US=CE=C Property of the
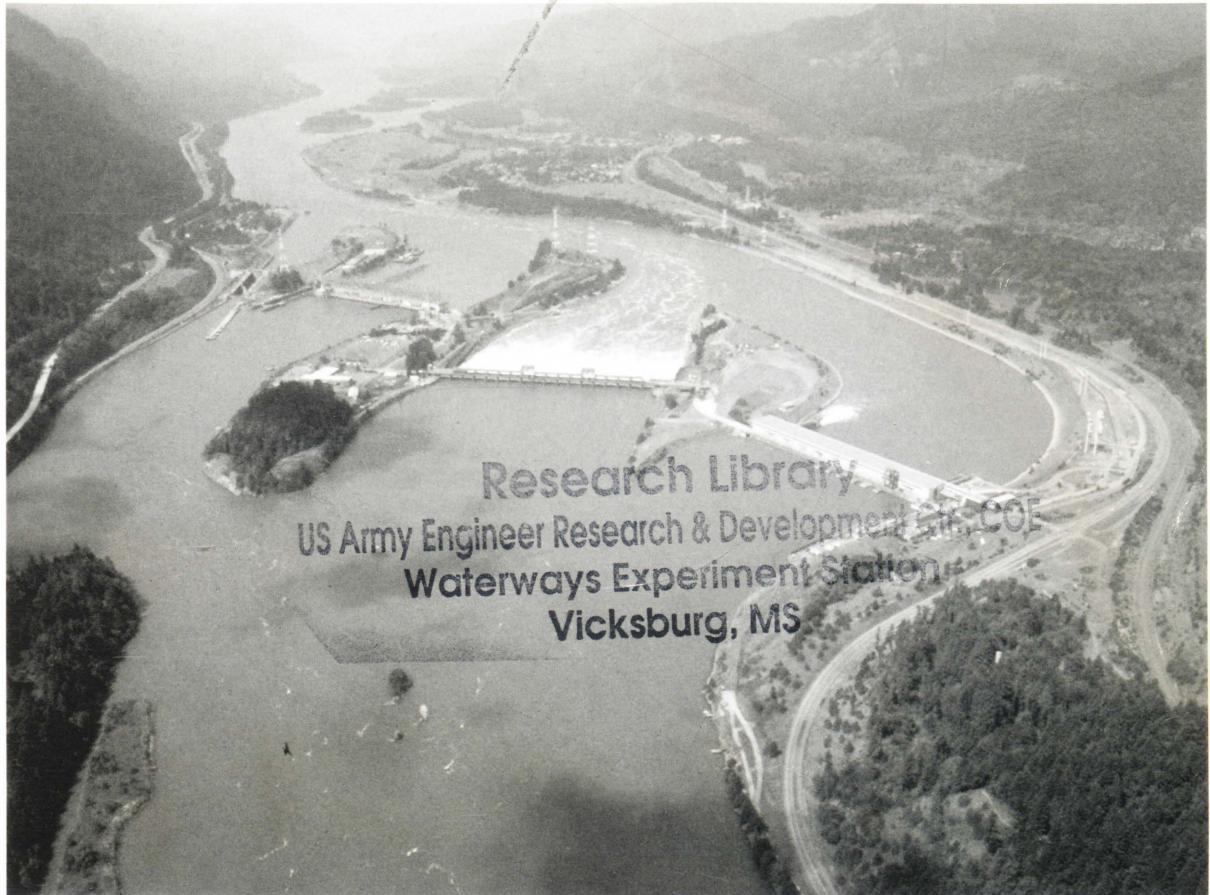United States Government
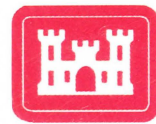
**US Army Corps
of Engineers**®
Engineer Research and
Development Center

Workshop on Standardizing Hydroacoustic Methods of Estimating Fish Passage for Lower Columbia River Dams

Gene R. Ploskey, Deborah S. Patterson,
Carl R. Schilt, and Michael E. Hanks

September 2000

Workshop on Standardizing Hydroacoustic Methods of Estimating Fish Passage for Lower Columbia River Dams

by   Gene R. Ploskey

Environmental Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Deborah S. Patterson

Dyntel Corporation
3530 Manor Drive
Vicksburg, MS 39180

Carl R. Schilt, Michael E. Hanks

AScI Corporation
1365 Beverly Road
McLean, VA 22101

Final report

Contents

Preface

Deborah Patterson, Dyntel, arranged for workshop facilities and travel, recorded the proceedings, and along with Mmes. Athena Stillinger and Gina George, ERDC contract students, transcribed tape recordings into text in Appendix A.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC and COL James S. Weller, EN, was Commander.

This report should be cited as follows:

1 Workshop Summary

Overview

The U. S. Army Engineer District, Portland, funded this research to evaluate possibilities for standardizing hydroacoustic methods for estimating fish passage through U. S. Army Corps of Engineer dams on the lower Columbia River, Washington and Oregon. The effort included this standardization workshop involving experts with fixed-aspect hydroacoustics, statistics, or fish passage. The goal of the workshop was to increase the consistency and comparability of fish-passage estimates by different researchers among sites and years by identifying important considerations and guidelines for hydroacoustic sampling, data processing, and data analysis. The two-day workshop was held at the Best Western Motel in Cascade Locks, Oregon, on September 16 and 17, 1997. This research effort also involved intensive sampling of a single intake at Bonneville Dam in 1997 to experimentally identify factors affecting hydroacoustic estimates of FGE and ways to reduce bias (Hanks and Ploskey, In Press).

Information from separate monitoring efforts can and should yield more than a collection of unique annual reports. A regional, multiple-year database on hydroacoustic estimates of smolt passage may become feasible after standardization. These standardized data may facilitate identification of trends and effects that could not be resolved from individual efforts or a synthesis of results presented in annual reports.

The standardization effort was not intended to stifle the development of new sampling methods or approaches. New and innovative approaches will continue to be funded as research and development studies. However, promising new techniques from research eventually may be adopted as standards after their usefulness is evaluated.

The workshop was informal and limited to active participants (i.e., there was no outside audience). It was recorded on videotape, but only as a tool for developing this written summary and transcript. The workshop product may have broader application to the Columbia and Snake River basins, but initially the focus was on lower Columbia River dams. This workshop represents a first step toward identifying possible standards for fixed-aspect hydroacoustic sampling of juvenile salmonids on the lower Columbia River.

Headings indicating the time and date in this summary parallel those listed the workshop transcript (Appendix A). This organization should help people reading the summary to identify sections of the transcript that may be of interest for detail. Although there was an attempt to stick to the planned agenda, the conversations were often wide-ranging and some topics were revised. Table 1, below, is meant to aid the reader in finding specific topics in the transcript.

Table 1. General list of topics in each workshop session			
Date	Time	Pages	Topics
9/16	0800-1000	31-57	Welcome, Goals, Limitations Gear quality and types (single Vs split beam) Sampling strategies, Variability of data Deployment, Single and split beams, Beam angles Assumptions regarding fish distributions Sampling strategies to improve precision Comparison with other gear types Detectability models and assumptions Fish size and target strength
9/16	1030-1230	57-85	Detectability and detectability modeling
9/16	1300-1500	85-112	Detectability, Detectability by deployment Sampling designs and deployment strategies Ratio estimates, Ratio estimates by deployment Sampling schemes involving multiplexing Systematic and random sampling in time Comparison with other studies Fish passage and its relationship to flow Communication and coordination among groups Comparisons with different gear types
9/16	1500-1700	112-137	Non-target species, Noise from wind, rain, debris Allocation of sampling effort in space and time Temporal scale of analysis and reporting
9/17	0800-1000	138-166	Temporal sampling, Effect of zero data, Extrapolation Random Vs systematic sampling Effects of reporting deadlines on analysis quality Sources of variability, Sources of error Estimating bias and error Quality assessment and control for tracking
9/17	1027-1225	166-198	Manual tracking Vs autotracking Problems with current "Black Box" auto-trackers Spatial and temporal extrapolation and expansion Summing temporal estimates and variances Species composition Acceptance of hydroacoustic data Detection efficiency, Checks on detectability models Variability of passage across dams and routes Sampling sluiceways and other shallow spaces Reporting schedules

8:00 A.M.– 10:00 A.M. Tuesday, 9/16/1997

Gene Ploskey opened the workshop by describing the Portland District's sponsorship and the goals, the objectives, and the likely product. He described how guidelines and standards might be used to design studies, evaluate proposals, review earlier efforts, and increase the consistency and usefulness of future results. He also mentioned his expectation that the workshop would generate some lively discussions. He took a minute to describe invitational travel orders, the location of restroom facilities, and his expectations for the workshop.

2

After an hour of discussing the workshop agenda and objectives, panelists reached a consensus that the scope of the effort would include fixed-aspect hydroacoustic sampling of juvenile salmon to estimate fish passage efficiency (FPE) for lower Columbia River projects. This scope was broad enough to include elements from three main CE programs for juvenile salmon: the spill program, intake screening, and surface bypass. The scope excluded adult salmon passage and hydroacoustic evaluations of smolt behavior, except when smolt behavior might influence hydroacoustic detectability and resulting estimates of fish passage.

John Skalski pointed out the importance of accurately defining FPE. He and Gary Johnson provided a layman's definition of project FPE as fish passage by non-turbine routes, including fish screened from turbines and bypassed, divided by total fish passage at a project. Estimates can be made on a variety of time scales ranging from daily to seasonally. John Skalski noted that the nice thing about having project FPE as a goal is that you will obtain data on spatial and temporal distributions of passage and any other passage estimates you might want to make. In contrast, having vertical or horizontal distribution data does not necessarily allow you to make higher order estimates like project FPE.

Workshop participants generated a list of non-turbine routes (Table 2). Only the first four routes were considered significant in terms of the volume of water and the proportion of fish likely to be passed. Each of the four significant routes present different sampling challenges and potential biases. The goal is to estimate of fish passage with minimal bias.

Table 2. List of non-turbine fish passage routes.
Spill bays
In-turbine screening to a juvenile bypass system (JBS)
Ice and trash sluiceways
Surface collectors
Navigation Locks
Adult fish ladders

Considerable discussion followed about obtaining unbiased estimates of fish passage given potential vertical and lateral skews in distributions of fish passage, not just at a powerhouse or spillway but among intakes, within intakes, and even across a single hydroacoustic beam. Concerns were not related solely to detectability but to locating and orienting hydroacoustic beams to obtain unbiased estimates of what was passing a single opening. The group concluded that vertical and lateral distributions of fish are rarely uniform, especially on short time scales, and that it is important to consider the distribution of passage in designing a sampling effort.

Tim Mulligan pointed out that the distribution of detections can be highly variable across a single hydroacoustic beam and will bias passage estimates because detectability is not uniform. He also said that an assumption that over some part of a geometrical structure there is a uniform distribution of fish and one can sample ten percent of it is pretty naïve. John Skalski added that accuracy and precision are not the same thing, that precision is affected by the number of

transducers and how they are allocated, whereas accuracy is degraded by systematic error.

If every passage route has a different and unpredictable distribution of passage or if distributions vary through time, then systematic deployments may provide reasonable estimates because the skews in distributions have more to do with random than systematic error. However, for a single intake, sampling the centerline when most fish pass on the sides would yield a biased estimate for that intake. Tim Mulligan indicated that split-beam transducers generally are useful because they can tell you something about spatial variability of fish. Marvin Shutters observed that sampling with a split beam may allow you to look at spatial variability, but it does not address the problem of uneven lateral distributions, if the beam angle is narrow relative to the intake width. Bill Nagy said that the advantage of a split-beam transducer is that it allows better characterization of detectability and sample volume than a single-beam transducer does.

If the goal is to estimate project FPE and there are a limited number of transducers, John Skalski recommended randomizing transducer locations laterally within the constraint of the beam width. John Hedgepeth and others agreed that this might be the best approach, to assume that fish distributions are not uniform laterally and simply develop a randomized sampling design to account for it. It will not measure the variance but will eliminate the bias on average. Other options include using multiple transducers in some intakes to document patterns, moving transducers laterally, or rotating them to provide lateral variation in coverage while integrating most of the vertical distribution component. Tim Mulligan observed that a single narrow beam with multiple aiming was much more desirable than using a single wider-beam transducer for sampling a river cross section. Several panelists lamented the relatively high cost of split-beam transducers and of rotators, which precludes widespread use. For example, it would be difficult to envision deploying 50 split-beam transducers or 50 single-beam transducers each with a programmable rotator to estimate project FPE.

The discussion next turned to equipment and settings. Sam Johnston indicated that settings were more important than types of equipment as long the equipment is of scientific quality. Others agreed with Sam. Ping rate and the frequency of sound were identified as important because the frequency determines the persistence of sound in confined spaces and may limit ping rate because of noise. Gene Ploskey tried to steer the discussion toward defining adequate spatial coverage for the width of a passage route. Sam Johnston pointed out that sampling volume is important because it is directly related to sample variability but that detectability within that volume is crucial because unknown or unpredictable detectability may compromise estimates. Marvin Shutters noted that if detectability is adequate, increased temporal sampling could provide some compensation for sampling a very small fraction of the cross sectional area by reducing variances. Gary Johnson offered that most people try to put in the fattest beam possible to obtain a decent sample volume, but it could be statistically modeled to obtain better insight. Unlike temporal variability, spatial variability for a single passage route is rarely estimated. The underlying assumption is that spatial variability within an intake is negligible relative to

variability among intakes, units, spill bays, and among structures like spillways and powerhouses. Also, there is no way to estimate spatial variability without installing multiple transducers within an intake or movable transducers, which usually is not economically feasible and is extremely rare.

During the preceding discussions about lateral distributions of fish passage and equipment, the panelists generated a list of list of transducer types and important information that each type can provide (Table 3).

There also was mention of putting single or split-beam transducers on a rotator to create a scanning beam that could programmed to rotate in 6-degree increments and sample to detect fish traces. This would be an advantage over the Mesotech type of scanning head, which spins rapidly and detects individual echoes but not consecutive echoes corresponding to a fish trace. A multi-beam transducer would provide the same information as a single-beam mounted on a single-axis rotator, except it would not have to be moved. Off-the-shelf multi-beam transducers are two-dimensional but Bob Johnson has been developing a method of 3-dimensional tracking using two multi-beam systems.

Don Degan brought up a concern that the problem with accurate sampling had less to do with the type of transducer beam and more to do with sampling what you think you are sampling. An example was presented of aiming transducers so that they detect fish passing in proportion to actual passage. This prompted Tim Mulligan to revisit issues associated with sampling assumptions and the reality of distributions of fish passage. Tim believes you still have a sampling problem even if you randomly allocate transducer locations within intakes or spill bays because you are not randomizing in time, only once in space.

Table 3. Information provided by different types of transducers.					
Information	Single	Dual	Scanning	Split beam	Multi-beam
Passage estimate	x	x	x	x	x
Target strength		x		x	
Beam width		x		x	
Angle off axis		x		x	
Trajectory	range	range	Single hit	3 dimensional	3-dimensional
Facilitated tracking in noise				x	

John Skalski explained that, in expectation of all possible sampling locations, random allocation of transducer locations provides an unbiased estimator for passage at a project, although perhaps not for a single intake. Several people agreed that the best approach to accurately estimate fish passage through an intake would be to randomize lateral sampling locations spatially and temporally (perhaps with a rotator). However, cost constraints in making project FPE estimates likely preclude greater randomization of sampling locations than once per season.

Don Degan indicated that in his experience, most of the error in sampling results from not understanding and accounting for the extent of variation in fish passage and biological reasons for its occurrence, not from poor detectability.

Both Don and Marvin Shutters mentioned the usefulness of sampling with methods other than hydroacoustics to better document spatial variability. John Skalski and Marvin Shutters warned that all methods, including fyke netting, have potential for bias. Options for addressing variations in lateral distributions within a single route were reiterated. They include sampling with methods other than hydroacoustics, hydroacoustic sampling with multiple transducers, or sampling with one or two transducers rotated or moved to cover a greater portion of the area of interest through time.

The discussion next shifted to variability among intakes of a single unit. Gene Ploskey described how A, B, and C intakes differ structurally and how flow patterns could be different. John Skalski stated that historical data at Wells Dam clearly indicated that there was no consistent relationship between passage through A, B, and C intakes of different turbine units. He concluded that the best approach was to assume that all intakes are different in term of fish passage and to randomly sample intakes. Apparently, data from Wells Dam and many other dams support the contention that there are no consistent patterns anywhere. If economically feasible, he recommended randomly sampling two of three intakes per unit so inferences could be made probabilistically for the third intake. His recommendation was to characterize sources of higher variability first. Usually, variability decreases in proportion to spatial and temporal scale, so you would expect more variation among dam structures (spillway versus powerhouse) and turbine units than among slots within turbine units and more among slots than within slots. The goal should be to randomly select slots to sample and then the next level of reducing bias would be to randomize the transducer locations within the slots. Gary Johnson recommended that the group generate a prioritized list of critical uncertainties for estimating fish passage (Table 4).

Table 4. Critical uncertainties in estimating fish passage.
The assumption of uniform distributions of fish passage across a passage route and within a hydroacoustic beam (detectability)
Hydroacoustic detectability and model accuracy
The assumption that fish passage is independent of noise
Variation in effective beam width due to variation in fish aspect, target strength, and velocity
Equivalent detectability between or among sample locations

Tim Mulligan noted that the assumption of a uniform distribution within a beam is the most difficult to address because with a single-beam system you must assume a uniform distribution, which likely is not valid. Tim spoke of 8-10 fold differences in estimates of adult passage depending upon whether the within-beam distribution was accounted for or not. His application involved deploying a 2-degree split beam horizontally across a river to count adults moving upstream. The problem was that most adults moved along the bottom and caused a significant skew across the horizontal beam. Others panelists pointed out that a lateral skew in the distribution of smolt in a 6-m wide intake is much less likely to produce such a skew across a 6-degree vertical beam. Two fold differences have been observed across the width of a sluice gate or intake slot at Bonneville Dam. Eight-fold differences are more in line with differences observed among 1-m strata in vertical distributions in turbine intakes.

Bob Johnson observed that detectability and the certainty associated with it seems to be the central theme of what we're talking about, as well as critical

uncertainties associated with it. Tim agreed and added that the most insidious problem is bias associated with detectability because it cannot be measured as easily as variance. Often you must rely on some non-acoustic technique or a good physical model to try to correct for it.

The discussion leading up to the first break addressed obtaining target strength information directly from split-beam sampling or indirectly from other sources. Split beam sampling can make us aware of problems with fish-passage distributions and provides target-strength information useful for filtering fish, defining sample volumes, and deriving reasonable expansions. Sam Johnston indicated that target strength was really the key to getting at detectability but that all available information should be used. Examples included length frequency data from fish bypass systems or netting and hydroacoustic estimates of target strength that may be affected by fish aspect and trajectory through a beam. Don Degan provided an example of using netting data on threadfin shad to estimate sample volumes because numbers of shad were too high to acoustically estimate target strength of individual fish. Most panelists seemed to agree that length-frequency-distribution data from sources other than hydroacoustics would be useful provided the distributions corresponded to the target strength distribution of fish passing through a particular route. Marvin Shutters reminded panelists that species composition and length frequency data were available from bypasses at Corps dams but that these data could be biased because they represent only guided fish, not all fish.

10:30 A.M. – 12:00 P.M. Tuesday, 9/16/1997

After the break at 10:30 am, the workshop discussion moved to detectability and expanding counts, which the group had been touching upon most of the morning. Gene Ploskey asked the panel to provide a rule of thumb for establishing the minimum distance for sampling based upon detectability. Bill Nagy indicated the minimum distance was the range at which the probability of obtaining the required minimum number of echoes was too small to provide meaningful data. He added that, given acoustic noise in most cases, counting three-hit fish was pushing acceptable limits. Marvin Shutters added that detectability can be good even at range of 2 m.

On the Columbia River projects, samplers try to maximize ping rate so that detectability for the range of interest from the transducer approaches an asymptote. Sam Johnston indicated that the sampling volume is limited to ranges beyond which there is no significant change in detectability. Some users, like Tim Mulligan and sometimes Sam Johnson, adjust detectability within their sampling volume depending upon target strength and the location of a fish in the beam, but this requires a split-beam system.

Tim Mulligan pointed out that detectability could also be limited at long ranges as the signal to noise ratios decline. Several panelists said that most juvenile fish sampling on the Columbia River was limited to relatively short ranges (< 30 m) and to relatively narrow transducer beam widths (6-10 degrees) so that volume back scattering usually was not a limiting factor.

John Skalski made the point that transducers deployed to estimate FGE in a single intake should have similar beam widths and detectability curves so there is some error compensation in the ratio estimator. Sam Johnston said you have to do the detectability modeling regardless of what nominal beam widths are used because velocity often varies with range. He stated that having a narrow beam could be advantageous because it will have less volume reverberation and the ping rate can be increased. Bill Nagy indicated that ranges could be different for identical transducers sampling guided and unguided fish and that could create differences among sample volumes. Several panelists thought that detectability modeling was an important issue for all studies.

The group decided to generate a table of critical factors affecting detectability and took a few minutes to decide on a format. The group decided to identify separate factors as controllable and uncontrollable and mark those that are not commonly modeled with an asterisk (Table 5).

Sam Johnston mentioned that the sensitivities of narrow beams do not drop off as fast as those of wide beams, and Tim Mulligan brought up sampling close to boundaries as a significant problem related to detectability. In discussing which variables are commonly modeled, John Hedgepeth mentioned that he has a model that uses signal-to-noise for finding out maximum ranges for transducers, but that it is not usually included in modeling. Sam Johnston said signal to noise is partially taken care of by the threshold setting.

