UTILIZATION OF OFF-CHANNEL DREDGE PONDS TO INCREASE JUVENILE CHINOOK SALMON REARING HABITAT[1]

by

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Abstract. The Yankee Fork of the Salmon River, Idaho, historically supported large runs of anadromous salmonids, primarily spring chinook salmon and steelhead trout. These runs have been dramatically reduced in the last 20-25 years due to localized mining activities and the effects of downstream hydroelectric developments. The mining activities resulted in the complete rechanneling of portions of the Yankee Fork and the deposition of extensive unconsolidated dredge piles which degraded much of the rearing and spawning habitat in the Yankee Fork. Fisheries studies indicated that chinook salmon smolt production in the Yankee Fork is limited by the availability of rearing habitat, and as a result, enhancement efforts were focused on ways of increasing or improving available rearing space. The river is bordered by over 30 ponds of varying size, shapes, and depth, that are remnants of the dredging operation. Most of the dredge ponds are off-channel and have no direct surface connection with the main channel. Engineering concepts were developed that focused on connecting off-channel dredge ponds to the river thereby increasing usable rearing habitat. Four series of dredge ponds were constructed, each containing 2 to 7 ponds connected in series. Inlets and outlets to the ponds were designed to allow easy access by juvenile chinook salmon. Incorporation of these dredge ponds to the Yankee Fork has increased the rearing capacity of the Yankee Fork river by 24,000 smolts.

Additional Key Words: Oncorhynchus tshawytscha, habitat preference, supplementation, habitat enhancement

Introduction

Historically, the Yankee Fork of the Salmon River in Idaho historically supported large spawning populations of anadromous salmonids, primarily chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss). These runs have been dramatically

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reduced in the last 20-25 years due in part to localized mining activities, and downstream effects associated with hydroelectric developments.

Past dredge mining activities in the stream channel and adjacent floodplain resulted in the complete rechanneling of lower portions of the Yankee Fork and the deposition of large unconsolidated spoil piles. Such mining activities eliminated or degraded much of the rearing and spawning habitat in the lower Yankee Fork. As a result, the Yankee Fork drainage is under-utilized with respect to salmon and steelhead production. Without the replacement or enhancement of this habitat, salmon and steelhead production potential in the drainage will remain below historic levels.

The Shoshone-Bannock Indian Tribes have treaty guaranteed anadromous fishery rights outlined in the Fort Bridger Treaty of 1868 and continue to fish the Yankee Fork when excess fish are available. Through their concern for this resource, the Tribes sponsored a habitat enhancement effort in the drainage in order to develop a sustained harvestable fishery. Funding was provided by Bonneville Power Administration under the auspices of the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (Anonymous 1987).

Prior studies (Konopacky et al. 1986, Reiser and Ramey 1988, Richards and Cernera 1988) indicated that the quantity of rearing habitat was limiting to spring chinook salmon populations within the river. These studies also documented the quantity and quality of fisheries habitat throughout the drainage. Enhancement efforts were therefore focused on increasing rearing habitat for juvenile salmon.

As a result of mining, numerous dredge/settling ponds were left as isolated aquatic habitats scattered among the spoil piles. These ponds were of varying sizes, depths and location in respect to the main river channel. Most of the ponds lacked direct surface connection to the river and therefore were not utilized by chinook salmon. Data obtained from engineering and fisheries studies resulted in a plan to connect some of these ponds to the river thereby augmenting the available juvenile rearing habitat in the basin. The purpose of this paper is to describe the general methodology used in connecting the ponds to the river and document fish utilization of the pond habitat.

Study Area

The Yankee Fork River is a major tributary to the upper Salmon River and is located in Custer County, Idaho within the Challis National Forest. The Yankee Fork is a medium-gradient system which flows through narrow canyons and moderately wide valleys of lodge pole pine (Pinus contorta) and Douglas fir (Pseudotsuga menziesii) forests. The upper portion of the Yankee Fork and its major tributary, West Fork, provide excellent spawning and rearing habitat for spring chinook and steelhead trout. A 9.6-Km stretch of the lower portion of the Yankee Fork river between Jordan Creek and Polecamp Flat, flows through an area that was extensively dredge mined for gold in the 1930's and 1950's. Currently this section of river is characterized by relatively wide, straight channels dominated by boulder and cobble substrate. Channel banks are sparsely vegetated and long sections contain no riparian zones. The river is bordered by over 30 ponds of varying size, shape, and depth, that are remnants of the dredging operation (Figure 1).

