Response to the Questions of the Implementation Team Regarding Juvenile Salmon Transportation in the 1998 Season

ISAB REPORT 98-2

Richard N. Williams, Chair
Peter Bisson
Charles C. Coutant
Daniel Goodman
James Lichatowich
William Liss
Lyman McDonald
Phillip Mundy
Brian Riddell
Jack A. Stanford
Richard R. Whitney, Co-Chair

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EXECUTIVE SUMMARY

This report is the ISAB response to three questions raised by the National Marine Fisheries Services' Implementation Team in the letter of December 3, 1997 from Dr. Michael Schiewe, National Marine Fisheries Service, to Dr. Richard Williams, Chair of the ISAB concerning the possible consequences of juvenile transportation in 1998 on subsequent adult returns and straying of salmon and steelhead from the Snake River. During the course of preparing answers to the questions, the ISAB noted a mismatch between the questions and the available information. The method of transportation for which information is available is not the same as the current method of transport. The kinds of fish on which transport has been tested are not the same as those for which protection is most critical, the listed species. Therefore, drawing analogies between different modes of transportation and different species of fish introduces substantial uncertainty. Given the magnitude of uncertainty imposed by the nature and extent of available information, it continues to be prudent to exercise caution in weighing the possible risks against the perceived benefits of juvenile transportation. Here are brief answers to the questions.

1. " ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the survival to adult returns between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"

Statistically significant differences have not been documented on a stock by stock basis. The present mixed-stock truck and barge transportation system probably would improve survival for some affected populations, given the same in-river survival levels present during the NMFS studies. However, the effect of transportation on any particular population is unknown. Barging juvenile stream type chinook (spring/summer) and steelhead should improve survival for some populations of these two types of fish, but it is not known which populations would benefit. It is important for managers to understand how individual populations fare under transport, because the combined effects of collection and transportation may decrease survival for some populations, life history types and species. With respect to the Snake River, the effects of barging have been systematically studied with modern (post-1982) tagging methods only for stream type chinook and steelhead taken as a single group. Although some portion of all emigrants is trucked, the effects of trucking juveniles from the Snake River have not been systematically studied. The effects of transport accrue only to those animals entrained (collected) in the bypass systems. Ample evidence is available to demonstrate that the collection efficiency of each bypass system varies by species, life history type and population. Within species and populations, the collection efficiency of

the bypass systems is a function of the physiological state of the fish, time of year, and other factors.

2. " ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the straying rate between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"

There are sometimes differences in the straying rate between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in the river. Documented instances of transportation-related straying appear to be related to lack of adequate imprinting, and most often occurred in the course of truck transportation. Differences had no apparent relation to the range of flow conditions prevalent for the experimental lots of fish for which these differences were measured, but reviews on this subject have been limited. Whether or not the observed differences in straying rate are biologically meaningful is unknown. Without knowledge of whether the differences are biologically meaningful, questions concerning statistical significance are meaningless.

3. " Based on your comprehensive review and analyses of whether differences in survival to adult returns and straying rate are real and significant, what is the likelihood that collection and transportation of salmon and steelhead at the Snake River projects and McNary Dam in 1998 will result in an increased adult return compared to allowing those same fish to migrate in-river?"

Considering all species, life history types and populations together, the effects of combined trucking and barging on adult return and straying rates are uncertain. For the stream type chinook (spring/summer) salmon and steelhead populations of some hatcheries and watersheds, it is likely that collection and barge transportation in 1998 would result in an increased adult return compared to allowing those same types of fish to migrate in-river, given that hydroelectric operations in 1998 are representative of the past. However, the increase in stream type chinook salmon and steelhead could be the result of selective enhancement only of some stocks, and we have no basis for knowing which stocks would benefit and which might be disadvantaged by this action. We emphasize that the benefit of any single action, such as smolt transportation, needs to be evaluated not only for its average benefit, but also in regard to the variation in benefits within and between populations.

RECOMMENDATIONS

1. We recommend a 1998 management approach that divides juvenile emigrants throughout the migration season between barging and natural emigration. In the long term,the result should be to apply mitigation measures evenly across all stocks. The 1998 management approach should work in concert with hydroelectric system operations that maximize survival of natural emigrants. The available information does not support taking the majority of emigrants of any stock into transportation. A spread the risk approach involving the use of barges, spill and other measures intended to enhance downstream passage survivals should be started each year as early as possible and continued as late as possible to protect the entire spectrum of the salmon and steelhead emigration.

