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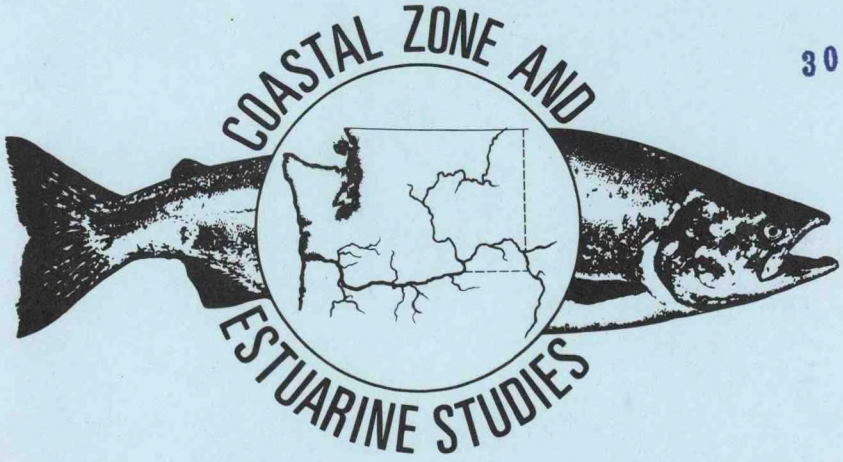

EFFECTS OF THE INTERMITTENT OPERATION OF SUBMERSIBLE TRAVELING SCREENS ON JUVENILE SALMONIDS, 1982

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INTRODUCTION

Recently there has been concern by the U.S. Army Corps of Engineers (CofE) that submersible traveling screens (STS), which are used to guide migrating juvenile Pacific salmon and steelhead out of turbine intakes, are wearing out sooner than anticipated. Screen repairs are not only costly, but can also result in a loss of fish collection if a breakdown occurs during the fingerling migration. Presently STSs are operated continuously during the downstream migration of juvenile salmonids, with the time period ranging from about 4 months at the Snake River collector dams to as much as 9 months at the Columbia River dams. The life of STSs could be extended considerably if they were operated intermittently. Intermittent operation would produce a substantial savings in material and labor costs and also result in a more dependable fish collection system.

In the spring and summer of 1982, the National Marine Fisheries Service (NMFS) sought to determine if intermittent operation of STSs would adversely affect migrating juvenile salmonids at Lower Granite and McNary Dams. Specifically NMFS wanted to determine the following: (1) was there an increase in the impingement of fish on the STS during the nontraveling portion of the intermittent cycle, (2) were there increases in descaling and stress during the intermittent operation, and (3) was the fish guiding efficiency (FGE) of the STS reduced during intermittent operation (McNary Dam).

Studies were done at the two dams because conditions are different. For example, at Lower Granite Dam, intake velocities are nearly 7 ft/s, whereas at McNary Dam they are about 5 ft/s. Also, large numbers of subyearling fall chinook salmon migrate through McNary Dam, but fewer subyearlings move through Lower Granite Dam.

PROCEDURES

Target species for the tests were subyearling chinook salmon, yearling chinook salmon, and yearling plus steelhead. The testing program was divided into four phases to cover the smolt migrations at Lower Granite and McNary Dams:

Phase I--tests with yearling chinook salmon and steelhead at Lower Granite Dam during April.

Phase II--tests with yearling chinook salmon and steelhead at McNary Dam in May.

