DEPARTMENT OF FISH AND GAME
Sacramento Valley-Central Sierra Region

Lower American River Chinook Salmon Escapement Survey October 2004 – January 2005

By

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Introduction

Adult fall-run Chinook salmon ascend the American River for approximately 23 miles from the confluence of the Sacramento River near Discovery Park to the terminus of anadromous migration at the Nimbus fish weir, just below Nimbus Dam. Spawning occurs within the eighteen miles of river from about Paradise Beach to Nimbus fish weir. However, most spawning occurs in the uppermost three miles of the river near Sunrise Avenue Bridge upstream to the Nimbus fish weir.

Spawner escapement surveys have been conducted on the lower American River to estimate the number of returning adult Chinook salmon for nearly 60 years. This information is important in guiding development and evaluation of management decisions. The four goals of the 2004 lower American River spawner escapement survey were (1) estimate the number of spawners; (2) determine the sex and age composition; (3) determine the egg retention of the females in the run; and (4) determine the percentage of coded-wire tagged (CWT) fish within the fresh samples.

Materials and Methods:

The lower American River salmon escapement survey was conducted from the Nimbus weir downstream to the Watt Avenue Bridge; a distance of 12.9 river miles. The river was stratified into three reaches (Table 1). All reaches were surveyed once a week from October 18, 2004 through January 13, 2005. Each weekly survey consisted of a crew of six to seven people and took three to four days to complete.

Table 1. American River fall-run Chinook salmon escapement survey reaches.

Reach	Location	Miles
1	Nimbus Fish Weir to Elmanto Access	3.4
2	Elmanto Access to Goethe Park Footbridge	3.5
3	Goethe Park Footbridge to Watt Avenue Bridge	6.0
Total		12.9

Each week all fresh carcasses (either one clear eye or pink gills) were counted and tagged with a color-coded hog ring on the upper jaw for adults and lower jaw for grilse. A unique color was used each week to identify the carcasses to a specific tagging week. Each tagged carcass was returned to flowing water for dispersal. All fresh carcasses below Gristmill Fishing Access were chopped to avoid tagged fish from floating out of the study area. Fresh carcasses with missing adipose fins were identified as carcasses with a CWT. Heads were removed from the CWT carcasses and affixed

with a jaw tag for further analysis of any CWT's. In the course of this action, CWT carcasses were chopped in half and recorded as a fresh chopped carcass.

A subset (91%) of fresh carcasses and all CWT carcasses were sexed and measured to the nearest centimeter (cm) Total Length (TL). Fish $\geq$ 68 cm TL were considered adults, and those < 68 cm TL were classified as a grilse, or young adult. All fresh female carcasses measured were checked to determine the degree of egg retention. Each was identified as either completely spawned (0 to 30% eggs retained), partially spawned (>30 to 70% eggs retained), or un-spawned (nearly full ovaries).

All observed decomposing carcasses were counted but not tagged. Decomposing and recovered (previously tagged) carcasses were chopped in half to prevent recounting. Fresh adult carcass data was used in the Schaefer mark-recovery method (Schaefer, 1951) as modified by Taylor (1974) to produce an escapement estimate. The grilse population was determined by the proportion of grilse from the total number of fresh carcasses observed. The total Chinook salmon escapement is calculated by summing the in-river population estimate with the total number collected at Nimbus Fish Hatchery and the number of salmon carcasses that get impinged on the upstream side of the Nimbus fish weir. The Nimbus fish weir is not totally effective at blocking 100% of the salmon and some fish are able to move upstream of the weir. These fish that escape around the fish weir eventually die and are impinged on the upstream side of the weir.

Daily water temperature, flow, and clarity were collected throughout the sampling period. Mean daily water temperature and flow were obtained from U.S. Bureau of Reclamation gauging stations located on the lower American River at Hazel Avenue, William Pond Park, and Watt Avenue. Water clarity was measured with a secchi disk to the nearest cm.