2. We recommend that trucks not be used in the transportation program. There is a paucity of data on the effects of Snake River trucking on salmon and steelhead so that necessary information to guide management actions is absent. Most historical information on truck transportation shows lesser survival benefits and more problems with homing than have been experienced with barge transportation.

3. We recommend that management actions intended to protect salmon and steelhead be population specific to the maximum extent possible. Management decisions should be based on the expected outcomes of clearly defined actions on the spawning populations from specific watersheds, as opposed to extension of T/C comparisons of outcomes of mixed stocks resulting from unspecified actions. For the protection and enhancement of life history and stock diversity that is critical for recovery, it is important that comparisons of survival of transported and natural emigrants be assessed based on returns to, and spawning success within, the spawning grounds of individual stocks.

INTRODUCTION

This report is the ISAB response to three questions raised by the National Marine Fisheries Services' Implementation Team in the letter of December 3, 1997 from Dr. Michael Schiewe, National Marine Fisheries Service, to Dr. Richard Williams, Chair of the ISAB.

The questions asked were:

1. **" ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the survival to adult returns between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"**

2. **" ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the straying rate between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"**

3. **" Based on your comprehensive review and analyses of whether differences in survival to adult returns and straying rate are real and significant, what is the likelihood that collection and transportation of salmon and steelhead at the Snake River projects and McNary Dam in 1998 will result in an increased adult return compared to allowing those same fish to migrate in-river?"**

PROCEDURE FOLLOWED

In developing our response, we arranged a briefing at a December 17, 1997 meeting of the ISAB in Portland. We invited interested parties to participate in the briefing. Participants were representatives of the National Marine Fisheries Service, the U.S. Army Corps of Engineers, Idaho Department of Fish and Game, and the Columbia River Intertribal Fish Commission. We also received a written briefing from Oregon Department of Fish and Wildlife. In addition to these, we relied upon the references cited at the end of this report. We would have preferred to produce a formally documented, in-depth report, but available time did not allow such a response. Available time was constrained by the requirement to provide analysis useful for 1998 management decisions.

We applied the conceptual foundation developed by the Independent Scientific Group in *Return to the River* (ISG 1996) to the questions before attempting to answer them. From that perspective, it became

apparent that the questions of December 3, as well as the original concept of transportation, assumes that a single answer exists with respect to the effects of transportation on salmon and steelhead without reference to differential effects on species or specific populations, or the conditions imposed by different modes of transportation. In *Return to the River*, the ISG described three elements of a conceptual foundation, the third of which applies to this situation, "Life history diversity, genetic diversity and metapopulation organization are ways salmon adapt to their complex and connected habitats" (ISG 1996). These essential factors (population complexity and diversity) enable salmonids to cope with environmental variation that is typical of freshwater and marine environments (ISG, 1996).

An overarching question is therefore raised as to whether the various types of transportation affect all salmonid species, life history types and populations equally (i.e., it is non-selective) or whether they affect different species, life history types and populations differently (i.e., it is selective). If the latter, the transportation program may benefit some stocks, while at the same time eroding overall levels of life history diversity, genetic diversity and metapopulation organization essential to sustainable production. We address this overarching question in our response.

ISAB RESPONSES TO THE QUESTIONS

1. " ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the survival to adult returns between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"

The data suggest differences in the rates of survival to adult returns between stream type (spring/summer) salmon and steelhead that are transported as juveniles versus those left to migrate in-river. These differences, transport minus in-river, are both positive and negative, but total annual differences are more likely to be positive than negative. The extent to which any difference may be biologically meaningful appears to depend on a number of physical and biological factors. The physical factors include watershed of origin (e.g. the distance of the rearing grounds from the point of transportation, and the related factor of time of the year of transport), and the biological factors include species, life history type, and population. Population specific factors such as rate of growth and state of maturity on entering the hydroelectric system may also determine the extent to which transport is biologically meaningful. As a consequence, transport is unlikely to be biologically meaningful to all of the salmon and steelhead populations in the Snake River basin, although it could be biologically

meaningful to some stream type populations. Some of the observed differences for stream type salmon and steelhead (both positive and negative) are statistically significant based on our limited review of original data. However statistical significance is primarily a function of sample size and does not insure that the differences are biologically meaningful.

2. **" ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the straying rate between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"**

There are sometimes differences in the straying rate between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in the river. Documented instances of transportation related straying appear to be due to lack of imprinting. The largest rates of straying occurred in the course of truck transportation. Differences in straying rates have no apparent relation to the range of flow conditions prevalent for the experimental lots of fish for which these differences were measured. Whether or not the observed differences in straying rate are biologically meaningful is unknown. Without knowledge of whether the differences are biologically meaningful, questions concerning statistical significance are meaningless.

