survey was equal to the sum of all counts on that date, times the sum of all counts for the year divided by the sum of all counts over all dates and years (i.e., row total times column total divided by grand total). This assumes a multiplicative relation between yearly count and unit count, with no interaction. Because the foot-count schedule and the method of estimating escapements was not initiated until 1983, escapement estimates for 1979–1982 include interpolations for a larger number of surveys per year, than for estimates after 1982.

We noted that the number of spawning fish in the study area peaked earlier in the season in wet years, and later in the season in dry years (Figure 2). We classified each year from 1979 to 1993 as a normal, wet, or dry year: “wet” if the precipitation at the Ketchikan airport National Oceanic and Atmospheric Administration (NOAA) weather station was greater than 13.2 cm between 1 and 10 September, “dry” when less than 9.2 cm of precipitation was recorded between 1 and 20 September, and “normal” if precipitation did not fall into one of those two categories. Since 1993, missing surveys were interpolated based on data from years with the same precipitation classification (Table 1). The 1979–1993 data were used as a base. Each year was added to the base, so that interpolations for each subsequent year were based on the entire data set from all previous years.

Table 1.–Annual foot surveys and estimated escapement to McDonald Lake, 1979–2005.

Survey Date[a] Survey No.	23-Aug 1	31-Aug 2	10-Sep 3	20-Sep 4	28-Sep 5	10-Oct 6	20-Oct 7	Sum of Surveys	Precipitation[b]	Escapement Estimate (x 1000)	Weir Count (x 1000)
1979	2	**1,191**	5,010	6,600	**6,732**	**2,395**	**286**	22,215	normal	30	
1980	1,363	**4,714**	19,500	14,775	13,378	**2,119**	**185**	56,034	wet	75	
1981[c]	1,370	2,825	**19,550**	23,050	11,000	1,025	**195**	59,016	wet	130	130
1982	0	9,000	13,200	6,100	**7,444**	**1,410**	**123**	37,277	wet	50	
1983[c]	500	3,200	11,500	15,000	8,000	2,500	**531**	41,231	normal	55	56
1984[c]	0	12,000	21,600	27,100	24,800	7,100[d]	200	92,800	normal	124	121
1985	35	1,425	15,600	27,300	23,890	6,250	**971**	75,471	normal	101	
1986	1,500	9,000	9,200	24,900	25,400	600	**317**	70,917	dry	95	
1987	2	5,000	16,100	**46,030**	**42,530**	27,880[e]	2,800	140,342	normal	187	
1988	20	5,780	25,000	12,500	6,600	700	1	50,601	wet	67	
1989	150	165	13,000	**18,617**	24,000	100	**730**	56,763	normal	76	
1990	3	2,950	23,000	22,780	33,600	2,100	275	84,708	dry	113	
1991	304	30,000	27,770	34,300	27,000	**4,714**	579	124,667	wet	166	
1992	5	5,500	28,300	20,600	**14,948**	5,250	**248**	74,851	wet	100	
1993	4	57	3,950	14,100	37,000	4,300	370	59,781	dry	80	
1994	0	250	11,000	28,600	32,700	6,100	49	78,699	wet	105	
1995	0	918	12,975	16,130	2,260	600	**147**	33,030	dry	44	
1996	315	**2,489**	7,372	16,865	16,300	3,055	41	46,437	normal	62	
1997	0	9,533	11,775	**14,144**	13,900	1,853	128	51,333	wet	68	
1998	225	5,762	11,520	12,793	7,625	5,108	81	43,114	wet	58	
1999	355	5,202	20,557	22,540	15,940	**2,540**	54	67,188	wet	90	
2000	**109**	9,761	17,610	25,605	7,458	**7,325**	84	67,952	normal	91	
2001	213	4,910	11,275	11,656	3,700	207	**106**	32,067	wet	43	
2002	**40**	**1,253**	5,568	8,000	4,405	61	**0**	19,327	wet	26	
2003	40	9,455	15,780	20,353	16,052	5,095	139	66,914	wet	89	
2004	0	44	4,420	**5,434**	5,920	134	3	15,955	normal	21	
2005	42	205	10,200	10,375	**9,839**	3,455	**348**	34,464	normal	46	

[a] Survey dates are approximate.

[b] Bold entries have been interpolated by iteration (row total * column total/grand total) for “wet”, “dry”, or “normal” precipitation years. Years were classified as “wet” if the cumulative 1-10 Sept. precipitation totaled more than 13.2 cm at the Ketchikan airport NOAA weather station. Years were classified as “dry” if the cumulative 1-20 Sept. precipitation totaled less than 9.2 cm at the Ketchikan airport NOAA weather station.

[c] Weir counts were used for the escapement estimates in 1981, 1983, and 1984.

[d] The survey for 10 Oct. 1984 is the average of counts for 5 Oct. (14,000) and 16 Oct. (200).

[e] The survey for 10 Oct. 1987 is the average of counts for 7 Oct. (36,000) and 12 Oct. (19,760).

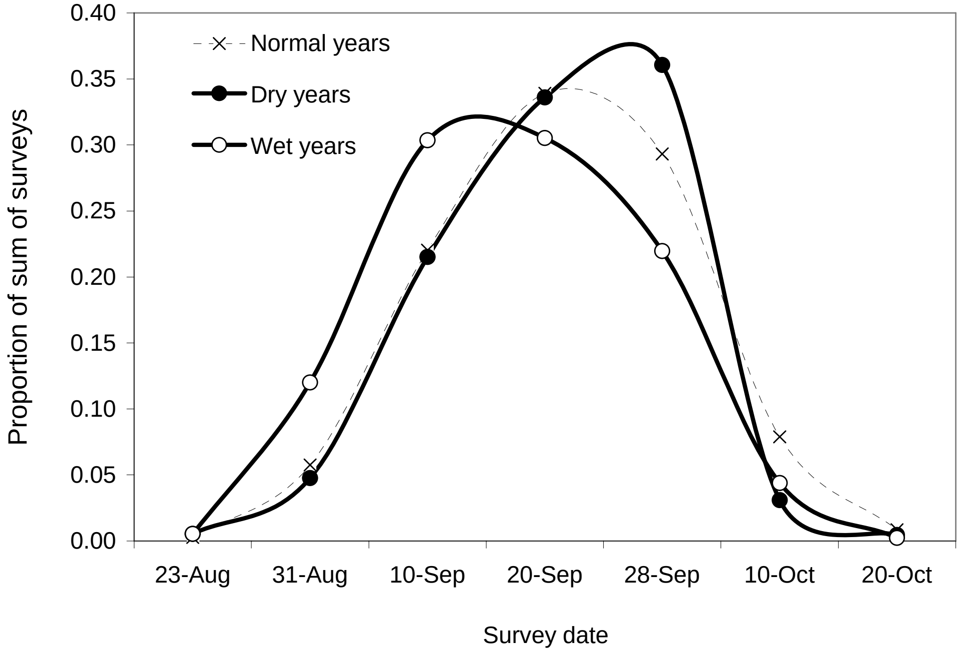

Figure 2.–Average run timing of McDonald Lake sockeye salmon into the spawning stream for years classified as normal, wet, or dry precipitation.

HARVEST ESTIMATES

Because much of the commercial harvest of the McDonald Lake stock takes place in distant, mixed-stock fisheries, we do not have the same kind of comprehensive commercial harvest information for this stock that we have for some other sockeye stocks in the state. Some information regarding the distribution of McDonald Lake sockeye salmon in U.S.-Canada boundary area fisheries was provided by joint U.S.-Canada mark-recapture studies conducted in 1982 (Hoffman et al. 1983), and 1983 (Hoffman et al. 1984). The best information that we have is limited to adult returns from coded wire tagging studies conducted by ADF&G in the 1980s through early 1990s. Both studies showed that the McDonald Lake stock migrates around Prince of Wales Island through Sumner and Clarence straits to the north, and Dixon Entrance to the south, and is harvested in all the Alaskan commercial fisheries and gear groups from Districts 101 through 107, and in British Columbia Areas 1 and 3 (Geiger et al. 2004). McDonald Lake sockeye salmon have also been harvested in directed purse seine fisheries in upper west Behm Canal, ADF&G test fisheries in west Behm Canal, and a personal-use fishery in Yes Bay.

In the mid-1990s, runs to McDonald Lake were projected to be well above escapement needs, and beginning in 1993, sockeye salmon that had bypassed traditional fisheries, and were projected to be in excess of escapement needs, were harvested near McDonald Lake in a near-terminal purse seine fishery in upper west Behm Canal. ADF&G test fisheries were used to determine run-strength prior to commercial fishery openings. Maximum harvests occurred in 1993 (150 thousand) and 1996 (250 thousand), and harvests averaged 32 thousand sockeye salmon a year from 1997 to 2001 (Figure 3).

While we have adequate estimates of harvest in these directed purse fisheries, and in test fisheries, we do not have high quality estimates of the harvest in the personal-use fisheries in the terminal area at Yes Bay. There is no careful accounting of the personal-use take, although fishers are supposed to return permits together with a record of their catch and are required to report their catch from the previous year before they can be issued a new permit. There was no monitoring prior to about 5 years ago and only nominal penalties for non-reporting in the personal-use fishery. Even if the sum of the recorded harvest on the returned permits represents a substantial undercount, this source of mortality must typically represent less than 10% of the entire run. We simply assumed that the sum of reported catch on the returned harvest permits was adequate for our purposes. Estimated personal-use catches averaged about 5,700, from 1985–2004, with a range of about 1,100 in 1985 to 10,000 in 1994 (Figure 3). The sport fish harvest was assumed to be around 200 fish annually (Geiger et al. 2004), and likely accounted for very small fraction of the total annual run.

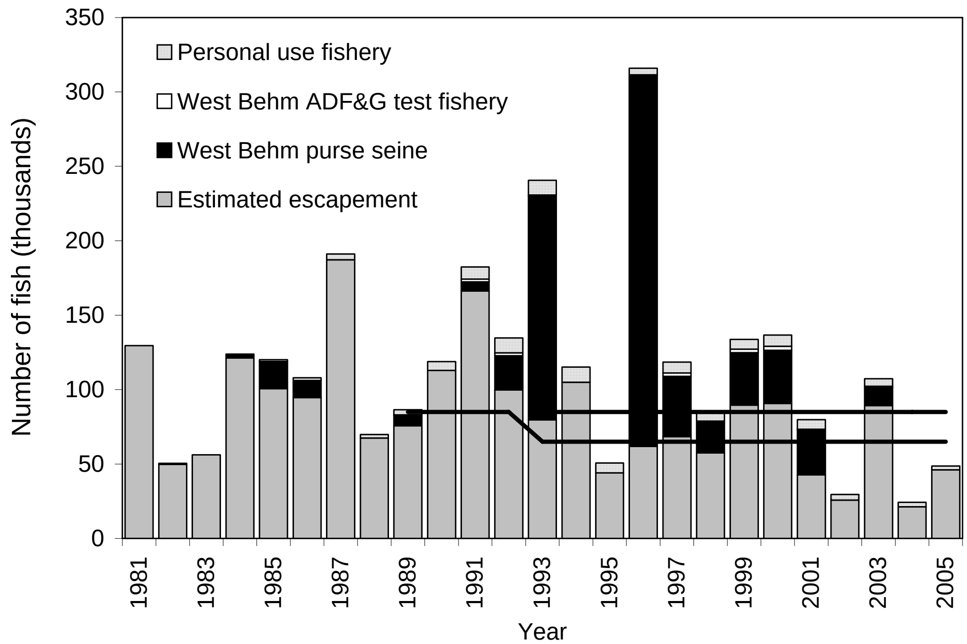

Figure 3.–Estimated escapement of McDonald Lake sockeye salmon, and estimated personal-use and terminal harvest in west Behm Canal, 1981–2005. The solid lines represent the 1989 escapement goal of 85,000, which was changed to a range of 65,000 to 85,000 in 1993.