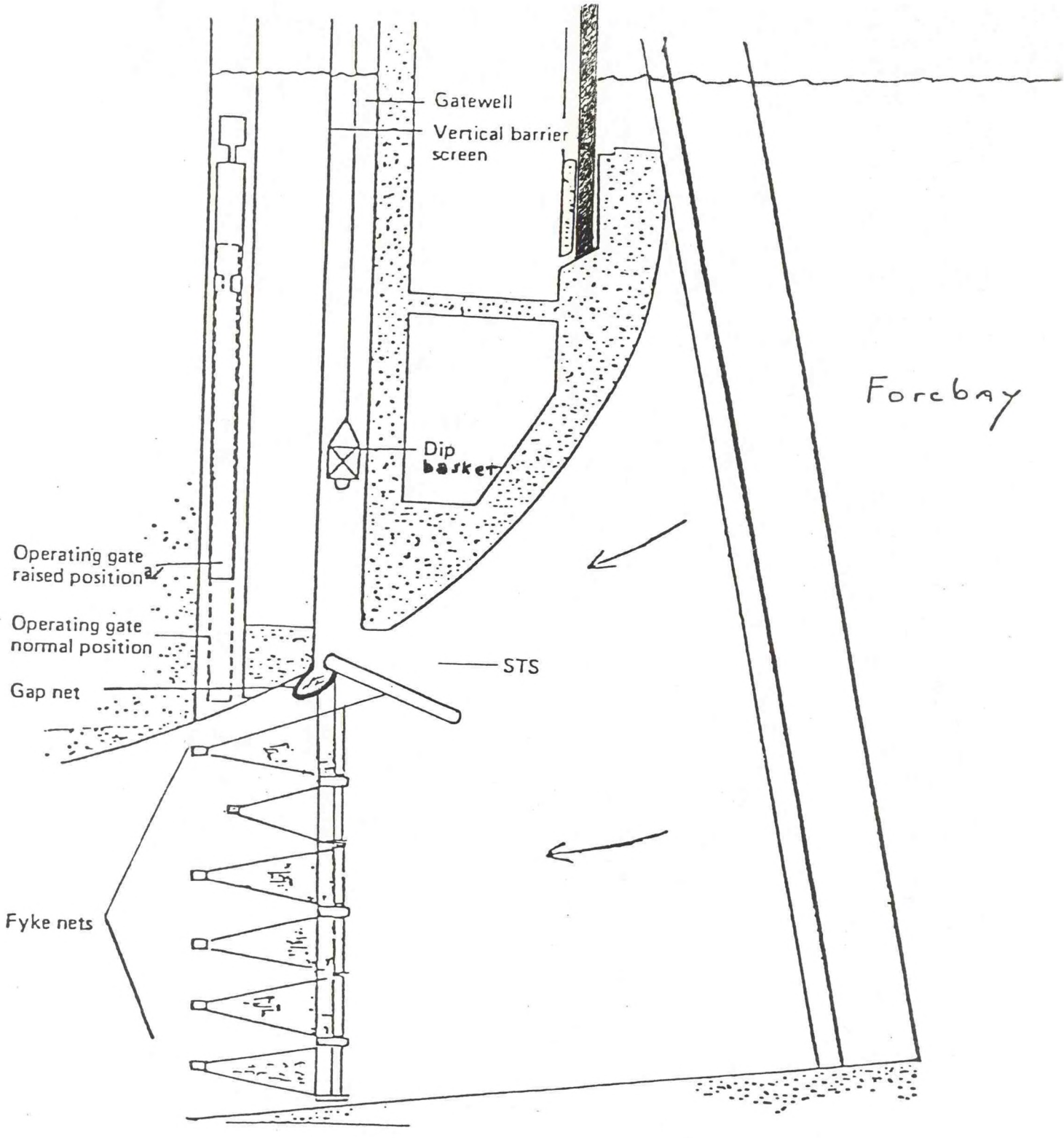
Phase III--tests with subyearling chinook salmon at Lower Granite Dam in June.

Phase IV--tests with subyearling chinook salmon at McNary Dam during late June and July.

Turbine loadings were 135 megawatts (peak efficiency) and 80 $\pm$ 5 megawatts for the tests at Lower Granite Dam and McNary Dam, respectively.

Gap Loss

A gap net attached to the top of the STS (Figure 1) was used to determine if fish impingement increased during intermittent operation of the STS. The gap net was secured to a hinged frame attached to the top and back side of the STS and was raised into a fishing position with a cable. When the net was raised, the gap between the top of the STS and the concrete beam directly beneath the vertical barrier screen was closed off. As the mesh of the STS traveled over the top roller during the travel cycle, fish and debris impinged on the mesh were washed off and into the



a/ Simulated John Day Dam condition.

Figure 1.--Cross section of a turbine intake at McNary Dam, showing a submersible traveling screen (STS) and sampling nets. The basic design of the turbine intake at Lower Granite Dam is similar to McNary's, although there are some definite structural differences.

gap net. All fish collected in the gap net, however, were not necessarily impinged fish. Fish could also be caught that were carried through the gap by the water current or perhaps on their own volition.

The percentage of fish collected in the gap net was determined by comparing the gap net catch to the gatewell catch for an intermittent (test) or continuous (normal) operating condition. It was assumed that increased impingement would be manifested by a significantly higher gap net catch.

