Investigation of Rearing & Release Strategies Affecting Adult Production of Spring Chinook Salmon

presented by

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Abstract.-For over 15 years, all spring chinook salmon released from Warm Springs National Fish Hatchery have been externally marked to identify them as hatchery fish. This marking program has made it possible to study rearing and release strategies at the hatchery. Our goal in investigating the various release groups is to determine which of several treatments maximize adult yield while minimizing impact upon wild fish populations. In this paper, a number of fish culture questions will be addressed. Can diet and medication affect prevalence of bacterial kidney disease and adult yield? Do fish released in the fall contribute to adult production? Is there differential survival based on size at release? What rearing density will maximize adult yield? Does fin clipping affect returns? Are we still dazed by diet, densities and disease?

Introduction

The study site is Warm Springs National Fish Hatchery (NFH). Rearing units consist of 2 adult holding ponds, 3 catch ponds, 30 Burrows ponds, and 20 starter tanks.

The hatchery is located at River Mile 8 on the Warm Springs River, within the Warm Springs Indian Reservation of Oregon. The Warm Springs River is in the Deschutes River subbasin of the Columbia River. The Deschutes River flows into the Columbia River upstream of Bonneville and The Dalles Dams, 205 miles upstream from the Pacific Ocean. A detailed description of spring chinook salmon and the Deschutes River subbasin can be found in Lindsay et al. (1989) -and- Oregon Department of Fish & Wildlife and Confederated Tribes of the Warm Springs Reservation of Oregon (1990).

Since the start of production in broodyear (BY) 1978, spring chinook released from the hatchery have been externally marked to identify them as hatchery fish. This marking program has made it possible to study rearing and release strategies at the hatchery to maximize adult yield while

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minimizing impact upon wild fish populations (Olson et al. 1995). The external marks applied include ventral and adipose fin clips. The use of an internal coded-wire tag was associated with the adipose fin clip (AdCWT) on spring chinook. Since broodyear 1982 all spring chinook production was externally marked and since broodyear 1990 was 100% AdCWT.

An osteo-mark was another internal mark used for hatchery evaluation. Oxytetracycline (OTC) in the feed produces white bands "rings" on bony structures in fish (Hendricks et al. 1991). These rings are seen when the bony structure is dissected and viewed under ultraviolet light.

Does fin clipping affect returns? For 3 broodyears, we applied ventral fin clips or AdCWT to juvenile fish in order to evaluate the effect of the two marks on survival to adult. It appears that when comparing ventral fin clips to AdCWT fish, ventral fin clips were not detrimental to survival as previously suspected at Warm Springs NFH (Figure 1). A final report on this marking study is being developed.

Hatchery spring chinook rearing and release strategies

Releases from the hatchery were typically split into fall (subyearling) and spring (yearling) releases. The fall release ranged from < 10% to > 50% of the total production (Figure 2). The fall / spring split release was initiated after observing that the first year's production (BY78) had a bimodal length frequency distribution in the fall, with the larger fish appearing to show signs of smolting (silvery and loss of parr marks). Higher than normal mortality of these larger fish was also observed when they were held overwinter until the following spring.

In September, the large fish were separated by use of a grading device in a fish loading pump, or starting in 1988, passive in-pond graders. The larger fish were released in early October at 9 to10 per lb.(>140mm fork length) . Smaller fish were reared overwinter and released in April at 15 to 20 per lb.

Oxytetracycline (OTC) was fed to the larger fall release group until broodyear 1985. Starting with the 1987 brood, the smaller fish released in spring received OTC. At the hatchery, a section of vertebrae from the caudal peduncle was dissected from adult fish and examined under an ultraviolet lighted microscope for presence/absence of the OTC "ring".

Do fall releases contribute to adult returns? The fish released in the fall do survive and contribute to adult returns. In some years, the larger fall released fish returned to the hatchery at a higher rate (Figure 3), but the larger fish released in the fall also produced a higher percentage of age 3 jacks relative to the age 4 and 5 adult return (Cates 1992).