Distant, Traditional Mixed-stock Commercial Fisheries

Most of the information on the contribution and distribution of the McDonald Lake sockeye salmon in the Alaska traditional commercial harvest comes from coded wire tag studies conducted by ADF&G in 1982–1985, and 1986–1991. Tag recoveries were expanded by fishery sample size (Clark and Bernard 1987). Useful information provided by these studies is limited to only three years of adult returns: 1985, 1989, and 1990. Tag returns in 1991 were biased by very low initial rates of tagging and recovery. Fewer than 6,000 smolts were tagged, 51% of which were tagged during the last 3 days of the 6-week tagging period, and only 112 tagged adults were recovered in the commercial fisheries.

Contributions and harvest rates of McDonald Lake sockeye salmon in both Alaska *and* British Columbia have been reported in sockeye salmon run-reconstruction analyses in Gazey and English (2000), and English et al. (2004 and *In prep*.). Those harvests were estimated in conjunction with multi-time-period sockeye salmon run-reconstruction analyses of commercial fisheries in northern British Columbia and southern Southeast Alaska by the Northern Boundary Technical Committee of the Pacific Salmon Commission (described by Gazey and English 2000). Combining the coded wire tag information and the Gazey and English reconstruction, we will present three catch series as different "cases," based on simple assumptions and statistics derived from coded wire tag estimates.

The coded wire tagging studies showed that McDonald Lake sockeye salmon were harvested primarily in the District 106 drift gillnet fishery, followed by the District 101 and 104 purse seine fisheries (Table 2). Coded wire tag recoveries in 1991 suggested that the McDonald Lake stock was harvested primarily in the District 101 fisheries; again, however, we note that the 1991 tag estimates were likely plagued by very low initial rates of tagging and inadequate catch sampling. Commercial fisheries in British Columbia were not sampled for coded wire tagged sockeye salmon at all, and estimates of the contribution of McDonald Lake sockeye salmon to Canadian fisheries are not available from the coded-wire tagging studies.

Tagged McDonald Lake sockeye salmon were recovered from the commercial fisheries from early July to early September. There were sufficient tag recoveries to examine the seasonal run timing in the District 106 drift gillnet fishery (the primary intercepting fishery) in 1989 and 1990 (Appendix A). In 1989, tagged McDonald Lake sockeye salmon were recovered in District 106 during the weeks 2 July–19 August (Statistical Weeks 27–33), and in 1990 the weeks 1 July–1 September (Statistical Weeks 27–35; Figure 4); however, in both years approximately 90% of the tags were recovered over a 5-week period during the weeks of about 9 July-11 August. The longer run timing in 1990 may simply reflect a greater abundance of McDonald Lake sockeye salmon in 1990.

The harvest rate on McDonald Lake sockeye salmon was calculated by first estimating the total harvest by statistically expanding sampled commercial fishery recoveries for the fraction of the return not tagged, based on the observed tag ratio in the escapement. The average harvest rate was estimated to be 47% of the total annual run, over the 3 years of coded wire tag recoveries, 1985, 1989 and 1990 (range: 36%–53%). Over that same span, contributions of McDonald Lake sockeye salmon were estimated to comprise an average of 7% of the sockeye salmon harvested in Districts 101–107 (range: 5%–8%). These estimates are based on estimates of escapement that we assume to be approximately known. As we have already pointed out, the estimates of escapement magnitude are based on very little information, and are in need of recalibration.

Run-Reconstruction Harvest Estimates

We used several data sources to compile three separate estimates of the total annual harvest and total run of McDonald Lake sockeye salmon, for the 22 years, 1982–2003. We estimated the commercial harvest from coded wire tagging studies of adult McDonald Lake sockeye salmon that returned in 1985, 1989, and 1990. We also used commercial harvest estimates from sockeye salmon run-reconstruction analyses in Gazey and English (2000), and English et al. (2004 and *In prep*.). The total number of sockeye salmon harvest annually in the District 101–107 commercial fisheries, the west Behm Canal ADF&G test fishery, and the Yes Bay personal-use fishery, were obtained from the ADF&G Integrated Fisheries Data Base on 22 March, 2005. The annual sport harvest of approximately 200 fish, annual brood stock harvest, and annual estimates of escapement were obtained from Geiger et al. (2004).

Table 2.–Distribution of coded wire tag recoveries of McDonald Lake sockeye salmon (expanded for variable sampling rate) in the commercial fisheries of Southeast Alaska, 1985, and 1989–1991.

	Proportion Harvested by Area and Gear				
	1985	**1989**	**1990**	**1991**	**Average**
Total Tags Recovered	47	90	190	32	
Total Expanded Tags	203	370	670	112	
District 101-11 Gillnet	7%	2%	2%	26%	9%
District 101 Annette Island Gillnet	4%	2%	7%		3%
District 101 Seine	40%[a]	8%	9%	15%	18%
District 101 Annette Island Seine	3%	---	---	5%	2%
District 101 Annette Island Trap	1%	---	---		<1%
District 102 Seine	9%	17%	9%	16%	13%
District 103 Seine	---	---	<1%		<1%
District 104 Seine	10%	13%	17%	32%	18%
District 106 Gillnet	28%	57%	56%	6%	37%
District 107 Seine	---	1%	---		<1%
District 102 Troll	---	---	<1%		<1%

[a] In 1985 nearly 60% of the expanded District 101 purse seine tags were recovered in west Behm Canal Districts 101-85 and 101-90.

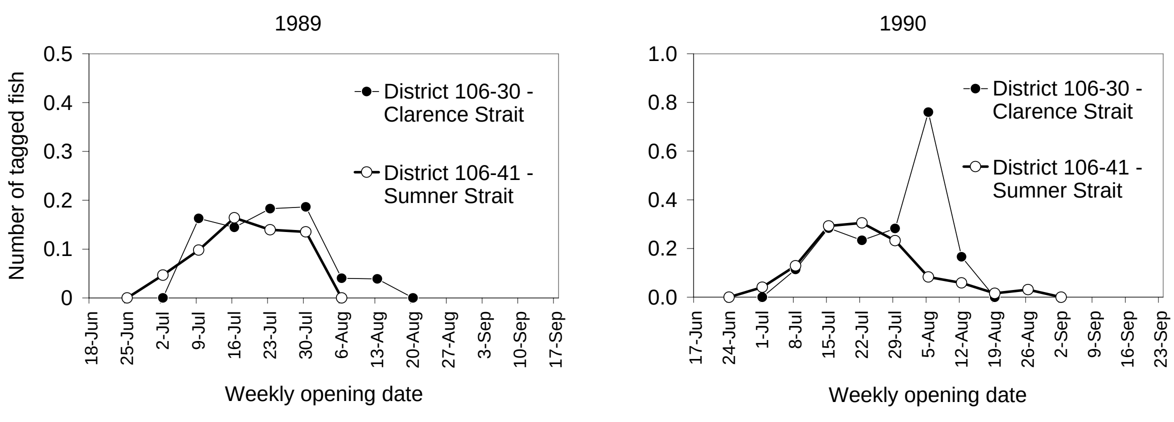

Figure 4.–Estimated catch-per-boat-per-day of coded-wire tagged McDonald Lake sockeye salmon in the District 106 drift gillnet fishery, 1989–1990.

Case 1 (the Gazey and English estimates): We used the estimates of the number of McDonald Lake sockeye salmon harvested annually in commercial net fisheries of both Alaska *and* British Columbia reported in English et al. (2004 and *In prep.*), for 1982–2003. These harvests were estimated in conjunction with multi-time-period sockeye salmon run-reconstruction analyses of commercial fisheries in northern British Columbia and southern Southeast Alaska by the Northern Boundary Technical Committee of the Pacific Salmon Commission (described by Gazey and English 2000). To those run-reconstruction estimates, we added the number of sockeye salmon harvested in ADF&G test fisheries in west Behm Canal, personal-use fisheries in Yes Bay, and sport fisheries at McDonald Lake. We also added the number of sockeye salmon that were killed for brood stock by ADF&G or the Southern Southeast Regional Aquaculture Association (SSRAA; Table 3).

Table 3.–Estimated commercial harvest and total run (in thousands) of McDonald Lake sockeye salmon, 1982–2003 based on the "Case 1" Gazey and English reconstruction. The category of all commercial harvest includes estimates taken from run-reconstruction analyses in English et al. (2004 and *In prep.*), and represents the commercial catch in Alaska and British Columbia fisheries both inside and outside of Behm Canal.

Year	All Commercial Harvest	West Behm Canal ADF&G Test Fish	Yes Bay Personal Use[a]	Assumed Sport Fish	Brood Stock	Total Estimated McDonald Harvest	Estimated Escapement	Estimated Total Run
1982	86.5	0.0	NA	0.0	0.0	86.5	49.7	136.2
1983	103.3	0.0	NA	0.0	0.0	103.3	56.1	159.4
1984	174.9	0.0	NA	0.0	0.0	174.9	121.2	296.1
1985	185.7	0.0	1.2	0.2	0.0	187.1	100.7	287.7
1986	153.0	0.0	1.8	0.2	0.0	155.0	94.6	249.6
1987	232.8	0.0	4.0	0.2	0.0	237.0	187.2	424.2
1988	99.3	0.0	2.3	0.2	2.9	104.8	67.5	172.3
1989	121.6	0.7	3.4	0.2	4.0	129.9	75.7	205.6
1990	153.4	0.4	5.7	0.2	0.6	160.4	113.0	273.4
1991	223.3	1.8	8.2	0.2	1.3	234.7	166.3	401.0
1992	215.2	1.9	9.9	0.2	2.0	229.2	99.8	329.0
1993	425.0	0.7	9.9	0.2	1.9	437.7	79.7	517.4
1994	140.8	0.1	10.2	0.2	1.4	152.8	105.0	257.7
1995	90.5	0.4	6.7	0.2	0.8	98.6	44.1	142.6
1996	535.4	0.0	4.4	0.2	0.0	540.0	61.9	602.0
1997	203.0	2.3	7.3	0.2	0.0	212.8	68.5	281.2
1998	107.3	0.6	6.1	0.2	0.0	114.3	57.5	171.8
1999	165.8	2.4	6.5	0.2	0.3	175.2	89.6	264.8
2000	167.9	2.7	7.6	0.2	0.3	178.6	90.6	269.3
2001	112.0	0.9	6.3	0.2	0.3	119.8	42.8	162.5
2002	43.5	0.5	3.7	0.2	0.2	48.1	25.8	73.9
2003	113.4	0.9	5.2	0.2	0.4	120.1	89.2	209.4

[a] Estimates of the personal-use catch for Yes Bay are not available prior to 1985.