3. **" Based on your comprehensive review and analyses of whether differences in survival to adult returns and straying rate are real and significant, what is the likelihood that collection and transportation of salmon and steelhead at the Snake River projects and McNary Dam in 1998 will result in an increased adult return compared to allowing those same fish to migrate in-river?"**

For each and every Snake River salmon and steelhead population it is not likely that collection, trucking and barging at the Snake River projects and McNary Dam in 1998 would result in an increased adult return compared to allowing those same fish to migrate in-river. For some stream type salmon and steelhead populations, it is likely that collection and barge transportation would result in an increased adult return compared to allowing those same fish to migrate in-river. For other salmon and steelhead populations, collection and transportation may result in a decreased adult return compared to allowing those same fish to migrate in-river.

Concluding response

It is impossible to reconcile a maximum transport approach to salmon recovery with protection of the remaining diversity of salmon and steelhead populations in the Snake River basin. Our answers and conclusion are further discussed in the following sections.

SUPPORTING INFORMATION

The degree to which the available information on juvenile transportation is applicable to advising management in 1998 is a matter of concern. The method of transportation, barging, for which information is available, is not the same as the current method of transport, combined trucking and barging. The kinds of animals on which barge transport has been tested since 1982, run-of-the-river stream type (spring/summer) chinook and steelhead, are not the same as those for which protection is most critical, the listed species of fall chinook, sockeye, wild spring/summer chinook and wild steelhead. Run-of–the river animals are most likely to be steelhead and stream type chinook that originated in hatcheries, as opposed to the listed species that are by definition wild animals that originated from natural spawning. The degree to which information that was collected in the Snake River prior to 1983, or that was collected outside the Snake River basin at any time, may apply to the 1998 juvenile transportation management situation is a matter of some uncertainty. Nonetheless, the ISAB believes the following summary and interpretations of scientific information provide a useful context for consideration of the three questions on transportation.

Description of Transportation

The original concept of transportation was to provide salmon and steelhead smolts with a route of passage through the hydroelectric system that avoided the mortality they would otherwise experience in the reservoirs and at the dams. Collection of juvenile salmon for transportation depends upon their diversion by way of the turbine intake bypass systems at the dams (Mighetto and Ebel 1994). Transportation began as a management measure in 1975 after a decade of research led to the conclusion that in most cases, seasonal average adult return rates of mixed stocks of predominantly stream type salmonids that were transported as juveniles, exceeded the return rates of similar fish that migrated in-

river (Ebel 1980; Ebel et al. 1973; Mighetto and Ebel 1994). Concerns about homing and straying induced by transportation have not been adequately addressed by research programs, although some studies have been attempted as reviewed by Mundy et al. (1994). More information on this subject is provided below in the section on Impairment of Homing.

Modern transportation experiments model "transportation" as a single treatment effect represented by barging (Achord et al. 1992, Harmon et al. 1989, 1993, 1995-96; Marsh et al. 1996, 1997; Matthews et al. 1990, 1992). The data for barging juvenile stream type chinook and steelhead in the Snake River suggest differences in the rates of survival to adult to the point of collection for transportation between stream type (spring/summer) chinook salmon and steelhead that are transported by barge as juveniles versus those left to migrate in-river (Ward et al. 1997). Some of the observed differences in rate of return between transported and non-transported salmon (both positive and negative) are statistically significant based on our limited review of original data, and the analysis provided by Ward et al. (1997). However statistical significance does not insure that the differences are biologically meaningful.

Estimates of the effects of transport on survival of salmonids made after the 1982 season in the Snake River (Achord et al. 1992; Harmon et al. 1989, 1993, 1995-96; Marsh et al. 1996, 1997; Matthews et al. 1990, 1992) are generally regarded by researchers as being more reliable than those made before then (Matthews 1992). The improvement in reliability was due to advances in fish handling technology and time trends in physical conditions affecting survival in the hydroelectric system of the Snake River. Another limitation in interpretation of transport experiments is that time trends in stock composition of the experimental subjects are a factor in determining transport to control return rates (Matthews 1992). Large increases in the proportion of hatchery spring/summer chinook in transportation have been suggested as an explanation for unexpectedly low rates of adult return in transported subjects (Matthews 1992). For the purposes of management decisions, the results of the modern transportation experiments (Achord et al. 1992; Harmon et al. 1989, 1993, 1995-96; Marsh et al. 1996, 1997; Matthews et al. 1990, 1992) would be the most informative.