So...Will the larger fish graded in the fall survive if reared overwinter in the hatchery and released the following spring? Looking at percent adult recoveries, it appears that the larger fish do survive if held overwinter at the hatchery but at a lower rate than the smaller fish (Figure 4).

Is the fall/spring pond splitting strategy better than the standard spring yearling release? The strategies investigated include the fall / spring split - graded (as previously described) and the fall / spring split - volitional release groups. The partial volitional release typically started 2 to 3 weeks before the forced release date in the fall and spring. Instead of grading, the fish exited the hatchery on their own volition for about 3 to 4 weeks in both the fall (October / November) and following spring (March/April). Approximately 10% of the fish were estimated to exit during the fall period. Past records indicate that a mixture of sizes exit the hatchery from this fall volitional release. To release the fish from the pond, the exit screens were pulled in front of the dam boards (current practice is to place a stand pipe in the drain outlet). The remaining fish were reared overwinter and allowed to exit volitionally from late-March through April. Some fish were also reared overwinter until the yearling spring release period with no fall emigration. This was the standard spring yearling release group.

Looking at percent adult returns...there appears to be mixed results between the spring yearling and fall/spring graded release strategy. <u>The fall/spring volitional release appears to be the best strategy (Figure 5).</u>

Can rearing environment affect adult returns? Starting with broodyear 1989 an alternative rearing environment was tested using the adult brood holding ponds. There are two brood holding ponds, approximately 50X26 foot oval shaped with 6 foot water depth. The raceways are modified Burrow's ponds (30 @ 75X16 foot rectangles with 1.7 foot water depth) and are where juvenile production typically occurs. After spawning adult fish in the fall, the brood ponds were cleaned and approximately 16,000 juvenile fish were transferred to each of the two ponds at a density of around 0.3 lbs/cuft at release. The burrows ponds received from 26,000 to 52,000 fish per pond or about 1.8 lbs/cuft for a pond of 39,000 fish at release.

Looking at 3 broodyears and percent adult recovery...<u>The fish which overwintered in the adult holding ponds at low densities survived substantially higher compared to fish reared in the typical raceway environment (Figure 6).</u>

Does rearing density affect adult yield? The hatchery has also looked at reduced overwinter rearing densities at 20,000 to 30,000 per pond compared to 50,000 to 60,000 per pond after the fall graded release. Prior to broodyear 1987, it was standard practice to grade out the larger fish and release them in the fall, then combine the ponds of remaining smaller fish. Approximately 60,000 per pond of the smaller fish were reared overwinter until the spring release = High Overwinter Rearing Density. Are there any adult survival benefits from not combining the ponds of smaller fish after the fall release? Approximately 30,000 per pond of the smaller fish were reared overwinter until the spring release = Low Overwinter Rearing Density.

<u>For the 1987 and '88 broodyears, more adults were recovered from the low overwinter density groups (Figure 7).</u> In Broodyear 1989 both groups had poor survival.

To specifically address the question of rearing density and the effect upon adult survival, a rearing density study was developed, modeled after Joe Banks study with spring chinook at Carson NFH (Banks 1994).

For 3 broodyears, 3 rearing densities were investigated at 26K, 39K, and 52K per pond -or- 1.2, 1.8, and 2.4 lb/cuft at release, respectively. The fish received a spring yearling release (no fall/spring split) with 2 ponds per treatment per year with a unique coded-wire tag for each pond.

We have preliminary data on returns to the hatchery for broodyear 1992. Broodyears 1990 and 1991 survived poorly regardless of rearing density, in part from on-hatchery disease and otter predation as well as poor off-station survival.

What we see is that percent survival and adult yield per pond was higher for the lower density groups (Figure 8). Again, this is preliminary data but combined with the other information at the hatchery on overwinter densities, density does affect survival to adult, with lower densities producing higher survival rates and number of adults.

Now we will take a look at some fish health applications.

What about diet and bacterial kidney disease (BKD) of juvenile fish affecting adult survival? Two diets were compared, Abernathy Dry and BioMoist. The study was set up by fish health specialists assuming that dry diets enhance the prevalence of BKD. The fish were also marked so adult survival could be determined from the two diets.