Case 2 (average harvest rate estimates): The average harvest rate on McDonald Lake sockeye salmon in the traditional Alaskan commercial fisheries was estimated to be 47% of the total annual run, based on the 3 years of coded wire tag recoveries (range: 36%–53%). We estimated an intermediate statistic for the run of McDonald Lake sockeye salmon for 1982 to 2003, by dividing the annual escapement estimate by 53% to expand for distant harvest. We then added all sockeye salmon harvested in the terminal west Behm Canal purse seine fishery, ADF&G test fisheries in west Behm Canal, personal-use fisheries in Yes Bay, and sport fisheries at McDonald Lake. We also added the number of sockeye salmon that were killed for brood stock by ADF&G or SSRAA (Table 4). Canadian harvests of McDonald Lake sockeye are not represented in this run reconstruction scenario.

Table 4.–Estimated commercial harvest and total run (in thousands) of McDonald Lake sockeye salmon, 1982–2003 based on the "Case 2" harvest rate assumptions. The distant commercial harvest in Alaska fisheries was estimated by assuming a 47% harvest rate, and expanding the estimated escapement by 53%, and this represents the commercial catch in mixed-stock fisheries outside of Behm Canal. Canadian harvests are not included in this scenario.

Year	Distant Estimated Commercial Harvest	West Behm Canal Purse Seine	West Behm Canal Test Fish	Yes Bay Personal Use[a]	Assumed Sport Fish	Brood Stock	Total Estimated McDonald Harvest	Estimated Escapement	Estimated Total Run
1982	44.1	0.8	0.0	NA	0.0	0.0	44.9	49.7	94.6
1983	49.8	0.0	0.0	NA	0.0	0.0	49.8	56.1	105.9
1984	107.5	2.7	0.0	NA	0.0	0.0	110.2	121.2	231.4
1985	89.3	18.3	0.0	1.2	0.2	0.0	108.9	100.7	209.6
1986	83.9	11.5	0.0	1.8	0.2	0.0	97.4	94.6	192.0
1987	166.0	0.0	0.0	4.0	0.2	0.0	170.2	187.2	357.3
1988	59.8	0.0	0.0	2.3	0.2	2.9	65.3	67.5	132.8
1989	67.1	6.7	0.7	3.4	0.2	4.0	82.2	75.7	157.9
1990	100.2	0.0	0.4	5.7	0.2	0.6	107.2	113.0	220.1
1991	147.4	6.2	1.8	8.2	0.2	1.3	165.1	166.3	331.3
1992	88.5	23.0	1.9	9.9	0.2	2.0	125.6	99.8	225.4
1993	70.7	150.3	0.7	9.9	0.2	1.9	233.7	79.7	313.4
1994	93.1	0.0	0.1	10.2	0.2	1.4	105.0	105.0	210.0
1995	39.1	0.0	0.4	6.7	0.2	0.8	47.2	44.1	91.2
1996	54.9	249.6	0.0	4.4	0.2	0.0	309.2	61.9	371.1
1997	60.7	40.4	2.3	7.3	0.2	0.0	110.9	68.5	179.4
1998	51.0	20.7	0.6	6.1	0.2	0.0	78.7	57.5	136.2
1999	79.5	35.2	2.4	6.5	0.2	0.3	124.1	89.6	213.7
2000	80.4	35.8	2.7	7.6	0.2	0.3	126.9	90.6	217.5
2001	37.9	29.8	0.9	6.3	0.2	0.3	75.5	42.8	118.2
2002	22.9	0.3	0.5	3.7	0.2	0.2	27.7	25.8	53.5
2003	79.1	12.0	0.9	5.2	0.2	0.4	97.9	89.2	187.1

[a] Estimates of the personal-use catch for Yes Bay are not available prior to 1985.

Case 3 (Constant contribution rate estimates): This estimate of the total harvest of McDonald Lake sockeye salmon in Alaska fisheries was based on coded wire tagging results that showed McDonald Lake fish comprised an average 7% (range: 5%–8%) of the total sockeye salmon harvested in the traditional commercial fisheries in Districts 101–107. First, we subtracted the number of sockeye salmon harvested in west Behm Canal (Districts 101-80 to 101-90) from the total annual sockeye salmon harvested in Districts 101–107, and multiplied the remainder by 7%. We then added all sockeye salmon harvested in the terminal west Behm Canal purse seine fishery, ADF&G test fisheries in west Behm Canal, personal-use fisheries in Yes Bay, and sport fisheries at McDonald Lake. We also added the number of sockeye salmon that were killed for brood stock by ADF&G or SSRAA (Table 5). Canadian harvests of McDonald Lake sockeye are not represented in this run reconstruction scenario.

Table 5.–Estimated commercial harvest and total run (in thousands) of McDonald Lake sockeye salmon, 1982–2003 based on the "Case 3" contribution rate assumption. The commercial harvest in Alaska was estimated by assuming that 7% of the sockeye salmon harvested annually in Districts 101–107 (not including west Behm Canal fisheries) are McDonald Lake stock, and this represents the commercial catch in mixed-stock fisheries outside of Behm Canal. Canadian harvests are not included in this scenario.

	Distant Estimated Commercial Harvest	West Behm Canal Purse Seine	West Behm Canal Test Fish	Yes Bay Personal Use[a]	Assumed Sport Fish	Brood Stock	Total Estimated McDonald Harvest	Estimated Escapement	Estimated Total Run
1982	58.3	0.8	0.0	NA	0.0	0.0	59.1	49.7	108.8
1983	65.6	0.0	0.0	NA	0.0	0.0	65.6	56.1	121.7
1984	44.3	2.7	0.0	NA	0.0	0.0	47.0	121.2	168.2
1985	77.7	18.3	0.0	1.2	0.2	0.0	97.4	100.7	198.0
1986	62.2	11.5	0.0	1.8	0.2	0.0	75.7	94.6	170.3
1987	37.7	0.0	0.0	4.0	0.2	0.0	41.8	187.2	229.0
1988	62.0	0.0	0.0	2.3	0.2	2.9	67.5	67.5	135.0
1989	77.9	6.7	0.7	3.4	0.2	4.0	92.9	75.7	168.6
1990	88.4	0.0	0.4	5.7	0.2	0.6	95.4	113.0	208.4
1991	90.8	6.2	1.8	8.2	0.2	1.3	108.4	166.3	274.7
1992	120.3	23.0	1.9	9.9	0.2	2.0	157.4	99.8	257.2
1993	145.9	150.3	0.7	9.9	0.2	1.9	308.9	79.7	388.6
1994	112.5	0.0	0.1	10.2	0.2	1.4	124.4	105.0	229.4
1995	89.3	0.0	0.4	6.7	0.2	0.8	97.4	44.1	141.5
1996	119.7	249.6	0.0	4.4	0.2	0.0	374.0	61.9	435.9
1997	131.3	40.4	2.3	7.3	0.2	0.0	181.6	68.5	250.0
1998	62.8	20.7	0.6	6.1	0.2	0.0	90.5	57.5	148.0
1999	40.2	35.2	2.4	6.5	0.2	0.3	84.8	89.6	174.4
2000	41.2	35.8	2.7	7.6	0.2	0.3	87.8	90.6	178.4
2001	77.0	29.8	0.9	6.3	0.2	0.3	114.6	42.8	157.3
2002	21.9	0.3	0.5	3.7	0.2	0.2	26.7	25.8	52.5
2003	52.8	12.0	0.9	5.2	0.2	0.4	71.6	89.2	160.8

[a] Estimates of the personal-use catch for Yes Bay are not available prior to 1985.

Although each of the three catch series has it's own weakness, all three paint a surprisingly similar picture of the McDonald Lake harvest. In each case, moderately large harvests continued until the mid-1990s, when there were two extremely large spikes in catch; following those spikes, catches returned to lower levels, with a very low catch in 2002 (Figure 5).

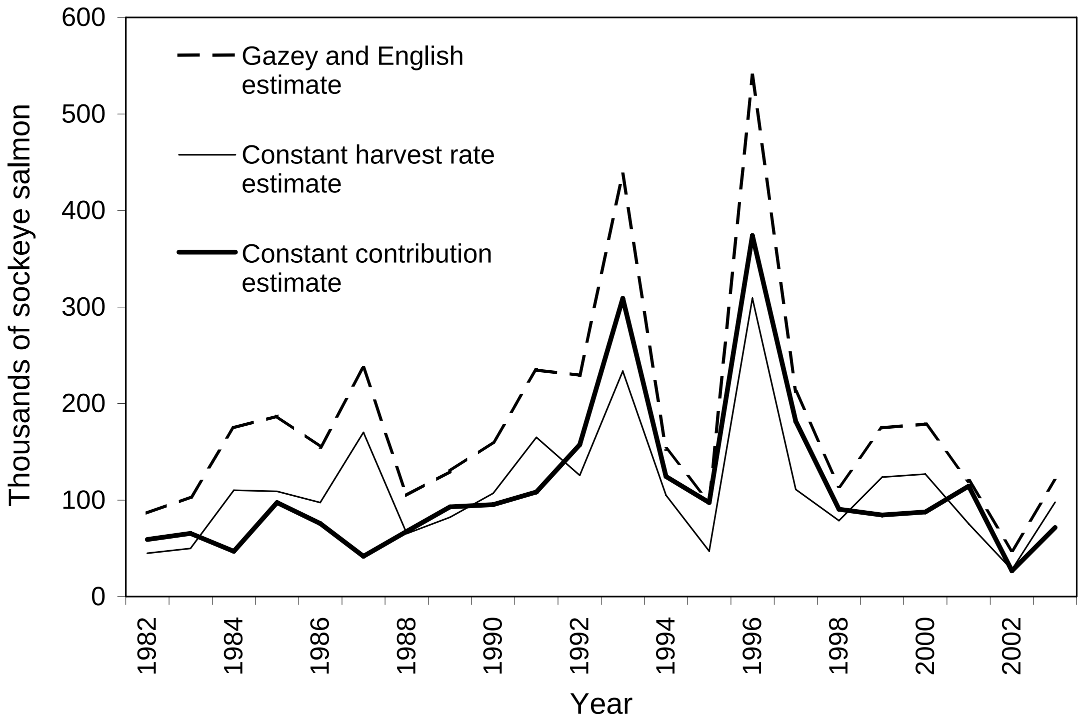

Figure 5.–Three proposed total-harvest series from the McDonald Lake sockeye stock. The series represented by the dashes was derived from the Gazey and English run reconstruction and includes harvests in Canadian fisheries. The series shown by the thin line represents a series derived by assuming a constant harvest rate on the McDonald Lake stock in distant mixed-stock fisheries, and the series shown with a thick line represents a series derived based on assuming a constant contribution rate; these scenarios do not include harvests in Canadian fisheries.

