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COASTAL ZONE AND ESTUARINE STUDIES

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ABSTRACT

In 1984, the National Marine Fisheries Service continued to evaluate the effects of collecting and transporting juvenile salmonids from upriver dams on the Columbia and Snake Rivers to a release site downstream from Bonneville Dam on the Columbia River.

Returns of jack spring/summer chinook salmon previously transported from Lower Granite Dam by barge in 1983 indicated the best return since the 1975 outmigration.

Fall chinook salmon tagged as juveniles at McNary Dam between 1980 and 1983 and transported below Bonneville Dam continue to provide significantly more returning adults than corresponding controls released below McNary Dam. Returns of jacks tagged as juveniles at McNary Dam in 1983 indicate there is no significant difference between adult returns from juveniles transported by barge or truck.

In 1984, a total of 46,173 spring chinook salmon smolts and 33,529 steelhead smolts were marked at Lower Granite Dam to provide an index of the success of the barge transportation program.

Standard seawater challenge tests conducted on spring chinook salmon smolts at Lower Granite Dam indicated that no increase in stress occurred between the gatewells and the end of the bypass gallery, but a significant increase occurred between the end of the bypass gallery and the separator. We speculate that the majority of this increase occurred during passage through the downwell.

The extended seawater holding study conducted at Lower Granite Dam was terminated prematurely when a water valve was inexplicably closed. Limited

information from the study demonstrated that bacterial kidney disease has some delayed effect on the spring chinook salmon population transported from the Snake River. An estimate of the magnitude of the problem awaits future study.

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INTRODUCTION

In 1984, the National Marine Fisheries Service (NMFS) under contract to the U.S. Army Corps of Engineers (CofE) continued to evaluate the effects of collection and transportation on juvenile salmonids at dams on the Columbia and Snake Rivers. This year's research had the following major objectives: (1) continue evaluation of previous transport efforts by recovery of adults, previously tagged as juveniles, in the various fisheries, at hatcheries, from natal spawning areas, and at dams; (2) mark spring chinook salmon and steelhead smolts at Lower Granite Dam to index the success of transport by barge; (3) conduct seawater challenge stress tests on spring chinook salmon smolts to isolate areas of stress between the gatewells and the fish separator at Lower Granite Dam; and (4) determine the relative ability of juvenile spring chinook salmon sampled from various points within the collection/transport system at Lower Granite Dam to survive an extended holding period (120 days) in artificial seawater.

ADULT RETURNS TO THE COLUMBIA AND SNAKE RIVERS

Returns of tagged adults from spring/summer chinook salmon previously transported as juveniles from Lower Granite Dam in 1983 and fall chinook salmon previously transported as juveniles from McNary Dam between 1980 and 1983 were monitored throughout 1984. There were no tagged steelhead from transport experiments expected back in 1984. We did, however, monitor returns of tagged steelhead from a Dworshak Hatchery homing experiment funded by the Bonneville Power Administration (BPA).

Tagged adult salmonids were recovered by operating tag detection equipment in fishways at Bonneville, McNary, and Lower Granite Dams. In 1984, these facilities were operated from 15 July to 15 October at Bonneville Dam, 23 July to 25 November at McNary Dam, and 1 March to 30 November at Lower Granite Dam. Additional tagged adults were recovered at hatcheries, from spawning grounds, in the Columbia and Snake River sport fisheries, and from various commercial fisheries including ocean catches.

Spring/Summer Chinook Salmon

A total of nine spring/summer chinook salmon jacks were recovered at Lower Granite Dam between 5 June and 13 July 1984. Further, six of nine were captured between 2 and 5 July 1984. These fish were tagged as juveniles at Lower Granite Dam then transported by barge and released into the Columbia River near Beacon Rock downstream from Bonneville Dam in the spring of 1983. The timing of recovery indicates that most of these fish were probably summer run stock. Subsequent recoveries of these fish upstream at hatcheries or at the trapping operation on the South Fork of the Salmon River (summer chinook salmon stock) should verify the proper stock identification. The numerical strength of the jack return and the number of fish carrying coded wire tags indicate the best return since the 1975 outmigration.

Fall Chinook Salmon

A total of 236 adult fall chinook salmon were recovered at the trapping facilities at Bonneville and McNary Dams through 9 November 1984 (see Appendix Tables 1.1 to 1.13). No tagged fall chinook salmon were captured at Lower Granite Dam.

Most tags from fisheries, hatcheries, and spawning grounds in 1984 have not been received but should be available in early 1985. New information from these recovery areas is obviously limited; however, all available data were incorporated into Table 1, Figure 1, and the appendix tables for review.

The transport to control ratios for adults recovered from all locations for study years 1978-83 are extremely encouraging. In all groups where sufficient data are available, G-statistic analysis indicates that the return of transported fish is significantly higher (P<0.001) than the return of corresponding controls (Table 1). In most instances, four or more transported fish were recovered for every control. The groups where insufficient data were recovered involved at least two age classes of adults that will subsequently enter our analysis.

In 1983, fall chinook salmon juveniles were marked for truck versus barge transport and transport/control comparisons. Based on the return of jacks, both transport groups returned at significantly higher rates (P<0.001) than the controls (Fig. 1). However, there was no significant difference between the truck and barge groups. There is no biological evidence to date that indicates barging fall chinook salmon would provide more adult returns than trucking. Schreck et al. (1983) reported that stress levels (as measured by cortisol titers) were not increased during truck transportation. Similarly, Park et al. (1983 and 1984) demonstrated that transportation alone or marking without transportation did not result in increased mortality (results based upon 5-d delayed mortality observations). Marking combined with truck transportation did result in significantly higher mortality than the unmarked control. In summation, it

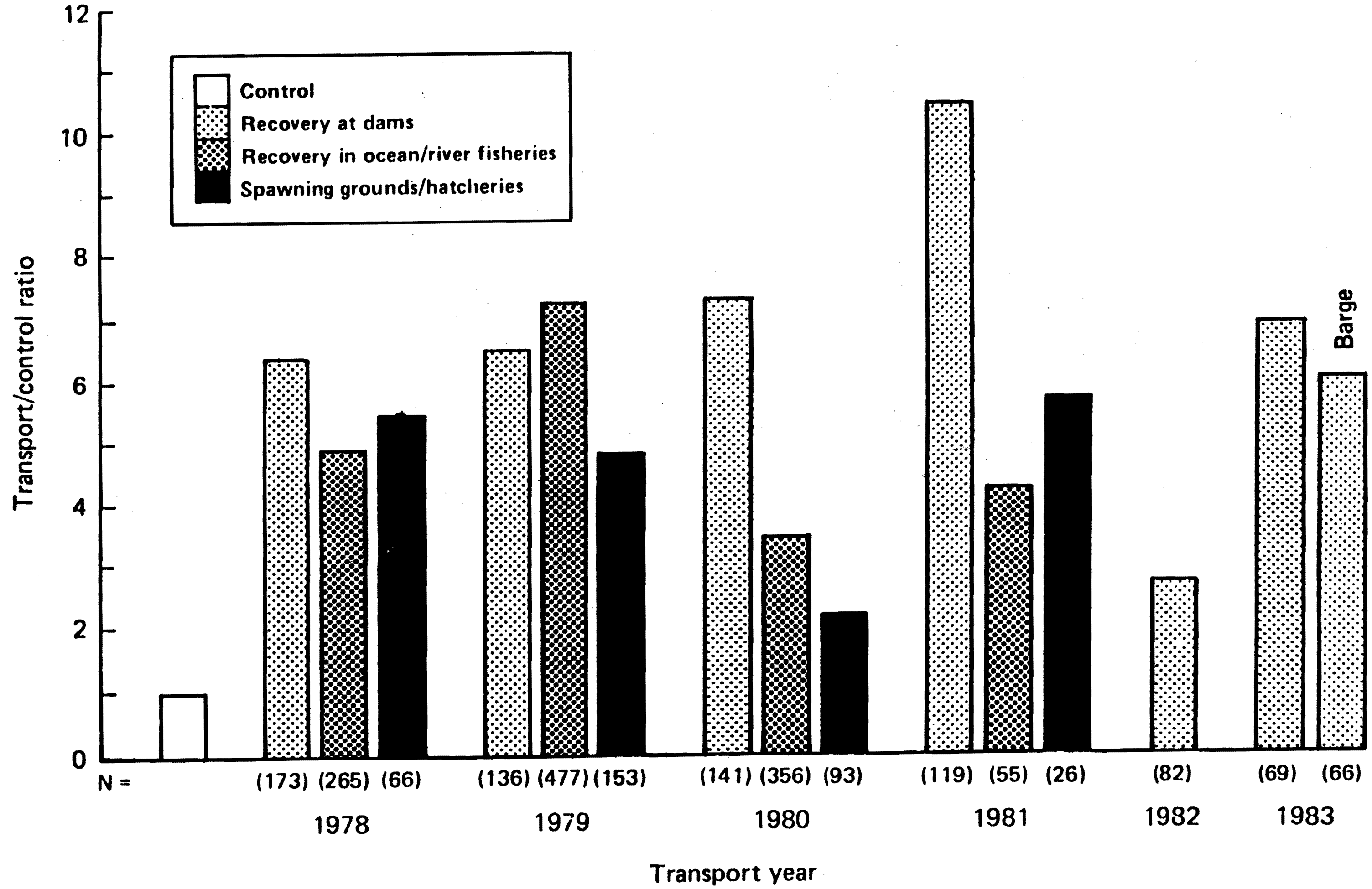

Figure 1.--Transport/control ratios for McNary Dam truck transportation tests with fall chinook salmon, 1978-83 (includes barge test group for 1983).