Methods

Development of Ponds as Off-Channel Rearing Habitat

Both in-channel and off-channel development of additional rearing habitat were originally considered as possible options. A brief comparison between the benefits and cost of the two alternatives suggested that the development of the off-channel ponds provided the greatest benefit at the least cost (Reiser and Ramey 1987).

Aerial photographs and U.S.G.S. topographic maps of the mined area were used to aid in the selection of ponds which would be amenable to development. Four distinct series of ponds were selected. A detailed field survey of the four ponds series was performed which provided ground topography and pond water surface elevations. Numerous spot pond depth measurements were taken and combined with pond surface area in order to quantify the available habitat. Water quality samples were obtained from several of the ponds to assure that the water would provide acceptable rearing habitat for juvenile chinook. Tests were performed for dissolved oxygen, water temperature, conductivity, turbidity, and heavy metals.

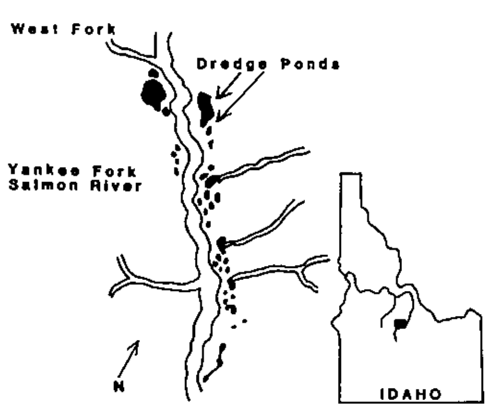

Figure 1. Location of dredge ponds along the Yankee Fork of the Salmon River.

Engineering concepts for the four pond series entailed interconnecting all ponds within each pond series with channels. Inlets and outlets for each pond series to and from the Yankee Fork River were then provided. The plan and profile of a typical pond series is shown in Figure 2. An intake structure at the upstream end of each pond series provided a means to control flow into the ponds. In addition, flow control structures, constructed of redwood, were placed at the downstream end of most ponds for water level controls. The dredge-mining left behind a highly permeable valley floor and ground water echange occurs between the ponds and the river. Consequently, the flow control structures were designed with adjustable weirs to give some flexibility in operating and adjusting the flow through the ponds. Flow control structures provided flexibility in the operation and management of the ponds. The interconnecting channels were designed to provide good rearing habitat while dissipating the necessary flow energy. The alignment, shape, and substrate of the channels were adjusted to a natural, stream-like appearance. Considerable effort was expended in the placement of boulders in the channels in order to improve the available rearing habitat and to minimize any potential migration barriers into and among the ponds. The opening of the ponds to the river created about 4 acres of pond habitat along with about 2000 feet of channel habitat.

Pond Series 1 has a total of five ponds. Due to the location of these ponds with respect to the Yankee Fork River, it was not feasible to provide an inlet to the pond series. Consequently, the ponds series outlet is the only access to and from the Yankee Fork. This pond

