SELECTIVE PREDATION/DEVELOPMENT OF PREY PROTECTION 8200300

SHORT DESCRIPTION:
Assess the relative vulnerability of juvenile salmonids of varying condition to predation, the mechanisms underlying potential increases in vulnerability, and develop measures that will protect outmigrating juvenile salmonids from resident fish predators, particularly northern squawfish.

SPONSOR/CONTRACTOR: USGS-BRD
US Geological Survey, Biological Resources Division
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SUB-CONTRACTORS:
Oregon Department of Fish and Wildlife

GOALS

GENERAL:
Supports a healthy Columbia basin, Increases run sizes or populations, Adaptive management (research or M&E)

ANADROMOUS FISH:
Hydro ops, mainstem passage, construction

RESIDENT FISH:
Research, M&E

NPPC PROGRAM MEASURE:
5.6A.13, 5.7B.2 & 5.7B.23

RELATION TO MEASURE:
The project is collecting behaviorial data on northern squawfish and predation vulnerability data on juvenile salmonids in forebay and tailrace environments of Columbia River hydroelectric dams which will help evaluate potential success of surface bypass systems and improve location of juvenile fish bypass outfalls.

BIOLOGICAL OPINION ID:
NMFS BO Action Nos. 11, 14, 15, 23

OTHER PLANNING DOCUMENTS:
NMFS SRSRP - 2.3.d.3, 2.8.a.1. and Wy Kan Ush Mi Wa Kush Wit - Predator Control and Surface Bypass (pp. 5B-29)

TARGET STOCK	LIFE STAGE	MGMT CODE (see below)
LWSNFH spring chinook	Juvenile/smolt	N/A

BACKGROUND

HISTORY:
BPA has funded predation research since 1982. This project started as a cooperative effort between ODFW and the USFWS to determine the loss of outmigrating juvenile salmonids in John Day Reservoir. Results of that study indicate a loss of about 3 million juvenile salmonids to predation annually in that reservoir. Phase 1 of this study included documentation of dietary and consumption rates of four predators (northern squawfish, smallmouth bass, walleye, and channel catfish). Phase 2 of this project, which is ongoing, was research into the relative vulnerability of juvenile salmonids of varying conditions to predation. Phase 3, also ongoing, is designed to develop measures for protecting juvenile salmonids from northern squawfish predation, including development of biological criteria for design and operation of juvenile fish surface bypass systems and bypass exit design and

location.

BIOLOGICAL RESULTS ACHIEVED:

To date, a variety of results have been achieved, including: (1) documentation of dietary and consumption rates of major predators; (2) documenting the system-wide significance of the potential for predation-related mortality of juvenile salmonids; (3) documentation of selective predation on dead, descaled, physically stressed, dissolved gas exposed, BKD-infected, and naive juvenile salmonids; (4) documented the swimming performance of northern squawfish; (5) evaluated the efficacy of different hatchery release strategies; and (6) criteria for design and location of juvenile fish bypass outfalls.

PROJECT REPORTS AND PAPERS:

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Lucchetti, G. L., and G. A. Gray. 1988. A prototype water reuse system. The Progressive Fish Culturist 50: 46-49.

Mesa, M. G., S. D. Duke, and D. L. Ward. 1990. Spatial and temporal variation in proportional stock density and relative weight of smallmouth bass in a reservoir. Journal of Freshwater Ecology 5: 323-339.

Mesa, M. G., D. M. Gadomski, and T. M. Olson. 1992. The vulnerability of juvenile chinook salmon to predation by northern squawfish. Pages 173-179, in Workshop Proceedings- Passage and survival of juvenile chinook salmon migrating from the Snake River Basin. American Fisheries Society, Idaho Chapter, Moscow, Idaho.

Mesa, M. G. and T. M. Olson. 1993. Prolonged swimming performance of northern squawfish: can water velocity be used to reduce predation on juvenile salmonids at Columbia River dams? Transactions of the American Fisheries Society 122: 1104-1110.

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ADAPTIVE MANAGEMENT IMPLICATIONS:

Descriptions of the dietary habits and consumption rates of juvenile salmonids by predators in John Day Reservoir provided some of the first documentation of predation as a mortality factor and was used as baseline data for an array of future studies. Information gained from studies on selective predation has helped to assess the relative significance of predation as a mortality factor of juvenile salmonids. In addition, this information should allow managers to assess the effects of various stressors that juvenile salmonids commonly encounter and devise mitigative measures if necessary.

Research designed to protect juvenile salmonids from predation has focused on reducing the number of predator-prey encounters or reducing the frequency of successful prey captures. Such measures include fish bypass design changes, altering dam operations, altering hatchery release practices, and conditioning hatchery-reared fish to predators before release. Northern squawfish relative densities and predation indices have been high in Bonneville Dam forebay. Information collected in this study

will be used to direct the development of design criteria for surface bypass collection systems (SBSC's) at Bonneville Dam, thus reducing predator-prey encounters and problems or delays in SBCS passage.