Table 1.--Transport benefit ratios and statistical significance for fall chinook salmon 1978-83.

Year of release	Adult recovery area	Number returns Transport	Control	Benefit ratio[a]	"G" statistic probability
1978	Col. R. traps	150	23	6.2:1	"G"= 97.344; P<0.001
	Combined fisheries	220	45	4.7:1	"G"=117.716; P<0.001
	Spawning grounds-hatcheries	56	10	5.3:1	"G"= 32.823; P<0.001
1979	Col. R. traps	120	16	6.4:1	"G"= 73.829; P<0.001
	Combined fisheries	427	50	7.2:1	"G"=275.651; P<0.001
	Spawning grounds-hatcheries	128	25	4.8:1	"G"= 62.423; P<0.001
1980	Col. R. traps	123	18	7.6:1	"G"= 93.379; P<0.001
	Combined fisheries	274	82	3.6:1	"G"=119.958; P<0.001
	Spawning grounds-hatcheries	68	35	2.0:1	"G"= 12.594; P<0.001
1981	Col. R. traps	108	11	10.4:1	"G"= 90.962; P<0.001
	Combined fisheries	44	11	4.1:1	"G"= 20.950; P<0.001
	Spawning grounds-hatcheries	22	4	5.4:1	"G"= 13.578; P<0.001
1982	Col. R. traps	58	24	2.4:1	"G"= 15.438; P<0.001
	Combined fisheries	4	2	--Insufficient data--	
	Spawning grounds-hatcheries	1		--Insufficient data--	
1983	Col. R. traps	59[b]	10	6.9:1	"G"= 45.414; P<0.001
	Combined fisheries			--Insufficient data--	
	Spawning grounds-hatcheries			--Insufficient data--	

a/ Adjusted for number of smolts released in each group.

b/ There were also 56 fish returning from a barge test lot with a transport benefit ratio of 6.0:1.

appears that either barges or trucks can be used with equal success for transportation of juvenile fall chinook salmon, and the survival of either group of transported juveniles will be significantly increased over those not transported.

All available information strongly suggests that the mass transportation effort at McNary Dam was a major contribution to the very strong run of "upriver bright" fall chinook salmon in 1984. The strongest age class in this year's run was 3-ocean fish (except jacks) which migrated to sea in 1981. Coincidentally, McNary Dam was first fully screened for maximum collection and transportation of fish in 1981 (Basham et al. 1982). Basham et al. (1982) also reported that over 2 million fall chinook salmon juveniles were transported that year compared to a previous high of 571,000 in 1980 (Park et al. 1981). Two-ocean age fish (1982 outmigration) were also aided by the transport of 1.6 million juveniles (Basham et al. 1983). We note that the percent of 2-ocean age fish from the 1982 transport group returning to trapping facilities is higher than in most previous years (see Appendix Tables 1.1 to 1.13). However, the transport benefit ratio for the 1982 group is lower than previously observed indicating that the survival of non-transported fish was relatively high--a factor which should benefit the 1985 run considerably.

One could argue that the restrictions placed on Oregon and Washington coastal fishing in 1984 aided this year's run substantially. However, tag returns from ocean fishing areas for "upriver bright" stocks do not support this theory. Since 1978 (year of outmigration), we have recovered 895 tags from the coast-wide interagency sampling network. Of these, 33 or only 3.7% were sampled from the Oregon and Washington coastal waters. The other 96.3% were caught in Alaskan and Canadian waters. Consequently a total closure of Oregon-Washington coastal fishing waters would have a relatively minor impact on Columbia River "upriver bright" fall chinook salmon returns.

SPRING CHINOOK SALMON AND STEELHEAD SMOLT MARKING, LOWER GRANITE DAM

In 1984, we continued marking spring chinook salmon smolts and began marking steelhead smolts to index the relative success of the barge transportation program. A total of 46,173 spring chinook salmon and 33,529 steelhead were marked with adipose fin-clips (chinook salmon) or left ventral fin clips (steelhead), freeze brands, and coded wire tags. To separate discrete portions of the outmigrations of both species, freeze brands were rotated four times on chinook salmon and five times on steelhead; coded wire tags were changed seven times on chinook salmon and five times on steelhead (see Appendix Tables 2 and 3 for specifics on numbers marked for each brand rotation and wire tag code by species). No controls of either species were marked. Sampling and marking procedures and techniques (including pre-anesthesia) were the same as described by Park et al. (1984).

BYPASS GALLERY AND PIPE STRESS TESTS AT LOWER GRANITE DAM

The CofE is currently developing plans for major modifications to the fingerling bypass and collection system at Little Goose Dam. A major component of these modifications involves the possible installation of a new bypass pipe similar to the one in use at Lower Granite Dam to transfer smolts from the bypass gallery to the separator/raceway complex. Various other methods of transfer such as an open flume are also under consideration. The CofE and the fisheries agencies desire a system that will deliver smolts to the holding area in the best possible physical condition with minimal stress.

The bypass pipe transfer system currently in use at Lower Granite Dam appears to deliver fish from the gatewells to the collection facility in excellent physical condition. However, stress research conducted by Congleton et al. (1982) and Park et al. (1983) demonstrated that spring chinook salmon smolts experienced an increase in stress during passage from the gatewells to the separator within the collection system at Lower Granite Dam. Unfortunately, these earlier studies did not provide information necessary to determine if the increase occurred during passage from the orifices leading from the gatewells through the bypass gallery area or between the terminal end of the gallery and the separator.

To determine which of these areas was responsible for the increase in stress measured in the earlier studies, the NMFS conducted another series of seawater challenge stress tests at Lower Granite Dam in the spring of 1984. In these tests, spring chinook salmon smolts were sampled from the gatewell and pre-separator areas and, in addition, from the terminal end of the bypass gallery just prior to the downwell which leads directly to the bypass pipe. Sampled smolts were subsequently challenged to lethal (standard) and sublethal levels of artificial seawater with direct mortality and plasma Na^+ and Cl^- levels used as relative stress indices, respectively.

Methods

On 16 April, we conducted a preliminary test series to determine the appropriate salinity levels for both the standard and sublethal seawater challenge tests. For the standard tests, we desired a salinity level that would provide a mortality level of approximately 5% in least stressed fish. To determine this level, we randomly sampled four groups of smolts from the C-Slot gatewell of Turbine Unit 6. These groups were subsequently challenged to salinity levels of 28, 30, 32, and 34 ppt artificial seawater for 24 h. For the sublethal tests, we desired the highest salinity level that would result in no mortalities in the highest stressed fish. To determine this level, we randomly sampled four groups of smolts from the pre- separator area. These groups were subsequently challenged to salinity levels of 22, 24, 26, and 28 ppt artificial seawater for 24 h. The results of these tests indicated that 34 and 26 ppt were the appropriate salinity levels for the standard and sublethal tests, respectively.

After establishing the appropriate salinity levels, we sampled and challenged to seawater groups of smolts for both tests concurrently from the areas described below:

1. Gatewell Group. These fish were a composite sample from any three of the B-Slots in Units 1, 2, 3, or 6. The relative stress level of this group was considered an average representation of the relative stress level of the entire population in all of the intake gatewell slots.

2. Bypass Gallery Group. These fish were sampled from a trap that we installed in the downstream end of the bypass gallery. Any difference in the relative stress level measured between this group and the previous

group represented stresses incurred during passage through the gatewell orifices and the bypass gallery.

3. Pre-Separator Group. These fish were sampled between the bypass pipe upwell area and the fish separator. Any difference in the relative stress level measured between this group and the previous group represented stresses incurred while passing through the downwell at the end of the bypass gallery, the bypass pipe, and the bypass pipe upwell.

We conducted three separate test series beginning on 17 April and ending on 22 April. Each standard test series consisted of three randomized replicates of approximately 20-30 fish per replicate; each sublethal test series consisted of one replicate of approximately 15-20 fish.

The seawater challenge test procedures were basically the same as those described by Park et al. (1983); however, the seawater exposure time was reduced from 48 to 24 h. In the standard tests, mortalities and survivors were counted, weighed, and measured to fork length after the 24-h exposure period. All survivors were subsequently released. In the sublethal tests, all test fish were weighed, measured to fork length, sacrificed, and bled after the 24-h exposure period. The blood plasma samples were then appropriately stored for subsequent laboratory analysis of Na^+ and Cl^- levels by flame spectrophotometer and Buchler Chloridometer[1/], respectively.

In the standard test series, live and dead fish counts were used in a contingency table analysis utilizing the G-statistic (Sokal and Rohlf,

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1/ Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

1981) for significance. Analysis of variance was used for statistical comparisons in the sublethal test series. Significance was established at ($P<0.05$) for comparisons between or among test groups in both test series.