Mixed results were observed on the effect of BKD prevalence in the juvenile fish fed the two diets (Mavis Shaw, Warm Springs NFH, February 11, 1997 correspondence). Juvenile fish fed the dry diet had a high prevalence of BKD the first year studied. The following year both diet groups had high BKD prevalence in the juvenile fish and in broodyear 1989 the dry diet fed fish had lower BKD levels (Figure 9). Please note that a portion of the dry feed diet was determined to be of poor quality in broodyear 1988 which may have also influenced the results.

What about survival to adult? Generally speaking, two out of three years studied...juvenile fish fed the Abernathy Dry Diet had lower survival to adult, broodyear 1989 the exception (Figure 9).

Recently the hatchery has started looking at: ***What is the effect of feeding Erythromycin to juvenile salmon for control of BKD at Warm Springs NFH?*** This study was undertaken under Investigative New Animal Drug 4333. Spring chinook salmon reared at Warm Springs NFH, as well as wild juveniles and adults in the Warm Springs River itself, are infected to varying extent with *R. salmoninarum*. The objectives of the study are to determine the potential benefits of oral erythromycin treatment on the survival of juveniles in the hatchery, the levels of soluable antigen produced by *R. salmoninarum* in juveniles in the hatchery as an indirect measure of the level of infection, and survival to adult. The Lower Columbia River Fish Health Center of the USFWS is the lead investigator. The study was initiated in broodyear 1993 and continues to the present.

Drug concentrations in the diet and feeding regimes provided a daily dosage of 100 mg/kg body weight. Control and treatment fish were fed three times daily. Feeding rates were calculated based on feeding 2% body weight of fish per day. The drug was erythromycin thiocyanate (Aquamycin 100). Erythromycin therapy was administered for 21 days for each of two treatments in spring and summer. Juvenile fish health sampling and pond mortality data was also collected.

We have hatchery recovery data that so far includes four year old adult returns from fall 1997 for broodyear 1993. We see substantial difference in survival to adult between the control and treatment groups. The groups from the medicated feed survived better than the standard spring yearling release and fall/spring split volitional release groups (Figure 10). Again this is preliminary data. Along with juvenile and adult fish health information, we will be looking at these returns for the next 5 plus years.

Another on-going Fish Health practice at Warm Springs NFH is Enzyme-Linked Immunosorbent Assay (ELISA) based segregation of eggs and juvenile fish. ***Do progeny segregated by ELISA survive?*** This practice started with broodyear 1984. Adults were also injected with Erythromycin. At time of spawning, adults were sampled and eggs segregated based on the ELISA optical density (O.D.) measurement. Eggs have been culled from females with ELISA O.D.>0.5. Eggs from females with O.D. < 0.5 were kept for production and segregated into two or more groups. This segregation occurred through the juvenile rearing phase. The juvenile fish were differentially marked to identify them at adult recovery.

So far, only broodyear 1993 has shown the expected response...lower BKD ELISA values : higher survival to adult. This relationship was not evident in all other broodyears (Figure 11). Please note that higher ELISA groups often were reared at lower densities, which influences survival. Also, the hatchery has an open water supply and resident Warm Springs River fish have BKD (reservoir of infection).

The main point is that ELISA groups with O.D. < 0.5 can survive and contribute to adult returns. But we also need to look at the data further - Has the proportion of low and high groups changed over time? Do low and high groups that survive produce the next generation of low and high groups? Do ELISA groups with O.D. > 0.5 survive? What is the on-hatchery mortality of the different ELISA groups? Any relationship of juvenile BKD incidence and adult survival?

Future Rearing and Release Strategies at Warm Springs NFH

Rearing densities <26,000 per pond (< 1.2 lb/cuft at release) - We have seen benefits from reduced rearing densities, but how low can you go and still maximize adult yield? We may want to investigate rearing densities of 19,500 and 13,000 per pond. A good time to experiment with these low rearing densities may be during low adult return years.

Alternative rearing environment - The hatchery has recently installed 20% shade cloth and sprinklers over the ponds for rearing during the summer and fall months. From what was presented on the NATURES work, we may want to try some alternative rearing environments as well. What about large root wads for in-pond diversity? Increase percent shade >50%?. Could a different pond design be installed?