In contrast to the modern transport experiments, the actual method of transportation is not uniformly applied across species within a year, or within a species across years. Both barges and trucks are used in varying combinations to transport juvenile salmon and steelhead from the Snake River. Mixtures of many different populations, consisting of members of listed species, non-listed ESU species, and non-

listed/non-ESU salmonid species, are moved down the river by various combinations of truck and barge trips during only a portion of each migration season. The transportation system is therefore a mixed-stock combined barge and truck operation applied to the numerical majority of the emigrants. During the five years ending in 1996, 92 percent (annual range 32 - 99%) of juvenile fall chinook transported from Lower Granite Dam were moved by truck. At the same location, during the same years, 24 percent (annual range 8 - 66%) of the wild sockeye/kokanee and 2.5 percent of the wild steelhead (annual range 1 - 4%) were moved by truck. During 1993 - 1996, nine percent (annual range 3 - 12%) of the wild spring/summer chinook were moved by truck from Lower Granite Dam.

Within the Snake River, information about the effects of truck and barge transport on other salmon life history types, on the populations of individual drainages, and on other anadromous species is lacking (Mundy et al. 1994; Harmon et al. 1995, 1996; Marsh et al. 1996, 1997; Ward et al. 1997). In particular, estimates of the effects of variable combinations of truck and barge transport from the Snake River for the four Snake River ESU's have not been made. The kinds of fish on which transport has been tested within the Snake River (Mundy et al. 1994; Harmon et al. 1995, 1996; Marsh et al. 1996, 1997; Ward et al. 1997) are not the same as those for which protection is most critical, the listed species. In the case of stream type chinook (spring and summer chinook) and steelhead, the effects on survival of barge transport from the Snake River have been compared to those emigrating within the federal hydroelectric system. Even so, stream type chinook and steelhead are much broader taxonomic groupings than the two listed species which they contain (Snake River wild spring/summer chinook and Snake River wild steelhead). Steelhead is a different species from sockeye, and fall, or ocean type, chinook. Stream type chinook is a life history type that is different from fall, or ocean type, chinook and it is a different species altogether from sockeye salmon.

Different species, life history types and populations of salmon and steelhead are expected to respond differently to any consistently applied means of juvenile transportation. Any single species, life history type, or population is expected to respond differently to variably applied types of juvenile transport. In the case of Snake River salmon, it is not advisable to use estimates derived from barging for one species to infer the consequences of combined trucking and barging for other species. As a group, the listed species are quite biologically diverse, and the type of transportation program applied each year differs among listed species, and within each listed species.

In spite of barge and truck transportation as a continuing management measure since 1980, threatened Snake River listed species of spring/summer and fall chinook, steelhead, and the endangered listed species of sockeye have continued to decline. The Proposed Recovery Plan for Snake River Salmon calls for improvements in both transportation and in-river passage (NMFS/NOAA 1995, p. V-2-13). Transportation is also recommended in the Northwest Power Planning Council's Fish and Wildlife Program (NPPC 1994) and in the report of the National Research Council's Committee on Protection and Management of Pacific Northwest Anadromous Salmonids (NRC 1996). Both the NPPC and the NRC attach caveats regarding uncertainty due to poorly understood factors, such as the possible effects of transportation on the homing ability of returning adults. At the same time, both the Independent Scientific Group appointed by the Northwest Power Planning Council and the NRC Committee concluded that transportation taken alone is not sufficient to overcome the current negative effects of habitat loss, hydropower operations and other sources of mortality for juvenile salmon (ISG 1996; NRC 1996).

Collection of salmon and steelhead smolts for transportation

Before they can be transported, salmon and steelhead smolts must be collected from the river. Interception takes place at the so-called "collector dams", as designated in the NMFS Proposed Recovery Plan (1995) for Snake River Salmon (Lower Granite, Little Goose and Lower Monumental). In addition, the barges and trucks that are loaded at the three Snake River collector dams may stop in the Columbia River at McNary Dam to take on individuals from the anadromous salmonid species that are collected there.

Ability to intercept anadromous salmonids depends upon the fish guidance efficiency (FGE) of the turbine intake screens in place at those projects (Whitney et al. 1997). FGE is different for each project, species, time of day (especially day versus night), design and configuration of the screen, degree of smoltification of the fish, and progress of the season. A further complication is that the bulk of stream type (yearling) chinook and steelhead are early emigrants, with sockeye being somewhat later, while ocean type (subyearling) chinook, though present through the season, predominate among the later emigrants (Fish Passage Center Annual Reports).

