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ASSESSMENT OF THE VIBERT BOX AS A TECHNIQUE TO AUGMENT BROWN TROUT REPRODUCTION IN THE WOLF RIVER, LANGLADE COUNTY, WISCONSIN

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ABSTRACT

The use of 54 single-compartment Vibert boxes to stock 40,000 eyed brown trout eggs in the Wolf River and several small tributary streams in October 1973 proved unsuccessful in achieving a significant liberation of fry. Although some hatching success was observed, overall egg mortality was very high, 95-100% in most boxes examined during the fall and winter. Extremely cold water temperatures were suspected as the principal cause of egg mortality. The temperature of the Wolf River was at or near 32 F for 121 consecutive days.

Limited hatching success was noted in a small tributary stream whose flow was essentially composed of groundwater. Successful use of the Vibert box is believed to be contingent upon implantation in areas of significant groundwater emergence or where temperatures remain above 35 F; these conditions exist in some Wolf River tributaries.

The Vibert technique is not advocated for use in the Wolf River or in other Wisconsin streams where winter water temperature regimes are similar to those encountered in this study.

CONTENTS

INTRODUCTION

Available data (Steuck et al., in prep.) suggest that natural reproduction of brown trout (Salmo trutta) in the Wolf River is inadequate to provide a satisfactory sport fishery. Although a sparse population of brook trout (Salvelinus fontinalis) is present, brown trout sustain the sport fishery. Fishery investigations and assessments of angler harvest have demonstrated that stocked brown trout, both fingerlings and yearlings, carry over (survive a year or more in this environment) and make up a significant part of the population and catch. The Wolf River is a Class II(a) brown trout stream in that portion designated as trout water.

The current management strategy in the Wolf is to stock the river with brown trout fingerlings in the fall and yearlings in the spring. In 1973 several Trout Unlimited (TU) chapters proposed an alternative method, the use of Vibert boxes to increase the fingerling stocks of brown trout. Subsequently a cooperative project was conceived between the Wisconsin Department of Natural Resources (DNR) and the Wolf River, Wisconsin (based in Langlade) and Oak Brook, Illinois chapters of TU to test the Vibert box technique in the Wolf River and several of its small tributary streams. The DNR provided my time and the eyed eggs from brown trout brood stock. Trout Unlimited provided the 54 Vibert boxes and the services of the people (TU members) who implanted the boxes.

Vibert boxes have been used, with varying degrees of success, either to establish salmonid populations in streams lacking natural reproduction or to increase standing stocks of fingerlings. The usual procedure consists of placing fertilized trout eggs in Vibert boxes, which are slotted plastic containers about 2" x 2" x 3" (Fig. 1). The boxes are then implanted in streambed gravel, where the eggs incubate and the fry eventually hatch and emerge from the boxes. The method was developed about 30 years ago by Dr. Richard Vibert, a French fisheries biologist, and has been used extensively in France and other European countries. The technique is reported, in the explanatory brochure by Pezon and Michel, Vibert box manufacturers, to have achieved hatching success in excess of 90% in some cases (Anonymous 1951), although detailed documentation of these successes was not obtainable.

Claimed advantages of the Vibert box as an incubation chamber are that it is an extremely convenient means of placing fish eggs where they do not naturally occur, and that it gives the eggs protection against predators. Fish that emerge from Vibert boxes planted in natural environments are believed by box proponents to be better fish -- hardier and wilder -- than fish that have been planted as fingerlings or older fish. Proponents claim that if the Vibert box method is successful (i.e., a large proportion of the eggs hatch and the fry survive), it is cheaper than and can replace simple fish stocking, and it possibly results in fish more capable of survival than recently stocked fish.

At the outset of this experiment, however, it was acknowledged that the factor(s) now limiting or preventing natural reproduction of brown trout in the Wolf River might interact with and adversely affect the success of the Vibert technique as well. It has been assumed for some time that very low water temperature is the principal reason for poor reproductive success in the Wolf, although other environmental variables probably interacted with water temperature in preventing or limiting reproduction of brown trout in the Wolf River. The objective of this project, though, was to observe hatching and emergence success of the Vibert box rather than to measure the variables affecting egg and fry survival, with the exception of the possible influence of the water temperature regime. This report documents the events and observations that occurred during the study period and discusses the work and results of other investigations with Vibert boxes.

CHARACTERISTICS OF THE STUDY AREA

The Wolf River in Langlade County is a large stream averaging 176 ft wide. It is a medium-hard-water stream having slightly alkaline, light brown water. Stream flow at Langlade averages 464 cfs. Flow extremes have ranged from a low of 119 cfs following the 1976 drought to a high of 2,200 cfs in early spring 1973 (15 March) (U.S. Geological Survey 1974). Velocity measurements of 0.9-4.7 ft/sec have been recorded. River stage at Langlade ranges between 7.24 and 9.48 ft, a differential of 2.24 ft. Ice dams have elevated the stage to 9.98 ft (on 5 December 1968) (U.S. Geological Survey 1974). Normal stage variation exclusive of precipitation or spring runoff extremes is less than 1 ft.

Stream gradient in the trout water portion of the Wolf River averages 14 ft/mile. Gravel and rubble substrates are common, as are large boulders. Rapids and riffles are common occurrences. Water temperatures range from slightly below 32 F to highs of 83 F. The highs are usually of short duration, whereas freezing temperatures prevail for about 4 months. Absence of a strong groundwater influence is responsible for these temperature extremes. The 90% to 10% duration discharge ratio is about 0.3, an indication that groundwater is not a large component of river flow. The duration discharge ratio describes stream stability in terms of flow: the higher the ratio, the stabler the stream flow.