Results and Discussion

The data presented here represent only the first two of the three planned test series. An unknown problem developed while we were sampling the gallery trap during the third test series. Unlike the first two tests, fish that were removed from the trap during the third test exhibited varying degrees of descaling and injury. We attempted several subsequent tests with different modifications in our trap operating techniques but were unable to rectify the problem before time constraints combined with excessive numbers of steelhead smolts forced us to terminate testing. In retrospect, we surmise that the trap simply did not operate effectively when larger numbers of smolts were present as was the case during the third and subsequent tests. Large numbers of smolts may have entered the small sanctuary area of the trap too quickly causing some to exit and re-enter the trap several times.

Figure 2 illustrates the results of the two successful standard seawater challenge tests. In both tests, analysis of the data indicates that no increase in stress occurred between the gatewell groups and the bypass gallery groups but a highly significant increase ($P<0.01$, $df=1$) occurred between the bypass gallery groups and the pre-separator groups.

Results of the sublethal test series were inconclusive. In the first test, there was no statistically significant difference in plasma Na^+ levels among the three test groups (Table 2), but a significant increase

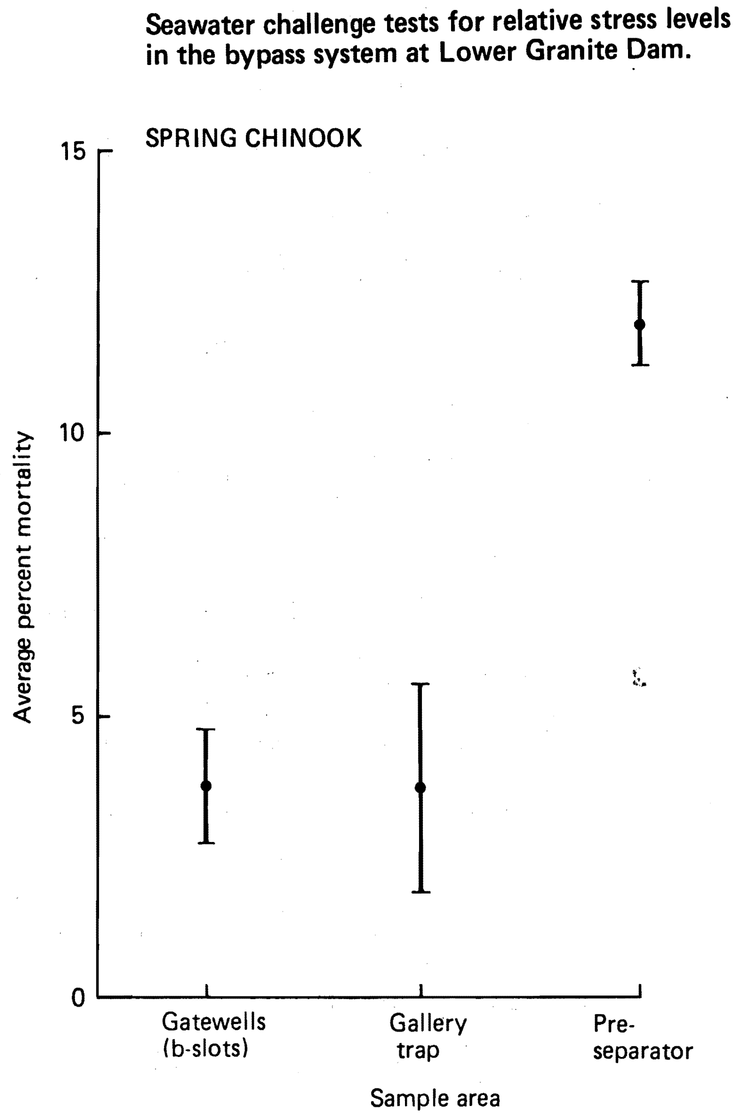

Figure 2.--The average percent mortality of spring chinook salmon smolts sampled from the B-Slot gatewells, the terminal end of the bypass gallery, and the pre-separator and challenged to artificial seawater for 24 h at Lower Granite Dam, 1984 (vertical lines represent S.E.).

Table 2.--The average levels ± S.E. of plasma Na^+ and Cl^- in spring chinook salmon smolts sampled from the B-Slot gatewells, the terminal end of the bypass gallery, and the pre-separator and challenged to artificial seawater at 26 ppt for 24 h at Lower Granite Dam, 1984.

Test no.	Plasma Na^+ (meq/liter)			Plasma Cl^- (meq/liter)		
	B-Slot gatewells	Bypass gallery	Pre-separator	B-Slot gatewells	Bypass gallery	Pre-separator
1	156.2 ± .63	157.5 ± 1.5	157.0 ± 2.0	132.0 ± .56	137.0 ± 1.22	138.4 ± 2.12
2	156.8 ± .67	159.9 ± 1.6	161.9 ± 2.2	134.8 ± .70	135.8 ± 1.8	141.1 ± 2.5

($P>0.01$) in plasma Cl^- was measured between the gatewell group and the bypass gallery group. In the second test, a significant increase ($P<0.05$) in plasma Na^+ was measured between the gatewell group and the bypass gallery group, whereas a significant increase ($P<0.01$) in plasma Cl^- was measured between the bypass gallery group and the pre-separator group.

The inconsistency of these test results is perplexing. Theoretically, the results of these tests should be similar to the results of the lethal seawater challenge tests since both tests are designed to measure the effects of stress on the fishes ability to osmoregulate in seawater. Since the average plasma Na^+ and Cl^- values in all test groups were within normal ranges for salmonid smolts in seawater, the salinity level that we chose for testing may have been too low. In any case, it is apparent that more preliminary research is necessary before reliable data can be expected from this particular type of seawater performance test.

The results of the standard seawater challenge tests tend to implicate the bypass pipe as the area responsible for the observed increase in stress since it constitutes the major portion of this area of the bypass system. However, since the bypass pipe is approximately 400 yards long with water flows approaching 25 ft/sec (Matthews et al. 1977), smolts are exposed to conditions in the pipe for less than 1 minute. Cortisol measurements taken by the University of Idaho in 1982-83 indicated an increase in this stress hormone between the gatewells and the pre-separator of approximately 40-50 ng/ml[2/]. Since cortisol rises at approximately 5 ng/ml/min during a

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2/ Pers. commun. J. Congleton, Idaho Co-operative Fisheries Research Unit, University of Idaho, Moscow, Idaho 83843.

short-term handling stress (Strange et al. 1977), the relatively short exposure to the bypass pipe does not appear to be sufficient to account for the magnitude of the increase measured.

This scenario leads us to suspect that the majority of the stress response may result from adverse hydraulic conditions in either the downwell at the end of the bypass gallery or in the upwell at the end of the bypass pipe. Possible adverse hydraulic conditions in the downwell that may cause delay and swimming fatigue are: (1) an abrupt change in the flow pattern from horizontal to vertical at the entrance, (2) a substantial decrease in water velocity at the entrance, (3) cross currents caused by the make-up water gate located about 20-30 feet underwater, and (4) a relatively abrupt increase in water velocity near the entrance to the bypass pipe at the bottom of the downwell. In the upwell, we speculated that excessive flows through the inclined screen (especially near the beginning of the screen) may require smolts to swim vigorously in this area to avoid contact with the screen. To check this hypothesis, we took a series of flow velocity measurements at several locations under the screen this past fall. Average flow velocities ranged from 0.77 ft/sec to 1.02 ft/sec. We do not believe that velocities in this range would be sufficient to cause any problems in this area.

Although the bypass pipe may be adding some stress to smolts, we believe at this time that the downwell area is probably responsible for the majority of the stress increase measured in this area of the collection and bypass system. Our logic is, again, based upon the earlier cortisol measurements. We believe it is impossible for smolts to remain in the bypass pipe long enough to illicit a cortisol response of the magnitude measured during the earlier studies.

EXTENDED SEAWATER HOLDING STUDY, LOWER GRANITE DAM

Since 1975, upriver runs of spring chinook salmon have declined drastically in the Snake River basin and elsewhere. The decline has occurred despite major transportation efforts which have greatly benefited fall chinook salmon and, in particular, steelhead populations in the Columbia and Snake Rivers. Why spring chinook salmon have not responded similarly to the transport effort is not yet known.

Over the last 15 years, the outmigration of spring chinook salmon smolts has changed from one of nearly all wild to one of mostly hatchery origin. There is speculation that the hatchery fish being released in recent years are not up to the quality of the wild stocks. As a result, many of the smolts arriving at transport collector dams may not have the ability to survive the stresses associated with river migration or collection and transportation and subsequent seawater adaption. For example, it is commonly known that bacterial kidney disease (BKD) is present in the spring chinook salmon hatchery populations of the Snake River basin. It is also known that latent infections can be activated by stress, and the disease progression is chronic in nature. A disease such as BKD could be an overriding factor in the survival of all groups of smolts from the least stressed to the most stressed; or there may be a certain stress level necessary to activate the infection. If stresses associated with collection and transportation are activating latent BKD infections, smolts should begin dying approximately 30-90 days (depending upon subsequent environmental conditions) after release below Bonneville Dam. These mortalities would not appear in short-term, freshwater delayed mortality tests.

In the spring of 1984, the NMFS began a test to study the long-term survival and growth of spring chinook salmon smolts and their possible relationship to collection and transportation stress. The study was not intended to parallel absolute survival and growth in the sea, but rather to look at the relative differences in long-term survival and growth of smolts sampled from various areas of the collection and transport system.