To begin a test, we closed the gatewell orifice(s) and removed all the fish from the gatewell using a dip basket (Swan et al. 1979). The gap net was then raised into the fishing position and the test started. During the test, we dipped fish out of the gatewell periodically to determine if sufficient numbers of fish were accumulated for statistical significance. To terminate a test, the turbine was shut down, and all remaining fish were removed from the gatewell. The STS was then brought to the surface, and the fish were removed from the gap net.

The intermittent operation of the screen was controlled by an automatic timer. The travel time during the on portion of the cycle was set at 1.5 min. This resulted in the screen mesh traveling about 1.25 revolutions during each on cycle. To some extent, this exposed a different section of the screen to the flow during the off portion of each cycle.

During Phase I (Lower Granite yearling chinook salmon and steelhead tests), three screen operating modes were tested: (1) 20 min off, (2) 30 min off, and (3) normal operation (control condition). In the Phase II tests (McNary yearling chinook salmon and steelhead), the cycling modes were: (1) 20 min off, (2) 5 h off and (3) normal operation. Varying

the off periods was done to determine if differences in gap net catch or fish quality could be detected.

The cycling modes for test Phases III and IV (subyearling chinook salmon tests) were: (1) 20 min off, (2) 4 h off, and (3) normal operation. These tests were conducted similarly to the Phase I and II tests except for the 4-h off test. For this mode, the gap net was not raised at the start of the test but at the conclusion of the test just prior to starting up the screen. In this manner, any fish impinged on the mesh of the STS would have remained in place until the screen was turned on. The gap net catch therefore, reflected primarily only impinged fish.

The length of each time cycling test and the accompanying control was approximately 4 to 6 h when yearling chinook salmon and steelhead were the target species. When subyearling chinook salmon was the target species, the length of the test was 4 to 5 h at Lower Granite Dam and usually 2 to 3 h at McNary Dam. The shorter tests at McNary Dam were conducted in an attempt to preclude excessive collections of subyearlings and debris in the fyke nets (see Guiding Efficiency).

An underwater television camera was scheduled for use to record impingement and debris conditions at Lower Granite Dam. However, turbid water limited visibility and made it impractical to use the camera in 1982.

Descaling

A subsample of juvenile salmonids collected from the gatewell was checked for descaling. Normally during a test, at least 100 juveniles of each target species were checked for descaling unless the catches were too

small. A fish was considered descaled if it was missing approximately 10% or more of its scales.

Stress Assessment

To determine if test fish were more stressed than control fish, we subjected subsamples of juvenile chinook salmon to seawater challenge tests. The seawater challenge test is a type of stress test that enables one to compare stress differences between test and control fish. If a fish is highly stressed, then its likelihood of dying in the seawater is greatly increased over a less stressed fish. A typical seawater challenge test consisted of holding a group of 20 to 30 fish in a 10-gal aquarium, which contained seawater (30°/oo), for 48 h. Mortalities were counted at the end of 24 and 48 h.

Guiding Efficiency

During an off period if significant amounts of debris accumulated on the STS it is conceivable that an increased percentage of the fish could be deflected under the STS resulting in a lower fish guiding efficiency (FGE). To assess changes in FGE in relation to time cycling, an STS equipped with fyke nets was used. These tests were conduced in conjunction with other ongoing STS studies.[1/] The FGE for an STS during time cycling was compared to the FGE of a continuously operating STS.

Time cycling FGE tests were only done with subyearling chinook salmon at McNary dam during Phase IV testing. Subyearlings, which are smaller,

[1/] Details of FGE test procedures are described in: "Research at McNary Dam to Develop and Implement a Fingerling Protection System for John Day Dam," by Richard F. Krcma and Michael H. Gessel NMFS, Preliminary Report to U.S. Army Corps of Engineers, Contract DACW57-82-F-0373. September 1982.

weaker swimmers, and somewhat less concentrated near the ceiling of the turbine intake than yearling salmonids, would probably have a greater tendency to be deflected under an STS that had become plugged with debris.

Debris Monitoring

Debris conditions can vary considerably due to river conditions, time of year, and location. To determine if any dramatic changes in the effectiveness of the STSs occurred during a test phase, the debris collected from the gap net was quantified.

Debris was categorized into two classifications, large or small. Large debris consisted of tree branches, long sticks, large pieces of bark, etc. In general, it was debris greater than 1 foot in length. This material was quantified as numbers of individual pieces collected during a test. Small debris was mostly aquatic vegetation, leaves, small twigs, wood chips, etc. This material was placed into a container and quantified by volume (cubic feet) for each test.

