GAS BUBBLE DISEASE MONITORING AND RESEARCH 9602100

SHORT DESCRIPTION:

I. Provide training and QA/QC for Smolt Monitoring Program personnel examining fish for signs of GBT. II. conduct experiments to determine the progression and diminution of GBT signs in juvenile salmonids exposed to water with high total dissolved gas (TDG); determine the effects of water with high TDG on the ability of juvenile salmonids to resist disease, respond to stress, etc. III. Determine depths and locations of radio-tagged juvenile salmonids during their downstream migration in an effort to determine vertical and horizontal distribution and exposure histories; one use of these data will be in the COE CRiSP and GasTrans models. IV. Determine prevalence and severity of GBT in larval fishes of the Columbia basin

SPONSOR/CONTRACTOR: USGS-BRD
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SUB-CONTRACTORS:
Johnson Control Services, Inc.

GOALS

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

ANADROMOUS FISH:
Research, M&E

RESIDENT FISH:
Research, M&E

NPPC PROGRAM MEASURE:
5.6E1;10.1

RELATION TO MEASURE:
Researching effects of dissolved gas supersaturation on juvenile fish mortality; researching vertical distribution of juvenile salmonids for evaluation of their risk to dissolved gas supersaturation and exposure histories; determining the incidence of GBT in larval and early-juvenile resident fish.

BIOLOGICAL OPINION ID:
NMFS BO: 2-The COE shall spill at Snake and Columbia river projects in order to increase fish passage efficiency and survivals at the dams; 16-The BPA, COE, and BOR shall participate in... a monitoring and evaluation program to investigate the effects of dissolved gas supersaturation...; 17-The BPA and COE shall participate with NMFS in activities to coordinate the regional passage and life cycle models and to test the hypotheses underlying those models.

TARGET STOCK	LIFE STAGE	MGMT CODE (see below)
Columbia/Snake river resident fishes	Larval and early juvenile	
Snake/Columbia river hatchery chinook salmon	Juvenile	A
Snake River hatchery steelhead	Juvenile	A

AFFECTED STOCK	BENEFIT OR DETRIMENT
Larval and early-juvenile resident fishes	Beneficial

BACKGROUND

BIOLOGICAL RESULTS ACHIEVED:
Under project 87-401, we developed a non-lethal method for assessing GBT, monitored fish at dams in 1995, and began work on s

ome objectives of this project. In 1996, we monitored fish at seven dams, continued lab work and began work on the pressure-sensitive radio tag. Lab work on GBT signs has been the basis for the methods used in examinations to determine the prevalence and severity of GBT signs in fish via the Smolt Monitoring Program. We validated the use of the pressure-sensitive tag for use in juvenile steelhead and determined accuracy and precision of the tag in 1996.

PROJECT REPORTS AND PAPERS:

Draft 1996 reports on laboratory work , monitoring, and radio telemetry are available from BPA.

ADAPTIVE MANAGEMENT IMPLICATIONS:

I. Monitoring GBT signs in salmonids provides biological criteria upon which water and fisheries managers can base in-season spill regulation (this project performs training and QA/QC for the monitoring program).
II. Results of the laboratory research (development of GBT signs and the sub-lethal effects of exposure to water with high TDG) will provide information upon which managers can base monitoring protocols and biological criteria for water regulation. Analysis of physiological data and behavioral data (Objective III) can be used in a model to predict the level of mortality expected based on water quality and GBT signs observed in migrating fish.
III. Results of this project can be used as a base of information about the depths used by individual juvenile steelhead in the Columbia River. This knowledge is essential to understand the effects high TDG may have on these animals. Each meter of depth allows compensation for approximately 10% of supersaturation.
Data from this study can be used 1) as a model of individual fish exposure to TDG that can be duplicated in laboratories to determine the risk different levels of TDG have on juvenile salmonids migrating in the river; 2) as a source of a horizontal and vertical component in geographical information systems (GIS) housing TDG data for the prediction of the risk of TDG on juvenile salmonids; 3) as a source of definitive fish depth information in reservoirs and near dams for the design of surface collectors for the passage of fish around dams; and 4) to refine current survival models such as CRiSP, the TDG component of which is based on a simplistic, untested hypothesis of a constant depth during migration.