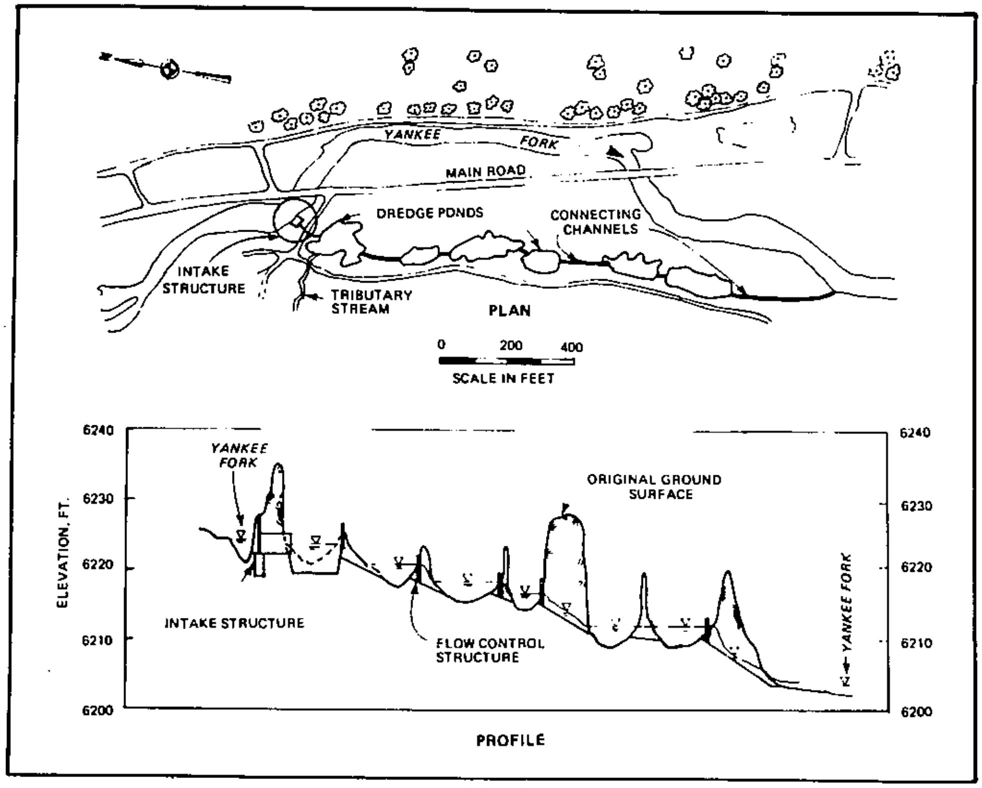

Figure 2. Plan and profile of pond series 2.

series presently relies entirely on groundwater flows for its water supply. A culvert beneath the main road connects this pond series to the Yankee Fork. A smaller pre-existing culvert was replaced to facilitate access of the juvenile salmonids to the ponds via the outlet.

Pond Series 2 has six ponds and a total length of about 485 feet. A small stream discharges directly into the uppermost pond resulting in water levels in some ponds to be about 0.6 m above the adjacent Yankee Fork level. Several Alternatives were considered for connecting the pond series to the river. The selected alternative entailed directly connecting the uppermost pond to the Yankee Fork thereby lowering pond level to river level. The pond was dredged to approximately the same depth as before the connection was made. Alternatives of connecting the ponds to a point farther upstream along the Yankee Fork were less desirable due to topography considerations and reduced accessibility by juvenile salmonids.

Pond series 3 has three ponds totaling about 545 m in length. The intake structure is located 45 m from the river which makes it less susceptible to damage during high flows. A small pool between the river and the intake structure acts as a sedimentation basin reducing the sediment load into the pond series.

Pond Series 4 also has three ponds, one of which 0.24 hectares in size. The original design concept utilized a large perforated pipe buried beneath the Yankee Fork to supply sediment-free water to the pond series. Prior to implementation, this concept was altered to a surface water withdrawal so that migrating salmonids can access the pond series through both the inlet and the outlet.

Fisheries Studies

Although juvenile salmon typically prefer relatively slow moving water associated with cover similar to that found in the ponds (Lister and Genoe 1970, Everest and Chapman 1972), the size, shape, and biological characteristics of the ponds differed from what is typically found in the mainstem Yankee Fork. The ponds were larger and with flows reduced compared to the pools and backwaters associated with the river. Available cover was primarily aquatic vegetation instead of river cobble and woody debris. Overhead cover was virtually non-existent in pond series 3 and 4. Due to these differences, pond microhabitat and fish utilization of this habitat was determined to provide a greater understanding of how best to operate and maintain the pond series. These investigations were conducted in pond series 3 and 4.

Pond shapes were traced on graph paper from 1:24,000 air photos. Available habitat types within each pond series were assessed by ground survey and delineated on the pond maps. Habitat types were based on; proximity of habitat to the bank or to open water, the depth of that habitat (<1m=shallow, 1m or >=deep) and cover availability. Cover components included; boulders, woody debris, macrophytes and algal mats. The total area of each individual habitat type was summed to determine total area per pond series. Area measurements transposed from air photos were verified by ground survey of representative pond sections.

Table 1. Habitat classification in pond series 3 and 4.