Data Analysis

Gap net catches were evaluated by comparing percent gap net catches for the tests and controls.

$$\text{Percent gap net catch} = \frac{\text{gap net catch}}{\text{gap net catch + gatewell catch}} \text{ X } 100$$

For the descaling tests, the number of descaled fish was expressed as a percent of the total subsample. Likewise in the seawater challenges, the mortalities were expressed as a percent of the total subsample.

The FGE of an STS was determined using the following formula:

$$\text{FGE} = \frac{\text{gatewell catch}}{\text{total catch}} \text{ X } 100$$

The total catch consisted of the collections from the gatewell, gap net, and fyke nets.

RESULTS AND DISCUSSION

Lower Granite Fish Tests

Test results for yearling chinook salmon and steelhead indicated no higher proportional catches in the gap net when the screen was time cycled for 20 or 30 min versus normal operation (Table 1, Appendix Tables A1, A2). These data implied no increase in fish impingement on the mesh of STSs during time cycling over normal operation.

Results from the descaling research and seawater challenge tests indicated no harmful effects on yearling chinook salmon during the 20- or 30-min time cycling tests versus normal operation (Table 1).

In May and June, hatchery releases of subyearling chinook salmon were made in the Snake River system above Lower Granite Dam. Results for the Phase III time cycling tests with subyearling chinook salmon were inconclusive because sample sizes were inadequate (Appendix Table A3). Descaling of subyearling chinook salmon was minimal--ranging from 0.0 to 2.6% with a mean of 0.7% for four time cycling test replicates.

McNary Fish Tests

Tests at McNary Dam showed no increased gap catch, descaling, or mortality during seawater challenge for yearling chinook salmon during intermittent operation of the STS (Table 2 and Appendix Table A4). The same was true for steelhead, except steelhead were not included in seawater challenge testing (Table 2 and Appendix Table A5).

Table 1.--Results of time cycling tests for traveling screens at Lower Granite Dam, April 1982.

Species	Traveling screen status	Average gap net catch a/ (%)	Average descaling a/ (%)	Average mortality in seawater challenges a/ b/ (%)
Chinook salmon (Primarily yearling)	20 min off	9.1 (3)	3.5 (4)	3.8 (8)
Chinook salmon (Primarily yearling)	30 min off	12.6 (2)	2.5 (3)	7.2 (6)
Chinook salmon (Primarily yearling)	Control (normal operation)	12.6 (3)	3.9 (3)	7.2 (6)
Steelhead	20 min off	4.9 (3)	2.5 (4)	
Steelhead	30 min off	2.7 (2)	1.3 (3)	
Steelhead	Control (normal operation)	8.0 (3)	3.2 (3)	

a/ Number of replicates shown in parenthesis.

b/ Chinook salmon only.

Table 2.--Results of traveling screen time cycling tests with yearling chinook salmon and steelhead at McNary Dam, May 1982.

Species	Traveling screen status	Average gap net catch [a] (%)	Average descaling [a] (%)	Average mortality in seawater challenges [a] [b] (%)
Chinook salmon (yearlings)	20 min off	5.6 (3)	5.9 (4)	4.1 (8)
Chinook salmon (yearlings)	$\geq$ 5 h off	3.8 (3)	7.9 (3)	4.7 (5)
Chinook salmon (yearlings)	Control (normal operation)	7.3 (3)	7.5 (3)	5.4 (6)
Steelhead	20 min off	5.4 (3)	9.4 (4)	
Steelhead	> 5 h off	5.9 (3)	8.5 (3)	
Steelhead	Control (normal operation)	8.1 (3)	10.6 (3)	

[a] Number of replicates shown in parenthesis.

[b] Chinook salmon only.

For subyearling chinook salmon, the mean proportional catch in the gap net was higher during intermittent operation than normal operation (Table 3 and Appendix Table A6). During the first experiment (one test and one control), there was a significantly higher gap net catch during the intermittent mode than during normal operation (chi-square test, 1 df, $P<0.05$). In the second and third experiments, there were no significant differences during the two screen operating conditions ($P>0.10$). The first experiment was conducted in late June when the mean fork length of the subyearlings was approximately 75 mm. During the subsequent experiments, which were done in late July, the mean length was approximately 100 mm. The smaller subyearlings were probably more vulnerable to impingement than the larger subyearlings, which could have been responsible for the significant increase in the proportional gap net catch during the first experiment.