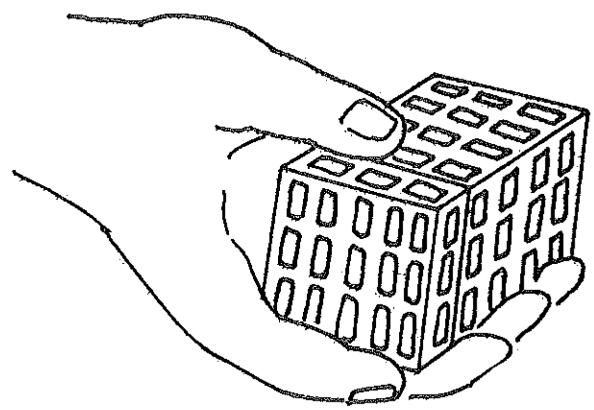

Figure 1. Rough sketch of the Vibert box used in this study. (Sketch by Georgine Price)

The 460-sq-mile watershed that sustains this part of the Wolf River is 95% wooded and wildland. The climate is characterized by a winter that starts abruptly in mid-November and lasts until early April. Annual precipitation averages 31 in. with 40% occurring as snow. The watershed is underlain by crystalline bedrock. Surface features are a result of glaciation and the glacial deposits range from 100 to 200 ft in thickness except where bedrock is locally exposed. About 72% of the watershed is composed of loams, sandy loams, and silty loams, soils which possess moderate infiltration capabilities. Sand and sandy loams cover about 25% of the watershed; this soil type is highly permeable. The remaining 3% is silty and clay loam having a slow infiltration rate. Permanent human population density (1970) is about 90 people/sq mile.

The Wolf River sport fishery consists of brown trout, a few brook trout, and smallmouth bass (Micropterus dolomieui). Northern pike (Esox lucius) and an occasional walleye (Stizostedion vitreum vitreum) are also caught. Sixteen species of forage fishes also inhabit the river. It is the brown trout that attracts anglers, however, and this fishery yields trophy fish (20+ in.) to the creel.

METHODS

Since proper site selection is crucial to the successful incubation of trout eggs, I held a training session in site selection for the participants in this project 1 month prior to the date of implantation. The Whitlock slide series (developed by David Whitlock, a proponent of the Vibert box) describing the Vibert box technique and procedures was viewed and site selection criteria relating to substrate, placement depth, and water velocity were explained. Judgments were to be visual and subjective. The classroom session was followed by a field trip to the river, where practical exercises in site selection, excavating of the stream bed, and placement of Vibert boxes were conducted. Following the training exercise, Wolf River Chapter members of Trout Unlimited devoted several weeks to the location of satisfactory sites and the procurement of supplemental gravel for the artificial redds. These preliminaries expedited implanting of the Vibert boxes on the day of installation.

Eyed brown trout eggs were obtained from the DNR fish hatchery at Wild Rose in Waushara County on the afternoon of 19 October 1973. (The project schedule is given in Append. A.) The 40,000 eggs had been taken from early-spawning brood fish on 24 September 1973 and had been incubated at a constant 50 F. The eggs were picked and placed on trays in a standard egg transport box. Each tray was covered with a moist cloth diaper and ice was placed in the top compartment to maintain a cool, moist environment.

Departure from Wild Rose was at 3:00 p.m. for the night's stopover at Shawano, a 65-mile trip. The eggs remained in the vehicle overnight with the air temperature reaching a low of 38 F. The 34-mile trip from Shawano to Langlade on the Wolf River was begun at 5:15 a.m. the following day (20 October) and the destination was reached in about an hour.

At 7:45 a.m. on 20 October preparations were begun to transfer the eggs to Vibert boxes. The temperature of the top tray of eggs, determined from a Taylor pocket thermometer that had been placed on the tray during initial packing, was 35 F. The eggs were again picked, and only a few dead eggs were found. The egg trays were placed in water with ice. Eight hundred eggs were counted and placed in a Vibert box. The remaining boxes were filled to approximately the same level, representing approximately 800 eggs. The charged Vibert boxes were then placed in portable coolers containing ice and water for transport to the stocking sites. Forty of the boxes were destined for the Wolf River and 14 for 3 small Wolf tributaries -- Creek 31-16 (4 boxes), Creek 32-9 (5), and Spring Creek (5). One of these tributaries, Creek 31-16, served as a control stream where egg development could be readily monitored. General locations of the Vibert box implants are shown in Figure 2.

Each box was numbered, using a metal tag. The anchoring system used was a nylon line and lead weight. A standard form was filled in for each box, giving box number(s), box location, and site description (Append. B). Before the boxes were placed in the stream bed, river water was gradually added to the eggs in the transport container to bring them within a few degrees of the stream temperature. Three teams of 4 people each were then dispatched to predetermined locations. Members of the Wolf River Chapter of TU who selected the sites served as crew leaders. The water was too deep and the bottom material too coarse at most sites to excavate the stream bed easily. Rather than placing the boxes in excavations of the stream bed, therefore, the crews used a mounding technique (Fig. 3).

The day of implantation (20 October) was bright and mild, with an early afternoon air temperature of 60 F. The river temperature was 42 F at the start of implanting and had warmed to 49 F by the end of the day.

Periodic inspections, which I performed, were planned of selected Vibert sites to assess egg viability during the course of incubation. My visits were not made at regular intervals except during the first 2-1/2 months, when I made inspections about every 2 weeks. Following this period, a month or more separated visits. Since very cold water temperatures were suspected of being responsible for poor natural reproduction of brown trout in the Wolf, a Ryan (Model D-45) continuous recording 45-day thermograph was placed in the river on 26 October 1973 (Fig. 2). The instrument was located about 1,200 yards downstream from State Highway 64 adjacent to the Cap Buettner property. The thermograph was serviced every 45 days.

