Fish Release Strategies at Iron Gate Hatchery: 2007 Fall Yearling Chinook Salmon Emigration Behavior

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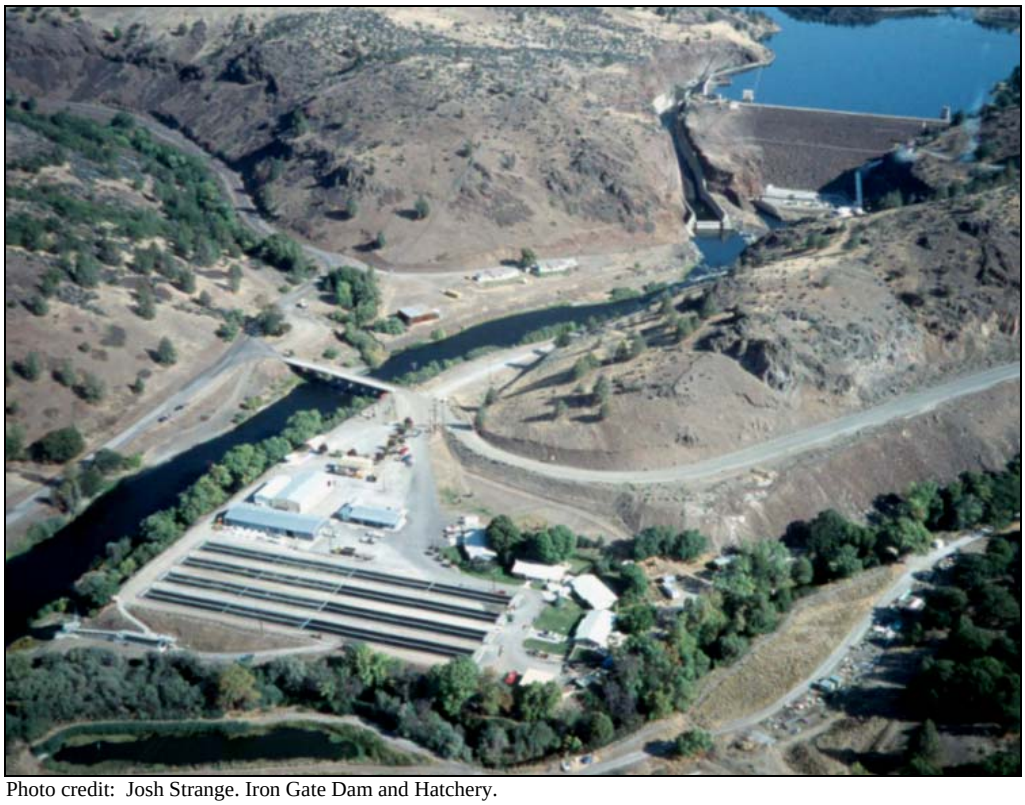

Photo credit: Josh Strange. Iron Gate Dam and Hatchery.