Improve water quality during the rearing phase - Water temperature and rearing conditions at the hatchery are less than ideal for raising salmon because the rearing ponds are dependent upon untreated river water. Daily maximum summer water temperatures often hit 20 C. The use of untreated river water for juvenile rearing also creates fish health problems in the hatchery. We are currently developing a plan for disinfection and summer cooling using reuse and ozone treatment.

Diet- We need to continue application and investigation of the medicated feed program. We could also possibly develop alternative programmed feed schedules for targeting different sizes at release. Are on-demand feeders available and functional for semi-moist diets?

Release Strategy- We need to be cognizant of the effect of our hatchery releases on wild fish production, particularly our fall releases which overwinter in freshwater before entering the ocean. Can we develop a release strategy which maximizes adult yield and minimizes impact on wild fish? What about volitional releases only during the spring period as yearlings? How can we maximize survival and minimize number of on-station releases?

Acknowledgments

For development of this paper I wish to recognize contributions from USFWS staff at Warm Springs National Fish Hatchery, Lower Columbia River Fish Health Center, Columbia River Fisheries Program Office, and staff with the Confederated Tribes of the Warm Springs Reservation of Oregon. I wish to specifically acknowledge help from members of the 1997 hatchery evaluation team, Mike Paiya, Mavis Shaw, Randy Boise, Steve Turner, Theresa Kerr, Susan Gutenberger, Colleen Fagan, and our data manager, Steve Pastor. Brian Cates was responsible for Warm Springs hatchery evaluation prior to 1990 (Cates 1992). And without the help of our marking crew (Skip Walch, Steve Olhausen, Dan Magneson, Pat Kemper and Chuck Fuller), these evaluations would not be possible. Although many people have contributed to this paper, information and views presented in this report are my own and do not necessarily agree with all parties or policies.

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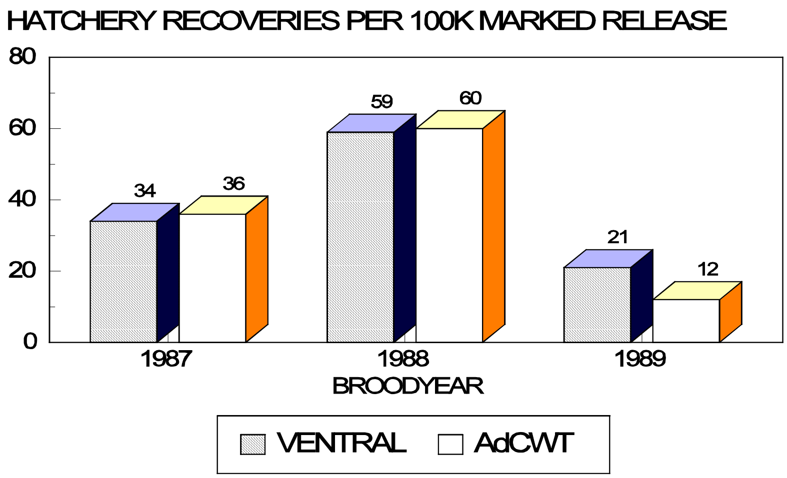

Figure 1. Ventral fin clip vs. Adipose fin clip/Coded-wire tag survival.

