The Use of Passive Integrated Transponder (PIT) Tags as a Tool to Monitor and Manage Adult Chinook Salmon Returns to Idaho

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Background

In 2006, the Idaho Department of Fish and Game (IDFG) began increasing the number of Passive Integrated Transponder (PIT) tags injected into hatchery spring/summer Chinook salmon smolts to gain the ability to use the tags to monitor and quantify adult returns (for the purpose of this report, "adult" includes jacks). By release year 2008 (BY 2006), all hatchery Chinook salmon smolt releases from IDFG-operated hatcheries contained a representative group of PIT tags with the exception of off-site releases of Rapid River Chinook salmon into the Little Salmon River and in the Snake River at Hells Canyon Dam. Currently, over 230,000 PIT tags are implanted into Chinook salmon leaving IDFG hatcheries annually (Figure 1).

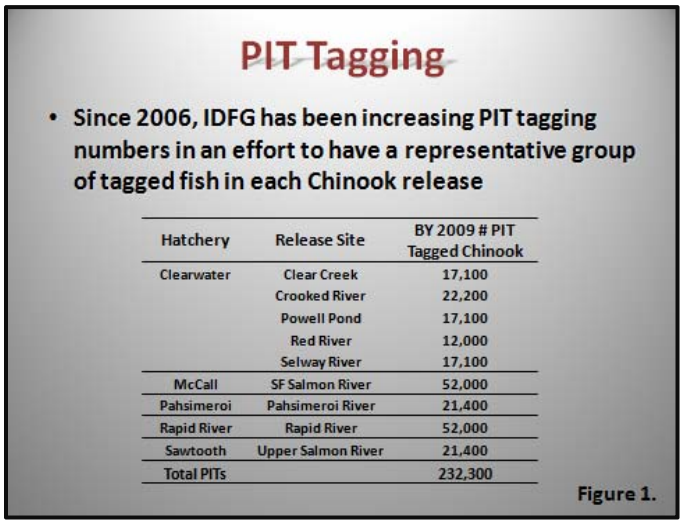

Figure 1.

Adult Monitoring

Starting in 2009, adult PIT tag detections have been monitored throughout the return at Bonneville, McNary, Ice Harbor, and Lower Granite dams. These PIT tag detections are expanded by the juvenile tagging rate for run-at-large (monitor mode) tags from the separation-by-code process. The expanded detections are used to generate daily in-season return estimates by hatchery, release site, and age at each dam. These daily updates are posted to a shared website (https://research.idfg.idaho.gov/PublicDocuments/Forms/AllItems.aspx) Monday through Friday throughout the adult run. Also throughout the run, weekly teleconference calls are held to discuss the updated run projections, run status, harvestable shares, hatchery operations and fishery status. Participation in these weekly calls typically includes, but is not limited to, IDFG, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, Nez Perce Tribe, Shoshone Bannock Tribe, and Idaho Power Company. This coordinated process enables the most up to date in-season estimates to be available to all parties and for real time management decisions to be made.

What We Gain

Release Group	2010 Granite Pre-Season Adult Forecast	Final Lower Granite Adult Estimate
Dworshak	8,729	3,735
Kooskia	1,691	3,666
Selway	2,496	1,627
Powell	2,496	729
SF Clearwater	3,726	3,510
Total Clearwater R.	19,138	13,267
Rapid River	76,153	22,038
Sawtooth	1,644	689
Pahsimeroi	9,775	5,051
McCall SFSR	31,755	6,305
Total Salmon R.	119,327	34,082
TOTAL	138,465	47,349

Figure 2.

