Study AFS 40

STATE OF ALASKA

Jay S. Hammond, Governor

Completion Report for

CRYSTAL LAKE FISH HATCHERY MODIFICATIONS

Enhancement of Sport Fish Resources
by the Fisheries Rehabilitation Enhancement
and Development Division

by

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COMPLETION REPORT

State:	ALASKA	Name:	Sport Fish Investigations of Alaska
Study No.:	AFS 40	Study Title:	CRYSTAL LAKE HATCHERY
Job No.:	AFS 40-2	Job Title:	Crystal Lake Fish Hatchery Modification - Phase II

Period Covered: February 24, 1975 to December 31, 1975.

ABSTRACT

Crystal Lake Hatchery was constructed during the period 1971 to 1973 under funding from Alaska's $3 million 1968 general obligation bond issue. Modifications to and deletions from the original construction plans were required to keep construction costs from exceeding the available funds. Ten planned concrete recirculating raceway ponds were replaced by a single, less expensive, butyl-lined earthen pond. This substitution reduced the hatchery's planned production capacity from 45,400 kilograms (100,000 pounds) of fingerlings and smolts to 27,200 kilograms (60,000 pounds).

A $500,000 general obligation bond issue was passed by Alaska voters in 1974 to reinstate the ten concrete ponds to increase Crystal Lake Hatchery salmonid production. However, inflated construction costs necessitated a request for additional federal aid funding.

Funds were obtained, and the ponds were constructed in 1975. As the ponds were pressed into service, excessive mortalities and signs of gas embolism were observed in coho, *Oncorhynchus kisutch* (Walbaum), fry and fingerlings reared in the new ponds. Saturometer tests revealed supersaturated nitrogen levels of 106%. In both the 1974 and 1975 brood years of coho, bacterial kidney disease was diagnosed.

Changes were made in the concrete pond's water supply and drainage systems. The departure from the recirculating raceway concept essentially changed these ponds to traditional "U-shaped" raceway ponds.

No gas bubble disease has been observed in any lots of 1976 brood fry or fingerlings reared in the modified ponds.

BACKGROUND

Location

Crystal Lake Hatchery is located near the Mitkof Highway, about 29 kilometers (18 miles) south of Petersburg. The site is within the Tongass National Forest and partially within the City of Petersburg power project withdrawal area. A gravel road runs from the highway to the hatchery. A timber bridge across Blind Slough is adequate for legal highway loads. The area in general is very flat, low-lying and grassy. The underlying soil is of a gravelly nature, and is only 0.3 to 1.2 meters (1 to 4 feet) below the top soil. The hatchery was located as close as possible to the Petersburg power plant in order to keep the land fill requirements at a minimum and to use the available level ground.

Water Supply

The primary source of water for the hatchery is Crystal Lake, located approximately one mile from the hatchery at approximately 396 meters (1,300 feet) elevation. Water can be obtained either from Crystal Creek or from the discharge of the City of Petersburg's hydroelectric plant, located adjacent to the hatchery.

The Petersburg power plant obtains water via penstocks and a pipeline directly from Crystal Lake. The water runs a Pelton wheel, with a tailrace discharge into Crystal Creek.

Since the Petersburg hydro-electric generator is on line virtually full-time, Crystal Lake water from the plant tailrace is available almost constantly at a rate of not less than 0.28 cms(10 cfs). The Pelton wheel has a tailwater elevation level of 10.8 meters (35.6 feet). This elevation cannot be increased and thus establishes the maximum head on the water to be used by the hatchery. The water is picked up by connecting onto the end of the tailrace discharge line to a 76.2 (30-inch) diameter pipe and diverting the flow with the 76.2 cm (30-inch) diameter supply line to the hatchery. A short surge tube prevents the tailwater from rising above the 10 meter (33 foot) level and also serves to divert excess water while simultaneously maintaining a head on the supply line. A diversion valve permits the power plant tailrace to function normally if the hatchery is shut down, or it may be used to control flows to the hatchery.

Station Construction

The State of Alaska's 3 million dollar bond issue funded the basic construction of Crystal Lake Hatchery. The purpose of the hatchery was to enhance the State's salmon resources. Planning and site selection was accomplished between 1968 and 1970. The Blind Slough near Petersburg, Alaska was selected as the hatchery site and construction was started in 1971. Due to inflation of construction costs from 1968 to 1971, several features were deleted or modified from the original hatchery design. The ten concrete recirculating raceway ponds originally planned were replaced by a less expensive and less efficient single, divided butyl-lined earthen pond. Initial phase of hatchery construction was completed in February 1973.