To conduct the test, we developed a completely closed artificial seawater recirculation system for use at Lower Granite Dam. The system, designed to maintain water quality sufficiently to hold approximately 1,100 spring chinook salmon smolts for 120 days, was installed in a NMFS research barge moored at the dam. During the peak of their outmigration, spring chinook salmon smolts were sampled from several areas of the collection and transport system at the dam and subsequently transferred into this system for long-term observations.

Methods

A schematic of the closed artificial seawater recirculation system that we designed and used for this study is shown in Figure 3. Artificial seawater was pumped at approximately 34 gallons/minute in sequence through a pressurized sand filter for removal of relatively large particulate matter, through an ultraviolet light chamber to eliminate water borne pathogenic bacteria and viruses, through a water chiller to maintain the water temperature between 9° and 12° C, and finally into a biological filter to eliminate metabolic wastes. This filter consisted of a 4-ft by 4-ft wooden box filled with a 6-inch bottom layer of river rock, a 42-inch middle layer of crushed oyster shell, and a 2-inch upper layer of activated

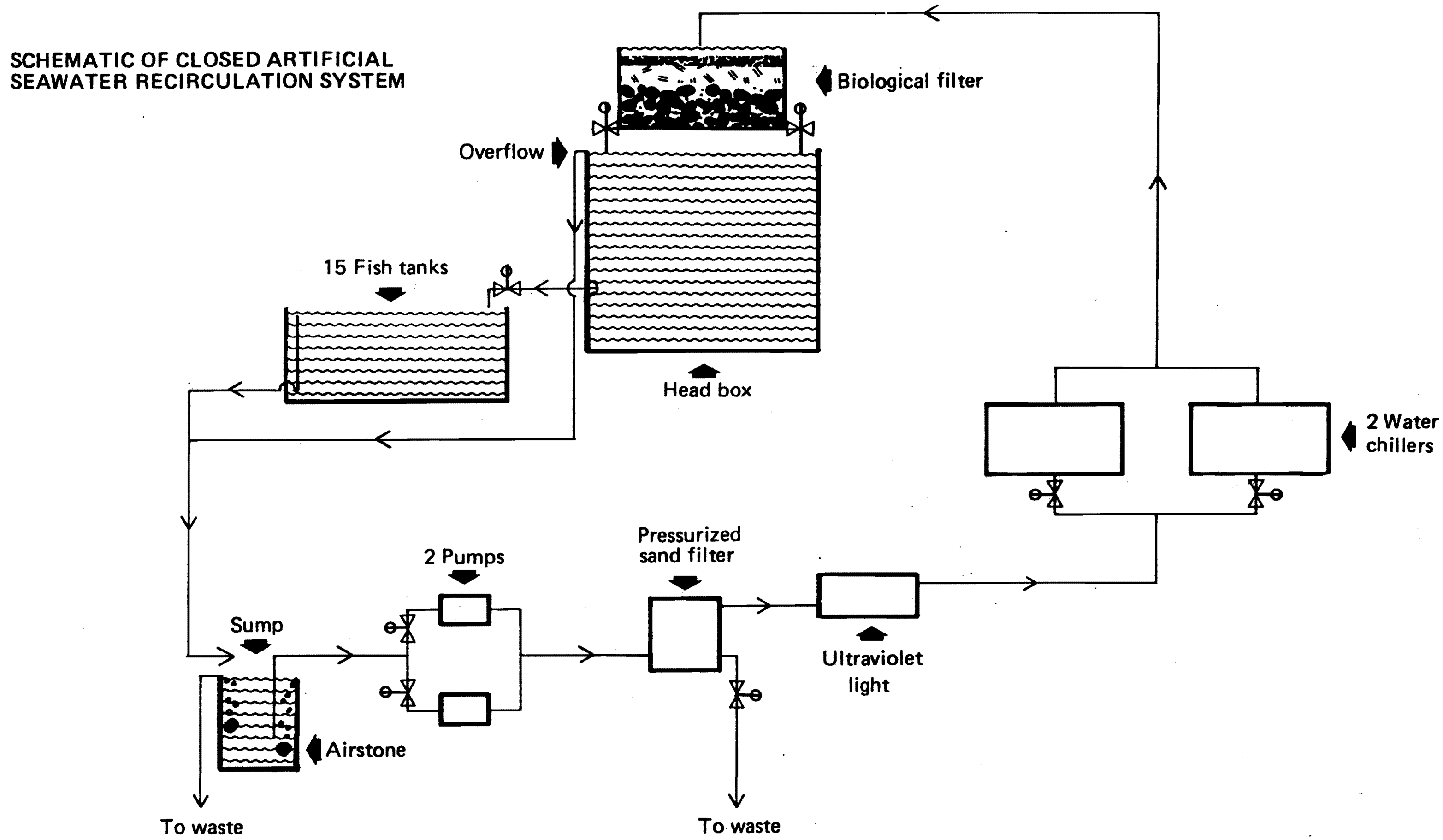

Figure 3.--Schematic of a completely closed artificial seawater recirculation system designed to hold spring chinook salmon smolts for 120 days at Lower Granite Dam, 1984.

coconut charcoal. Water flowed by gravity through the filter media into a 2,000-gallon head box and out to 15 separate 500- to 600-gallon circular redwood fish holding tanks. An overflow standpipe in each holding tank returned the used water to a 230-gallon common sump from which the water was pumped to repeat the cycle. The sump was equipped with two large air stones attached to an air compressor to re-aerate the water.

On 1 May, the peak of the outmigration, we sampled and placed in the holding tanks three randomized replicates of approximately 75 spring chinook salmon smolts each from the areas described below:

1. C-Slot Gatewell Group. This group represented smolts that had entered these gatewells and, therefore, were exposed to minimal stresses (Park et al. 1983).

2. Pre-Separator Group. This group represented smolts that had been exposed to stresses involved in passing from the gatewells and through the bypass gallery and pipe area.

3. Raceway Group. This group represented smolts that had passed through the same areas as the previous group and, in addition, were exposed to stresses associated with passage through the fish separator and into a fish holding raceway.

4. Marked With Pre-Anesthesia + 8 h Transport Group. This group represented smolts that had passed through the same areas as the previous group. Further, they were handled and marked utilizing the pre-anesthesia concept we had previously developed (Park et al. 1983; 1984) and were subsequently transported in a simulated manner for 8 h in a small fish transport tanker.

5. Marked Without Pre-Anesthesia + 8 h Transport Group. This group was the same as the previous group with the exception that they were handled and marked without using pre-anesthesia.

The 15 test replicates of smolts were sampled and transferred into the fish holding tanks utilizing water-to-water transfer techniques that we previously developed for the short-term seawater challenge stress tests (Park et al. 1983). They were held in fresh water for 4 days before we began to gradually increase the salinity to 30 ppt over a 23-day period. To achieve gradual acclimation to seawater, we had originally proposed to increase the salinity level in four successive steps to 10, 20, 25, and 30 ppt and hold the fish at each level for 5 days before increasing the salinity to the next level in 1 day. However, we discovered that it was impossible to increase the salinity level of the system by 10 ppt in a single day due to the amount of time necessary to mix the required amount of artificial seawater. Therefore, we raised the salinity level by roughly 1.5 to 2.0 ppt on a daily basis until a 30 ppt salinity was reached. After reaching this level, we replaced approximately 1.8% of the artificial seawater on a daily basis for the duration of the study.

All test fish were fed to satiation three times daily with Oregon moist pellet (OMP) fish formula. Excess feed along with fish excrement was vacuumed from the tank bottoms every third day.

Water quality variables including temperature, O_2, pH, salinity, and un-ionized ammonia (NH_3+) were recorded on a daily basis.

Mortalities were removed daily, weighed, measured to fork length, checked for descaling and injury, and examined internally for the presence of BKD lesions and other abnormalities.

Results and Discussion

Although we had planned to hold the test fish for approximately 120 days, an unfortunate incident which resulted in termination of the test occurred sometime during the night of Day 43 (13 June 1984). When we arrived at the facility the next morning to check the system, we found that nearly all of the test fish were dead. The reason was immediately obvious. A valve in the water supply line located just past the pressurized sand filter had been inexplicably turned off resulting in a complete loss of water flow to the remainder of the system. As of this writing, we have been unable to determine exactly how this event occurred. However, the test was not a complete loss since we were able to salvage the information from the first 43 days of holding.

The mortality data recorded before the aforementioned incident occurred are presented in Table 3. We have divided the mortalities into two groups--initial mortalities which occurred from 1 to 25 May and later mortalities which occurred from 26 May to 13 June. The initial mortality levels ranged from 0.6% in the group sampled from the C-Slot gatewells to 11.9% in the group marked without pre-anesthesia and transported. These results follow the same basic pattern that we observed in previous stress research. That is, as fish progress through the system and accumulate stress and injury, the mortality level also increases. However, the overall initial mortality level for all test groups combined was a surprisingly low 5.3%. Apparently, spring chinook salmon smolts exposed to various areas of the collection and transport system at Lower Granite Dam are capable, at least initially, of surviving fairly well. It is

Table 3.--Summary of mortalities in extended seawater holding tests conducted at Lower Granite Dam, 1984.

