State of California **The Resources Agency**

M e m o r a n d u m

Date: November 25, 2002

To : Bob McAllister
Senior Fishery Biologist

From : Michael Wallace
Assoc. Biologist, Natural Stocks Assessment Project

Subject: 2002 Klamath Basin Juvenile Salmonid Emigration Patterns Through the Klamath Estuary

Attached you'll find a description of the emigration pattern of juvenile Chinook salmon passing through the Klamath River estuary from March through August 2002. The description is based on the catch-per-unit-effort (CPUE) of Chinook and CWT's recovered from adipose fin-clipped juvenile Chinook by the Natural Stocks Assessment Project (NSA). I also estimated the ratio of natural to hatchery origin young-of-the-year (yoy) Chinook emigrating through the Klamath River estuary. I also present some limited information about the emigration of other juvenile salmonid species. All the data presented in this memo is preliminary and subject to revision.

NSA sampled the Klamath estuary once a week with a beach seine in the lower estuary (River Mile 0-1.5) and a boat electrofisher in the upper estuary (RM 2-4). Beginning in 1993, (excluding 1995) NSA established standard sampling sites and methodologies in the Klamath estuary to monitor natural and hatchery juvenile Chinook emigration and to compare annual changes in relative abundance and size of juvenile salmonids occurring there. In 2000 and 2001 we added an additional three seining sites to the lower estuary sampling plan. These consisted of an additional site on the sand spit separating the estuary from the ocean and two sites adjacent to the mouth of Hunter Creek, a cool water tributary which enters the estuary at approximately river mile1.5. I added the Hunter Creek sites to see if juvenile salmonids used the cool water as a refuge from warm water in the same way they use the mouths of cool water tributaries upstream of the estuary. I did not include these three sites in our comparisons to past years because NSA did not sample these sites in past years. In 2002 NSA dropped the Hunter Creek sites because we had collected the information we needed and didn't feel it was prudent to continue capturing and handling the large number of fish utilizing this area.

I calculated the median days at liberty (DAL) for each Chinook salmon tag code by determining the number of days between their releases from the hatchery to their capture in the estuary (Table 1). For CWT Chinook released over multiple days I used the mid-point of release dates as the release date. I feel the mid-point release date must be within 7 days of the entire range of release dates in order for a meaningful travel time to be calculated.

I made weekly estimates of the number of hatchery fish in our sample by multiplying the number of fish captured in each tag code by its ratio of untagged to tagged fish reported by basin hatcheries (Table 2). Any Chinook not accounted for by hatchery expansion were assumed to be of natural origin. In weeks when the estimated number of hatchery Chinook exceeded the actual number of fish captured, I used the actual number of fish

Table 1. Summary of young-of-the-year CWT juvenile Chinook salmon captured in the Klamath River estuary March-August 2002.

Release Site	**CWT**	**Size at Release**	**Release Dates**	**No. Tagged**	**No. Released**	**No. Cap**	**Median DAL**	**Range DAL**	**AVG FL**
	0601020400	91/lb	May 10	49,315	815,593	2	36	33-39	101.5
	0601020401	90/lb	May 21	47,538	806,918	0	-	-	-
IGH	0601020402	85/lb	May 28	51,363	1,648,495	0	-	-	-
	0601020403	105/lb	June 5	50,545	1,495,322	6	27	13-35	94.8
IGH TOTAL				198,761	4,764,328	8	29	13-39	96.5
	065281	39/lb	June 3-10	89,482	276,612	9	14	11-24	104.1
TRH(s)	065282	39/lb	June 3-10	85,978	273,636	8	22	11-55	99.8
	065283	45/lb	June 3-10	73,788	227,742	5	27	11-42	98.2
TRH SPRING TOTAL				249,248	777,990	22	20	11-55	101.8
	065284	71/lb	June 3-10	119,555	368,099	14	29	11-66	91.5
	065285	71/lb	June 3-10	114,119	379,607	14	24	19-55	88.6
TRH(f)	065286	86/lb	June 3-10	126,135	384,128	22	29	17-74	87.0
	065287	86/lb	June 3-10	121,607	377,601	25	33	17-82	88.0
	065290	126/lb	June 3-10	10,234	30,805	2	40	24-55	80.0
	065291	126/lb	June 3-10	8,269	24,890	0	-	-	-
TRH FALL TOTAL				499,919	1,565,130	77	30	11-82	88.3

Table 2. Total number of Chinook salmon released and coded-wire tagged from Klamath basin hatcheries and expansion factors used to determine the hatchery component of emigrating chinook in the Klamath River estuary, 2002.

HATCHERY	CWT CODE	UNMARKED FISH	TAGGED FISH	EXPANSION FACTOR
	0601020400	813,593	49,315	16.50:1
	0601020401	806,918	47,538	16.97:1
Iron Gate	0601020402	1,648,495	51,363	32.09:1
	0601020403	1,495,322	50,545	29.58:1
	065284	368,099	119,555	3.08:1
	065285	379,607	114,119	3.33:1
Trinity River	065286	384,128	126,135	3.05:1
(fall run)	065287	377,601	121,607	3.11:1
	065290	30,805	10,234	3.01:1
	065291	24,890	8,269	3.01:1
Trinity River	065281	276,612	89,482	3.09:1
(spring run)	065282	273,636	85,978	3.18:1
	065283	227,742	73,788	3.09:1

captured as the number of hatchery fish present. Also, if there were more than one tag group represented during those weeks I "pro-rated" the number of each group by their percentage of expected occurrence. For example, the untagged to tagged ratio is roughly 30:1 for IGH tag group 0601020403 and 3:1 for all TRH fall and TRH spring tag groups (Table 2). Therefore, if we captured one CWT fish from each group I assumed a total of 36 hatchery fish were present in our catch. However, if we captured one fish from each tag group but only had 20 fish in our catch, I assumed all were hatchery fish but attributed 30/36 (83.3%) of the catch to IGH (.833*20=16.7) or 17 out of 20 fish to IGH. I then followed the same steps to allocate the number captured to the other groups of fish. I then summed the weekly estimates to determine the total portion of captured Chinook that were of hatchery origin by month and season (Tables 3&4). NSA retained all captured adipose fin clipped Chinook and decoded their CWT's to evaluate the emigration patterns of known origin hatchery fish.