Habitat Type	Pond Series 3 Area(m^2)	%	Pond Series 4 Area(m^2)	%
Bank/Shallow/No Cover	505	15.4	349	12.3
Bank/Shallow/Cover	419	12.7	167	5.8
Open/Deep/No Cover	67	2.0	287	10.1
Open/Deep/Cover	658	20.0	1501	52.7
Open/Shallow/No Cover	349	10.6	84	3.0
Open/Shallow/Cover	656	19.9	117	4.1
Bank/Deep/Cover	167	5.1	58	2.0
Bank/Deep/No Cover	103	3.1	8	0.3
Channel/Cover	285	8.7	278	9.7
Channel/No Cover	81	2.5	0	0
*Bottom with Algae	1900	57.8	1843	64.7

*Bottom with Algae= summation of habitat types 2, 4, 6, and 7

On June 1, 1988, 27,000 and 23,000 juvenile chinook salmon were released in pond series 3 and 4, respectively. Fish habitat utilization was determined during the latter part of each month in each pond series from June through August. Fish were counted by divers equipped with snorkel and mask (habitat types 1 through 8), seineing (habitat type 11) and electrofishing (habitat types 9 and 10) (Table 1). All snorkeling and electrofishing were initiated at the downstream most section of the pond series and continued progressively upstream.

Data on fish populations were obtained by electrofishing (DC) in representative sections of channel habitat within each pond series. Block nets were set at the upper and lower ends of the area to be sampled and the area was shocked. A multiple step removal depletion method (Zippin 1958) was used to estimate abundance. In addition, seine hauls (10 x 1m, 5mm mesh leaded line) were made in representative sections of vegetated pond bottoms of known area. These areas were unsuitable for electrofishing or direct observation.

In several small shallow ponds that lacked cover, fish were counted by one person equipped with polarized lenses observing fish from the bank. In all other ponds, fish were enumerated by divers equipped with snorkel and mask. When pond widths were narrow enough to allow underwater observation of both banks from the center of the pond, one diver would approach the downstream end of the pond and slowly swim north, noting presence of fish and the habitat type in which they were seen. In wider pond segments, two divers would enter the downstream end of the pond segment and swim upstream parallel to each other in "lanes" (Platts et al. 1983). Each observer counted fish in his lane only. Lane width was dictated by underwater visibility (the maximum distance at which we could recognize an object the size of the smallest fish). Divers positioned themselves about 1m ahead of the other. This facilitated the counting of any fish that tended to move laterally. Using this technique, diver counts would include all fish present from the bank out to the center of the pond. In extremely large sections of certain ponds, after the divers moved upstream for a known distant, they would leave the bank and swim (noting fish) in a lane across the open body of water to the other side of the pond.

Results

Microhabitat Evaluation

Eleven different microhabitat types were observed and delineated (Table 1). In both pond series, benthic habitat with an algal-mat cover (habitat type 11) encompassed the largest percent of the overall pond habitat. This habitat was actually the summation of several other micro habitats (Table 1). Open deep water with cover was the predominant single habitat type found in both pond series. Open deep water with no cover was the least available habitat in pond series 3. No channel habitat without cover was found in pond series 4.

Habitat Utilization

Age 0+ chinook density estimates for ten of the eleven habitat types were lumped into 3 basic habitat groups; bank, open water or channel. Each of these

Table 2. Mean densities of juvenile chinook salmon in pond series 3 and 4.

Habitat Type	Cover Present	fish/m²	SD	n
Bank	No	0.14	0.36	35
	Yes	0.18	0.43	27
Open Water	No	0.12	0.36	21
	Yes	0.31	2.90	59
Channel	No	0.0	0.0	3
	Yes	6.26	6.30	10

habitat types was further divided into those with and without cover. Sampling periods and pond series were combined in order to observe general trends.

Initial densities of juvenile chinook salmon were 0.12 fish/m^2 and 0.11 fish/m^2 in pond series 3 and 4, respectively. Fish however, did not disperse evenly throughout the ponds. In general, throughout the course of the summer, densities were greater in all habitat types when cover was available (ANOVA, $p<0.05$). Densities ranged from 0.12 fish/m^2 in open water that did not have cover to 6.26 fish/m^2 in channel habitat with cover (Table 2).