Sample site	Initial mortalities 1 - 25 May				Mortalities from 26 May - 13 June			
	No. live	No. dead	Total	Percent mortality	No. mortalities	BKD positive	Pinhead	Mortality cause unknown
Control (C-slot)	313	2	315	0.6	1	1	0	0
Pre-separator	197	11	208	5.3	7	7	0	0
Raceway	173	4	177	2.3	7	4	1	2
Mark with pre-anesthesia +8 h transport	207	17	224	7.6	4	0	4	0
Mark without pre-anesthesia +8 h transport	192	26	218	11.9	4	4	0	0
Total	1,082	60	1,142		23	16	5	2
Grand average				5.3				

noteworthy that all of the smolts that were descaled or injured died during this time period. Also, BKD lesions were not observed in any of these initial mortalities. In contrast, during the later time period, 16 of the 23 recorded mortalities contained extensive BKD lesions in their kidneys. The fish that died with BKD lesions present were spread throughout the test groups. Unfortunately, the numbers were too low to determine if a pattern relative to the different test groups was developing.

The sudden and continued appearance of mortalities that contained BKD lesions after 25 days of holding suggests that the disease was present in a latent state and may have been activated by the stresses associated with collection and transportation. We cannot be certain about this scenario because the single mortality from the C-Slot Gatewell Group (least stressed group) also contained extensive BKD lesions. In addition, we do not know if fish with BKD would have continued to die and, if so, what the magnitude of the mortalities may have been if the test had continued for the entire 120 days.

One positive result of the test was that the recirculation system successfully maintained critical water quality variables within the desired ranges (see Appendix Table 6). We had been particularly concerned about controlling NH_3^+ levels within the system because we did not have sufficient time to condition the bio-filter properly before placing test fish in the system. The NH_3^+ level rose to a high of 0.013 ppm on Day 31, remained at this point for several days, and then appeared to be declining when the test was involuntarily terminated. Therefore, we feel confident that the recirculation system that we designed for this study would have successfully held test fish for the proposed 120-day period if the accident had not occurred.

In summation, the limited information obtained during this study demonstrated that BKD has some delayed effect on the spring chinook salmon population collected and transported from the Snake River. We feel it is imperative to repeat the test to gain an insight into the magnitude of the problem and possibly determine if activation of the disease is related to stresses associated with collection and transportation practices.

SUMMARY AND RECOMMENDATIONS

1. A total of nine spring/summer chinook salmon jacks were recovered at Lower Granite Dam. These fish were tagged as smolts at the dam in 1983 and subsequently transported by barge to below Bonneville Dam. The numerical strength of the jack return and the number of fish carrying tags indicate the best overall return of this stock since the 1975 outmigration.

2. Fall chinook salmon tagged as juveniles at McNary Dam between 1980-83 and transported for release below Bonneville Dam continue to provide significantly more returning adults than corresponding controls released below McNary Dam. Further, returns of jacks tagged as juveniles at McNary Dam in 1983 indicate that barge transport does not provide more or less returning adults than truck transport.

3. The mass transportation of large numbers of juveniles beginning in 1981 was a major contributor to the strong run of "upriver bright" fall chinook salmon in 1984.

4. Totals of 46,173 spring chinook salmon and 33,529 steelhead were marked at Lower Granite Dam in 1984 to index the relative success of transportation from the Snake River.

5. Standard seawater challenge tests on spring chinook salmon smolts at Lower Granite Dam indicated that an increase in stress occurred between the end of the bypass gallery and the pre-separator. The sublethal seawater challenge test results were variable and inconclusive. We speculate that the majority of the increase in stress measured by the standard test series occurred during passage through the downwell.

6. The extended seawater holding study was terminated prematurely. Limited information from the study demonstrated that BKD has some delayed effect on the spring chinook salmon population transported from the Snake River. We recommend repeating this study in the spring of 1985.

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Appendix Table 1.--Adult fall chinook salmon returns through 9 November 1984 showing year and place of recovery. The table is divided into 13 subunits by the year the juveniles were marked at McNary Dam and the condition being tested.

9 NOV 84

Appendix Table 1.1

1978 MCNARY - TRUCK
FALL CHINOOK

MARKS USED RAIC1 RAIC3 ORGNLG LG

NUMBER RELEASED 40361

RECOVERY AREA	1978	1979	1980	1981	1982	1983	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS								
BONNEVILLE TRAP	0	21	4	5	13	1	44	0.109
MCNARY TRAP	0	59	15	11	10	0	95	0.235
ICE HARBOR TRAP	0	0	1	3	1	0	5	0.012
LOWER GRANITE TRAP	0	5	0	0	0	0	5	0.012
PRIEST RAPIDS TRAP	0	0	0	0	1	0	1	0.002
OCEAN FISHERIES								
ALASKA	0	0	4	61	30	0	95	0.235
BRITISH COLUMBIA	0	10	13	28	9	1	61	0.151
WASHINGTON	0	0	2	0	1	0	3	0.007
OREGON	0	0	0	2	0	0	2	0.004
RIVER SPORT								
COLUMBIA R. BELOW SNAKE R.	0	3	0	1	0	0	4	0.009
COLUMBIA R. ABOVE SNAKE R.	0	1	0	0	0	0	1	0.002
SNAKE RIVER	0	0	0	0	0	0	0	0.000
RIVER COMMERCIAL	0	6	8	5	5	0	24	0.059
INDIAN FISHERY	0	3	3	22	2	0	30	0.074
HATCHERIES								
DWORSHAK H.	0	0	1	0	0	0	1	0.002
BONNEVILLE H.	0	0	0	0	1	0	1	0.002
WELLS H.	0	4	0	11	1	0	16	0.039
PRIEST RAPIDS H.	0	13	0	16	1	0	30	0.074
STREAM SURVEY	0	0	0	2	6	0	8	0.019
TOTALS	0	125	51	167	81	2	426	1.055
PERCENT OF RECOVERY	0.0	29.3	11.9	39.2	19.0	0.4		

Appendix Table 1.2

1978 MCNARY — TAILRACE
FALL CHINOOK

9 NOV 84

MARKS USED LAIF1 LAIF3 PUGNBL YWXYGN NUMBER RELEASED 38137

RECOVERY AREA	1978	1979	1980	1981	1982	1983	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS								
BONNEVILLE TRAP	0	4	1	4	2	0	11	0.028
MCNARY TRAP	0	7	2	1	1	0	11	0.028
LOWER GRANITE TRAP	0	1	0	0	0	0	1	0.002
OCEAN FISHERIES								
ALASKA	0	0	0	16	2	0	18	0.047
BRITISH COLUMBIA	0	2	3	4	3	0	12	0.031
WASHINGTON	0	0	1	1	0	0	2	0.005
RIVER SPORT								
COLUMBIA R. BELOW SNAKE R.	0	1	0	1	0	0	2	0.005
COLUMBIA R. ABOVE SNAKE R.	0	0	0	1	0	0	1	0.002
SNAKE RIVER	0	0	0	0	0	0	0	0.000
RIVER COMMERCIAL	0	0	3	1	0	0	4	0.010
INDIAN FISHERY	0	2	1	2	1	0	6	0.015
HATCHERIES								
WELLS H.	0	1	0	1	1	0	3	0.007
PRIEST RAPIDS H.	0	1	0	5	0	0	6	0.015
STREAM SURVEY	0	0	0	0	1	0	1	0.002
TOTALS	0	19	11	37	11	0	78	0.204
PERCENT OF RECOVERY	0.0	24.3	14.1	47.4	14.1	0.0		

Appendix Table 1.3

1979 MCNARY – TRUCK

FALL CHINOOK

MARKS USED: RA3 1 RAI+3 RDPKOR; RA3 2 RAI+4 LBYWLG; RA3 3 SM RDLBYW; RAI+1 RDLGPK; RAI+2 RDPKLB

NUMBER RELEASED 132919

RECOVERY AREA	1979	1980	1981	1982	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS								
BONNEVILLE TRAP	0	26	9	25	6	0	66	0.049
MCNARY TRAP	0	34	5	4	0	0	43	0.032
LOWER GRANITE TRAP	0	0	0	0	0	0	0	0.000
PRIEST RAPIDS TRAP	0	0	0	11	0	0	11	0.008
OCEAN FISHERIES								
ALASKA	0	0	11	157	75	0	243	0.182
BRITISH COLUMBIA	0	16	31	46	11	0	104	0.078
WASHINGTON	0	0	5	4	1	0	10	0.007
OREGON	0	0	0	1	0	0	1	0.000
RIVER SPORT								
COLUMBIA R. BELOW SNAKE R.	0	1	0	0	0	0	1	0.000
COLUMBIA R. ABOVE SNAKE R.	0	2	0	0	0	0	2	0.001
SNAKE RIVER	0	0	0	0	0	0	0	0.000
RIVER COMMERCIAL	0	2	5	15	3	0	25	0.018
INDIAN FISHERY	0	1	9	19	12	0	41	0.030
HATCHERIES								
DWORSHAK H.	0	0	1	0	0	0	1	0.000
BONNEVILLE H.	0	0	0	2	0	0	2	0.001
WELLS H.	0	0	5	16	0	0	21	0.015
PRIEST RAPIDS H.	0	0	21	35	2	0	58	0.043
STREAM SURVEY	0	0	1	38	7	0	46	0.034
TOTALS	0	82	103	373	117	0	675	0.507
PERCENT OF RECOVERY	0.0	12.1	15.2	55.2	17.3	0.0		