Table 5. Critical Factors Affecting Detectability.	
Controllable	**Uncontrollable**
Beam width	Signal to noise ratios in the intake (noise)*
Ping rate	Range
Threshold	Fish speed through the beam
Minimum number of echoes	Fish trajectory through the beam
Beam shape	Echo or target strength distribution and ping to ping variability*
	Within beam distribution*
	Boundary conditions
*Factors that are not commonly considered in detectability models	

Tim Mulligan pointed out that all detectability models assume that the fish density is uniform. When you talk about an effective beam width, you are assuming a uniform fish distribution over the beam cross section, but effective beam width is meaningless if you don't have a uniform fish distribution over width of the beam. Tim's point was that you should be very cognizant of fish distribution being non-uniform over your beam because it will lead to measurement artifacts. The same number of fish moving through the edge of the beam will give you a much different number of echoes coming back as moving through the center of the beam. The secret is that the variability over the width of the beam has to be small. Then you can account for it. If the variability is large, which it often is in the situation Tim faces, it is important to be cognizant of that because it potentially can be the largest source of error. He gave an example of counting only 10 % of the adult fish filmed passing a river cross section because most passed through the bottom edge of their acoustic beam. In Tim's cases the non-uniformity across the beam cross section probably results from the behavior of adult fish hugging the bottom boundary. This boundary

happens to be on one side of his horizontal beam. Tim found that he could not ignore this factor.

Marvin Shutters indicated that this gets back to what we were talking before about how to move the transducer around or some use apriori knowledge of the distributions through the passage route. Tim agreed. John Skalski reiterated that there often is compensation in sampling guided and unguided fish, if both estimates are similarly biased. However, that doesn't escape the problem of combining estimates for different units or structures. As long as you are taking ratios, this may not be bad, but as soon as you start going from one unit to the next or from one route to the next then you need absolute counts. You need bias-corrected values. Going from FGE at a turbine slot to FGE or FPE at the dam is a quantum leap in terms of what you need to do. You have to go from indices to absolute abundance. John's other comment was that in this list some of the critical factors are things that we can control. Some are not. Like beam width, ping rate, minimum number of hits, and threshold are things that we have some control over. The other uncontrollable factors are problematic and need further attention. Bob Johnson pointed out that this is where behavioral information becomes important so we know something about what the fish are doing. He also indicated the importance of knowing a lot about hydraulics in the region being sampled so reasonable assumptions can be made.

Uncontrollable factors were identified and marked with an asterisk in Table 4. The uncontrolled factors can be further subdivided into those that can be reasonably estimated and those that cannot. For example, fish velocity in high flow areas can be estimated from hydraulic models and these data should be consulted for detectability modeling. Other factors like echo or target strength distributions relative to noise and fish passage distributions must be assumed or measured and often are of the greatest uncertainty.

John Skalski said is important to make the distinction between spatial distributions within an intake and within a beam because they must be handled differently. The within beam issues that Tim brings up in can be handled by using a very narrow beam relative to the slot width or measuring the distribution and correcting accordingly. With in-slot distributions you must move the beam from one location to another or have multiple beams. Don Degan pointed that the two problems are radically different. In an intake, you are sampling a small part of the area of interest in which densities may be variable throughout the range. He concluded that Tim has the opposite problem because he is sampling across a wide range of densities across a single beam. John Skalski agreed that within beam distributions are a hydroacoustic issue whereas uniformity within a slot is a sampling or statistical issue and is dealt with very differently.

The panel revisited the choice of beam widths with less than a consensus that seemed to depend upon experiences and objectives. Panelists opinions ranged from using the widest possible beam to maximize coverage to using a narrow beam to maximize ping rate and signal to noise ratios while guarding against within skews in distributions of fish across beams. Bob Johnson said that in a large open area you probably want the widest beam possible. However, if sampling next to a boundary that might influence fish distributions you should be more careful about the fish distribution across the beam. Tim disagreed. He

believes that you would be worse off using a wide beam if variability in the lateral distribution were high and better off if variability were low. Don Degan tried to clarify by saying the choice depended on the bias in distributions more that variability therein. For example, if you have highly variable passage that it was not consistently biased toward the edge of the beam then you would want a wider transducer. John Skalski warned not to let the choice be determined by assumptions about the things you cannot control. Gene Ploskey pointed out that lateral distributions of fish passage through a single route rarely have been estimated so we don't have a large historical reference from which to assess the potential problem.

Tim Mulligan added that our general reference comes from years of sampling in lakes and oceans where you expect a uniform distribution of fish over the beam cross section. When you are sample horizontally in a river cross section and know that the vertical distribution across your beam varies greatly and consistently, you have to account for it or your estimates may off by an order of magnitude. Don Degan pointed out that we usually sample near the middle of an intake bay rather than on the edge.

The group reiterated the need to randomize sampling locations within single passage routes to obtain, in expectation, an unbiased estimate of passage for all routes at one structure, although passage at any one route may be biased. The more routes the better. However, the panel also acknowledged the need to obtain more information on lateral distributions of passage through various single routes to better understand the magnitude of the potential problem. Until enough information is available, the best course of action is to assume that every intake is different until proven otherwise. The optimum course of action would be to randomly sample lateral locations in all routes regularly through time, but for now, economics dictate that a single randomization must be sufficient. John Skalski stated that all science is an art of compromise between the theoretical desired goal and logistical capability. As for replacing faulty equipment during the season, the consensus was not to re-randomize locations if the goal was project FPE, but that there could be reasons for re-randomizing depending upon the sampling design.

The discussion next turned to the shortest timeframe for making unbiased estimates of passage, knowing that the design will yield an accurate seasonal estimate for the entire dam. In short, should we be providing estimates of daily averages per unit or bay? John Skalski pointed out that overall estimates will have better precision with increased sampling duration, but that daily estimates can be in expectation unbiased if enough sampling effort is allocated. It apparently depends upon the objective. If the out-migration is expected to last a week, then you have to design for that. If you want independent estimates from day to day to test differences in treatments, for example, then some randomization of sampling locations within test slots would be desirable. If the objective is broad seasonal trends for a powerhouse, then it probably makes more sense to look at weekly estimates, as in Gary Johnson's example for the Lower Granite Powerhouse. John Skalski indicated that most FPE designs tend to have a particular level of precision for the end of the season. To expect the same level of precision from daily estimates is naïve and will be disappointing. The consensus seemed to be that decisions should be made early in the study design

so that everyone from sponsors to interested agencies understand the objectives and anticipated level of precision for different time frames. Daily estimates can be unbiased and precise but it will require greatly increased effort. Weekly, monthly, and seasonal estimates are more fitting for the level of effort usually expended on the Columbia River. Marvin Shutters said that it could be dangerous to present daily estimates to the region, and Gary Johnson pointed out that it is always desirable to present cumulative statistics in interim reports.

Cliff Pereira questioned whether moving transducers within a slot would alter the detectability model, and the consensus was that it would change if noise conditions changed but that every slot likely would be different. Sam Johnston added that effort should be allocated more toward routes with the highest passage rates, and John Skalski concurred. John gave an example of how moving one transducer at Wells Dam from a slot with low passage to one with high passage reduced the overall variance by 50 %. Even small changes can make a big difference and preliminary information should be examined to see if estimates could be improved. According the John Skalski, the general rule is to put more effort at the higher sources of variability.

Gary Johnson suggested that the panel recommend detectability modeling rather than trying to list guidelines for specific settings. The idea was that detectability is influenced by a combination of factors and settings. Gene Ploskey asked what the minimum acceptable level of modeling should be. The panel concluded that it should include all variables commonly modeled (Table 4) and enough discussion to indicate an understanding of possible interactions of things that can and cannot be controlled. Certainly, things that can be controlled should be included. The consensus was that we should expect to see discussion of detectability modeling in proposals and model results in reports as part of quality control. If nobody includes results of modeling, how will the state-of-the-art advance? Marvin Shutters said that standard methods probably were used to model detectability originally but that in subsequent years they may be a slow evolution from that under the assumption that detectability is still good. Don Degan wanted to know what amount of effort was reasonable. For example, should you use mean velocity for an intake or look at velocity by range. How should it be measured? Marvin Shutters suggested that maximum velocities should be used so detectability estimates would be conservative. Velocities and target strengths are two factors that can change seasonally.

The standard that evolved from discussions was that detectability modeling should be done before the study, important parameters (Table 4) monitored throughout the study, and remodeling and adjustments made to expansion factors whenever conditions change significantly. The entire process should be documented in reports. Sam Johnston suggested that models be reexamined as season progress, as Tim Mulligan does, to adjust estimates for changing conditions. It is too late after the season has ended. Bill Nagy suggested that the minimum for handling seasonal changes in target strength would be to model for the smallest targets expected in summer at the highest velocities so that anything larger or slower would be adequately detected. Sam Johnston added that the model should tell you whether big changes occurred and if a change in detection criteria would be necessary. Gary Johnson suggested that it might be easier to keep track of important parameters like velocity or target strength and rerun

models when a major change occurs to document that sampling is still adequate. The goal is to make certain that the assumption of effective beam width is always valid.

1:00 P.M. – 3:00 P.M. Tuesday, 9/16/1997

Gene Ploskey asked about existing models and the future of detectability modeling. John Hedgepeth indicated that detectability modeling is a two dimensional plot of effective beam width by range from the transducer. He added that it would be nice to publish a model on the web that others could verify. He mentioned the model used at BioSonics, Incorporated. The panel indicated that many of the parameters listed in Table 4 were included in the model, except signal to noise ratio and target-strength distributions. Several panelists mentioned problems with using black box models, where sensitivity of effective beam width to every input variable is unknown. John Hedgepeth pointed out that having open source code would be a nice place to start.

Sam Johnston pointed out that models cannot be tested unless you have something that can really measure the parameters in the field, and Tim Mulligan concurred and added that verification is very difficult. Problems with evaluating the performance of detectability models were mentioned. Tim Mulligan said that his group had been surprised by how much poorer models work in practice than tank measurements would lead you to believe. Poor signal-to-noise conditions in sampling situations are a large part of the reason. Tim uses video cameras to independently evaluate hydroacoustic estimates and adjust his model, but the process is difficult. He indicated that a split beam system works well when there is only one fish in the beam but that degradation occurs faster than you would think from instrument specifications when multiple fish appear.

Gary Johnson mentioned that there are other ways to verify, such as comparing passage estimates with estimates made by other sampling methods. Marvin Shutters added that if hydroacoustic estimates are highly correlated with estimates from other methods, the detectability assumptions probably are valid. Most panelists concurred that cross validation is an important tool. John Skalski mentioned the use of scanning-head sonar at Lower Granite as a way to look at the distribution of echoes across an intake. A single or split beam transducer that rotated and sampled at 6-10 degree increments could be used for the same purpose and would provide information on the distribution of fish traces as opposed to the distribution of echoes.

Other controlled ways of evaluating model parameters were mentioned. John Hedgepeth suggested moving rotating hydroacoustic beams at different rates over stationary targets of varying target sizes as a way to examine velocity and target-strength interactions. Acoustic tags also could be passed through stationary beams. Some parameters can be measured in the field with split-beam systems, e.g., velocity and target strength. Noise levels might also be artificially adjusted in a laboratory setting.

The next topic discussed was estimation of FGE in a turbine intake. John Skalski began by describing experiments conducted at Lower Granite Dam. In-turbine FGE was estimated in three ways: (1) one transducer sampling guided fish and another sampling unguided fish in a slow multiplex, (2) one transducer sampling guided fish and another sampling the total of guided and unguided, and (3) one up-looking transducer sampling unguided fish at short range and guided fish at greater ranges. Apparently, estimates by the third deployment had the greatest precision because of covariance (simultaneous sampling of guided and unguided fish). Bill Nagy asked if the same benefits might be derived from fast-multiplexing an up-looking and down-looking transducer, provided the ping rate was not limited by noise reverberation. The answer was yes because covariance was the important ingredient. If two transducers can sample simultaneously at high enough rates to provide adequate detectability, the same benefits should accrue. Gene Ploskey described fast multiplexing one down-looking transducer sampling unguided fish and another up-looking transducer sampling guided fish with an overall ping rate of 30 pings per second (15 pings / second on each transducer) at Bonneville Dam in 1996. This approach allowed simultaneous sampling of guided and unguided fish with the widest part of each beam. Marvin Shutters mentioned similar sampling at John Day Dam. Sampling range is limited to be about 17 or 18 m at 30 pings per second to allow for multiplexer switching time. Travel time is not, in and of itself, a limiting factor.

The next topic of discussion was temporal sampling. John Skalski started off describing how the precision of sampling was improved by having more frequent samples per hour such as 12 1-minute samples as opposed to two six minute samples per transducer hour. The limitation is mostly in the ability of people to load and process the frequent samples. Systematic sampling is most convenient for the hardware, software, and people but requires the use of random sampling formulas for estimating the variance from systematic sampling. This is less than perfect but at least conservative because variances are overestimated. The key to increasing precision is more frequent, short-duration samples per hour. John said he believed that the reason had more to do with the patchiness of detected fish than with the fraction of the hour sampled. When asked how short the samples could be, he responded that you might go to 24 half-minute samples but that the cost of processing goes up appreciably. Gary Johnson said their standard was 2 to 3 minutes per sample. Tim Mulligan mentioned that there must be a lower limit depending upon the duration of fish in the beam and the range of sampling. John said that simulations show that the increase in precision levels off. There is a point of diminishing returns. John Hedgepeth mentioned the equipment must switch which takes time, and Sam Johnston added that switching time causes loss of sampling time.

Gary Johnson asked if there was anything that should be covered regarding the ratio estimation for fish passage at spillways or sluiceways. John Skalski explained that it was not inherently different in that you estimate passage independently for each structure and then combine the estimates in any ratio combination of interest. For example, spill efficiency is the number of fish passing the spillway divided by total project passage. The key is to sample each set of passage routes independently, unbiasedly, and precisely. The overall precision of separate components is a function of the sum of squares of coefficients of variation for each set of passage routes. You want to put the most

sampling effort at those locations that have the highest variation. Estimates of passage and variance add to provide estimates of total passage and variance for all similar routes at a powerhouse or spillway. Ratios are calculated from sums of counts and variances, but you don't want to take averages of ratios. Gary Johnson interjected that the standard is to estimate passage independently on a route specific basis. John continued that if you are happy with the precision at individual sets of routes you should be happy with the precision of the ratio estimators. Marvin Shutters pointed out that ratio estimates of FGE for a single intake may be less susceptible to bias from skewed lateral distributions than passage estimates, if guided and unguided fractions are similarly skewed. He added that accuracy is more important for ratios calculated from passage estimates for separate routes that are independently estimated. John Skalski agreed. Sam Johnston said that the problem often comes in estimating the denominator for FPE. Gary Johnson explained how they used the total count from pier nose transducers to weight FGE per unit and then calculate the guided and unguided components. In short, the in-turbine estimates provided the FGE ratio, but passage rates for guided and unguided fish were calculated from unit FGE estimates and pier-nose totals. The pier-nose total was considered a better estimate of passage because it correlated with the smolt-monitoring index for Lower Granite. John Skalski described how pit-tagging estimates also corresponded closely with hydroacoustic estimates of spill effectiveness. John went on to stress the importance of coordinating studies and cross validating results. He and Gary Johnson mentioned pit tagging, radio telemetry, and hydroacoustics. Unfortunately, most cross validation is more serendipitous than purposeful.

John Skalski also indicated that relations between FPE and dam operation show the need for more purposeful manipulations of operations to investigate their effects on FGE. Without such manipulations we will never learn how to optimize FGE. Pit tagging data suggest that dam operations have a significant effect on FPE but these associated effects are only based upon opportunistic examination of existing data, not purposeful manipulation indicating cause and effect. He emphasized the dynamic nature of flow and FPE, which suggest that much more can be learned by coordinated studies. He acknowledged that it is difficult to provide operations suitable for concurrent studies. Marvin Shutters mentioned some success in manipulating operations at John Day Dam to learn about the effect on dissolved gas and at Bonneville Dam regarding adult fallback. John went on to say that the goal should be to optimally design not just studies, but operations, at a site.

Bill Nagy asked if it was reasonable to evaluate something like a surface collector in a year or two given real-world variability. John Skalski's diplomatic response brought laughter from the panel. He acknowledged that we often try to view results under a very limited range of conditions because of constraints imposed by needs for better fish protection or other political reasons. He went on to say that he didn't think constraints to integrated manipulation studies were imposed with malicious intent. It is just difficult to get people to understand and recognize the potential benefits because of the overwhelming complexity. Marvin Shutters mentioned that continuously shifting priorities within the region

did not help. Gary Johnson said that needs at the river operations level were often different and of higher priority than biological studies. John Skalski said that even at the principle-investigator level, it is rare to develop coordinated plans ahead of time, although it would be invaluable. Marvin indicated that this type of coordination had been a goal of the planning group for several years. Gene Ploskey said that he thought major study coordination requires higher level coordination because individual principal investigators usually are stretched to the limit.

The discussion regressed slightly to clarify the need to weight FGE by the passage of fish through turbines. In short, estimates of FPE for a powerhouse should ideally be based upon the ratio of the sum of guided passage to total passage, instead of the average of ratios at every intake. The same is true in calculating weekly or seasonal FGE at a single intake from daily estimates. The proper approach to estimate total project FGE depends, in part, on the sampling design. Bill Nagy asked if the inverse correlation between FPE and fish passage that John Skalski described could have resulted from noise. John explained that the correlation also was apparent in pit-tagging data so that two independent data sets showed the same thing.

Next, there was a brief discussion about using data from smolt-monitoring data as an indication of fish passage. Tim Wik explained that he thought smolts were sampled six times per hour and that samples ranged anywhere from six seconds on up depending on the number of fish passing through the system. Numbers of collected fish apparently are expanded for the fraction of each hour sampled and multiplied by the ratio of the total project flow to the powerhouse flow. This assumes that spill-effectiveness is 1:1. This volume-weighted index to guided fish passage correlated well with Battelle's estimate of guided fish passage calculated as FGE from in-turbine transducers times the total powerhouse passage estimate from pier-nose transducers. John Skalski reiterated that he believes there is a significant relation between project flow (operations) and FPE. Correlations between the two have been observed in three sets of data (hydroacoustics, pit tagging, and radio telemetry) from Lower Granite, not just hydroacoustics, which some in the region always seem to question. This finding is a clear justification for more well coordinated, multidisciplinary studies involving manipulation of project operations so we begin learning more about how to maximize FPE.

The group next discussed non-acoustic studies as concurrent checks on and validations of hydroacoustic results. Marvin Shutters pointed out that hydroacoustic and radio telemetry estimates of powerhouse versus spillway passage were very similar at The Dalles in 1996. There was agreement that radio telemetry was especially valuable since it provides some survivorship data as well as passage route information, but it is very expensive. John Skalski suggested that appropriately designed radio telemetry studies might reveal not only some gross things about movement, run timing and the disposition of fish among routes but also reach survival, FGE, spill effectiveness, turbine survival, and spill survival. Pit tag studies were discussed briefly, especially the development of larger diameter (4 ft diameter) detectors for sluiceways.

The group then produced a list of non-acoustic studies that might be useful to compare to hydroacoustic studies (Table 6).

Table 6. List of sampling methods that can be used to corroborate hydroacoustic-sampling results.
Methods
Turbine intake ("fyke") netting
Sluiceway netting
Purse seining
Trawling
Underwater video
Pit tagging
Radio telemetry
Smolt monitoring counts
Bypass sampling
Transportation collection estimates

3:00 P.M. - 5:00 P.M. Tuesday, 9/16/1997

The group began by considering the issue of non-target species, especially late season shad, in hydroacoustic sampling. Gene Ploskey shared regression results of hydroacoustic data (from BioSonics, Inc.) regressed on netting data (NMFS) from a turbine intake at John Day Dam. There were both "guided" and "unguided" data sets and the r^2 relating the hydroacoustic counts and the concurrent counts of salmonids from netting was about 0.6 or better in all cases and sometimes 0.8 or higher. He suggested that those data indicated that the hydroacoustic count was predominantly salmon in those data sets and deviations from such agreement between hydroacoustic counts and results from other methods might be due to non-salmon echo returns. There was a brief discussion of the leverage of outlying points and log transformation to reduce it.

Hydroacoustic monitoring is sometimes "swamped" by shad, especially in late summer at the lower dams. The adult shad are about 4-5 times the length of the age-0 summer chinook with which they co-occur. Gene Ploskey suggested that monitoring ladder counts for shad abundance, which usually starts to increase by early June and is problematically high by July. Marvin Shutters said that Bryan McFadden, with BioSonics, had experienced a sudden increase in targets that were attributed to shad in mid July at Bonneville Dam in 1997.

Time in the beam was discussed as an indicator of a larger (more powerful) animal swimming against the flow. It was suggested that a maximum number of echoes could be set to exclude many traces that were from fish larger than smolts. Marvin Shutters said that regardless of filtering on the number of hits, many off-axis shad would still be detected as smolts. Sam Johnson suggested that there might be a bimodal distribution of velocities indicating proportions of smolts and shad.

No one knew if data on the size and species of non-salmonids was kept from smolt monitoring facilities at the lower dams but that was suggested as an avenue for exploration. Tom Wik said that on the Snake River, records were kept on all

16

species. Gary Johnson said species composition varied among bypasses, intakes, and the surface collector Lower Granite, so what was needed was species composition by passage route. Variability within and among intakes, units, dams, and across time was reemphasized, along with differences across species and life stages.

Target strength, including a possible bimodal distribution of target strengths, was discussed as a tool to separate shad traces from smolt traces. There was agreement that distinguishing the two types was very difficult with single beam gear since an off axis (larger) shad would be indistinguishable from a more on axis (smaller) smolt. Split-beam hydroacoustics can describe target size, path through the beam, and rate of travel. Bill Nagy was convinced that single beam data alone could not be used to reliably distinguish smolt traces from shad traces because there are many echoes that are outside the nominal beam. He seconded Gary Johnson's suggestion that a split-beam system might be used in tandem with single beams to help inform the analysis of single beam data. Target strength mapping using the methods that Tom Carlson had used for smolts was suggested as a necessary first step.