Thus, collection and transportation protocols are highly differential in application to species, life history type and population due to differences among populations in factors such as timing of downstream migration and arrival at collection sites, fish guidance efficiency, and whether the fish are transported by barge or truck. Intolerance to any of these modes of treatment could contribute progressively to loss of life history and population diversity. Moreover, when salmon populations are organized into metapopulations (NRC 1996, ISG 1996), transportation protocols that selectively favor certain populations over others could continue to erode, rather than restore, metapopulation integrity in river basins.

The modern assessments of Snake River transport of spring/summer chinook, as provided by current research programs (Achord et al. 1992; Harmon et al. 1989, 1993, 1995-96; Marsh et al. 1996, 1997; Matthews et al. 1990, 1992), apply only to mixed-stock barging, not trucking. Further we note that a single point estimate of the mixed-stock barging transport benefit ratio is highly unlikely to apply to the present combination of truck and barge transportation, let alone to capture the risk to salmon recovery posed by variability among spawning populations in the transport benefit ratio. Members of the spring/summer chinook ESU are not distinguished from other spring/summer chinook in the data gathering programs of the federal government on transportation (1996 Annual Report on Transportation, US Army Corps of Engineers). Although some hatchery spring/summer chinook are also members of the spring/summer chinook ESU, federal data gathering programs segregate the emigrants into "hatchery" and "wild" categories. There are no data and analyses that establish the applicability of barge transport benefit ratios (based on mixtures of hatchery and wild spring/summer chinook) to transport by both truck and barge of the listed spring/summer chinook species. We could find no analysis of the applicability of mixed stock barge transport benefit ratios to the listed spring/summer chinook salmon species. Application of a single estimate of an attribute to all populations of spring/summer chinook in the Snake River basin is not consistent with the federal recovery efforts and the ISG's conceptual foundation developed in *Return to the River*, nor is it advisable.

The fact that time of arrival of salmon at the dams has a clear effect on how and whether the emigrants are transported (see 1996 Annual Report of Transportation) illustrates the variable application of transport methods across populations and species. A variable proportion of each of the 38 spring chinook populations identified in the Proposed Recovery Plan (NMFS/NOAA 1995) will be subject to truck transportation each year. Trucking is invoked in response to declining numbers of downstream

migrating smolts at different times each year as a means of saving on the cost of barging. Note that trucking of juveniles is based on an economic criterion, rather than a biological one, without a clear understanding of its biological outcomes. Consequently, spring chinook with relatively late and protracted timing of emigration, such as Imnaha spring chinook (Blenden et al. 1997), are more likely to be transported in trucks than are spring chinook with relatively relatively average emigration timing. Listed species emigrating later in the year, such as juvenile fall chinook, are highly likely to be trucked. Listed species with timings intermediate to spring and fall chinook, such as sockeye, are sometimes trucked or not (see 1996 Annual Report of Transportation). Emigrants that arrive after the close (end of October), or before the opening (beginning of April) of the present transportation season are not transported by any means at all. The extent to which some portions of some spring chinook populations may be moving down the river near the end of, and after the close of the transport season is not well known, however some juveniles are moving down the main Snake River at all times sampling is in place to detect them (1996 Annual Report of Transportation, USACE). For example, Kucera (presentation to Lower Snake River Compensation Program, Boise, Idaho, February 1998) reported that up to a third of the juvenile spring chinook tagged annually in the Imnaha River basin emigrated after September. An implication of these facts is that, in order to protect genetic diversity among the emigrants, management schedules should be based on timing of migratory behavior as verified by actual levels of abundance each season.

Impairment of upstream migration of transported salmon

Homing. Questions about possible effects of transportation on homing ability of salmon were addressed by NMFS/NOAA investigators in the early phases of their studies. They concluded that there was no evidence that relative return rates of transported and control groups are lower at locations beyond the capture site (Ebel et al. 1973; Slatick et al. 1975; Ebel et al. 1980). Mundy et al. (1994) observed that the early studies were not specifically designed to detect effects on homing, and that low recovery rates of test fish severely limited statistical power, independent of study designs.