Results

Mean daily flow ranged from 1,514cfs to 1,809 cfs during the three month survey period. Flow was constant around 1,500 cfs during the first four weeks and then increase to around 1,750 cfs through the week of December 20 (Week 10). By the week of December 27 (Week 11), the flow was decreased back to 1,500 cfs for the remainder of the survey (Figure 1). Water temperature in the American River ranged from 17.3 ºC (63.1 ºF) to 9.0 ºC (48.2 ºF). Water clarity ranged from 0.5 to 4.0 meters during the survey. Water clarity was lowest during the week of January 10 (Week 13).

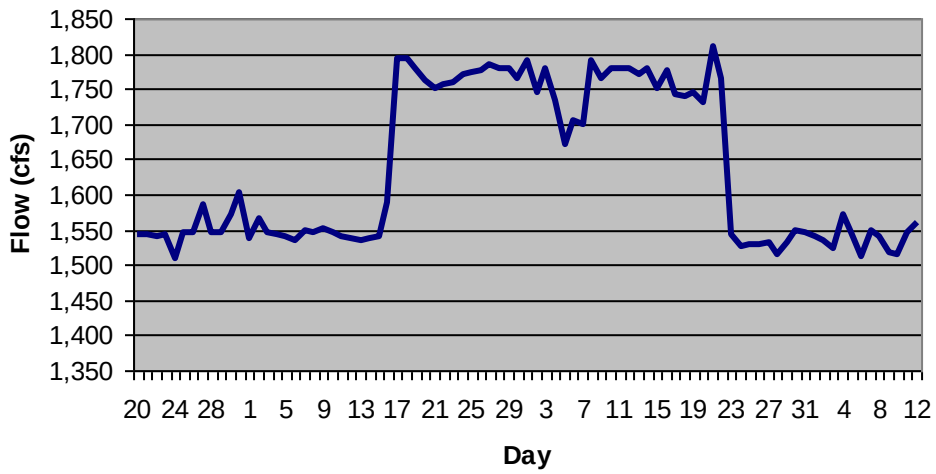

Figure 1. Mean daily flow (cfs), October 20, 2004-January 12, 2005.

Temporal Distribution

A total 40,906 salmon were observed during the 2004 American River escapement survey, including 4,695 fresh and 36,211 non-fresh carcasses (Table 2). Fresh carcasses were first observed during the week of October 20 (Week 1) and were present throughout the survey period (Figure 2). The number of fresh carcasses observed increased through the week of November 15 through November 24 (Week 5 and 6) and then decreased. The number of non-fresh carcasses observed exhibited a similar trend (Figure 4).

Table 2. General survey information for the American River fall-run Chinook salmon escapement survey, October 20, 2004–January 10, 2005.

Week	Dates	Carcasses Observed	
		Fresh	Non-fresh
1	Oct 20-Oct 21	1	8
2	Oct 25- Oct 28	6	7
3	Nov 1-Nov 3	49	45
4	Nov 8-Nov 10	470	651
5	Nov 15-Nov 18	969	4,479
6	Nov 22-Nov 24	950	6,230
7	Nov 29-Dec 2	725	7,385
8	Dec 6-Dec 9	597	5,948
9	Dec 13-Dec 16	525	6,111
10	Dec 20-Dec 22	253	2,980
11	Dec 27-Dec 29	101	1,289
12	Jan 3-Jan 6	28	882
13	Jan 10-Jan 12	21	196
Total		4,695	36,211