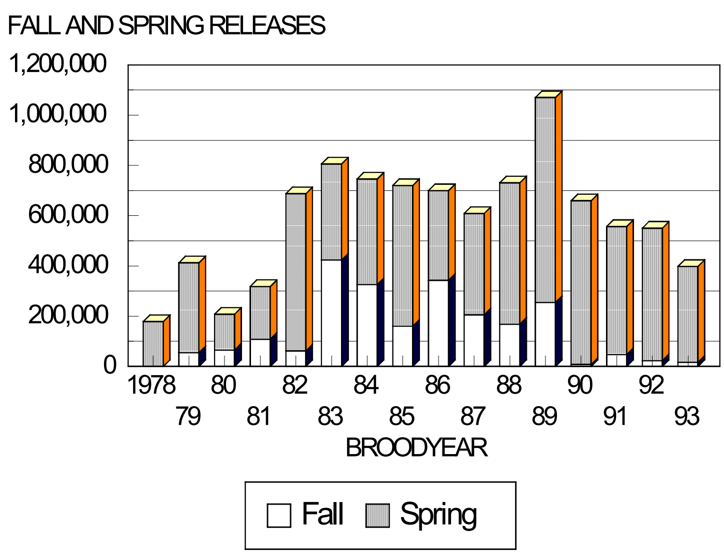

Figure 2. Spring chinook salmon production releases.

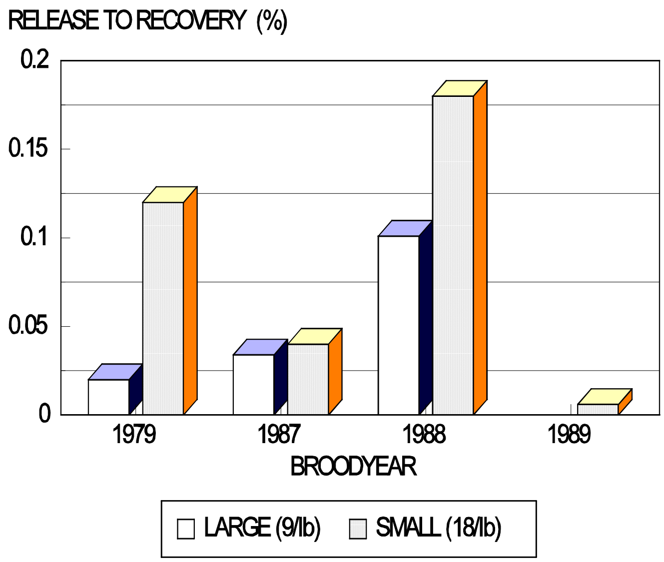

Figure 3. Spring release and survival of large and small fish

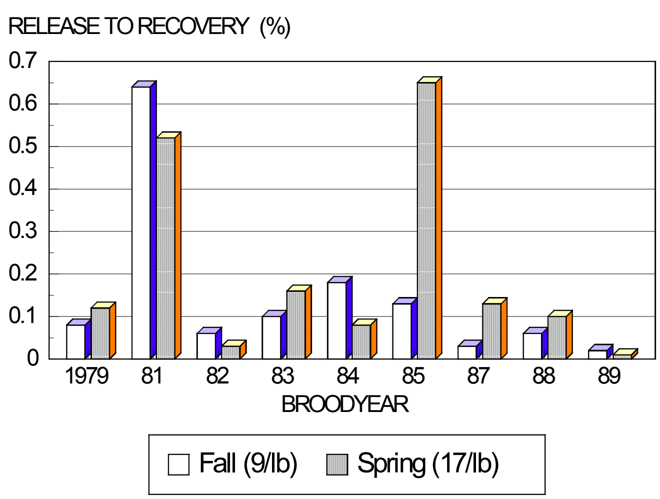

Figure 4. Graded fall and spring release survival.

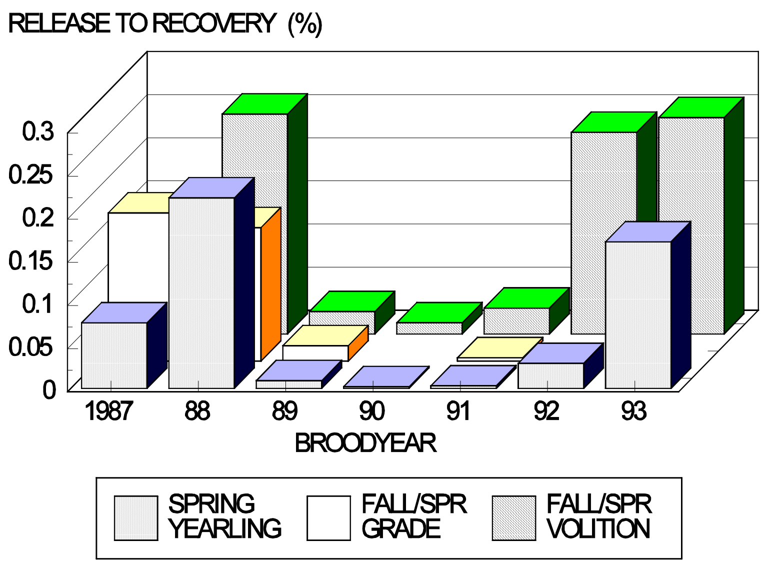

Figure 5. Adult yield of 3 different pond release strategies.