Abstract: Greater return rates and reduced competition with wild fish suggest that substantially increasing the proportion of Chinook salmon released from Iron Gate Hatchery as yearlings in the fall as opposed to sub-yearlings in the early summer is likely to be beneficial. However, prior to this study there was no information on the emigration behavior of yearling Chinook salmon released from Iron Gate Hatchery to help validate this management prescription. In order to address this lack of information, we surgically implanted a total of 30 Chinook salmon yearlings with radio transmitters and released them from Iron Gate Hatchery on November 13, 2007 as part of their typical yearling release. Of these, at least 23 (77%) emigrated to the first receiver station at rkm 282; by comparison a minimum of five of the 30 tagged fish reached the estuary, yielding an overall apparent survival rate of 17% with an average emigration duration of 44.6 d and an average travel rate of 6.6 km/d. No sources of mortality were documented. Apparent survival was calculated as opposed to known survival because the final fates of fish were not known with certainty. For example, fish that were that entered a reach but did not exit were assumed to be mortalities, but other possible reasons could include tag failure, tag loss, or fish holding until after tag battery exhaustion. None of these scenarios are considered likely for a variety of reason but it should be noted that apparent survival estimates can be consider the minimal actual survival experienced by tagged fish and would be adjusted upwards if any of the other reasons did indeed occur. All applicable fish exhibited slowed emigration and apparent holding at some point above the Salmon River confluence (rkm 107). The majority of fish emigrated from the vicinity of the hatchery at rkm 309 to below rkm 282 relatively quickly (mean of 1.7 d and 15.9 km/d; n=18). The most common area of slowed emigration was between the Shasta to the Scott rivers (mean of 23.5 d and 2.1 km/d; n=6). The fastest emigration rates (individual maximum of 149.2 km/d for a given reach) were observed in the lower Klamath River below its confluence with the Salmon River wherein the highest apparent survival rates were also observed. Depending of the precision of information required, another year of investigation may be warranted in which case the same study approach should be used with a greater sample size (e.g. 100 to 300 tags), and if funding permits, manual tracking and ultrasonic transmitter capabilities should be added.

Introduction

Iron Gate Hatchery (IGH) is operated to mitigate for lost salmonid production between Iron Gate and Copco dams. Current fall Chinook salmon goals and constraints for the hatchery require the release of 4,920,000 sub-yearling smolts (typically released from mid-May to early June) and 1,080,000 yearlings (released during late October or November).

Hatchery operations should ideally meet production targets while maximizing efficiency and minimizing negative impacts on wild fish. The release of nearly five million sub-yearling smolts from IGH coincides with seasonal reductions in Klamath River flow, deterioration of water quality, and peak myxozoan pathogen infectivity (i.e. *Ceratomyxa shasta* and *Parvicapsula minibicornis*) (for further information on these pathogens see Stocking et al. 2006). Therefore, a large number of hatchery fish are forced to compete with natural fish for typically limited and marginal habitats in an infectious environment. A joint Hatchery Review Committee Report (CDFG and NMFS 2001)[1] noted these environmental and competition problems and recommended consideration for expanding

[1] California Department of Fish and Game and National Marine Fisheries Service Southwest Region Joint Hatchery Review Committee, 2001: "DFG should consider the desirability of expanding the chinook yearling program at IGH and reducing the chinook smolt production. Releasing fewer smolts and more yearlings would relieve some of the hatchery-natural interactions that occur during the low-flow and poor water quality conditions present in the Klamath River during June and July. The time of the yearling release from IGH occurs during October 15 – November 15, which coincides with flow release increases from Iron Gate Dam, increased precipitation in the Klamath Basin, and substantially improved water quality conditions in the Klamath River. Interactions between hatchery and natural Chinook would be minimized as a result of improved water quality and because most natural Chinook would have already left the Klamath Basin."

the yearling program at IGH accompanied with a reduction in sub-yearling smolt production. Furthermore, yearling released fish have a higher survival rate than sub-yearling smolts (Hankin 1990); therefore fewer fish could be released to achieve similar returns of adults.

Given river conditions and wild fish distribution during the fall release of yearlings, it is likely that competition with wild juvenile Chinook salmon would be significantly less as compared to the sub-yearling smolt release groups in late spring and early summer. Greater return rates and reduced competition with wild fish suggest that substantially increasing the proportion of Chinook salmon released as yearlings in the fall is likely to be beneficial. However, prior to this study there was no information on the emigration behavior of yearling Chinook salmon released from IGH to help validate this management prescription. In order to begin gathering information on emigration behavior of yearling Chinook salmon released from IGH, we initiated a radio biotelemetry study in the fall of 2007 with the results reported herein. The objectives of this initial study were to:

1. Determine the emigration behavior of yearling Chinook salmon released from IGH in the fall of 2007. Specific behavioral components include travel rates, movement patterns, and potential movement triggers.
2. Provide data that could be used to assess emigration survival.
3. Evaluate the utility of radio biotelemetry for studying the emigration of IGH Chinook salmon yearlings.