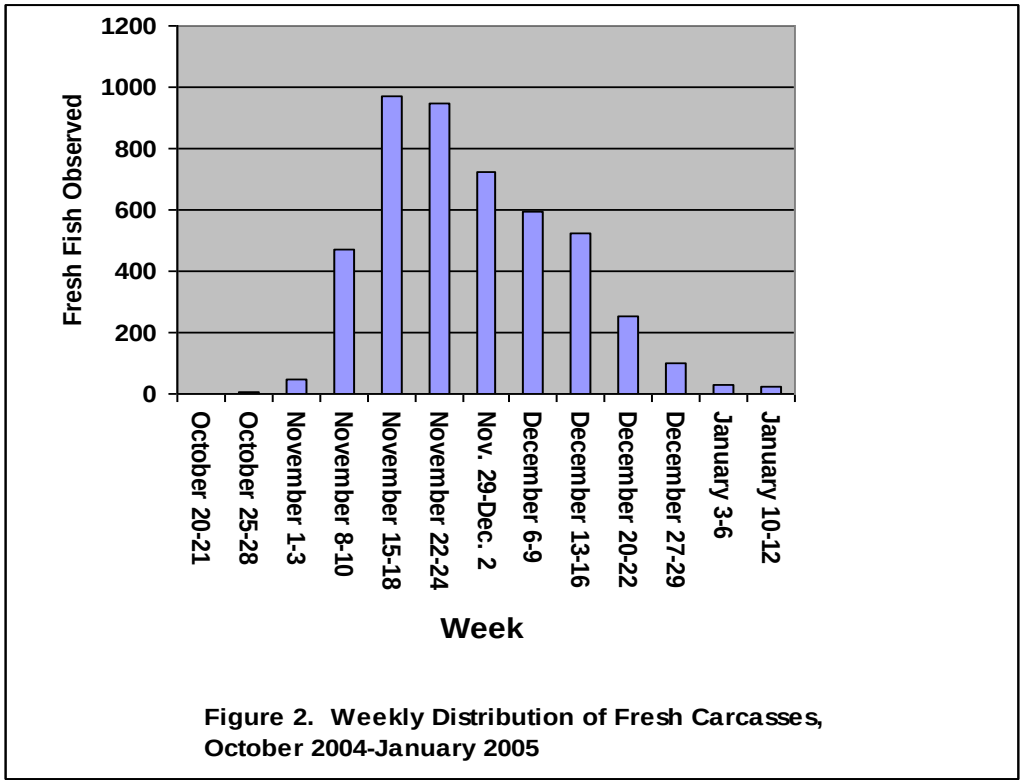

Figure 2. Weekly Distribution of Fresh Carcasses, October 2004-January 2005

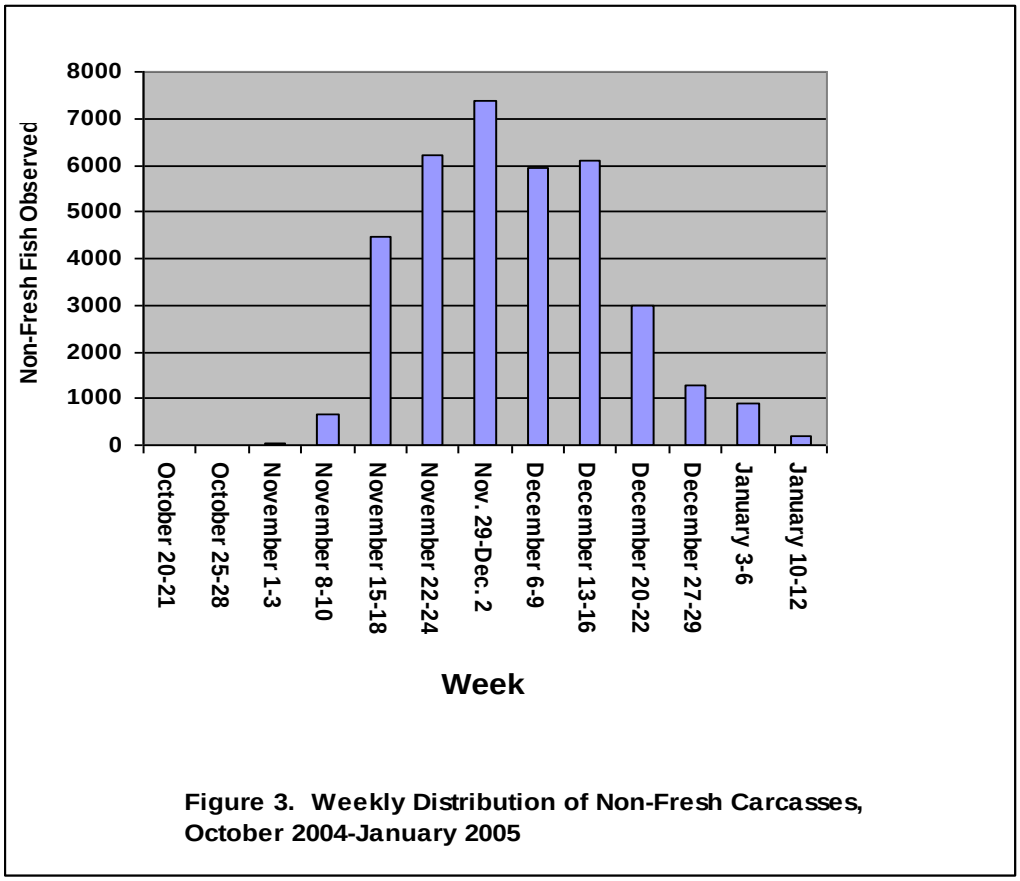

Figure 3. Weekly Distribution of Non-Fresh Carcasses, October 2004-January 2005

Age Composition

Grilse comprised 15.5% (729) of the total catch of fresh carcasses (Table 3) and weekly percent composition ranged from 4% to 100%. The greatest number of grilse (24) was observed during Week 5. Adults comprised 84.5% (3,966) of the fresh carcasses. The greatest number of adults (817) was observed during Week 5.

Table 3. Age composition (grilse and adult) of fresh carcasses observed, October 2004-January 2005.

Week	Grilse		Adult	
	Number	Percent	Number	Percent
1	1	100	0	0
2	1	17	5	83
3	12	24	37	76
4	100	21	370	79
5	152	16	817	84
6	151	16	799	84
7	103	14	622	86
8	93	16	504	84
9	70	13	455	87
10	33	13	220	87
11	4	4	97	96
12	4	14	24	86
13	5	24	16	76
Total (Percent)	729	(15.5)	3,966	(84.5)

Sex Composition

Female Chinook salmon comprised 55% (2,350) of the 4,280 fresh carcasses (adult and grilse) examined for sex, while male Chinook salmon comprised 45% (1,930) (Table 4). Most female (91%) and male (78%) fresh carcasses were collected in Reach 1.

Table 4. Sex composition of all fresh Chinook salmon carcasses identified to gender, October 2004-January 2005.

Reach	Male	Female	Total
1	1,515	2,133	3,648
2	356	196	552
3	59	21	80
Total	1,930	2,350	4,280

Twenty-one percent of the 1,929 fresh male carcasses and 11% of the 2,348 fresh female carcasses were grilse (Table 5). The overall ratio of adult male to adult female was 1 to 1.4. Adult females were most abundant every week except during Week 3 of the carcass survey. The overall ratio of male grilse to female grilse was 1.6 to 1. Female grilse were most abundant only during weeks 10, 11, and 13.

Table 5. Sex composition of fresh Chinook salmon grilse and adult carcasses, October 2004-January 2005.