Imprinting. Imprinting by juvenile salmon is a factor that needs to be considered in their transportation. There is an implicit assumption in the use of transportation that salmon will return to the desired point of origin (spawning grounds) rather than the point of release. At the same time, it has been demonstrated that salmon can be transferred to new locations (Fulton and Pearson 1981; Donaldson and Allen 1958;

Vreeland et al.. 1975; Slaney et al. 1993; Wagner 1969; Cramer 1981). In fact, off-station release (transport by truck for release away from the hatchery) to enhance local fisheries, particularly of steelhead, has become a common practice throughout the Pacific Northwest (Johnson et al. 1990). In the mid-Columbia region, off-station releases of steelhead into the tributaries are the common practice of the Washington Department of Fish and Wildlife

Transportation Effects on Homing. As noted above, the NMFS studies of salmon and steelhead transported by barge have revealed no apparent effect on homing or straying of returning adults, though conclusions relevant to transportation operations are limited by study designs (Mundy et al. 1994). On the other hand, where analyses are available on trucked fish, returning adults have been observed to exhibit some impairment in their ability to find their way. Immigrating sockeye and chinook adults that were transported as juveniles may use a passage route that differs from that of control fish (Chapman et al. 1997). Transported sockeye and chinook have shown higher rates of fallback as immigrating adults than did control fish (Chapman et al. 1997). Adult chinook and steelhead exhibited delayed or interrupted migration in the lower river (Bjornn and Ringe 1984; Hisata 1980). Hisata (1980) reported studies that included transport of steelhead by truck to below Priest Rapids Dam and to below Bonneville Dam and a group that was transferred from trucks to barges at Richland, WA for transport below Bonneville Dam. The group that was transferred from truck to barge at Richland exhibited more homing impairment than either of the other transported groups. In an attempt to improve homing ability, the fish in Bjorrn and Ringe's study (1984) and Hisata's (1980) study were acclimated in order that they would become imprinted to local waters prior to their transport, but to no avail.

Transportation Effects on Straying. Pascual and Quinn (1994) observed that chinook displaced from their hatchery of origin and released at other locations showed patterns of straying on return that were most similar to fish that originated from the new locations, rather than resembling patterns of fish released from their hatchery of origin. In a 1995 paper, after recognizing there is a genetic effect on homing, they hypothesized that, "...the fish must actually migrate at the time when they are exposed to the odors (upon which they will imprint) or they do not fully imprint on them." (Pascual, Quinn and Fuss 1995, p. 316).

Straying Rates. In Hisata's (1980) study, there were a total of 36 adult steelhead recaptured at Lower Granite Dam. Strays amounted to 15% of the total recoveries of transported fish and 2% of the combined control groups. Chapman et al. (1997) reported strays to tributaries outside of the mid-

Columbia consisting of 7 transported sockeye and 3 controls out of over 3,000 comparable total adults recovered (0.3% total), and 11 transported chinook and 1 control out of perhaps 423 comparable fish (2.8% total). They felt that these numbers were not outside of what might be expected for any group of salmon. Bugert et al. (1997) reported that transported yearling fall chinook in their (Snake River) study strayed at a rate of 5.2% compared to 0.3% for control fish released in the river. Thus, the preponderance of evidence we examined showed that transportation by truck increased the rate of straying.

Recent observations (e.g., Chilcote 1998) of increasing numbers of stray Snake Basin steelhead into Columbia River tributaries, such as the Deschutes and John Day rivers, are cause for serious concern with respect to the genetic integrity of native steelhead stocks. It has not been determined what is responsible for this observed increase in steelhead straying. Given the literature record, described above, and given the present lack of specific information on the effects of the Snake River transportation program on homing and straying, transportation continues to be a factor of concern. Clearly additional monitoring and evaluation are needed on this problem.

To summarize the information on homing as it might be affected by transportation, we note that:

1. Salmon allowed to migrate naturally for a distance in the river before being collected for transportation did not exhibit significant difficulties in homing to the point of collection, although their route of passage differed from control groups (Chapman et al. 1997).

2. There is no clear evidence of impairment of ability of transported fish to return to spawning grounds or hatcheries located above the point of collection, except that straying is increased for truck transported fish (various sources cited earlier).

3. "Acclimation" intended to imprint the fish as a substitute for migration in the river is not sufficient to provide necessary imprinting cues for transported fish (Hisata 1980, Bjornn and Ringe 1984).

4. The point of release of transported fish is important as it affects their passage route (Chapman et al. 1997).

5. There is a significant difference in return rates and impairment of homing between trucked and barged fish, with barged fish performing well and trucked fish performing poorly.