Results from the 4-h impingement tests, designed to collect only impinged fish, indicated a small percentage of subyearling chinook salmon were being impinged when the STS was off (Table 3). Although only a small percentage of fish (1.3%) were involved, a large number of subyearlings could be impinged on STSs considering that there are 42 STSs at McNary Dam and millons of subyearlings are entering the turbine intakes.

A percentage of the subyearlings impinged during normal operation could theoretically survive if they escaped off the mesh and entered the gatewell or were carried through the gap. However, survival of the latter group would be impacted due to turbine mortality.

During time cycling operation, the number of impinged fish that could survive would be very small, especially for those that became impinged early in the off segment of the cycling mode.

Table 3.--Results of traveling screen time cycling tests with subyearling fall chinook salmon at McNary Dam, June and July 1982.

Traveling screen status	Average gap net catch[a] (%)	Average descaling[a] (%)	Average fish guiding efficiency[a] (%)
20 min off	3.0 (3)	2.7 (4)	62.0 (4)
>4 h off	1.7 (3)[b]	4.4 (3)	--
Control (normal operation)	1.7 (4)	3.1 (4)	54.2 (4)

[a] Number of replicates shown in parenthesis.

[b] Gap net raised only at conclusion of test; theoretically collected only fish impinged on STS.

Subyearlings impinged near the end of the off cycle would of course, have a greater likelihood of survival. Prentice and Ossiander (1974) observed that when spring chinook salmon fry (buttoned-up) were impinged for 3 min at an approach velocity of 3 ft/s, they displayed oxygen stress and internal hemorrhaging; their survival rate was 97.3% after being held for 48 h. After 6 min of impingement there was a loss of equilibrium and increased oxygen stress in some fry, however, the survival rate after being held for 48 h was also 97.3%. Subyearling chinook salmon migrating through McNary Dam are considerably larger than buttoned-up fry, but they may be encountering approach velocities greater than 3 ft/s.

Presently, we are unable to say exactly how long subyearling chinook salmon can be impinged on an STS at McNary Dam without suffering acute or chronic damage. Safe impingement time could be determined experimentally by subjecting subyearling chinook salmon smolts to impingement velocities similar to those encountered on the mesh of the STS.

Intermittent operation of the STS (20 min off) appeared to slightly improve FGE with subyearling fall chinook salmon (Table 3). However, because of considerable variability among the replicates, no statistically significant differences could be measured between the FGE during intermittent and normal operations (Appendix Table A6). Based on these results with subyearlings, it is reasonable to assume that intermittent operation of the STS would not deleteriously impact the STSs fish guiding ability with yearling (or older) salmonids migrating past McNary Dam.

Debris Appraisal

The amount of debris collected in the gap nets at Lower Granite and

McNary Dams during time cycling tests was relatively small. Large debris collected at Lower Granite (15 April to 9 June) averaged 2.2 pieces/h (Appendix Table A7). During tests at McNary Dam (5 May to 24 July), it averaged only 1.1 piece/h (Appendix Table A8). Small debris averaged 0.16 ft^3/h at Lower Granite Dam and 0.09ft^3/h at McNary Dam. It would appear that if FGEs were to be adversely affected by debris, it would probably be by small debris accumulating on the mesh during the off period rather than the large debris.

The largest collection of small debris occurred during the normal screen operating mode at McNary Dam during 27 June to 23 July. The combined length of the three replicates of this test totaled 6.7 h, during which time 2.29 ft^3 of small debris was collected for an average amount of 0.34 ft^3/h. If an off time of 20 min had been the cycling mode, only about 1/3 of this amount or 0.11 ft^3 of small debris would have accumulated on the mesh. If this amount of debris were evenly distributed over the total cross sectional area of the mesh, it would amount to only about 0.004 inch depth or 0.576 $inch^3/h$ of debris per square foot of screen surface.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Intermittent operation of traveling screens at Lower Granite and McNary Dams did not increase impingement rates for yearling chinook salmon and steelhead. Descaling rates and mortalities in seawater challenge tests (chinook salmon) were no higher during intermittent operation than during normal operation.

2. At McNary Dam, a small percentage (at least 1.7%) of subyearling chinook salmon were impinged on the STS while it was off. Although the percentage of fish impinged was small, the total number of fish impacted could be significant, considering there are 42 STSs at McNary Dam and millions of fall chinook salmon enter the turbine intakes.