The use of PIT tags to monitor adult returns typically provides us with a more accurate return estimate than we get from pre-season forecasts that are based on simple sibling regression models. Figure 2 shows a comparison of two- and three-ocean adult return forecasts versus in-season return estimates from expanded PIT tags in 2010. As you can see, while the forecasts for the Clearwater River were close

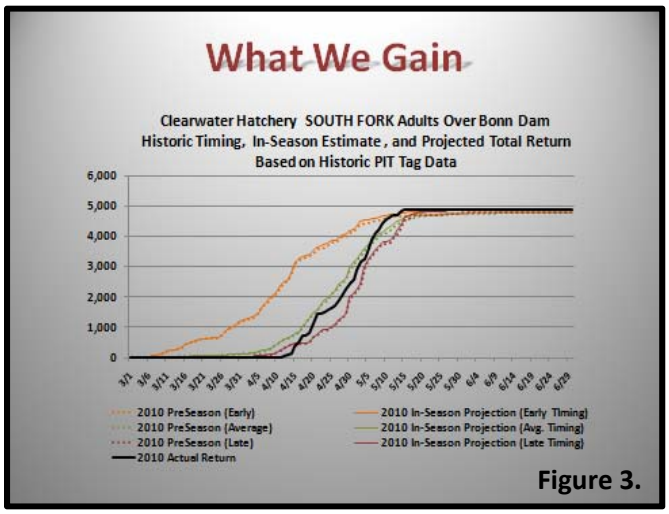

Figure 3.

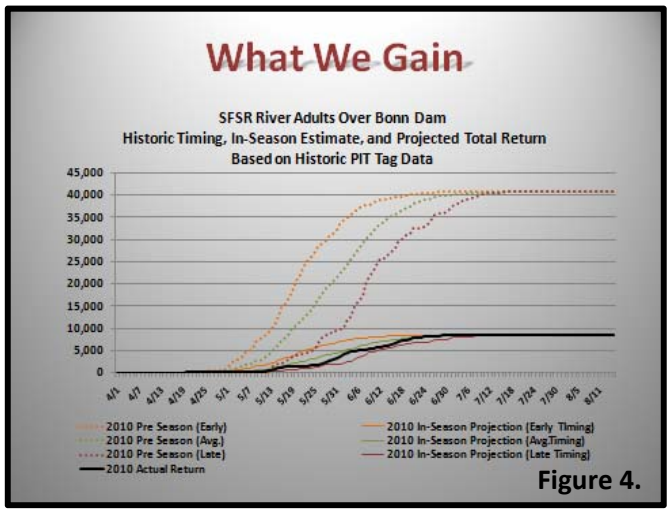

Figure 4.

to the PIT tag estimates, the Salmon River forecasts were much higher than the actual return based off of PIT tag estimates. Figures 3 and 4 compare an in-season estimate that is very close to a preseason forecast (Figure 3, South Fork Clearwater 2010) versus an in-season estimate that is a lot lower than the preseason forecast (Figure 4, South Fork Salmon River 2010). This emphasizes the value of having a tool that can be used to generate in-season stock and age specific return estimates as these more accurate numbers enable more precise management. In addition to in- and post-season return estimates, adult return monitoring also provides more robust stock and age specific data for inter-dam conversion rates, run timing, fallback with reascension rates, and after hour's passage rates at each dam. All of these are important monitoring and evaluation metrics that aid in run reconstruction.

Addressing Issues

While PIT tag expansions provide valuable adult return data, there are some shortcomings associated with using PIT tags to estimate adult returns. In looking at historic adult return estimates, there was evidence that expanding PIT tagged adults by juvenile tagging rates was underestimating the return. This was likely due to issues such as unaccounted for tag shedding and differential survival post release. While evidence for this exists, historically it has been difficult to estimate rates of PIT tags in adult returns because hand scanning at hatchery racks is not 100 percent efficient. To get at the true tagged proportions within the adult returns, we had in-ladder detection arrays installed in both the South Fork Salmon River (Figure 5) and the Sawtooth Fish Hatchery adult traps. The South Fork array was installed


Figure 5.

prior to trapping in 2009 and the Sawtooth array prior to trapping in 2010. These array systems have repeat antennas which allow us to get detection efficiencies which in turn, allow us to get at the true proportion of PIT tags in the adult return, by age class. We can then correct the expasions rates and use the corrected expasions to adjust our estimates downriver at in-stream arrays and at the dams. However, these adjustments can only be done post-season and cannot be used to adjust in-season return estimates. Figure 6 shows an example of these adjusted expansions for the South Fork Salmon River at Lower Granite Dam for the 2010 return. Using these corrected expansions, we have found in-season stock specific estimates range from 11 – 37 percent low and that the level of underestimation varies across years, locations, and between age classes. However, despite this level of underestimation, return estimates can still be corrected post-season for locations that we have in-ladder arrays and in-season numbers are still more accurate than relying on preseason forecasts.

