A Comparison of Two Starter Feeds for Spring Chinook Salmon at Kooskia National Fish Hatchery

Final Report

by the

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Introduction

After incubation and hatching, spring Chinook salmon larvae typically remain on the bottom of their rearing container until the yolk sac has been absorbed sufficiently to allow the fry to move up into the water column. At this point in the life cycle, the young larvae are typically referred to as swim-up fry. Bringing the swim-up fry onto feed for the first time is one of the most critical steps in the hatchery production cycle. As the available energy reserves in the yolk sac are depleted, it is vital for the developing fry to make the transition to actual food in order to grow and mature. Making the transition period as short as possible decreases the potential for delayed development and poor fish health. If the transition takes too long, the fry can become so weakened that they may not be able to take food, even when it is readily available, resulting in mortality (Piper *et al*. 1992).

Commercially manufactured starter feeds for hatchery production programs are developed with species specific preferences in mind. The industry standard for most state and federal Chinook hatchery programs in the Columbia River basin, including both Dworshak and Kooskia NFHs since the mid-1980's, has been moist and semi-moist feeds produced by Bio-Oregon. Bio-Diet Starter, a semi-moist feed was highly preferred when bringing yolk-sac fry onto first feed because of its soft, moist texture, excellent palatability, and high feed conversion record. However, in 2006, Bio-Oregon was acquired by another commercial feed company, Skretting, and although a new generation of semi-moist feed is being offered, it is not available in starter feed sizes and is significantly more expensive than the previous Bio-Oregon products.

Several commercial feed companies have expended considerable time and resources researching new and improved dry diets featuring high quality, high protein/fat contents. These new dry diets have proven to be very successful for rearing steelhead at Dworshak NFH (Jones and Izbicki 2000). However, it is unclear if these feeds will be as effective for rearing spring Chinook salmon. Therefore, the decision was made to evaluate available dry starter feeds. After careful consideration of the feeds available and consultations with other hatchery personnel about their experiences, two dry starter diets were selected for evaluation at Kooskia NFH: BioVita Starter (formerly Nutra Plus), manufactured by Skretting, and EWOS Micro, manufactured by EWOS.

The goal of this study was to determine which starter feed was the most effective and efficient for helping spring Chinook salmon fry make the transition to first feeding at Kooskia NFH.

Methods

Tanking

Brood year 2006 spring Chinook salmon at Kooskia NFH were transferred from incubation trays to 30'X4' fiberglass nursery rearing tanks on March 14, 2007. The nursery tanks were located outside and hold about 718 gallons of water. Fry were stocked at about 50,000 fish per tank with the flow set at about 18 gallons per minute on single pass use. The resulting density index was

about 0.23, or about double the standard density used for initially tanking fry out of incubation trays. Doubling the density was required because of on-going maintenance being performed on the water re-use system and limited well water. Water temperature at the time of tanking was about 50° F.

Twelve tanks were used for the experiment; six for the Bio-Oregon and six for the EWOS. Because of the tendency for the EWOS feed to float on the surface of the water, laminar flow diverters were placed on the standpipes prior to feeding during the first two weeks. This procedure diverted flows to the bottom of the tanks, reducing surface flow and allowing the feed to stay on the surface for a longer period of time rather than being swept out through the tail screens.

Feeding and Daily Care

On the first day after the fry were tanked, they were left alone to acclimate to their new environment. On day two, each raceway was given approximately one teaspoon of #0 starter to introduce them to the new scent of the feed. During the next several days the amount of feed was increased slightly each day until the fish were taking feed at the manufacturer's recommended feed rate. The feed was dispersed throughout the rearing unit with a hand held strainer every hour during an eight hour work day. Feeding was conducted slowly and deliberately to insure that fish had adequate opportunity to take feed. Observations of feed dispersal in the tanks were noted during feeding and the tanks were cleaned daily by brushing off the tail screens and bottoms of the tanks to eliminate waste and excess feed. Mortalities were removed and counted daily from each tank.

Data Collection and Analysis

To obtain representative samples, a random sample of five fish were collected from each replicate tank in each treatment; five fish each from the headbox region of two tanks, five fish each from the middle of two tanks, and five fish each from the outlet region of two tanks. A total of 30 fish were collected from each treatment group and killed with a heavy dose of MS-222, measured for fork length to the nearest mm, and weighed to the nearest 0.1 gram. Condition factors were calculated for each individual fish using the formula:

$$\text{Condition} = \text{Weight} \times 10^5 / \text{Length}^3 \quad \text{(Anderson and Gutreuter 1983)}$$

Mean lengths, weights, and condition factors were calculated and compared for significant differences using a two-sample T-Test (Snedecor and Cochran 1978). Mortalities were collected daily and were used to calculate the total mortality for each tank. The mean total mortalities for each treatment group were compared for significant differences using a two-sample T-Test (Snedecor and Cochran 1978). Differences between means were considered to be significant for values of $P \leq 0.01$.

Results

Time to First Feeding

All tanks of fish for both treatment groups responded to feed introductions on the first day. By day three, most fish were responding and feeding actively during each hourly feeding throughout the day and all tanks were being given the full ration amount recommended by the manufacturer.