In fiscal year 1975, a referendum for $500,000 in general obligation bonds was approved for construction of the ten recirculating raceway concrete ponds originally planned. Cost estimates prepared and bids received still exceeded the funds available so federal aid was requested. Funding was obtained and final construction plans were advertised for bid in March 1975. The ponds were completed in October 1975.

RECOMMENDATIONS

1. To continue to investigate means of reducing supersaturated gas levels in Crystal Lake Hatchery pond water.

2. To use a straight raceway pond design in future construction at this station.

OBJECTIVES

1. To construct ten (10) Burrows' type ponds and appurtenant facilities.

TECHNIQUES

Construction

Tryck, Nyman and Hayes was awarded the contract for engineering, designing, planning and surveying. Cooper Construction Company of Anchorage was low bidder and received the construction contract. Notice to proceed was issued on May 28, 1975 and work actually began in June 1975. Bob Culross of Tryck, Nyman and Hayes was the resident project inspector. Construction cost estimates are provided in Table 1.

The project included all work necessary to complete, ready for use, ten reinforced concrete fish rearing ponds. Each pond was approximately 4.9 meters wide by 22.9 meters long by 1.2 meters deep (16 feet by 75 feet by 4 feet), including all supply and drain piping. Preliminary cost estimates were prepared and are shown in Table 1.

The first stage of construction was removal of the old butyl lining of the original earthen pond, disassembly of the wooden center dividing wall, and excavation of all related piping. This was accomplished on schedule in June 1975. The excavated bedding sand from the butyl lining was then stockpiled.

Following this, the necessary piping for pond water supply and drains was installed, pressure-tested, and covered with bedding sand. Forms for pouring the pond bottom slab were constructed in place, reinforcing steel assembled and the concrete trucked in and poured. The forms for

Table 1. Crystal Lake Fish Hatchery Rearing Ponds (Preliminary Estimate).

Item	Number	Units	Cost Per Unit	Total
Excavation	1,200	c.y.	10.00	$ 12,000
Fine Grading	20,700	s.f.	.50	10,350
Liner Removal	16,800	s.f.	.25	4,200
Pipe Removal	250	l.f.	25.00	6,250
8" Concrete Slab	15,960	s.f.	10.00	159,600
Const. Joints w/Waterstop	959	l.f.	5.00	4,795
6" Concrete Walls	1,256	l.f.	40.00	50,240
12" Concrete Walls	590	l.f.	50.00	29,500
Drain Trenches w/Screens	300	l.f.	100.00	30,000
Cutlet Structure	10	ea.	2,500.00	25,000
Nozzle Header	20	ea.	500.00	10,000
Turning Vane Assbly, (6 vane)	20	ea.	600.00	12,000
Turning Vane Assbly. (5 vane)	20	ea.	500.00	10,000
Walkways	160	l.f.	25.00	4,000
Pond Lining (Vandex)	20,110	s.f.	0.50	10,055
Feeder Assembly	10	ea.	750.00	7,500
30" PR Pipe	95	l.f.	50.00	4,750
24" PR Pipe	34	l.f.	35.00	1,190
24" PS Pipe	185	l.f.	35.00	6,475
20" PR Pipe	84	l.f.	32.00	2,688
14" PR Pipe	70	l.f.	30.00	2,100
12" PD Pipe	215	l.f.	25.00	5,375
10" PD Pipe	640	l.f.	25.00	16,000
6 " PS Pipe	20	l.f.	15.00	300
4 " PS Pipe	270	l.f.	15.00	4,050
30 X 20 Wyes or Tees	3	ea.	400.00	1,200
24 X 20 Wyes or Tees	1	ea.	400.00	400
24 X 4 Wyes or Tees	10	ea.	200.00	2,000
20 X 20 Wyes or Tees	5	ea.	300.00	1,500
12 X 12 Wyes or Tees	11	ea.	250.00	2,750
10 X 10 Wyes or Tees	10	ea.	250.00	2,500
20" 90° Ell	1	ea.	200.00	200
10" 90° Ell	10	ea.	150.00	1,500
4" Valves	20	ea.	200.00	4,000
24 X 6 Saddles	6	ea.	300.00	1,800
12" Shear Gate	10	ea.	500.00	5,000
14" Shear Gate	10	ea.	600.00	6,000
20 X 14 Reducer	10	ea.	300.00	3,000
30 X 24 Reducer	1	ea.	500.00	500
24 X 20 Reducer	1	ea.	400.00	400
				$461,168
Mobilization				60,000
5% Contingencies				26,058
Engineering Design				35,000
Resident Engineer Services				
3.5 man-months @ 4,500	= $15,750			
Per diem & Travel	= 5,000			
	$20,750			20,750
TOTAL				$602,976

the pond walls were then assembled, the required amount of reinforcing steel wired in place, and the concrete poured. Forms were left in place for about 48 hours, then removed.

