State Fish Hatcheries and Invasive Species Don't Mix

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INTRODUCTION

The Vermont Fish and Wildlife Department is responsible for the protection and management of the state's fish populations. Cultured fish are stocked in natural and manmade areas that are excellent for growth and survival but have little or no spawning habitat. Other stocking areas include natural water bodies where spawning and nursery habitats have been destroyed or isolated from growth habitats by structures such as dams. But perhaps the most visible role of cultured fish is to provide recreational angling for the public. Each year specific water bodies succumb to heavy fishing pressures. Cultured fish can reverse this adverse condition. The Ed Week Fish Culture Station is the newest and largest of the five Vermont state fish hatcheries. It began raising fish in 1991 and releases nearly three-quarters of a million fish per year. Species include brook trout, brown trout, lake trout and rainbow trout as well as steelheads and landlocked Atlantic salmon. Most fish are released as 15-30 cm (6–12 inches) yearlings for statewide stocking. However, Ed Weed is also the home of about 5000 Vermont Trophy Trout. These two-year-old brown and rainbow trout are released every spring for immediate recreational angling. Excess fish are sold to surrounding states for similar purposes.

BACKGROUND

The Ed Weed Fish Culture Station is located on Grand Isle in the middle of Lake Champlain in Northwest Vermont. This large glacial lake has depths reaching 120 meters (394 feet) and experiences an annual autumnal overturn between the top warm epilimnion layer of the lake and the deeper cold hypolimnion layer. The unique design of this culture station takes advantage of the different water temperatures at different depth in Lake Champlain. A deep water inlet located 55 meters (180 feet) below the surface supplies cool water all year round and a shallow inlet just 9 meters (30 feet) below the surface supplies warm water in the summer. The water temperature differs by nearly 17º C (30º F) between the two inlets during the summer months. Blending water from these two inlets in varying proportions provides the right temperature for rearing the trout and salmon without energy intensive temperature control measures. The initial design called for water to enter the hatchery's pump station by static lake level pressure through a 90 cm (36-inch) pipe from each of the two inlets. The water was then pumped up gradient to three large rotary micro screens with 21-micron (0.0008 inch) polyester woven elements. Each rotary screen is 1.5 meters (5 feet) in diameter and 3.7 meters (12 feet) long. From the rotary screen filters, the water was fed by gravity to a chamber where liquid oxygen was introduced to super saturate the water with O_2. Next the water entered ten raceways (long shallow open-topped concrete tanks) each 30 meters (100 feet) long where the fish were reared. After flowing the length of these tanks, the water cascaded to ten more raceways downstream where more fish were reared. Each of the twenty raceways contains approximately 20,000 fish. Water leaving the final ten raceways flows to an on-site wastewater treatment plant that consists of chemical dosing, clarification and polishing pond before discharge back to the lake. The hatchery system is permitted for a maximum flow of 42,000 m^3/day (11 MGD) but typical rates are 32,000 m^3/day (8.5 MGD).

PROBLEM

Sometime between 1993 and 1994 zebra mussels, *Dreissena polymorpha*, were introduced to the south end of Lake Champlain. Because the rotary micro screens allow a certain amount of water to by-pass the screening media, they were found to be ineffective at preventing all life forms of zebra mussels from entering the hatchery. For two seasons the Ed Weed Fish Culture Station did not use the shallow water inlet for fear of contaminating the hatchery with zebra mussels. Because of this, the propane-fired boiler used in the wintertime had to be used all year long to raise the temperature of the deep water to the desired level. This greatly raised the cost of operating the station. Something had to be done to reduce the hatchery's operating costs while assuring no zebra mussels on the premises.

ALTERNATIVES

The first alternative for controlling zebra mussels at the culture station was to use various chemicals such as biocides or strong oxidants. This method was quickly thrown out do to the potentially disastrous effects it could have on the fish being reared.

The second alternative investigated for the protection of the hatchery from zebra mussels was ozone treatment of the incoming lake water. This method of treatment is an effective control for zebra mussels but was found to be too expensive and the high dosage and long contact times[1] required made it impractical at this facility.

The third method for zebra mussel control looked at was ultraviolet light (UV). While effective at killing the mussels during most of their life stages, required exposure time was a factor in eliminating this approach.

Finally, mechanically removing all viable life forms of zebra mussels with pressure filtration was examined. This method resulted in no chemical residue, was not energy intensive, provided positive physical removal (or destruction) of all zebra mussel life stages and was proven reliable in similar applications. This method using Amiad Automatic Self-Cleaning EBS Filters was chosen for the control zebra mussels at the Ed Weed Fish Culture Station and began operation in November 1996.

DESIGN CHANGES

Because Amiad EBS Filters require pressure to operate properly, the filter station had to be located downstream of the pump station. This meant that no protection was afforded the two 90 cm (36 inch) inlet pipes to the pump station. To maintain free flow in these pipes, pigs are pushed by water pressure every May from the pump station to the inlets out in the lake. This scrubs all attached zebra mussels from the inlet pipes keeping them from building up layers of attached mussel shells, which could restrict flow. The pipes between the pumps and the filters are drained twice a year to desiccate any zebra mussels that might be attached. Shells from dead mussels will then be dislodged from the pipe wall with subsequent water flow and removed by the filters.

Nine Amiad EBS Filters with 25.4 cm (10 inch) inlet and out flanges and nominal 25-micron (0.001 inch) screens (35-micron absolute) were added just downstream of the pumps with valving to allow any number of filters to be used on either the shallow or deep inlets. The shallow and deep inlet waters are mixed for temperature control just after the filters. Water then travels to the existing rotary micro screens for a second filtration. Next a UV system was installed downstream of the rotary screens just before oxygenation.