3. For subyearling chinook salmon, intermittent operation of the STSs at McNary Dam did not increase descaling rates, however, the average gap net catch (indicating impingement) did increase slightly during intermittent operation (from 1.7 to 3.0%).

4. Debris accumulation on the mesh during off periods was minimal during the time periods tested. The average amount of small size debris estimated to cover the screen mesh during a 20 min off period of a cycling mode at McNary dam was only 0.576 $inch^3/h$ per square foot of screen surface.

Recommendations

1. Conservatively, STSs could be operated intermittently--15 min off and at least 1.5 min on--at Lower Granite and McNary Dams during the early spring when juvenile steelhead and yearling chinook salmon are migrating. Although we observed no increases in gap net catches, descaling rates, or mortalities in seawater challenge tests when the STS was turned off for longer than 15 min, we feel the screens should not be left off longer than 15 min. The amount of debris in the water changes frequently and therefore to prevent a potential build-up of debris on the STS it is probably best to cycle them about every 15 min.

A final recommendation would be contingent upon future research (included in research proposed for Lower Granite Dam in 1983) to definitely determine that impingement is not occurring on the STS. If impingement is occurring, then the amount of off time may have to be reduced.

2. During subyearling chinook salmon migrations at Lower Granite and McNary Dams, we would recommend only a 3 min off cycle. The reduced off time is needed to protect fish impinging on the STS. It may even be advisable to operate the STSs continuously from 2000 to 2400 h when many fish are moving through the dam. Impingement of subyearling chinook salmon occurred at McNary Dam and probably also occurs at Lower Granite Dam, where intake velocities are greater than those at McNary Dam.

3) To determine safe impingement times on an STS, it would be useful to conduct a laboratory study utilizing yearling and subyearling chinook salmon smolts. Various impingement velocities, i.e., those encountered at Lower Granite and McNary Dams, could be tested. These results could possibly lead to a lengthening of the off time for an STS, particularly for subyearlings.

4) Intermittent operation of the STSs must be monitored to ensure that the screens are operating properly. Perhaps a recording strip tape that shows time and amperage could be used in the monitoring effort.

ACNOWLEDGEMENTS

We wish to thank Messrs. Gene Matthews and Thomas Ruehle and their staffs for doing the seawater challenge tests. NMFS personnel from the Pasco and Clarkston, Washington, field stations aided immensely in the completion of the research. Finally, we wish to thank the U.S. Army Corps of Engineers personnel at Lower Granite and McNary Dams for their outstanding cooperation.

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APPENDIX A

APPENDIX TABLES A1-A8

Appendix Table A1.--Catches of juvenile chinook salmon (primarily yearlings), descaling rates, and seawater challenge mortalities during time cycling tests at Lower Granite Dam in April 1982.

Traveling screen status	Dates of tests	Gap net catch (No.)	Gatewell catch (No.)	Total catch (No.)	Percent descaling [a]	Percent mortality in seawater challenges [a] [b]
20 min off	4/15	39	340	379	3.8 (106)	0.0 (23), 0.0 (11)
20 min off	4/16	38[c]	334	372	1.8 (110)	0.0 (26), 5.5 (18)
20 min off	4/17	8	288	296	4.7 (106)	3.6 (28), 12.0 (25)
20 min off	4/20	37	224	261	3.8 (105)	5.9 (34), 3.7 (27)
30 min off	4/22	60	413	473	4.0 (100)	20.0 (20), 11.1 (27)
30 min off	4/23	14	98	112	1.6 (64)	0.0 (14), 0.0 (19)
30 min off	4/24	15[d]	178	193	2.0 (100)	8.7 (23), 3.4 (29)
Normal operation	4/18	10	91	101	7.8 (51)	0.0 (21), 11.8 (17)
Normal operation	4/19	63	360	423	3.8 (105)	14.3 (35), 13.0 (23)
Normal operation	4/21	19	128	147	0.0 (80)	3.8 (26), 0.0 (22)

[a] Sample size shown in parenthesis.

[b] Two replicates for the seawater challenge were carried out for each test; the results of both replicates are shown.

[c] Gap net frame fell from raised position due to bracket failure.

[d] Part of gap net everted at conclusion of test.

Appendix Table A2.--Catches of juvenile steelhead and descaling rates during time cycling tests at Lower Granite Dam in April 1982.

