

DEPARTMENT OF FISH AND GAME
Sacramento Valley-Central Sierra Region

**Lower American River Chinook Salmon Escapement Survey
October 2003– January 2004**

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 Nimbus Dam. Spawning occurs within the eighteen miles of river from about Paradise Beach to Nimbus Dam. However, most spawning occurs in the uppermost three miles of the river near Sunrise Avenue Bridge upstream to the Nimbus 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 2003 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 14, 2003 through January 14, 2004. Each weekly survey consisted of a crew of six to seven people and took three to four days to complete.

Reach	Location	Miles
1	Sailor Bar 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. 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. The remaining portion of the CWT carcasses were then chopped in half and recorded as a fresh chopped carcass.

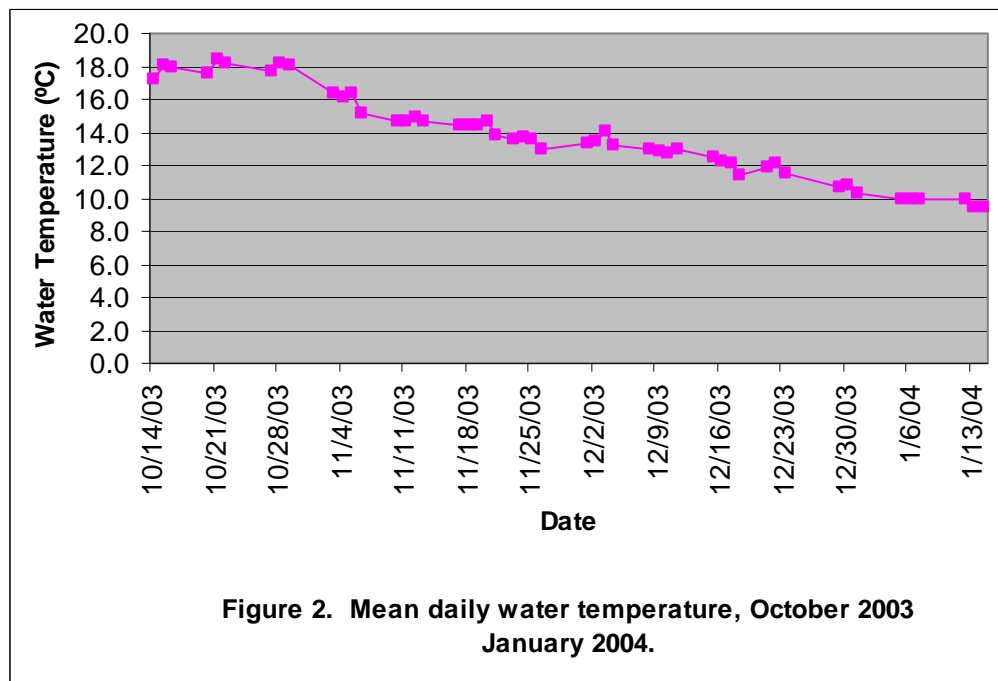
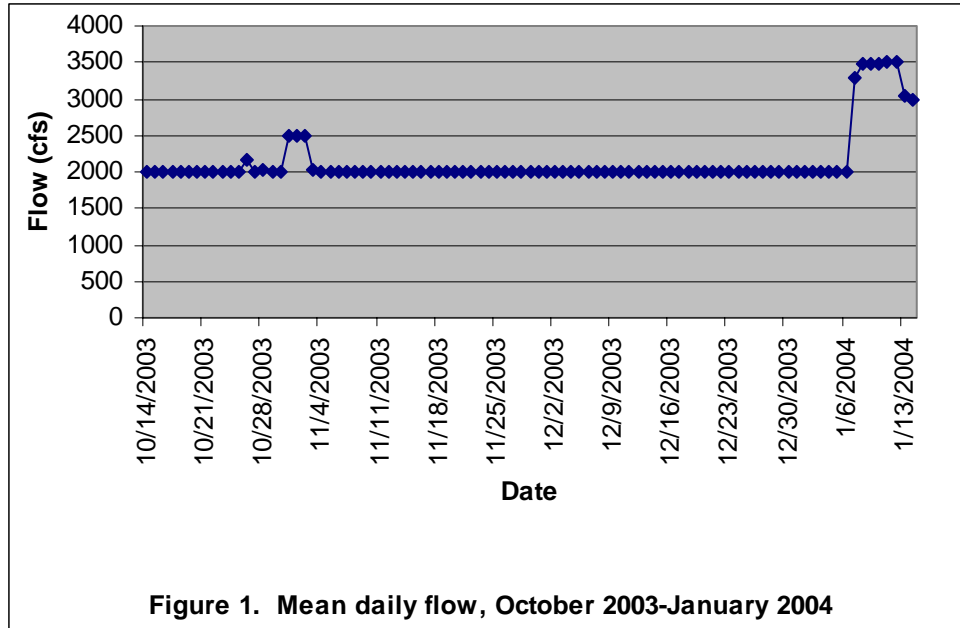
A subset of fresh carcasses and all CWT carcasses were sexed and measured to the nearest centimeter (cm) Total Length (TL). Fish > 68 cm TL were considered adults, and those \leq 68 cm TL were classified as a grilse, or young adult. All fresh female carcasses were identified as either completely spawned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