Backfilling of all required areas was satisfactorily accomplished. Cylinder tests to monitor the quality of concrete were conducted on each load to monitor product uniformity and quality.

After the concrete had set, Vandex surfacing was applied as per vendors instructions. Following drying of the Vandex coating, aluminum turning vanes were bolted in place in each pond corner. The water supply nozzles were also installed at this time. Fiberglass standpipes were then installed and the pond floor drain screens bolted down. Stop logs and pond screens were set in place. The initial phase of pond construction was thereby complete.

Area cleanup and ground dressing to grade was accomplished by October 8, 1975. The Alaska Department of Fish and Game at that time accepted beneficial occupancy of the ponds. The completed project was accepted on October 17, 1975. The work was 21 days late and the contractor was assessed for damages for 16 days. The completed ponds were inspected by the U.S. Fish and Wildlife Service regional engineer on November 13, 1975 and later by the federal coordinator. The ponds were then filled with water, scrubbed down, flushed, and refilled for use.

Dissolved Gas Measurements

Dissolved gas tests were conducted by the Crystal Lake Hatchery staff, using a gas saturometer. Confirmation of results was obtained by having U.S. Geological Survey personnel conduct duplicate tests; similar checking of techniques had been done prior to this project.

Fish Pathology Examinations

Fish health examinations were conducted by personnel from the Fish Pathology Laboratory of the Alaska Department of Fish and Game in Anchorage, and by the U.S. Fish and Wildlife Service's Western Fish Disease Laboratory in Seattle, Washington.

FINDINGS

Construction Results

With the exception of leaking standpipes all systems worked correctly as designed.

Biological Results

Coho smolts, *Oncorhynchus kisutch* (Walbaum), of the 1974 brood at a size of approximately 44 fish per kilogram (20 per pound) were transferred to the ponds. At first all appeared satisfactory; however, as time progressed, mortality of the fish increased. Symptoms observed on dead fish included a mild gas embolism similar to that described by Wood (1974). Bacterial kidney disease was diagnosed in samples of fish examined by the Western Fish Disease Laboratory.

In March 1976, 1975 brood coho fry at 1984 fish per kilogram (900 per pound) were placed in the new ponds, and symptoms similar to those exhibited by the smolts soon developed. Bacterial kidney disease was confirmed in samples of coho fingerlings sent to the Alaska Department of Fish and Game Fish Pathology Laboratory in Anchorage, and to the Western Fish Disease Laboratory.

Tests for dissolved gas levels were conducted by the hatchery staff and revealed a supersaturation of dissolved nitrogen up to 106% in the pond water whereas it had only been 104% in the butyl-lined pond. These data were confirmed by tests done by U.S. Geological Survey staff (Table 2).

The problem was attributed to supersaturation of water by air in the recirculating drain system. Due to the sub-surface discharge of the pond water supply inlets, air pressure did not reach equilibrium at atmospheric level. Presumably, the height of the standpipes prevented them from carrying a full volume of water, thus air in the pipes supersatured the water which was then carried into the pond water supply system which was under pressure. Since nitrogen is the major component of air, dissolved nitrogen levels in the pond water increased.

Gas embolism has been observed by others in fry and fingerlings reared in water having supersaturated levels of dissolved nitrogen. Stroud, Gouch and Nebeker (1975) observed that gas supersaturation levels of 107% caused severe gas bubble disease (GBD) in cutthroat trout, *Salmo clarki* Richardson, fry. They also found that while juvenile steelhead, *Salmo gairdneri* Richardson, subjected to 110% nitrogen supersaturated water for up to 336 hours experienced no immediate deaths, they did exhibit external lesions on the fins, tail and opercula. Wood (1974) states that fingerling and yearling Pacific salmon subjected for prolonged periods to nitrogen supersaturation levels of 105% to 112% experienced eye damage and blindness. This conditon was found in both 1974 and 1975 broods of coho Crystal Lake Hatchery concrete ponds.

Outbreaks of bacterial kidney disease are sometimes precipitated by environmental or physiological stresses. We speculate that the stress induced by exposure to the supersaturated nitrogen levels in this instance was a likely precipitating factor in the kidney disease infection observed.

Modifications

Changes were made in the new ponds in an attempt to reduce the supersaturated nitrogen levels. Pond water inlet nozzles were changed to discharge water above the surface through a 10.2 cm (4 in.) PVC pipe. The standpipes were replaced with stop logs, and a divider wall was installed between the end of the center wall and the pond end. The main water supply system to the hatchery was modified to utilize penstock water (Crystal Lake) instead of water from Crystal Creek (see Table 2).