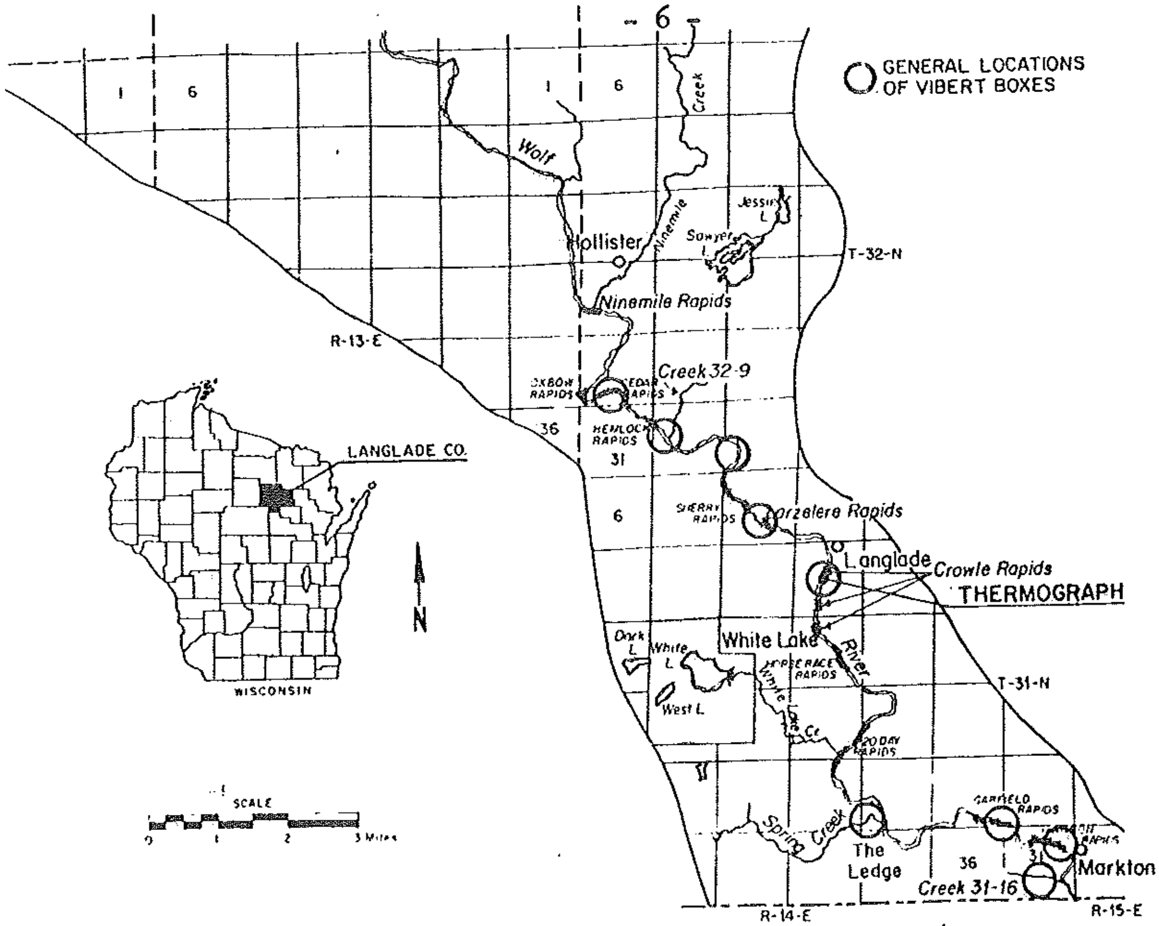

Figure 2. General locations of Vibert box implants in the Wolf River and 3 tributaries.

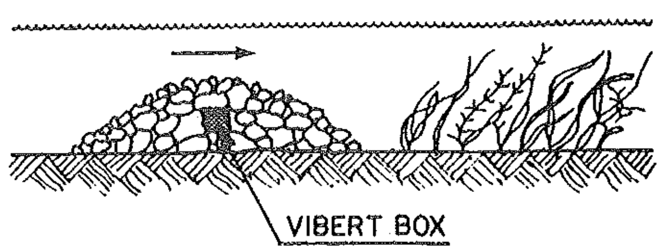

Figure 3. Illustration of the mound technique of installing the Vibert box.

RESULTS

I began monitoring of the Vibert boxes shortly after their installation. The boxes' remoteness and difficulty of access precluded follow-up examination of each site. The viability characteristics observed in the 26 boxes monitored (48% of the 54 boxes planted) were believed to be indicative of the viability characteristics at all the box locations. Stream data, implantation details, and observations made are given below for each stream monitored. The number of days between implanting and inspection are noted in parentheses.

Creek 31-16 (T31N, R15E)

Four Vibert boxes were installed in this small creek. They were implanted about 10 ft apart approximately 75 ft upstream from the Wolf River. This creek is a hard-water stream having clear water and an average width of 5 ft. Normal stream flow is estimated to be less than 0.5 cfs. Groundwater makes up a major part of its discharge. In late August, with air temperature 79 F, the water temperature was found to be 64 F. Sand is the predominant bottom material, with some gravel present.

Six days after the implanting of the 4 Vibert boxes (26 October), the eggs exhibited 95% viability. The 8 November (19th day) inspection revealed 90% viability. On 20 November (31st day), viability remained at the 90% level. On this date, 2 boxes were removed and 425 eggs were transported to the Woodruff Fish Hatchery for continued observation of incubation. These eggs were placed in a hatching jar with circulating water and protected from direct sunlight. By 18 December (59th day) about 2/3 of these eggs had hatched and more were to come. There was minor egg mortality during this period in the hatchery. Hatchery water temperatures ranged between 35 and 40 F, averaging 37 F.

Stream inspections were resumed on 6 December (47th day) and 2 viable brown trout fry were observed outside an artificial redd. However, egg mortality was now 85-90%. On 19 December (60th day) the remaining 2 Vibert boxes were removed. Viable brown trout fry were observed in each box and 18 were recovered from the redd. The estimated egg mortality in these 2 boxes was between 80 and 90%.

Sometime between 20 November (31st day) and 6 December (47th day) egg mortality increased substantially (from 10% to 85-90% in these 16 days). Stream temperature at the time of installation (20 October) was 46 F. The 1st inspection (26 October) found the water temperature 49 F. The following 4 inspections, between 8 November and 19 December, revealed water temperatures between 36 and 40 F, the average being 37.5 F.

Although egg mortality was relatively high, in excess of 80%, brown trout fry were hatched in the Vibert boxes and some fry were found in the artificial redds. An electrofishing survey the following August (1974) in the 400 ft upstream from the Wolf River captured 29 brook trout (2.0-6.9 in.) and 12 brown trout (2.5-4.4 in.). All of the brown trout were presumed to be fingerlings. Some or all of these brown fingerlings may have been progeny of the Vibert boxes; however, no previous documentation of the fish species inhabiting this creek had been made. Brown trout fingerlings in lesser numbers have been found in other small creeks tributary to the Wolf River where no egg plants have been made; thus the brown trout fingerlings in this creek may have been native and cannot be assumed to have originated from Vibert boxes.