Chinook Emigration

For the second consecutive year river flows in the Klamath-Trinity (K-T) basin were below average which appeared to have the following detrimental effects on juvenile salmonids leaving the basin; 1) juvenile salmonid abundance was below average compared to past years; 2) yoy Chinook were smaller than past years; and 3) yoy Chinook emigration was earlier than past years (possibly due to inhospitable conditions upstream of the estuary). Also, there was a high incidence of disease in yoy Chinook from the Klamath River (Ken Nichols, USFWS, personal communication).

Table 3. Origin and portion of **young-of-the-year** Chinook salmon emigrating through the lower Klamath River estuary based on expansions of CWT's recovered during standard sampling of sites 1-5, March-August 2002. Numbers in parenthesis are actual numbers of captured salmon containing CWT's.

WEEK OF	TOTAL CHINOOK	IGH 061240	IGH 061243	TRHs 065281	TRHs 065282	TRHs 065283	TRHf 065284	TRHf 065285	TRHf 065286	TRHf 065287	TRHf 065290	NO. NATURAL	NO. HATCHERY	PERCENT NATURAL
3/05	0	0	0	0	0	0	0	0	0	0	0	0	0	-
3/18	1	0	0	0	0	0	0	0	0	0	0	1	0	100.0
3/25	0	0	0	0	0	0	0	0	0	0	0	0	0	-
Total	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**100.0**
4/02	2	0	0	0	0	0	0	0	0	0	0	2	0	100.0
4/08	6	0	0	0	0	0	0	0	0	0	0	6	0	100.0
4/17	4	0	0	0	0	0	0	0	0	0	0	4	0	100.0
4/22	1	0	0	0	0	0	0	0	0	0	0	1	0	100.0
4/29	0	0	0	0	0	0	0	0	0	0	0	0	0	-
Total	**13**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**13**	**0**	**100.0**
5/08	0	0	0	0	0	0	0	0	0	0	0	0	0	-
5/13	5	0	0	0	0	0	0	0	0	0	0	5	0	100.0
5/20	10	0	0	0	0	0	0	0	0	0	0	10	0	100.0
5/29	0	0	0	0	0	0	0	0	0	0	0	0	0	-
Total	**15**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**15**	**0**	**100.0**
6/03	7	0	0	0	0	0	0	0	0	0	0	7	0	100.0
6/12	5	5(1)	0	0	0	0	0	0	0	0	0	0	5	0
6/17	6	0	0	0	0	0	0	0	0	0	0	6	0	100.0
6/26	213	0	0	6(2)	9(3)	6(2)	12(4)	30(9)	18(6)	12(4)	0	120	93	56.3
Total	**231**	**1(5)**	**0**	**6(2)**	**9(3)**	**6(2)**	**12(4)**	**30(9)**	**18(6)**	**12(4)**	**0**	**133**	**98**	**57.6**
7/01	125	0	30(1)	3(1)	0	0	6(2)	7(2)	24(8)	19(6)	3(1)	33	92	26.4
7/10	185	0	89(3)	0	0	0	0	7(2)	3(1)	19(6)	0	67	118	36.2
7/19	134	0	0	0	0	6(2)	6(2)	0	9(3)	9(3)	0	104	30	77.6
7/22	44	0	0	0	0	0	0	0	3(1)	0	0	41	3	93.2
Total	**488**	**0**	**118(4)**	**3(1)**	**0**	**6(2)**	**12(4)**	**13(4)**	**40(13)**	**47(15)**	**3(1)**	**242**	**245**	**50.2**
8/01	158	0	0	0	3(1)	0	3(1)	3(1)	0	3(1)	3(1)	143	15	90.5
8/08	91	0	0	0	0	0	0	0	0	0	0	91	0	100.0
8/12	88	0	0	0	0	0	3(1)	0	0	0	0	85	3	96.6
8/19	13	0	0	0	0	0	0	0	0	0	0	13	0	100.0
8/28	11	0	0	0	0	0	0	0	0	3(1)	0	8	3	72.7
Total	**361**	**0**	**0**	**0**	**3(1)**	**0**	**6(2)**	**3(1)**	**0**	**6(2)**	**3(1)**	**340**	**21**	**94.2**
TOTAL	**1,109**	**1(5)**	**118(4)**	**9(3)**	**13(4)**	**12(4)**	**31(10)**	**47(14)**	**58(19)**	**65(21)**	**6(2)**	**747**	**361**	**67.4**
JUN-SEP TOTAL	**1,080**	**1(5)**	**118(4)**	**9(3)**	**13(4)**	**12(4)**	**31(10)**	**47(14)**	**58(19)**	**65(21)**	**6(2)**	**718**	**361**	**66.5**

Table 4. Origin and portion of **young-of-the-year** Chinook salmon emigrating through the upper Klamath River estuary based on expansions of CWT's recovered during standard sampling March-August 2002. Numbers in parenthesis are actual numbers of captured salmon containing CWT's.