Don Degan recalled that, from mobile surveys at John Day at least, he had seen that fish distribution tended to be shallower after the shad arrived. He suggested that shad and smolts might be separated by their respective depth distributions.

Gene Ploskey mentioned hydroacoustic sampling of sluiceways and weirs and the discussion moved on to physical, as opposed to biological, problems with hydroacoustic sampling. The near proximity of boundaries, including the air-water interface, present problems and sluiceways or weirs can be as little as three feet deep. John Hedgepeth said that near-surface sampling was possible, that higher (420 kHz) frequency systems are better than lower (120 kHz) frequency systems and that wind driven waves compound the problems at the air-water interface. Strong side lobes make the boundary problems worse.

Marvin Shutters said that wind generated noise makes hydroacoustic tracking at The Dalles impossible a lot of the time due to wave and air in the upper water column. The sluice chute at Bonneville Powerhouse 2 also has been impossible to sample at times. Gary Johnson said that Lower Granite sampling was on the lee side of the dam most of the time so that wind wasn't such a problem, but turbulence off trash and log booms could be bad. Sam Johnston said that wind would sometimes shut down sampling a Wanapum Dam, where the area of interest is within 2 m of the surface of the water. Gene Ploskey pointed out that rain also mixes air bubbles into the upper water strata and can present problems for tracking.

Gary Johnson said that they (Battelle) keep track of time lost in sampling and factor that loss into their expansions of count. Since they only process one half of the sampled time intervals, they are able to skip particularly noisy intervals in favor of others that are trackable. Sam Johnson said that, at Wanapum Dam, the very noisy data are excluded from the immediate ("real time") analysis but is revisited later and compared to earlier counts at the same place. They look at the data just before and after the noisy part. They try to use as much data as possible

to improve their estimate of variance. Gary Johnson said that the tracking at Lower Granite is rather conservative and that trackers are trained to throw out doubtful traces. He said more sophistication might be possible with automated tracking.

A discussion of the problems involved with automated tracking followed. Gene Ploskey identified noise as the most serious problem for the system his team was developing. They had a system to automatically edit out bubble clouds but that left fragments, some of which were automatically tracked as fish because they happened to meet tracking criteria. They now have a noise index to quantify trackable time for expansion purposes. It identifies the proportion of pings that have more than some threshold number of echoes. Bill Nagy said that they had discussed regressing counts by human trackers on the noise index and counts by the autotracker to see how useful the latter might be for adjusting the autotracker counts. Gene Ploskey said that the automatic tracker consistently overestimates passage, probably due to tracking noise, and that counts probably can be adjusted and improved. Sam Johnson suggested simultaneous echo integration to identify noisy data. John Hedgepeth suggested that a non-hydroacoustic index of potential for noise, such as wind speed or an index of non-fish targets in the water (leaves, sticks etc) might be recorded along with the hydroacoustic data.

Tim Mulligan wanted to know why a person couldn't just review the hydroacoustic data and pick out the noisy parts. Bill Nagy said that the noise isn't always in obvious bubble clouds but sometimes appears as lines that trail out of bubble clouds. The current programs will count those and sometimes the sparse noise is more problematic than are dense clouds of bubbles. The program has no context. Tim Mulligan said that his group uses automatic tracking but that they then review it visually and edit out the very noisy parts. A human is capable of much finer pattern recognition and has a "global perspective" that the program lacks. Concerning automated tracking, Gene Ploskey reminded everyone that human trackers are not perfect and that, especially with noisy data, there can be poor correlation among people tracking the same data.

John Hedgepeth said that one might see just the tail end of a long noise event as transducers are switched for sampling. The thinning noise might be counted as fish by a human tracker or an automated system, unless there's some record of overall ambient noise through time. Bill Nagy said that his program was good at recognizing bubble clouds based on number of hits on one ping and that edge smoothing had reduced the problem of bubble trails being tracked. He stressed the need for conservative tracking for all systems. Both up-looking, bubble-prone transducers and downward-aimed transducers which are likely to produce cleaner data should be tracked very conservatively to avoid inflated "guided" counts.

A discussion of the problem of reflective debris in the water followed. Unlike air bubbles, leaves, wood pellets, and similar bodies are likely to move with the water and may produce echo traces that appear similar to those produced by passing smolts in hydroacoustic data. Gene Ploskey said that leaf litter at Richard B. Russell Dam (upper Savannah River) had made hydroacoustic passage estimates there impossible from October through December.

Bob Johnson said that a small amount of that sort of noise might be worse than a large amount since it would be harder to identify. He indicated that pulse width criteria had been helpful at Lower Granite. Gary Johnson explained that at Lower Granite (1996 and 1997), they found a poor correlation between hydroacoustic counts and the smolt monitoring index at a time when the river was full of debris. An analysis of a five-day sample of echoes from low debris days was compared to a similar sample from high debris days. Low debris echoes were very similar and had short pulse widths, similar to the outgoing pulse. The high debris echoes were more varied and had longer pulse widths. They reasoned that a smolt (or a smolt gas bladder) was small enough to be a point reflector and should produce an echo pulse very similar in duration to the source pulse. A larger target, such as a stick or tree branch, might reflect sound from several different adjacent points. To the extent that those different return pulses had different ranges from the sounder, and therefore different 2-way travel times, the returns would be spread over a longer return pulse width. At Lower Granite, the high noise data was post processed to exclude returns longer in duration than 0.45 msec, rather than using the 0.4-0.6 msec limits that were used for cleaner data. Gary Johnson stressed that such a procedure improves the data but does not correct it. Sam Johnson said that phase correlation between echoes on a split-beam system indicate whether echoes are from the same target. He also suggested that the ratio of the all echoes to the number in tracked fish could provide a useful noise index. Hydroacoustic Technologies, Incorporated, used such an index at Wanapum Dam.

The discussion shifted to hydroacoustic sampling design. John Skalski said that passage estimates usually are based on the unit hour as the fundamental sampling block. Daily totals, for example, can be obtained by adding the hourly estimates for every day. The variance is the sum of hourly variances. The goal is to not only get a point estimate but a variance estimate for all of the sampled time and space blocks. Missing data can be estimated, up to a point, if necessary.

When a unit cannot be sampled for logistic reasons (not enough transducers, etc.) then a two-stage, "nested" design can be used. For example, two out of the three slots are randomly chosen and then those two are sampled in time. The resulting estimate of passage has two sources of variability, sampling in space (two of three units) and sampling in time. Then counts and variances must be expanded for the slot that was not sampled before the hourly estimate can be made.

For temporal sampling, one might sample systematically or randomly six one-minute intervals per hour. Those samples, each expanded by a factor of 10, are summed to produce the passage estimate for that hour. The six counts also are used to compute the variance estimate for that hour. That variance and the expanded total count are fundamental building blocks for all estimates of longer duration. The hours are not magical. It just seems that for most dam operations all the operational changes have occurred on the hour. Therefore, it just became a natural unit to use. Most statistics beyond hourly estimates (days, weeks, or seasons) are a simple sum of hourly counts and variances for any or all locations. Variances can be summed, whereas standard errors and confidence intervals cannot. The variance includes the variance in passage and most of the error associated with technique.

For ratio estimates like FPE for different passage structures, the overall estimate of variance is computed using the "Delta method," which combines estimates of total passage for spill, total guided passage, total unguided passage, and total sluice passage, for example, in the final calculation.

If a choice is to be made between sampling more locations (intakes or spill bays) or more time, it is better to sample more locations because it is more likely to decrease the variance and improve precision. It is acceptable, over a season, to sample only five or six minutes per hour at any one space. There is a diminishing return point in temporal sampling more than in spatial sampling. One five-minute sample will not allow an estimate of within hourly variance. Two 2.5-minute samples will allow a variance estimate, but five one-minute samples would be better. This would capture not only within-hour variability but also some of the measurement error inherent in the technique.

John Skalski provided a list of priorities for fixed aspect hydroacoustic sampling at dams. The overall rationale was:

Emphasize spatial sampling over temporal sampling. Sample all intakes of all units if possible. If it is impossible to sample all intakes of all units, sample all units before sampling more than one intake on any unit. If it is impossible to sample all units, select units for sampling randomly. Sample more than one intake per unit if possible to permit an estimate of within unit variance. If full coverage of all intakes is impossible, use random rather than systematic (for example, all middle intakes) sampling. Only sampling middle intakes allows inference only on middle intakes. Any remaining transducers should sample wherever passage (and therefore variance) is likely to be high. The unit hour is a convenient temporal sampling unit. Sub-sampling the hour into two (and preferably more) time intervals permits a computation of the variance associated with the fish passage estimate for that hour.

This scheme is consistent with sampling most where variance is highest. The highest variance is likely between units, then within units, then across time. One should first sample all units. If there is only one transducer per unit, they should be assigned randomly. More transducers per unit should also be assigned randomly within units but according to expected passage (and variance) between units. More spatial coverage is better but the same is not always true of temporal coverage.

Since temporal sampling is less critical than is spatial sampling, John Hedgepeth wanted to know about possible guidelines for allocating effort in temporal sampling. Perhaps there is a point at which to shut down transducers and reduce the data load on the processing resources. The group agreed that it is wiser to collect all the data possible and to allow a statistical analysis of the precision determine how much of it should actually be analyzed.

John Skalski emphasized that the precision improves with the number of samples per hour and for estimates made for longer periods, i.e., seasonal precision > monthly > weekly > daily > hourly. If weekly or even daily estimates are needed, then reducing sampling time would be a mistake. Sponsors and scientists should discuss the trade off and limitations of sampling and

reporting schedules ahead of time so that everyone has the same expectations for sampling precision.

There was some discussion about how to handle sample intervals that could not be tracked because of noise, and about the underlying assumption that fish densities are independent of noise. Usually the noisy intervals with < 50 % trackable time are not processed in favor of intervals that can be processed. The cutoff is arbitrary. John Hedgepeth suggested incrementally raising the voltage threshold the same for both clear and noisy echograms until you could count fish on both echograms, as one way to test the assumption that fish densities were independent of noise. Tim Mulligan said that in his experience bubble clouds and boat wakes were uniformly made up of low target strengths and that adult salmon appear as higher target strengths inside the noise. Don Degan said that fish could be picked out as high amplitude traces in noise just exceeding threshold voltages, and several other panelists mentioned using echo amplitude as a way to identify fish in noise. Bill Nagy said that for most tracking of small fish, echo amplitudes from fish and noise do not differ enough for tracker to reliably identify fish in noise. Sam Johnson suggested using a dual beam transducer and comparing amplitudes of echoes in fish detected on the narrow beam but obscured by noise on the wide beam to see if amplitude differences could be detected. He also suggested using two different frequency transducers aimed in the same volume to test the assumption that fish densities were independent of noise. Sam Johnston mentioned simultaneous 40- and 20-log-of-range processing as a useful way to identify segments of echograms that were too noisy for tracking.

8:00 A.M.-10:00 A.M. Wednesday, 9/17/1997

Gene Ploskey started the discussion with a sampling scheme for a single transducer. Gene asked John Skalski whether using very short sample intervals might present a problem of too many zero counts that could adversely affect the variance estimate. Skalski said that the "finite sampling" method used is nonparametric in that it does not assume any distribution qualities for the data for parameter estimation, except for confidence intervals. A data set consisting of multiple samples per hour over many hours for one or more days is probably large enough to approach normality. He cautioned that there are two ways to process these data. One can look at mean number of fish per time interval and associated variance or one can look at total number of fish per interval and that variance. The latter is usually what is of interest, the total passage for an hour. We want a sampling design that minimizes hourly variances. So taking ten half-minute samples is better than two samples of two and a half minutes each, but there is a diminishing returns point.

Random sampling through time is preferable to systematic sampling. The formulas are more valid for random sampling. With systematic sampling, it is possible that more effort raises variance, and some sampling frequencies seem to raise variances unpredictably at some places and times. A state-of-the-art multiplexer is capable of random sampling, but it can confuse and increase the work for people tracking fish. Gary Johnson said random sampling also might result in cross talk among transducers.

John Hedgepeth asked about computing variances on continuous sampling. Skalski said that there are two sources of error, sampling error and measurement error. Continuous sampling eliminates sampling error but not measurement error, which is very hard to estimate. He was unaware of anyone doing continuous sampling except riverine sampling in Alaska. Sampling for a transducer usually covers from 5% to 20% of full time.

Gene Ploskey raised the issue of sampling design, tracker workload, and the required reporting frequencies. He suggested a sampling scheme to balance precision, turn-around time, and labor costs. John Skalski said that the objective should be stated clearly. For any precision on a daily basis (for FGE, FPE, etc.) the day must be intensively sampled over time. Precise daily estimates might require double or triple labor. Shorter time estimates have higher variance and less precision. Gene Ploskey and Gary Johnson agreed that a week was the absolute minimum for an FPE estimate.

Tim Mulligan considered bias to be a more insidious problem than variance. He suggested comparing hydroacoustic measures of passage with pit tags or other methods. What is needed is a regular check for instrument malfunction, data problems, or violation of assumptions. That is separate from and before statistical analysis. John Skalski said that current models permit estimation of measurement error (as opposed to variability in nature) but that such systems are not yet worked out for hydroacoustics. John Hedgepeth suggested comparing data from two transducers concurrently sampling the same volume of water. There was a lengthy conversation about problems with the use of two transducers to measure systemic error, including that both transducers might have the same type of error. The issue of fish actually occurring non-uniformly in the beam as well as being non-uniformly detectable was also discussed.

Gene Ploskey brought up the issue of human error in hydroacoustic tracking. Gary Johnson described having seen discrepancies among individuals tracking the same data, especially with noisy data. Gary Weeks said that at Russell Dam (upper Savannah River) one transducer per night was tracked by two people and that discrepancies of >20% were resolved case by case. Gary Johnson suggested that, as a minimum, quality assurance and quality control methods should be reported. He emphasized the importance of training, communication, and an early start on the season to reduce tracker biases. There was general agreement that having all trackers in the same place and working together was good policy.

There was talk about data distribution among human trackers, from randomizing the distribution to giving the most difficult data to the most experienced people. Gary Johnson said that the same person always tracked the surface prototype collector data at Lower Granite Dam.

Gary Weeks asked about the difference in the possible error inherent in one fish in data averaging five fish *vs* 100 fish per hour. John Skalski said the important factor is percent error, not absolute numbers for major performance of the project, but for something like comparing structural configurations in an experimental design, a 20% difference could be important. Although John Skalski suggested that bias might be more likely towards undercounting than over-counting, the consensus was that error was probably in both directions, but

that individuals might consistently err one way or the other. The importance of training and supervision was reemphasized.

Different schemes for checking tracking performance were suggested. For example, a supervisor could track samples of each tracker's output or trackers could check each other on a regular basis, thereby verifying that they are within some limit of similarity by percent. Systematically or randomly distributing data from different systems to different people was mentioned as a way to avoid bias from differences in counts among trackers. Everyone agreed that whatever quality control and assurance methods are developed should be a regular part of reporting.

The conversation returned to the development and implementation of automated tracking. Several groups have been advancing automated tracking and others have automated tracking programs. Gary Weeks described the WES effort to calibrate their autotracker by applying filters to remove structural echoes and noise until the program performed similar to a human tracker. Bill Nagy said that the current system was single beam but that split beam would be much easier because it has three-dimensional information. A ping gap that is obvious in split beam data may not exist in single beam data. He said that even the single-beam tracking system is promising and that while a program would never have the understanding of context and judgement of a human, autotracking has the advantage of consistency. He also admitted that, at this point in its development at least, it would need to be verified by manual tracking. Tracking parameters will also need to change with changing conditions such a fish size or noise.

An extended discussion of problems in developing and implementing automatic tracking followed. BioSonics, Incorporated uses a system at Wells Dam, but John Hedgepeth was unfamiliar with it. He was using an echo integration automated system in New York. Bill Nagy again recommended split beam systems because three-dimensional autotracking has distinct advantages over tracking two-dimensional data from single beam systems, especially with regard to noisy environments. Tim Mulligan's group did all of their tracking automatically with a human checking the output every day, and doing echogram generation and manual tracking of a subset. There was another brief discussion about validation by netting.

10:27 A.M.– 12:25 P.M., Wednesday, 9/17/1987

Gary Johnson returned to automatic tracking in order to list factors to compare with manual tracking: (1) consistency, (2) pattern recognition, (3) ability to handle noise, and processing time.

Sam Johnson added that a human, especially a naïve human, might persevere in tracking a data set that was too noisy whereas an automated system would "blow up" and call attention to the problem. Bill Nagy added that an autotracker would plug into data processing systems readily. Cliff Pereira said that the "black box" nature of the autotracker, that users might not understand it, could

present problems. There was a discussion of autotracking programs developed by HTI and BioSonics and some of algorithms used. Gene Ploskey and Tim Mulligan said that they began developing their own systems out of frustration with the lack of flexibility or documentation of available systems.

John Skalski pointed out that even a good human tracker can become complacent and may not notice a sudden increase in count due to a transducer shifting. He suggested routine higher level checks. Marvin Shutters said that was the point of frequent reporting, to identify problems early. John Skalski encouraged greater and more regular of scrutiny of the data resulting from tracking before the reporting stage so that the reasons for unexpected results or changes in results can be evaluated quickly.

Gene Ploskey directed the discussion to expanding hydroacoustic counts to the entire cross section of a passage route. John Skalski said that it was important not to analyze sampling periods and then average those but to calculate total fish passage and then divide that by the total water passed through the orifice over the same time. "You don't take averages of ratios; you take ratios of averages or sums."

There was a short discussion on handling turbine-off periods, when fish passage is zero for some units. The panel concluded that off turbines and associated zeros would bias estimates of the horizontal distribution of passage if those times were included in estimates. The solution is to report horizontal distributions for consistent powerhouse operations and make certain that those are adequately described. The group quickly revisited expanding variances before moving on to discussing estimates of species composition.

There was a brief discussion of using species composition data to estimate passage or FPE on a species-specific basis. John Skalski said that there are two sources of variation, one for total passage, and the other for species composition. Just as with a ratio estimate such as FGE, one would use a "Delta method" to make the estimates. Unfortunately, species composition estimates from smolt monitoring and netting seldom have variance estimates. Other methods of propagating the error on species composition were discussed.

There was a rambling discussion of the need for sampling and estimating lamprey passage, separating squawfish and shad from juvenile salmon hydroacoustically, comparing hydroacoustics to netting, and the lack of agency appreciation of hydroacoustics. John Skalski said that when different runs last different times that there is no penalty for different sample sizes in point estimations, as there is in hypothesis testing.

Gene Ploskey asked for comments on detection efficiency indices or detection modeling. The purpose was to determine if the predicted average number of pings per fish matched the observed average cord length through the observed detection cross section of the beam. He was primarily interested in differences in detection for different transducers and possible corrections of expanded counts to reflect those differences. Tim Mulligan said that it was more important to know the distribution of echoes per trajectory. Then, assuming uniform fish distribution in the beam cross section, one can compare the observed distribution

24

to the expected distribution. This provides a check for the uniform distribution assumption. Sam Johnson said split beam would permit another level of analysis on the individual cords. Tim Mulligan described placing fish in an orientation frame in situ and measuring effects of aspect on target strength when noise was more typical of sampling conditions routinely encountered. He suggested it as a way to check a model and verify detectability assumptions. Bill Nagy described work with a Monte Carlo model that used net determined fish distributions from The Dalles. It was used to suggest the best deployment to hydroacoustically sample fish without bias. Don Degan described injecting potatoes as targets at Buzzard's Roost Dam in the southeastern U.S. He said potatoes are better than fish because fish tumble and give varying target strengths.

One important reason for standardizing detectability is for estimating horizontal distributions. If detectability is not equal among transducers because of differences in flow or noise, estimates of horizontal distributions may be questionable. There was a short discussion of extrapolation and interpolation in time and space (intakes). The difficulty of extrapolating across the dam was brought up. Since the ends of the powerhouse typically have higher passage, such extrapolation may not be justified. There was more support for split-beam sampling and for simultaneous sampling FGE with up-looking and down-looking transducers.

John Skalski said that simple random sampling is best, blocked for structure type (spill bays, turbine units) and that more spatial coverage is always better, especially in high passage (and therefore high variance) places. He encouraged a willingness to adjust sampling design (especially transducer allocation and placement) as the season progresses.

There was also some discussion of problems getting the beam close enough to an opening when sampling forebays so that fish were committed to passing and hydroacoustic detections reflected passage. This is especially problematic for sluice and surface collector openings when they must be monitored upstream. They also briefly discussed dealing with spatially skewed fish distributions detected by video monitoring.

Marvin Shutters said that it was the responsibility of the researcher to point out limitations of the study. That led to some discussion of the time needed for reporting. Marvin agreed that strict daily or weekly passage reporting is a bad policy and leads to bad science. Sam Johnson said that daily reporting is reasonable but expensive. Gene Ploskey said that the first years of a project, rapid turn-around times are difficult because so much effort is expended designing deployments, sampling, and developing data handling protocols and programming. It is much easier to meet deadlines if consistent sampling is done at the same project for several years. In short, continuity of projects is an asset. Bill Nagy said that sub-sampling and autotracking would help streamline the process and reduce costs. Gene Ploskey said that daily reporting is not reasonable if it precluded quality-control checks.

Gary Johnson admitted that frequent reporting for the Lower Granite project allowed researchers to catch problems before the final report. By summer, reanalysis had shifted some estimates, but confidence in spring data was high.

The reporting schedule was dictated by the decision-making schedule. He said that it was important for sponsors and researchers to frankly communicate and accept both the need for and the limitations inherent in rapid reporting. He said that the early reports are mostly just a data summary without graphs and statistics but provide a start on the final report. John Skalski added that the feedback aspect of in-season reports is important for quality control in studies. He stressed that it takes at least as much time for analysis and reporting as it does for data collection. He said that a 1:1 ratio of reporting time to data collection time was the bare minimum that 2:1 is quite reasonable, and that 3:1 would be luxurious.