Alternatives to transportation

Juvenile salmon migrating downstream can pass through the turbines, through the intake bypass systems, or through spill (Whitney et al. 1997). Small numbers of juvenile salmon may pass through the navigation channels or fish ladders. Bypass systems are being altered to improve their effectiveness in increasing survival of some types and species of emigrants. Because FGE's have not been high enough to meet the NMFS or Council goals of 80% fish passage efficiency, FPE, (FPE = proportion not entering turbines) at all dams, spill has been provided during specified periods in amounts aimed at achieving the 80% passage goal. At times of low flow, this has necessitated shutting down some turbines. Surface bypass systems are presently being evaluated at several projects. Based on experience at Wells Dam, this approach offers a potential for achieving the 80% passage goal without the use of spill as an adjunct. Full testing and development of this alternative for the hydroelectric system is expected to extend over a number of years, and its ultimate effectiveness and its implementation schedule will be different for each dam.

A further factor in evaluating transportation is the fact that as fish passage facilities are installed and improved at the dams, mortality experienced by juvenile salmon migrating downstream is being reduced (Iwamoto et al. 1994; Muir et al. 1995, 1996; Whitney et al. 1997). Spill at the dams is an obvious alternative to transportation that has been demonstrated to improve survival for fish passing in the river that has been called for by both NMFS and the Council. For example, Wells, Dam has a fully functioning fish passage facility that successfully uses spill to divert 89% of the juvenile emigrants away from the turbine intakes. However, the Wells Dam is the only hydrocombine design among mainstem Columbia and Snake river dams. The hydrocombine design makes spill particularly attractive from both biological and economical perspectives. Rocky Reach, Rock Island, Wanapum and Priest Rapids dams pass a portion of the approaching fish through spill according to criteria established through proceedings of the Federal Energy Regulatory Commission. All of the Corps of Engineers projects on the Snake River as well as McNary and Bonneville dams on the lower mainstem are equipped with passage facilities. Passage may be able to replace transportation as a juvenile passage survival improvement measure. For example, Bugert et al. (1997) found no differences in rate of survival among control and transported groups of hatchery fall chinook released above and below respectively, two dams on the Snake River (Lower Monumental and Ice Harbor dams), during the period 1985 to 1990. Both of those projects were equipped with turbine intake bypass systems. Ward et al. (1997) reviewed 11 studies of

transportation of chinook conducted over the period 1968 to 1989. Because conditions for in-river passage improved over that time period, they found it necessary to adjust data from 1979 to account for a range of estimates of reservoir and dam mortality by 14%, 16%, and 18%, while the data for 1986 and 1989 were adjusted by smaller numbers, 5%, 10% and 15%. We note that those numbers would be reduced still further under conditions at present, due to improvements in bypass facilities, provision of spill and other factors (Whitney et al. 1997). Improvements in bypass diminish the utility of transport for salmon recovery.

It should be noted, however, that application of spill and bypass has some of the same uncertainties as transportation. Information is needed on the characteristics of fish that are included in spill. Information is lacking on the mix of life history types or species composition of the fish included in spill and bypass. Similarly, evaluation of the efficacy of surface bypass needs to address the range of species and populations that may be expected to use it.

In summary, spill and bypass at the dams are alternatives to transportation that have been demonstrated to improve survival for fish passing in the river. Both have been called for by NMFS and the Council. The amount of spill appropriate to a given percentage of fish collection for transportation can be estimated, thereby minimizing the unnecessary collection of fish.

DISCUSSION

The ISAB noted with concern a mismatch between the focus of several ESA-driven recovery plans and programs with that of the transportation program. Outside the mainstem, federal recovery efforts are focused on protection of species, life history types and populations. Within the mainstem, federal recovery efforts depend heavily on a mitigation measure, truck and barge transportation, applied to the aggregate of all emigrants without knowledge of the impacts on individual species, life history types and populations.

The NMFS Proposed recovery plan (NMFS/NOAA 1995) identified 37 extant populations of spring/summer chinook, as well as one unlisted extant population within the Snake River basin (Table IV-1). It is clear from this that NMFS recognizes the importance of preserving the genetic diversity

reflected in the adaptive differences between local populations within the ESU. Because the loss of genetic diversity can be irreversible, such losses could reduce the sustainability of recovery. Similarly, the recently published biological assessment for Upper Columbia and Snake River steelhead (USACE 1998) makes clear the interdependence of multiple species on the effect of individual recovery measures. Recent reviews of the salmon recovery problem (ISG 1996; NRC 1996) have also placed considerable emphasis on population and life history diversity and expressed concerns over management actions, such as the transportation program, that may selectively benefit some stocks (particularly upriver hatchery origin stocks), while eroding overall species, population and life history diversity.

Current ecological science advises managers of exploited animal populations to protect the genetic and physical diversity of both the target populations and the ecosystem within which they exist (FAO 1995; Mangel et al. 1996). Existing transport studies (Achord et al. 1992; Harmon et al. 1989, 1993, 1995-96; Marsh et al. 1996, 1997; Matthews et al. 1990, 1992) were not intended to establish the impacts of transport on genetic diversity of listed species, nor on attributes of other species. In the long-term, protection of listed species will require protection of ecosystem functions, including allied aquatic species (Mangel et al. 1996).