WEEK OF	TOTAL CHINOOK	IGH 061240	IGH 061243	TRHs 065281	TRHs 065282	TRHs 065283	TRHf 065284	TRHf 065286	TRHf 065287	NO. NATURAL	NO. HATCHERY	PERCENT NATURAL
4/03	0	0	0	0	0	0	0	0	0	0	0	-
4/23	0	0	0	0	0	0	0	0	0	0	0	-
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**100.0**
5/01	0	0	0	0	0	0	0	0	0	0	0	-
5/14	1	0	0	0	0	0	0	0	0	1	0	100.0
5/21	10	0	0	0	0	0	0	0	0	10	0	100.0
5/30	12	0	0	0	0	0	0	0	0	12	0	100.0
Total	**23**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**15**	**0**	**100.0**
6/04	12	0	0	0	0	0	0	0	0	12	0	100.0
6/10	25	0	0	0	0	0	0	0	0	25	0	100.0
6/18	168	17(1)	30(1)	19(6)	10(3)	3(1)	6(2)	0	0	83	85	49.4
6/24	45	0	30(1)	0	0	0	0	3(1)	3(1)	9	36	20.0
Total	**250**	**17(1)**	**59(2)**	**19(6)**	**10(3)**	**3(1)**	**6(2)**	**3(1)**	**3(1)**	**129**	**121**	**51.6**
7/02	99	0	0	0	0	0	3(1)	0	6(2)	90	9	90.1
7/08	170	0	0	0	3(1)	0	3(1)	0	0	164	6	96.5
7/17	296	0	0	0	0	0	0	0	0	296	0	100.0
7/24	221	0	0	0	0	0	0	3(1)	0	218	3	98.6
7/30	165	0	0	0	0	0	0	0	0	165	0	100.0
Total	**951**	**0**	**0**	**0**	**3(1)**	**0**	**6(2)**	**3(1)**	**6(2)**	**933**	**18**	**98.1**
8/15	109	0	0	0	0	0	0	0	0	109	0	100.0
8/20	84	0	0	0	0	0	0	3(1)	3(1)	78	6	72.7
Total	**193**	**0**	**0**	**0**	**0**	**0**	**0**	**3(1)**	**3(1)**	**187**	**6**	**96.9**
TOTAL	**1,417**	**17(1)**	**59(2)**	**19(6)**	**13(4)**	**3(1)**	**12(4)**	**9(3)**	**12(4)**	**1,272**	**145**	**89.8**
JUN-SEP TOTAL	**1,394**	**17(1)**	**59(2)**	**19(6)**	**13(4)**	**3(1)**	**12(4)**	**9(3)**	**12(4)**	**1,249**	**145**	**89.6**

In 2002 the migration rates of IGH Chinook and TRH fall-run Chinook were the second fastest on record, while TRH spring-run Chinook was intermediate to past years (Table 5). Low river flows and the relatively large size of Chinook released from K-T basin hatcheries probably contributed to their relatively fast emigration rates in 2002.

The composition of natural vs. hatchery yoy Chinook in our catches was different between the lower and upper estuary (Table 6). During sampling from June through August, natural origin Chinook accounted for 66.5% of our catch in the lower estuary and 89.6% in the upper estuary. The samples showed that hatchery origin Chinook comprised the greatest proportion of NSA's catch during early July in the lower estuary and late June in the upper estuary (Tables 3&4). Overall estimates (upper and lower estuary catches combined) suggest that about 80% of the juvenile Chinook captured by our project during 2002 were of natural origin (Table 6). This year the natural Chinook component was less than last year but was still relatively high compared to other years (Table 6). **However, our CPUE data suggests that the high portion of natural origin Chinook was not due to high abundance of natural origin chinook, but due primarily to the low abundance of hatchery Chinook in the upper and lower estuary (Table 7).**

The abundance of naturally produced yoy Chinook was below average compared to past years (Table 7). CPUE and percent composition of natural origin Chinook were lower than last year in both the upper and lower estuary. Natural Chinook arrived in the estuary in low numbers

Table 5. Median travel time (in days) of young-of-the-year Chinook salmon from hatchery release to capture in Klamath River estuary, 1993-2002.

	Travel Time		
Year	**IGH**	**TRH fall-run**	**TRH spring-run**
1993	52	28	13
1994	26	71	54
1996	33	39	19
1997	43	59	39
1998	40	66	35
1999	30	75	32
2000	31	52	17
2001	32	30	12
2002	29	30	20

Table 6. Proportions of natural and hatchery origin young-of-the-year Chinook salmon migrating through the Klamath River estuary, 1993-2002.

	Lower Estuary		Upper Estuary		Total	
Year	% Natural	% Hatchery	% Natural	% Hatchery	% Natural	%Hatchery
1993	83.5	16.5	85.7	14.3	85.5	14.5
1994	78.0	22.0	73.4	26.6	76.3	23.7
1996	76.3	23.7	66.0	34.0	69.8	30.2
1997	58.1	41.9	47.5	52.5	49.0	51.0
1998	37.2	62.8	68.3	31.7	56.7	43.3
1999	58.9	41.1	81.3	18.7	79.6	20.4
2000	58.0	42.0	60.1	39.9	59.0	41.0
2001	87.1	12.9	91.9	8.1	89.7	10.3
2002	66.5	33.5	89.6	10.4	79.5	20.5

Table 7. Overall CPUE of natural, IGH, and spring and fall-run TRH Chinook salmon captured in the lower and upper Klamath River estuary, 1993-2002.

	LOWER (Fish/1000ft^2)					UPPER (Fish/minute)				
Year	Nat	IGH	TRHf	TRHs	Total	Nat	IGH	TRHf	TRHs	Total
1993	3.26	0.27	0.49	0.06	4.08	6.77	0.18	0.93	0.19	8.07
1994	6.17	1.28	0.03	0.43	7.91	2.42	0.66	0.004	0.04	3.13
1996	2.57	0.12	0.28	0.42	3.39	3.87	0.56	0.83	0.50	5.76
1997	1.82	1.08	0.19	0.04	3.13	5.25	5.14	0.53	0.14	11.06
1998	2.67	2.95	1.03	0.53	7.18	4.17	0.58	1.28	0.08	6.11
1999	0.59	0.24	0.12	0.05	1.00	8.80	1.32	0.54	0.16	10.82
2000	2.01	1.26	0.14	0.08	3.49	3.16	1.61	0.38	0.11	5.26
2001	2.88	0.23	0.15	0.004	3.26	4.14	0.20	0.12	0.03	4.49
2002	1.71	0.29	0.40	0.06	2.46	3.83	0.24	0.10	0.11	4.28

beginning in April and May (Appendix 1&2). Natural Chinook CPUE peaked during late July and early August in the lower estuary and in mid July in the upper estuary (Appendix 2&3).