Gary Johnson described "automatic reporting" on the Internet for the Walla Walla District. He found it very helpful. There was more discussion of the dangers of rapid reporting. Marvin Shutters said that the first number people see is the one they remember no matter the disclaimer that the results are preliminary. There was some discussion of sponsor oversight in processing and quality control. Gene Ploskey indicated that important conclusions could change depending upon how much of the data are processed. He described how preliminary results of a blocked trash rack experiment in 1996, based on 20 % of the data, showed no effect, whereas analysis of all data showed a highly significant effect.

Recommendations

Standards

These items were deemed important enough to propose as standards for hydroacoustic fish passage studies. Some of the recommended standards were not specifically discussed in the workshop because panelists take them for granted.

1. Use scientific-grade equipment with a highly accurate time-varied gain, stable electronics, and high digital-sampling rate (> 50,000 samples / second) for measuring voltages associated with echoes.
2. Have transceivers, transducers, and cables scientifically calibrated before and after every field season.
3. Report calibration data (source level and receiver sensitivity), thresholds, and receiver gains that equalize the output voltage for of all transducers.
4. Describe detectability modeling and results in proposals and final reports for every type of transducer deployment. Variables affecting detectability (e.g., water velocity, target- or echo-strength distributions) should be monitored throughout the study, and remodeling and expansion adjustments made as needed during the study. Changes in detectability and any required adjustments should be discussed in the report.
5. Ensure that hydroacoustic beams sampling guided and unguided fish for FGE estimates have very similar detectabilities so that detectability does not systematically bias estimates. The same person or autotracker should be used to track the data that determine both the numerator and denominator of FGE estimates for single routes.

6. Ensure that tracking of guided and unguided fish is very conservative with respect to noise. If sampling is simultaneous, time rendered untrackable by noise on one transducer should not be tracked on the other transducer even if noise is not present. Alternatively, separate estimates of fish per unit of "trackable time" should be standardized to a consistent scale for both transducers. Noise is usually more common near the top of turbine intakes and may hinder tracking of guided fish more than tracking of unguided fish.

7. Report fish tracking criteria (e.g., number of echoes, slope, linearity, and range) and any filters applied in post processing that might alter estimates. Discussion of underlying assumptions is desirable.

8. Report detailed statistical methods, including temporal sampling sequences, all spatial and temporal expansions of counts and variances, and formulas for calculated metrics.

9. Avoid wherever possible and otherwise quantify and correct systematic bias that can result from inter-tracker differences in fish counts during data processing Data from different locations that will be combined to estimate performance measures such as FPE or spill efficiency should be randomized before being distributed to trackers so that inter-tracker differences in counts cannot systematically bias estimates. If trackers regularly process data from the same location, inter-tracker comparisons, such as double-blind tests, should be made to quantify differences.

10. Ensure that automatic tracking counts are highly correlated with counts from experienced human trackers throughout the sampling season, and regressions and associated statistics should be reported whenever autotracking is used.

11. Base Project FPE upon independent, route-specific estimates of fish passage that are combined using the Delta method as described in (Skalski et al. 1996).

12. Sum estimates of guided and unguided fish separately before calculating ratios and associated variances when calculating FPE for multiple similar routes or estimating weekly, monthly, or seasonal FPE from daily estimates (see Skalski et al. 1996).

13. Document quality assurance and control steps in proposals and methods and results in reports.

Guidelines

The following items are recommended guidelines for improving hydroacoustic estimates of fish passage and project FPE but are not recommended as standards at this time.

1. Coordinate with the sponsor, other researchers, and statisticians before the field season to make certain all possible cross checks with other gears are being used to maximum advantage. Continue coordination throughout the field season. Formation of an ad hoc statistical work group is recommended.

2. Discuss expectations for precision before the study begins. Precision generally is greater for estimates based upon longer time intervals of sampling (season > month > week > day).

3. Use a priori knowledge about fish distributions across the beam and noise conditions to improve the selection of nominal beam angle for transducers. A rule of thumb is that a narrower beam is better if distributions are not uniform or if the environment is noisy. If spatial variability perpendicular to

the beam is low, a wider beam that does increase volume-reverberation noise is desirable. Passage estimates can be biased if the distribution of passage across the beam is high skewed, and this is less likely to happen with a narrow beam.

4. Monitor the through-system performance of every transducer by checking and recording the range and amplitude (voltage) of echoes from consistent reference points (e.g., the surface, bottom, or structure). The average voltage of background noise in ranges of specific interest also can be recorded daily.

5. Allocate effort to emphasize spatial sampling with more transducers rather than sampling more minutes per hour with fewer transducers because that is more likely to reduce variances.

6. Assume that the distribution of fish passage through any one route is not uniform laterally or vertically. Spatial variability extends over the whole project, across dam structures (such as powerhouses or spillways), among spill bays, turbine units, turbine intakes, surface passage routes, and within individual routes such as intakes, spill bays, or sluiceways. Sampling should be designed to estimate this variability by randomizing sampling locations among and within passage routes.

7. When possible, validate the assumption of uniform lateral fish distribution by intensive sampling at one or more intakes This might be done with multiple single beams, a multi-beam system, or one or two single beams on a programmed rotator or rail system. However, these approaches may be prohibitively costly for large studies sampling many routes. More data are needed to quantify the magnitude of potential error.

8. Review prior studies that might provide information on the rates of fish passage and variance at the dam, and use reliable information to allocate transducers spatially to increase precision. If reliable information is available, use it to allocate more transducers to locations that consistently have the highest passage and variability. Consider relocating one or two transducers to locations passing high numbers of fish as this change may greatly increase precision.

9. Consider sampling with one split-beam transducer deployed similarly to many single-beam transducers to enhance the interpretation of single-beam data. Split-beam data permit three-dimensional tracking of targets and direct estimation of factors affecting detectability (e.g., distributions of fish trajectories, speeds, duration in beam, and target-strength distributions). This information can be used to calculate sample volumes more accurately. The distribution of fish directions through the beam in forebay samples can be used to assess the probability that detected fish actually entered a specific route.

10. Increase the precision of FGE estimates by sampling guided and unguided fish simultaneously. This can be done by fast multiplexing two separate transducers, one for sampling guided fish and the other for sampling unguided fish, or by sampling both guided and unguided fish with one transducer. Advantage is provided by increased covariance. If ping rates are not limited by sound reverberation, fast multiplexing two transducers can provide more uniform detectability for guided and unguided fish than can sampling with one transducer where detectability is lower for fish at shorter ranges.

11. Describe effects of noise on data processing and criteria for excluding samples based upon the ranges or times that could be tracked. For example,

many researchers drop samples in which 50 % of the sample time was too noisy to track fish. The fraction of trackable range required also should be identified and reported.

12. Expand estimated counts in within-hour samples by the ratio of sample duration to trackable time or dropped if this ratio is < 0.5, where 0.5 is the minimum acceptable fraction of trackable time.

13. Examine and compare non-hydroacoustic estimates of fish passage and ratio estimators to hydroacoustic estimates whenever possible. Independent verification of the accuracy of hydroacoustic estimates can greatly strengthen study results.

14. Use all available information about fish size distributions to help model detectability, including direct measures of target strength, echo strength distributions, and length frequencies from direct capture sampling.

15. Sample all turbine units by randomly selecting one or two intakes per unit. Randomly sampling of two intakes per unit allows estimation of within-unit variation and may be desirable for units with the highest rate of fish passage.

16. Include at least one of every two or three consecutive spill bays in sampling.

17. Take frequent short samples within an hour (e.g., 15 1-minute samples / hour). That is better than a few longer duration samples (3 5-minute samples / hour) for reducing variances and increasing precision. At least two samples per transducer hour are needed to estimate variance. For temporal sampling, the unit hour is convenient since it usually coincides with dam operations.

18. Use, if needed, pulse-width criteria for filtering echoes from debris, as non-point targets usually return echoes with pulse widths exceeding the transmitted pulse width.

19. Describe interference caused by vortices, turbulence, entrained air, plant debris, or non-target species of fish with reference to dates of occurrence, duration, frequency, and impacts on data processing and hydroacoustic estimates. Remedial measures to reduce impacts of interference, examples of which were described in this workshop, should be described in sufficient detail for readers to assess degradation of data quality. The ratio of all echoes near tracked fish to those in tracked fish can be a useful noise index.

20. Reduce bias due to passage of American shad in late June and July samples by filtering tracked fish to eliminate those with mean echo strengths (or target strengths) exceeding –45 or –46 dB. Tracked fish with longer duration in beam (indicated by the number of echoes / fish) relative to the mean duration before shad arrived also can be filtered, particularly in the upper water column where shad densities are highest. A split-beam transducer deployed the same as single-beam transducers can provide target strength data and information about the proportions of large fish to smolt-sized fish passing through time.

21. Try to operate equipment so that effective beam angle (detectability) is for at least four echoes per fish because the probability of tracking noise is higher if three-echo fish are accepted.

22. Use all available information about hydraulic patterns (from physical and numeric models or empirical data) and fish behavior for detectability modeling. If available data are insufficient, arrangements should be made to acquire specific information for each deployment. The consensus of workshop panelists was that you cannot know too much about hydraulic patterns and fish behavior when estimating fish passage.

23. When replacing faulty equipment during the season, do not re-randomize locations if the goal was project FPE.

Literature Cited

Hanks, M. E. and G. R. Ploskey. In Press. Experimental Hydroacoustic Deployments to Improve Estimates of Fish Guidance. Draft Technical Report to the U. S. Army Engineer District, Portland.

Skalski, J. R., G. E. Johnson, C. M. Sullivan, E. Kudera, and M. W. Erho. 1996. Statistical evaluation of turbine bypass efficiency at Wells Dam on the Columbia River, Washington. Canadian Journal of Fisheries and Aquatic Sciences 53(10): 2188-2198.

2 Workshop Transcript

The following text is a transcript of the workshop proceedings that was recorded on videotape and transcribed later. Participants were provided a copy of the transcript and asked to edit their comments for inclusion in this transcript.

8:00 A.M.– 10:00 A.M. Tuesday, 9/16/1997

Gene Ploskey This workshop is on standardization. What we will do is follow the agenda, make lists of concerns or lists of equipment or lists of whatever we think is important. Deborah Patterson will do the recording for us. We may have to help her with spelling since she is not versed in the field. The main thing is to generate lists and try to prioritize listed items, and as we go through that process, have a great interchange of ideas and lively discussions. The agenda is not fixed in stone; it is merely a guideline. The product that comes out of this will be a Corps of Engineers written technical report, including a summary and synthesis of what we discuss and an appendix of the workshop transcript. We are not going to set standards today. We are merely going to talk about things that might be standardized to improve the comparability of data sets that come out of collections among years and projects. It is important that we come out of the field with something that has some value beyond just a written annual report. Hydroacoustic data might be incorporated in a database in the future that could be long term for single projects or even multiple projects.

The sponsor for this workshop is the U.S. Army Engineer District, Portland. The purpose is to look for possibilities for standardizing hydroacoustic and statistical methods for estimating the passage or passage efficiency of juvenile salmon on the lower Columbia River. We are looking for guidelines, bounds, or rules of thumb, if that makes sense. Some of which, after this process, might become standards. They might be used as checklist to design future studies, evaluate proposals, or review earlier studies. I hope that the guidelines and standards will increase the consistency and usefulness of results of future studies. Who knows, perhaps we will do this again and standards will begin to emmerge that extend beyond the lower Columbia River dams. The scope as you see in the agenda includes everything from equipment that you might

deploy and how you deploy it, detectability, all the way through to the statistical analysis of the data and reporting. What I am hoping for in this, and I think it will turn out that way, is that we will get loosened up and have some good lively discussions. We want to be critical of hydroacoustic sampling to identify ways to improve our performance. As we all know, there are all sorts of potential biases in acoustic sampling depending upon how we deploy transducers. If we eliminate the bias, the statistics should be straightforward. We have two statisticians here that I think they will help us a lot.

I have a few housekeeping items to discuss. Most of you, except for Tim Mulligan, are on an invitational travel order. Deborah brought copies of those vouchers that you will need to fill out. At the end of the workshop, we will take about fifteen minutes to help you fill out those vouchers as a group. You need to keep receipts for the hotel, commercial vehicles, toll bridges, and gas for vehicle. You don't need to worry about the food receipts. The bathrooms are just out the door to the left, and there are several places to eat in Cascade Locks and more across the river and east in Stevenson, WA.

In terms of making fish passage estimates, what in this agenda is the most important?

Don Degan
I guess what I would look at first is what is the objective of the study, because I would base what kind of acoustic equipment and how to set it up and what I am doing based on the objective. You generally have an objective when you set up your sampling on the Columbia River for fish passage efficiencies. We would want to start there and work towards that. Any kind of objective, like fish passage would make it easier for me to centralize my thoughts.

Gary Johnson
It seems there are three main areas as far as smolt protection at the dams goes. We're talking about smolts, right? Downstream migrants, no adult stuff?

Gene Ploskey
There are no adults.

Gary Johnson
Okay, for smolt protection at dams, there are three main Corps of Engineer programs. The spill program, which is part of the gas abatement work, intake screens, and then the surface bypass program. From those, we do many different studies that have specific objectives. There will be things like FGE and FPE, various distributions, horizontal, diel, and vertical and a sundry of other things.

Marvin Shutters
Are those passage rates through experimental structures, overflow weirs, or surface collectors. On the distribution questions, vertical and horizontal distribution information

Chapter 2 – Workshop Transcript

would feed into design efforts, but we are most interested in fish passage rates through structures. That is the basic measurement.

John Hedgepeth   Did you mention the approach behavior estimates there?

Marvin Shutters   Yeah, Gene and I talked about this ahead of time, and I think we want to stick more closely to passage estimates, the fixed-aspect type, just for time. Because we could spend a couple of days on the behavioral work.

John Hedgepeth   We can do all the work for the radio-tracking guys!

Marvin Shutters   What's that? Hydroacoustics is important for the behavioral stuff. You know I've been pushing to keep that going and to get it expanded. But, for our purposes here I think we should get together another time to talk about behavioral stuff.

John Hedgepeth   So, for our purposes, we're just going to talk about efficiencies in relation to those three categories.

Marvin Shutters   I think so. A lot of this stuff can play into behavior, split beam, and what you do. But I don't want to spend a lot of time getting into behavioral stuff because you can see we have lots of points here to go through.

Gene Ploskey   From that, we can say that the focus will be mostly the fixed-aspect passage estimates and ratio estimators. I think there are obviously all kinds of gear out there that is used for other things, but I think Marvin is right. Behavioral evaluations are mostly experimental.

John Hedgepeth   Let me interrupt you for just a second. Someone showed me a graph just before I came here showing that detectabilities may have been influenced by fish behavioral changes over years at, I think, John Day Dam. That you assume that the fish are going to be traveling at certain depths and you base your detectability models on that. If it changes, then maybe you are going to have to consider how fish are approaching the project. I wasn't particularly thinking of any of that experimental stuff, but I think we are going to have to consider where the fish are and how they are approaching. At least in the near field.

Marvin Shutters   That certainly is important in the sense of detectability. But what I didn't want to spend a lot of time on is how you handle your tracking, transducer data, multi-beam data or that sort of behavioral stuff. We can skip the small scale, micro-scale behavior in terms of velocity. But certainly any aspects of behavior that affect detectability or accuracy of estimates of passage. We would want to talk about that. I think that is on the agenda.

Gene Ploskey	One important consideration of fish behavior is hydrology in front of an intake where water approaches. That coupled with fish behavior leads to fish trajectory. I would agree that is important.
Don Degan	You have to approach it two different ways. One is that you can get an index and look at that over time as an indicator of what is passing through that system rather than an actual estimate of a count of fish coming through. And that may work fine for a particular dam, but it may not work very well at another dam because you have to set up the equipment differently, because of different behavior of fish approaching the dam, different hydraulics in front of the dam, things like that. So to me we should be more interested in an actual count of the fish moving through a structure.
Marvin Shutters	Maybe we should generate a list like we suggested on here of objectives. For most of the stuff we are doing on the lower Columbia, we do need passage estimates. We are doing stuff like fish passage efficiency where we would be comparing the number going through the spillway with the number going through a turbine. The sort of index you are talking about would only be valid in turbines or within spill bays. I would rather compare differences in detectability and spatial distributions within intakes.
John Skalski	That also brings up the issue of whether you do FGE at a turbine unit or FPE for a project. Because FGE at a turbine unit all you need is guided and unguided ratios but at a project you need to weight those by the number of fish going through those various units. So the order of effort going from FGE at a turbine unit to a hydro project is a quantum jump and it has very different design elements. I think we start off with and discuss what you would do at a turbine unit and then go to the next level. Once we know what the options are there, then what is the next step in trying to get an FPE estimate, for example, at a project.
Gene Ploskey	I know where this is going just in terms of where the Corps is being pushed. That is in the direction of knowing what this passage efficiency is going to be at whole structures. The Corps is supposed to maximize fish passage efficiency for projects. Of course, projects on the lower river have more trouble than up-river projects. Bonneville is the worst in terms of FGE at individual intakes. Nobody has ever measured FPE at Bonneville. It is very complex with two powerhouses and a spillway. I think we want to focus on fish passage efficiency for whole projects, but we do it with a model of turbine intake or a spill gate and problems sampling those.

John Skalski	That is an element. When it gets to a project, that is ten percent of the overall design elements. Then you have to sample probabilistically and realistically at all of the different passage routes to be able to get to project FPE. That is where the pain comes in because modern hydroacoustic effort and costs go up astronomically.
	Any sampling program has three elements to it. It has the temporal, which you can allude to be the most important. Equally important is the spatial sampling. How many units, what units do you sample? You don't necessarily have to sample them all. However, you do have to sample in some way that can make inferences to the rest. If you drop any one of those, your program is going to fail. Therefore, I don't think you can inherently make assumptions to get away from the spatial aspect. You have to incorporate the spatial aspect of the sampling inherently at the beginning of the program. Which turbine slots within which turbine units, which spill bays, how many spill bays? Whether you use sluiceways are very, very important. It is an integral part of the whole picture. Because you will have potentially both spatial and temporal elements to the variance as you alluded into it, depending on how you design those studies. Spatial elements of that variance can be huge and often dictates that we sample very extensively at a dam to eliminate that variance source.
Gene Ploskey	To summarize our objective, we're going to focus on fish passage efficiency for a whole project on the lower Columbia River. Water probably is deeper in most cases at down-river than at upriver dams, and juvenile salmonids generally are older and distributed deeper than fish at up-river projects. We'll point toward that overall objective and try to identify what passage routes deserve the most attention based upon the opinion of this group. Then, if we can't ignore any, we had better assign some level of effort to those that seem miniscule. We want to estimate project FPE and underneath that we have a whole list of structures or openings that need to be sampled.
John Skalski	First, we have to define what FPE is. You can't estimate something if you don't know what it is. We inherently think you know what it is until you get formal and then it becomes somewhat elusive.
Gary Johnson	Excuse me John, may I define it? I'm afraid John will get us all confused.
John Skalski	I told you not to say anything!
Gary Johnson	FPE in layman's terms is passage by non-turbine routes divided by total passage.

John Skalski	Seasonally or daily…
Gary Johnson	Non-turbine means, of course, guided in the case of projects with screens.
John Skalski	And then to confuse things…
Gary Johnson	I can't hold you back!
John Skalski	Because it gets us back to the spatial realm of things. The non-turbine routes are what? The spill bays, the sluiceways, potentially the guided routes, the surface fish bypasses. And then the denominator, the total, includes all those routes including the unguided fish. So, if we are going to estimate this critter, you have to be able to estimate those various elements in those various routes. Skipping a route in some ways degrades the definition of that FPE.
Gene Ploskey	We have our ratio down the left side. Why don't we just go ahead and jot down the various routes that might be included. You named most of those.
John Skalski	Non-turbine, spillways, the sluiceways, the guided fish.
Gary Johnson	And, surface bypasses, if you have them. The sluice chute at Bonneville Second Powerhouse, for example. Now some of these may not apply.
John Skalski	We'll get to that a little later.
John Hedgepeth	How about navigation locks and fishways?
Gene Ploskey	You want to put down the locks? We can strike it later.
Gary Johnson	Strike it right now!
John Skalski	Have you ever sampled a lock?
Gary Johnson	It's just not very much water, relatively speaking.
Marvin Shutters	It's worth looking at that at times just to see if it is significant.
Bill Nagy	What's meaningful to me about this list is the very different kinds of structures. Each is very different to monitor and the estimate you get from each one of these places carries it's own bias in terms of standardization. I wouldn't expect the numbers to be comparable.
Gene Ploskey	Turbines at the three lower dams have different types of screens or in the case of The Dalles, no screens.

Marvin Shutters	We still need to have the total turbine passage even if we do have guided and unguided fish to evaluate spill efficiencies. I'm not sure if that is something we can talk about -- to add unguided and guided or if it should be a separate estimate of turbine passage.
Gary Johnson	Excuse me. Is the sluice chute at the second Powerhouse also included under sluiceway, Gene?
Gene Ploskey	Yes. Okay, we have under project FPE, a lot of different routes that have to be sampled. Are we bringing Don Degan any closer to getting his equipment together.
Don Degan	Gene, I think I am a lot closer that what I was before. Because now this is a standardization of how you measure fish passage regardless of what type of opening it is and each of these openings are going to be probably a different type of equipment, a different type of setup. And possibly, a type of expansion of those numbers with the aim of what we're going for is the number that is a real number and not an index. And to get the best real numbers among all these different types of openings we're not going to be able to set up and have a standard set of equipment. My objective then would be to set up, design the study, and collect the best data I can given circumstances of that opening that I have to sample.
John Skalski	I think that is exactly right. When I approach a study, the first thing I do is list the openings. Next, I address the issue as to how do we get our best estimates of each opening of the total passage of fish going through that opening, whether it's over a day, week, or season. I would treat each one of those openings as a separate component that could be added together.
Gary Weeks	Sounds like what we are saying is that if you want to know true FPE you need to have absolute numbers and not indices?
Marvin Shutters	If your objective is things like run timing or relative estimates of passage, then indexing is fine. But for this objective it's not.
Gary Johnson	I don't know about that. I would say that if you had equivalent detectability between the various spots, you can still have relative estimates and make an index of FPE and it would be a very good number.
Marvin Shutters	If you have equivalent detectability and if the horizontal distribution is equivalent through those routes. And then you are getting to an approach trying to make an estimate of passage.
Gene Ploskey	They actually estimate FPE now for all of the dams on the lower Columbia River. Probably the others as well. Whether

they sample or not.