In contrast, the transportation program focuses on the aggregate of all emigrants without knowledge of the impacts on individual species, life history types and populations. Evaluation and estimates of transportation effects are based on these aggregates, not on individual population estimates, therefore, extension of these T/C comparisons (based on groups of mixed stocks) to individual populations, particularly critically depressed ESA listed stocks, is fraught with uncertainty (see Mundy et al. 1994). The estimates for the effects of barge transportation on juvenile fall chinook from McNary Dam are presently being re-evaluated and will not be complete until the end of the 1998 season of adult returns (Marsh et al. 1997). But since the McNary fall chinook estimates are for barging, the revised estimates have serious limitations with respect to the Snake River, since the majority of juvenile Snake River fall chinook is transported by truck (1996 Annual Report of Juvenile Fish Transport, US Army Corps of Engineers). In the absence of other information for this type of salmon, it may be reasonable for managers to adopt the conclusion of Ward et al. (1998) "that large-scale transportation by truck was unlikely to benefit juvenile chinook salmon." (Ward et al. 1997, p. 652). In conclusion, we advise against excessive reliance on superficial interpretation of present data on tagged fish to draw inferences about the benefits of transportation. We found some of the assertions advanced at the December briefing

to be open to question on several basic grounds. Examination of the methodological issues should be an important focus for future evaluations.

CONCLUSIONS

Conclusion: Spreading the risk of negative outcomes among alternative routes of hydroelectric passage is advisable to prevent a recovery action that is designed to improve survival of one listed species from becoming a factor in the decline of another species.

Conclusion: Spreading the risk of negative outcomes among alternative routes of hydroelectric passage is advisable in the face of uncertainties associated with potential negative effects of transportation on genetic and life history diversity.

Conclusion: Hydroelectric system operations need to be conducted to maximize survival for emigrants remaining within the Federal Columbia River Power System, regardless of the transportation protocol. Under all transportation protocols some natural emigrants will remain, because no bypass system can collect all individuals for transportation.

Conclusion: Spill at the dams is an alternative to transportation that has been demonstrated to improve survival for fish passing in the river. The amount of spill appropriate to a given percentage of fish collection for transportation can be estimated, thereby minimizing unnecessary collection of emigrants.

Conclusion: The application of mixed-stock barge and truck transportation to recovery of the listed salmon species in the Snake River during the 1998 salmon emigration season needs to be approached with caution.

Conclusion: Information specific to the listed species is particularly important when applying a type of recovery method such as the present collection and transportation system, because the present system of collection and transportation does not apply equally to all members of the ESU's, and other salmonid life history types.

Conclusion: The estimates of the survivals to adult of barge transported stream type (yearling) chinook and steelhead juveniles are not the same as those achieved by the present mixed-stock truck and barge transportation system for the four listed salmon species and their constituent populations.

Conclusion: Estimates of the effects of variable combinations of truck and barge transport from the Snake River are not available for any type of fish. Estimates of the effects of transportation applicable to individual species for barging alone, and for trucking alone, do not make possible statistical inferences on the effects of a transportation system that annually trucks and barges a variable percentage of multiple listed species each year.

Conclusion: Trucks should not be used in the transportation program due to lack of information needed to advise management, due to the absence of current research programs to collect such information, and because historical indications on truck transport are negative.

Conclusion: Barge transport alone may provide enhanced survival for some populations of the listed spring/summer chinook and steelhead species, but the effects of trucking on these populations is unknown.

Conclusion: As alternatives to transportation are getting closer to achieving hydroelectric project passage goals, emphasis should be placed on these approaches in preference to transportation insofar as they can avoid the difficulties experienced by some transported fish.

Conclusion: Application of the ISG's conceptual foundation to available information on transportation causes us to question whether any system of juvenile transport can be made compatible with the life history requirements of all migratory fish species and life history types (i.e. sockeye and anadromous kokanee) native to the Snake River basin.

Conclusion: Comparisons of transported and river-run fish should be evaluated by returns to the spawning grounds of individual stocks where the effects of transport on survival and spawning success may be measured for the full diversity of populations under management.

Conclusion: If the critically important, long-standing questions concerning the effect of transportation on listed species identified in this report cannot be answered, the application of juvenile transportation as a recovery tool for listed species will continue to include significant uncertainties.

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