NSA's estimate of juvenile natural Chinook abundance was lower in 2002 than 2001. The spawner escapement estimate for adult natural Chinook in 2001 was also slightly lower than the 2000 estimate. Low river flows in 2002 and 2001 likely created poor rearing conditions in the mainstem river that may have reduced the survival of natural Chinook the last two years. Foott et al. (2002), painted a bleak picture of overall fish health in the mainstem Klamath River and estuary in 2001 and preliminary data suggest that Klamath River Chinook had a high incidence of disease again in 2002 (Ken Nichols, USFWS, personal communication).

The smaller average size of yoy Chinook in 2002 and 2001 also suggests that rearing conditions in the basin were poor the last two years. The average size of yoy Chinook in 2002 was among the smallest on record (Tables 8&9). For example, in the lower estuary the seasonal mean FL was 85 mm in 2002 compared to 96 mm in 2000 and in the upper estuary their average FL was 85 mm in 2002 compared to 100 mm in 2000. The smallest August FL's occurred in 2002, 2001, and 1994 (Tables 8&9) which were also the years with the lowest river flows during this study.

TRH spring Chinook CPUE was about average compared to past years (Table 7). They arrived in mid June in the upper estuary and in late June in the lower estuary. Their emigration peaked the week of their arrival in the upper and lower estuary (Appendix 1&2). Typically TRH spring Chinook are the first hatchery Chinook to reach the estuary and have a shorter average travel time from hatchery to the estuary than IGH and TRH fingerling fall Chinook. This year TRH spring Chinook had the shortest travel time from hatchery release to the estuary, but IGH fish were the first hatchery Chinook to arrive in the estuary because IGH released a portion of their fish earlier than TRH released their fish (Table 1). TRH spring Chinook are considerably larger at hatchery release than the other fingerling Chinook stocks released from IGH and TRH (Table 1). Their larger size probably causes them to migrate faster than the other stocks of smaller hatchery Chinook. It has been well established that larger yoy Chinook migrate faster than smaller sized fish in the Klamath-Trinity basin (USFWS 1998; Wallace 1995; memo dated 12/15/98 from Michael Wallace to Gary Stacey).

TRH fall Chinook CPUE was above average in the upper estuary and the second lowest on record in the lower estuary this year (Table 7). They arrived in the upper estuary in mid June and their

Table 8. Monthly mean fork length (FL), standard deviation (SD) and number (n) of young-of-the-year Chinook salmon measured in the lower Klamath River estuary 1993-2002.

Year	May			June			July			August			September			Total		
	n	FL	SD	n	FL	SD	n	FL	SD	n	FL	SD	n	FL	SD	n	FL	SD
2002	8	64.8	8.0	47	89.9	6.1	248	85.4	6.9	149	87.2	5.3	-	-	-	461	85.3	8.9
2001	80	69.0	16.6	313	87.3	7.9	444	86.1	7.1	407	89.0	6.9	151	96.4	7.9	1395	87.4	9.8
2000	40	67.6	9.3	205	91.0	10.1	237	91.6	8.7	177	97.3	8.5	177	113.7	8.4	836	96.2	14.1
1999	-	-	-	15	94.3	2.6	184	92.2	7.2	115	97.9	7.5	48	113.8	10.9	362	96.9	10.5
1998	-	-	-	110	88.7	4.9	234	89.7	5.8	195	92.8	6.9	153	106.3	7.0	692	94.1	9.2
1997	50	55.1	13.1	278	94.3	7.1	184	92.4	5.5	74	97.9	7.3	-	-	-	586	90.8	13.3
1996	79	75.9	14.2	254	87.3	10.4	174	88.8	7.4	134	89.0	6.3	-	-	-	641	86.7	10.4
1994	42	51.4	11.3	195	88.6	9.4	304	84.1	5.8	526	89.1	6.5	5	99.8	7.5	1072	86.2	10.3
1993	56	49.5	11.5	137	83.7	15.7	344	86.3	7.3	45	98.9	11.3	12	111.5	6.7	594	83.7	16.1

Table 9. Monthly mean fork length (FL), standard deviation (SD) and number (n) of young-of-the-year Chinook salmon measured in the upper Klamath River estuary 1993-2002.

Year	May			June			July			August			September			Total		
	n	FL	SD	n	FL	SD	n	FL	SD	n	FL	SD	n	FL	SD	n	FL	SD
2002	23	74.4	14.0	158	91.0	8.4	465	82.1	6.3	136	89.8	7.3	-	-	-	782	85.0	8.5
2001	83	86.9	10.5	322	88.7	9.2	387	84.6	6.4	206	87.7	7.1	-	-	-	998	86.8	8.1
2000	29	91.9	13.7	171	100.7	11.8	431	93.8	7.2	222	97.4	6.8	251	112.6	9.5	1104	99.8	11.4
1999	-	-	-	62	93.7	6.8	426	91.0	7.2	380	98.8	8.6	468	116.6	10.8	1336	102.3	14.1
1998	-	-	-	-	-	-	328	89.1	8.1	519	92.3	6.7	237	103.3	6.6	1084	93.7	8.8
1997	14	96.3	11.6	154	95.4	10.0	512	93.6	6.6	298	95.1	6.4	-	-	-	978	94.4	7.3
1996	-	-	-	359	89.4	9.6	304	87.5	7.8	200	88.5	6.2	-	-	-	863	88.5	8.3
1994	17	89.8	20.9	281	89.8	8.7	247	82.8	6.6	149	87.4	7.2	-	-	-	696	86.8	8.8
1993	6	67.3	11.8	280	89.0	13.5	297	86.8	7.3	422	96.2	7.5	490	112.0	9.0	1495	98.0	14.0