Creek 32-9 (T32N, R14E)

Five Vibert boxes were implanted in this small creek. All were placed in an area 150-400 ft upstream from the Wolf River. This stream has hard water that is stained. Stream width averages 4 ft. Normal stream flow is estimated to be about 1 cfs. Although groundwater input is evident, surface drainage appears to be prominent. Late September water temperature was 56 F with an air temperature of 75 F. Sand is the predominant bottom material, with very limited areas of gravel.

The creek was first inspected on 8 November (19th day), when 1 of the boxes was examined. Ninety percent of the eggs were viable. Although the Wolf River had shelf ice near shore and slush ice farther out, Creek 32-9 was still open. The next inspection was not made until 10 April 1974 (174th day). The creek on this date was above normal and carrying melt water and was turbid with sand carried in suspension. The artificial redd sites were not examined for egg viability.

The last examination of this creek occurred on 10 May (203rd day). All of the Vibert boxes were removed and the artificial redds examined for fry. No fry were recovered from the boxes or redds. The egg masses in these boxes were reduced in volume, it is believed by egg mortality and subsequent decay rather than hatching. The space left in the boxes, 50-75% of their volume, was packed with sand and some silt. Egg mortality in all boxes was probably 100%. The late inspection of these boxes may have precluded an appropriate assessment of mortality, however.

During an electrofishing survey of this stream 1 year before the egg implants on 20 September 1972, 2 brook trout were captured in the stretch where the Vibert boxes were later installed. One was a fingerling less than 3 in. long; the other was an adult in the 6.0-6.4-in. size range. About 2/3 mile farther upstream, 9 brook trout were captured in the 1.5-5.9-in. size range.

Spring Creek (T31N, R14E)

Five Vibert boxes were implanted in a 120-ft-long stretch of this stream. All were located within an area 30-150 ft upstream from the Wolf River. Spring Creek is a hard-water stream having clear water; its average width is 8 ft. Normal stream flow is estimated to be between 2 and 3 cfs. August stream temperatures of 55-58 F at an air temperature of 79 F suggest that there is a strong groundwater influence.

The creek was inspected on 14 February (116th day) and all the Vibert boxes were removed and examined. The previous night's minimum air temperature was well below 0 F; the creek was 80-90% open except for the 150 ft upstream from the Wolf River. All the artificial redd sites were heavily silted, particularly those nearest the Wolf River. The cause of this siltation, in gravel sites that had been deemed appropriate sites for implanting boxes the previous fall, was ice in the Wolf River which caused water to back up about 200 ft into Spring Creek. This inundation substantially reduced the velocity of Spring Creek, causing its silt load to be deposited in the lower 200 ft of this stream rather than in the Wolf River.

Although all the Spring Creek Vibert box sites were heavily silted, 2 boxes contained few or no eggs. The remaining 3 boxes exhibited virtually 100% egg mortality and their original egg mass remained intact. It is probable that the 2 boxes with no eggs achieved a high hatching rate and liberated their fry. However, although each of the 5 artificial redds was examined for fry, none were found.

Wolf River

Thirty-six Vibert boxes were implanted in the Wolf River and 4 were placed in the mouths of 2 small groundwater rivulets. (Characteristics of the Wolf River have been previously described.)

Examination of arbitrarily selected sites (chosen primarily for their accessibility) began on 8 November (19th day). Water temperature was 33 F, and slush ice, which began forming on 5 November, filled the stream channel. The eggs examined exhibited 90% viability. On 20 November (31st day) the river was 37 F, a response to warmer weather, and egg mortality was 72%. Inspection on 6 December (47th day) revealed 100% egg mortality and a water temperature of 32 F. Sampling on 19 December (60th day) found the water temperature just under 32 F and about 99% egg mortality. Sixteen hatched but dead fry were observed in one Vibert box in addition to 2 dozen dead fry with their head protruding through the egg wall. After placement of the box in a styrofoam transport container, 4 viable fry and 3 hatched but dead fry were observed several hours later.

The 4 January (75th day) inspection of several sites in the Wolf revealed nearly 100% egg mortality. Water temperature was then 32.5 F. The heads of several dead embryos in one box protruded through their egg walls. In another box 2 dozen dead and 1 viable fry were observed. The 3rd box yielded 1 viable fry. The 2 boxes in which hatched but dead fry and several viable fry were observed were located near the mouth of a small spring creek. The water temperature at this location was slightly above 33 F, somewhat warmer than at the other river locations. Fungus was prominent in one of these boxes.

An inspection on 28 March 1974 (159th day) found the fastest-flowing parts of the river beginning to open although the water temperature was 32 F. Egg mortality was high, 95+%, but one of the 2 boxes examined contained 5 viable fry, and 10 were recovered from the redd. The other box, at a different location, exhibited 100% egg mortality and some fungus.

The last inspection, on 10 April (174th day), found the river temperature 45 F. Five boxes, all in the same area but on different sides of the river, were examined. Four of the 5 revealed 100% egg mortality. The 5th box, exhibiting 95% egg mortality, contained 5 viable fry in the yolk sac stage in the bottom of the box. Examination of the redd yielded 2 viable fry, also in the yolk sac stage. All of these fry wiggled away upon release.

The recording thermograph malfunctioned on one occasion: it provided no temperature data from 20 January through 14 February. Prior to the malfunction the water temperature had been 31-32 F since 4 December. It is unlikely that the water temperature during the malfunction deviated significantly from 32 F. Daily maximum and minimum water temperatures of the Wolf from 26 October 1973 through 18 April 1974 (except for the malfunction period) are provided in Table 1.

Table 1. Daily minimum and maximum water temperatures of the Wolf River during the study period. (Temperature data obtained from a Ryan (Model D-45) recording thermograph.)