PURPOSE AND METHODS

SPECIFIC MEASUREABLE OBJECTIVES:

I. Train investigators in methods to determine GBT in fish and provide QA/QC during in-season examinations.
II. (1) Determine the progression and diminution of external and internal signs of GBT in chinook salmon and steelhead held in shallow tanks containing water with high TDG (110, 120 & 130%) at various temperatures (8, 12, 15 C). (2) Determine the sub-lethal effects of exposure to gas supersaturated water on the ability of juvenile chinook salmon to resist disease, respond to stress, and develop full smolt characteristics.
III. Determine the vertical and horizontal distribution of juvenile steelhead migrating in the Snake and Columbia rivers at times of high TDG. (1) Test a newly developed depth-sensing miniature radio transmitter for use in juvenile salmonids. (2) Determine the horizontal and vertical distribution of individual migrating juvenile chinook salmon and steelhead in a reservoir.
IV. Determine the incidence of gas bubble trauma in larval and juvenile resident fishes. (1) Determine effects of sampling gear on symptoms of GBT in these fishes. (2). Determine how GBT may influence growth and survival of these fishes.

CRITICAL UNCERTAINTIES:

I. (1) Non-lethal signs of GBT can be used to predict risk
II. (1) Current technology is adequate to detect significant effects of exposure to GBT.
III. (1) Tagged fish behave as untagged fish in the reservoir. (2) Radio signals can be detected at depths of tagged fish. (3) Tagged fish can be located and followed without affecting fish behavior.
IV. (1) Larval and early-juvenile resident fishes can be sampled in the reservoirs without affecting GBT signs.

BIOLOGICAL NEED:

If we are to regulate flows in the Snake and Columbia rivers to optimize survival of salmonids, we must know what effect water manipulations will have on those fish. Furthermore, we must develop protocols for monitoring fish and establish criteria to determine when to alter water regulation. There is currently much debate over the extent of the role high TDG, from NMFS BO #2, plays in fish survival in the Columbia River basin. Current monitoring programs are based on the examination of passively (collected at dams) and actively (collected with purse seines) captured fish. These programs are needed for monitoring purposes, but do nothing to help understand the root of the issue: How deep are the fish and what is their relative exposure to TDG. This

question is of the utmost importance because fish depth is one of the most important factors determining the presence and severity of GBT. Data on the exposure histories, including depths and TDG at fish locations, will enable researchers and managers to assess and predict the effects of TDG on juvenile salmonids. Repeated measures from individuals is the most appropriate method for this purpose. There is currently no program to examine larval or early-juvenile resident fishes. The exposure of larval and early-juvenile resident fishes is of concern because they are typically located in the near-surface waters where they are the most susceptible to GBT.

HYPOTHESIS TO BE TESTED:

1) Non-lethal measures of GBT can be used to estimate risk of mortality in migrating salmonids. 2) Juvenile salmonids' ability to resist disease, respond to stress, and develop smolt characteristics is affected by exposure to water with high TDG. 3) The radio transmitter consistently indicates the correct depth to the nearest 0.3 meters. 4) Depths of juvenile salmonids are greater than the compensation depth. 5) Juvenile salmonids migrate deeper in the water column in areas of high TDG than in those of low TDG. 6) Depths of migrating steelhead are constant. 7) The incidence of GBT in larval and early-juvenile resident fishes is not zero. 8) Water with high TDG affects growth and survival of larval and early-juvenile resident fishes.

ALTERNATIVE APPROACHES:

Acoustic telemetry was considered an alternative to radio telemetry because it is less affected by water depth. This method was rejected because acoustic signals are greatly affected by entrained air, such as found in and around dams.