Methods

We evaluated the emigration behavior of yearling Chinook salmon released from IGH in the fall of 2007 using radio biotelemetry. We surgically implanted coded radio micro-transmitters (Lotek NTC-M #3 0.53 g in air with an 8 second coded burst interval at 166.620 mHz with S1 antenna and 2000 code set) into 30 yearling Chinook salmon on November 8th, 2007 prior to their release from IGH on November 13th and 14th, 2007. Yearlings at IGH typically average 150 mm fork length by November and transmitters were sized accordingly with a minimum battery life of approximately 41 days. We randomly captured fish from raceway G with a dip net. All fish were tagged by Greg Stutzer of the FWS, who has been responsible for surgically implanting micro-transmitters in coho smolts at IGH on numerous occasions. Tagging procedures were identical to those described in Beeman et al. 2007. After surgery we held tagged fish in perforated buckets overnight in a protected rearing trough. The following morning we visually inspected all fish for signs of stress or suture problems before release back into raceway G. We also tested all radio transmitters for functionality.

We determined the movements of tagged fish during their emigration using a network of automated radio receiver stations (Lotek SRX or Grant Systems Engineering Orion receivers) distributed along the mainstem Klamath River from the vicinity of Iron Gate Dam to the vicinity of the Klamath River estuary (Table 1). This station network was

also used concurrently for tracking adult coho as part of a study led by the Karuk Tribe and previously for tracking juvenile coho as part of a study led by the USGS (Beeman et al. 2007). We used coded transmitters and random burst intervals to minimize frequency overlap and signal collision problems. We did not conduct any manual tracking of tagged fish. Receiver stations were remained operational for 100 days after tagging, which is 59 days longer than the minimum battery life of the tags and 42 days longer than the longest confirmed tag battery life.

Apparent survival was calculated by dividing the number of fish that entered and exited given reach by the number of fish that entered but did not exit that reach within the 100 day study period. Apparent survival is the appropriate term as opposed to known survival because the final fates of fish were not known with certainty. For example, fish that were that entered a reach but did not exit were assumed to be mortalities, but other possible reasons could include tag failure, tag loss, or fish holding until after tag battery exhaustion. None of these scenarios are considered likely for a variety of reason but it should be noted that apparent survival estimates can be consider the minimal actual survival experienced by tagged fish and would be adjusted upwards if any of the other reasons did indeed occur. For a thorough discussion of the strengths, weaknesses, and assumptions involved in calculating apparent survival in this manner, readers should refer to the methods discussion beginning on page 33 of Beeman et al. (2007). Detection probability for each station was calculated by dividing the number of fish that were detected by the station by the number of fish that actually passed the station (as determined by upstream and downstream station detections). Apparent survival estimates were adjusted upwards by dividing apparent survival by the detection probability if detection probabilities were less than 100%.

Results

Fates and Survival

A total of 30 yearling Chinook salmon were successfully radio tagged on November 8th, 2007 prior to their release into the mainstem Klamath River on November 13 and 14th, 2007 in conjunction with their non-tagged cohorts per standard practices at IGH. Relevant tagging and biometric data is presented in Table 2 along with the final known fate or last detection for each fish. Of these 30 tagged Chinook salmon yearlings, at least 23 (77%) emigrated downstream to the first radio station at Trees of Heaven (rkm 282). By comparison, only five fish were confirmed to have reached the vicinity of the Klamath River estuary (Blakes station at rkm 13) yielding an overall apparent survival rate of only 17%. Apparent survival rates for each monitoring reach are included in Table 1.