Date	Min °F	Max °F	Date	Min °F	Max °F	Date	Min °F	Max °F
26 Oct 73	51	54	15 Dec	31	31	28 Feb	31	31
27	47	51	16	31	32	1 Mar	31	31
28	43	47	17	31	31	2	31	31
29	43	45	18	31	32	3	31	31
30	41	46	19	31	31	4	31	31
31	43	45	20	31	32	5	31	32
1 Nov	41	43	21	32	32	6	31	31
2	40	42	22	32	32	7	31	31
3	39	42	23	32	32	8	30	31
4	36	40	24	32	32	9	30	31
5	32	38	25	32	32	10	30	31
6	32	34	26	32	32	11	31	32
7	32	32	27	32	32	12	31	32
8	30	32	28	32	32	13	31	31
9	30	30	29	32	32	14	31	31
10	30	30	30	31	32	15	31	31
11	30	30	31	32	32	16	31	31
12	30	32	1 Jan 74	32	32	17	30	31
13	32	33	2	31	32	18	30	31
14	32	35	3	31	31	19	31	31
15	35	34	4	31	32	20	31	31
16	31	34	5	31	32	21	31	31
17	30	33	6	31	32	22	31	31
18	31	34	7	31	32	23	31	32
19	34	36	8	32	32	24	31	32
20	35	38	9	31	31	25	32	32
21	38	41	10	32	32	26	32	32
22	36	39	11	32	32	27	32	32
23	34	37	12	32	32	28	31	32
24	34	36	13	31	32	29	31	31
25	34	36	14	32	32	30	31	31
26	36	37	15	32	32	31	31	31
27	37	39	16	32	32	1 Apr	31	31
28	34	38	17	32	32	2	31	31
29	32	34	18	32	32	3	31	31
30	32	33	19	31	32	4	31	32
1 Dec	32	32	20 Jan-14 Feb -- No record			5	32	36
2	32	34	15 Feb	32	32	6	34	38
3	34	36	16	31	32	7	37	42
4	32	36	17	32	32	8	36	41
5	31	32	18	31	32	9	38	42
6	31	32	19	32	32	10	39	46
7	31	32	20	32	32	11	42	46
8	31	31	21	31	32	12	40	42
9	31	31	22	31	32	13	38	40
10	31	31	23	31	32	14	36	39
11	31	32	24	31	31	15	34	40
12	32	32	25	31	31	16	37	44
13	31	31	26	31	31	17	42	47
14	31	32	27	31	31	18	46	49

On the day the Vibert boxes were installed (20 October), the water temperature ranged from 42 to 49 F. A week later (26 October), when the thermograph was installed, the river was in the low to mid-50's F. During the next 9 days minimum water temperatures were between 36 F and 47 F. On 5 November the minimum water temperature reached 32 F for the 1st time, and slush ice had begun forming in the river. On 8 November 30 F was recorded and for the next 3 days the river held at a constant 30 F. Early November was unusually cold, with air temperature lows of from 8 F to -11 F from 5 to 10 November. In mid-November temperatures moderated, with the river reaching a high of 41 F. Minimum water temperatures during the last half of November varied from 30 F to 34 F or slightly higher.

On 5 December the river entered a period in which the minimum and maximum temperatures would not vary more than 1 F, holding at between 31 F and 32 F for 121 consecutive days beneath ice cover. The first break in this temperature occurred on 5 April, when the river rose to 36 F and then continued to progressively warm up.

Average discharge during the study period was 376 cfs (Table 2). Stream flow ranged from a low of 280 cfs to a high of 601 cfs. No dewatering of the artificial redds was observed nor were any redds embedded in ice. Free-flowing water was found at each site inspected. The quantity of water, represented by stream flow and river stage, was adequate to cover the artificial redds.

DISCUSSION

Supplementation of inadequate natural reproduction of trout in habitat such as the Wolf River that is favorable to survival, and perhaps to reproduction, has consisted of stocking various trout age groups, usually fall fingerlings or spring catchables. The intent of these measures is to bolster existing stocks to meet sport fishery needs. In most stocked trout streams, success has been short term; i.e., put and take resulted from the stocking of catchables, and survival of fingerlings to legal size has been poor to nonexistent. The Wolf River is an exception to this norm, as stocked fingerling and yearling trout do achieve carryover status. The unknown quantity is the survival level attained by these stocked age groups.

An alternative to such stocking is the use of trout ova. On Vancouver Island, British Columbia, MacKinnon (1960) transplanted eyed pink salmon (Oncorhynchus gorbuscha) eggs directly into the gravel of an artificial spawning channel and achieved 95% fry output. In a study of spawning gravel conditions and the survival of steelhead trout, Coble (1961) stocked steelhead eggs in plastic mesh sacks in Oregon and documented embryonic survival that ranged from 16 to 62%. In Scotland, Egglishaw and Shackley (1973) stocked a trout stream with Atlantic salmon (Salmo salar) eggs and achieved a successful hatch, with 13.5% survival to a length of 3.1 in.

In Michigan, Hansen (1975) used Vibert boxes in a study of the effects of groundwater on natural brown trout redds. He observed egg survival of 5-52%. Where viable fry were liberated, survival from the egg stage ranged between 21 and 66%. Bjornn (1978) achieved a 40-95% hatch of swim-up fry from steelhead trout eggs placed in an artificial incubation channel. The aforementioned studies demonstrate that satisfactory egg incubation and fry liberation can be attained from salmonid eggs stocked in suitable stream bed locations or artificial spawning channels.

Successful use of the Vibert box technique requires that certain environmental conditions prevail at the sites selected for the implanting of eggs. White (1973) enumerated the general requisites for salmonid reproduction. These consist of proper temperature, bed materials, volume, velocity, and oxygen. He noted that successful spawning occurs within a narrow range of current speeds except where there is substantial groundwater influx. Eggs usually lie beneath 6-8 in. or more of gravel and require well oxygenated water with adequate velocity percolating through the gravel. Therefore egg survival and fry production are contingent upon proper site selection for the artificial redds.

Reiser and Wesche (1977), in an intensive study of several Wyoming streams, measured various physical and hydraulic parameters to define the criteria associated with the selection of spawning sites by brook and brown trout. Their study also included an egg planting experiment utilizing green brown trout eggs in Vibert boxes. This phase of their study monitored embryo survival at sites exhibiting different physical and hydraulic characteristics.

After 90 days they assessed egg viability and most of the boxes revealed 100% mortality. Several boxes located in a riffle area thought to offer high survival potential were frozen solid. The highest egg survivals observed (20% and 7%) were found where Vibert boxes were placed in natural redds. The gross mortality observed even in those areas thought to provide the best combination of physical and hydraulic conditions suggests that factors other than spawning criteria influence egg survival. Several explanations were offered for the high egg mortality, with extremely low water temperatures assumed to be the probable cause. Reiser and Wesche concluded that spawning criteria cannot stand alone as factors to determine selection of the best sites for embryo survival. Suitable incubation flows, presumably within and outside the redd, must also be defined.