Gary Johnson	Are those absolute estimates?

Gene Ploskey   You'd be doing better than what they are doing now, which is to look at the passage route of the water. It doesn't vary much from year to year.

Tim Wik   Spillway versus turbine?

Gene Ploskey   Spillway versus turbine, assuming fish passage is directly proportion to flow. As bad as we might be in trying to estimate project FPE, some effort at equalizing our sampling effort over all the structures would certainly be better than where we are now.

I guess we have our sampling objective; it is to estimate one big number. Within that, we have a whole lot of sampling challenges. Should we then take each one of these routes and talk about how we sample it? Is that a reasonable approach? That deviates from where the agenda went, but would be perfectly fine.

Bill Nagy   I think the kinds of problems are of the same nature in any one of the routes.

Marvin Shutters   It is. I think if we follow the agenda we'll get to everything. Other objectives would vertical distribution and horizontal distribution.

John Skalski   One of the nice things is if you do adequate sampling to get a good FPE, you'll definitely have all the data you need to get both spatial and temporal distributions. Conversely, it's not necessarily true.

Gary Johnson   So we've taken on the big one, FPE at a lower Columbia River Dam. I agree with John Skalski. All that other stuff falls out. Even in the stuff I mentioned like screens and FGE's, surface bypass efficiencies, sluice chutes, and spill efficiencies. You can get those with data you get for FPE.

John Skalski   You have and you can get anything else you want. I think it is important that you recognize, and you did, that just estimating, vertical distribution and horizontal distribution does not give you some of these higher order estimates that we want.

Tim Mulligan   I'm going to ask what might be a naïve question, because I'm not at all conversant with juveniles at dams. But certainly vertical and horizontal distribution play key roles on what you see. But tied in with that is also the instrumentation you are using. You might see something completely different in terms

of the data that you get with the different horizontal or vertical distribution with the same number of fish going by. So certainly it really depends a lot on your signal to noise ratio. If you're seeing everything that goes by perfectly, you can ignore vertical and horizontal distributions in terms of detectability. Oftentimes, that is not the case. You only detect a fraction of what goes by so that both horizontal and vertical distribution plays a role in what you actually observe.

Marvin Shutters   In our situations we almost never think we are going to see everything going by.

Tim Mulligan   I guess what I mean is even those that go through your beam, you don't see completely.

Marvin Shutters   Right.

Tim Mulligan   You can't assume that the beam is covering some particular area of space uniformly.

Sam Johnston   In the case of horizontal distribution, I think we're talking mostly between structures, not within an individual structure.

Tim Mulligan   I would like to focus within a beam.

Marvin Shutters   I think that is very important and something that is not addressed often enough.

Sam Johnston   It's sort of a different thing from the horizontal distribution across the dam. It is certainly interesting.

Marvin Shutters   That comes under the issue of uniform distribution for sampling detectability and expansion.

Gene Ploskey   I think this is very important. I know that we deployed four underwater cameras along a sluiceway weir and found a two-to-one skew toward the sides of the opening. If you put a transducer in the middle, you would underestimate the number fish passing into the sluiceway. Fish are rarely uniformly distributed.

Don Degan   I guess, to me, this part was just what John pointed out regarding spatial distribution. Whether it is large scale among the units or within the unit itself. You have to answer that question. Whether it is horizontal or vertical because you have to have that information to know that you were taking a representative sample.

Gene Ploskey   The way it often works is you get one shot at going in and deploying and then the crane operators all leave. You can't go in and look at the horizontal distribution for a turbine unless

	you specifically design a preliminary study to learn how to improve your estimates.
Don Degan	I think Tim's point is that there is another component to sampling. That is detectability. I think that is outlined somewhere else.
Gene Ploskey	Why don't we move on and talk about equipment and setting? Obviously, you must have scientific grade equipment with accurate time-varied gains. What else is important?
John Hedgepeth	Ping rate considerations play a big role.
Sam Johnston	Equipment settings seem to be more important than types of equipment. I think all of the equipment that everyone uses here is of scientific quality. It's more of what are the settings and the specific details of those things.
Gene Ploskey	Including frequency.
John Hedgepeth	Interaction between ping rate and frequency. If you should choose a lower frequency than is normally used, you might have the sound bouncing around so much you can't maintain a high ping rate and thus get your detection on fish. So that is why equipment has probably evolved to the stage that it is today.
Gene Ploskey	I think then under equipment we'll get to selection of beam shapes and that sort of thing.
John Skalski	Can I interject? One way of looking at it is bias versus precision or systematic error versus random error. At least I typically assume that the bias is largely going to come from systematic error associated with the hydroacoustic equipment. They aren't calibrated correctly or they are missing targets. Whereas the sampling precision is more, quite often, associated with where and how much we allocate. How many transducers and how often do we use them influences the precision while the equipment per se has a potentially higher influence on the accuracy or bias.
John Hedgepeth	Except for the horizontal distribution.
John Skalski	Yeah. Except if you put all your transducers in the middle and all the fish are on the sides of the slot you have bias there as well. But I think quite often you need to separate out those two elements. Keep in mind that accuracy and precision are not the same thing.
Gene Ploskey	If I hear everybody correctly, we are saying that probably most transceivers out there in use today are of sufficient quality.

They range in frequency from about 200 kHz although they could be 120 or lower frequency all the way up to 420. That I know of, that is the range of frequencies that are used. So, then it becomes more of an issue of coverage, which is listed under transducers. So, if we have a certain opening, can we come up with a rule of thumb that you might pick a certain transducer for its coverage? And what is insufficient coverage for the width of an intake or the size of an opening? In other words, where do you start worrying about how much you expand?

Marvin Shutters   In the matter of sampling, the area of the sampling is not as important as that you know what volume you are sampling and that you do indeed have full detectability within that.

Sam Johnston   Whatever sample volume you have certainly has an impact on the variability. Of course, the more volume, the lower variability. But on the other hand, if the detectability is either unknown or sort of unpredictable or maybe related to the density of fish, things like that, then you get into real problems. And your estimators are incorrect. Not just too variable, they are just wrong.

Marvin Shutters   If you do have a very small sample area or have a high variance you can counteract that simply by increasing your temporal sampling.

Gene Ploskey   There are transducer beam widths, say a six-degree beam, that might be deployed at short range to sample guided fish within a turbine. Is there some point where you worry about that beam being such a small part of the width of the intake? Obviously, some estimates can be better than others depending upon coverage.

Gary Johnson   I think that is a good question for the statisticians. Practically speaking, we've always tried to put the fattest beam in to have decent sample volume. And we get what we get. Oftentimes, it turns out to be about 10 to 15% of the cross-sectional area, which doesn't seem like a lot from the sample point of view. Maybe it's okay. As I said though, this is a question that somebody needs to do some statistical modeling with, perhaps.

Gene Ploskey   When you expand variances, don't you take whatever the expansion factor is and square it and multiply it times the variable?

John Hedgepeth   No, we just get the number and the variances are calculated from that number without any consideration of that variability. I guess the assumption is that it is negligible in relation to the rest of it.

John Skalski	Or some index that is proportional in instances back to whether being absolutes or indices.
Gene Ploskey	We do that for time. If we sample ten minutes out of an hour, we expand the time. You do that expansion of the variance.
John Skalski	Absolutely. But unless you get multiple transducers or multiple locations within a slot where the transducer is sampling, there is no way to capture that spatial variability within a slot. With only one location and one transducer, you're stuck assuming you have a representative index. You have the choices of where you can randomize the locations of that transducer within the constraints of the size of the beam. But ultimately, we do not typically have multiple transducers within a single slot. I think that is extraordinarily rare. I don't think I've seen that on the river, but that is where the potential sampling bias is.
Tim Mulligan	I guess that would be my main concern. Certainly our experience is that fish distribution, even on a small scale, are quite variable spatially. They are not uniform at all. So taking an assumption that over some part of a geometrical structure you have a uniform distribution of fish and you are going to sample ten percent of it is pretty naïve. And if those things are temporally variable too, that just adds to the difficulty of finding out what is actually going by. That is sort of why we're all wedded to split-beam systems because at least they tell you where in the beam you're getting the signal. It tells you something about the spatial variability over the section that you are actually sampling.
John Hedgepeth	So it gives you a measure of bias. Is that what you are saying?
Tim Mulligan	It gives you some measure of bias
John Hedgepeth	So you redirect your beam?
Marvin Shutters	Excuse me; I'm not familiar with what your sampling situation is.
Tim Mulligan	I don't work with dams. I look at the adult fish swimming upstream and we look horizontally. There is typically quite a variability in the density of fish within a beam width in the number of fish going by, and if that changes over time then it means your detectability is changing over time. Somehow you have to correct for the detection efficiency versus where they actually are in the beam. What I'm trying to say is small-scale spatial distribution, in my experience, plays a major role in the signal that you actually see. And I'm wondering if it's equally dominant in looking at fish across a spillway.

Gene Ploskey	I think so. What you are saying Tim, fits right into a discussion of tradeoffs in selecting different types of transducers. I think most people would probably agree that the split beam is certainly the way to go for a number of reasons. The one you just mentioned and we will get to it later in terms of tracking, as well.
John Hedgepeth	It might tell you that you have a bias, but it's not absolutely going to correct it. It seems like your sampling design is the way to approach it. Especially if you have a sample and a lot of gear and now we're going to bring out an expensive piece of hardware, which is a split beam. You might be better off with a good sampling design and not make an assumption that the fish are uniformly distributed.
Gene Ploskey	In some cases go in with multiple transducers and document patterns.
John Hedgepeth	Or just randomly allocate your positions.
John Skalski	Yes! Those are the two options. Replicate transducers within a slot or randomize position of the one. You won't be able to capture the variance, but you will be able to eliminate the bias on the average. Typically, if you just put all of your transducers in each slot and always in the middle. It seems to work pretty good as far as we can discern. We seem to get reasonably consistent estimates, but if you wanted to capture that spatial variance, you would have to have more multiple transducers in the slot. For project-wide FPE we're talking thirty to forty transducers. You're doubling that. What you could do potentially is randomize the location within the constraints of the cone and the size of the slot if you had to.
Sam Johnston	I think that the temporal variation in their position compounds that for us. But, as you say, over a long period of time, it will even out.
Gene Ploskey	Cost is certainly a factor, too. As John Hedgepeth mentioned, a split beam transducer generally costs more than a single beam transducer. But if there were definite reasons why we might want to use split beam, we know that there are advantages to it, including tracking fish in noise. We found there is certainly a huge advantage to split beam in that we can track fish in a much noisier environment than you can with a single beam.
Marvin Shutters	Usually in an in-turbine estimate of passage you have a twelve-degree split beam. And you can look at the spatial distribution within that beam. That is not addressing the spatial distribution within the rest of the intake anymore than the single beam does.

Bill Nagy	The thing here for me about split beam and single beam is that with the split beam you can characterize detectability much better than you can with the single beam. In fact, I am beginning to doubt if you can ever determine the detectability for a single beam transducer except under unrealistically ideal conditions. The detectability is a much more complicated kind of problem than we've ever really dealt with that you don't know where the fish are coming through in the beam with the single beam equipment. You don't know big fish…little fish. You are only getting, in these applications, as few as three and maybe as many as ten or fifteen hits. That's why the equipment issue here for me, split beam versus single beam, is detectability. I don't think we characterize the detectability adequately enough and we end up getting huge bias in our estimates. Because of that, the split beam is a big step toward really establishing detectability.
Gene Ploskey	I agree with what you are saying. There are definite advantages to the split beam, but I don't think we can afford to put fifty transducers out at Bonneville. Fifty some transducers starts to become cost prohibitive.
Tim Mulligan	I wonder if you have considered moving the transducer instead of multiple transducers. Either move it horizontally or you tilt it, something like that. So, you get a larger coverage with a single transducer. We certainly have to do that in the river. It is much cheaper than buying ten transducers.
Gene Ploskey	I have always been interested in a reasonably priced rotator with precise adjustable stops. It would not have to be high speed or provide feed back on aiming angles, just be robust. Most rotators on the market are relatively expensive. Turbine intakes at lower Columbia River dams can be 75-125 feet tall.
Marvin Shutters	Not that tall!
Gene Ploskey	They're not that high? Well, 100 feet tall and on the order of twenty to twenty-five feet wide. It would help to have rotators on transducers aimed up and down so that both sampled different lateral areas while integrating most of the vertical component.
John Hedgepeth	You could also make a scroll mount to move the transducer across the intake. Set a rotator on top of that and you would have a very flexible system.
Tim Mulligan	We found that a narrow beam with a lot of multiple aiming was much more desirable than trying to fill a whole, in our case, river cross section with a single beam. With a wide single beam, your beam pattern falls off very gradual so you've got a

large area of low detection efficiency and if you have what you're claiming where they combine the edges where your detection efficiency is low, you've got the worst of all possible systems.

Bill Nagy
You could set a wide beam for short range and a narrow beam for the longer range if you have to cover a large area. I don't think we've ever done that.

Gene Ploskey
I wonder what the problems with that might be in terms of the expansion and ratio estimators like FGE. That's also coming up. We're doing pretty well on time. I want to generate a table. If we could list transducer types across the top and maybe objectives up and down. We have a lot of different transducer types. We have single beam, dual beam, split beam, single-dual, and scanning. Split beam and multi-beam are what I have listed here. As far as I know that's most of them. If we have a list of those and I just want to generate a table that shows what the transducers are across the top and then either the objective or the information that is generated from each one or it could be an advantage. So we can go through and put in check marks. Target strength might be one of the categories on the 'Y' axis. Across the top let's put down single, dual beam, scan, split, and multi-beam. On there we could pick whatever we want. Maybe this is just an exercise because I want this table. If you don't like it, somebody just holler. Let's say as an objective you wrote down estimate of passage. The number of fish passing through an intake. Obviously you could estimate passage with all of them except probably the scanning and the multi-beam.

John Hedgepeth
You could probably use the scanning to estimate passage too. And the multi-beam.

Gene Ploskey
So just write 'all' there and draw a line. I don't know where this is leading and if it fails to go anywhere quickly we'll stop.

Marvin Shutters
I have a question on scanning. Are you talking like the Mesotech scanning sonar, like at John Day?

John Hedgepeth
I know that there is a French group that's having McClinton's group in Scotland calibrate scanning sonar so it's possible to do it. It's not quite off the shelf right now.

Bob Johnson
The Mesotech systems can be calibrated, but I think a Stanley type of a beam could be a scientific sounder type single beam.

John Hedgepeth
Yeah! On a high-speed rotator.

Bob Johnson
That would actually be a very good way of looking at an intake.

John Hedgepeth	That's what Tim Mulligan was just talking about. Just moving the beam.
Marvin Shutters	So, scanning isn't really a transducer type, it's just moving a transducer
John Hedgepeth	No, if the rotator is in a fixed location then just moving the transducer from that fixed location.
Sam Johnston	Any kind of transducer can do that…single beam…
John Hedgepeth	I think multi-beam is kind of the same thing except you don't have to move it. You get all that information without moving it.
Sam Johnston	Instead of mechanical tension it's electrical and a bunch of elements.
Gene Ploskey	Maybe if we put target strength for the next one. You can get an estimate of target strength from the dual beam; I guess the scanner, too.
John Hedgepeth	I don't think from the scanner.
Gene Ploskey	Well, I guess not because you have different aspects.
Bob Johnson	You could put a split beam on it.
Gary Johnson	Use a split beam and turn it around (Group laughter)
Gene Ploskey	Can you get an estimate of target strength from a multi-beam?
Marvin Shutters	Not now!
Bob Johnson	No better than a single beam.
Gene Ploskey	So a sub-category of target strength is its influence on effective beam width. This was where we were headed a little while ago with the discussion of the advantages of certain transducers. As you said, Bill, you obtain more information about sample volume when you can estimate target strength.
Bill Nagy	Target strength is kind of a very indirect way of getting it. There are better ways to do that. For example, with split beam to get an estimate of your sample volume. Another classification would be trajectories or something like direction or location.
Gene Ploskey	Go ahead and put down trajectories, and then under single beam you would put change in range because it's one-

dimensional.

Sam Johnston	You can arrange it at an angle, but usually that is not too helpful.
Gene Ploskey	With split beam you get 3D trajectory. You get that as well with a multi-beam.
Marvin Shutters	Well, a multi-beam is not three-dimensional is it? It's only two-dimensional. I know you're working on three-dimensional.
Bob Johnson	On the shelf multi-beam is two-dimensional.
Gene Ploskey	So trajectories and beam width all affect detectability which is where we are headed later.
Gary Johnson	It might help, Gene, as a variation of this theme to have angle off axis. Would that be useful?
Gene Ploskey	Angle off axis?
Sam Johnston	It's sort of under target strength as well.
Gary Johnson	Yes, that's what I said…variation on the theme.
Don Degan	May I ask a question, maybe of the statisticians. From my experience at Russell and some of the other sites, I don't know if this is similar on the lower sites on the Columbia River or not. But, I'm not convinced that a transducer beam is really an important issue here. I think from what I've seen, if you can sample what is going through the intake with a transducer beam then you can estimate fish passage. But the problem oftentimes comes in the distribution of fish passing through an opening is not uniform. At times I've seen where that is the overriding factor that is causing erroneous fish passage estimates rather than the transducer beam or anything else. It's that you're not sampling what you think you are sampling. To me it all goes back to first identifying what an adequate sub-sample is. Not what type of beam you are using, but identifying what you need to sub-sample. Once you do that, you can get by with a two-degree single beam transducer without it making any difference as long as you are adequately sub-sampling. So, to me, that is the first question, not what kind of transducer should be used in what case. Because in a lot of cases you can use any kind of transducer as long as you have it aimed in the right place. You're going to be sampling what you need.
Gene Ploskey	Yeah! Aimed or moved!

Tim Mulligan	That's not exactly true! There's quite an interaction between the detectability and the spatial distribution of the fish. It depends on if the spatial distribution of the fish varies over the range that you are seeing them in the beam. Then you have a problem.
Don Degan	I'm talking about the actual spatial distribution of fish entering an opening.
Tim Mulligan	That's right! And what I'm saying is that if you divide that into a small area and the spatial distribution varies over that small area that you are looking at, you also have the detection problem.
Don Degan	I think that can be overcome by how you aim the transducer and how you sample.
Tim Mulligan	I don't think you can unless it's static. Unless the distribution is…
Don Degan	The distribution is non-uniform, but it is not constant. But it remains similar enough. If you have a high density or high passage rate in the center of the opening it's always high and it may be lower on the outside edges or maybe the reverse of that. But there is always a relationship that is based on where the fish are passing.
Tim Mulligan	That's what I mean. If it's static then maybe your problem goes away, but knowing whether it's static is not easy. I guess what I'm saying is what you see from your instrument is a combination of instrument effects and the fish distribution itself. So that if the fish were in the middle of the beam at one depth and then at the edge of the beam at another depth and they were the same density, you would observe different densities. If you don't have any information about where they are, the information you are getting from your system does not compensate for that difference. The spatial distribution has to be uniform over the area that you are actually sampling. If you are sampling a large depth like the one I talked about, then it's very different.
Marvin Shutters	Vertical distribution doesn't have to be uniform.
Tim Mulligan	I'm talking mainly about horizontal distribution.
Marvin Shutters	Horizontal distribution is critical.
John Hedgepeth	So, if we're getting an FPE project-wide number and you randomly allocate your transducers horizontally and they are single beams, you still have a problem?

Tim Mulligan	Yes. Unless you are going to randomly allocate within a sluiceway each hour or each day or something like that.
John Hedgepeth	Randomly allocate completely.
Tim Mulligan	Yeah! So if you can do it temporally sufficiently enough within a sluiceway then your problem goes away. But if you are talking about random allocation…you put it in one portion of sluiceway one and another portion of sluiceway two…to me that doesn't get it either.
John Skalski	In expectation it does. In expectation of all possible amortization it is an unbiased estimator.
Tim Mulligan	Yeah!
John Skalski	It is all you can probably do with transducers.
Sam Johnston	No, because the one transducer may only see 50% of the fish while the other transducer sees 20% of the fish.
Tim Mulligan	That's right. You're still assuming that what you've measured is proportional to what is there, but it may not be.
Sam Johnston	Because of the horizontal distribution.
Gary Johnson	So what do you do?
Tim Mulligan	If you keep randomizing, you overcome the problem.
Sam Johnston	Keep moving within the one structure.
Tim Mulligan	Then you overcome the problem, but if you set it up once and it's that way for the whole season, then you have to assume that each sluiceway is exactly the same and your total randomization is among sluiceways. And that to me doesn't make sense.
John Hedgepeth	What if you had two transducers per slot.
Tim Mulligan	Well, that's better at randomization than one. But it's still not a hell of a lot. The naïve assumption is that what the transducer sees is what actually went through. That is not necessarily correct. It's only what the transducer sees is what went through plus where it went through its beam.
Don Degan	Yeah, I understand that. That's a totally different question than what I'm getting at. What my point is that there are biological reasons for fish going through an opening at different areas that's not anything to do with detectability whatsoever. And if

you understand a little bit about the biological reasons why a fish is going through near the surface, bottom, sides, or middle then you can document that with other sampling gears. It gives you a better idea of what you need to do and how to set up your sampling. Then you can answer the question about detectability of your system at that point. First, you have to have some idea of how much variation there is naturally and biologically through space and time. From what I've seen in the training samples, poor understanding of variability accounts for most of the error in sampling.