Emigration Behavior

Emigration movement patterns were variable between tagged individuals but several consistent patterns were apparent. First, all fish with sufficient telemetry records

displayed a contiguous period of slowed movement, likely extended rearing which we termed holding, at some point during their outmigration above the confluence of the Salmon River (rkm 107). The actual locations of slowed movement varied but the two most common areas were between the Shasta (rkm 282) and Scott rivers (rkm 233) and between IGH (rkm 309.5) and the Shasta River (Figure 1). Average duration of residence for fish that held in these reaches, and had detections at both applicable stations, were 23.5 d (2.1 km/d, *n*=6) and 35.9 d (0.8 km/d; *n*=3) respectively. By comparison, fish that did not hold in these reaches had average values of 0.6 d (58.1 km/d; *n*=6) and 1.7 d (15.9 km/d; *n*=18) respectively. No manual tracking was conducted, so more precise holding locations were not determined. Secondly, with two exceptions, all fish traveled rapidly through the Scott River to Seiad Valley (rkm 212) reach with an average travel rate of 57.3 km/d (*n*=13). Attributes of this river reach or fish condition that contributed to the faster travel rates are unknown. Finally, all applicable fish (*n*=5) traveled rapidly though the lower Klamath River from the Salmon River confluence (rkm 107) to the estuary (rkm 13) with an average travel rate of 30.5 km/d. Therefore, total emigration duration in the mainstem Klamath River was determined for only five of the 30 tagged fish, resulting in total transits times of 24.4 to 54.0 d (mean of 44.6 d; 6.6 km/d) from rkm 309.5 to rkm 13. The fastest travel rates for a given reach were observed within the lower Klamath River with a individual maximum of 149.2 km/d (fish #31 from rkm 71 to 33). No information was available on estuary residency and ocean entry since radio transmitters do not function properly in high salinity environments.

Flow rates in the Klamath River are compared to tagged fish movements in Figure 2. River discharge as measured by flow would be expected to influence emigrating behavior and travel rates of Chinook salmon juveniles; however, there were no obvious correlations upon visual inspection. For example, initiation of periods of rapid or especially slow movement did not necessarily match substantial increases or decreases in flow. While there were no obvious correlations between flow and fish emigration behavior, it is too early to conclude that flow has no influence, partly due to the relatively small sample size. Water temperature records for the mainstem Klamath River are difficult to obtain during the winter; however, water temperature would not be expected to be a major factor influencing annual variability in emigration behavior of tagged Chinook yearlings in the fall and winter due to generally stable and cold thermal pattern during that time of year. Thus no movement triggers were identified in this study.

Utility of Methods

This initial study of Chinook salmon yearling emigration demonstrated that radio biotelemetry can be successfully used to determine their emigration behavior, however, the level of precision in determining emigration behaviors is dependent of the level of tracking effort (i.e. the number of fixed site receivers and whether manual tracking is conducted or not). Surgery was apparently successful, transmitters performed as specified, and receiver stations were free of inherent flaws. Station performance suffered at one location due to human error. Fortunately all of these problems are correctable with greater attention to detail, although multi-agency sharing of the station array requires extra careful planning and communication. Assuming sufficient funding was secured,

manual tracking could be added to determine more precise holding locations and habitat associations during periods of slowed emigration and holding, which would aid in evaluating the potential for competition with naturally produced salmonids. The area in need of greatest improvement is the inability to track fish upon entry into the estuary and nearshore ocean. Overcoming this obstacle requires adding ultrasonic biotelemetry capabilities, for which there are two options: 1) use Lotek's combined acoustic and radio transmitters; or, 2) tag fish with an additional ultrasonic transmitter with a programmed delayed start. Both of these options would greatly increase study costs. The second option is favorable for a variety of reasons, but the size of the fish's visceral cavity impose limitations of the size and number of tags that can be implanted successfully. Obviously the number of tagged fish we need to be increased for a more thorough study (e.g. up to 100 to 300 fish) to remove uncertainties associated with a small sample size.