Table 2. Daily discharge, in cubic feet per second (cfs), of the Wolf River at Langlade during the study period. (Data obtained from USGS gaging station at Langlade.)

Day	Oct 1973	Nov 1973	Dec 1973	Jan 1974	Feb 1974	Mar 1974	Apr 1974
1	377	458	464	330	280	420	450
2	366	452	440	330	280	430	460
3	366	434	410	340	280	440	490
4	366	416	394	340	280	450	508
5	377	355	355	340	280	460	574
6	371	308	339	340	280	500	574
7	366	420	310	340	280	540	601
8	377	440	310	340	280	580	588
9	399	420	300	330	290	560	567
10	416	400	300	330	290	480	574
11	458	380	300	330	290	460	560
12	458	388	290	330	290	450	703
13	434	394	290	320	290	440	1,070
14	410	410	290	320	290	430	1,090
15	394	394	280	320	290	430	1,060
16	382	388	280	310	290	430	1,030
17	366	440	280	310	290	430	975
18	360	388	280	310	290	420	957
19	355	388	280	300	290	420	912
20	350	382	280	300	290	420	868
21	350	470	280	300	300	420	825
22	350	594	280	300	310	420	800
23	344	527	280	300	310	410	750
24	339	547	280	300	320	410	719
25	339	567	380	300	330	410	719
26	339	560	280	300	350	410	688
27	334	560	290	290	380	410	630
28	514	554	290	290	400	420	560
29	470	534	300	290	-	420	534
30	428	452	310	290	-	430	521
31	422	-	320	290	-	440	-
Median	386	447	311	315	301	445	712
Maximum	514	594	464	340	400	580	1,090
Minimum	334	308	280	290	280	410	450

It is apparent that successful use of the Vibert technique requires more than subjective determinations as to box location, even when specific site selection criteria are adhered to. Good site selection is likely to be critical in those streams subjected to extended winter hardships of ice and very low water temperatures.

The Wolf River study revealed a very high rate of egg mortality in most of the boxes examined. Overall hatching success was insignificant in bolstering the brown trout fingerling population. The study's most notable hatching success, about 20%, occurred in a Wolf River tributary, Creek 31-16. Temperatures in this stream probably did not fall below 35 F during the incubation period. Even at this temperature, mortality was excessively high. In the Wolf River, where the temperature was at or near 32 F for a long period, mortality was extremely high. I have assumed, although the evidence is circumstantial, that very low water temperatures were the primary cause of egg mortality, a conclusion also reached by Reiser and Wesche (1977). In North Carolina, Harshbarger and Porter (1979) reported substantial egg mortality in Whitlock-Vibert boxes and in direct gravel plants that corresponded with a period when the weather was cold enough to produce anchor ice. However, Hansen (1975) found reasonable levels (16-51%) of brown trout egg survival in northern Lower Michigan after 102 days of incubation in Vibert boxes at redd temperatures of 32 F or slightly higher.

The question arises as to whether or not circumstances surrounding the source of eggs might be a factor in survival. Do eggs initially incubated at, or from brood stock exposed to, greater temperature extremes exhibit better survival potential than those incubated at relatively constant temperatures? Eipper (1963) noted that acclimation to high or variable water temperatures may be one of the mechanisms by which the hatchery water supply influences subsequent stream survival of stocked trout. He commented that in many situations relatively cool and constant water temperatures during incubation may adversely affect the survival rate of the fish produced. Combs and Burrows (1957) reported that chinook and pink salmon eggs, if initially incubated at a temperature above 42 F for 1 month, could tolerate very low temperatures for long periods. Their study also revealed that chinook salmon eggs incubated at a constant temperature of 35 F exhibited virtually complete mortality.

The brown trout eggs in this study were obtained from brood stock exposed to a temperature that ranged from 40 F to 60 F and averaged 50 F. Eggs were subsequently incubated in the hatchery at a constant temperature of 50 F for 25 days, a condition that may be quite different from the temperature regime characterizing trout eggs developing under natural stream conditions. Eggs obtained from spawning stocks that live under temperature conditions more similar to those in natural streams might be better for use in Vibert box plants. However, it is doubtful that any hatchery would approach the austere temperature conditions encountered in this study. The alternative for obtaining such eggs, therefore, would be to collect eggs from wild trout just prior to natural spawning, or create the necessary temperature regime artificially in the hatchery.

Water temperature not only plays an important role in incubation but also influences the well-being of the fry. Even if a successful hatch is achieved at very low temperatures, there is the risk of heavy mortality among the fry. Embody (1934) found that brown trout eggs developed normally at a temperature as low as 35 F, although losses at the lowest temperature were above normal. He concluded that if eggs first became eyed at temperatures above 40 F, as was the case for the eggs in this study, development could safely be completed at extremely low temperatures. Davis (1956), however, was of the opinion that fry hatched from eggs incubated at very low temperatures are usually weaker and suffer heavier losses than fry from eggs incubated at normal temperatures. Temperature requisites for brown trout egg hatching and fry survival in the wild would appear to require further investigation.

Variation in Vibert box style and in box planting techniques may also influence egg hatching and fry survival. In North Carolina, Harshbarger and Porter (1979) compared egg and fry survival using 2 planting techniques and eyed brown trout eggs. One technique consisted of using 2 different styles of Vibert boxes, the standard single-compartment unit and the 2-compartment Whitlock one. The other method consisted of depositing eggs directly into the stream gravel. Biweekly observations revealed egg mortality of 5%/week regardless of technique during the eggs' 1st month in the stream. After 4 weeks the mortality rate of eggs in boxes and of those in direct plants started diverging. The divergence increased into the 7th week, with higher mortality occurring in the Vibert boxes. At the 7th week a threefold increase in mortality occurred at all sample sites involving both techniques. This increased mortality rate corresponded with a period of very cold weather which produced anchor ice in the stream. This study revealed that the production of swim-up fry from eggs planted directly into the gravel was 2.5 times greater than that from eggs in 2-compartment Vibert boxes. No eggs hatched in the 1-compartment boxes, which were the same as those used in this study. Their conclusion, though tentative, was that intragravel egg plants were superior to Vibert boxes for introducing large numbers of eggs into streams for incubation.