Week	Grilse				Adult			
	Male		Female		Male		Female	
	Number	%	Number	%	Number	%	Number	%
1	1	100	0	0	0	0	0	0
2	1	100	0	0	2	40	3	60
3	7	58	5	42	21	62	13	38
4	62	69	28	31	149	41	214	59
5	90	62	56	38	283	37	483	63
6	75	59	52	41	296	42	404	58
7	65	63	38	37	284	47	355	53
8	54	64	31	36	210	43	281	57
9	33	59	23	41	155	44	199	56
10	12	46	14	54	82	43	107	57
11	1	33	2	67	23	34	45	66
12	4	100	0	0	10	38	16	62
13	2	40	3	60	7	44	9	56
Total (Percent of age class)	407	(62)	252	(38)	1,522	(42)	2,096	(58)

Egg Retention

Of the 2,322 fresh adult and grilse female carcasses that were observed for egg retention, 50% were completely spawned, 31% were unspawned, and 19% were partially spawned (Table 6). Female salmon with high egg retention were observed nearly each week through Week 12. Egg retention in females was highest during Weeks 2 and 3 (100 and 67%, respectively), but fell below 50% as the season progressed. The percentage of females classified with ovaries containing >30% full was higher than those with ovaries containing < 31% full through Week 5. However, $\geq$51% of females observed from Week 6 through Week 13 had ovaries that were empty.

Table 6. Egg retention summary for female Chinook salmon carcasses, October 2004-January 2005.

Week	# females checked for egg retention	0 to 30% eggs retained	>30 to 70% eggs retained	>70% eggs retained
		Number (%)	Number (%)	Number (%)
1	0	0	0	0
2	3	0	0	3 (100)
3	18	4 (22)	2 (11)	12 (67)
4	239	67 (28)	75 (31)	97 (41)
5	533	189 (35)	114 (21)	230 (43)
6	452	233 (51)	71 (16)	148 (33)
7	356	222 (62)	56 (16)	78 (22)
8	309	185 (60)	53 (17)	71 (23)
9	218	132 (61)	41 (19)	45 (21)
10	119	81 (68)	11 (9)	27 (23)
11	47	37 (79)	4 (9)	6 (13)
12	16	12 (75)	3 (19)	1 (6)
13	12	11 (92)	1 (8)	0
Total (Percent of Total)	2,322	1,173 (50)	431 (19)	718 (31)

Coded-wire tagged fish

Of the 4,695 fresh carcasses that were observed during the survey, 199 were observed with missing adipose fins and classified as CWT fish. Weekly percentage of CWT fish ranged from 0.0 to 16.7% and averaged 4.2% (Table 7). The highest percentage of CWT fish was observed during Weeks 2 and 12.

Grilse comprised 2% (4) of the total number of CWT Chinook salmon and weekly percent composition ranged from 0 to 8% (Table 8). Adult CWT Chinook salmon comprised 98% (195) of the CWT carcasses observed. The greatest number of adult CWT Chinook salmon (55) was observed during Week 5.

Table 7. Number and percentage of fresh CWT Chinook salmon carcasses observed, October 2004-January 2005.		
Week	Number of fresh carcasses observed	Number of CWT fish observed (Percent)
1	1	0 (0)
2	6	1 (16.7)
3	49	6 (12.2)
4	470	18 (3.8)
5	969	55 (5.7)
6	950	33 (3.5)
7	725	39 (5.4)
8	597	23 (3.9)
9	525	12 (2.3)
10	253	5 (2.0)
11	101	2 (2.0)
12	28	4 (14.3)
13	21	1 (4.8)
Total (Percent of total)	4,695	199 (4.2)

Table 8. Age composition (grilse and adult) of CWT carcasses measured, October 2004-January 2005.					
Week	Number of fresh CWT carcasses observed	Grilse		Adult	
		Number	Percent	Number	Percent
1	0	0	0	0	100
2	1	0	0	1	100
3	6	0	0	6	100
4	18	0	0	18	100
5	55	0	0	55	100
6	33	1	3	32	97
7	39	2	5	37	95
8	23	0	0	23	100
9	12	1	8	11	92
10	5	0	0	5	100
11	2	0	0	2	100
12	4	0	0	4	100
13	1	0	0	1	100
Total (Percent of total)	199	4	(2)	195	(98)

Female adult CWT Chinook salmon comprised 66% of the adult CWT Chinook salmon observed (Table 9). In addition, there were more female CWT grilse (75%) than male CWT grilse.