Appendix Table 1.4

9 NOV 84

1979 MCNARY — TAILRACE

FALL CHINOOK

MARKS USED						NUMBER RELEASED	112718
	LA5 1	LA5 2	LA5 3	LAIM1	LAIM2		
	LAIM3	LAIM4	PR	RDLGYW	RDYWPK		
	LBYWLB	RDLBPK					

RECOVERY AREA	1979	1980	1981	1982	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS								
BONNEVILLE TRAP	0	4	0	5	1	0	10	0.008
MCNARY TRAP	0	2	0	1	0	0	3	0.002
LOWER GRANITE TRAP	0	0	0	0	0	0	0	0.000
PRIEST RAPIDS TRAP	0	0	0	3	0	0	3	0.002
OCEAN FISHERIES								
ALASKA	0	0	3	16	10	0	29	0.025
BRITISH COLUMBIA	0	1	2	5	0	0	8	0.007
WASHINGTON	0	0	0	1	0	0	1	0.000
RIVER SPORT	0	0	0	0	0	0	0	0.000
RIVER COMMERCIAL	0	0	3	4	0	0	7	0.006
INDIAN FISHERY	0	0	2	1	2	0	5	0.004
HATCHERIES								
DWORSHAK H.	0	0	1	0	0	0	1	0.000
WELLS H.	0	0	1	3	0	0	4	0.003
PRIEST RAPIDS H.	0	0	8	7	2	0	17	0.015
RINGOLD H.	0	0	0	1	0	0	1	0.000
STREAM SURVEY	0	0	0	2	0	0	2	0.001
TOTALS	0	7	20	49	15	0	91	0.080
PERCENT OF RECOVERY	0.0	7.6	21.9	53.8	16.4	0.0		

Appendix Table 1.5

9 NOV 84

1980 MCNARY — TRUCK
FALL CHINOOK

MARKS USED RAIC1 RAIC3 LA HO

NUMBER RELEASED 80213

RECOVERY AREA	1980	1981	1982	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS							
BONNEVILLE TRAP	0	19	8	27	3	57	0.071
MCNARY TRAP	0	12	18	24	9	63	0.078
LOWER GRANITE TRAP	0	0	1	2	0	3	0.003
OCEAN FISHERIES							
ALASKA	0	0	10	120	0	130	0.162
BRITISH COLUMBIA	0	2	34	33	0	69	0.086
WASHINGTON	0	1	5	6	0	12	0.014
RIVER SPORT	0	0	0	0	0	0	0.000
RIVER COMMERCIAL	0	1	2	12	0	15	0.018
INDIAN FISHERY	0	4	8	36	0	48	0.059
HATCHERIES							
WELLS H.	0	2	0	3	0	5	0.006
PRIEST RAPIDS H.	0	4	13	17	0	34	0.042
RINGOLD H.	0	0	0	2	0	2	0.002
STREAM SURVEY	0	0	10	17	0	27	0.033
TOTALS	0	45	109	299	12	465	0.579
PERCENT OF RECOVERY	0.0	9.6	23.4	64.3	2.5		

Appendix Table 1.6

9 NOV 84

1980 MCNARY — TAILRACE
FALL CHINOOK

MARKS USED LAIF1 LAIF3 CE CEDY

NUMBER RELEASED 84587

RECOVERY AREA	1980	1981	1982	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS							
BONNEVILLE TRAP	0	4	1	7	2	14	0.016
MCNARY TRAP	0	0	1	0	0	1	0.001
ICE HARBOR TRAP	0	2	0	0	0	2	0.002
LOWER GRANITE TRAP	0	1	0	0	0	1	0.001
OCEAN FISHERIES							
ALASKA	0	0	6	27	0	33	0.039
BRITISH COLUMBIA	0	0	13	10	0	23	0.027
WASHINGTON	0	0	0	3	0	3	0.003
OREGON	0	0	1	0	0	1	0.001
RIVER SPORT	0	0	0	0	0	0	0.000
RIVER COMMERCIAL	0	0	0	2	0	2	0.002
INDIAN FISHERY	0	1	2	17	0	20	0.023
HATCHERIES							
PRIEST RAPIDS H.	0	4	6	12	0	22	0.026
STREAM SURVEY	0	0	5	8	0	13	0.015
TOTALS	0	12	35	86	2	135	0.159
PERCENT OF RECOVERY	0.0	8.8	25.9	63.7	1.4		

Appendix Table 1.7

9 NOV 84

1981 MCNARY – TRUCK
FALL CHINOOK

MARKS USED RAI+1 RAI+2 RAI+3 RAI+4 031733 NUMBER RELEASED 42924

RECOVERY AREA	1981	1982	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS						
BONNEVILLE TRAP	0	2	12	31	45	0.104
MCNARY TRAP	0	38	12	11	61	0.142
LOWER GRANITE TRAP	0	1	1	0	2	0.004
OCEAN FISHERIES						
ALASKA	0	2	0	0	2	0.004
BRITISH COLUMBIA	0	7	22	0	29	0.067
WASHINGTON	0	0	0	1	1	0.002
OREGON	1	0	0	0	1	0.002
RIVER SPORT						
COLUMBIA R. BELOW SNAKE R.	0	0	0	0	0	0.000
COLUMBIA R. ABOVE SNAKE R.	0	0	2	0	2	0.004
SNAKE RIVER	0	0	0	0	0	0.000
RIVER COMMERCIAL	0	0	2	0	2	0.004
INDIAN FISHERY	0	0	7	0	7	0.016
HATCHERIES						
RAPID RIVER H.	0	0	1	0	1	0.002
WELLS H.	0	0	1	0	1	0.002
PRIEST RAPIDS H.	0	2	12	0	14	0.032
STREAM SURVEY	0	1	5	0	6	0.013
TOTALS	1	53	77	43	174	0.405
PERCENT OF RECOVERY	0.5	30.4	44.2	24.7		

Appendix Table 1.8

9 NOV 84

1981 MCNARY – TAILRACE
FALL CHINOOK

MARKS USED LAIM1 LAIM2 LAIM3 LAIM4 031732 NUMBER RELEASED 42580

RECOVERY AREA	1981	1982	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS						
BONNEVILLE TRAP	0	1	0	4	5	0.011
MCNARY TRAP	0	4	0	1	5	0.011
LOWER GRANITE TRAP	0	1	0	0	1	0.002
OCEAN FISHERIES						
BRITISH COLUMBIA	0	1	4	0	5	0.011
WASHINGTON	0	0	0	1	1	0.002
RIVER SPORT	0	0	0	0	0	0.000
RIVER COMMERCIAL	0	0	0	0	0	0.000
INDIAN FISHERY	0	0	5	0	5	0.011
HATCHERIES						
PRIEST RAPIDS H.	0	1	0	0	1	0.002
STREAM SURVEY	0	1	2	0	3	0.007
TOTALS	0	9	11	6	26	0.061
PERCENT OF RECOVERY	0.0	34.6	42.3	23.0		

Appendix Table 1.9

9 NOV 84

1982 MCNARY – TRUCK
FALL CHINOOK

MARKS USED RAV 1 231614 RAV 2 RAV 3 231610 231612

NUMBER RELEASED 39693

RECOVERY AREA	1982	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS					
BONNEVILLE TRAP	0	15	19	34	0.085
MCNARY TRAP	0	11	12	23	0.057
LOWER GRANITE TRAP	0	1	0	1	0.002
OCEAN FISHERIES					
BRITISH COLUMBIA	0	2	0	2	0.005
RIVER SPORT	0	0	0	0	0.000
RIVER COMMERCIAL	0	0	0	0	0.000
INDIAN FISHERY	0	2	0	2	0.005
HATCHERIES					
RAPID RIVER H.	0	1	0	1	0.002
TOTALS	0	32	31	63	0.158
PERCENT OF RECOVERY	0.0	50.7	49.2		

Appendix Table 1.10

9 NOV 84

1982 MCNARY - TAILRACE

FALL CHINOOK

MARKS USED	LAH 1	LAH 2	LAIF1	LAIF2	LAIF3	NUMBER RELEASED	38683
	LAIF4	LAIC1	LAIC2	LAIC3	LAIC4		
	LAIM1	LAIM2	LAIM3	LAIM4	231609		
	231611	231613					

RECOVERY AREA	1982	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS					
BONNEVILLE TRAP	0	5	16	21	0.054
MCNARY TRAP	0	1	1	2	0.005
LOWER GRANITE TRAP	0	1	0	1	0.002
OCEAN FISHERIES					
ALASKA	0	1	0	1	0.002
BRITISH COLUMBIA	0	1	0	1	0.002
RIVER SPORT	0	0	0	0	0.000
RIVER COMMERCIAL	0	0	0	0	0.000
INDIAN FISHERY	0	0	0	0	0.000
HATCHERIES	0	0	0	0	0.000
TOTALS	0	9	17	26	0.067
PERCENT OF RECOVERY	0.0	34.6	65.3		

Appendix Table 1.11

9 NOV 84

1983 MCNARY — TRUCK

FALL CHINOOK

MARKS USED RAIJ1 RAIJ2 RAIJ3 231625 231628 231631

NUMBER RELEASED 35279

RECOVERY AREA	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS				
BONNEVILLE TRAP	0	31	31	0.087
MCNARY TRAP	0	28	28	0.079
LOWER GRANITE TRAP	0	0	0	0.000
OCEAN FISHERIES	0	0	0	0.000
RIVER SPORT	0	0	0	0.000
RIVER COMMERCIAL	0	0	0	0.000
INDIAN FISHERY	0	0	0	0.000
HATCHERIES	0	0	0	0.000
TOTALS	0	59	59	0.167
PERCENT OF RECOVERY	0.0	100.0		