Summary

We conclude that yearling Chinook salmon released from IGH in the fall hold for extended periods in the mainstem Klamath River before emigrating to the ocean. The potential for hatchery fish to compete with wild fish during this time of year is presumed to be minimal due to low water temperatures allowing the use of mainstem habitat, but further study would be needed to understand the actual competitive dynamics during the fall and winter. Movement patterns varied from fish to fish and no movement triggers were identified. Depending of the precision of information required by managers to make a decision, another year of investigation may be warranted, in which case we recommend using the same study design with a greater sample size, and if funding permits, the addition of manual tracking and ultrasonic transmitter capabilities.

Tables

Table 1. Station locations used to track the movements of IGH Chinook salmon yearlings in the fall and winter of 2007. Apparent detection probability is reported for each station along with overall and reach specific apparent survival. Detection probability was calculated by dividing the number of fish that were detected by the station by number of fish that actually passed the station (as determined by downstream station detections). Apparent survival was calculated by dividing the number of fish that entered and exited given reach by the number of fish that entered but did not exit that reach within the 100 day study period.

Location	RKM	Type	Detection Probability	Reach Survival	Overall Survival	Fish Entering
Iron Gate Hatchery	309.5	lotek	na	na	na	30
Trees of Heaven	282	orion	87%	77-88%	77-88%	23
Blue Heron	233	lotek	100%	70%	53%	16
Seiad Valley	212	orion	100%	94%	50%	15
Happy Camp	177	lotek	100%	87%	43%	13
Klamath at Salmon	107	lotek	100%	46%	20%	6
Weitchpec Klamath	71	orion	100%	83%	17%	5
Steelhead Lodge	33	lotek	100%	100%	17%	5
Blakes	13	lotek	100%	100%	17%	5

Table 2. Tagging and biometric data for all 30 yearling Chinook salmon plus final known fates or last detections.

Fish #	Date	Freq	Code	FL mm	WT g	Ad Clip	Fate or last detection
1	11/8/2007	166.620	**19**	140	30.9	n	happy 12/4
2	11/8/2007	166.620	**14**	137	29.9	n	blakes 12/27
3	11/8/2007	166.620	**25**	132	28.3	n	seiad 12/22
4	11/8/2007	166.620	**23**	146	37.3	n	trees 11/17
5	11/8/2007	166.620	**22**	154	42.9	n	blakes 1/3
6	11/8/2007	166.620	**15**	161	53.6	n	iron gate
7	11/8/2007	166.620	**20**	139	33.5	n	trees 11/14
8	11/8/2007	166.620	**13**	157	49.57	n	trees 12/22
9	11/8/2007	166.620	**18**	163	54.78	n	happy 11/30
10	11/8/2007	166.620	**24**	155	43.43	n	iron gate
11	11/8/2007	166.620	**16**	155	40.06	n	trees 11/16
12	11/8/2007	166.620	**21**	171	73.34	y	blakes 12/29
13	11/8/2007	166.620	**12**	160	51.98	n	iron gate
14	11/8/2007	166.620	**17**	143	34.30	n	trees 11/16
15	11/8/2007	166.620	**11**	149	45.92	n	happy 11/17
16	11/8/2007	166.620	**36**	161	47.24	n	happy 11/18
17	11/8/2007	166.620	**35**	150	40.89	n	salmon 1/5
18	11/8/2007	166.620	**39**	147	42.11	n	happy 12/19
19	11/8/2007	166.620	**29**	136	27.47	n	iron gate 11/16
20	11/8/2007	166.620	**38**	153	38.70	n	no detections
21	11/8/2007	166.620	**34**	149	43.35	n	happy 12/23
22	11/8/2007	166.620	**26**	148	37.67	n	seiad 12/17
23	11/8/2007	166.620	**37**	145	37.50	n	trees 11/14
24	11/8/2007	166.620	**33**	135	31.86	n	iron gate
25	11/8/2007	166.620	**30**	140	30.30	n	trees 11/14
26	11/8/2007	166.620	**32**	161	49.06	n	happy 12/12
27	11/8/2007	166.620	**27**	155	46.02	n	blakes 1/5
28	11/8/2007	166.620	**28**	150	44.81	n	trees 11/16
29	11/8/2007	166.620	**29**	144	37.95	n	duplicate code
30	11/8/2007	166.620	**31**	153	42.56	n	blakes 12/6