All observed decomposing carcasses were counted but not tagged. Decomposing and recovered (previously tagged) carcasses were chopped in half to prevent recounting. The Schaefer mark-recovery method (Schaefer, 1951) as modified by Taylor (1974) was used to produce an escapement estimate. The grilse population was determined by the ratio of grilse to adults from the fresh carcasses measured. The total Chinook salmon escapement is calculated by summing the in-river population estimate with the total number collected at Nimbus Fish Hatchery.

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 2,012 cfs to 3,542 cfs during the three month survey period. Flow was relatively constant at just above 2,000 cfs throughout the period with the exception of two flow fluctuations during the beginning and end of the survey (Figure 1). Water temperature in the American River ranged from 17.6 °C (63.7 °F) to 10.1 °C (50.1 °F) (Figure 2). Water clarity ranged from 2 to 4.7 meters during the survey (Table 2). Water clarity was lowest during Week 13 (January 5-7).



period (Figure 3). The number of fresh carcasses observed increased through Week 6 and then decreased. The number of non-fresh carcasses observed exhibited a similar trend (Figure 4). Given an estimated 2 week delay for spawning and mortality (Snider and Vyverberg, 1995), these results indicate that the bulk of spawning occurred during Weeks 4 through 6 (November 3 through November 21, 2003).

Table 2. General survey information for the American River fall-run Chinook salmon escapement survey, October 14, 2003–January 14, 2004.

Week	Dates	Flow (cfs) ^{1/}	Secchi (meters) ^{1/}	Water Temp. ^{1/}		Carcasses Observed	
				°C	°F	Fresh	Non- fresh
1	Oct 14-Oct 16	2,005	4.3	17.7	63.9	21	44
2	Oct 20- Oct 22	2,006	4.7	18.1	64.6	21	69
3	Oct 27- Oct 29	2,012	4.0	18.0	64.4	53	196
4	Nov 3-Nov 6	2,007	3.9	16.0	60.8	172	385
5	Nov 10-Nov 13	2,003	3.5	14.7	58.5	486	942
6	Nov 17-Nov 21	1,998	3.9	14.3	57.7	1,644	4,803
7	Nov 23-Nov 26	2,003	3.2	13.4	56.1	1,378	6,262
8	Dec 1-Dec 4	2,003	3.4	13.5	56.3	975	12,643
9	Dec 8-Dec 11	1,999	3.1	12.9	55.2	757	11,345
10	Dec 15-Dec 18	1,998	2.8	12.1	53.8	538	7,175
11	Dec 21-Dec 23	2,003	2.8	11.8	53.2	312	3,715
12	Dec 29-Dec 31	2,001	2.2	10.6	51.1	67	2,083
13	Jan 5-Jan 7	2,428	2.0	10.0	50.0	30	849
14	Jan 12-Jan 14	3,182	2.2	9.7	49.5	14	188
Total						6,468	50,690

^{1/} Mean daily measurement.

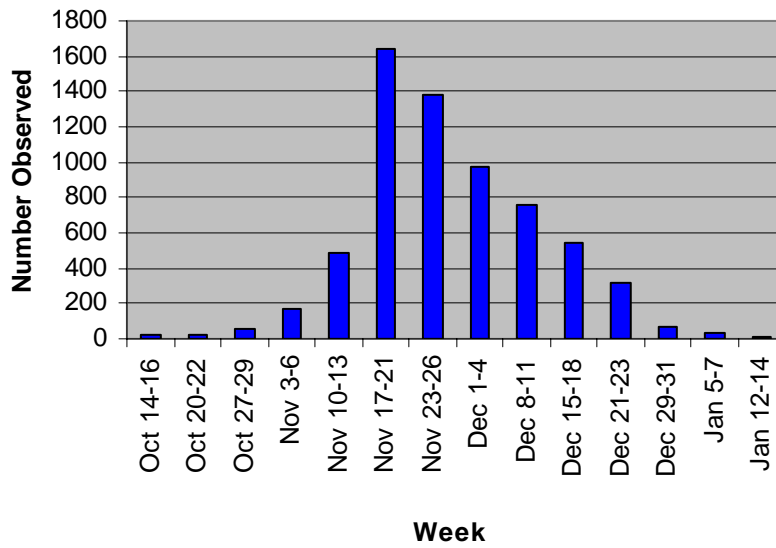


Figure 3. Weekly distribution of fresh carcasses, October 2003-January 2004.