emigration peaked in early July (Appendix 2). This peak was about two weeks later than last year but a couple of weeks earlier than other years. In the lower estuary they arrived in late June and their abundance peaked in early July and they were present until the end of sampling in late August (Appendix 3). Prior to 2001 TRH fall Chinook abundance typically peaked in July and August (CDFG 2000; CDFG 2001). Their 30 day median travel time to the estuary the past two years are the second fastest migration rates on record (Table 5). They were markedly larger at release in 2001 compared to this year and past years which likely contributed to their fast migration rate in 2001. Lower river flows in 2001 and 2002 may have also lowered travel times by reducing rearing habitat in the river that may either forced the fish to keep emigrating downstream or increased the mortality of fish attempting to rear so we were more likely to capture the early migrating fish. Even though the size at release of TRH fall Chinook in 2002 was not as large as 2001 the average size was still larger than the Department's 90 fish/lb release goal so they still migrated quickly out of the basin. This suggests that when K-T basin hatcheries meets the Department's size goal for yoy Chinook it likely reduces potential competition between natural and hatchery yoy Chinook by shortening the time hatchery and natural fish have to share the river.

The CPUE of IGH Chinook in 2002 was below average in the upper and about average in the lower estuary (Table 7). IGH fish arrived in the estuary in mid June and persisted through mid July (Appendix 2&3). Their emigration peaked in mid June in the upper estuary and in early July in the lower estuary. Their emigration time was the second fastest on record (Table 5). This year IGH conducted a different release strategy from past years. In past years IGH would attempt to hold their fingerling Chinook until they reached 90 fish/lb and then release the entire group, usually 4 to 5 million fish at one time in early to mid June. There was concern that releasing this many hatchery fish at once would overwhelm available habitat and food resources and increase competition between hatchery and natural Chinook. So this year IGH separated the fingerling Chinook into four groups and starting in mid May released each group as they attained 90 fish/lb except for the last group that was released at a smaller size so they could emigrate from the area before water temperatures became too warm (Table 1). For the first time since our monitoring began NSA captured fish from the smallest fish size group at a higher rate than the other larger fish size groups. Also for the first time the small fish size group had a shorter travel time than the larger fish tag groups (Table 1). In other years we observed that the CWT group containing the smallest sized fish was captured at a lower rate and had a longer DAL than the other CWT groups containing larger fish. This year we captured very few IGH marked Chinook so with the small sample size the apparent behavior of the small sized groups may just be an anomaly in the data. Or, changing river conditions between mid May and mid June may have imposed different environmental conditions on each release group and caused them to behave in different ways. Or, the earlier fish may not have been as far along in the smolting process as the last release group which may have slowed the migration rate of the early release group. In any event, DFG should examine juvenile salmonid screwtrap data collected from the K-T basin by other agencies to increase the sample size of CWT fish to determine if this emigration pattern really occurred.

Coho Emigration

During 2002, CPUE of yearling coho salmon peaked during early to mid May in the upper estuary and late May in the lower estuary (Tables 10&11). Yearling coho CPUE in the upper estuary was about half as much as their CPUE in 2001. Low flows during 2001 may have limited the survival of yoy coho last summer thereby reducing the abundance of yearling coho emigrating this spring. The CPUE of coho in the lower estuary was higher in 2002 than 2001 but almost half the coho captured in the lower estuary were captured in one set. Due to the high variation in beach seine catches and the large size of yearling coho I believe that boat electrofishing gives us the best estimate of coho abundance.

Table 10. Monthly catch-per-unit-effort of juvenile coho salmon, steelhead trout and coastal cutthroat trout captured in the lower Klamath River estuary 1993-2002. Three sites were excluded from the 2000 and 2001 catches and one site from 2002 catches so that we could compare these year's CPUE to past years.

Year	May				June				July				August				September				Total			
	Effort	Coho	SH	CUT	Effort	Coho	SH	CUT	Effort	Coho	SH	CUT	Effort	Coho	SH	CUT	Effort	Coho	SH	CUT	Effort	Coho	SH	CUT
2002	101.6	0.74	0.06	0.15	107.8	0.00	0.14	0.54	98.3	0.00	0.03	0.04	102.0	0.00	0.04	0.22	-	-	-	-	409.7	0.18	0.07	0.24
2001	95.0	0.04	0.12	0.18	105.5	0.00	0.04	0.04	135.8	0.00	0.10	0.01	108.4	0.00	0.04	0.08	105.2	0.00	0.00	0.05	549.9	0.01	0.06	0.07
2000	58.1	0.15	0.33	0.12	94.4	0.01	0.01	0.24	76.1	0.00	0.28	0.28	107.8	0.00	0.03	0.07	99.1	0.00	0.03	0.07	435.5	0.02	0.11	0.15
1999	19.9	0.90	0.00	0.05	102.6	0.99	0.14	0.12	81.2	0.00	0.43	0.16	104.8	0.00	0.25	0.14	78.8	0.00	0.43	0.17	387.4	0.31	0.28	0.14
1998	-	-	-	-	29.9	0.00	0.30	1.04	56.3	0.02	0.28	0.57	67.3	0.00	0.15	0.18	45.4	0.00	0.04	0.46	198.8	0.01	0.19	0.48
1997	47.9	1.40	1.42	1.92	89.5	0.03	0.19	0.52	70.7	0.00	0.00	0.14	63.7	0.00	0.00	0.02	-	-	-	-	276.2	0.25	0.31	0.54
1996	27.2	0.07	0.47	0.33	62.8	0.02	1.21	0.80	84.8	0.00	0.00	0.01	96.7	0.00	0.02	0.01	-	-	-	-	271.4	0.01	0.34	0.22
1994	96.5	0.00	0.03	0.01	101.5	0.00	0.13	0.05	87.5	0.00	0.00	0.00	116.3	0.00	0.01	0.01	-	-	-	-	424.9	0.00	0.04	0.02
1993	27.8	0.18	0.07	0.54	51.4	0.00	0.08	0.12	97.2	0.00	0.11	0.12	118.2	0.00	0.00	0.02	83.6	0.00	0.00	0.00	378.3	0.01	0.04	0.09