PURPOSE AND METHODS

SPECIFIC MEASUREABLE OBJECTIVES:

1. Compare rates of return of naive vs. predator-conditioned juvenile salmonids after release from a hatchery.

2. Assess the metbolic consequences of various exogenous stressors (e.g., physical stresses, BKD, exposure to gas supersaturation) to juvenile salmonids

3. Assess the effects of turbidity and refugia on the ability of juvenile salmonids in varying states of health to avoid predation

4. Evaluate response of northern squawfish (SQF) to surface collector prototypes, project operations, and presence of juvenile salmonids in Bonneville Dam forebay
5. Use electrofishing to assess relative densities of northern squawfish, collect diet information, and verify radio telemetry and hydroacoustic results
6. Assess feasibility of increasing proportions of juvenile salmonids guided by SBCS by removing northern squawfish

CRITICAL UNCERTAINTIES:

For the SBCS research, extensive movements of radio-tagged SQF among reservoir areas and across dams may limit information obtained from relatively small release groups. Information collected in 1997 on migrational behavior will help determine the number of SQF to be released in 1998.

BIOLOGICAL NEED:

Information on selective predation will help finalize our assessment of the behavioral effects of a common juvenile salmonid condition, namely predator-naive fish. Not only will this research allow us to ascribe some ecological significance to this condition, but the information has the potential to provide justification for changes in current management practices. In addition, the information gained from this research is useful to our understanding of the significance of predation as a mortality factor on juvenile salmonids. Information on the metaboloic costs of certain stressors will allow us to explore some mechanisms that may be responsible for some of the differential predation results we have observed in our past research. In addition, evaluating the effects of turbidity and refugia on predator avoidance will provide increased ecological realism and insight into the nature of salmonid-predator interactions and behavior.
Knowledge of SQF distribution, behavior, and relative densities in Bonneville Dam forebay is critical to the design of effective SBCS structures. Evaluation of factors affecting smolt and SQF behavior in response to SBCS's has been identified as a critical component of the development process. Agencies are concerned that the presence of SQF near SBCS's may deter smolts from entering or result in increased predation.

HYPOTHESIS TO BE TESTED:

1. There is no difference in the rate of return to the hatchery of naive and predator-conditioned juvenile salmonids.
2. The metabolic costs associated with various stressors are not sufficient to explain deficits in predator avoidance ability of juvenile salmonids.
3. Turbidity and access to refugia do not influence the predator avoidance ability of juvenile salmonids.
4. Northern squawfish do not congregate near or within SBCS structures.
5. Presence of SQF near SBCS does not prevent or deter smolts from entering SBCS structures.
6. Behavior of SQF at Bonneville Dam does not vary as a function of SBCS operation, project operations, or numbers of smolts present.

ALTERNATIVE APPROACHES:

N/A

METHODS:

1. Experiments assessing the rates of return of predator-conditioned juvenile salmonids will be conducted at Little White Salmon NFH. Briefly, fish reared in three identical raceways will be subjected to predation for a time period (to be determined) prior to their release and will be classified as treatment fish. Control fish will be reared in three different raceways and will consist of normal production fish. All raceways will be filled with similar amounts of substrate and structure to provide fish with escape or hiding areas. About 65,000 fish per raceway (390,000 total) will be used. To facilitate identification of release groups, 25,000 fish per raceway will be marked with coded-wire tags. The number marked will allow a rigorous and powerful statistical evaluation of return rates. Sampling for indicators of stress (plasma cortisol), smoltification (Na+,K+-ATPase), length and weight will occur monthly during the study.

2. We will use a combination of static and swimming respirometry to assess the metabolic costs associated with various stressors. Juvenile salmonids will be obtained from local hatcheries and reared in our laboratory. After an acclimation period, groups (or individuals) will be exposed to various stressors, including multiple physical stressors, BKD infection, and exposure to gas supersaturation. Basically, we will evaluate stressors that we have studied in the past. After fish have been exposed to the stressor of interest, they will be subjected to either a static or swimming performance test in modified Blazka-type respirometers. We will monitor oxygen consumption and time to fatigue (during swimming tests) in groups of stressed and unstressed fish. Data will be used to derive and evaluate the scope for activity of fish in different states of health (i.e., the amount of energy available to carry out the daily activities of life). In addition, data will be incorporated into bioenergetic models to assess the potential effects such costs may have on fish in the wild.