ENHANCEMENT

ADF&G began to focus attention on McDonald Lake starting in the late 1970s, as part of a region-wide program to rehabilitate sockeye salmon runs in Southeast Alaska through lake fertilization and fry stocking. Over the past 23 years, the McDonald Lake system was enhanced through a lake fertilization program. Lake fertilization is an attempt to increase the primary production of a sockeye salmon nursery lake through the application of essential nutrients (nitrogen and phosphorous), and in turn increase the production at higher trophic levels. The desired product is healthier (larger) sockeye smolt, increased fry-rearing capacity, higher survival rates, and increased adult returns (Smith 1969; LeBrasseur et al. 1978; Barraclough and Robinson 1972; Stockner and MacIsaac 1996).

Preliminary limnological data were collected at McDonald Lake in 1979–1981, and the lake was fertilized from 1982 to 2004. The enhancement program was assessed through annual monitoring of the zooplankton and chemical properties of the lake, and through estimates of fall fry abundance. McDonald Lake sockeye salmon fry were also back-planted into the lake in 1989 (3.5 million fry) and 1990 (1.0 million fry).

LAKE FERTILIZATION

McDonald Lake was enriched with liquid fertilizer having a nitrogen to phosphorous atomic ratio of 27:7 (Olson 1989). During most of the enhancement project, the quantity of fertilizer applied to the lake each year was equal to 90% of the critical phosphorus load, as calculated after Vollenweider (1976), and determined from annual late fall or early spring phosphorus concentrations in McDonald Lake (see Appendix B for specific annual fertilizer applications). Fertilizer was applied weekly to the upper half of the lake. The prescription for phosphorous was much higher from 1983 to 1989, than it was in later years (Figure 6). From 1982 to 1985, however, up to 25% of the fertilizer remained in the fertilizer storage barrels in the form of a crystalline precipitate, and it was determined that up to 50% of the phosphorous may not have been added to the lake in those years.

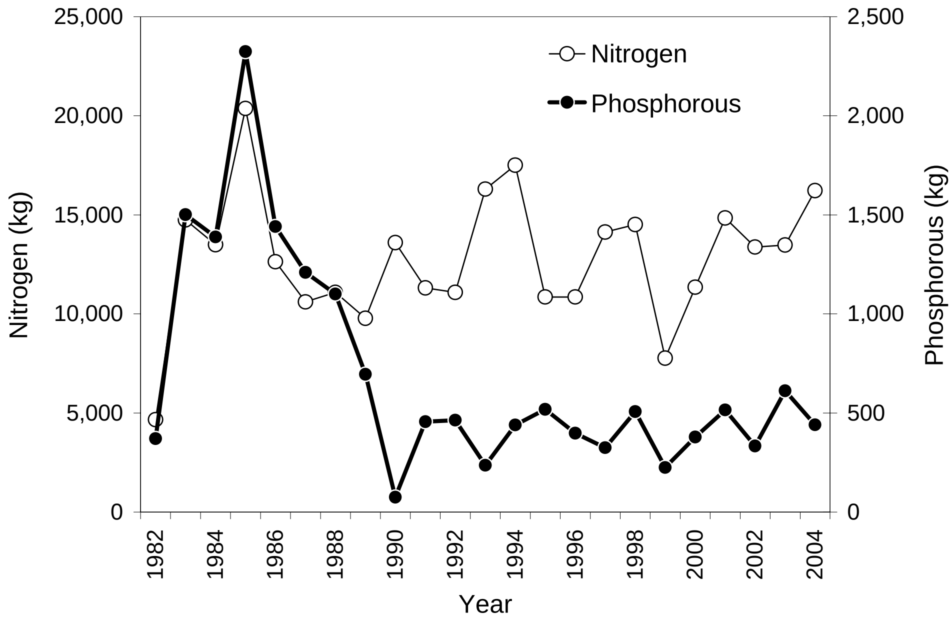

Figure 6.–Annual nitrogen and phosphorous loads applied to McDonald Lake in the form of liquid fertilizer, 1982–2004.

LIMNOLOGICAL DATA

Limnological data were first collected at McDonald Lake in May, June and December of 1979. Limnological data were collected monthly from May to September during nearly all years, 1980–2004, with sampling being conducted from 7 or more months in 1980–1992. Thus, although we have 26 years of limnological data, we have only 2 years of comprehensive pre-fertilization data (1980–1981) to compare to data from years that the lake was fertilized. Sampling method for McDonald Lake was briefly described by Zadina and Heinl (1999), and followed methods outlined in Koenings et al. (1987). Water and zooplankton samples were collected at 2 stations (A and B), one inside and one outside the fertilized area, from 1979 to 2003 (a third station, C, was also sampled from 1982–1985). Two additional sampling stations were added and sampled only for zooplankton from 1994 to 2004: one each inside and outside the fertilizer application areas of the lake. Samples were analyzed for a suite of chemical characters at the ADF&G, Commercial Fisheries Division Limnology Laboratory in Soldotna, Alaska.

The summer (May–September) concentration of total nitrogen in the lake was relatively stable compared to the concentration of total phosphorous (Figure 7). The total phosphorous concentration

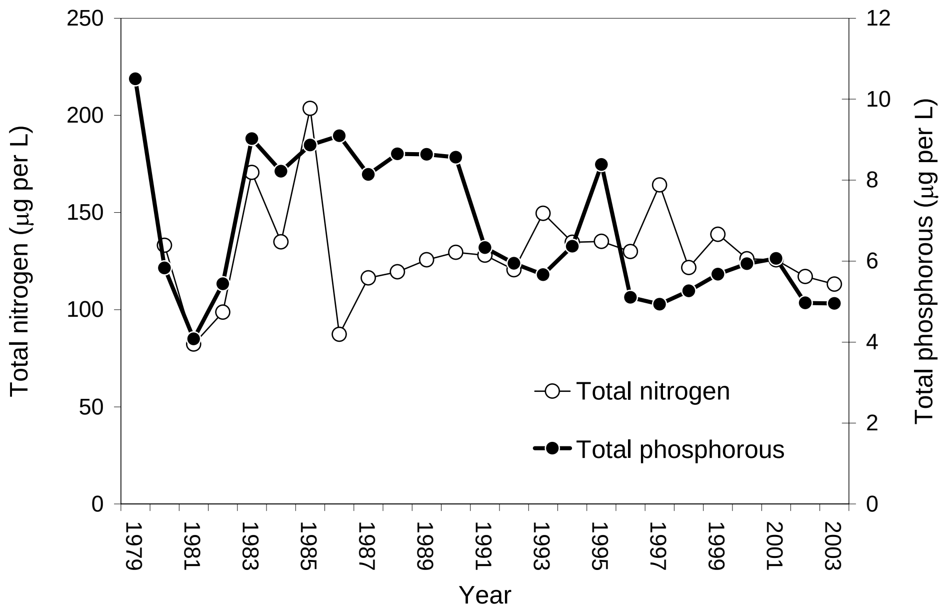

Figure 7.–Mean annual concentrations of total nitrogen and total phosphorous in McDonald Lake during May–September, 1979–2003.

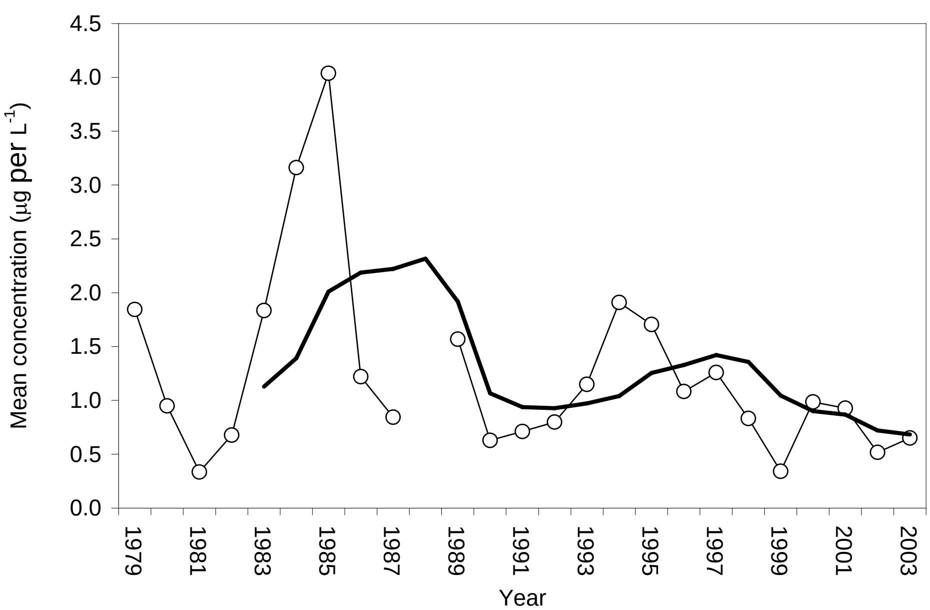

Figure 8.–Mean annual concentration of Chlorophyll *a* in McDonald Lake during May–September. The heavy black line shows the 5-year moving average concentration.

averaged 8.6 μg/L from 1983 to 1990, but declined thereafter, and averaged 5.8 μg/L from 1991 to 2003. Note that the highest total phosphorous concentration during the study period was 10.5 μg/L recorded in 1979, prior to enrichment of the lake.

The authors of the initial limnological studies at McDonald Lake (from 1980 to 1986) reported increases in primary production and secondary production following the initial application of fertilizers to McDonald Lake (Burkett et al. 1989). Since 1986, however, summer production of Chlorophyll *a* has been variable, and appears to have trended downward (Figure 8). Over that same time period, a similar downward trend was exhibited by the total zooplankton density and total weighted biomass of zooplankton in the lake (Figures 9 and 10). Zooplankton in the order Cladocera are the preferred prey of sockeye salmon fry (Koenings and Burkett 1987). Trends in the mean density and weighted biomass of Cladocera closely followed trends shown by the total zooplankton population (Figures 9 and 10).