Table 11. Monthly catch-per-unit-effort of juvenile coho salmon, steelhead trout and coastal cutthroat trout captured in the upper Klamath River estuary 1993-2002.

Year	May				June				July				August				September				Total			
	Effort	Coho	SH	CUT	Effort	Coho	SH	CUT	Effort	Coho	SH	CUT	Effort	Coho	SH	CUT	Effort	Coho	SH	CUT	Effort	Coho	SH	CUT
2002	100.3	1.00	1.65	0.21	109.1	0.01	0.58	0.21	156.2	0.00	0.23	0.14	60.5	0.00	0.28	0.26	-	-	-	-	426.0	0.24	0.66	0.19
2001	125.4	1.69	0.57	0.33	107.0	0.04	0.64	0.55	151.1	0.00	0.08	0.07	123.5	0.00	0.27	0.19	-	-	-	-	507.0	0.43	0.36	0.28
2000	57.8	2.23	3.20	0.45	91.6	0.07	1.88	0.34	130.3	0.01	0.97	0.17	97.8	0.00	0.86	0.08	109.8	0.00	0.77	0.11	487.3	0.28	1.34	0.20
1999	-	-	-	-	25.6	0.04	0.74	0.74	108.6	0.00	1.33	0.09	130.6	0.00	0.28	0.01	136.6	0.01	0.54	0.07	434.8	0.01	0.65	0.09
1998	-	-	-	-	-	-	-	-	128.4	0.01	0.97	0.33	180.0	0.00	0.40	0.02	84.7	0.01	0.20	0.00	393.0	<0.01	0.54	0.11
1997	24.8	0.57	1.62	0.36	99.2	0.01	1.36	0.29	154.0	0.00	0.84	0.12	128.6	0.00	0.31	0.02	-	-	-	-	406.6	0.04	0.85	0.15
1996	-	-	-	-	84.7	0.04	2.01	0.58	99.2	0.00	1.02	0.26	93.6	0.00	0.88	0.17	-	-	-	-	277.4	0.01	1.27	0.33
1994	109.4	2.39	0.52	0.48	154.2	0.01	0.10	0.16	158.5	0.01	0.01	0.01	200.8	0.00	0.00	0.03	-	-	-	-	623.0	0.43	0.12	0.14
1993	10.1	0.50	0.60	0.60	77.1	0.00	0.51	0.36	77.8	0.00	0.06	0.04	152.3	0.00	0.07	0.03	199.0	0.00	0.18	0.06	516.2	0.01	0.19	0.10

Of the 203 yearling coho salmon smolts NSA captured in 2002, 126 (62.1%) were released from TRH, 7 (3.4%) were released from IGH and 70 (34.5%) were natural fish. There was no apparent difference in emigration timing between natural and hatchery coho. Natural origin coho comprised 34.5% of our yearling coho catch in 2002 compared to 26.8% in 2001 and 39.1% in 2000 (CDFG 2002; CDFG 2001). Hatchery origin coho smolts were considerably larger than natural coho smolts. In the upper estuary the mean FL of coho smolts was 200 +/- 32 mm (n=89) for TRH fish, 216 +/- 19 mm (n=2) for IGH fish and 135 +/- 30 mm (n=12) for natural origin coho. In the lower estuary the mean FL of coho smolts was 186 +/- 23 mm (n=23) for TRH fish, 156 mm (n=1) for IGH fish and 132 +/- 13 mm (n=34) for natural origin coho. The composition of our lower estuary catch contained about five times the percentage of natural coho smolts (53 of 88, 60.2%) than the upper estuary catch (12 of 103 smolts, 11.7%). In 2001 the composition of our lower estuary catch contained almost twice the percentage of natural coho smolts (97 of 282, 34.4%) than the upper estuary catch (43 of 244 smolts, 17.6%). It may be that natural coho are lingering in the lower estuary longer than hatchery coho prior to ocean entry increasing their chances of being captured, or that large numbers of natural coho are emigrating from Hunter Creek and moving downstream directly into the lower and bypassing the upper estuary upstream of Hunter Creek.

Steelhead Emigration

Juvenile steelhead CPUE in 2002 was below average in the lower estuary and about average in the upper estuary compared to past years (Tables 10&11). Their abundance peaked in May in the upper estuary and June in the lower estuary. Juvenile steelhead CPUE in the upper and lower estuary from 1996-2000 is higher than levels observed in 1993 and 1994 (Tables 10&11) and in the late 1980's (CDFG unpublished data) during the prolonged drought of the late 1980's and early 1990's. The increased steelhead CPUE observed by NSA suggests that steelhead production in the K-T basin has increased during the last 5 to 6 years of relatively good water years. The last 2 years of low river flows have apparent reduced their abundance below that of 1996-2000 but it is still higher than during the drought.

Of the 374 steelhead NSA captured IN 2002, 48 (12.8%) were hatchery origin fish. All hatchery steelhead were from TRH. This is similar to the hatchery steelhead composition in 2001. The last two years are the highest hatchery contribution observed by NSA. I think this is due to NSA initiating sampling at an earlier date than past years resulting in intercepting hatchery marked steelhead at a greater rate than past years. Most of the emigrating hatchery origin steelhead passed through the estuary in April prior to the start of sampling in past years. It appears that hatchery origin steelhead leave the Klamath basin rather quickly, about 1 month after their release from basin hatcheries.