Traveling screen status	Dates of tests	Gap net catch (No.)	Gatewell catch (No.)	Total catch (No.)	Percent descaling [a]
20 min off	4/15	86	1621	1707	1.0 (100)
20 min off	4/16	45[b]	612	657	3.0 (100)
20 min off	4/17	4	310	314	0.0 (103)
20 min off	4/20	8	86	94	6.0 (84)
30 min off	4/22	8	456	464	0.0 (100)
30 min off	4/23	14	360	374	2.0 (100)
30 min off	4/24	26[c]	881	907	2.0 (100)
Normal operation	4/18	25	215	240	3.0 (100)
Normal operation	4/19	31	391	422	5.6 (108)
Normal operation	4/21	7	106	113	1.0 (102)

a/ Sample size shown in parenthesis.

b/ Gap net frame fell from raised position due to bracket failure.

c/ Part of gap net everted at conclusion of test.

Appendix Table A3.--Catches of subyearling fall chinook salmon and descaling rates during time cycling tests at Lower Granite Dam in June 1982.

Traveling screen status	Dates of tests	Gap net catch (No.)	Gatewell catch (No.)	Total catch (No.)	Percent descaling [a/]
20 min off	6/ 7	2	17	19	0.0 (17)
20 min off	6/ 8	0	12	12	0.0 (12)
20 min off	6/ 9	6	39	45	2.6 (38)
4.9 h off [b/]	6/10	0	6	6	0.0 (6)

a/ Sample size shown in parenthesis.

b/ Gap net was raised only at conclusion of test to collect any fish impinged on STS.

Appendix Table A4.--Catches of juvenile chinook salmon (yearlings), descaling rates, and seawater challenge mortalities during time cycling tests at McNary Dam in May 1982.

Traveling screen status	Dates of tests	Gap net catch (No.)	Gatewell catch (No.)	Total catch (No.)	Percent descaling [a/]	Percent mortality in seawater challenges [a/] [b/]
20 min off	5/ 5	21	242	263	8.0 (112)	6.3 (16), 6.7 (30)
20 min off	5/ 7	11 [c/]	339	350	6.4 (110)	3.2 (31), 6.5 (31)
20 min off	5/12	11	454	465	7.1 (113)	3.3 (30), 7.1 (28)
20 min off	5/14	5	73	78	2.2 (46)	0.0 (11), 0.0 (16)
≥ 5 h off	5/17	11	208	219	5.4 (112)	3.4 (29) [d/]
≥ 5 h off	5/18	7	195	202	7.9 (114)	3.1 (32), 3.6 (28)
≥ 5 h off	5/19	8	274	282	10.5 (114)	6.1 (33), 7.4 (27)
Normal operation	5/ 6	25	260	285	4.6 (109)	15.0 (20), 11.5 (26)
Normal operation	5/11	34	641	675	8.8 (114)	2.9 (34), 3.0 (33)
Normal operation	5/13	9	101	110	9.0 (67)	0.0 (17), 0.0 (17)

a/ Sample size shown in parenthesis.

b/ Two replicates for the seawater challenge were carried out for each test; the results of both replicates are shown.

c/ Part of gap net badly torn.

d/ Only one replicate was done for this test.

Appendix Table A5.--Catches of juvenile steelhead and descaling rates during time cycling tests at McNary Dam in May 1982.

Traveling screen status	Date of tests	Gap net catch (No.)	Gatewell catch (No.)	Total catch (No.)	Percent descaling [a/]
20 min off	5/ 5	6	143	149	8.0 (113)
20 min off	5/ 7	4[b/]	267	271	10.3 (116)
20 min off	5/12	5	97	102	8.4 (95)
20 min off	5/14	4	50	54	10.9 (46)
≥ 5 h off	5/17	7	141	148	10.2 (118)
≥ 5 h off	5/18	5	61	66	9.3 (54)
≥ 5 h off	5/19	7	124	131	5.9 (118)
Normal operation	5/ 6	5	114	119	9.0 (111)
Normal operation	5/11	5	80	85	7.6 (79)
Normal operation	5/13	11	67	78	15.2 (66)

a/ Sample size shown in parenthesis.

b/ Part of gap net badly torn.

Appendix Table A6.--Catches of subyearling fall chinook salmon, descaling rates, and fish guiding efficiency rates (FGE) during time cycling tests at McNary Dam in June and July 1982.