Marvin Shutters   To address this kind of stuff, we've talked about the ideal approach would be a transducer mounted on the bottom on a rail or something that would move and randomly sample different horizontal areas. Could all the problems also be addressed by using the traditional center line up-looking deployment and then finding a correction factor, a calibration for that. Not assume uniform distribution, but use what Gary did at Bonneville this year. He loaded up with eight transducers in the unit to try to map the distribution within an intake so he can apply that distribution to the center. You also could use fyke-net data to get the correlation between your hydroacoustic estimate and your fyke net estimate to use an expansion factor rather than assume uniform distributions.

John Skalski   Statistically you can't, from my understanding. Some people question the accuracy of fyke net data.

Marvin Shutters   Every sampling method has a bias.

John Skalski   Yes!

John Skalski   Conceptually, we use ratio estimators to calibrate one versus another.

Marvin Shutters   Not necessarily!

John Skalski   No!

Marvin Shutters   I would take it as far as saying Unit 8, this year, and probably go ahead and still say expanding that to certainly Unit 8 as long as there are no other big structural hydraulic changes there. Then we could use that distribution there. And maybe for all the center intakes of Bonneville, maybe. Beyond that, I'd be very uncomfortable.

Gary Weeks   So that leaves us with two methods of addressing this. One is some sort of apriori knowledge about the distribution and the second is triangulation.

Gene Ploskey   That about sums it up. The easiest and simplest thing to do

would be to randomize the position of your transducers among and within intakes. That's what I heard John say. Ideally, the best thing to do would be to sample spatially within all intakes with a rotator or some moving mechanism. There are also advantages in using split beams to determine whether you have a problem within the beam that you use. I think everybody here would agree there are a mix of transducers that would be useful for estimating passage. To just go out and use all single beams would not be as good as having some split beams mixed in at different places. The minimum is that you go out there and deploy single beam transducers and you at least try to randomize within and among turbine intakes. Would it be advantageous to put effort in A, B and C intakes? They are different structurally, the way the sides go in and in the way they open to the spiral case. The flow among intakes can be quite different. Intake C actually has dead areas where the flow goes in, up, and then down into the turbine. In A and B slots flow follows the scroll case and slides right through the turbine. You can actually have nearly dead water in your C intakes just because of the way they are designed. They're a lot different from the center intakes probably in the terms of the way they pass fish and in terms of the way fish move through them. Would it be advantageous to put extra effort on a turbine and try to sample spatially?

John Skalski   There is a long history at Wells Dam trying to characterize the relationship between fish passage between A, B and C slots. I think one of the things they learned, Gary, correct me on this, from unit to unit, the relationship between A, B and C slots was not consistent. I think you see that dam after dam after dam. I think it's a fools gambit at any point in this time to start using one unit, one slot that's characteristic of all three or the relationship between two slots of one unit to be characteristic of all units. I'd rather go for a probabilistic point of view is sample, if you can't afford three transducers for the three slots in a turbine unit, then randomly sample two out of three and make inferences to the third probabilistically. We can do that. We can incorporate the variance of that uncertainty and extrapolate to the third slot within the unit. I think this last year at one dam; we were forced to sample all the B units against recommendations. And surprisingly all the B units are different. No two things are the same. The bottom line assumption is that everything is different in every way possible.

Gary Johnson   That's what Tim said.

John Skalski   And so far of all the number of dams we've sampled that seems to be true. There are no consistent patterns. Don't assume so. Let the sampling process characterize that. But to go in with some apriori assumption of similarity it's a fool's

gambit. I think we have probably ten years of data on the Columbia River to say that every dam and every dam slot is different.

Gene Ploskey   That's very good!

John Skalski   We learned it the hard way. I think in terms of like some of the PUD's we spent several years trying to characterize our relationship and finally realized there isn't one between A, B and C slots. You're wasting time. Go ahead and assume they are different. Probabilistically sample and you can get good results the first year. Otherwise, you are going to lead yourself down a tunnel that's going to get you nowhere.

Gary Johnson   So the probabilistic sample of Wells Dam in the final two years of the total project evaluation of FPE essentially was to sample fish passage in 27 of 30 intakes and 5 of 5 bypass routes.

Gene Ploskey   You sampled everything!

John Skalski   Pretty much, yeah. We can talk about this later in terms of sampling effort, where to put the sampling. But, the ideal is to put as much effort in the higher order source of variability. In other words, unit to unit is more variable than slot to slot, which is more variable than hour within the slot or day to day within the slot. Then hour is less variable than day to day. So the more you characterize completely the higher order source of variability, the better precision you get. So this is what we ended up doing at Wells ultimately was to start sampling two of the three turbine slots because of logistic limitations and equipment limitations. There was still a lot of slot-to-slot variability in our estimates, although we characterized all the fish passage and we sampled 24 hours a day at a slot and we sub-sampled minutes within the hour. In many places you find that variability is proportional to fish passage. We had the most fish where we had the most variability. We found at Wells that you could literally move one of those 30 transducers and cut the variance of your estimate of fish passage in half. For example, we moved one transducer from a turbine unit that had three turbine slots covered but very low passage and very little slot to slot variability. Moving one transducer to another turbine unit that had only two of three slots covered but high fish passage and large variability among slots, cut the variance in half for a whole project.

Gene Ploskey   So obviously apriori knowledge of what your distribution of passage would help you tighten up your precision.

John Skalski   Absolutely! It happens that apriori knowledge of the horizontal distribution helps tremendously. But in the absence of that, always sample as much as possible, as completely as

possible, your higher order sources of variability.

Gary Johnson   To tie in John's point back to what Tim was saying during that work, it's still in a given intake. Of course, we assume what we detected was proportional to what was passing. So I wanted to add that I agree with Tim that that probably isn't true. But when you sample enough spots, I'd like to ask this: does it wash out. In other words, can we live with that total project FPE estimate given that type of approach although we have a limitation of this detectability?

Marvin Shutters   What if you pose the question as, "Is it proportionate to the number of fish?" I would say certainly. But, is it accurate? Probably not.

Gary Johnson   Is the expansion accurate?

Sam Johnston   Do we know that the detectability differences are systematically biased? In other words, do all the A slots have fish on the edges and all the B slots have fish on the edges.

Gary Johnson   So I'm asking if you do make your estimates over enough locations over a long enough time, will that work?

John Hedgepeth   I don't think so because you could have a difference between your turbine and non-turbine. You could have all the fish on the edges of the turbine and all the fish in the center of the non-turbine. Then you have an incorrect result.

Gary Johnson   Practically speaking, does that approach work?

John Skalski   I think practically, you get better in the sense that variances decrease in terms of scale. You have more variability between units than you do slots within a unit and you have less variability probably among fish within a slot than you have between slots. I think you could probably have a bigger problem with accuracy, in other words bias, by sampling just the B slots than if you had randomized those transducers having put them in the middle. Because there is a lot more slot variability within those units. Therefore, I think you minimize the bias by randomizing the transducers between the slots and then the next level of reducing bias would be to randomize the transducer locations within the slots. Again, that should improve the precision, but the first chunk is going to be to characterize the higher source of variability. Sampling those non-probabilistically is not realistic. So I think asymptotically you get better and better. As you go further and further down the only variability is at small spatial scale and temporal scales. Yes, you'll have bias, but it will be less than if you keep going to the higher sources. It will be there, we just don't know how much.

Marvin Shutters	We should still be looking for that within intake distribution to give us the warm fuzzy feeling that we are nailing it or to show us that we are not. Otherwise, we have to rethink the whole thing. For turbines, there is a lot of the fyke-net data that suggests that distributions are rarely highly skewed and that hydroacoustics does a reasonable job. The sluiceway that Gene was talking about, not so good.
Gary Johnson	Gene, maybe for the purpose of the workshop we could generate a list of critical uncertainties in this work. I guess the first one that we…
Gene Ploskey	I don't think we have enough paper!
Group laughter	
Gary Johnson	I don't know if that is part of what you are looking for, just a suggestion.
Gene Ploskey	Yeah, that's fine!
Gary Johnson	And then people can go off and work on them.
Gene Ploskey	Yeah, you want to do that right now, before we take a break?
Gary Johnson	If they think it's useful.
Marvin Shutters	I think it would be.
Gene Ploskey	Can we do it fast?
Gary Johnson	Just do a running tally.
Marvin Shutters	As we come up with things, maybe pull them out as you are reviewing.
Gene Ploskey	Are we talking about like John's rundown, that you have certain things that affect your FPE estimate more than others, like among powerhouses and spillways as well as among units.
John Skalski	As well!
Gene Ploskey	Is that more important than among turbines?
John Skalski	Absolutely, because we would expect fish passage to be demonstrably different between a spillway than a turbine unit. You have to sample both. That's why you can't ignore a particular route. That's why I think we need to define FPE and what the routes are that they need to address. All will have to be addressed if you are going to try to get a realistic and

	unbiased estimate of FPE. If we ignore one, we're going to have problems.
Marvin Shutters	I think what Gary was saying, and I agree, that we are coming up with some things here, some assumptions, that the techniques we rely on may or may not be valid.
Gary Johnson	That are uncertain.
Marvin Shutters	They are critical to the estimates and they are uncertain. And I think we need to have those pointed out as he said so we can start working on them. We could see where we do need to put our effort.
Gene Ploskey	We can hang the list up someplace or we can start now and add a few items to it and as we hit others we add them.
Gary Johnson	Tim, I'll try and then you correct me where I've missed it. The critical uncertainty that I've heard here that hits home with me was the assumption of uniform distribution across a passage route and the methodology that is typically used to generate the passage rate estimate. Just put down uniform distributions as a critical uncertainty.
John Skalski	The assumption of uniform distribution.
Bob Johnson	On two scales, right Tim, within beam as well as within the slot?
Tim Mulligan	Yeah, within beam is the one that is really difficult to get at because with a simple system you always assume that it's uniform within the area that you are looking.
Marvin Shutters	Would your within beam, does that come under maybe detectability models or detectability assumptions?
Tim Mulligan	Oh yeah!
Bob Johnson	One thing that's been really noticeable to me and I haven't been talking too much, but I'm listening. It seems like detectability comes up about every other word. It seemFs to me like the theme of what we're talking about here is the issue of detectability and the critical uncertainties attached to that.
Tim Mulligan	And there are a lot of the things that John was talking about in terms of variance which is a lot easier to measure than detectability which is bias. That's the insidious problem.
John Skalski	Exactly! That's why you really need to separate out precision versus bias and precision versus accuracy.

Tim Mulligan	Bias is the most difficult to try to get a handle on because oftentimes you have to measure versus some non-acoustic technique or have a really good physical model of what is going on to try to correct for it. It's the most insidious problem, I think, in all types of fish passage.
Gene Ploskey	Could we add detectability then as a second item or is that just really part of...
Gary Johnson	I would suggest you kind of wait and let the pieces that Bob was talking about fall out as specific uncertainties. In other words, detectability itself might be too general.
Gene Ploskey	Okay.
Marvin Shutters	We have detectability coming up on the agenda, so maybe we could start filling that in.
Gene Ploskey	Target strength information is useful for filtering fish, defining sample volumes, and deriving reasonable expansions. Is it reasonable to obtain target strength information from juvenile bypass facilities. I know that Don Degan has taken back calculated target strengths for fish that were netted for hydro power in North Carolina and used those estimated sample volumes for a single beam. At any rate, what he did was used fish links from netting data. So they fyke netted a unit. Or you could use them for bypass data where they actually measure a large number of fish that are bypassed and sampled. Could you use that information to estimate target strength or is that target strength completely different than depending on your trajectory and everything else.
Sam Johnston	Yeah, the answer is that you do have to sort of do both. You not only have to know the size of the fish, but then there are all other aspect questions and trajectory questions that come into target strength. Target strength is really the key to getting at detectability. So you could measure target strength, but you don't really know if it's a big fish or at some funny angle of a little fish.
Don Degan	I remember what that's in reference to. We were having a difficult time with threadfin shad passage because we were having huge quantities of fish coming through over a short period of time. So we couldn't actually measure any individual fish with the acoustics. We have many net data, so we use that net data. What you have is a uniform population of fish. They are all 50 mm, plus or minus 10 mm and they are all, 90% of them, being entrained. So that's probably the character point you're talking about here.
Gene Ploskey	So then the answer according to Sam, and I think most

everybody probably agreed, that information might be useful if that's the size of the fish. Maybe in dorsal aspect or whatever that are going through. But you really need to measure acoustically because you may have different trajectories.

Gary Johnson   How much do we know about the target strength of the fish we are sampling anyway? In other words, target strength data for juvenile salmon?

Gene Ploskey   We've come back to that. Tom Carlson's been taking some measurements of juvenile salmon from the Columbia River at different aspects. So there is some interesting information that will come out of that.

Marvin Shutters   One thing I'd like to note, fish juvenile bypass data are available. It's good to keep in mind for all studies that that kind of information is there. Also, keep in mind that that is a biased sample of the fish passing the project. It's only the guided fish. And there are different guidance efficiencies for five species depending upon proportions passing the powerhouse or spillways.

Gary Johnson   I agree. We just can't win. This is getting depressing.

Tim Mulligan   Think of that as job security.

Gene Ploskey   Lets take a break.

10:30 A.M. – 12:00 P.M. Tuesday, 9/16/1997

Gene Ploskey   Okay, the next segment that takes us up to lunchtime deals all around with detectability, which is what we've been beating all around with most of the morning anyway. Under transducer deployment, I was thinking we could come up with rules of thumb that make any sense like nominal beam angle versus range from the transducer that you'd want to sample. That's a lot like saying, do you want a fat beam or a skinny beam, I guess. It seems to me that there is some point with a six-degree transducer you don't want to be counting fish within three, four or maybe even five meters. The further away you can be from it, the better in terms of detectability. Is there some minimum distance?

Bill Nagy   It gets down to what's the minimum number of echoes from the target that you're willing to count as a detection.

Gene Ploskey   We could start there. That's a good one too. When we go in and we sample we arbitrarily or not so arbitrarily say we have to have four hits on a fish before we count it as a fish. Is there

some minimum there? Could you take a three hit fish? I guess it depends on the noise.

Bill Nagy	The noise. In any realistic situation, you're really pushing it if you're counting just three hits on a fish because of the noise.
Gene Ploskey	So obviously three is the minimum. The beam is quite narrow for almost all of these transducers, quite narrow near the transducer. At 10 m, a six-degree transducer has a beam diameter of about 1 m. I guess this gets back to what I brought up about the expansion. You're going to expand this for the width of the intake. I think the conclusion earlier was it didn't really matter how big that expansion was.
Marvin Shutters	For the detectability models, some of your laws and all of the assumptions that went into that show you get good detectability as close as two meters. You'll have higher variance because you have a very narrow sampling area.
Gene Ploskey	But we don't account for that.
Marvin Shutters	That's a variance that shows up as a sample variance.
John Skalski	Well, some of that is incorporated. If you are sub-sampling in the hour, taking five one minute samples within a sixty minute period, the variable on those five one minute samples includes not only the actual temporal variability but also measurement error. Not bias, but random error will be incorporated as well. So you are partly correct. It will incorporate some of that as long as it is non-systematic error.
Marvin Shutters	Why I'm saying that increase in variance shows up in sampling is because your expansion is so much larger for those fish that are detected. If you catch a couple of fish real close in one sample, it's a much higher estimate for total passage for that two-and-one-half minute sample.
Gene Ploskey	After you expand it?
Marvin Shutters	After you expand it. The next two-and-one-half minute sample you don't have any, so you get a lower estimate so you get a more variable (higher variance) estimates.
Gene Ploskey	Wouldn't the variance for the near transducer ranges actually be lower for what you detect?
Sam Johnston	We usually do the expansion first and then the variance.
Tim Mulligan	I think the relative variance is what you are talking about. The relative variances would be larger because you've got a very small sample size.

Gene Ploskey	So what we do is we detect fish at a certain range and then we expand that fish to the width of the intake.
John Skalski	As well as the probability of detecting fish at that particular range. So you've got a hit divided by the probability of detecting fish at that particular range and then expand it to the horizontal width of the orifice your sampling. Therefore, it is two expansions of sorts. It's all done simultaneously, but it's all there.
Gene Ploskey	The probability of detecting a fish at that range comes from some probability or some detection model.
Sam Johnston	In a sense, you are estimating an effective beam width over which you will detect all the fish that arrive in the beam width. That's based on the velocity and the ping rate.
Marvin Shutters	I think I heard John say that you are adjusting your detection of the fish. Are you adjusting after detectability within your sampling volume? Does anyone do that?
Tim Mulligan	Yeah, I do it. You can with a split beam. You could do it within the beam, but only with a split beam.
Marvin Shutters	I can see how the detectability model shows effective beam width changing by range up until it comes asymptotic. Could that be applied to your counts where you use a different effective of beam width for each range?
Sam Johnson	Yeah. We have done that on a couple of projects back east where there were wide variations of fish size. So we had to put the fish size into this curve that doesn't get asymptotic for quite a ways until you get to a far range. Most of the time on the Columbia River we just adjust ping rates up so that we get a real sharp increase in detectability. We only use the ranges beyond which there isn't a difference in detectability of range.
Gene Ploskey	That's what I was getting at. Because I haven't seen calculations where the modeled probability of detection was actually used in the expansion. I always assumed, as Sam said, that sampling was far enough from the transducer that detectability was considered to be uniform.
Gary Johnson	I think what John was referring to was that increase in probability of detection as you get further out of range because of the beam getting wider.
Gene Ploskey	That's just the ratio of the width of the intake to the width of the beam.

Gary Johnson	Yeah.
Marvin Shutters	It could become a two step process if you make it uniform by range and then take that expansion to the width.
John Skalski	Take the cone, make it a column, and then spread the column to the width.
John Skalski	You can go to the next step. There is still some bias in there that…
Tim Mulligan	That was my thinking that I was harping on earlier. If the spatial variability varies over your beam, you can correct for that if you know where in the beam it is.
John Skalski	Yes.
Gene Ploskey	I think where all of this is heading is detectability modeling. That will be the last section on the agenda before lunch, as far as the state of the art. I know within our group we often try to avoid sampling too close to transducers where we have differential detectability with range. And there are old simple detectability models that have been around for a long time that you can use, but it's a very complex problem.
Tim Mulligan	Can I ask a question? Do you guys not have difficulty if you're trying to detect the small fish at long range, as well, where the noise is now getting worse? Do you not have a volume back scattering that's generating noise so signal to noise gets lower as you get further out?
Gene Ploskey	Yes.
Gary Johnson	Ranges are relatively short, like thirty meters.
Bill Nagy	Our experience has been tremendous problems with volume back scattering. Usually it is due to entrained air.
Tim Mulligan	But the signal to noise is going to be a function of the range in the conical beam. Since the signal is a point source scatterer and the volume scatter is getting larger, the signal to noise will degenerate at longer range. So your detectability will begin to fall off. I heard you say asymptotic and I was wondering what happens at the far range unless you have crystalline water.
Marvin Shutters	That's the issue of why a six-degree beam becomes more prevalent is you get smaller reverberation.
Sam Johnston	Many of the places we are sampling, for example the common ones, in front of the spillway, in front of the turbine and I say in front of both of those, that usually isn't a factor. In turbine

	it definitely is. If you are looking at scanning horizontally long ranges then it's definitely affected. The ranges here are twenty meters, maybe thirty meters at far range.
John Skalski	I think this issue that you've alluded to and I've alluded to, also has an emphasis of how you distribute the transducers. I can keep on harping about making sure that if you are going to use multiple transducers, be sure they are all of the same type. Because otherwise they have inherent differences in detectability not because of the cone shape, but because of the probability of a four-ping hit for example on many different tangents. Therefore, especially if you are doing FGE at a single unit, I do not want to see two different beam compositions. One doing the guided and one doing the unguided. I think that is magical.
Gene Ploskey	What about at different structures?
John Skalski	I get fussy with FGE because you must have inherently equal detectability. Just think about it. It is bad if you're trying to get a four-ping count with different sized cones. It depends on the length of the tangent of a fish going through at a particular range. The distribution of the length of those tangents is different. The probability of getting four echoes changes, even at the same range for different cone configurations and we do not correct for that typically.
Gene Ploskey	So, I wouldn't want to stick twelve degree single beam transducers into the spillway and stick six degree single beams into the turbines.
Bob Johnson	That kind of variability can be within your sample volume as well.
John Skalski	Oh, yeah. I'm not a hydro statistician, but I would think that at least if you use similar beams the bias rather cancels out. So, if you're using those relative indices, you have bias in counts and fish distributions but it is constant hopefully. However, if you start with different beams and assume that somehow you're going to get transposing calculation errors to offset the bias is even more of a prayer.
Bill Nagy	If you put a six-degree for guided fish and a six-degree for unguided fish, you're still may not get the same beams if the ranges are greatly different. I agree with what you say. That's what you need to do, but as a practical thing, it's very difficult.
John Skalski	I wouldn't want to confound the problem then by having two different cone configurations for the guided and unguided. It only makes a bad situation intolerably worse or incalculably worse would probably be a more accurate description.