LOWER GRANITE		Raw Detections		Corrected Detections**			
Brood Year	Expansion*	RAL @ LGD	R2R LGD	RAL @ LGD	R2R LGD	Estimated Number	Original Est. from Juv. Tag Rate
2005	199.0	2	0	2	0	398	62
2006	45.8	214	71	214	71	9,871	6,234
2007	35.7	55	16	55	16	1,977	1,677
						12,246	7,973

* Corrected for Adult PIT tag ratio at Rack

** Corrected for 100% LGD detection efficiency

Figure 6.

In addition to monitoring adults at these array systems, we are midway through a double marking study at the Powell Satellite Facility. Brood Year 2006 Chinook salmon from Clearwater Fish Hatchery destined to be released at the Powell Satellite in 2008 were part of a double marking study designed to investigate shed rates of PIT tags from release to adult return and to estimate if PIT-tagged fish exhibit differential survival from non-PIT tagged fish. Prior to the release of these fish, the water intake for the pond froze over, resulting in a loss of water into the pond and the mortality of about half or the release group. The surviving fish from this study returned as one-ocean jacks in 2009 and two-ocean adults in 2010. All returning fish were thoroughly double scanned with both a CWT wand and handheld PIT tag reader to confirm the presence or absence of tags. Eight treatment fish and 12 control fish returned to Powell in 2009 as jacks. Of these eight treatment fish, one was missing a PIT tag (12.5% shed rate). In 2010, 36 treatment fish and 31 control fish returned. Of these 36 treatment fish 11 had lost their PIT tags (30.6%) shed rate. Also, at some facilities we have started experimenting with a pump array system to get at the true number of PIT tagged fish as they are loaded onto trucks for release to get a better idea of true on-station shedding/survival.

Summary

Having representative PIT tag groups in the majority of our releases provides a tool to get real time in-season estimates of adult returns at four of the eight lower Columbia and Snake River dams. These estimates are distributed and discussed through a shared website and weekly teleconference calls throughout the adult return which allows for more accurate and timely management and coordination. While these in-season estimates provide more accurate stock- and age-specific estimates than preseason forecasts, tag shedding and mortality cause these estimates to be low. However, in-ladder array systems allow us to correct these estimates at some of our facilities for run reconstruction purposes post-season. We will continue to monitor the rates at which PIT tagged adults return and continue to evaluate, and hopefully quantify, possible causes of these differential return rates.

Acknowledgements

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- Biomark

IDFG Response to ISRP Comments

ISRP Comments:

The value of this paper would be greatly enhanced if it reviewed all available literature in an effort to determine PIT tag shed rates for each age class of salmon. What factors contribute to tag loss? Are there methods to minimize tag loss? Continued research into tag loss is critical because many decisions in the Basin are based on PIT tag data. High and variable tag loss could introduce significant error in survival rate estimates, leading to the misinterpretation of data from hydrosystem and supplementation experiments, and from harvest management.

IDFG Response to ISRP comments:

Very little literature exists in regards to adult age- or sex- specific PIT tag retention. At this time, there are two papers that cover this topic to some degree.

Prentice, E. F., D. J. Maynard, S. L. Downing, D. A. Frost, M. S. Kellett, D. A. Bruland, P. Sparks-McConkey, F. W. Waknitz, R. N. Iwamoto, K. McIntyre, and N. Paasch. 1994. Comparison of long-term effects of PIT tags and CW tags on coho salmon (Oncorhynchus kisutch). Pages 123–137 in A study to determine the biological feasibility of a new fish tagging system. Bonneville Power Administration Annual report for 1990–1993, BPA Report DOE/BP-11982-5, Portland, Oregon.