Table 2. Dissolved Nitrogen and Water Temperature Data in Crystal Lake Hatchery Water Intake and Concrete Rearing Ponds, March 1976 to February 1977.

Main Water Supply	1976 Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1977 Jan.	Feb.
Nitrogen Sat. (%)	103	104	104	ND	104*	104	105	101**	102	102	101***	103
Temperature (°C)	1.0	1.0	1.8	ND	5.4*	8.5	8.4	8.1	4.0	3.0	2.6	1.6

Pond Water - Concrete Ponds

Nitrogen Sat. (%)	106	106	106	ND	104*	104	105	103**	101	102	102***	102
Temperature (°C)	7.4	7.2	7.5	ND	11.0*	10.0	9.0	8.3	4.0	8.3	8.0	8.1

* U.S.G.S. data, confirmation of Crystal Lake Hatchery data.
** Modified water intake structure to use 100% tailrace water.
*** Modified concrete primary pond water inlet and drain structures.
ND = No data

The combined changes in the ponds and water intake system were effective in reducing the nitrogen supersaturation. Saturometer tests made after the changes were completed showed dissolved nitrogen levels of about 102% (Table 2).

None of the lots of 1976 brood fry and fingerlings reared in the ponds since the changes were made have shown symptoms of gas buble disease and they are responding well to general husbandry. However, dissolved nitrogen levels of 102% are near the tolerance threshold for salmonid fry, and efforts to further reduce the dissolved gas concentration must be continued.

DISCUSSION

These latest modifications changed the entire pond design and operation from the original recirculating raceway concept to a "U-shaped" raceway system. The turning vanes and 15.2 cm (6 in.) inverted channel support were removed because they provided no advantage in the altered ponds. Removal of the channel beam also removed a "death trap" for fish that would jump at the water turbulence of the nozzles, land in the channel-up area and smother. The costs involved in these modifications are presented in Table 3.

The self cleaning feature of the recirculating raceways was sacrificed in making the modifications. Instead of a continuous removal of waste material by the current in the pond, it is now necesary to vacuum the ponds periodically; a standard procedure with U-shaped race-way ponds.

Recirculating raceway style ponds work satisfactorily in some locations, but have caused various problems in others. At Crystal Lake they were unsatisfactory. The design feature wherein water is introduced beneath the surface of the ponds does not permit escape of excess gases which would allow the dissolved gas level to reach atmospheric equlibrium. Straight raceway ponds would be more appropriate for future construction at Crystal Lake Hatchery.

LITERATURE CITED

Stroud, R. K., Bouck, G. R., and Nebeker, A. V. 1975. Pathology of acute and chronic exposure of salmonid fishes to supersaturated water. Technical Paper No. 3954, Agricultural Experiment Station, Oregon State University, Corvallis, Oregon.

Wood, J. W. 1974. Diseases of Pacific salmon; their prevention and treatment. State of Washington, Department of Fisheries, Hatcheries Division, Second edition.

Table 3. Crystal Lake Hatchery Pond Modification - Materials and Costs

Materials	Function	Cost
134 lin. ft. 2" X 6" T&G	Pond drain stop logs	$ 35.00
400 lin. ft. 2" X 6"	Fish jump covers for vane supports	87.00
57 lbs aluminum flat bar	Stog log guide extension	92.00
3-1/3 hrs. shop labor	Cut & form aluminum stop log channels	77.00
48 5/16" bolts	Stop log guide anchors	5.00
Air freight	On tools from Anchorage needed to change drains	27.00
39 lbs. 1/8" aluminum sheet	Stop log drain guide channels	62.00
Concrete fasteners	Securings for stop log channel guides	49.00
2 hammer drills	Drilling holes in pond wall for anchors	160.00
2 bx. flush shells, 6 flush shell chucks, 2 handles	For securing screen frames and stop log guides	93.00
1 flush shell shank 1 shuck head	To drill holes for above	20.00
Plastic pipe, couplings, caps & cement (PVC)	Changing under water nozzles to surface flow	27.00
Drill bits, solder breaker, plastic caps	Misc. for changing water inlets	11.00
Plastic pipe, couplings, pipe caps, joint cement	Changing water inlets	27.00
10 iron plate rings	Sealing base for stand pipe drains	224.00
40 20' X 3" X 12" lumber	Pond walkway	525.00
15.5 lbs mild steel plate	Drain guide retainers	8.00
Shop labor	Make 12 aluminum drain channels	108.00
130 lbs. aluminum sheet	Material for new stoplog guides	226.00
20 aluminum channels	Center wall dividers	220.00
TOTAL		$2,083.00

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