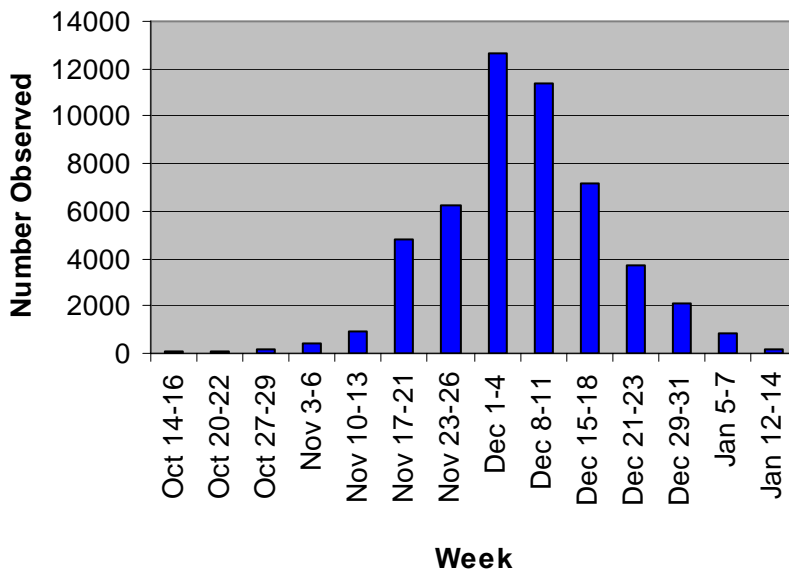


Figure 4. Weekly distribution of non-fresh carcasses, October 2003-January 2004.

Age Composition

Grilse comprised 7.3% (183) of the total catch of fresh measured carcasses (Table 3) and weekly percent composition ranged from 0% to 12.5%. The greatest number of grilse (42) was observed during Week 5. Adults comprised 92.6% (2,313) of the measured carcasses. The greatest number of adults (514) was observed during Week 6.

Week	Grilse		Adult	
	Number	Percent	Number	Percent
1	0	0	20	100
2	1	5	20	95
3	4	8	47	92
4	20	12	150	88
5	42	9	423	91
6	35	6	514	94
7	25	7	351	93
8	11	5	231	95
9	21	9	214	91
10	8	5	159	95
11	9	7	124	93
12	7	12.5	49	87.5
13	0	0	4	100
14	0	0	7	100
Total (Mean)	183	(7.3)	2,313	(92.7)

Sex Composition

Female Chinook salmon comprised 61% (1,523) of the 2,496 fresh carcasses examined, while male Chinook salmon comprised 39% (973) (Table 4). Most female (80%) and male (66%) fresh carcasses were collected in Reach 1.

Reach	Male	Female	Total
1	641	1,223	1,864
2	259	246	505
3	73	54	127
Total	973	1,523	2,496

Fourteen percent of the 973 fresh male carcasses and 3% of the 1,523 fresh female carcasses aged were grilse (Table 5). The overall ratio of adult male to adult female spawners was 1 to 1.8. Adult females were most abundant every week except towards the beginning and end of the carcass survey. The overall ratio of male grilse to female grilse was 3 to 1. Female grilse were most abundant only during weeks 3 and 10.

Week	Grilse				Adult			
	Male		Female		Male		Female	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1	0	-	0	-	11	55	9	45
2	1	100	0	-	6	30	14	70
3	1	25	3	75	19	40	28	60
4	18	90	2	10	58	39	92	61
5	35	83	7	17	142	34	281	66
6	28	80	7	20	177	34	337	66
7	19	76	6	24	105	30	246	70
8	6	55	5	45	82	35	149	65
9	15	71	6	29	82	38	132	62
10	3	37	5	63	68	43	91	57
11	7	78	2	22	53	43	71	57
12	5	71	2	29	26	53	23	47
13	0	-	0	-	1	25	3	75
14	0	-	0	-	5	71	2	29
Total (Mean)	138	(75)	45	(25)	835	(36)	1,478	(64)

Spawning Success

Of the 1,523 fresh adult and grilse female carcasses that were observed for egg retention, 48% had completely spawned, 37% were unspawned, and 15% were partially spawned (Table 6). Unspawned female salmon were observed nearly each week through Week 12. A high percentage ($\geq 90\%$) of unspawned females was counted through week 4, but decreased as the season progressed. The percentage of females classified as unspawned or partially spawned was higher than spawned females through Week 5. However, $\geq 23\%$ of females were unspawned from Week 6 through

Week 11. From Week 6 through Week 14, completely spawned females ranged from 50 to 100 percent of the female carcasses examined during a given week.