Table 9. Sex composition of CWT Chinook salmon grilse and adult carcasses, October 2004-January 2005.

Week	Grilse				Adult			
	Male		Female		Male		Female	
	Number	%	Number	%	Number	%	Number	%
1	0	-	0	-	0	-	0	-
2	0	-	0	-	0	-	1	100
3	0	-	0	-	3	50	3	50
4	0	-	0	-	8	44	10	56
5	0	-	0	-	19	35	36	65
6	0	-	1	100	7	21	26	79
7	1	50	1	50	14	36	25	64
8	0	-	0	-	9	39	14	61
9	0	-	1	100	4	33	8	67
10	0	-	0	-	1	20	4	80
11	0	-	0	-	0	-	2	100
12	0	-	0	-	3	67	1	33
13	0	-	0	-	0	-	1	100
Total (Percent by age class)	1	(25)	3	(75)	67	(34)	128	(66)

Population Estimate

A total of 3,074 fresh adult carcasses was tagged from Week 1 through Week 11 of which 1,426 tags were subsequently recovered (Table 10). Overall tag recovery rate was 46.4% and weekly recovery rates ranged from 16.7 to 66.7%. The modified Schaefer model produced an adult in-river escapement estimate of 74,991 (Table 11). Since adults made up 84.5% of the escapement, a total escapement (adult and grilse) of 88,747 was calculated by dividing the adult estimate by 0.845. Grilse comprised 15.5% (13,756) of the population.

Table 10. Weekly summary of tagging and recapture of fresh adult Chinook carcasses, October 2004-January 2005.											Carcasses Recovered	Carcasses Counted
Week of Recovery (j)	Week of Tagging 2	3	4	5	6	7	8	9	10	11		
-	-	-	-	-	-	-	-	-	-	-	-	-
3	2										2	94
4		4									4	897
5		1	122								123	4,533
6			11	231							242	6,058
7			1	51	238						290	6,615
8			1	4	55	180					240	5,514
9			4	1	12	45	237				299	5,498
10					1	10	46	72			129	2,764
11						2	3	11	40		56	1,238
12								3	13	25	41	942
13											0	
-	-	-	-	-	-	-	-	-	-	-	-	-
Recovery R(i)	2	5	139	287	306	237	286	86	53	25	Total Tags Recovered: 1,426	Total Counted: 34,153
Tagged M(i)	3	30	345	685	662	491	439	229	138	52	Total Fish Tagged: 3,074	
M(i)/R(i)	1.5	6.0	2.5	2.4	2.2	2.1	1.5	2.7	2.6	2.1	Recovery: 46.4%	

Table 11. Lower American River adult Chinook salmon population estimate using the Schaefer model based on tagging fresh adult carcasses with all captured untagged carcasses removed, October 2004-January 2005.											
Week of Recovery (j)	Week of Tagging										
	2	3	4	5	6	7	8	9	10	11	Totals
3	141										
4		5,382									
5		221	11,159								
6			683	13,802							
7			57	2,777	11,745						
8			57	219	2,734	8,568					
9			183	44	477	1,714	6,689				
10					46	444	1,513	4,108			
11						92	102	648	2,302		
12								184	778	1,195	
Subtotals	141	5,603	12,139	16,842	15,002	10,817	8,304	4,939	3,080	1,195	
Tags		-30	-345	-685	-662	-491	-439	-229	-138	-52	-3,071
Estimated Population of natural spawning adults											74,991

In addition to the 88,747 salmon that returned to the lower American River downstream of Nimbus weir, there were 26,400 salmon (12,741 adult and 13,659 grilse) that entered Nimbus Hatchery.

There were an additional 10,483 adult and grilse carcasses removed from the upstream side of the Nimbus fish weir. By combining the in-river escapement (88, 747) with the total number of Chinook salmon collected at the Nimbus Fish Hatchery (26,400) and at the Nimbus fish weir (10,483), the 2004 fall-run Chinook salmon escapement for the lower American River was estimated to be 125,630.

