Newcomb

DEVELOPMENT OF A NONTRAVELING (BAR SCREEN) FISH GUIDING DEVICE

Contract Nos. DACW57-79-F-0163
and DACW57-79-F0274

SUMMARY REPORT

by

Clifford W. Long
Richard F. Krcma
Michael H. Gessel
Timothy W. Newcomb

NOAA
National Marine Fisheries Service
Northwest and Alaska Fisheries Center
Coastal Zone and Estuarine Studies Division
2725 Montlake Boulevard East
Seattle, Washington 98112

November 1979

INTRODUCTION

In 1979, the National Marine Fisheries Service (NMFS) continued development of the bar screen (BS) fish-guiding device in the turbine intakes at McNary Dam. The objectives were as follows: (1) complete tests to define the best bar-screen design and method of deployment, and (2) compare the fish-guiding efficiency (FGE) of the bar screen with that of the submersible traveling screen (STS). This report summarizes the results of the study to date.

FIELD CONDITIONS AND EQUIPMENT DESIGN AND DEPLOYMENT

Bar screens were deployed within intake A, B, and C, of Turbine Five at McNary Dam. Ambient velocities at maximum turbine load within these intakes are 6.2 fps in Intake A, 5.8 fps in Intake B, and 3.6 fps in Intake C.

Each intake was equipped with a bar screen scoop that guided fish into the gatewell. In addition, a bar screen deflector affixed to the trash racks guided deeper fish up into those flows intercepted by the scoop.

Three sets of bar screens (one set equals one scoop and one deflector) were deployed at once. The sets differed in porosity, wire (bar) width, and interspace between bars. The bar screens having a 35% porosity had a bar width of 0.090 inch and an interspace of 0.050 inch; 52% porosity screens had a bar width of 0.075 inch and an interspace of 0.083 inch; and 62% porosity screens had a bar width of 0.074 inch and an interspace of 0.125 inch.

Tests were conducted in which the face of the scoop was set at an angle to the approaching flow of either 60, 50, 40, 30, or 20°. In tests where the deflector also was used, angles-to-flow of 40, 30, or 20° were employed. The deflector and scoop were always set so they overlapped from 1 to 5 feet; i.e., so that deflector was sure to guide fish up into flows intercepted by the scoop.

RESULTS

BAR SCREEN DESIGN

1. Tests in 1978 with a 35% porous scoop and deflector showed that overlapping the devices by only 4 feet caused a significant reduction in FGE indicating a severe disruption of flow. Tests in 1979 showed that the screens having 52 and 62% porosity had consistently higher FGEs than those having a 35% porosity. In addition, the higher porosity scoops and deflectors could be overlapped by as much as 5 feet without a reduction in FGE.

2. Screens having an interspace of 0.125 inch, gilled excessive numbers of small salmonids and ammocoetes. However, an interspace of 0.083 inch only caused gilling in intakes having the highest water velocities, and then primarily only at the terminal 2 feet of the scoop. An interspace of 0.050 inch (35% porosity) showed no evidence of gilling. We speculate that reducing the interspace of the 52% screen from 0.083 to 0.070 inch may eliminate gilling. By using the same wire size, porosity will be reduced only 4%; i.e., from 52 to 48%, and FGE will probably not be affected.

SCREEN DEPLOYMENT

A. For fish >70 mm in length.

1. Where the angle between the screen face and flow direction (angle-to-flow) exceeded 45°, excessive impingement was experienced. At shallower angles-to-flow, the percentage of fish intercepted by the scoop alone is significantly fewer than desired. We concluded, therefore, that both the scoop and deflector will be required to guide the desired percentage of fish at McNaryd Dam.

2. Escapement of fish through the 6-inch gap at the terminal end of the scoop was reduced to 3% or less (all species considered) by employing a gap deflector and by raising the scoop to the standard elevation. Even closing the gap completely to eliminate escapement proved feasible in that FGE was not impaired, and the rate of accumulation of debris on the scoop was not increased.

3. Best FGE was obtained when the scoop (52% porosity) and deflector (62% porosity) were used together with a 2-foot overlap. With this deployment, FGE for steelhead and chinook salmon was equal to that obtained with the STS. The bar screen guided significantly fewer sockeye, however, than the STS (Table 1).

4. Incidence of descaled fish (all species) was low for fish guided by either the bar screen or the STS, and the descaling was not significantly higher than for fish entering gatewells volitionally.

5. Chinook salmon guided by either the bar screen or the STS were not significantly fatigued by comparison with chinook salmon entering gatewells volitionally.

Table 1.--Fish-guiding efficiency of submersible traveling screens (STS) and bar screens (BS) using 52% porous scoop and 62% porous deflector deployed with 2-foot overlays of scoop and deflector. Test fish were 70 mm in length.

Guiding device	Chinook salmon (%)	Steelhead (%)	Sockeye salmon (%)
STS	71	68	55
BS	71	64	32

B. For fish <70 mm in length.

1. Fish ranging from 35 to 70 mm in length (present from mid-May to 10 June) were impinging in significant numbers on the bar screen during routine tests.

2. Impingement was eliminated by reducing the swimming speed required of fish to prevent impingement according to vector analysis. The angle-to-flow for a given water velocity had to be matched to the fish's estimated swimming ability. In six tests replicated from 3 to 5 times each, an average impingement of 19% was experienced under conditions where the minimum swimming speed required to avoid impingement was 1.74 fps. It was reduced to 1 to 6% impingement where swimming speed required was 1.1 to 1.4 fps. It was further reduced to 0% impingement where the swimming speed required was 0.8 fps (Table 2).

Table 2.--Observed impingement of fish 70 mm in length for various combinations of estimated water velocities and guiding angles.

Test no.	Water velocity (fps)	Guiding angle (degrees)	Required swimming velocity[a/] (fps)	Observed impingement (%)
1	3.2	30	1.74	19.0
2	2.5	30	1.36	5.0
3	2.2	30	1.2	1.0
4	2.2	30	1.2	1.0
5	2.0	30	1.1	6.0
6	2.0	20	0.78[b/]	0.0

a/ Swimming velocities given are calculated minimums required if fish are to avoid impingement.

b/ Information in the literature shows that chinook salmon from 35 to 45 mm in length have a sustained swimming speed of 0.6 fps; burst speed is estimated to be 2.0 to 2.2 times sustained swimming speed.

CONCLUSIONS

1. Two separate bar screens (a scoop and a deflector) are required at McNary Dam to obtain a FGE equal to that of the STS.

2. The bar screens employed should have an approximate porosity of 52% and interspaces (clearance between the bars) of less than 0.083 inch to eliminate gilling of small fish and lamprey ammocoetes. The largest allowable interspace that does not cause such gilling has not been precisely determined. However, we believe that an interspace of 0.070 inch may suffice.

3. To avoid impingement of small salmonids (35-40 mm in length), vector analysis appears to be a satisfactory method of adjusting screen angle-to-flow in accordance with the velocity of the water approaching the screen. Research underway in the Pasco Laboratory, however, will aid in verifying this concluison.

RESEARCH IN PROGRESS

The swimming speed required at the bar screen can be reduced by either reducing the guiding angle of the screen or reducing its porosity. Reducing the guiding angle causes fewer fish to be intercepted. However, reducing the porosity of the screen (within limits) reduces the water velocity but does not require the guiding angle to be decreased. Further studies on reducing the velocities of the screen are being completed in the oval flume at the Pasco Biological Field Station where precision can be obtained in setting experimental parameters and making measurements and observations.

Detailed analyses of the complete data are underway. The final results will be included in our final report.