FILTER OPERATION

The following is a brief description of how each EBS Filter operates. Water from the lake flows into the filter through the inlet flange of the filter body as shown in Figure 1. Water then proceeds through the multi-layer cylindrical 316L stainless steel weavewire filter element (screen) from the inside out causing particulates larger than the filtration degree (pore size) of the screen to accumulate on its inside surface. When a 0.34 bar (5-psi) pressure differential is reached across the screen due to debris build-up, the filter begins a cleaning cycle. During the cleaning cycle, there is no interruption of flow downstream of the filter. The filter operation and cleaning cycle is controlled and monitored by a Programmable Logic Control (PLC).

The cleaning cycle utilizes a device called a suction scanner consisting of a 316 stainless steel hollow tube that slowly rotates and moves linearly inside the cylindrical screen. A flush valve opens normally connecting the inside of the suction scanner to atmosphere. Nozzles branch from the central tube of the suction scanner with openings only a few millimeters from the screen surface. The differential gauge pressure between the water inside the filter body and the atmosphere outside the filter body creates high suction forces at the openings of each of the suction scanner nozzles. This suction force causes water to flow backward through the screen in a small area at each nozzle pulling the filter cake off the screen and sucking it into the suction scanner and out the exhaust valve to waste. A differential pressure of at least 2.4 bars (35 psi) at the nozzle opening is required for efficient screen cleaning. However, at Ed Weed the difference between the filters operating pressure of 1.7-2 bars gauge (25-30 psig) and atmosphere, 0 bar gauge (0 psig), is insufficient. Therefore, centrifugal pumps were installed in the flushline after the exhaust valve. The negative gauge pressure of about –1 bar (-15 psig) developed by the pumps and the positive gauge pressure of 1.7-2 bars (25-30 psig) inside the filter body result in a differential pressure at the nozzle openings of 2.7-3.1 bars (40-45 psig) that is sufficient for good screen element cleaning.

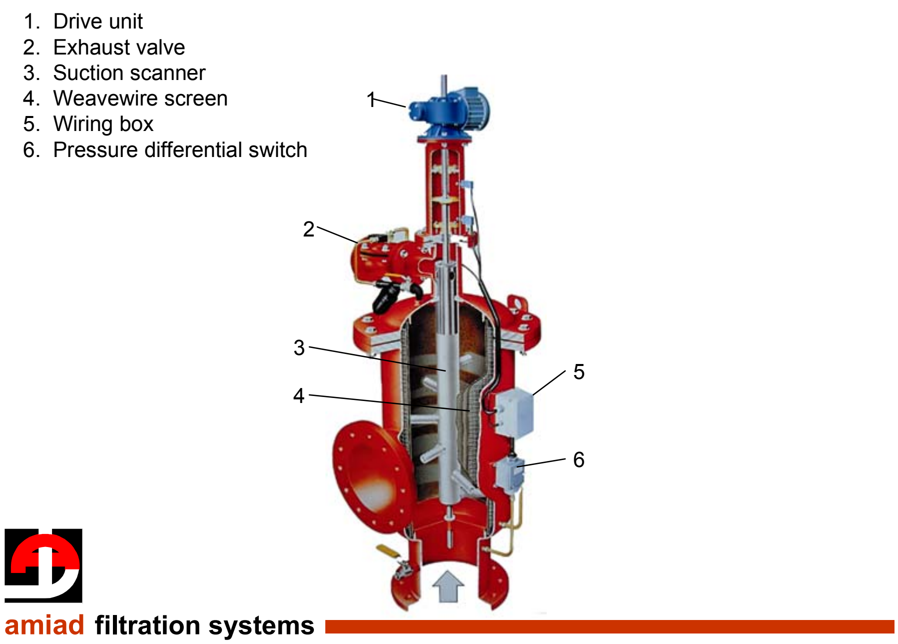

Figure 1

The electric driving mechanism rotates the suction scanner at a slow, fixed rotation while simultaneously moving the scanner linearly at a fixed speed by the action of a threaded shaft and fixed nut. The combination of rotation and linear movement gives each suction scanner nozzle a spiral path along the inside surface of the filter screen. The cleaning cycle is completed for each filter in 30 seconds during which time the nozzles remove the captured debris from the entire filtration area of the screen element. A more detailed explanation of the operation of this type filter can be found in the paper SELF-CLEANING PRE-FILTRATION FOR R.O. AND OTHER MEMBRANE SYSTEMS.[2]

MAINTENANCE

Since the water temperature at both the shallow and deep inlets are similar in during the winter months, only the deep inlet is used so the nine Amiad EBS Filters are bypassed the months of December, January, February, March and April. During this time the filters are routinely dismantled to inspect and wash the screens, replace seals and check for any needed repairs. During the nearly seven years of operation, one of nine drive motors has failed and two or three differential pressure switches and limit switches had to be replaced. These repairs seem minor considering the fact that each filter flushes 30-300 times per day, depending on water quality conditions.

ECONOMICS

Total installation cost for the zebra mussel control filtration system, including mixing valves, piping, filters, controls, and the steel building enclosure was $1,000,000 US. Such expense has been paid back many times over the last seven years in propane savings alone. This coupled with the fact that the State of Vermont supports a fishing industry of hundreds of millions of dollars a year makes the value of zebra mussel control in a major hatchery such as Ed Weed incalculable.

CONCLUTION

Though Lake Champlain has been contaminated with zebra mussels for nearly ten years, no mussels have been found inside the Ed Weed Fish Culture Station since the installation of the Amiad EBS Filters. After nearly seven years of operation, repairs on the nine filters and ancillary equipment have been minimal.

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