Appendix Table 1.12

9 NOV 84

1983 MCNARY — BARGE

FALL CHINOOK

MARKS USED RA3 1 RA3 2 RA3 3 231626 231629 231632

NUMBER RELEASED 38860

RECOVERY AREA	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS				
BONNEVILLE TRAP	0	34	34	0.087
MCNARY TRAP	0	22	22	0.056
LOWER GRANITE TRAP	0	0	0	0.000
OCEAN FISHERIES	0	0	0	0.000
RIVER SPORT	0	0	0	0.000
RIVER COMMERCIAL	0	0	0	0.000
INDIAN FISHERY	0	0	0	0.000
HATCHERIES	0	0	0	0.000
TOTALS	0	56	56	0.144
PERCENT OF RECOVERY	0.0	100.0		

Appendix Table 1.13

9 NOV 84

1983 MCNARY — TAILRACE

FALL CHINOOK

MARKS USED: LA2L1 LD2T1 231633 | LA2L3 LA2X1 | LD2L1 LA2X3 | LA2T1 231627 | LA2T3 231630

NUMBER RELEASED 40301

RECOVERY AREA	1983	1984	TOTALS	PERCENT RETURN
RIVER SYSTEM TRAPS				
BONNEVILLE TRAP	0	7	7	0.017
MCNARY TRAP	0	3	3	0.007
LOWER GRANITE TRAP	0	0	0	0.000
OCEAN FISHERIES	0	0	0	0.000
RIVER SPORT	0	0	0	0.000
RIVER COMMERCIAL	0	0	0	0.000
INDIAN FISHERY	0	0	0	0.000
HATCHERIES	0	0	0	0.000
TOTALS	0	10	10	0.024
PERCENT OF RECOVERY	0.0	100.0		

Appendix Table 2.--Summary of brands and wire tag codes used to identify juvenile spring chinook salmon marked at Lower Granite Dam and transported by barge to below Bonneville Dam, 1984.

Date	Position of brand and orientation	Wire tag code	Number marked
4-16	RA-L, 1	23, 16, 41	715
4-17	RA-L, 1	23, 16, 41	1,371
4-18	RA-L, 1	23, 16, 41	1,507
4-19	RA-L, 1	23, 16, 41	353
Totals	RA-L, 1	23, 16, 41	3,946
4-19	RA-L, 1	23, 16, 42	1,476
4-20	RA-L, 1	23, 16, 42	2,180
4-21	RA-L, 1	23, 16, 42	2,164
Totals	RA-L, 1	23, 16, 42	5,820
4-21	RA-L, 1	23, 16, 43	389
Totals	RA-L, 1	23, 16, 43	389
4-23	RA-L, 2	23, 16, 49	4,689
4-24	RA-L, 2	23, 16, 49	2,931
4-25	RA-L, 2	23, 16, 49	3,044
4-26	RA-L, 2	23, 16, 49	3,256
Totals	RA-L, 2	23, 16, 49	13,920
4-26	RA-L, 2	23, 16, 50	3,410
4-27	RA-L, 2	23, 16, 50	5,464
4-28	RA-L, 2	23, 16, 50	4,919
Totals	RA-L, 2	23, 16, 50	13,793
4-29	RA-L, 3	23, 16, 48	3,959
4-30	RA-L, 3	23, 16, 48	350
5-01	RA-L, 3	23, 16, 48	350
5-02	RA-L, 3	23, 16, 48	350
5-03	RA-L, 3	23, 16, 48	184
Totals	RA-L, 3	23, 16, 48	5,193
5-05	RA-L, 4	23, 16, 47	949
5-06	RA-L, 4	23, 16, 47	624
5-07	RA-L, 4	23, 16, 47	100
5-08	RA-L, 4	23, 16, 47	100
5-09	RA-L, 4	23, 16, 47	100
5-10	RA-L, 4	23, 16, 47	100
5-11	RA-L, 4	23, 16, 47	100
5-12	RA-L, 4	23, 16, 47	300
5-14	RA-L, 4	23, 16, 47	300
5-15	RA-L, 4	23, 16, 47	439
Totals	RA-L, 4	23, 16, 47	3,112

Total marked--46,173

Appendix Table 3.--Summary of brands and wire tag codes used to identify juvenile steelhead marked at Lower Granite Dam and transported by barge to below Bonneville Dam, 1984.

Date	Position of brand and orientation	Wire tag code	Number marked
4-23	RA-L, 1	23, 16, 44	1,500
4-24	RA-L, 1	23, 16, 44	1,015
4-25	RA-L, 1	23, 16, 44	561
4-26	RA-L, 1	23, 16, 44	1,510
4-27	RA-L, 1	23, 16, 44	875
4-28	RA-L, 1	23, 16, 44	598
Totals	RA-L, 1	23, 16, 44	6,059
4-28	RA-L, 1	23, 16, 45	1,279
4-29	RA-L, 1	23, 16, 45	1,269
Totals	RA-L, 1	23, 16, 45	2,548
4-30	RA-L, 2	23, 16, 46	1,167
5-01	RA-L, 2	23, 16, 46	1,443
5-02	RA-L, 2	23, 16, 46	1,730
5-05	RA-L, 2	23, 16, 46	845
Totals	RA-L, 2	23, 16, 46	5,185
5-06	RA-L, 3	23, 16, 51	1,537
5-07	RA-L, 3	23, 16, 51	1,217
5-08	RA-L, 3	23, 16, 51	941
5-09	RA-L, 3	23, 16, 51	821
5-10	RA-L, 3	23, 16, 51	1,040
5-11	RA-L, 3	23, 16, 51	1,056
5-12	RA-L, 3	23, 16, 51	1,183
Totals	RA-L, 3	23, 16, 51	7,795
5-14	RA-L, 4	23, 16, 52	1,351
5-15	RA-L, 4	23, 16, 52	2,400
5-17	RA-L, 4	23, 16, 52	3,028
5-18	RA-L, 4	23, 16, 52	500
5-19	RA-L, 4	23, 16, 52	500
Totals	RA-L, 4	23, 16, 52	7,779
5-22	RA-7F, 1	23, 16, 52	2,129
5-24	RA-7F, 1	23, 16, 52	1,034
5-27	RA-7F, 1	23, 16, 52	1,000
Totals	RA-7F, 1	23, 16, 52	4,163

Total marked--33,529

Appendix Table 4.--Bypass gallery and pipe test data for spring chinook salmon smolts sampled from B-Slot gatewells, a gallery trap located at the downstream end of the bypass gallery, and the pre-separator area and subsequently challenged to artificial seawater at 34 ppt for 24 h. Table includes test numbers, descaling, total biomass, and average length of live and dead fish by test condition and replicate. (Includes some steelhead which were unintentionally sampled with spring chinook salmon in some tests.)

		Dead fish						Live fish						
		No. nondescaled		No. descaled		Average fork length (mm)		No. nondescaled		No. descaled		Average fork length (mm)		
Test no.	Date	Chin	Sthd	Chin	Sthd	Chin	Sthd	Chin	Sthd	Chin	Sthd	Chin	Sthd	Total biomass (gm)
							Test condition - Gatewell 1B							
1A	5/17-18	1	0	0	0	89.0	--	49	2	1	0	123.1	172.5	1,131.6
1B	5/17-18	0	0	0	0	--	--	54	0	2	0	113.2	--	1,033.1
1C	5/17-18	0	0	0	0	--	--	50	0	4	0	116.9	--	875.0
2A	5/19-20	0	0	0	0	--	--	41	2	2	0	127.8	182.0	1,200.0
2B	5/19-20	1	0	1	0	108.5	--	36	0	0	0	127.4	--	850.2
2C	5/19-20	7	0	3	0	124.2	--	39	4	2	0	128.3	175.5	1,269.5
Totals or averages		9	0	4	0	107.2	--	269	8	11	0	122.8	176.7	1,059.9
							Test condition - Gatewells 2B and 3B							
1A	5/17-18	3	0	0	0	118.7	--	41	1	0	0	132.6	226.0	1,132.1
1B	5/17-18	1	0	1	0	105.5	--	26	0	2	0	129.5	--	828.2
1C	5/17-18	0	0	1	0	115.5	--	22	0	1	0	139.2	--	641.2
2A	5/19-20	0	0	0	0	--	--	11	2	0	0	140.0	170.5	400.0
2B	5/19-20	1	0	0	0	113.0	--	15	3	0	0	144.8	177.7	690.5
2C	5/19-20	0	0	0	0	--	--	24	2	0	0	137.5	212.0	850.0
Totals or averages		5	0	2	0	113.2	--	139	8	3	0	137.3	196.6	757.0

Appendix Table 4.--cont.