I observed a mortality pattern in Creek 31-16 similar to that noted by Harshbarger and Porter (1979). During the 1st month after egg implantation, mortality was in the 5-10% range. Between the 4th and 7th weeks mortality increased to 80-90%. Although very cold weather occurred during the 4th week (6 consecutive days with minimum air temperatures of from 8 F to -11 F), I have no reason to believe that the water temperature fell below 35 F.

The artificial redds, being of the mound type, presumably had their temperatures positively correlated with those of the stream. There was no reason to believe that the Wolf River implants encountered any groundwater influence. However, several locations were in proximity to groundwater creeks or rivulets which could have moderated the main river temperature slightly, possibly creating more favorable microhabitat for incubation. There was extremely limited hatching success in one of these locations, but dead fry were also evident.

The brown trout eggs used in this study were obtained from domestic brood stock; they were spawned 4-6 weeks earlier than spawning occurs in the wild in this area. The eggs taken on 24 September 1973 were incubated at 50 F for 25 days before they were put in Vibert boxes and planted. Brown trout eggs at Wild Rose will hatch in 43 days at 50 F (Don Czeskleba, pers. comm.). These eggs had completed 58% of their incubation requirement as of 19 October. During the transfer their temperature was reduced to a low of about 35 F for nearly 24 hours. After implanting in the Wolf River on 20 October, the eggs were subjected to a river temperature that progressively warmed during that day from 42 F to 49 F. During the following weeks they were exposed to fluctuating temperatures of 36 F to 54 F prior to freeze-up. The eggs in Creek 31-16 were exposed to a stream temperature range of 36-46 F. A few fry were liberated in early December and more were collected by the middle of the month, 47-60 days after they were removed from the hatchery. These circumstances and the successful hatching of fry at the Woodruff Hatchery suggest that no congenital defects existed and that handling and temperature changes in transit did not contribute to the high mortality subsequently observed.

In northern Wisconsin brown trout usually spawn in late October or early November. However, I have observed spawning activity in northern Wisconsin in late September in a stream (Deerskin River in Vilas County) that receives annual stockings of Wild Rose brown trout. Assuming an incubation time of 5 months in streams having very low temperatures, northern Wisconsin wild fry would be liberated in mid- to late March, just prior to river warmup. If fry hatch in mid-December, well in advance of the normal time, their survival potential is likely to be very low because they are not in synchronization with natural events. Their ability to feed at very low temperatures may be inadequate to achieve survival if they are faced with 3-1/2 months of 32 F water temperatures. A study of the relationship of the feeding behavior of young sockeye salmon to water temperature (Brett 1971) suggested that no voluntary feeding occurred below 36.5 F. The use of early eggs (the only eggs used in this study) is of questionable value in an area where the conditions for survival are at their minimum and where "premature" fry would emerge in an extremely harsh environment.

Inadequate river flow did not appear to be a cause of egg mortality. All sites were adequately covered with water. Changes in velocity may have occurred at some sites after ice formation, thereby altering percolation and sediment deposition rates. Sand and silt accumulation in the Vibert boxes was not a major problem except that noted in Spring Creek and Creek 32-9. Deposition of sand on the downstream side of the mounded redds was frequently noted, however. Where this occurred sand would pile up toward the top of the mound and partially bury the lower third to half of the redd. If the redds had been excavated this problem would probably have been alleviated. If mound redds are used they should be elongated, about 3 times as long as wide. The box should be placed in the forward third of the mound to escape sand encroachment from the downstream side. Whether or not this placement will permit adequate percolation of water through the redd is unknown.

Temperatures in the Wolf River were severe. The instrumentation recorded a substantial number of 31 F readings. During initial freeze-up there were 5 consecutive days with minima of 30 F. (No intraredd temperature measurements were taken in the study.) It is likely, though unproven, that this 5-day period of 30 F water was the critical factor in egg mortality. Below-freezing temperatures over an extended (even 5-day) period can be a critical factor in the mortality of trout eggs. Whether 30 F temperatures actually occurred might be questioned; a mercury-filled Taylor pocket thermometer never recorded a surface temperature below 32 F during 6 midwinter visits to the river.

The thermograph was in 18 in. of water on the stream bottom. No anchor or frazzle ice was observed at its location. Although others (E. Avery and J. Mason, pers. comm.) have recorded 31 F with similar instruments, they, too, questioned this temperature. Accuracy of the instruments is $\pm 2\%$. I suspect that it would be appropriate to assume that 32 F (± 0.05 F) was the lowest actual water temperature in this study, with the possible exception of the freeze-up period, when supercooled water below 32 F may have occurred for several days in early November.

The roles of fungus infection, siltation, inadequate levels of dissolved oxygen, and other kinds of environmental stress in the mortality of Vibert box eggs and fry were not studied during this project. Any of these factors may have been considerably more important in egg mortality than assumed. Low water temperature was considered the primary cause of mortality.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

The Vibert technique has achieved varying levels of success as an incubation chamber. Direct stocking of eyed eggs into stream gravel has also been successful. Stocking of fry, fingerlings, and older salmonids is also a recognized strategy. Conversely, all of these methods have had failures in achieving management objectives. Their success is dependent on mitigating or accommodating the environmental constraints (among them low water temperatures, siltation, fungus, and predation) that limit desirable results, or on restricting their use to situations in which environmental conditions are favorable. To state that any one technique is a panacea in overcoming a deficiency in a local, statewide, or regional sport fishery is presumptuous.

Some lay conservation organizations, particularly the Federation of Fly Fishermen and Trout Unlimited, are advocates of the Vibert system as a method of increasing trout stocks or the quality of the stocks in trout streams. Their thrust in this direction is commendable, and no issue is taken with their objective. I would caution Vibert box proponents, however, that there are limitations. The Vibert box, when successful, is a convenient method of planting eggs where they do not naturally occur. But just as fish stocking has failed to be the universal solution to the problem of inadequate stocks it was once believed it would be, it would be comparable folly to suggest that only eggs need be stocked in streams to achieve sport fishing objectives.