3. To evaluate the effects of turbity and access to refugia, we will conduct selective predation experiments similar to those we have conducted in the past. However, we will conduct these experiments under one of three conditions: (1) in water that has turbidity matching that of the Columbia River; (2) in tanks that provide prey with access to refugia in the form of rocky substrates and/or vegetation; and (3) in tanks that have both turbid water and access to refugia. Selective predation experiments will be conducted in a large, flowing water raceway and two 4-m-diameter circular tanks. Predators (either northern squawfish or smallmouth bass) will be captured from the Columbia River, transferred to our laboratory, and maintained in either the raceway or circular tanks. Prey will be juvenile spring chinook salmon obtained from local hatcheries. Our objective is to create two prey types, depending on the experiment: treatment fish (e.g., BKD-infected or physically stressed) and control fish (i.e., unstressed). Groups of treatment and control fish will be simultaneously introduced to predators and predation allowed to proceed for a specified time. After the predation bout, survivors will be collected and enumerated. We will conduct several replicates of a predation experiment under the different tank conditions and analyze the data using a heterogeneity chi-square procedure.

4. We will use radio telemetry and Global Positioning Systems (GPS) to track SQF locations in the forebay of Bonneville Dam to evaluated their behavior in response to the presence of surface collector prototypes, emigrating smolts, and varying project operations. About 60 SQF will be captured by electrofishing and held up to 12 h prior to surgical implant of digitally-encoded radio transmitters. Fish will be released and tracked during day and night with Lotek, Inc. SRX 400 receivers using boats, aircraft, and fixed antennae from April through August. Data will be downloaded daily and GPS will be used to determine SQF locations. Electrofishing will be used to collect digestive tract samples and determine relative densities (CPUE) of SQF in Bonneville Dam forebay. We will analyze fish distribution over time using a GIS database. Proportional distribution of SQF will be compared to river discharge, smolt abundance, radio-tagged smolt locations, hydroacoustic results and project operations using multivariate and one-way ANOVA. Electrofishing data will be used to determine estimates of consumption and relative density.

PLANNED ACTIVITIES

SCHEDULE:

Implementation Phase **Start** 1998 **End** 1999 **Subcontractor**

Task 1. Continue evaluation of returns of adults to hatchery for analysis of naive/experienced training experiments
2. Construct respirometers, acquire necessary equipment, and initiate metabolic cost experiments.
3. Design methods to create turbidity, acquire necessary equipment, and initiate selective predation experiments.

PROJECT COMPLETION DATE:
2000

OUTCOMES, MONITORING AND EVALUATION

SUMMARY OF EXPECTED OUTCOMES

Contribution toward long-term goal:
The results from this project provide informatiorn to assist managers in the deveolpment of criteria for hatchery and project construction and operations to minimize losses to predators. Also, the results from this study should allow managers to better assess the potential efficacy of certain actions, such as the system-wide predator control program.

Information products:
The research on differential predation of Adult returns should provide us with further insight into the potential for training hatchery-reared fish to avoid predation, thus increasing survival. Our work on the metabolic costs of various stressors should yield some information on the underlying causes of differential predation. The information we collect on the effects of turbidity and refugia should provide a more ecologically-based perspective upon which to evaluate our past research on predator-prey interactions. Because of the unique nature of this research, we fully expect our findings to be published in peer-reviewed journals. Insufficient information on SQF behavior in Bonneville Dam forebay and effects of SBCS on predator-prey interactions exists to predict future study results.

MONITORING APPROACH

RELATIONSHIPS

RELATED NON-BPA PROJECT	RELATIONSHIP
Movement and behavior of radio-tagged juv. sal..... COE	This project is closely integrated with the Surface Bypass Program

OPPORTUNITIES FOR COOPERATION:
SBCS research is dependent upon timely issuance of Section VII ESA permits and WDFW collection permits. Collaboration is ongoing with the National Marine Fisheries Service, the Waterways Experiment Station of the COE, and the Oregon State University Cooperative Fisheries Research Unit.

COSTS AND FTE

1997 Planned: $462,872

FUTURE FUNDING NEEDS:

FY	$ NEED	% PLAN	% IMPLEMENT	% O AND M
1998	$540,000		100%	
1999	$540,000		100%	
2000	$280,000		100%	
2001	$0			

PAST OBLIGATIONS (incl. 1997 if done):

FY	OBLIGATED
1982	$202,813
1983	$279,495
1984	$359,947
1985	$450,394
1986	$440,528
1987	$296,255
1988	$377,641
1989	$231,047
1990	$141,646
1991	$253,898
1992	$689,089
1993	$1,193,968
1994	$861,513
1995	$764,724
1996	$367,946
1997	$462,872

TOTAL: $7,373,776

Note: Data are past obligations, or amounts committed by year, not amounts billed. Does not include data for related projects.

1997 OVERHEAD PERCENT: USGS-BRD 38%, ODFW 20.5%

HOW DOES PERCENTAGE APPLY TO DIRECT COSTS:
USGS-BRD total direct costs 38%, except subcontracts which is 19%

CONTRACTOR FTE: 4

SUBCONTRACTOR FTE: 4