OMICS International
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J Aquac Res Development 2015, 6:6
http://dx.doi.org/10.4172/2155-9546.S1.003

International Conference on Aquaculture & Fisheries

July 20-22, 2015 Brisbane, Australia

Production of wild phenotypes under fish culture conditions for liberation into rivers

Schreck, Carl B [1], **Billman E J, Unrein J, Chitwood R, Whitman L D, Schroeder R K, Sharpe C S, Kimmel C, McGibben N, Brignon B, Munakata A, Cogliati K** and **Noakes D L G**
[1]Oregon State University, USA

Fish culture can be a useful for reestablishing depleted populations of endangered fishes. It is also useful for providing study animals for release into the wild when wild stocks are unavailable for such purposes. We present findings from research on juvenile Chinook salmon *Oncorhynchus tshawytscha*, Steelhead trout *Oncorhynchus mykiss* and bull trout *Salvelinus confluentus,* demonstrating that special diets, feeding strategies, fish densities and temperature in-tank structure are all viable tools that result in phenotypes that match those of wild fish more closely than those reared under typical aquaculture conditions. For example, wild fish can display considerable variation in downstream-movement life history tactics. Chinook salmon reared in circular tanks self-sort into surface and bottom oriented groups starting just after per os feeding begins. Morphometric analysis suggests that the surface phenotype is similar in shape to wild fall migrants and parr from downstream sites. The benthic phenotype fish are similar to wild spring migrants and fish collected concurrently up-river. Bone structure analysis of the head suggests that these differences rest with the jaw. Plasma sodium, gill Na/K ATPase and boldness analyses also revealed early effects of rearing conditions. Behavioral tests found that minute (<0.5°C) temperature decrease results in downstream movement by various species of anadromous salmonids. Similar downstream movement was displayed by surface-oriented laboratory Chinook in the fall (concurrent with timing of the fall out migration of wild Chinook; bottom-oriented Chinook had significantly less movement at this time. We suggest that downstream movement of juveniles soon after emergence is associated with differentiation in the expression of life history variation. This contention is also supported by movement studies in large artificial streams and in a small tributary stream. Structure in rearing tanks also affects performance of bull trout. Fish reared with some simple structure had significantly larger brains, were bolder and were better predators like wild fish that were also tested than fish reared in typical hatchery troughs. Body shape, coloration and fin condition are strongly influenced by feeding tactic, structure and density.

carl.schreck@oregonstate.edu

Intensification of salmonid production

Asbjørn Bergheim
IRIS – International Research Institute of Stavanger, Norway

Commercial scale production of salmon and trout has only lasted for 30-40 years. Over this period, a remarkable progress took place within vital fields, such as genetics, nutrition and medicines, and not, least, a revolution regarding engineering and farm management. This presentation emphasizes intensification attempts of the production from the fry stage to harvest made possible by introduction of new technology and alternative farming regimes. In land-based farming of smolt, launching of oxygen (DO) injection has reduced the water consumption by some 75% and even further to 90% while combining oxygenation and stripping of carbon dioxide (CO_2) in the tanks. Such combined water treatment is indicated 'partial recirculating aquaculture system (partial RAS)'and is at present the dominating system for smolt production in Norway. A vital contribution is development of efficient technology removing 60-90% CO_2 per flow passage. Fully RAS, also including biofiltration, is rapidly expanding in most salmonid producing countries and is now representing more than half of the total smolt production in Chile. Such highly producing systems means improved sustainability in terms of strongly reduced water consumption and lower effluent loading due to particle removal and sludge utilization. The traditional transfer of smolt (50-100 g) to sea cages is gradually being replaced by production of so-called super-smolt of 500-1,000 g in land-based RAS or in closed floating cages before stocking in open cages. This extended 'smolt stage' results in a shorter production cycle, less sea lice and disease problems (e.g., infectious pancreas necrosis) and reduced discharge of feed-based wastes.

Asbjorn.Bergheim@iris.no