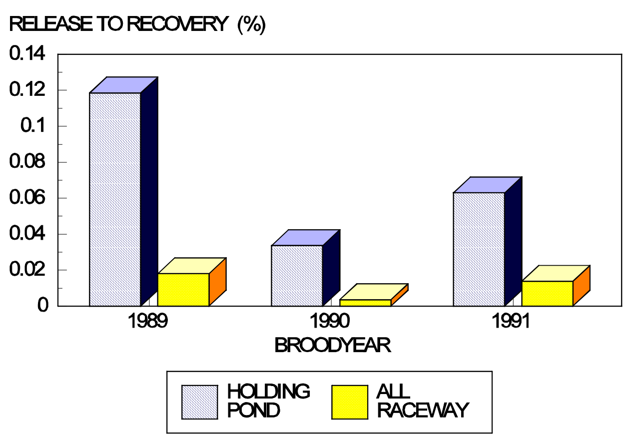

Figure 6. Survival of holding pond overwinter rearing.

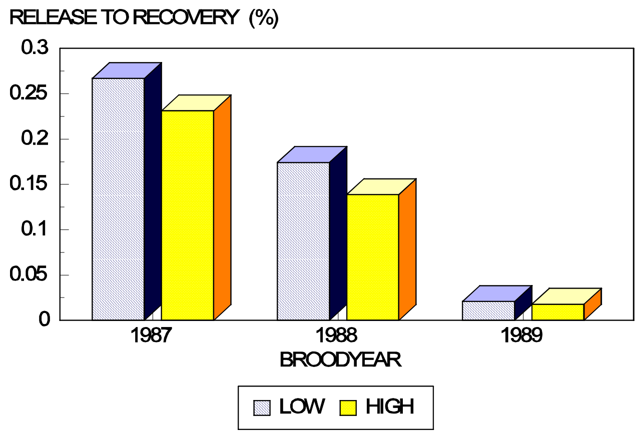

Figure 7. Overwinter rearing and survival at 20K-30K fish/pond (low) and 50K-60K fish/pond (high).

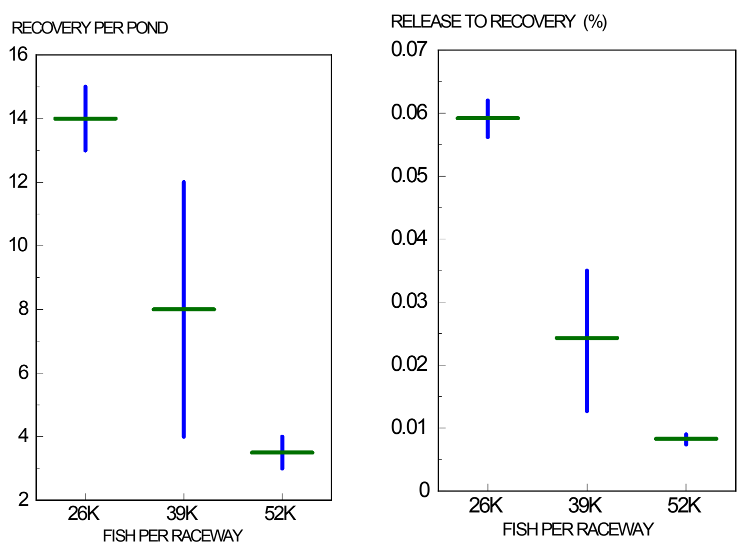

Figure 8. Rearing density study hatchery returns, broodyear 1992.