Knudsen, C., M. Johnston, S. Shroder, W. Bosch, D. Fast, and C. Strom. 2009. Effects of Passive Integrated Transponder Tags on smolt-to-adult recruit survival, growth, and behavior of hatchery spring Chinook salmon. NAJFM 29:658-669.

In the Prentice et al. paper, it was determined through double tagging (PIT and CWT) that tag loss was higher in returning age 2 and 3 female Coho salmon than in returning age 2 and 3 males. Adult females showed a 47.9% loss of tags while males only lost 11.3% of their tags (data from two return years). This tag loss appeared to occur primarily during late maturation and it was concluded that females have a much higher rate of tag loss near full maturation due to the fact that female Salmonids drop eggs into their body cavity prior to being expelled through the ovipositor. Because fish are PIT tagged in the body cavity, the PIT tag would be free floating among the eggs and could be expelled as an irritant.

Similarly, we have found through investigations at the South Fork Salmon River ladder array, that there are differential tag loss rates between males and females. For brood years 2005 and 2006 combined, overall tag loss for males was 24.3% while for females it was 52.5% (Figure 7.)

To further investigate, all fish returning in 2011 to the SFSR trap with a PIT tag are being externally marked. When these fish are ripe and removed on spawning days, they will be checked again for tags to see what the rate of PIT tag shedding is in sexually maturing fish that have made it back to hatchery holding. If the majority of tag loss does occur primarily during late maturation as Prentice et al. suggest, then correcting PIT tag expansions at lower Snake River and Columbia River dams based off of adjusted adult tag rates at time of terminal trapping may not be valid and unadjusted expansions at these dams may be more accurate.

Figure 7. Estimated PIT tag loss for brood year 2005 and 2006 SFSR male and female Chinook salmon. Not enough tag recoveries were made to include the 3-ocean component from each brood year.

			1 and 2-Ocean Male Returns				2-Ocean Female Returns			
Brood Year	Return Year	Trap	Males Trapped	Expected CSS/BDL PIT Recoveries	Actual CSS/BDL PIT Recoveries	Estimated PIT Loss	Females Trapped	Expected CSS/BDL PIT Recoveries	Actual CSS/BDL PIT Recoveries	Estimated PIT Loss
2005	2008	SFSR	1,957	93	70	24.85%				
2005	2009	SFSR	1,480	70	53	24.77%	2,170	103	62	39.98%
2006	2009	SFSR	5,295	258	196	23.99%				
2006	2010	SFSR	1,686	82	62	24.49%	3,286	160	63	60.63%

The Knudsen paper did not investigate tag loss by sex but instead looked at tag loss across age classes and over time, using double tagging with PITs and CWT as well. This paper showed that average tag loss was 2.0% in juveniles prior to release, and 18.4% for fish returning 6 months to 4 years after release. This study indicated that most PIT tag loss had occurred within the first 6 months post-release, as no significant loss was observed in older fish. However, fish were examined prior to full development of gametes. The study also showed that due to tag loss and lowered survival of tagged fish, that SARs based on PIT tagged fish were 25% lower than SARs based off of CWT.

Preliminary data from these two papers coupled with preliminary data from IDFG could suggest that there is a differential survival/tag loss resulting in a 25% lower number of PIT tagged fish within the first six months and additional tag loss, up to 35%, occurs in females pre spawn. However, data supporting this conclusion is preliminary and additional years of monitoring are needed.

IDFG agrees that "*Continued research into tag loss is critical because many decisions in the Basin are based on PIT tag data."* And we are currently in the process of adding in-trap array systems to the three Clearwater Fish Hatchery satellite facilities (Powell, Red River, Crooked River) so that we can expand our ability to monitor differential return rates of PIT tagged fish and further investigate potential causes and timing of tag loss and differential survival. Once tag loss is better understood, methods to minimize it will be more attainable.