JUSTIFICATION FOR PLANNING:

N/A

METHODS:

I. GBT Monitoring.

(1) We will provide training, quality assurance and quality control for the monitoring of juvenile salmonids for GBT in the Columbia and Snake rivers. The monitoring personnel will be hired under a separate contract through the Fish Passage Center Smolt Monitoring Program budget. Training will most likely occur at the Columbia River Research Laboratory as this facility can produce supersaturated water and fish with various signs of GBT. Our staff will then visit the monitoring sites on a regular basis during the migration season to provide QA/QC services.

II. GBT Laboratory Research

(1) In the laboratory, we will conduct several studies over the next five years: (1) assess the progression and severity of GBT in juvenile salmonids exposed to various TDG levels and water temperatures; (2) assess the effects of GBT on infectious disease progression and stress responses of juvenile salmonids; and (3) assess the effects of GBT on smolt development and ability to survive in saltwater. For all of these studies, we will use fish obtained from local hatcheries (about 2000-3000 fish annually). For study #1, we will expose groups of fish to standard TDG levels and water temperatures. During their exposure, fish will be sampled at selected time intervals and examined for progression and severity of GBT in the lateral line, fins, body surface, and gills. Data will be used to construct time series analyses of GBT progression and to relate the severity of GBT signs to the onset of mortality. For study #2, we will expose fish to high TDG and subsequently challenge them with a dose of BKD. We will then assess the effects of TDG exposure on BKD progression and mortality. As a corollary, we will expose fish that already have BKD to high levels of TDG and assess the progression of signs and subsequent mortality. Finally, for study #3, we will expose fish that are actively smolting to high levels of TDG. Fish will be sampled for physiological indicators of smoltification and also examined for the progression and severity of GBT. As a final test, seawater challenges may be done to assess the effects of GBT (and perhaps BKD) on the ability of juvenile salmonids to survive in seawater.

(2) Much of the data generated by the progression of GBT signs research is descriptive in nature; hypothesis testing is not relevant. Within each time interval, we will average lateral line and gill data, determine standard errors and prevalence, and plot the data over time. For the fins, we will plot average and maximum severity rankings and prevalence over time using data from all fins combined or data from selected fins. Mortality will be plotted as a cumulative percentage over time. We will fit a curve through the points by eye and estimate the time to 50% mortality (i.e., the LT50) by extrapolation. We will examine the potential relationship between GBT signs and mortality by using correlation and regression analysis. At certain levels of mortality, e.g. the LT5 or LT10, we will characterize the average GBT signs in the sample population at that time.

We will also determine sub-lethal effects of exposure to supersaturated water by conducting disease challenges similar to that described by Maule et al. (1987, 1989) for Vibrio anquillarum and that developed by R. Pascho (USGS-BRD, Northwest Biological Science Center, Seattle) for Renibacterium salmoninarum. Physiological measures of smoltification and stress will be monitored and assayed based on protocols described by Beeman et al. (1994, 1995), Haner et al. (In press) and Schrock et al.