Test no.	Date	Dead fish: No. nondescaled Chin	Dead fish: No. nondescaled Sthd	Dead fish: No. descaled Chin	Dead fish: No. descaled Sthd	Dead fish: Average fork length (mm) Chin	Dead fish: Average fork length (mm) Sthd	Live fish: No. nondescaled Chin	Live fish: No. nondescaled Sthd	Live fish: No. descaled Chin	Live fish: No. descaled Sthd	Live fish: Average fork length (mm) Chin	Live fish: Average fork length (mm) Sthd	Total biomass (gm)
Test condition - Gatewell 6B														
1A	5/17-18	1	0	0	0	111.0	--	22	0	2	0	120.8	--	412.8
1B	5/17-18	0	0	0	0	--	--	18	1	3	0	118.3	142.0	425.0
1C	5/17-18	0	0	0	0	--	--	22	0	0	0	122.0	--	400.0
2A	5/19-20	0	0	0	0	--	--	29	10	0	1	119.5	162.3	1,100.0
2B	5/19-20	0	0	0	0	--	--	33	8	1	1	126.5	169.9	1,100.0
2C	5/19-20	1	0	0	0	110.0	--	21	2	3	0	127.8	168.0	537.0
Totals or averages		2	0	0	0	110.5	--	145	21	9	2	122.5	160.6	662.5
Test condition - Gallery trap														
1A	5/17-18	0	0	0	0	--	--	19	0	0	0	128.5	--	450.0
1B	5/17-18	0	0	1	0	198.0	--	21	0	0	0	123.8	--	533.5
1C	5/17-18	0	0	0	0	--	--	18	0	1	0	129.7	172.0	425.0
2A	5/19-20	1	0	0	0	118.0	--	17	10	1	0	127.7	177.9	917.7
2B	5/19-20	0	0	0	0	--	--	29	4	0	0	133.7	173.8	650.0
2C	5/19-20	3	0	0	0	125.3	--	24	8	0	0	131.5	177.0	1,042.2
Totals or averages		4	0	1	0	147,1	--	128	22	2	0	129.2	175.2	669.7
Test condition - Preseparator														
1A	5/17-18	2	0	0	0	108.0	--	17	0	0	0	118.5	--	329.6
1B	5/17-18	1	0	1	0	109.5	--	15	0	1	0	127.3	--	525.0
1C	5/17-18	0	0	3	0	107.7	--	18	1	0	0	123.7	135.0	393.5
2A	5/19-20	2	0	1	0	117.3	--	19	3	1	0	122.6	161.0	501.0
2B	5/19-20	0	0	2	0	123.5	--	18	0	0	0	128.1	--	445.8
2C	5/19-20	3	0	0	0	106.3	--	21	0	0	0	122.7	--	471.4
Totals or averages		8	0	7	0	112.1	--	108	4	2	0	123.8	148.0	444.4

Appendix Table 5.--Individual plasma Na^+ and Cl^- levels (meq/liter) in spring chinook salmon smolts sampled from the B-Slot gatewells, a trap located at the downstream end of the bypass gallery, and the preseparator area and subsequently challenged to artificial seawater at 26 ppt for 24 h at Lower Granite Dam, 1984. Test 1 was conducted from 17 to 18 April and Test 2 from 19 to 20 April.

B-Slot gatewells				Bypass gallery				Pre-separator			
Test 1		Test 2		Test 1		Test 2		Test 1		Test 2	
Na^+	Cl^-	Na^+	Cl^-	Na^+	Cl^-	Na^+	Cl^-	Na^+	Cl^-	Na^+	Cl^-
158.5	131.7	158.4	136.3	153.0	132.4	161.3	135.6	163.0	149.7	186.4	169.3
154.0	133.5	157.0	134.2	174.5	152.8	190.3	169.6	153.0	134.4	160.8	135.8
153.0	130.6	157.0	135.7	152.5	136.5	153.1	131.0	153.0	134.5	155.5	135.4
153.5	133.6	157.9	140.5	156.5	136.1	161.8	138.5	147.0	132.2	161.3	141.0
149.0	130.0	148.8	137.0	156.0	131.1	153.6	133.7	151.5	133.2	157.5	132.4
156.0	135.5	158.4	128.2	151.0	130.4	158.4	132.0	150.0	133.9	163.7	140.0
150.5	128.6	162.3	132.0	161.5	139.1	157.5	132.2	153.5	136.2	168.6	144.5
155.5	132.5	159.4	134.9	165.5	137.8	162.8	135.5	154.0	133.4	156.0	136.3
159.0	129.9	161.8	130.9	166.0	138.5	157.5	136.4	182.0	153.1	163.3	140.9
155.0	133.3	162.3	136.7	159.5	138.2	156.5	135.0	158.0	137.1	160.8	138.8
151.5	128.6	154.1	127.9	153.5	130.8	169.5	147.2	148.0	131.1	158.9	133.8
156.5	131.1	170.5	145.9	153.5	138.5	157.0	134.3	169.0	158.3	156.5	137.3
155.0	126.8	157.5	136.7	151.5	132.6	156.0	127.2	155.0	134.5	151.7	134.8
157.5	133.0	156.5	136.6	151.0	133.8	155.5	135.6	156.0	134.4	154.6	131.9
153.0	130.6	153.1	130.1	148.5	131.8	157.9	131.4	156.0	135.7	183.5	167.5
156.0	128.8	155.5	133.8	154.0	130.9	156.0	127.7	170.0	159.6	157.5	139.8
156.5	134.5	157.0	129.0	160.0	147.6	159.9	133.2	156.0	133.7	155.5	138.1
157.5	133.1	154.6	134.2	155.0	137.9	160.4	132.5	154.5	132.4	162.3	141.9
161.0	138.3	153.6	131.2	171.5	144.8	160.8	136.9	153.5	131.4		
155.0	126.9	152.6	132.3	155.0	135.4	158.9	136.2				
157.0	129.9	155.5	134.6	164.5	142.1	157.0	131.7				
163.0	135.5	150.7	134.8	151.5	136.0	156.5	133.8				
156.0	130.5	156.0	130.3								
156.5	132.8	157.0	140.8								
161.0	138.0	156.5	130.5								
157.5	134.5	157.0	136.6								
163.5	134.3	158.9	134.3								
154.0	128.0	156.5	133.2								
158.5	135.0	159.4	135.6								
		158.4	138.6								
		156.5	133.7								
		152.6	137.5								
		155.1	143.5								
		152.6	134.2								

Appendix Table 6.--Temperature, oxygen, pH, salinity, and ammonia (NH_3^+) levels by date in the extended seawater rearing studies conducted at Lower Granite Dam, 1984.

Date	Temperature °C Tank	Temperature °C Head box	O_2 (ppm)	pH	Salinity (ppt)	NH_3^+ (ppm)
05-02-84	10.5	10.0	-	-	-	-
05-03-84	12.2	10.5	8.4	-	-	-
05-04-84	07.8	08.0	9.5	-	-	-
05-05-84	09.0	10.0	-	-	02.3	-
05-06-84	10.0	10.0	9.9	-	04.2	-
05-07-84	11.0	12.0	9.4	-	06.5	-
05-08-84	11.0	11.0	9.4	-	08.0	-
05-09-84	11.0	11.0	9.0	-	09.5	-
05-10-84	10.5	10.0	9.0	-	12.0	-
05-11-84	11.0	10.5	8.7	-	14.5	-
05-12-84	10.5	10.5	9.0	7.91	16.0	-
05-13-84	10.5	10.5	9.0	7.90	17.0	-
05-14-84	09.5	09.0	9.2	7.69	17.5	-
05-15-84	10.5	10.0	9.0	7.80	20.0	-
05-16-84	10.5	10.0	9.1	7.70	21.0	-
05-17-84	09.5	09.5	9.2	7.75	22.5	-
05-18-84	09.5	09.5	9.3	7.82	24.0	-
05-19-84	10.0	09.5	8.3	7.40	26.2	-
05-20-84	09.5	09.5	8.8	7.50	26.0	-
05-21-84	09.5	09.5	8.9	7.84	26.0	-
05-22-84	09.5	09.5	8.7	7.82	26.0	0.005
05-23-84	10.0	09.5	9.1	7.55	27.0	0.004
05-24-84	10.0	09.5	9.2	7.80	28.0	0.007
05-25-84	09.5	09.5	8.3	7.85	30.0	0.008
05-26-84	09.5	09.5	9.5	7.85	30.0	0.009
05-27-84	10.1	09.5	9.5	7.86	30.0	0.011
05-28-84	10.0	09.5	8.9	7.87	29.5	0.011
05-29-84	10.0	09.0	8.9	7.86	29.8	0.011
05-30-84	09.5	09.0	8.9	7.85	28.5	0.011
05-31-84	09.5	09.0	8.9	7.86	28.5	0.012
06-01-84	10.0	10.0	9.0	7.86	28.1	0.013
06-02-84	10.1	09.8	9.2	7.86	29.0	0.013
06-03-84	10.2	09.0	9.0	7.84	29.1	0.013
06-04-84	09.5	09.5	9.2	7.85	28.5	0.013
06-05-84	11.0	11.5	9.0	7.78	29.0	0.013
06-06-84	10.1	10.1	9.0	7.87	29.1	0.013
06-07-84	13.1	13.0	9.0	7.84	28.9	0.013
06-08-84	07.5	07.5	9.0	7.79	28.4	0.013
06-09-84	09.8	09.5	9.0	7.75	28.4	0.013
06-10-84	09.9	09.8	9.0	7.76	28.9	0.011
06-11-84	09.8	10.0	9.0	7.74	29.0	0.011
06-12-84	09.9	09.9	9.0	7.82	28.8	0.012
06-13-84	11.0	09.0	9.0	7.86	29.0	0.012