Table 6. Spawning completion (egg retention) summary for female Chinook salmon carcasses, October 2003-January 2004.

Week	# females checked for egg retention	Spawned	Unspawned	Partially Spawned
		Number (%)	Number (%)	Number (%)
1	9	0 (0)	9 (100)	0 (0)
2	14	0 (0)	12 (86)	2 (14)
3	31	0 (0)	30 (94)	1 (6)
4	94	4 (4)	84 (90)	6 (6)
5	288	76 (27)	162 (56)	50 (17)
6	344	177 (52)	97 (28)	70 (20)
7	252	154 (61)	61 (24)	37 (15)
8	154	86 (56)	42 (27)	26 (17)
9	138	90 (65)	33 (24)	15 (11)
10	96	67 (70)	22 (23)	7 (7)
11	73	46 (63)	18 (25)	9 (12)
12	25	23 (92)	1 (4)	1 (4)
13	3	3 (100)	0 (0)	0 (0)
14	2	1 (50)	0 (0)	1 (50)
Total (mean)	1,523	727 (48)	571 (37)	225 (15)

Coded-wire tagged fish

Of the 6,468 fresh carcasses that were observed during the survey, 464 were observed with missing adipose fins and classified as CWT fish. Weekly percentage of CWT fish ranged from 4.8 to 28.6% and averaged 7.2% (Table 7). The highest percentage of CWT fish was observed during Weeks 2 and 14.

Grilse comprised 6.3% of the total number of CWT Chinook salmon and weekly percent composition ranged from 0 to 25% (Table 8). The greatest number of CWT grilse (11) was observed during Week 6. Adult CWT Chinook salmon comprised 93.7% (435) of the measured CWT carcasses. The greatest number of adult CWT Chinook salmon was observed during Week 6 and 7.

Table 7. Number and percentage of fresh CWT Chinook salmon carcasses, October 2003-January 2004.

Week	Number of fresh carcasses observed	Number of CWT fish observed (Percent)
1	21	1 (4.8)
2	21	4 (19)
3	53	5 (9.4)
4	172	18 (10.5)
5	486	72 (14.8)
6	1,644	99 (6)
7	1,378	94 (6.8)
8	975	57 (5.8)
9	757	58 (7.7)
10	538	28 (5.2)
11	312	16 (5.1)
12	67	4 (6)
13	30	4 (13.3)
14	14	4 (28.6)
Total	6,468	464 (7.2)

Table 8. Age composition (grilse and adult) of CWT carcasses measured, October 2003-January 2004.

Week	Number of fresh CWT carcasses observed	Grilse		Adult	
		Number	Percent	Number	Percent
1	1	0	0	1	100
2	4	0	0	4	100
3	5	0	0	5	100
4	18	1	5.6	17	94.4
5	72	4	5.6	68	94.4
6	99	11	11	88	89
7	94	5	5.3	89	94.7
8	57	2	3.5	55	96.5
9	58	5	8.6	53	91.4
10	28	0	0	28	100
11	16	0	0	16	100
12	4	1	25	3	75
13	4	0	0	4	100
14	4	0	0	4	100
Total (Mean)	464	29	(6.3)	435	(93.7)

There were more adult CWT female Chinook salmon (62%) observed than adult male CWT Chinook salmon (Table 9). In contrast, there were more male CWT grilse (72%) than female CWT grilse.

Week	Grilse				Adult			
	Male		Female		Male		Female	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1	0	-	0	-	1	100	0	0
2	0	-	0	-	1	25	3	75
3	0	-	0	-	3	60	2	40
4	0	-	1	100	6	35	11	65
5	2	50	2	50	23	34	45	66
6	9	82	2	18	34	28	54	72
7	4	80	1	20	29	33	60	67
8	2	100	0	0	21	45	34	55
9	3	60	2	40	18	34	35	66
10	0	-	0	-	15	54	13	46
11	0	-	0	-	7	43	9	57
12	1	100	0	0	2	67	1	33
13	0	-	0	-	1	25	3	75
14	0	-	0	-	3	750	1	25
Total (Mean)	21	(72)	8	(28)	164	(38)	271	(62)

Population Estimate

A total of 4,186 fresh adult carcasses was tagged from Week 1 through Week 12 of which 1,527 tags were subsequently recovered (Table 10). Overall tag recovery rate was 36.5% and ranged from 14 to 45 percent. The modified Schaefer model produced an adult in-river escapement estimate of 146,945 (Table 11). Since adults made up 92.7% of the escapement, a total escapement (adult and grilse) of 158,516 was calculated by dividing the adult estimate by 0.927. Grilse comprised 7.3% (11,571) of the population.