(1994).
(3) Fish to be used in laboratory research will be hatchery chinook salmon and steelhead and will most likely be obtained from lower-river federal hatcheries.
III. Vertical and Horizontal Distribution
(1) Work in 1997 will include determining the validity of using the pressure-sensitive radio tag in juvenile chinook salmon, tagging and releasing chinook salmon and steelhead, and locating them by boat during their migration between Ice Harbor and McNary dams. Work in 1998 will include tagging fish and locating them by boat as well as with equipment mounted on McNary Dam, and 1999 will entail writing results.
Juvenile steelhead and chinook salmon of hatchery origin will be tracked through the Ice Harbor Dam-to-McNary Dam reach. This reach was selected because gradients of TDG occur due to the different TDG levels in the Columbia and Snake rivers. Fish collected at McNary, Lower Monumental, or Ice Harbor dams will be implanted with pressure-sensitive radio transmitters. Fish will be sequestered at Ice Harbor Dam for a period of at least 24 hours. Fish releases may be made on the spillway and powerhouse sides of the tailrace to mimic fish passage via these routes.
We propose to release five-to-ten fish every three-to-five days. This schedule is based on a median travel time of approximately three days between Ice Harbor and McNary dams (estimated from Fish Passage Center 1993, 1994). The actual number of releases will depend on the travel times of the tagged fish in each group. We plan to release a maximum of 200 fish during the study period in each year.
Telemetry equipment used from boats will consist of one receiver and 6-element antenna on each of two boats. Additional equipment will include global positioning systems and total dissolved gas meters. We will track fish using two boats each operating 24-h per day. We will use a tracking protocol designed to maximize the number of fish contacts as well as the amount of data collected from individual fish. We will alternate between attempting to locate as many fish as possible (Method 1) and intensely following individuals (Method 2). For example, we may spend several hours locating as many fish as possible and then spend 40 minutes following one randomly-selected individual. This process will be repeated until the fish have passed McNary Dam. This method will provide large amounts of data about within-fish variability in vertical and horizontal movements of individuals while allowing us to measure between-fish variability from a larger number of fish than if we intensely tracked a small number of fish.
At each fish contact, location via a global positioning system (GPS), TDG, water temperature, and fish depth will be recorded. All efforts will be made to avoid affecting fish behavior during data collection by keeping an adequate distance from the fish during tracking. Total dissolved gas meters will be tested on a regular schedule (at least weekly) to ensure they are operating within established criteria.
We plan to add fixed telemetry gear to McNary Dam during the 1998 migration year to provide a fixed end point, or exit station, for tagged fish, and to determine whether fish pass via the spillway or powerhouse. The latter information is needed for COE modeling of mortality due to TDG and GBT. This task was removed from the proposal prior to funding for 1997 due to budget constraints. This task will require an estimated additional $ 60,582 for a one-time purchase of equipment. This amount is included in the 1998 required funding amount.
Hydroacoustics will be used to determine if the depths and locations of tagged fish represent other fish in the reservoir. The horizontal and vertical distribution of tagged fish will be compared with locations of other fish in the reservoir identified using hydroacoustics to relate observational data on individual fish and the distribution of the population at large. Hydroacoustic information will be provided by a study titled “Symptoms of gas bubble disease induced in salmon by gas supersaturation” (BPA project number 9603100), headed by the USGS (Dennis Rondorf, Cook, WA) and the Columbia River Intertribal Fish Commission (CRITFC; Tom Backman, Portland, OR).
(2) Data collected will be analyzed using several methods. Distributions, measures of central tendency and associated errors in fish depth and TDG will be calculated for each fish and correlations between fish depth and TDG from the fish monitored using Method 2 will be examined for statistical significance. Within-fish variability in depth will also be estimated from this data. Data will be examined for diurnal trends and to determine if juvenile steelhead travel at a constant depth during migration or if their depth varies. Previous studies of the vertical distribution of juvenile salmonids indicate a diurnal change in vertical and horizontal distribution (Smith 1974; Ledgerwood et al. 1991). Correlations between fish depth, TDG, reservoir depth, and reservoir temperature will be examined from data collected using Method 1. Between-fish variability in depth will be estimated from this data. Fish tracks will be plotted using a GIS.
(3) This study will use juvenile steelhead and chinook salmon of hatchery origin. The numbers of fish needed for work in 1997 and 1998 will up to 300 of each species in each year, including fish for laboratory studies; no fish will be required in the year 1999. Fish will be taken from the collection facilities at either McNary, Ice Harbor, or Lower Monumental dams, depending on the availability of fish.
IV. A preliminary study will be conducted at the Columbia River Research Laboratory (CRRL) to evaluate possible effects of sampling gear types on gas bubble trauma symptoms in larval fishes. Based on previous work on larval fishes (Cornacchia and Colt 1984; Weitkamp and Katz 1980; Tim Counihan, CRRL, personal communication), symptoms of GBT often are gas bubbles