Figures

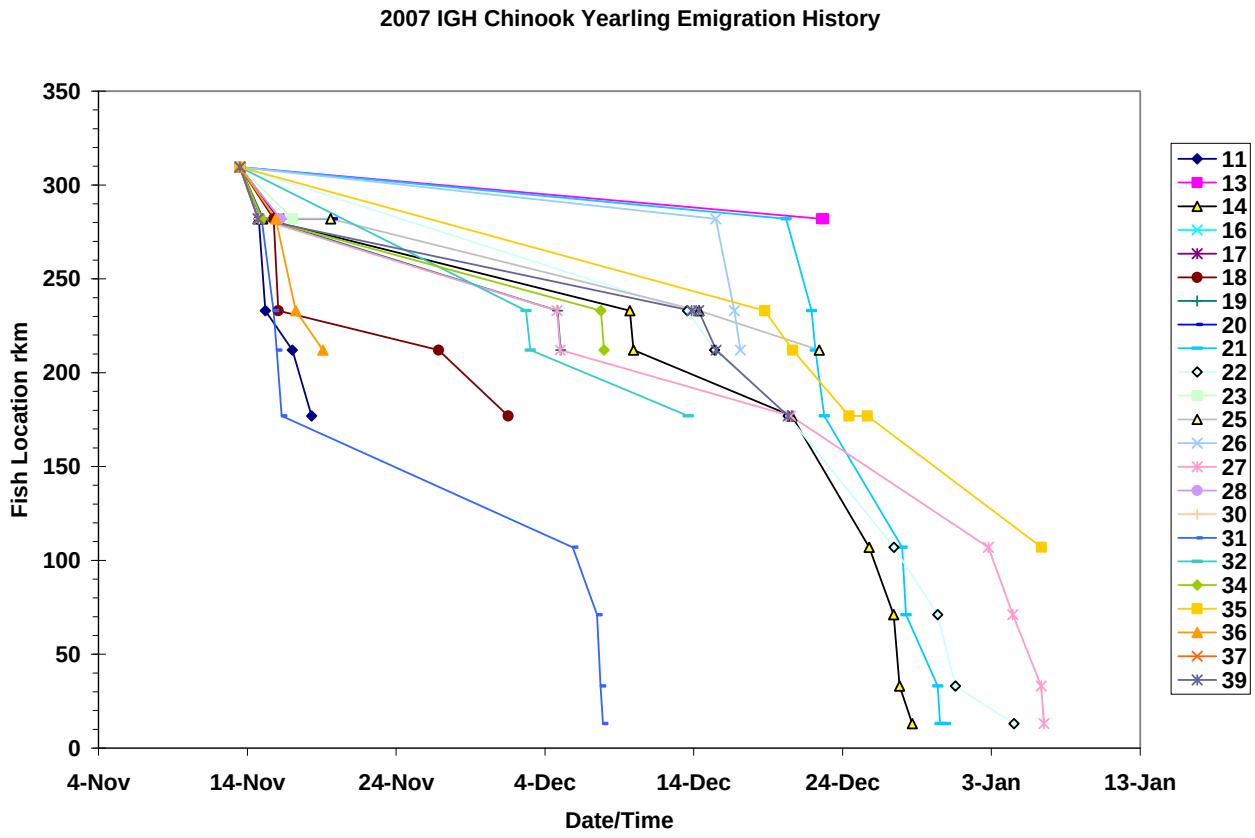

Figure 1. Emigration movement histories for the 23 tagged IGH Chinook yearlings detected at least a far downstream as the first listening station at Trees of Heaven (RKM 282). All river kilometers are measured from the mouth of the Klamath River. The first fish detection at each station is graphed.