Feed Dispersal

The two types of feed reacted differently when distributed. The Bio-Vita sank below the surface very slowly with uneaten feed eventually settling to the bottom of the tank where it was swept to the outlet region of the tank. The EWOS feed floated on the surface of the water with very little feed settling into the water column. With the laminar flow diverters in place, the feed moved very slowly to the outlet region of the tank, giving the fish adequate time to feed. Eventually, uneaten feed was swept through the tail screen and out of the tank.

Feeding and Growth

Feeding continued daily according to the study plan's established protocols without incident or noticeable differences until April 3. At that time, most of the fish in the EWOS treatment group began to appear to be smaller in size and in poorer condition than fish in the Bio-Vita treatment group, with a significant number of pinheads appearing the outlet sections of the tanks. The Idaho Fish Health Center was notified of the situation and on April 4 a biologist from the Idaho FHC collected a sample of ten fish from one of the EWOS tanks for examination. The preliminary examination indicated a high percentage of fish were very thin (almost pinheads) although internal examination of the stomachs confirmed the presence of food. The hatchery manager made the decision at that point to end the feed evaluation and converted all the EWOS tanks to Bio-Vita on April 9.

On April 11, the Idaho Fishery Resource Office and the Idaho FHC collected random samples of 30 fish from each of the treatment groups for examination and confirmation (**Table 1**). Mean lengths and mean weights for the Bio-Vita sample were significantly greater than for the EWOS sample ($P < 0.001$). However, condition factors were not significantly different ($P < 0.09$).

Mortality

The total mortality of each tank for both treatment groups from March 23 to April 11 is listed in **Table 2**. Mean total mortality was significantly higher ($P < 0.001$) for the EWOS treatment compared to the Bio-Vita treatment.

Table 1. Lengths, weights, and condition factors with statistical summary for juvenile spring Chinook salmon started on Bio-Vita and EWOS Micro starter diets at Kooskia NFH, 2007.

	Skretting BioVita			**EWOS**		
	Fork Length (mm)	Weight (grams	Condition Factor	Fork Length (mm)	Weight (grams	Condition Factor
	49	1.1	0.093	38	0.6	0.109
	47	0.9	0.087	45	0.9	0.099
	40	0.6	0.094	40	0.6	0.094
	44	0.8	0.094	38	0.5	0.091
	41	0.7	0.102	41	0.7	0.102
	41	0.7	0.102	42	0.8	0.108
	44	0.8	0.094	37	0.4	0.079
	44	0.8	0.094	39	0.5	0.084
	45	0.8	0.088	38	0.5	0.091
	44	0.7	0.082	40	0.6	0.094
	43	0.7	0.088	42	0.8	0.108
	40	0.5	0.078	43	0.8	0.101
	43	0.7	0.088	39	0.6	0.101
	39	0.5	0.084	40	0.7	0.109
	43	0.8	0.101	44	0.9	0.106
	40	0.6	0.094	45	0.9	0.099
	40	0.6	0.094	35	0.3	0.070
	51	1.2	0.090	41	0.7	0.102
	48	1.0	0.090	40	0.6	0.094
	47	0.7	0.067	44	0.9	0.106
	47	1.0	0.096	40	0.6	0.094
	45	0.9	0.099	41	0.6	0.087
	47	1.0	0.096	43	0.8	0.101
	43	0.7	0.088	43	0.8	0.101
	47	1.0	0.096	40	0.8	0.125
	37	0.4	0.079	38	0.5	0.091
	44	1.0	0.117	37	0.4	0.079
	43	0.8	0.101	38	0.4	0.073
	40	0.6	0.094	43	0.7	0.088
	44	0.8	0.094	38	0.5	0.091
Mean	**44**	**0.78**	**0.092**	**40**	**0.65**	**0.096**
Range	**37 - 51**	**0.4 – 1.2**	**0.067 - 0.117**	**35 - 45**	**0.4 - 0.9**	**0.07 - 0.109**
StdDev.	**3.27**	**0.19**	**0.009**	**2.58**	**0.17**	**0.01**

Table 2. Total mortality of spring Chinook salmon juveniles in each replicate raceway for each starter diet treatment group at Kooskia NFH, March 23 to April 11, 2007.

EWOS		BioVita	
Raceway	Mortalities	Raceway	Mortalities
3	248	19	208
5	344	21	157
7	375	23	132
11	196	25	223
13	299	27	285
15	386	29	162
Sum	**1848**		**1167**
Mean	**308**		**195**

Discussion

The most important aspect of the feed comparison for our purposes was the amount of time for the fish to go on feed once transfer from the incubation trays to the nursery tanks took place. Fish responded quickly to both feeds almost from the time that feed was first introduced. Within a day the fish were feeding actively. From our perspective both feeds are equivalent in this regard and we did not observe any meaningful differences between the two diets. For the next several weeks, both treatment groups continued to feed actively on their respective starter diet and took food readily, indicating that both feeds appeared to be satisfactory in terms of palatability.