in the mouth, gill cavity, intestinal tract, or other areas of the body cavity that could be extruded or ruptured upon net capture. We will spawn a representative fish taxon in the laboratory (for example, northern squawfish Ptychocheilus oregonensis), expose the resulting larvae to a range of TDG levels (supersaturated water is available at this facility, see Mesa et al. 1996; Mesa and Warren, In press), and compare symptoms of groups exposed to net capture to control groups. If net capture hinders our ability to detect signs of GBT, we will investigate other possible sampling options, such as bucket dipping larvae from shoreline areas with high larval fish densities. If sampling by nets is determined to be feasible based on preliminary laboratory work, larval fishes will be collected in the Columbia River from the drift with boat-towed plankton nets, and larval and young juvenile fishes will be collected from shoreline areas with small beach seines or dip nets. Sampling sites will be selected in areas with a range of gas saturation levels and also based on results of a study of larval and juvenile fishes of the Columbia River Basin (the John Day Reservoir, the Dalles Reservoir, and below Bonneville Dam) conducted during 1993-96 (Barfoot et al. 1994; Gadomski and Barfoot, In review). Dissolved gas saturation levels will be monitored concurrent with sampling. Larvae and young juveniles from collections will be anaesthesized with MS-222 buffered to a pH of 7 with sodium bicarbonate, identified to the lowest possible taxon following methods of Gadomski and Barfoot (In review), measured using an ocular micrometer fitted to a dissecting microscope, and examined for signs of GBT. Small larvae are nearly transparent, so internal bubbles should be evident, based on GBT research conducted on larval striped bass by Cornacchia and Colt (1984). Larger specimens will be examined for GBT using methodology developed for juvenile salmonids, with an initial scan for external gas bubbles in the lateral line, fins, eyes, and body surface, and then gill arch removal and examination under a compound microscope. The second objective is to determine how gas bubble trauma may affect larval and young juvenile fish growth and survival. The study will concentrate on species whose larvae exhibit signs of GBT in the field. Larvae and young juveniles for experiments will be obtained by spawning adults in the laboratory or by collecting wild larvae or juveniles in areas with low levels of saturation. Fish will be exposed to various levels of dissolved gas supersaturation at the CRRL, and growth and mortality will be monitored concurrent with observations of GBT symptoms.

PLANNED ACTIVITIES

SCHEDULE:

PROJECT COMPLETION DATE:
2000

CONSTRAINTS OR FACTORS THAT MAY CAUSE SCHEDULE OR BUDGET CHANGES:
I. None. II. Must obtain fish from local hatcheries. III. Use of Ringold SFH chinook salmon requires permit to transport fish from the Columbia River for release into the Snake River at Ice Harbor Dam. Use of Snake River hatchery chinook salmon requires ESA permit. Permission to take fish from the daily sample if required from operators of Smolt Monitoring facilities at Ice Harbor Dam and COE must allow us to work on the project. Funding must be approved and in place by approximately December of each year so equipment may be ordered in time for field work. This was a problem in both 1996 and 1997. IV. Must obtain an ESA permit to seine fish.

OUTCOMES, MONITORING AND EVALUATION

SUMMARY OF EXPECTED OUTCOMES

Expected performance of target population or quality change in land area affected:
I. A formal training and QA/QC program will benefit the Information on the prevalence and severity of GBT signs will help managers make decisions about the use of spill as a method of fish passage.
II. We will describe the progression of GBT signs leading to mortality in juvenile salmonids. We will determine the risk that exposure to water with high TDS poses for juvenile salmonids.
III. We expect fish depths are not constant during their migration, as variation in biological systems is the rule rather than the exception. We expect approximately 50-75% of juvenile steelhead will be in the upper 10 meters of the water column, based on studies using hydroacoustics or vertical gill nets. We expect we will be able to locate and track fish at these depths with the proposed radio transmitter. We will produce information about the variation and range of depths used by individual fish; little information on this subject was collected in 1996 due to late funding. This knowledge is required to understand the exposure of the fish to TDG and possible effects on survival. The COE is planning to use the exposure history information resulting from

this objective in their CRiSP and GasTrans models to predict mortality due to GBT.
IV. Quantification of the incidence of GBT in larval and early-juvenile resident fishes. There is currently no quantitative information on this subject in the Columbia basin.