Table 10. Weekly summary of tagging and recapture of fresh adult Chinook salmon carcasses, October 2003-January 2004.

Week of recovery (i)	Week of tagging												Tags recovered R(j)	Carcasses counted C(j)	Ratio C(j)/R(j)	
	1	2	3	4	5	6	7	8	9	10	11	12				
2	9													9	162	18.00
3		6												6	251	41.83
4			4											4	531	132.75
5				34										34	1364	40.12
6			1	9	111									121	6090	50.33
7					11	304								315	7393	23.47
8					3	67	257							327	12889	39.42
9						15	55	189						259	11456	44.23
10						1	4	31	133					169	7431	43.97
11							8	4	33	104				149	3881	26.05
12						1		4	12	40	44			101	2142	21.21
13							2			1	7	14		24	861	35.88
14								1	2	3		3		9	199	22.11
R(i)	9	6	5	43	125	388	326	229	180	148	51	17	Tagged fish recovered = 1,527			
M(i)	20	17	36	138	368	1,077	830	588	486	419	151	56	Total fish tagged = 4,186			
M(i)/R(i)	0.45	0.35	0.14	0.31	0.34	0.36	0.39	0.39	0.37	0.35	0.34	0.30	Overall ratio = 36.5%			

Table 11. Lower American River adult Chinook salmon population estimate using the Schaefer model based on tagging fresh carcasses with all captured untagged carcasses removed, October 2003-January 2004.

Population Estimate (i)														
Week of recovery (i)	Week of tagging												Totals	
	1	2	3	4	5	6	7	8	9	10	11	12		
1	360													
2		711												
3			3,823											
4				4,377										
5			362	1,454	16,447									
6					760	19,805								
7					348	7,330	25,791							
8						1,842	6,194	21,465						
9						122	448	3,500	15,790					
10							531	268	2,321	7,669				
11							59		218	687	2,402	2,763		
12								183			102	744	1,654	
13									57	119	188		219	
Subtotals	360	711	4,186	5,831	17,555	29,158	33,146	25,507	18,917	10,360	3,506	1,873	151,111	
Tagged		-17	-36	-138	-368	-1,077	-830	-588	-486	-419	-151	-56	-4,166	
Estimated population of natural spawning adults													146,945	

In addition to the 158,516 salmon that returned to the lower American River downstream of Nimbus weir, there were 14,887 salmon that entered Nimbus Hatchery. The total number of adult and grilse Chinook salmon collected at the Nimbus Fish Hatchery was 11,875 and 3,012, respectively.

There were an additional 15,454 adult and grilse carcasses removed from the Nimbus weir. By combining the in-river escapement (158, 516) with the total number of Chinook salmon collected at the Nimbus Fish Hatchery (14,887) and at the weir (15,454), the 2003 fall-run Chinook salmon escapement for the lower American River was estimated to be 188,857.

Conclusion and Discussion

A Chinook salmon escapement survey was conducted on the lower American River in 2003. Three reaches in the lower American River took three to five days to complete. Equal effort was applied to each reach by maintaining a consistent crew of six to seven people throughout the survey period.

The in-river escapement of Chinook salmon in the lower American River derived from the modified Schaefer method was estimated to be 158,516. The adult escapement estimate is more than three and three quarters greater than the previous 35 year (1967-2002) average of 41,445 fish (Table 12).

Since 2000, there has been an increasing trend in the number of returning fall-run Chinook salmon in the lower American River, and with that, a high degree of pre-spawning mortality. Water temperatures in early October most likely contributed to the high pre-spawning mortality observed during the beginning of the escapement survey (Weeks 1-4). After which, competition for spawning habitat was likely the cause of the steady trend ($\geq 23\%$) of pre-spawning mortality for female carcasses examined from Weeks 6-11.

The overall pre-spawning mortality averaged 37% for the entire period. Therefore, the number of returning females (61%) to the lower American River is reduced by 37%, or approximately 35,777 female Chinook salmon died before they spawned. This results in a spawning escapement estimate of approximately 122,739.

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
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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