Don Degan	I guess I didn't understand that.
Sam Johnston	You can certainly have the model either way. You have to have some type of detectability modeling saying, with this size cone I can detect fish with this beam width. You have to do that wherever you are. Because velocities are going to be different at these different locations and you have to do that anyway to make sure. As far as the beam being bigger or smaller, it may actually help to have a smaller beam because then the noise is less and you can go to a higher ping rate. There is less volume reverberation and so forth. In some cases, you can't get away from having different beam widths.
John Hedgepeth	This is a calibration issue?
John Skalski	I think so.
Bob Johnson	Is it a critical uncertainty?
Tim Mulligan	Well, it's a calibration issue. I hate to keep harping on the same thing, but all these models assume that the fish density is uniform over your beam. If the distribution isn't uniform over the beam, everything goes to hell in a hand basket quickly. In the rivers with the adults going upstream, we've had to go to narrower and narrower beams and even then, the distribution isn't uniform. So we're looking at a beam that's only two degrees vertically by ten degrees horizontally and distribution varies over that as well.
Bob Johnson	You're looking at these fish laterally from a side view?
Tim Mulligan	Yes.
Bob Johnson	Do you think that a lot of variability that you see in that might be…
Tim Mulligan	No!
Group (Laughter)	
Tim Mulligan	If you look at them from left to right then you should get the variability in their aspect ratio as they go by. Their aspect ratio should change dramatically from the top of the beam to the bottom of the beam, because that's where the density gradient is very large. You would think that their aspect ratio will be independent of where they are in the water column, but the high-density gradient is from the bottom up. And you might experience the high-density gradient from the walls of intakes or something in towards the middle and that's what you have to be wary of. The gradient over the width of your beam, there

	is no way to correct for it unless you know where the fish are in the beam.
Gene Ploskey	At some point this still goes back to transducers. Depending on how important your FGE estimates are and how much you are will to spend. I suppose if you went out and did everything with split beam transducers, you would come up with estimates that are more reliable.
Tim Mulligan	It's not necessarily split beams. You can use a narrow beam and a whole bunch of them. A narrow beam that moves back and forth or something like that would give better spatial resolution. The key is to quantify the variability over the area you are looking.
Gene Ploskey	As part of smolt detection, there are many factors that go into this. Can we make out a list of the factors and then prioritize them. Is that a reasonable exercise?
Gary Johnson	Yes!
Gene Ploskey	The models I'm familiar with are old ones and may be outdated. But if we could make a list of critical factors affecting detectability, then we could try to prioritize that list. I would assume those would be the ones that were accounted for in the simple models. Maybe we could get Tim to tell us about where we are going with detectability.
Marvin Shutters	We could separate this out into a couple of things. If there is a theoretical approach which I think we want to list here, what should go into a model and then secondly, what degrees of detectability should be addressed. Things like noise and structure.
Gene Ploskey	What's the most important factor or one of the most important factors?
Marvin Shutters	The beam width.
Sam Johnston	Ping rate related to velocity of fish.
Tim Mulligan	Signal to noise.
Marvin Shutters	Trajectory.
Bill Nagy	Threshold.
Gary Johnson	Minimum number of hits.
Gene Ploskey	Anything else?

Sam Johnston	In beam width there is sort of the beam shape as pertaining to the narrow beam. They don't drop off as quickly in their sensitivities. In the wider beams toward the edges they do drop off quite a bit so there is some factor there
Tim Mulligan	That's partly a problem. I don't know if you have boundaries like we do. We have to try to get very close to boundaries like the bottom. If you have to get close to boundaries like a cement wall it would be equally important to you.
Bill Nagy	Echo strength distribution of the fish, which is kind of like target strength. As the fish was coming through the beam he gets hit maybe five times or ten times or something. Each return has different echo strength and it's how many of those that are above threshold that determines whether you're going to get four. This is assuming you allow caps or whatever the minimum number of hits is. So, depending on what that distribution is, you'll either get the minimum number of hits or not. It's the idea that the fish has a target strength based on the size, based on it's aspect and then there is a random variation too from ping to ping and the echo size you get. That has a lot to do with the detectability.
Gene Ploskey	Are all of the listed items included in detectability models today?
Marvin Shutters	We could say that they are all in models. That the signal to noise and echo strength distribution...
John Hedgepeth	I have a model that uses signal to noise, but generally for finding out the maximum ranges for transducers, but that is pretty common.
Sam Johnston	It goes into it. Threshold sort of takes care of that also.
John Hedgepeth	One equation is the signal to noise. The other equation we use is the threshold and then we combine the two to get that to map out the beam for an effective range. I think in this kind of work we normally don't use the signal to noise as part of it. The answer is, I guess, signal to noise is used in models, but I don't think it's used in ours.
Gene Ploskey	Suppose we put a single asterisk by signal to noise. I assume that everything above that is used commonly in detectability models. The beam width, the ping rate, fish velocity, range, trajectory.
John Hedgepeth	What's the difference between trajectory and fish velocity. Isn't the velocity the vector, right?
Gene Ploskey	Not necessarily. It's how fast the fish are moving through the

beam.

John Hedgepeth	Should we be calling it speed just to be accurate. Normally engineers call velocity the vector and that could apply to trajectory.
Gene Ploskey	Okay, we've listed thresholds, minimum number of hits, and beam shape.
John Hedgepeth	Yeah, quadratic, semi-quadratic, Bessel function or something like that.
Gene Ploskey	Echo strength distribution?
Bill Nagy	Target strength?
Sam Johnston	And there again it goes into the threshold. What you are trying to do is make sure you can detect a fish
Marvin Shutters	You did the Monte Carlo simulation of turbine entrainment…you put that in your model, didn't you?
Bill Nagy	I did.
Gene Ploskey	But it's not commonly used, is that right? Signal to noise is not commonly used and the echo distribution is not commonly used?
John Hedgepeth	Threshold and minimum number of hits are common inputs for models.
Gene Ploskey	Basically, we've encountered most of these things except signal to noise is not common and consideration for the echo strength distribution. How do you incorporate signal to noise. Tim, you do that, right?
Tim Mulligan	Yeah, we try, but we have a very simple signal to noise regime similar to what Sam described. Therefore, it does not vary over the range. So, the setting of threshold and the target strength distribution of the fish combine to treat that problem. The one thing we do that is not on your list, that I've been harping about is, the fish distribution over the cross section of the beam. But then you have to have information on where the echoes are coming from either within the beam or a bunch of narrow beams and variability over the total area that you want to sample.
Gene Ploskey	Actually what we had on one of our other lists was distribution within the beam and lateral distribution, which would be more common in our case.

Marvin Shutters	I guess I'm not clear on what you are getting at with that. Regardless of where the fish is in the beam, this model should predict if you are going to detect it?
Tim Mulligan	No, that's not correct. If they are all on the very edge of the beam, you'll have a much lower number of echoes returned than if they were all moving right through the middle of the beam.
Marvin Shutters	Correct!
Tim Mulligan	So the same number of fish going through the beam will give you a different number of echoes than you actually see depending on where in the beam they actually moved.
Marvin Shutters	The question is not how many echoes they get, but what your detectability is?
Tim Mulligan	Detectability is proportional to if you saw enough echoes to track them.
John Skalski	Yes.
Marvin Shutters	So it's number of echoes.
Gene Ploskey	No. This distribution within the beam is skewed so that most fish are passing to one side and are less likely to return the minimum number of echoes relative to the few fish passing through the middle.
Marvin Shutters	Okay; I've got it. I'm separating that from detectability is what my problem is. In passage estimates, I look at it as you have an assumption of detectability that every fish went through your beam you saw. Also that the distribution of fish going through your beam was the same distribution going through the route. That's where you are saying it's different, that the distribution through your beam is not uniform. However, you are still detecting all of them that go through your beam.
Bill Nagy	No. ....
John Skalski	No.
Tim Mulligan	No.
Tim Mulligan	Detectability varies dramatically versus where the target is in the beam. Just assume a stationary target is in the very center of the beam and has the highest probability of giving you an echo back. The further it gets toward the edge of the beam, the lower the probability of returning an echo. Now, talk about a

fish actually swimming through a beam. Suppose it's a circular beam. When it's going through the center, it's going to start in an area of low detection probability, pass through an area of high detection probability and back to an area of low detection probability. It's also going to take the longest chord length to there. So, it has a fair chance of using a high number of echoes from it. Suppose the same fish now passes through just on the very edge of your beam. It's always in an area of low detection probability from the beam point of view and it has a much shorter chord length. So, the number of echoes you get back from it are going to be dramatically smaller than the one that passed through the middle of the beam. So your detection probability for tracking a fish moving through the edge of the beam has to be less than one going through the center of the beam. If your fish distribution varies over the beam then it's going to affect what you actually see.

Marvin Shutters   It affects your sample volume. But all these other things that are up here are going into your detectability along the edges, but you are saying your estimate of…

Tim Mulligan   All those things assume that you have a uniform fish distribution over the beam. If the fish distribution is not uniform then the model is inaccurate.

Marvin Shutters   These are individual fish-based, aren't they?

Tim Mulligan   No, they are based on uniform property over the beam usually. So when you talk about an effective beam width you are assuming a uniform fish distribution over the beam cross section. Beam width is meaningless if you don't have a uniform fish distribution over the beam width.

Bill Nagy   But on the scale of the beam the distribution is random. On the fish coming through there on the scale of the beam. Sometimes that may be true in some of what we've done. Like if the beam is one meter wide and a thirty-foot wide intake. You could probably assume that across that one meter in the center of the intake, it might be the wrong place to sample, but at least you could assume that across that beam you've got essentially uniform distribution. If the beam is wider though that's not a good assumption.

John Hedgepeth   I think on the edges of the beam you certainly have large detection, but that's your minimum detection and you set that as your minimum on the edges. You're always going to count what's in between the two and have now mapped out the cross section, whether you have a split beam or a dual beam. If you have a split beam there and all the fish are over on one side and your are counting only a few on the edge of that beam, you'll see that you need to move the beam. But that is all you

would see. In certain conditions you could correct for those detection losses based on your knowledge from the split beam, but when you mapped out the cross section from the single beam it certainly would not tell you that. But if you randomly positioned that single beam you are accomplishing the same.

Sam Johnston   One thing that I think is included in Tim's model that's not included in detectability models that we traditional use, and that is signal to noise and detectability difference on the edge because of signal to noise.

John Hedgepeth   On the edge. That's right. That is the only thing I can see that he's bringing up. And then you can correct for that.

Sam Johnston   For instance on the edge of the beam you know that the fish passes through a chord length long enough to get all the hits. You don't, you only get half of them because half of them are below the threshold and half of them are above.

John Hedgepeth   But we're not taking that into consideration, the signal to noise, except based on threshold.

Tim Mulligan   No, sorry. I didn't mean to imply that. You can model the detection probabilities as a function of where the target is in the beam. That includes things about where your threshold is, what the signal strength distribution back where the fish is.

John Hedgepeth   So what we need to do is include signal to noise in these models. Is that what you are saying? And the only way to do that is to use a split beam?

Tim Mulligan   No, I don't want to imply that the only solution is a split beam. Split beam equipment is useful but other options exist.

John Hedgepeth   Or moving the pencil beam?

Tim Mulligan   Yes. What I'm trying to say is I think you should be very cognizant of fish distribution being non-uniform over your beam. Because that will lead to measurement artifacts. The same number of fish moving through the edge of the beam will give you a much different number of echoes coming back as moving through the center of the beam. So unless you've accounted for that in some way, the split beam is one way of looking at that problem. But very narrow beams somehow scanned over a region are also an adequate way of doing it. The secret is that the variability over the width of the beam has to be small. Then you can account for it. If the variability is large, which it often is in the situation that I'm looking for and maybe in yours, be cognizant of that because it potentially can be the largest source of error. Let me give you an example. In the calibration experiment we did where we videotaped fish

going up the river at the same time they were swimming through our beam. So we actually videotaped the ones going through the beam. We used a very narrow beam very close to the bottom and we tracked about ninety-seven percent of them or something like that. This was the two-by-ten degree beam. We used an eight-degree circular beam. Some fish going through and we tracked about twenty percent of them because they are all on the very edge of the beam. If you do a correction model for the detection problem at the edge of the beam, we could essentially take that twenty- percent and bump it right back up to about the ninety-five percent level. Because now you know the distribution within the beam, you know what the detection is for a target of that size when it's that far off axis. So, I'm talking about a factor of four or five in there of what you thought you saw versus what was actually going past, because they were not uniformly distributed over the beam.

Marvin Shutters   What you are doing is combining what I see as two different steps. I think of us as approaching this as two different steps. What I think of as a detectability model is the probability of any one fish, which is in a beam being detected as opposed to what has to happen for it to be detected. And what you are saying is you get one on the edge. Some are detected, that's the limits to the effect of beam width in a detectability model. What you are looking at above that is distribution both within your beam and in the area not sampled by the beam. The expansion factor as we term it. What you are calling detectability modeling is encompassing everything. What I think about is individual based just to get your effective beam width. What is your volume sample?

Tim Mulligan   The reason I do that is because I've found that I can't ignore it. There is high variability within my beam width. If I do ignore it, I'm way off in terms of what affects me is in my bias. Typically you see much less than what actually passed. Sometimes only ten or twenty percent of what went past.

Marvin Shutters   So this gets back to what we were talking before about how to move the transducer around or some use apriori knowledge of the distributions through the passage route.

Tim Mulligan   Yeah. It won't really help you if what you are moving around is a wide-beam transducer and the fish are all tight against the walls of the area that you are looking at. You are still only going to be detecting a fraction of them. What it forces you to do is somehow have high detection at some point scanning the whole width across.

John Hedgepeth   Let's say we had a wide transducer and we had this knowledge of the distribution. Could we in expectation correct for the

loss of detection on the edge?

Tim Mulligan	Yeah, that's what it does. And it depends again how variable the distribution is spatially and temporally. If you just use a constant factor, you are assuming that what you mapped out one time applies on infinitum.
John Skalski	It gets to a couple of objectives too. Again, if you are using guided and unguided at a turbine unit they may have uneven horizontal distributions. But if they are both biased in the same way then there are relative indices that cancel out and you probably get a good FGE. But that doesn't escape the problem of them going to another unit and combining. As long as you are taking ratios, this may not be bad, but as soon as you start going from one unit to the next or from one route to the next then you need absolute counts. You need bias-corrected values. Going from FGE at a turbine slot to FGE or FPE at the dam is a quantum leap in terms of what you need to do. You have to go from indices to absolute abundance. That's always been a big jump for us, to say we aren't doing indices, we're doing actual counts and we need those kinds of corrections. The other comment I'd like to make, in this list some of the critical factors are things that we can control. Some are not. Like beam width, ping rate, minimum number of hits, and threshold are things that we have some control over. While the other ones are the ones that are really jerking us around, ones that we have to concern ourselves with.
Bob Johnson	Target strength, trajectory?
John Skalski	Yes. Those are the ones that we have to make assumptions and adjustments for. I think it would be useful to differentiate between those that are under our control versus those we have to make assumptions for or deal with mathematically.
Bob Johnson	Here's where some of the behavioral stuff comes in and we have to know something about what the fish are doing. We have to know a lot about what the hydraulics in the region that you are sampling to be able to make some reasonable assumptions about these things.
Gene Ploskey	Can we flag the ones that we don't control?
John Skalski	Fish velocity is something we can't control and range.
John Hedgepeth	Yeah, and target strength distribution.
Marvin Shutters	We can control range with our deployments.
Sam Johnston	Once the transducer is in we usually don't move it anywhere.

Gene Ploskey	Before we go any further with that, do we need to add another category down here for what we call lateral? Just call it distribution across the beam to account for Tim's concern.
Gary Johnson	We call that within the beam.
Gene Ploskey	I know we had it as a critical uncertainty. I just want to get it on this list.
Gary Johnson	Call it within beam distribution.
John Hedgepeth	Shouldn't you also consider the outside beam distribution? Maybe I'm being facetious here, but shouldn't it be just a spatial distribution?
Marvin Shutters	Back to my last comment. This fish passage, fixed aspect typically considers this under spatial expansion factors like we were talking about earlier under detectability modeling.
Gene Ploskey	But it does affect detectability. We don't really account for it. Nobody's ever done that.
Sam Johnston	We haven't been. When we get an effective beam we say that that is the effective beam where the fish are equally detectable all the way across it. We try to adjust our ping rates and everything to make that true. Still, at the edge of the beam, especially with increasing signal to noise, even though the chord length is long enough and the fish gets hit with enough hits, not enough of them come back above threshold for us to detect that.
Marvin Shutters	That's where the echo strength distribution comes into it, right?
Sam Johnston	Yes, relative to the signal to noise.
Bill Nagy	That's also where the fish distribution comes into it.
Gene Ploskey	Let's also add spatial distribution or lateral distribution. It's not spatial distribution; it's the distribution lateral to the axis of the acoustic beam.
John Skalski	Say that again.
Gene Ploskey	The distribution of fish lateral to the main axis of the acoustic beam.
Sam Johnston	I think that falls within beam distribution.
Gene Ploskey	If you are talking about the whole width of an intake you would have some distribution across that and of course

	wherever your beam is you would have potentially some distribution.
John Skalski	I think it's important to make the distinction because the ways you handle the two different problems are very different. The within beam is an issue that Tim brings up. To address it, you can use narrow beam or you can adjust for it mathematically and that corrects the within beam problem. You still have the within slot uniformity, which can be corrected by moving the beam from one location to another or having multiple beams. I would want to keep them separate because they way you attack the problems are different.
Sam Johnston	Yeah and there is outside detectability within the beam.
Don Degan	Generally, when you want to sample you want to sample across the wide variations and the density. If you want to sample within a lake or a river, you want to sample across the range of densities. And usually that's not the indication of hydroacoustics. In an intake, you're sampling a small part and you don't sample across the range. Tim has the opposite problem where he is sampling across a wide range of densities within a single beam rather than in most cases you have a transducer beam out there that is sampling a portion of the range of densities throughout the lake or within the intake. They are two different problems.
Gene Ploskey	We'll write down within slot or across the beam and we'll keep them separate.
Gary Johnson	Sam's point is that it is not a part of detectability. John's point is it is part of a next step or another step in the thing. I think you're mixing apples and potatoes.
John Skalski	Yes. Within beam is a hydroacoustic issue as far as I'm concerned. The uniformity within a slot is a sampling/statistical issue and is dealt with very differently.
Gene Ploskey	Okay, are there other factors that we can't control? We started underlining those that were out of our control. Deborah, go ahead and underline signal to noise. Is range? It's not always within our control. Sometimes you're stuck against a hard spot. Sometimes with range you can't back off far enough within turbine. Within beam distribution you can't control that. Echo strength distribution…you can't control that. Where were you going with this John?
John Skalski	I just think it is important to recognize what we can't control. I guess if you were the Army Corps claiming to have an RFP come out, it may be useful to have correspondents address these issues. Here are our choices and why we think these

	choices need to be considered. But certainly you can't change the fish velocity. You may have to deal with it somehow.
Gene Ploskey	Why don't we just go down the list then of the ones we do control and talk about how we make those decisions. What would you avoid? For example, the beam width. I think Gary Johnson said he wanted the widest beam that still gives you an adequate signal to noise?
Gary Johnson	Right, that's the conventional approach.
Gene Ploskey	So with beam width we can take the widest that still gives you adequate signal to noise.
Tim Mulligan	That was where we started and now we've ended up wanting the narrowest beam that we can get away with because of the within-beam variability.
Gene Ploskey	Right, so which is better?
Bob Johnson	That all depends on where you are deploying. If you have a large open area that you want to sample and probably want to sample as much area as possible. Sampling next to a boundary you would be more interested in the fish distribution across the beam.
Tim Mulligan	No, I would say it's the other way around. If there is a high variability, you're worse off to have a wide beam. Because you would have the same fish passing through giving you a varying signal and you have no measure that that's actually going ahead. If you have uniform variability across whatever you are looking at then the widest beam is your best solution.
Gene Ploskey	So under effective beam width put down that it depends on the distribution of fish across the axis of the acoustic beam.

Don Degan	You can have bias versus unbiased? You can have a biased non-uniform distribution, which is what you have with bias towards the edge of the beam or you can have highly variable passage that is not biased toward the edge of the beam. In the latter case, you would want a wider transducer.
Tim Mulligan	Yeah, if the spatial variability is low a wide beam is a good choice. If the spatial variability is high, a wide beam is a poor choice.
John Skalski	There is one thing in terms of like a response. Okay, we show the beam with a such and such because we believe the fish are behaving this way. Because of that, this seems to be the optimal way of sampling for this particular situation. So you'd be responding to those things you can control by what you assume to be those things you can't control. If velocity is fast, you are going to change the ping rate.
Gene Ploskey	I know that Bill Nagy has for a long time wanted to buy six-degree transducers with very low side lobes for signal to noise reasons. So it looks like that fits with the idea that a narrower beam is better than a wide beam if there is high variance in the distribution across the beam. We don't know that though. Not very many people have gone out and measured that lateral distribution.
Tim Mulligan	Could I just add to that. That's the deceiving part about it. All of the acoustic background is from down-looking systems in the lakes and oceans or what not where you expect the uniform distribution of fish over the beam cross section. They've always ignored any non-uniformity. When you are in a regime like all of us here are, I think, where that uniformity can no longer be ignored, you wonder why the rest of the acoustic system world has been so successful. They are in a much different regime. Certainly, our riverine experience is that if you ignore that variability you are in making a serious mistake. We start with detecting, trying to detect one hundred percent of the fish that went by and only detect twelve percent. This is one of the main reasons. And we are now up to, we think, detecting one hundred percent of the fish that went by.
Don Degan	We always sample in the middle of an intake bay instead of on the edge.
Gene Ploskey	It sounds like we need to randomize the position of transducers across intakes. We need to randomly pick intakes and maybe a random stratified picking of intakes and then within intakes have right, left, and center position from which to choose.
John Skalski	In expectation, if you randomly locate then you will get an unbiased estimate of passage. Any particular one of course

won't be true. On the average, that's all. On the average, if
you do this repetitively, you will get this type of performance
and because we have so many slots and so many places, you
probably would be getting close to that.

Gary Johnson   And that was my point. If you do it over enough time and over
enough locations, your number should be accurate.

Marvin Shutters   I don't think we can do it over enough time and enough spots
to make that work out. I think the only approach that would be
practical would be to go in and try to map the distributions
within intakes.

Gary Johnson   But they are so different between intakes. We did intakes 5B
and 2B at Lower Granite with a scan head and they were
different.

John Skalski   As I said, base assumption is everything is different until
proven otherwise. Go with that working hypothesis and design
around that.

Marvin Shutters   For a one year, say Bonneville 2nd Powerhouse. I know Unit
11 passed a lot more fish than anything else by far.