Present utilization and convservation potential of target population or area:
N/A

Assumed historic status of utilization and conservation potential:
N/A

Long term expected utilization and conservation potential for target population or habitat:
N/A

Contribution toward long-term goal:
A healthy Columbia basin requires that the effects of water with high TDG n anadromous and resident fishes be known.

Indirect biological or environmental changes:
N/A

Physical products:
Approximately 200 juvenile salmonids will be radio-tagged pre year under Objective 3.

Environmental attributes affected by the project:
N/A

Changes assumed or expected for affected environmental attributes:
N/A

Measure of attribute changes:
N/A

Assessment of effects on project outcomes of critical uncertainty:
I. (1) Backman (CRITFC) is assessing the relation between GBT signs at dams and those in their forebays. (2) Must be determined through experimentation and validation of assumptions.
II. (1) Unknown.
III. (1) Performed buoyancy tests in laboratory to confirm absence of tag effects; other studies can be used to determine likely effects based on tag size and body size. (2) Tests in 1996 indicated signals could be detected at depths of at least 14 m; fish were continuously contacted at up to about 12 m depth. (3) In-situ testing in 1996 indicated no abrupt changes in location or depth as boats approached tagged fish.
IV. (1) Laboratory tests will be used to indicate/identify effects of gear on GBT prevalence.

Information products:
I. QA/QC results will be reported to BPA in the form of interim and annual reports.
II. Lab studies of GBT in juvenile salmonids will be reported to BPA in the form of interim and annual reports and to peers through the peer-reviewed literature.
III. Depth-tag results will be reported to BPA in the form of interim and annual reports and to peers through the peer-reviewed literature. The USACE is planning to use this information in model development.
IV. Larval and early-juvenile studies of resident fishes will be reported to BPA in the form of interim and annual reports and to peers through the peer-reviewed literature.

Coordination outcomes:

Coordination with CRITFC, USACE and other BPA projects will result in information about in-situ fish distributions for use in modeling efforts to predict mortality based on gas supersaturation and fish distributions and migration rates in Columbia and Snake river reservoirs. These models efforts are being undertaken by the CRiSP and USACE GasTrans programs.

MONITORING APPROACH

Biological outcomes will be evaluated by the Gas Management Team, BPA, and USACE (through modeling efforts described earlier). Results will be reported in interim and annual reports and through oral presentation to interested parties prior to publishing in peer-reviewed journals.

Provisions to monitor population status or habitat quality:

N/A

Data analysis and evaluation:

I. The QA/QC data will be tabulated and presented to BPA.
II. Most data from GBT lab studies is descriptive mortality and will be plotted as a cumulative percentage over time. Prevalence and severity data of bubbles in the fins, lateral line, and gills will be averaged and plotted in a time series fashion. Data will be examined for correlations between mortality and GBT signs.
III. The data from the pressure-sensitive radio tag will be examined for normality prior to determination of measures of central tendency of fish depths and TDG. These measures will be examined for correlation with each other, and will be examined for patterns based on daylight and location. The vertical and horizontal distributions of radio-tagged individuals will be compared to that from hydroacoustics (provided by a cooperating project described earlier) to determine if hydroacoustic generalizations are indicative of individual movements. These hydroacoustic and radio-tag data will be used in models using predicted fish movements and gas transport to predict survival being created by USACE and CRiSP (University of Washington).
IV. Multiple regression analysis will be used to determine how environmental conditions affect the percentage of early stage resident fish with GBT. Analysis of variance will be used to test for differences in survival and growth in lab studies of early stage resident fish. Data from field studies will be evaluates based on lab studies indicating the effects of TDG and GBT on growth and survival.