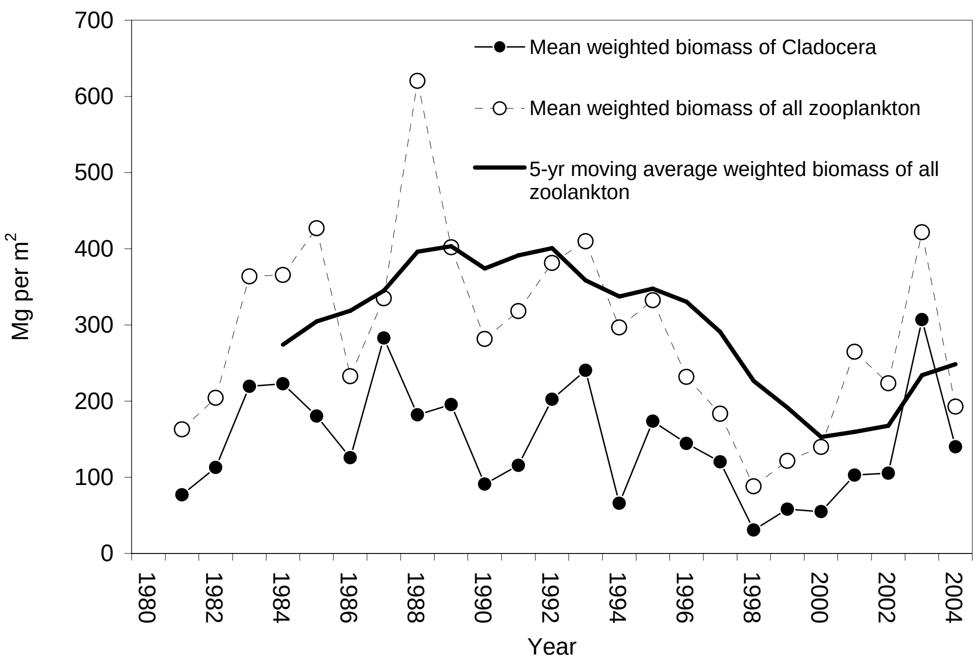

Figure 9.–Mean annual weighted biomass of total zooplankton and mean annual weighted biomass of Cladocera, 1980–2004. The biomass is a function of zooplankton density and zooplankton length. The heavy black line shows the 5-year moving average biomass of all zooplankton species.

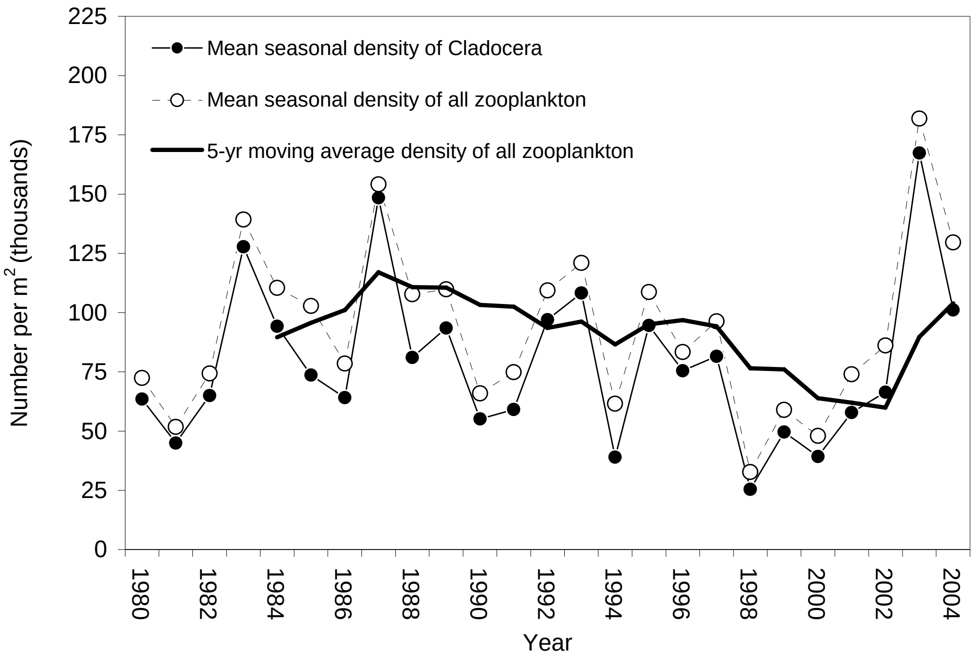

Figure 10.–Mean seasonal density of total zooplankton and mean seasonal density of Cladocera, 1980–2004. The heavy black line shows the 5-year moving average density of all zooplankton species.

In 2003, the total zooplankton density jumped to the highest level recorded (Figure 10). This recent increase in zooplankton population coincided with the decrease in the escapement level, suggesting a possible predator or top down control of the zooplankton. This natural increase in zooplankton population also seems to be linked to the Chlorophyll *a* but does not explain what seems like a downward trend of Chlorophyll *a* concentrations throughout the enhancement effort. Unfortunately, the large annual fluctuations in Chlorophyll *a* concentrations and zooplankton populations, combined with the lack of adequate baseline data, makes it difficult or perhaps impossible, for us to differentiate changes due to the effect of lake fertilization, if any, from natural variation in the system.

FALL FRY ABUNDANCE

Rearing sockeye salmon fry populations were estimated annually, from 1983 to 2004, using hydroacoustic gear to estimate abundance and mid-water trawl gear to estimate species and age composition. The methods and equipment used to conduct the sampling changed several times over the 22-year period, but the sampling methods generally followed those briefly described by Zadina and Heinl (1999), and Piston (2004). For this analysis we looked only at population estimates of age-0 sockeye salmon fry from sampling conducted in the fall. Fall surveys were conducted nearly annually, and provided us with the longest data series.

The age-0 sockeye salmon fry population averaged 1.4 million fish, 1982–1986, increased to an average of 3.1 million fry over the period 1987–1994, but then dropped back to an average of only 1.3 million fry from 1995 to 2004 (Table 6; Figure 11). Although the estimates of spawning escapement and rearing fry populations are rough at best, they do appear to track one another to the extent that we can see that escapements and fry populations were higher in the mid-1980s than they have been since the mid-1990s (Figure 11). This is a pattern very similar to that exhibited by the concentrations of total phosphorous (Figure 7) and Chlorophyll *a* (Figure 8) during the same time period, and also similar, to some degree, to the pattern shown by the total biomass and density of zooplankton in the lake (Figures 9 and 10).

Table 6.–Estimated sockeye salmon brood-year escapements at McDonald Lake, 1982–2003, and subsequent age-0 sockeye salmon fry population estimated one year later.

Brood Year	Estimated Brood-Year Escapement (Thousands)	Survey Year	Survey Date	Estimated Age-0 Sockeye Fry Population (Millions)	Age 1.3 Adult Return Year
1982	50	1983	7-Nov	1.5	1987
1983	56	1984	18-Sep	1.7	1988
1984	121	1985	18-Sep	1.2	1989
1985	101	1986	15-Sep	1.5	1990
1986	95	1987	1-Sep	1.2	1991
1987	187	1988	21-Sep	3.7	1992
1988	67	1989	25-Sep	2.9	1993
1989	76	1990	26-Sep	2.9	1994
1990	113	1991	21-Oct	1.1	1995
1991	166	1992	8-Nov	4.6	1996
1992	100	1993	14-Sep	4.0	1997
1993	80	1994	6-Oct	2.3	1998
1994	105	1995	No survey		1999
1995	44	1996	No survey		2000
1996	62	1997	10-Oct	2.0	2001
1997	68	1998	12-Oct	0.7	2002
1998	58	1999	21-Dec	1.3	2003
1999	90	2000	28-Oct	1.4	2004
2000	91	2001	Oct	1.9	2005
2001	43	2002	23-Oct	1.1	2006
2002	26	2003	8-Dec	0.5	2007
2003	89	2004	22-Oct	1.8	2008

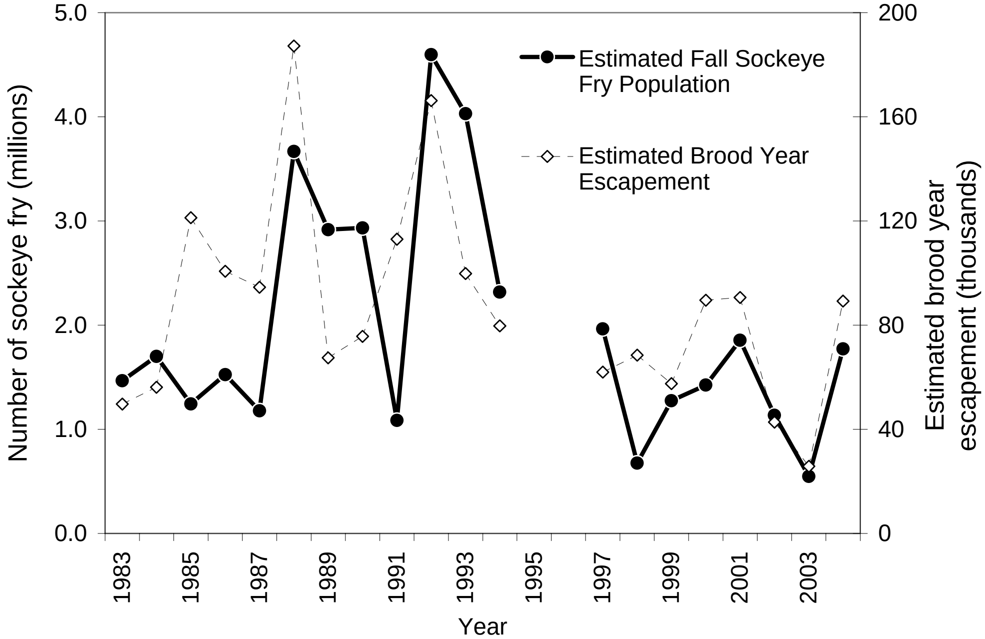

Figure 11.–Estimated fall population of age-0 sockeye salmon fry in McDonald Lake, 1983–2004, compared to the estimated brood-year escapement of adult sockeye salmon one year prior.

LAKE STOCKING

In recent times, McDonald Lake sockeye salmon eggs were collected in a total of 13 years, 1988–1995 and 1999–2003, and used as a brood source for six enhancement projects conducted in southern Southeast Alaska by ADF&G, the U.S. Forest Service, and SSRAA (Table 7). The vast majority of the eggs taken from McDonald Lake were used for a colonization project at Virginia Lake, following construction of a fish ladder at a flow-limiting barrier falls at the outlet of that lake (Edmundsen et al. 1991; Piston 2004). Virginia Lake already supported a small, pre-existing, native run of sockeye salmon. Approximately 8.9 million McDonald Lake sockeye salmon fry were stocked in Virginia Lake in combination with lake fertilization, between 1990 and 1996; however, that project met with poor success (Piston 2004). From 1989 to 1993, 1.3 million McDonald Lake sockeye salmon fry were stocked into Margaret Lake, following construction of a fish ladder on the outlet stream—that project was also largely unsuccessful (Cartwright et al. 1998). McDonald Lake fry were back-planted into McDonald Lake in 1989 and 1990. In 1990, rather than destroy 1.0 million fry that were in excess of enhancement needs at Virginia Lake, ADF&G back-planted the fry into McDonald Lake. The results of other lake stocking efforts using McDonald Lake brood stock have not been documented (Shrimp Bay) or are still ongoing (Neck Lake, Burnette Inlet).

Table 7.–Number of McDonald Lake sockeye salmon eggs taken for various enhancement projects, rearing agency, and release sites, 1988–1995 and 1999–2003.