Traveling screen status	Date of tests	Gap net catch (No.)	Gatewell catch (No.)	Fyke net catch (No.)	Expanded fyke net catch (No.) a/	Total expanded catch (No.)	Percent descaling (No.) b/	FGE (%)
20 min off	6/28	42	659	170	244	945	2.8 (107)	69.7
20 min off	7/20	25	1114	168	259	1398	5.0 (202)	79.7
20 min off	7/22	8	864	779	1092	1964	1.0 (202)	44.0
20 min off	7/24	11 c/	608	364	498	1117	2.1 (243)	54.4
> 4 h off	7/24	36 d/	981	-	-	1017	4.4 (158)	e/
> 4 h off	7/25	4 d/	264	-	-	268	4.2 (264)	e/
> 4 h off	7/26	0 d/	129	-	-	129	4.7 (129)	e/
Normal operation	6/27	8	284	95	131	423	5.4 (112)	67.1
Normal operation	7/19	4	355	386	552	911	3.8 (132)	39.0
Normal operation	7/21	2	273	290	395	670	1.5 (273)	40.7
Normal operation	7/23	17	726	200	294	1037	1.6 (184)	70.0

a/ Includes estimated fyke net catches; estimates were necessary at elevations where only a portion of the entire width of the turbine intake was sampled.
b/ Sample size shown in parenthesis.
c/ Gap net catch estimated.
d/ For three tests (>4 h off) gap net raised only at conclusion of test; theoretically collected only fish impinged on STS.
e/ No FGEs calculated during these tests.

Appendix Table A7.--Debris collected during screen cycling testing at Lower Granite Dam during 1982.

Date	Screen operating mode	Large debris		Small debris		Length of test
		No.	Pieces per h	Ft^3	Ft^3 per h	
Phase I Lower Granite Dam Tests (Yearling chinook salmon and steelhead)						
4/15/82	20 min off	15		0.77		5.6
4/16/82 a/	" " "	30		1.55		5.9
4/17/82	" " "	19		1.25		5.3
4/20/82	" " "	4		0.21		3.8
Sub total		68		3.78		15.0
Average			4.5		0.25	
4/18/82	Normal operation	6		0.22		5.9
4/19/82	" "	1		0.07		6.1
4/21/82	" "	5		0.18		5.2
Sub total		12		0.47		17.2
Average			0.7		0.03	
4/22/82	30 min off	0		0.62		5.0
4/23/82	" " "	6		0.18		4.8
4/24/82 b/	" " "	0		.00		3.9
Sub total		6		0.80		13.7
Average			0.4		0.06	
Phase III Lower Granite Dam Tests (Subyearling chinook salmon)						
6/7/82	20 min off	21		1.17		4.0
6/8/82	" " "	16		1.61		4.9
6/9/82	" " "	11		1.61		5.1
Sub total		48		4.39		14.0
Average			3.4		0.31	
Total		134		9.44		59.9
Average			2.2		0.16	

a/ Gap net not in full position for part of test.

b/ Half of gap net turned inside out at conclusion of test.

Appendix Table A8.--Debris collected during screen cycling testing at McNary Dam during 1982.

Date	Screen operating mode	Large debris: No.	Large debris: Pieces per h	Small debris: Ft^3	Small debris: Ft^3 per h	Length of test
Phase II McNary Dam Tests (Yearling chinook salmon and steelhead)						
5/5/82	20 min off	6		0.16		4.7
5/7/82 a/	" " "	1		0.07		5.4
5/12/82	" " "	5		0.07		5.1
5/14/82	" " "	2		0.14		5.2
Sub total		14		0.44		20.4
Average			0.7		0.02	
5/6/82	Normal operation	3		0.07		5.6
5/11/82	" "	5		0.07		4.7
5/13/82	" "	8		0.14		5.0
Sub total		16		0.28		15.3
Average			1.0		0.02	
Phase IV McNary Dam Tests (Subyearling chinook salmon)						
6/28/82	20 min off	0		0.54		2.9
7/20/82	" " "	0		0.07		1.6
7/22/82	" " "	4		0.79		2.0
7/24/82	" " "	4		0.41		2.5
Sub total		8		1.81		9.0
Average			0.9		0.20	
6/27/82	Normal operation	1		0.36		3.0
7/21/82	" "	5		1.14		2.3
7/23/82	" "	10		0.79		1.4
Sub total		16		2.29		6.7
Average			2.4		0.34	
Total		54		4.82		51.4
Average			1.1		0.09	

a/ Gap net badly ripped.