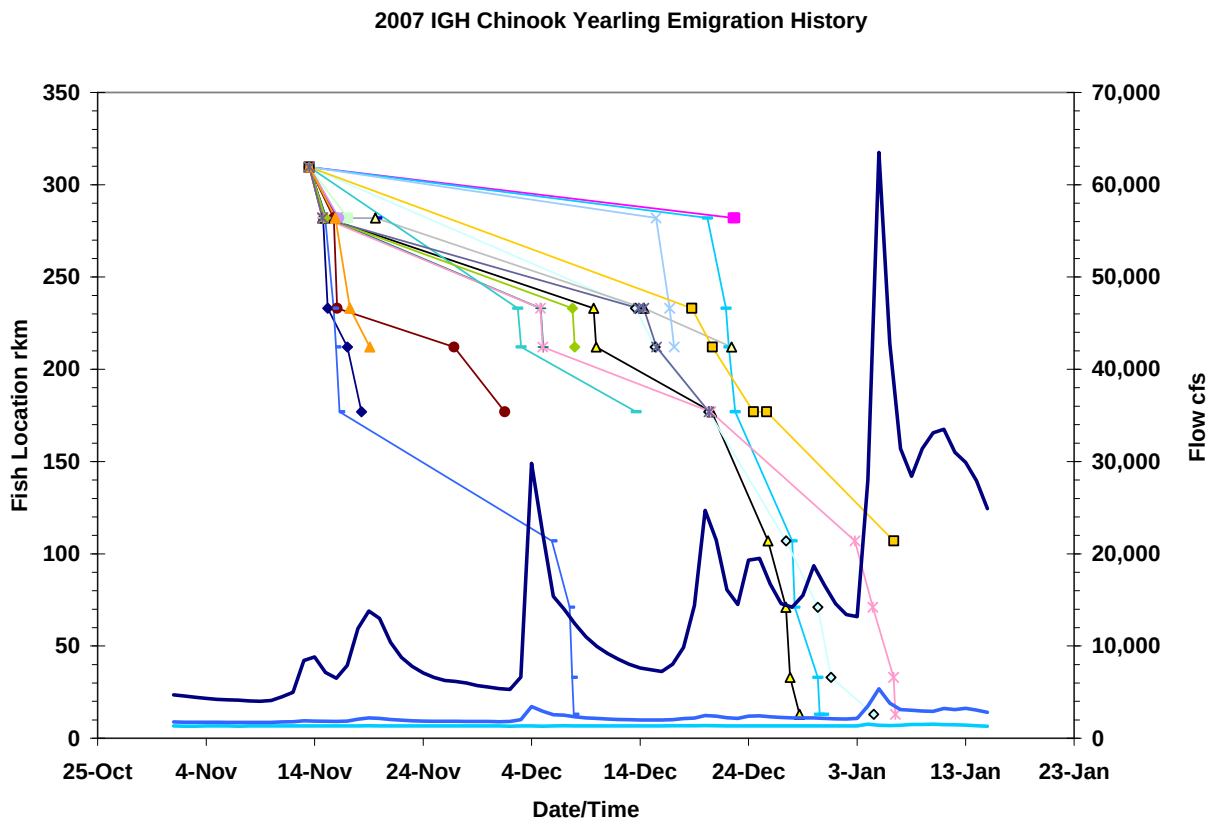

Figure 2. Emigration movement histories for the 23 tagged IGH Chinook yearlings detected at least a far downstream as the first listening station at Trees of Heaven (RKM 282) versus flow in the mainstem Klamath River at Blakes (rkm 13; dark blue line), Seiad Valley (rkm 212; medium blueline), and Iron Gate Dam (rkm 310; light blue line). All river kilometers are measured from the mouth of the Klamath River. The first fish detection at each station is graphed.

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