Information feed back to management decisions:

Through BPA and the Gas Management Team.

Critical uncertainties affecting project's outcomes:

See question "Summary of expected outcomes, K". The questions and answers seem essentially the same.

EVALUATION

Personnel examining fish for GBT as part of the Smolt Monitoring Program are performing satisfactorily based on QA/QC exams which will be reported to BPA. Lab and field work are completed within timeline specified in this document and are disseminated to interested parties.

Incorporating new information regarding uncertainties:

The research designs within this study are malleable to the extent that they could be adjusted accordingly by the investigators.

Increasing public awareness of F&W activities:

The BPA will be acknowledges as the funding agency in all publications and presentations.

RELATIONSHIPS

RELATED BPA PROJECT	RELATIONSHIP
8740100 Assessment of Smolt Condition for Travel	Cooperator. This study was part of work conducted under Objective 6 (Conduct research and monitoring of GBT in juvenile salmonids migrating in the Columbia and Snake rivers during times of high TDG)

RELATED NON-BPA PROJECT	RELATIONSHIP
CRiSP model development	The CRiSP model is being revised to include data such as ours in the gas mortality function.
Juvenile salmonid distribution estimation, DGAS 97(2)-1/ USACE	Working in same reach as radio telemetry objective. Will compare distribution results to determine if fish from radio tag and hydroacoustic studies indicate similar behavior.

OPPORTUNITIES FOR COOPERATION:
Telemetry equipment used in this study can also be used in the study "Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River basin", BPA project number 91-029. Funding must be received no later than December 1 to allow purchases of non-expendable equipment. Much of this equipment must be ordered 2-4 months in advance of the field work to ensure timely delivery.

COSTS AND FTE

1997 Planned: $850,654

FUTURE FUNDING NEEDS:

FY	$ NEED	% PLAN	% IMPLEMENT	% O AND M
1998	$1,118,430			
1999	$547,221			
2000	$440,010			
2001	$0			
2002	$0			

PAST OBLIGATIONS (incl. 1997 if done):

FY	OBLIGATED
1996	$550,961
TOTAL:	$550,961

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

OTHER NON-FINANCIAL SUPPORTERS:
USACE DGAS program (Rock Peters, Joe Carrol, Chris Pinney, Marshall Richmond , including the GasTrans modeling group; CRiSP program (Jim Anderson at University of Washington, Seattle).

LONGER TERM COSTS: N/A

1997 OVERHEAD PERCENT: 38%

HOW DOES PERCENTAGE APPLY TO DIRECT COSTS:
Total

CONTRACTOR FTE: 10 people, 6.29 FTE

SUBCONTRACTOR FTE: 14 people, 5.5 FTE

SUPPLEMENTAL ANADROMOUS FISH EVALUATION FACTORS:
The results of this project may indirectly contribute to increased adult return through a better understanding of the effects of TDG on juvenile salmonids. Laboratory work will result in an understanding of the effects of TDG on direct mortality and fish resistance to disease and the progression of symptoms in the disease, whereas field work will determine what the exposure histories of the juveniles are to TDG during their spring out migration. This information is essential to evaluate the effectiveness of the current program of passing juvenile salmonids over dams via spill. References from Objectives 1,2,3 methods are available on request.

SUPPLEMENTAL RESIDENT FISH EVALUATION FACTORS:
Objective IV of this project, investigating the incidence of GBT in larval and early-juvenile resident fishes in the Columbia Basin,

is needed to evaluate the impact of the present rule curves and spill program to pass juvenile salmonids. Larval and early-juvenile life stages of fishes are known to be very susceptible to the effects of TDG, but no concerted effort has been made to quantify the impact. This work is needed before BPA can state that all reasonable precautions have been undertaken to avoid adversely impacting habitat/populations of native resident fish. References from larval fish objective methods section are available on request.