Sea-run Coastal Cutthroat Trout Emigration and Estuary Rearing

During 2002 all juvenile coastal cutthroat trout captured were natural origin fish and their abundance was above average in the upper and lower estuary (Tables 10&11). The CPUE of sea-run cutthroat trout peaked in June in the lower estuary and was consistent throughout the season in the upper estuary but slightly highest in August (Tables 10&11).

In 2002 NSA attempted to continue marking coastal cutthroat trout, but due to the poor VI tag retention and increased difficulty of tagging fish due to the deterioration of the unused VI tags we discontinued marking cutthroat in May. Therefore we only marked and released 28 cutthroat trout and did not recapture any of them. The past two years of marking cutthroat trout indicate that they may rear for weeks to months in the Klamath estuary and that their growth rate is quite high (CDFG 2001; CDFG 2000).

Conclusion

The lower CPUE of natural and hatchery Chinook in the upper and lower estuary, the lower abundance of chinook emigrating in the late summer, and their smaller size in 2002 compared to past years suggest that yoy Chinook production in the K-T basin was similar to last year but poor compared to other years. Earlier NSA studies (Wallace and Collins 1997) hypothesized that increased mainstem river flows created more favorable in-river rearing conditions and increased the survival of late summer emigrating juvenile Chinook (summer flows were low in 2001 and 2002). Other studies from Oregon coastal rivers have shown that these later emigrating Chinook are larger upon ocean entry and have higher marine survival rates than earlier emigrating Chinook and therefore survive to adults at a higher rate (Nicholas and Hankin 1989). Perhaps the low river flows in the mainstem Klamath and Trinity Rivers reduced acceptable habitat in the basin, increased the incidence of disease or increased inter or intraspecific competition for food and space resources in the basin and reduced the survival of juvenile salmonids.

If you have any comments or questions please contact me at (707) 822-3702 or <mwallace@dfg.ca.gov>.

Michael Wallace
Associate Biologist

cc: Sara Borok, CDFG NCNCR
Steve Burton, CDFG NCNCR
Bill Chesney, CDFG NCNCR
Mark Hampton, CDFG NCNCR
Bill Jong, CDFG NCNCR
Neil Manji, CDFG NCNCR
Craig Martz, CDFG, NCNCR
Mark Pisano, CDFG NCNCR
Gary Ramsden, CDFG NCNCR
Mike Rode, CDFG NCNCR
Kim Rushton, CDFG NCNCR
Wade Sinnen, CDFG WAHCB
Gary Smith, CDFG NCNCR
Gary Stacey, CDFG NCNCR
Steve Turek, CDFG NCNCR
Mark Wheetley, CDFG NCNCR

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Appendix 1. Weekly and total seining catch-per-unit-effort (fish/1000ft^2) of young-of-the-year Chinook salmon at all sites in the lower Klamath River estuary, 2002.

JW	Date	Effort (ft)^2	Total # Chin	Total CPUE	No. IGH	CPUE IGH	No. TRH f	CPUE TRH f	No. TRH s	CPUE TRH s	No. Hatch	CPUE Hatch	No. Nat	CPUE Nat
10	3/05	23250	0	0	0	0	0	0	0	0	0	0	0	0
11	3/18	29900	1	0.03	0	0	0	0	0	0	0	0	1	0.03
12	3/25	27350	0	0	0	0	0	0	0	0	0	0	0	0
14	4/02	28600	2	0.07	0	0	0	0	0	0	0	0	2	0.07
15	4/08	24200	6	0.25	0	0	0	0	0	0	0	0	6	0.25
16	4/17	29275	4	0.14	0	0	0	0	0	0	0	0	4	0.14
17	4/22	31800	1	0.03	0	0	0	0	0	0	0	0	1	0.03
18	4/29	28025	0	0	0	0	0	0	0	0	0	0	0	0
19	5/08	28200	0	0	0	0	0	0	0	0	0	0	0	0
20	5/13	30050	5	0.17	0	0	0	0	0	0	0	0	5	0.17
21	5/20	32500	10	0.31	0	0	0	0	0	0	0	0	10	0.31
22	5/29	30600	0	0	0	0	0	0	0	0	0	0	0	0
23	6/03	36900	7	0.19	0	0	0	0	0	0	0	0	7	0.19
24	6/12	31450	5	0.16	5	0.16	0	0	0	0	5	0.16	0	0
25	6/17	30000	6	0.20	0	0	0	0	0	0	0	0	6	0.20
26	6/26	30700	213	6.94	0	0	72	2.35	21	0.68	93	3.03	120	3.91
27	7/01	33500	125	3.73	30	0.90	59	1.76	3	0.09	92	2.75	33	0.99
28	7/10	30700	185	6.03	89	2.90	29	0.94	0	0	118	3.84	67	2.18
29	7/19	27000	134	4.96	0	0	24	0.89	6	0.22	30	1.11	104	3.85
30	7/22	27900	44	1.58	0	0	3	0.11	0	0	3	0.11	41	1.47
31	8/01	24600	158	6.42	0	0	12	0.49	3	0.12	15	0.61	143	5.81
32	8/08	26100	91	3.49	0	0	0	0	0	0	0	0	91	3.49
33	8/12	26175	88	3.36	0	0	3	0.11	0	0	3	0.11	85	3.25
34	8/19	28000	13	0.46	0	0	0	0	0	0	0	0	13	0.46
35	8/28	22575	11	0.49	0	0	3	0.13	0	0	3	0.13	8	0.35
Total		**719,350**	**1,109**	**1.54**	**124**	**0.17**	**205**	**0.28**	**33**	**0.05**	**361**	**0.50**	**747**	**1.04**
Jun-Aug Total		**375,600**	**1,080**	**2.88**	**124**	**0.33**	**205**	**0.55**	**33**	**0.09**	**361**	**0.96**	**718**	**1.91**

Appendix 2. Weekly and total electrofishing catch-per-unit-effort (fish/minute) of young-of-the-year Chinook salmon in the upper Klamath River estuary, 2002.