Brood Year	Number of Fish Killed for Brood Stock	Eggs Taken (millions)	Agency	Release Site
1988	2,946	6.7	ADF&G	Virginia Lake, McDonald Lake
1989	4,032	5.4	ADF&G	Virginia Lake, McDonald Lake, Margaret Lake
1990	600	1.6	ADF&G	Virginia Lake, Margaret Lake
1991	1,268	3.2	SSRAA	Virginia Lake, Margaret Lake, Shrimp Bay
1992	2,001	3.3	SSRAA	Virginia Lake, Margaret Lake, Shrimp Bay
1993	1,922	3.0	SSRAA	Virginia Lake, Margaret Lake, Shrimp Bay
1994	1,422	2.3	SSRAA	Virginia Lake
1995	840	1.5	SSRAA	Virginia Lake
1999	300	0.5	SSRAA	Neck Lake
2000	300	0.5	SSRAA	Neck Lake
2001	294	0.5	SSRAA	Neck Lake, Burnette Inlet
2002	200	0.4	SSRAA	Neck Lake, Burnette Inlet
2003	406	0.7	SSRAA	Neck Lake

Note: SSRAA = Southern Southeast Regional Aquaculture Association
ADF&G = Alaska Department of Fish and Game

ESCAPEMENT GOAL ANALYSIS

The first sockeye salmon escapement goal for McDonald Lake was identified in 1989, using habitat considerations (the euphotic volume model; Koenings and Burkett 1987). This goal was set at 85,000 sockeye salmon, based on fry loading of the system, which translated into 2,500 spawning adults per euphotic volume unit. The escapement goal was lowered in 1993 to the current range of 65,000–85,000 sockeye salmon, based on a Ricker analysis. In 2003, ADF&G adopted that goal as a *biological escapement goal*, although the documentation for this goal has been lost (Geiger et al. 2004). Our original intent was to examine the available stock-recruit estimates for the system and derive an escapement goal based a stock-recruit model. Traditionally, escapement goals in Alaska have been developed with Ricker analysis (Quinn and Deriso 1999), using statistical models that forecast recruitment based on stock size. Considering all of the uncertainty in the escapement measures, and the associated uncertainty in the harvest estimates, we were unable to develop a statistically defendable stock-recruit analysis. Using some simple assumptions, we will recommend a *sustainable escapement goal*, based only on an examination of which historical escapements appear to have produced higher subsequent catches.

We first recast the Case 1 (Gazey and English) catch-year harvest estimates into brood year-based estimates of harvest (Table 8), using the age-class distribution developed from samples of the escapement (Appendix C). Of course, gill net fisheries may have been size and age selective, so that the age distribution in the escapement could be quite different than the distribution in the catch. Even so, we assumed, on average, this would be a reasonable approximation. Next, we deleted the observations for the 1988 and 1989 brood years, as the subsequent catches were affected by the return of stocked hatchery fish that were not the product of the brood year escapement. Then we ordered the observations by the estimated escapement levels. For the brood years we have harvest estimates (1980–1998, with the exception of 1988 and 1989), the escapement estimates ranged from 44,000 to 187,000. Finally, we divided the data set into thirds based on escapement level, and then we looked at the median catch in each third of the data. This division resulted in 6 observations in the first third, 5 observations in the second third, and 6 observation in the last third. We used medians for this purpose because this statistic is much more stable and resistant to outliers than averages.

Table 8.–Reconstructed harvest (in thousands) resulting from each brood year escapement (in thousands) from 1980 to 1998, excluding years affected by hatchery stocking (1988–1989). These estimates are based on the Case 1 harvest estimates, derived from the Gazey and English run reconstructions.

Brood Year	Escapement	Reconstructed brood year-based harvest
1980	75	220
1981	130	171
1982	50	176
1983	56	102
1984	121	181
1985	101	107
1986	95	240
1987	187	417
1990	113	95
1991	166	532
1992	100	215
1993	80	128
1994	105	183
1995	44	157
1996	62	126
1997	68	30
1998	58	131

In the third of the data set with lowest escapements, the escapements ranged from 44,000 to 68,000 sockeye salmon; the median brood year-based catch in this category was 129,000 sockeye salmon. In the third of the data with the middle values, the escapements ranged from 75,000 to 101,000 sockeye salmon, and the median catch was 215,000 sockeye salmon. In the upper third of the data set, the escapements ranged form 105,000 to 187,000 sockeye salmon, and the median catch was 182,000 salmon. A similar analysis using averages produced a much different picture. The very large estimated catches of 532,000 and 417,000 had a very big effect on the averages, and the average harvest was biggest in the third with the largest escapements. The large harvest estimates came from the largest brood year escapement measures of 166,000 and 187,000 in 1991 and 1987, respectively. However, the analysis with the medians leads us to conclude that, with the Case 1 harvest numbers, typically, in the past, harvest estimates were higher when escapements were in the middle third of the historic range.

Repeating the analysis with the other two cases gave slightly different results. The harvest estimates based on the Case 2 harvest rate assumptions produced the impression that harvests were highest when escapements were at the highest levels, although there was actually very little difference between the median harvest in the two groups (117,000 and 123,000 in the middle and upper groups, respectively). With the Case 3 contribution rate assumptions, there was virtually no difference between the median harvests between the middle and upper escapement level groups (107,000 and 106,000, respectively). In all cases the harvest estimates were higher with escapement estimates in the middle range than when they were in the lower range.

What we took from this analysis was that there is moderate evidence that escapements above about 70,000 fish typically lead to bigger harvests than escapements below 70,000 (Figure 12). We had a harder time judging what may have happened with escapements above about 100,000. The results for escapement estimates above 100,000 were sensitive to the particular assumptions that we used, but the results were still very similar. Although there is some justification for thinking very large escapements might produce larger average harvests in the future, we certainly do not feel comfortable recommending escapement levels that would preclude yield in years of moderate recruitment, based on this analysis. We do recommend that the stock be allowed to reach the upper end of this escapement goal range to provide future analysts with observations of the stock's performance at higher stock sizes.

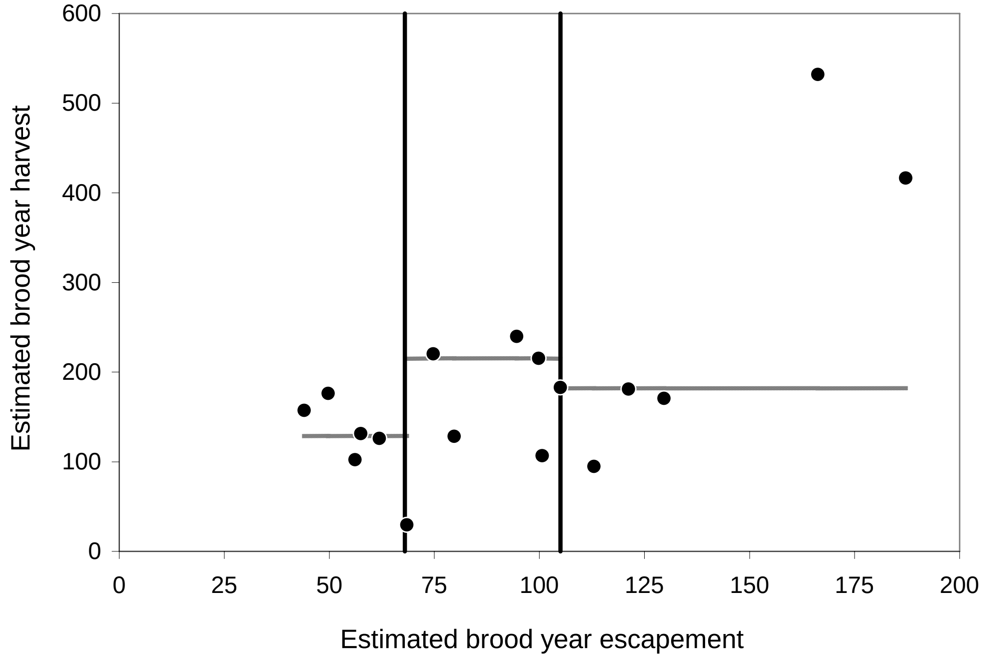

Figure 12.–Brood year escapement (thousands) together with the estimated brood year-based estimates of harvest (thousands), reconstructed using the Gazey and English estimates of harvest for McDonald Lake sockeye salmon. The vertical lines divide the data set into thirds based on escapement. The horizontal lines show the median catch level for each third of the data.

Rounding these numbers gives a recommended escapement goal range from 70,000 to 100,000 sockeye salmon. Not surprisingly, this recommendation is very similar to the recommendation that would be derived from what is sometimes called the Bue method (Bue and Hasbrouck 2001), which is to simply recommend the 25 and 75 percentile of the historical observed escapement. Most of the difference is due to discarding the two brood years affected by lake stocking. We chose not to use the Bue method for several reasons. First, for an escapement series that is declining, the Bue method will produce escapement goal ranges with a lower limit that will just follow the decline downward over time. The escapement series at McDonald Lake has been declining. In other words, we do not think that simply because escapements dropped below the previous escapement goal, that we should use that observation as a reason to lower the goal. More importantly, in our case, we do have some indication of what the yield was, even if that indication is imperfect. By using medians, rather than averages, we have guarded against letting a few large errors in the data have a strong effect on the recommendation. Our recommendation is simply based on the observation that harvests appear to have been typically higher in the past when the escapement was in the goal range we recommended.

STOCK STATUS AND DISCUSSION

This is the first attempt to critically assess the status of the McDonald Lake stock since the adoption of the Sustainable Salmon Fisheries Policy. As we tried to look at the available information, and reach some conclusions about the status of this sockeye salmon stock, we were hampered by a lack of a reliable stock-assessment history. Almost all of the research at this lake was designed to support enhancement projects, and the research has been focused on questions about limnology. The monitoring program for the lake was designed to show the changes in chemical or zooplankton abundance, rather than to assess the fishery status or to help establish escapement goals. The zooplankton measures we reviewed are consistent with freshwater conditions in the late 1990s being the cause of the lower stock productivity in recent years, but we don't know how to use that information to make any meaningful recommendation. This same signal we see in the zooplankton seems to have been in every measure we have of adult recruitment a few years later. We did not find any evidence that years of expensive lake fertilization has increased the productivity of the stock, or made the lake environment more favorable for sockeye salmon. Similarly, we cannot find any evidence that the lake fertilization has not worked as intended. We recommend that the limnological monitoring be refocused away from simple data gathering, and directed at a testable hypothesis about whether or not the lake fertilization is boosting productivity, and whether or not there is actually a benefit derived from this costly effort (see Appendix B for fertilization levels).

In all salmon stock assessments, the most basic piece of stock assessment information is the escapement. In our case, we have a long-term escapement measure, and this series is probably a very reliable tool for tracking escapement trends. We believe this method is sufficient to monitor the stock, and is better than "peak-count" methods, which have been used to set escapement goals for pink salmon in Southeast Alaska. The foot count method we used to measure escapement for this stock is closely related to the area-under-the-curve approach (e.g., English et al. 1992; Bue et al. 1998). Yet, with only two years of comparisons to weir counts, we cannot be sure that this series is scaled to a value that even crudely approximates the true escapement magnitude in any particular year. We will conduct mark-recapture escapement studies at McDonald Lake in 2005 and 2006. This information should provide us with a means to assess or recalibrate the current method of estimating the sockeye salmon escapement at McDonald Lake.