Total abundance of fish in each of the six habitat types was estimated by extrapolating mean density on the total area of the habitat. These values (expressed as percent of total) were then compared with habitat availability to determine if distinct habitat preferences existed (Figure 3). A definite preference was noted for channel habitat in and between the ponds in both pond series. Even though this habitat represented a relatively small portion of available habitat, a large portion of the total number of fish were found there. No other distinct preferences were observed. Fish appeared to avoid shallow water without cover in both pond series since the proportion found in this habitat was considerably smaller than the proportion of habitat available.

In both pond series 3 and 4, open water with and without cover comprised the largest percent (>55%) of the overall pond habitat. In pond series 3, this habitat was utilized by a correspondingly large percent (>50%) of the juvenile chinook. In pond series 4, however, open water habitats were utilized by less than 15% of the total number of fish. This would indicate some avoidance of open water habitat in pond series 4. The reason for this avoidance in pond series 4 may be related to the large size and depth of habitat available in the series. Most habitat in pond series 4 is located in one large deep pond. Pond series 3 has a larger number of smaller ponds.

Discussion

The addition of the pond habitat to the mainstem Yankee Fork River was an effective means of adding considerable rearing habitat for chinook salmon. Over 4 acres of habitat suitable for juvenile chinook was added by connecting ponds to the river through the excavation of channels and construction of check structures to control surface flows.

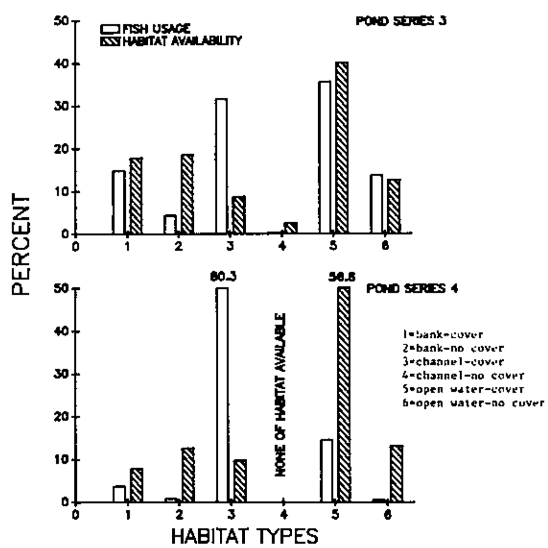

Figure 3. Habitat availability and fish habitat preference in pond series 3 and 4.

Fish distributions in the ponds during the summer of 1988 indicated juveniles would use available habitat although some preference was demonstrated for specific microhabitats within the ponds. The strong preference indicated for channel habitat may be due to rearing history of the fish in the hatchery. The fish were reared at high density in flow-through concrete channels that were most similar to channel habitat in the ponds. Habitat selection by these fish may have been somewhat different than their wild counterparts.

Since microhabitats with cover available in the form of woody debris, boulders and algae were preferred over similar habitat without cover, the ponds could be improved through the addition of cover. Small cedar or other available cut trees and branches could be placed in shoreline areas of the ponds to increase suitability for juvenile habitat. Addition of physical cover might also increase the quality of habitat in deep water areas.

The use of check structures at strategic locations in the pond series allows for alternative fish management strategies. Although the ponds were designed to provide easy access and full utilization by natural spawning populations of chinook salmon in the Yankee Fork, they may also be used as stocking points for hatchery releases of fingerlings. Large reductions in population size are often observed immediately following stream releases of chinook salmon (Richards and Cernera 1988). Pond habitat may provide a more suitable habitat for release of hatchery-reared fingerlings than more typical stream habitat. With relatively minor modifications, the ponds could also be adapted for use as low-tech rearing facilities (Reiser and Ramey 1988). Automatic feeding stations could be added to some of the ponds and movement of fish between ponds could be controlled with barriers so that much higher densities of juveniles could be reared than is possible through natural production.

Use of the off-channel dredge ponds for juvenile chinook rearing habitat provides a variety of fisheries management options in the drainage. Although riparian and other stream habitat lost during mining activities will never be fully replaced, the additional rearing habitat can provide partial compensation for this loss in relation to fish production.

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