The contention that trout hatched in a stream from egg plants are wild fish must be modified with acknowledgment that these eggs are usually obtained from brood (domestic) fish and the site of incubation will not alter the genetic characteristics of their progeny. Thus certain traits inherent in hatchery fish can be expected to be carried forward. It is hoped, however, that survivors of this technique will possess qualities that set them apart from recently introduced stocks, like being more "nativelike," wilder, sturdier, and abler to survive. They are also not subject to immediate angling mortality. Where avoidance of "put and take" stocking is sought, a reasonable and promising alternative to the stocking of catchables merits testing.

Although one experiment is not conclusive, this experience with the Vibert box technique was not encouraging. I still believe that the duration of freezing (32 F) water temperatures is the critical problem affecting brown trout reproduction in the Wolf River, although there may be other (still unmeasured) problems as well. Alleviation of this limiting factor is not practicable. The 5-day period of 30 F temperatures in early November was very likely the critical point in Wolf River egg mortality in this study. Therefore, if the Vibert technique has any potential in the study area, it may be in those small tributaries to the Wolf River that possess strong groundwater influx and suitable gravel. Furthermore, if Vibert boxes are planted in these tributaries, eyed eggs from late-spawning stock should be used and incubated at the lowest practicable temperature prior to implanting to discourage early fry emergence.

Fisheries studies (Steuck et al., in prep.) have revealed that 75% of the brown trout in the Wolf River are hatchery fish. Natural reproduction of brown trout in the Wolf appears to be extremely limited, which we attribute to prolonged periods of extremely low water temperatures, and there is no reason to believe that the Vibert box is capable of solving this or any other of the brown trout's problems of reproducing naturally in the Wolf River. It is therefore recommended that the current Wolf River management strategy of stocking the river with fall fingerling and spring holdover brown trout be continued.

APPENDIX A. Main dates, events, and observations of the study.* (Sites are the Wolf River, Creek 31-16, Creek 32-9, and Spring Creek.)

Site	Date	Event
(All)	24 Sep 1973	40,000 eggs taken from brood brown trout and incubated at constant 50 F at Wild Rose Fish Hatchery.
(All)	19 Oct 1973	Eggs transported to Langlade on Wolf River.
(All)	20 Oct 1973	Eggs placed in 54 Vibert boxes (c. 700-800 eggs/box). Temp. in boxes c. 35 F. Boxes planted: 40 - Wolf River (42-49 F: 20 Oct) 4 - Creek 31-16 (control stream) 5 - Creek 32-9 5 - Spring Creek.
All	22 Oct 1973	Monitoring begun of 26 boxes (rest were not monitored in study).
Creek 31-16 (4 boxes)	26 Oct 1973	Inspection: 95% eggs viable. (Creek has much groundwater discharge.)
	8 Nov 1973	90% eggs viable.
	20 Nov 1973	90% eggs viable. Portion of 2 boxes transported to Woodruff Fish Hatchery and placed in hatching jar at 35-40 F.
	6 Dec 1973	2 boxes inspected: 10-15% eggs viable.
	18 Dec 1973	About 2/3 of Woodruff control eggs had hatched.
	19 Dec 1973	Other 2 boxes inspected; 10-20% eggs viable.
Creek 32-9 (5 boxes)	Late Sep 1973	Water temp. 56 F. (Creek has some groundwater discharge.)
	8 Nov 1973	One box inspected: 90% eggs viable. (No ice in creek.)
	10 Apr 1974	Unsuccessful inspection; all sites ice covered.
	10 May 1974	All boxes inspected; probably no eggs viable.
Spring Creek (5 boxes)	Aug 1973	Water temp. 55-58 F. (Creek has strong groundwater influence.)
	14 Feb 1974	Inspection: 3 boxes -- c. 0 eggs viable; 2 boxes -- no eggs (high hatching and liberation rate probable).
Wolf River (40 boxes; arbitrarily selected sites examined)	8 Nov 1973	Water temp. 33 F. (Stream has little groundwater discharge.) Slush ice (beginning 5 Nov 1973) filled stream channel. 90% eggs viable.
	20 Nov 1973	Water temp. 37 F. 28% eggs viable.
	6 Dec 1973	Water temp. 32 F. No eggs viable.
	19 Dec 1973	Water temp. 32 F. No eggs viable.
	4 Jan 1974	Water temp. 33+ F. Three boxes inspected: fungus in 1 box.
	20 Jan-14 Feb 1974	Thermograph malfunctioned; no temp. data. Water temp. probably c. 32 F.
	28 Mar 1974	Water temp. 32 F. 2 boxes inspected: one -- 5% eggs viable; other -- 0 eggs viable, and fungus.
	10 Apr 1974	Water temp. 45 F. 5 boxes inspected: 4 -- 0 eggs viable; 1 -- 5% eggs viable.

*No viable fry were found during the study period inspections in Creek 32-9 or Spring Creek; a very few were found in Creek 31-16 and the Wolf River.

APPENDIX B. Form used to give box number(s) and locations and describe sites of Vibert box implants. (Example)

BOX NUMBER #1 SITE NUMBER #1 Creek 32-9 Eggs T32N R14E

SITE LOCATION: 400' from mouth

BOX PLACEMENT (draw in identifying features & box location)

use reverse side if necessary

STREAM LOCATION: ____ main channel ____ side channel X feeder stream

WATER TEMPERATURE 43 °F

CURRENT FLOW: ____ heavy X moderate ____ slow

BOTTOM TYPE: ____ hard gravel X loose gravel

____ other (specify) ____________

DEPTH: 1 feet 4 inches

REDD TYPE: ____ depression X mound

GRAVEL SOURCE: X stream bottom ____ other

Leader of Planting Crew: ____________

COMMENTS: ____________

RESULTS OF OBSERVATIONS DURING INCUBATION

1st INSPECTION: Date ____ Water Temp. ____° Obsvr. ____

Observations: ____________

2nd INSPECTION: Date ____ Water Temp. ____° Obsrv. ____

Observations: ____________

3rd INSPECTION: Date ____ Water Temp. ____° Obsrv. ____

Observations: ____________

RECOVERY

Date ____________ Number Unhatched Eggs ____________

COMMENTS: ____________

Recovery Made by: ____________

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