While we were able to develop several harvest series, these estimates of harvest are also problematic, largely because all of these estimates were based, to one extent or another, on estimates of escapement magnitude. The only possible independent verification we have for the recruitment benchmarks are the observations from the early 20th century. Typical recruitments of about 100,000–200,000, with catches of about 100,000 and escapements of about 60,000 seem entirely plausible, and consistent with the early historical record.

Even if we do not know the true magnitude of escapement into McDonald Lake, we do know that escapements were generally stable or even slightly increasing in McDonald Lake until the mid 1990s, and then escapements dropped somewhat after the escapement goal was lowered in 1993. The escapements were generally above or very nearly above the lower end of the goal until 2001, when escapements could have been met, had there been less directed harvest in Behm Canal. Escapements were missed by a wide margin in both 2002 and 2004. The escapement was better, but still below goal in 2005. Even though escapements were missed in 4 out of the last 5 years, the reasons these escapements were missed in 2001 where somewhat different than the reason in 2002 and 2004–2005. In 2001, the run appeared to be slightly below average, but still within the range of what might usually be called a normal run, and the escapement goal would certainly have been met had no directed harvest taken place in upper West Behm Canal in that year. In 2002, the run appears to have been well below the normal level, and that downward signal can be seen clearly in every measure we have for the stock. That year had the lowest reported subsistence take, the lowest reported escapement, and a large drop in each of the measures we have of commercial harvest. We do not yet have comparable measures of commercial harvest for 2004, but this seems to have also been a year of extremely low recruitment. Putting all of these measures side by side we can confidently conclude that the years after 2001 have been a period of persistent lower than average recruitment, but that recently there have been two years of extremely low recruitment.

As a part of this stock status review, we were required to examine the stock for a "chronic inability to meet escapement goals," with "chronic inability" defined as "the continuing or anticipated inability to meet the escapement threshold over a 4 or 5 year period." While we note that there have been 4 recent occurrences of missing escapement thresholds, we do not yet see this as an ongoing pattern, and we do not have any reason at this time to anticipate that the escapement goal will be missed in the future. If zooplankton abundance was related to the recruitment downturn, we note that zooplankton abundance measures returned somewhat to higher levels by about 2002. If the zooplankton decline was the cause of the sockeye recruitment decline, then the upward trend in zooplankton abundance levels should indicate that sockeye recruitment levels will return to higher levels in the next several years. We were also required to examine this stock for "chronic inability...to maintain expected yields." Again, the period after 2001 does seem to be a period of persistent lowered recruitment, and a period of reduced yields. However, at this time we view this phenomenon as normal stock fluctuation. Of course, we will revisit this issue in 2009, at a time when we expect to have three years of additional study of the escapement, and additional indicators of the yield levels. At this time, we do not recommend that the McDonald Lake stock be classified in any of the three kinds of *stock of concern* categories listed in the Sustainable Salmon Fisheries Policy.

We wish to quickly add that we recommend against lake stocking, or some other quick fix to try to increase recruitment. When lake stocking was recently undertaken at Hugh Smith Lake, near Ketchikan, the stocking increased escapement counts, but many of the stocked fish did not successfully breed and did not improve the overall stock productivity at Hugh Smith Lake (Andrew Piston, ADF&G, unpublished data; Geiger et al. 2005). While we can say that the Hugh Smith stocking increased what we might call the accounted escapement—those fish simply counted into the system, this stocking probably did not increase what we might call the effective escapement—which are those fish that actually breed and fully contribute to the next generations. A significant stocking project at McDonald Lake would likely be more expensive than simply managing the appropriate fisheries; the stocking would confound our ability to measure the effective escapement level, and there is no reason to think that lake stocking would return the McDonald Lake stock to a state of higher productivity. In addition to the Virginia and Margaret lake stocking projects already mentioned, hatchery supplementation was also used to increase recruitment at Eshamey Lake, and Coghill Lake in Prince William Sound in the 1990s. There again, the returning stocked fish did not appear to adequately integrate with the naturally breeding population, behaved abnormally within the lake, and did not improve the stock productivity within these systems (Morstad et al. 1996; and a detailed review in an unpublished 1994 ADF&G Memorandum from Dan Sharp to Wayne Donaldson). The scientific literature is full of reasons to think this kind of supplementation may actually reduce stock productivity (e.g., Ryman and Laikre 1991). Indeed, if the downturn in recruitment was caused by a downturn in zooplankton abundance, then stocking sockeye salmon into the lake would further depress zooplankton levels, and result in the productivity downturn lasting longer than it would otherwise.

We saw several problems with the previous escapement goal. We received well-deserved criticism because this goal was inadequately documented. In addition, the escapement goal range was quite narrow, considering the normal variation in the recruitment, and given reasonable expectations about management precision. While we wish we could have done a more complete and defendable job of revising the escapement goal, in the end we simply were stuck with all of the problems with the escapement and harvest estimates that we have already mentioned several times. We settled for the simplest method we could find that still made a reasonable and robust use of all of the information we had. We think the escapement goal we are recommending is safe, in the sense that this escapement level produced relatively high yields in the past. Had we used other escapement goal-setting techniques, based on averages, like a Ricker analysis, our recommended escapement goal range would have been higher. We are satisfied that we have recommended a well-reasoned goal, that should protect future yields, but we expect that future analyses, with more complete information, will result in higher goals.

Although it is just a cliché to end a technical report like this with a call for more study, there is a lot more we need to know about this system. It is possible that in the near future, genetic stock identification can be used to provide much better information about the contribution, and the time and area distribution of this stock in the commercial fisheries of southern Southeast Alaska. This information would be required if we were to improve run-reconstructions and escapement goals. Genetic sampling would be logistically easier, more cost-effective, than coded-wire tagging. Even though this is such an important sockeye stock, there has never been a long-term, fully funded effort to estimate escapement into this system. Obviously, we recommend a fully functional escapement-monitoring program, capable of reliably capturing the true escapement magnitude. We end this report satisfied that we have quantified the escapement trends and that we have recommended a reasonable and safe escapement goal. We will know even more about this system three years from now, when we expect to have three additional years of study of how the actual escapement level compares to our escapement estimates.

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APPENDIX A. DISTRICT 106 RECOVERIES OF CODED WIRE TAGGED MCDONALD LAKE SOCKEYE SALMON

Appendix A1.–Summary statistics for McDonald Lake coded-wire tagged sockeye salmon in the District 106 drift gillnet fishery, 1989.

Subdistrict Stratum	Stat Week	Sockeye Catch	Sample Size	Proportion Sampled	Clips Observed	Heads Received	All tags Detected	McD Tags	Expanded Tags	Boat-Days Per Week	CPUE McDonald Tags
106-30	25	1,188	179	15%	0	0	0	0	0	40	
106-30	26	1,774	66	4%	0	0	0	0	0	56	
106-30	27	2,500	58	2%	0	0	0	0	0	50	0
106-30	28	17,593	3,897	22%	6	6	4	4	18	111	0.163
106-30	29	19,900	4,272	21%	8	8	4	4	19	129	0.144
106-30	30	18,752	3,580	19%	9	9	9	9	47	258	0.183
106-30	31	10,974	3,116	28%	14	14	10	10	35	189	0.186
106-30	32	6,567	1,976	30%	4	4	2	2	7	165	0.040
106-30	33	3,096	541	17%	2	2	1	1	6	147	0.039
106-30	34	1,844	125	7%	0	0	0	0	0	186	0
106-30	35	579	154	27%	1	1	1	0	0	98	
106-30	36	50	18	36%	0	0	0	0	0	46	
106-30	37	26	8	31%	0	0	0	0	0	88	
106-30	38	5	0	0%	0	0	0	0	0	20	
106-41	25	5,049	2,503	50%	3	2	0	0	0	108	
106-41	26	6,953	3,262	47%	6	5	0	0	0	134	0
106-41	27	7,402	4,250	57%	9	9	4	3	5	112	0.047
106-41	28	23,825	7,494	31%	15	15	5	5	16	162	0.098
106-41	29	20,675	4,667	23%	14	14	7	7	31	189	0.164
106-41	30	15,819	5,128	32%	15	15	8	8	25	177	0.139
106-41	31	17,939	5,163	29%	16	15	9	7	26	192	0.135
106-41	32	4,018	1,856	46%	1	1	0	0	0	111	0
106-41	33	4,427	1,583	36%	2	2	1	0	0	132	
106-41	34	1,411	210	15%	0	0	0	0	0	183	
106-41	35	247	89	36%	1	1	1	0	0	84	
106-41	36	102	4	4%	1	1	1	0	0	50	
106-41	37	17	13	76%	0	0	0	0	0	66	
106-41	38	2	1	50%	0	0	0	0	0	16	

Appendix A2.–Summary statistics for McDonald Lake coded-wire tagged sockeye salmon in the District 106 drift gillnet fishery, 1990.

Subdistrict Stratum	Stat Week	Sockeye Catch	Sample Size	Proportion Sampled	Clips Observed	Heads Received	All tags Detected	McD Tags	Expanded Tags	Boat-Days Per Week	CPUE McDonald Tags
106-30	25	1,886	0	0%	0	0	0	0	0	60	
106-30	26	1,727	644	37%	0	0	0	0	0	84	
106-30	27	3,031	528	17%	0	0	0	0	0	64	0
106-30	28	6,284	1,989	32%	6	6	4	4	13	111	0.114
106-30	29	8,920	1,428	16%	6	6	4	4	25	88	0.284
106-30	30	20,625	2,498	12%	13	13	6	5	41	177	0.233
106-30	31	16,992	3,005	18%	10	9	7	7	44	156	0.282
106-30	32	10,262	2,214	22%	28	28	21	19	88	116	0.760
106-30	33	6,785	1,051	15%	7	7	7	4	26	156	0.166
106-30	34	2,637	359	14%	1	1	0	0	0	189	0
106-30	35	1,458	284	19%	0	0	0	0	0	162	
106-30	36	233	8	3%	0	0	0	0	0	162	
106-30	37	36	7	19%	0	0	0	0	0	74	
106-30	38	7	3	43%	0	0	0	0	0	72	
106-30	39	0	0		0	0	0	0	0	5	
106-41	25	3,151	1,431	45%	2	2	0	0	0	108	
106-41	26	4,567	2,276	50%	5	5	0	0	0	136	0
106-41	27	9,691	3,809	39%	10	10	3	2	5	124	0.041
106-41	28	19,163	11,059	58%	34	34	18	17	29	228	0.129
106-41	29	18,113	4,369	24%	22	22	11	11	46	156	0.292
106-41	30	30,256	9,860	33%	32	32	18	17	52	171	0.305
106-41	31	10,197	3,380	33%	14	14	10	10	30	130	0.232
106-41	32	4,240	1,088	26%	5	5	2	2	8	94	0.083
106-41	33	2,573	1,039	40%	4	4	3	2	5	84	0.059
106-41	34	2,049	801	39%	2	2	2	1	3	165	0.016
106-41	35	694	135	19%	1	1	1	1	5	165	0.031
106-41	36	97	15	15%	0	0	0	0	0	150	0
106-41	37	5	3	60%	0	0	0	0	0	52	
106-41	38	0	0		0	0	0	0	0	58	
106-41	39	0	0		0	0	0	0	0	6	

APPENDIX B. FERTILIZER APPLICATIONS

Appendix B1.–Annual fertilizer applications at McDonald Lake, 1982–2004.