JW	Date	Effort (sec)	Total # Chin	Total CPUE	No. IGH	CPUE IGH	No. TRH f	CPUE TRH f	No. TRH s	CPUE TRH s	No. Hatch	CPUE Hatch	No. Nat	CPUE Nat
14	4/03	870	0	0	0	0	0	0	0	0	0	0	0	0
17	4/23	1669	0	0	0	0	0	0	0	0	0	0	0	0
18	5/01	1473	0	0	0	0	0	0	0	0	0	0	0	0
19	5/14	1410	1	0.04	0	0	0	0	0	0	0	0	1	0.04
21	5/21	1447	10	0.41	0	0	0	0	0	0	0	0	10	0.41
22	5/30	1686	12	0.43	0	0	0	0	0	0	0	0	12	0.43
23	6/04	1755	12	0.41	0	0	0	0	0	0	0	0	12	0.41
24	6/10	1139	25	1.32	0	0	0	0	0	0	0	0	25	1.32
25	6/18	1833	168	5.50	47	1.54	6	0.20	32	1.05	85	2.78	83	2.72
26	6/24	1819	45	1.48	30	0.99	6	0.20	0	0	36	1.19	9	0.30
27	7/02	1986	99	2.99	0	0	9	0.27	0	0	9	0.27	90	2.72
28	7/08	1858	170	5.49	0	0	3	0.10	3	0.10	6	0.19	164	5.30
29	7/17	1889	296	9.40	0	0	0	0	0	0	0	0	296	9.40
30	7/24	1886	221	7.03	0	0	3	0.10	0	0	3	0.10	218	6.94
31	7/30	1751	165	5.65	0	0	0	0	0	0	0	0	165	5.65
32	8/15	1780	109	3.67	0	0	0	0	0	0	0	0	109	3.67
33	8/20	1850	84	2.72	0	0	6	0.19	0	0	6	0.19	78	2.53
Total		**28101**	**1417**	**3.03**	**77**	**0.16**	**33**	**0.07**	**35**	**0.07**	**145**	**0.31**	**1272**	**2.72**
Jun-Aug Total		**19546**	**1394**	**4.28**	**77**	**0.24**	**33**	**0.10**	**35**	**0.11**	**145**	**0.45**	**1249**	**3.83**

Appendix 3. Weekly and total seining catch-per-unit-effort (fish/1000ft^2) of young-of-the-year Chinook salmon at standard sites in the lower Klamath River estuary, 2002.

JW	Date	Effort (ft)^2	Total # Chin	Total CPUE	No. IGH	CPUE IGH	No. TRH f	CPUE TRH f	No. TRH s	CPUE TRH s	No. Hatch	CPUE Hatch	No. Nat	CPUE Nat
10	3/05	18000	0	0	0	0	0	0	0	0	0	0	0	0
11	3/18	25100	1	0.04	0	0	0	0	0	0	0	0	1	0.04
12	3/25	22250	0	0	0	0	0	0	0	0	0	0	0	0
14	4/02	23800	2	0.08	0	0	0	0	0	0	0	0	2	0.08
15	4/08	18600	6	0.32	0	0	0	0	0	0	0	0	6	0.32
16	4/17	24775	0	0	0	0	0	0	0	0	0	0	0	0
17	4/22	25500	0	0	0	0	0	0	0	0	0	0	0	0
18	4/29	23125	0	0	0	0	0	0	0	0	0	0	0	0
19	5/08	23700	0	0	0	0	0	0	0	0	0	0	0	0
20	5/13	25250	5	0.20	0	0	0	0	0	0	0	0	5	0.20
21	5/20	27600	3	0.11	0	0	0	0	0	0	0	0	3	0.11
22	5/29	25000	0	0	0	0	0	0	0	0	0	0	0	0
23	6/03	30150	3	0.10	0	0	0	0	0	0	0	0	3	0.10
24	6/12	26650	5	0.19	5	0.19	0	0	0	0	5	0.19	0	0
25	6/17	25500	3	0.12	0	0	0	0	0	0	0	0	3	0.12
26	6/26	25450	56	2.20	0	0	19	0.75	6	0.25	25	0.98	31	1.22
27	7/01	27200	90	3.31	22	0.81	42	1.56	2	0.07	66	2.43	24	0.88
28	7/10	25800	131	5.08	63	2.44	21	0.81	0	0	84	3.26	47	1.82
29	7/19	21600	133	6.16	0	0	24	1.11	6	0.28	30	1.39	103	4.77
30	7/22	23650	43	1.82	0	0	3	0.13	0	0	3	0.13	40	1.69
31	8/01	19600	138	7.04	0	0	10	0.51	3	0.15	13	0.66	125	6.38
32	8/08	19800	57	2.88	0	0	0	0	0	0	0	0	57	2.88
33	8/12	20775	80	3.85	0	0	3	0.14	0	0	3	0.14	77	3.71
34	8/19	23450	12	0.51	0	0	0	0	0	0	0	0	12	0.51
35	8/28	18375	8	0.44	0	0	2	0.11	0	0	2	0.11	6	0.33
Total		**590,700**	**776**	**1.32**	**90**	**0.15**	**124**	**0.21**	**17**	**0.03**	**231**	**0.39**	**545**	**0.92**
Jun-Aug Total		**308,000**	**759**	**2.46**	**90**	**0.29**	**124**	**0.40**	**17**	**0.06**	**231**	**0.75**	**528**	**1.71**