Conclusion and Discussion

Since 2000, there has been an increasing trend in the number of returning fall-run Chinook salmon in the lower American River. Although, the in-river escapement of Chinook salmon in the lower American River derived from the modified Schaefer method (88,747) was lower than the last four years, the adult escapement estimate is nearly double the previous 35 year (1967-2003) average of 44,609 fish (Table 12).

The percentage of grilse Chinook salmon collected in the 2004 escapement survey made up 15.5% of the population. However, the number of grilse returning to the Nimbus Fish Hatchery was considerably much higher (51%). This indicates that recovery rates for grilse carcasses are much lower in-river, and therefore, could underestimate the total in-river escapement population.

Higher than normal egg retention in female Chinook salmon in the lower American River continues to be a concern as this may have an impact on the cohort for future escapement returns. Water temperatures above 16 ºC have been common in the lower American River during the beginning of the escapement runs (Healey, 2004) which can delay migration and can contribute to female Chinook salmon to retain their eggs until suitable spawning temperatures are reached (Cuenco and McCullough, 1996). Also, temperatures above 15.5 ºC support several diseases, parasites, and fungus typically common in the environment (McCullough, 1999). The incidence of disease and mortality rate in Chinook salmon is enhanced by stress factors such as low flow, extended periods of unfavorable water temperature, crowding, injury, and other diseases present (EPA and NMFS, 1971).

Thirty-one percent of all fresh female Chinook salmon checked for egg retention had retained their eggs during the 2004 escapement survey. Therefore, the number of returning females (55%) to the lower American River is reduced by 31%, or approximately 15,131 female Chinook salmon died before they spawned. This results in an in-river spawning escapement estimate of approximately 73,616.

Table 12. American River Chinook salmon escapement estimates, 1967-2002.			
Year	Grilse	Adult	Total
1967 [a]	3,132	14,868	18,000
1968 [a]	2,777	23,423,	26,200
1969 [a]	8,208	35,452	43,660
1970 [a]	2,753	25,927	28,680
1971 [a]	5,210	36,470	41,680
1972 [a]	3,352	14,107	17,459
1973 [a]	4,688	77,554	82,242
1974 [b]	1,769	51,827	53,596
1975 [a]	2,699	29,433	32,132
1976 [b]	1,181	21,978	23,159
1977 [b]	4,701	36,904	41,605
1978 [b]	595	12,334	12,929
1979 [b]	896	36,419	37,315
1980 [b]	8,805	25,454	34,259
1981 [b]	2,521	40,941	43,462
1982 [a]	4,323	28,677	33,000
1983 [a]	7,313	19,087	26,400
1984 [c]	2,196	25,251	27,447
1985 [b]	11,392	44,728	56,120
1986 [b]	4,443	44,929	49,372
1987 [b]	2,960	18,185	24,145
1988 [d]	1,905	13,974	15,879
1989 [b]	2,459	14,619	17,078
1990 [b]	1,167	5,541	6,708
1991 [b]	1,506	16,639	18,145
1992 [b]	1,297	3,175	4,472
1993 [b]	6,162	20,624	26,786
1994 [b]	2,927	28,405	31,332
1995 [b]	7,010	63,086	70,096
1996 [b]	6,592	59,323	65,915
1997 [b]	4,220	42,668	46,888
1998 [b]	10,760	32,282	43,042
1999 [b]	7,716	40,509	48,225
2000 [b]	5,922	92,783	98,705
2001 [b]	10,463	120,322	130,785
2002 [b]	11,811	106,303	118,114
2003 [b]	11,571	146,945	158,516
Average	4,662	36,783	41,445

[a] Expanded direct counts; [b] Schaefer method; [c] Petersen method; [d] Jolly-Seber method

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