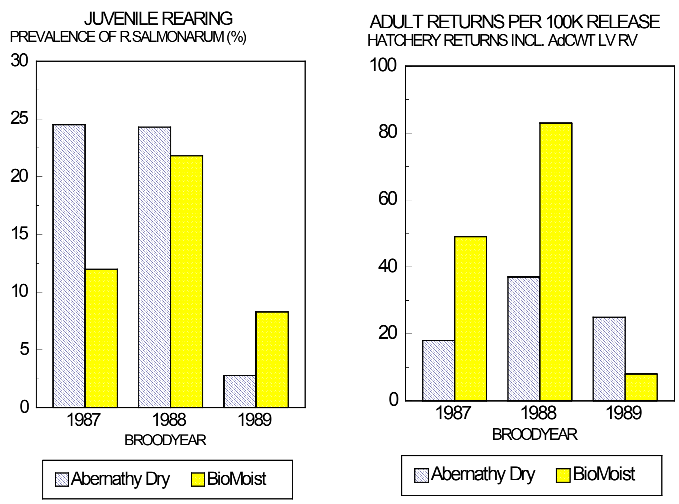

Figure 9. Diet, bacterial kidney disease, and adult yield.

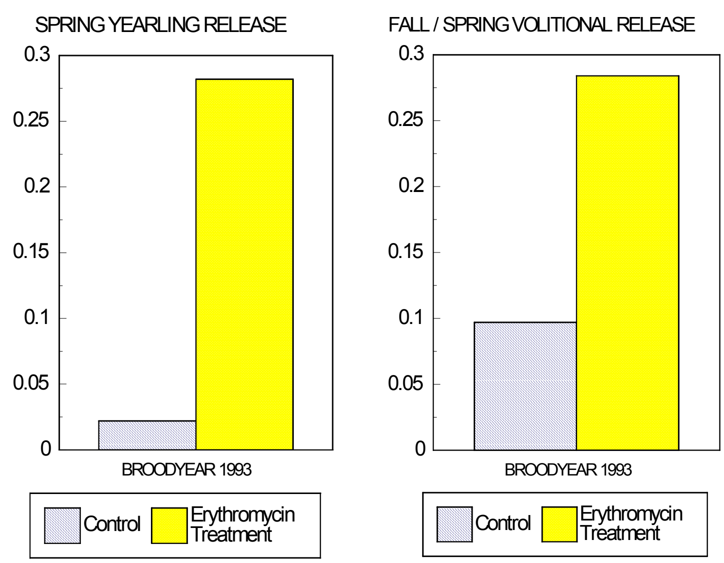

Figure 10. Hatchery adult recoveries (%) for medicated feed study

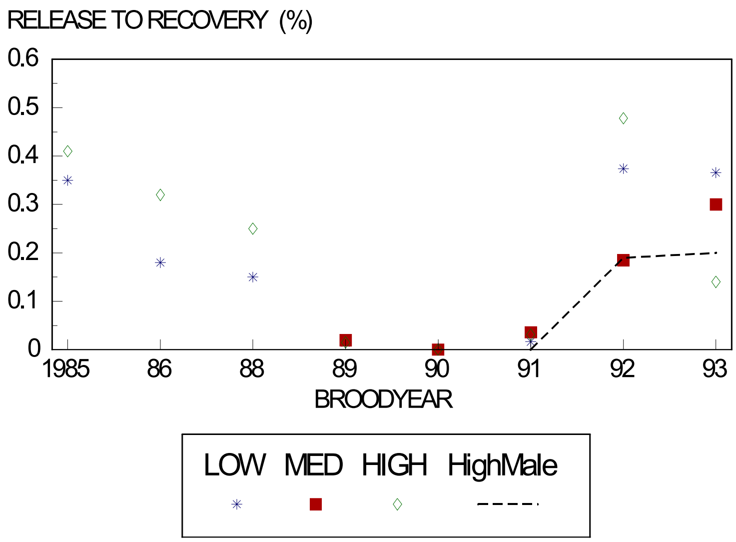

Figure 11. ELISA segregation of spawners with O.D. < 0.5. and survival of progeny to adult.