Year	Gallons of 27-7-0 fertilizer	Gallons of 32-0-0 fertilizer	Total Gallons Applied	Amount of Nitrogen Applied (27-7-0) Kg	Amount of Nitrogen Applied (32-0-0) Kg	Amount of Phosphorous Applied Kg	Total Nitrogen applied in Kg
1982[a]	2,530	880	3,410	3,253	1,415	371	4,669
1983[a]	10,230	990	11,220	13,155	1,592	1,501	14,748
1984[a]	9,460	825	10,285	12,165	1,327	1,388	13,492
1985[a]	15,840	0	15,840	20,370	0	2,324	20,370
1986	9,825	0	9,825	12,635	0	1,441	12,635
1987	8,250	0	8,250	10,609	0	1,210	10,609
1988	7,500	900	8,400	9,645	1,447	1,100	11,092
1989	6,635	2,150	8,785	6,320	3,458	695	9,778
1990	720	8,030	8,750	686	12,915	75	13,600
1991	4,350	4,460	8,810	4,144	7,173	456	11,317
1992	4,425	4,275	8,700	4,215	6,875	464	11,090
1993	2,250	8,800	11,050	2,143	14,153	236	16,296
1994	4,200	8,400	12,600	4,001	13,510	440	17,510
1995	4,940	3,825	8,765	4,706	6,152	518	10,857
1996	3,800	4,500	8,300	3,620	7,237	398	10,857
1997	3,100	6,950	10,050	2,953	11,178	325	14,131
1998	4,840	6,160	11,000	4,610	9,907	507	14,517
1999	2,150	3,560	5,710	2,048	5,725	225	7,773
2000	3,620	4,910	8,530	3,448	7,897	379	11,345
2001	4,920	6,315	11,235	4,687	10,156	516	14,843
2002	3,190	6,425	9,615	3,039	10,333	334	13,372
2003	5,840	4,920	10,760	5,563	7,913	612	13,476
2004	4,210	7,590	11,800	4,010	12,207	441	16,217

[a] From 1982 to 1985, up to 25% of the fertilizer remained in the fertilizer storage barrels in the form of a crystalline precipitate, and it was determined that up to 50% of the phosphorous may not have been added to the lake in those years.

APPENDIX C. AGE COMPOSITION OF MCDONALD LAKE SOCKEYE SALMON ESCAPEMENT

Appendix C1.–Age composition of the McDonald Lake sockeye salmon escapement, 1981–2004.

Year	Sample Size		Age Class 1.1	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3
1981	745	Number	3	25	0	557	17	0	143	0	0	0
		Proportion	0.4%	3.4%	0.0%	74.8%	2.3%	0.0%	19.2%	0.0%	0.0%	0.0%
		SE	0.2%	0.7%	0.0%	1.6%	0.5%	0.0%	1.4%	0.0%	0.0%	0.0%
1982	629	Number	2	30	2	462	54	1	78	0	0	
		Proportion	0.3%	4.8%	0.3%	73.4%	8.6%	0.2%	12.4%	0.0%	0.0%	0.0%
		SE	0.2%	0.9%	0.2%	1.8%	1.1%	0.2%	1.3%	0.0%	0.0%	0.0%
1983	1,363	Number	0	498	1	253	47	0	564	0	0	0
		Proportion	0.0%	36.5%	0.1%	18.6%	3.4%	0.0%	41.4%	0.0%	0.0%	0.0%
		SE	0.0%	1.3%	0.1%	1.1%	0.5%	0.0%	1.3%	0.0%	0.0%	0.0%
1984	928	Number	1	136	0	630	59	0	102	0	0	0
		Proportion	0.1%	14.7%	0.0%	67.9%	6.4%	0.0%	11.0%	0.0%	0.0%	0.0%
		SE	0.1%	1.2%	0.0%	1.5%	0.8%	0.0%	1.0%	0.0%	0.0%	0.0%
1985	537	Number	0	25	0	388	47	0	76	0	0	1
		Proportion	0.0%	4.7%	0.0%	72.3%	8.8%	0.0%	14.2%	0.0%	0.0%	0.2%
		SE	0.0%	0.9%	0.0%	1.9%	1.2%	0.0%	1.5%	0.0%	0.0%	0.2%
1986	555	Number	0	65	3	312	20	0	155	0	0	0
		Proportion	0.0%	11.7%	0.5%	56.2%	3.6%	0.0%	27.9%	0.0%	0.0%	0.0%
		SE	0.0%	1.4%	0.3%	2.1%	0.8%	0.0%	1.9%	0.0%	0.0%	0.0%
1987	833	Number	3	64	7	497	18	0	243	1	0	0
		Proportion	0.4%	7.7%	0.8%	59.7%	2.2%	0.0%	29.2%	0.1%	0.0%	0.0%
		SE	0.2%	0.9%	0.3%	1.7%	0.5%	0.0%	1.6%	0.1%	0.0%	0.0%
1988	1,063	Number	3	208	0	680	62	1	109	0	0	0
		Proportion	0.3%	19.6%	0.0%	64.0%	5.8%	0.1%	10.3%	0.0%	0.0%	0.0%
		SE	0.2%	1.2%	0.0%	1.5%	0.7%	0.1%	0.9%	0.0%	0.0%	0.0%
1989	530	Number	2	23	0	456	18	0	31	0	0	0
		Proportion	0.4%	4.3%	0.0%	86.0%	3.4%	0.0%	5.8%	0.0%	0.0%	0.0%
		SE	0.3%	0.9%	0.0%	1.5%	0.8%	0.0%	1.0%	0.0%	0.0%	0.0%
1990	794	Number	0	111	0	421	40	1	214	0	0	7
		Proportion	0.0%	14.0%	0.0%	53.0%	5.0%	0.1%	27.0%	0.0%	0.0%	0.9%
		SE	0.0%	1.2%	0.0%	1.8%	0.8%	0.1%	1.6%	0.0%	0.0%	0.3%

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Year	Sample Size		Age Class 1.1	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3
1991	791	Number	3	51	0	703	8	0	26	0	0	0
		Proportion	0.4%	6.4%	0.0%	88.9%	1.0%	0.0%	3.3%	0.0%	0.0%	0.0%
		SE	0.2%	0.9%	0.0%	1.1%	0.4%	0.0%	0.6%	0.0%	0.0%	0.0%
1992	739	Number	0	10	0	709	1	0	19	0	0	0
		Proportion	0.0%	1.4%	0.0%	95.9%	0.1%	0.0%	2.6%	0.0%	0.0%	0.0%
		SE	0.0%	0.4%	0.0%	0.7%	0.1%	0.0%	0.6%	0.0%	0.0%	0.0%
1993	628	Number	5	44	12	285	22	0	260	0	0	0
		Proportion	0.8%	7.0%	1.9%	45.4%	3.5%	0.0%	41.4%	0.0%	0.0%	0.0%
		SE	0.4%	1.0%	0.5%	2.0%	0.7%	0.0%	2.0%	0.0%	0.0%	0.0%
1994	670	Number	0	37	2	538	15	1	77	0	0	0
		Proportion	0.0%	5.5%	0.3%	80.3%	2.2%	0.1%	11.5%	0.0%	0.0%	0.0%
		SE	0.0%	0.9%	0.2%	1.5%	0.6%	0.1%	1.2%	0.0%	0.0%	0.0%
1995	904	Number	3	122	2	599	20	0	157	0	1	0
		Proportion	0.3%	13.5%	0.2%	66.3%	2.2%	0.0%	17.4%	0.0%	0.1%	0.0%
		SE	0.2%	1.1%	0.2%	1.6%	0.5%	0.0%	1.3%	0.0%	0.1%	0.0%
1996	618	Number	4	47	0	536	14	0	17	0	0	0
		Proportion	0.6%	7.6%	0.0%	86.7%	2.3%	0.0%	2.8%	0.0%	0.0%	0.0%
		SE	0.3%	1.1%	0.0%	1.4%	0.6%	0.0%	0.7%	0.0%	0.0%	0.0%
1997	812	Number	5	57	0	590	15	1	144	0	0	0
		Proportion	0.6%	7.0%	0.0%	72.7%	1.8%	0.1%	17.7%	0.0%	0.0%	0.0%
		SE	0.3%	0.9%	0.0%	1.6%	0.5%	0.1%	1.3%	0.0%	0.0%	0.0%
1998	753	Number	1	30	1	615	4	0	102	0	0	0
		Proportion	0.1%	4.0%	0.1%	81.7%	0.5%	0.0%	13.5%	0.0%	0.0%	0.0%
		SE	0.1%	0.7%	0.1%	1.4%	0.3%	0.0%	1.2%	0.0%	0.0%	0.0%
1999	839	Number	5	64	2	670	21	0	77	0	0	0
		Proportion	0.6%	7.6%	0.2%	79.9%	2.5%	0.0%	9.2%	0.0%	0.0%	0.0%
		SE	0.3%	0.9%	0.2%	1.4%	0.5%	0.0%	1.0%	0.0%	0.0%	0.0%
2000	825	Number	0	33	0	634	7	1	150	0	0	0
		Proportion	0.0%	4.0%	0.0%	76.8%	0.8%	0.1%	18.2%	0.0%	0.0%	0.0%
		SE	0.0%	0.7%	0.0%	1.5%	0.3%	0.1%	1.3%	0.0%	0.0%	0.0%

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Year	Sample Size		Age Class 1.1	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3
2001	685	Number	1	1	0	656	1	0	26	0	0	0
		Proportion	0.1%	0.1%	0.0%	95.8%	0.1%	0.0%	3.8%	0.0%	0.0%	0.0%
		SE	0.1%	0.1%	0.0%	0.8%	0.1%	0.0%	0.7%	0.0%	0.0%	0.0%
2002	545	Number	5	222	0	258	26	0	34	0	0	0
		Proportion	0.9%	40.7%	0.0%	47.3%	4.8%	0.0%	6.2%	0.0%	0.0%	0.0%
		SE	0.4%	2.1%	0.0%	2.1%	0.9%	0.0%	1.0%	0.0%	0.0%	0.0%
2003	615	Number	1	21	1	560	9	0	23	0	0	0
		Proportion	0.2%	3.4%	0.2%	91.1%	1.5%	0.0%	3.7%	0.0%	0.0%	0.0%
		SE	0.2%	0.7%	0.2%	1.2%	0.5%	0.0%	0.8%	0.0%	0.0%	0.0%
2004	231	Number	0	73	0	112	20	1	25	0	0	0
		Proportion	0.0%	31.6%	0.0%	48.5%	8.7%	0.4%	10.8%	0.0%	0.0%	0.0%
		SE	0.0%	3.1%	0.0%	3.3%	1.9%	0.4%	2.0%	0.0%	0.0%	0.0%