The report of severe 'pin-heading' in the EWOS Micro tanks, based on the preliminary examination on April 4, was not confirmed by the subsequent examination on April 11. Severe 'pin-heading' was not observed. Direct examination and statistical analysis of random samples confirmed that fish length and weight for the EWOS Micro group was significantly smaller than for the Bio-Vita group, although both groups had similar condition factors. While the EWOS fish were definitely smaller and not growing as fast as the Bio-Vita group (**Photo 1**), their physical condition was as good as the Bio-Vita group. At the same time, it's important to keep in mind that at the time the sampling was performed, the EWOS group had already been switched to the Bio-Vita diet two days earlier, which may have had some slight affect on their condition. One other aspect that needs to be considered is the darker physical coloring of the EWOS group compared to the Bio-Vita group (**Photo 1**). The darker coloring could be related to poorer nutrition (Ann Gannam, Abernathy SCTC; Marilyn Blair and Kathy Clemens, Idaho Fish Health Center). However, we have no quantitative data substantiating that relationship.

Statistical analysis of mortality indicated that the EWOS group was experiencing mortality at a significantly ($P < 0.001$) higher level than the Bio-Vita group. We have no data indicating a definite cause for the higher rate of mortality. However, it does seem to be consistent with some reports that have been made from other hatcheries that have evaluated the EWOS Micro starter diet (**Appendix 1**). The reported results from other evaluations, the data on mortality, and the observation that the EWOS group was growing at a significantly slower rate than the Bio-Vita group was sufficient for us to concur with the hatchery manager's decision to discontinue the feed evaluation and convert fish being fed the EWOS Micro diet to the Bio-Vita starter feed.

Although we have no definitive quantitative data to demonstrate a relationship between the nature of the diets and the differences in growth rates and mortalites, we made several casual observations that would warrant further study. The feeds were quite different in regards to the way food particles reacted after distribution. The Bio-Vita feed was characterized by slowly sinking into the water column whereas the EWOS Micro floated on the water surface. It appeared that the Bio-Vita particle size was significantly larger than the EWOS Micro. The fine powdery nature of the EWOS Micro appeared to facilitate keeping the feed on the surface of the water. One of the advantages of the slowly sinking feed over the floating feed was that the fry did not appear to have to swim as far up into the water column to obtain food and did not need to expend as much energy feeding. Along the same lines, it may be that with smaller particle sizes, the fry had to consume more particles of the EWOS Micro to obtain the same amount of caloric intake as a smaller number of the Bio-Vita food particles, again, expending more energy during feeding.

Having discussed the situation with the Abernathy Fish Technology Center, they concurred with our decision to discontinue the study at Kooskia NFH and indicated that other hatcheries that had been using the EWOS Micro starter feed had experience higher than normal rates of mortality after several months, possibly due to nutritional deficiencies. We offer no comments on what the longer term nutritional and fish health implications of feeding the EWOS Micro starter diet may be in regards to rearing spring Chinook salmon at Kooskia NFH.

Recommendations

The Hatchery Evaluation Team recommends that consideration be given to a more thorough evaluation of the EWOS Micro starter diet for a longer trial period in the future.

References

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Jones, R. and A. Izbicki. 2000. A Comparison of Three Starter Feeds For Steelhead Fry at Dworshak National Fish Hatchery. Final Completion Report. Dworshak National Fish Hatchery, U.S. Fish and Wildlife Service, Ahsahka, Idaho.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1992. Fish Hatchery Management. Department of the Interior, U.S. Fish and Wildlife Service, Washington D.C. 517 p

Snedecor, G.W. and W. G. Cochran. 1978. Statistical Methods. Iowa State University Press, Ames, Iowa, USA. 593 pp.

Photo 1. Physical examination and comparison samples of spring Chinook salmon fed two different starter diets at Kooskia NFH, 2007.

Attachment 1.

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United States Department of the Interior

FISH AND WILDLIFE SERVICE

April 20, 2007

Memorandum

To: Fishery Biologist, Idaho FRO
Attn: Ray Jones

From: Fish Nutritionist, Abernathy SCTC

Subject: Discontinuation of feeding trials at Dworshak and Kooskia NFHs

Abernathy Fish Technology Center conducted a feeding trial with several starters the National Fish Hatcheries (NFHs) were also testing, one of which was the EWOS Micro. We did not experience any problems with pin-heading or mortality. The trial was only run for two months so we may have missed the delayed mortality some of the hatcheries had. With this feed trial information and the fact that the EWOS representative said one of the problems could be a feed size change that was too large (from #0 to #1) I felt the trials at Dworshak and Kooskia could proceed but with caution.

However, I am in agreement with your decision to discontinue the starter feeding trials at Dworshak and Kooskia NFHs. Further evidence from other hatcheries indicate there could be a serious, possibly nutrition based, problem with the EWOS feed. High rates of pin-heading and mortalities have been seen at numerous hatcheries using the EWOS feed in environments covering a wide range of water qualities and fish feeders with different levels of experience. This pin-heading and mortality occur after about three weeks on the feed. A unique aspect of this problem manifests itself by not affecting the first feeding fry but causing mortalities later in the rearing period when the fish are larger and apparently have been on feed for a time.