Gene Ploskey   There was some disagreement about whether they were all fish
or not.

Gary Johnson   That's another issue.

Marvin Shutters   Okay. Suppose that we sample every other turbine intake
across an entire mythical powerhouse and also located
transducers within intakes randomly, not just on the centerline.
A transducer located dead center on Unit 12 is going to stay
there all year. On Unit 13, a transducer placed just off of the
pier nose will stay there all year. For randomization to resolve
skewed distributions, it seems that the transducers would have
to be moved around within the intake.

John Skalski   No necessarily.

Bill Nagy   Maybe that is what needs to be done, one way or another.

John Skalski   It would be better. The accuracy will be even better if you
move it around. In expectation, you will eliminate the bias.
For example, right now all of the transducers are being put into
the middle of the orifice. Therefore, if there is a bias in terms
of edge distribution, we have a consistent pattern where there
are more fish on the edges or less fish on the edges. We
definitely have a biased estimate of fish passage. But if you
have a number of those orifices all sampled randomly, on the
average you will get, even if they are only located once during

the season, a better estimate than if you do them all centerline. That's not going to be as good as if you relocated it daily or hourly, but it's still better. All science is an art of compromise between the theoretical desired goal and logistical capability. And we can push along and continue getting theoretically better and better by randomly locating at the beginning of the season than if we all centerline them. We know it's not as good as if we moved it every moment, but we're better on a continuum. And I think that's what we need to proceed with. At some point, logistics will say we won't do it and we can't do it and it's too costly and to stop because we can't do it perfectly isn't necessarily a good reason to stop in the middle. Because if we can get unbiased estimates on the average.

Gene Ploskey	There is usually a number of equipment failures that occur on any one of these projects regardless of what intake you put it in. If you have a transducer go out should you randomly select one intake and re-deploy?
John Skalski	No. I think it depends on the sampling design. It depends on how you designed that site to begin with whether it would be more conducive to re-randomize under those circumstances or put it back in the same position. I think the many designs we've used in the past at least on the river would say put it back where you had it.
Marvin Shutters	If you moved it to someplace that you get a higher estimate then that's going to confound whatever experiment is going on.
Don Degan	What is the shortest time line that you can make an estimate of what the passage is? If they want daily estimate of fish passage can you do that based on that sampling design knowing that over an entire season you might come up with an accurate estimate for that unit for that entire dam. But for that particular bay and that particular unit, are you going to get an accurate estimate of the passage? Should you be analyzing it and providing the numbers on daily unit averages of fish passage?
John Skalski	That's some kind of question. You'll get better and better precision as you sample longer and longer we know that. There is no reason why you can't get, with that single location distribution of transducers, locations at the beginnings, get daily estimates that are in expectation unbiased. There will be more quality in it between day to day, which is good sometimes. If you want to do comparisons having it in the same locations is the best place to have it. If you want independent estimates from day to day then you would be randomized. Given the logistics of moving the 30 or 40 transducers in each slot daily, I don't want to be the one to propose that. I've been threatened for lesser indiscretions.

Gary Johnson	We'll just say you proposed it. This was John's idea! I can answer that question a little bit. One of the things we did this year was daily estimates of certain things, but not daily estimates of other things. For example, we would estimate spill efficiency on a daily basis. That seemed to be variable on a daily basis. People were very interested in that. In the Lower Granite study, we said right up front that we didn't think the daily FGE estimates were that useful. We discussed it with everybody, and sponsors agreed they didn't really need daily FGE. We want to see weekly. Those are just some of the decisions that were made up front. Still, with the daily they get highly variable whether it's from bias or variance.
John Skalski	And designs tend to have a particular level of precision for the end of the season. Season-wide FGE or season-wide FPE is one thing. Then to say let's look at them daily and expect the same level of precision is both going to be naïve and very disappointing.
Marvin Shutters	It's very dangerous to present to the region.
John Skalski	People got in trouble not because the study was flawed or they did anything wrong. But it was that the people didn't appreciate how noisy the data was going to be as you get to the smaller and smaller time units. Then, when they saw them jumping all over they jumped over the fact that this is a natural sampling error within the level of effort. Over time people have tempered some their expectations and said, hey, if you want precise estimates don't expect them hourly. How do you think we can get good FGE daily? It will be much better weekly and during the season.
Gary Johnson	When we do these in season reports it's important to present the cumulative result. That's what most people look at anyway.
John Skalski	If someone wants a very precise daily FGE, we're going to have to nail that dam six ways to Sunday, with many more transducers and much greater effort. We can do it. I don't think the Army Corps has the budget to pay for it or any company has the manpower or equipment to do so, but it's conceivable. For what we have typically within a region which is still a very fortunate environment compared to most of the world. What we can do best is bigger units of time…weekly, monthly, seasonally.
Bob Johnson	Does that make sense from the standpoint of the creature we're actually trying to assess if the run comes through in a week?
John Skalski	If you know the run is in a week, then we should design so that

the precision for that weekly FGE which is seasonal also is precise. Again, there are three dimensions to sampling: spatial, temporal, and biological. The biology says you got it all happening in one week. That defines in part your domain. We need to consider that. If that's the case, we can design it so that you will have precision at some level into that period. It's all a matter of three different dimensions: spatial, temporal, and biological.

Cliff Pereira I like the idea of moving around these transducers. I guess it does raise the question of whether your detectability model should change to cover the different positions.

John Hedgepeth The noise can change. Hit some structure and the noise changes. That's a good point. The detectability would change in that case. Velocity changes.

Sam Johnston Maybe we should underline that…if any of those changes…(laughter)

John Skalski Realize that there are different problems between all the different slots we're already sampling.

Sam Johnston One of the things we haven't talked about in terms of sample design is as Marvin said, you know that a very high proportion of the fish are going through one of the units. So, you might want to concentrate your efforts there and forget about some of the others.

John Skalski Absolutely. Some examples at Wells, when we thought we had a particular horizontal distribution. Prior knowledge is very important. The more information that's put into the sample design, the more information you're going to pull out at the end of the study. So, you have some apriori assumptions extending from what the horizontal fish distribution is. I'd just say to keep from arguing, "just tell me roughly, do you expect more on the edges than in the middle or vice-a-versa." And they might say, "Well, sort of this or sort of that." I'll take 'sort of this'. It's better than assuming uniformity. But what we found with Wells, we couldn't sample every orifice, which meant every bypass and every turbine slot. But we could sample a fair number. But for those turbine units that had the most fish passage, we sampled all three out of three turbine slots. So then, we didn't have to worry about slot to slot variability. That's where we had a situation where we could literally move one transducer out of thirty and cut the variance in half. We had one situation where we had two out of three turbine slots we sampled, but that's where the majority of the fish were. Another turbine unit had three out of three slots, but almost no fish going through. We pulled one of the transducer slots out of there and put it into the one with high passage and

we killed all of the slot to slot variability that was causing most of the noise in the study. It's just remarkable how a little adjustment can do a lot. The reason is that unlike classical statistics that you get from the baby courses, variances are not all equal. You get more variance where the action is the biggest. So you put more effort where the action is the biggest and you can make substantial gains by doing very little.

Gary Johnson   Was that shift made from one year to the next or was that an in-season shift?

John Skalski   It was an in-season shift. My recollection is, we did it the first year. I got preliminary information after a week and then I called you up and said…

Gary Johnson   That's right, it was preliminary information.

John Skalski   After a week, I said "move the transducer there and I got holy hell. You said, "you want us to do what for why?" And I said to just do it. And you did it just to appease me, not thinking anything would change. But it really did have a great influence.

Gary Johnson   It was a great effect!

John Skalski   Again, I would want in terms of our standardization to be flexibly standard. You set up your best sampling design that you have during a season, but don't ignore the in-season information to improve upon it. Don't get so fixated that you have to be constant. This is a dynamic study and usually designed, at least with the studies I've been involved, with such and such blocks that you could add components very nicely. You can easily move pieces without any real destruction to the overall sampling design because counts and variances add together to estimate totals.

Sam Johnston   The obvious conclusion is that if you are trying to reduce the variability at a location where high fish passage is high, do all the across-turbine unit tests where the fish go and reduce that variability as much as possible.

John Skalski   The general rule seems to be to put more effort at the higher sources of variability, which gives you higher temporal scales and higher spatial scales. You get more spatial variability between turbine units than you will between slots and you will probably have more variability between slots than locations within a slot. So put your efforts where the higher levels of error are. Again, what we do temporally is we sample daily because there is a lot of day to day variability in fish passage which is greater than the diel and the within hours longer than the diel. So that's why we sample all the days, all twenty-four

hours and then only sample part of the time within an hour. Because we cut major sources of variance and then get down to the smallest sources that we can estimate. It works, but higher sources get more attention. More fish get more attention and it works.

Gene Ploskey — Obviously, this segment is going to take more time than we've allocated. But that's okay because my guess is one of the others, hopefully, will take less time. We have about ten minutes until noon. We have a list of factors affecting detectability and have identified the ones commonly included in models. We also have indicated which ones are controllable. In the ten minutes we have left, can we do something with this to wrap up this table. I had down to generate a list of guidelines for achieving adequate detection. Can we do that?

Gary Johnson — Maybe one way to look at that Gene and maybe it even gets towards a possible standard is to document your detectability model and run it and make sure it meets such and such a standard. You can get into the guidelines, but you can say you've got to ping fast, you've got to have narrow beam widths, whatever you can control, but clearly it's the combination of all of these factors that counts. So maybe you could cut to the quick, and set some possible standards for detectability.

Gary Weeks — When it comes in do you actually put numbers on these different components…some sort of weight?

Gary Johnson — It depends on your model, I guess.

Gary Johnson — So the guideline is to do detectability modeling.

Gene Ploskey — So if somebody models detectability, what's the minimum? Is there a minimum level of modeling that should be done. What elements are critical? If Joe Blow sends in a request for proposals (RFP) to Portland District or Walla Walla District, and they say we know how to sample this and sample that. Are we supposed to just stick a transducer in that hole and ping like crazy. That's not acceptable, but is there some minimum that we could set? Maybe we expect somebody to say we considered this.

Gary Johnson — Isn't that what the list is for?

Gene Ploskey — Yeah, it is a list of all of the things that ought to be considered.

Gary Johnson — So you want to prioritize the list?

Gene Ploskey — No.

John Hedgepeth	I think the double stars (referring to flip chart) are what we use now. I think everybody uses those. The only thing we're not really looking at is within beam distribution.
Sam Johnston	And the combination of signal to noise.
Gene Ploskey	Maybe we have one. That's what I'm asking.
John Skalski	There are certain factors you can't control and certain factors you can. I think you might want to see in the RFP that the person specifies beam width, beam shape, ping rate, minimum hit numbers that are going to be used, and justifies those choices based on the things you can't control. We think that fish velocities are going to be like this or there's going to be this range and this trajectory.
Gary Johnson	And then show the output from the detectability model.
Marvin Shutters	Probably more than one model would be generated. Perhaps we could take a model that addresses all of these.
Gene Ploskey	Maybe that would be a useful exercise as part of a research project to have somebody do some modeling of different things to help set boundaries. Obviously, it's a very complicated thing. Modeling is important. You can't come up with rules of thumb, guidelines. I mean you can, but you are apt to be leaving something out and I'm just thinking about the evaluation process in terms of the quality of what someone proposes.
John Skalski	I think the standard would be "Have they specified enough those things that they can control?". Did they include in their RFP the ping rate, the beam angle, and beam shape? If they haven't, then they maybe haven't gone through and thought about these other factors. So I would think the standard would be…here's four or five things they can control…are they specifying these and how are they justifying that choice?
Gary Johnson	And what detectability did they get out when they put these parameters in their model?
John Hedgepeth	Detectability usually is a two-dimensional plot of beam width by range. What would be nice would be to publish a model on the web or something like that that we could verify.
Gene Ploskey	The other part of this is not just setting standards for evaluating proposals or anything like that. But as a group, where should we be going? We have everything listed that should be considered. If we're not incorporating some of those things routinely, should we as a group say anything about that?

Bill Nagy	Yes. I think we probably all agree that any adequate study addresses detectability just as it addresses noise. I think many of the results we see don't directly address those things, but they should.
Gene Ploskey	I think it gets into reporting and quality control. You should expect to see detectability modeling in any report.
John Hedgepeth	I just looked at our two reports and I know that detectability models were run before the transducers were put in. I didn't see any mention of that in the report. Various calculations are mentioned in one report, but not in the other.
Gene Ploskey	We want these products to evaluate the quality of the work.
Marvin Shutters	I think many times there are standard methods that have been used and then there is a slow evolution from that. Researchers may do something slightly different each time with the assumption that detectability is good because this year's method is nearly like last year's. Actually, that assumption may not be true.
Don Degan	What depth would you propose that this be done? How are you going to determine the fish velocity in your model? Are you going to use a mean intake velocity? Are you going to look at velocity by range as expected across an intake?
Bill Nagy	With the split-beam you can measure the velocity.
John Hedgepeth	It is about the same as the velocity of water in general.
Gary Johnson	Maybe a little less.
Gene Ploskey	What kind of hydraulic information do we need?
Marvin Shutters	That is something else we really need to address. The maximum velocities that could exist really should be in your model. Like the flood river flows we had this year. No one expected those gates to be open fourteen feet. The fish were going through a lot faster than anyone's detectability model before the study started.
Gene Ploskey	What about the fish velocity?
Marvin Shutters	Yeah. I am saying we have to look at all possibilities and make it through and go back and double-check your detectability model after you see what has happened.
Sam Johnston	That's one thing you never do. What Tim does is actually look at the detectability as the season progresses. When it changes,

change the estimate.

Marvin Shutters   That was the question I had a couple of years ago at the Dalles. We had two spill levels and when we spilled a lot more water, we didn't get anymore fish through there. Is it because velocities were twice as high?

John Hedgepeth   The other factor that you considered in your talk (at AFS in Monterey) was the effect of changing the experiment on the detectability. You put an inclusion plate in or an overflow weir. How does that effect detectability in both conditions?

Marvin Shutters   Right. And that is in the velocity. I think that is something we've been remiss on and I'm certainly trying to push the Corps into getting more modeling up front of anyplace we're going to do hydroacoustics so we have this velocity stuff down.

Gene Ploskey   Is it important to have periodic checks on detectability as well, as the project progresses?

Bob Johnson   That is what Sam was saying.

Gene Ploskey   It seems reasonable. For example, Gary Johnson was concerned about target strength and changes in target strength seasonally. Certainly, we have that. We have bigger fish coming out in spring than in summer. That affects detectability. What would be the minimum detectability modeling that you might want?

Bill Nagy   The minimum is that you would set things up so that whether there are zeroes coming through fast or bigger fish in the spring coming through slowly. I think the way that it's usually been done is that you set things up to get adequate detectability. Whether that really happens or not, I don't know. You go with the static model of detectability all through the season assuming that you have set your threshold low enough and everything else to do this. That's may not be the best way to do it, but it would be the minimum, I guess.

Don Degan   That would be a poor way to do it, I would think. Because if the velocities changed dramatically or the distribution changes throughout the season you may not be sampling adequately. If you were going to base it on a certain number of hits over the entire season that you see on a echogram or something. That's going to change dramatically what your expansion would be. I think it would have to be done based on the physical parameters as you are sampling.

Sam Johnston   Fortunately, if we have this model we can just say well, we know that the flow has changed a certain amount. Put that into

the model and see what kind of an effect that has. Maybe some of these things won't change very much or maybe the changes won't have a big effect on the overall detectability. But when they do, then it's time to change the number of hits criteria or something.

Gary Johnson   Practically speaking, I think it would be a good idea for a guideline or standard if we keep track or document the values, if you will, for the parameters that go into the model during the season. Therefore, you can't say you just always assume the water is four feet per second and you keep an eye on that with your split-beam. Then where things go out of whack then you can run detectability. It probably doesn't make a lot of sense to be always just running your detectability model routinely. But if you keep track of the important parameters and then when you have an aberration, take care of it. That might be a good way to document that you are still doing a good job.

Marvin Shutters   John mentioned earlier today that at John Day this year because the fish distribution seemed a lot higher in the water column than what we had been looking at. He wanted to go back and look at detectability again. Good approach.

Gary Johnson   So, Gene, I'm hearing a standard here. I don't see standards listed on your wall over there.

Gene Ploskey   It should be done before the study and should be done some during the study and corrections should be made accordingly. Is that the standard? It should be reported?

Gary Johnson   Yes.

Marvin Shutters   (Pointing to the list) This should be data collected on fish velocity, ranges, thresholds.

Gene Ploskey   Certainly, thresholds, ping rates, and all of those things that we talked about.

Marvin Shutters   For each detectability model, run it again for each experimental block and make sure that you're still nailing it. Is your assumption for effective beam width still valid?

Gene Ploskey   Is the standard tight enough?

Gary Johnson   Maybe it helps to have it a little bit general for now, Gene. As long as the combination of things give you decent detectability. We still have the critical uncertainties that Tim brought up.

Gene Ploskey   Can we add anything to our to our critical uncertainty list to finish it?

Bob Johnson	Sounds like whether or not detectability gets reported is a critical uncertainty.
Gene Ploskey	It's true. It's true. I mean, there have been many studies where it has not been reported.
Bob Johnson	There may be none, but if it's not reported what is the standard for evaluation?
Marvin Shutters	And how is the effect of noise on detectability handled? Make notes somewhere in the report that it was often noisy. So?
Gene Ploskey	Well, we will come to that this afternoon. We should break for lunch.

1:00 P.M. – 3:00 P.M. Tuesday, 9/16/1997

Gene Ploskey	Are we finished with detectability? I guess that's the consensus. What about modeling detectability? Some of you have models. What's the best model out there? Has anybody published a model?
Tim Mulligan	I have a model that includes detectability in it, but the detectability is not modeled it is empirically determined.
Gene Ploskey	Isn't that what we are doing? I guess initially you model that with inputs and set bounds to make sure you are okay. If you provide checks over the course of a season wouldn't that be an empirical determination of detectability?
Sam Johnston	But you can't check it. You can't have the luxury of having the video camera in clear water.
John Hedgepeth	Gene we have that old program. I can certainly ask if we can send you a copy.
Gene Ploskey	It that the old Fortran version?
John Hedgepeth	Yes.
Gene Ploskey	We already have a copy of it, but not the source code so we could see how it works. I've used it before, but I believe it's quite a bit simpler than everything else we've put on the detectability list.
John Hedgepeth	I think it maps things up in degrees versus range.
Sam Johnson	Yeah, it does have trajectory. It doesn't have signal to noise but does have threshold, velocity, and range.

Gene Ploskey	It has, it has most of the things.
Sam Johnson	It has most of the important items (referring to the list).
Cliff Pereira	Now to say it has them, How do you know it's doing a good job? Those are input items.
Tim Mulligan	The input, the things you have an idea about, certainly you measure the beam width, you know the ping rate.
Cliff Pereira	But I mean how do you know what the model does with the inputs.
John Hedgepeth	That's what I was saying, you need the source code to start to examine the workings of a model. That might be a nice place to start.
Sam Johnson	It does make some assumptions like if the fish is above the threshold, you will record it as an echo. All it does is says within this number of degrees you'll see it if it hits on a target going this speed of this size through the bream. How that performs in a real situation, where a fish actually does that, that's a whole different question. And that's what Tim's model does.
Tim Mulligan	A first step at it anyway. Certainly, what we've been surprised by is how much poorer the systems work in practice than the tank measurements would lead you to believe. There is so much more variability and a poorer signal to noise environment. The systems are always advertised under pristine sort of conditions which is reasonable but to expect the instruments to perform that way in the field is a bit unrealistic. We've been finding looking at the videos of multiple fish in the beam versus what we get acoustically. If you tried to reconstruct the trajectory of fish when you've got 4-5 of them within a couple of meters, well, good luck in knowing how many fish are there much less reconstructing the echoes. The resolvability of them is not nearly what you would expect from the width of the transmitted pulse. Some real degradation occurs.
John Hedgepeth	Part of the detectability is in signal processing?
Tim Mulligan	I guess in the signal processing. I guess a lot of the echoes get rejected or what not I'm not really sure of the mechanism because we're still digitizing in the video part to get the fishes video position versus acoustic position. My feeling from looking at it is when there's only a single fish in the beam, split-beam systems work remarkably well. However, when there are multiple fish in the beam, degradation happens a lot

faster than you would think just based on the specifications for the instrument. It's a real eye opener to see how they actually perform in the field.

Gene Ploskey   Do we need adequate detectability models now?

Gary Johnson   What I am hearing is that existing models are good, but we need to attack the uncertainty of the within-beam distribution and how that affects the detectability. Correct me if I'm wrong, but it seems like the next generation of models needs to do more. Is that correct?

John Hedgepeth   It could be a little more complex for sure because it doesn't take into consideration, targets fading in and out, for instance. So I think you could build upon the existing frame work.

Sam Johnston   But in terms of checking for it, certainly you could do the model but you won't know if it works in practice until you have a system that can measure those variables. In other words you can make models and say that this thing will reject so many targets or whatever but you can't test it and verify unless you have something that can really measure the parameters in the field.

Tim Mulligan   Yeah, that's difficult.

Gary Johnson   Well that's a direct comparison, a direct verification. There are other ways to verify. I think Gene can talk about that. You can make your estimate of FGE, compare it to something else that measures FGE, and see whether the measures correlate and make sense.

Marvin Shutters   If the model works, the accuracy of your passage estimates should be high. The two factors that affect accuracy are detectability and the lateral distribution of passage through the expanded area, and either one or both could be leading to biased estimates. If you are getting accurate estimates, you must have both of them pretty well down.

John Skalski   Well, you can have very precise but inaccurate estimates.

Marvin Shutters   Of course, but that's not what I said. I said if you were getting accurate estimates, your detectability model is probably good and your assumptions of distribution probably good.

John Skalski   The thing is, it's easier to measure precision because you're using it within the data itself to measure that, but accuracy is relative to reality, which is what we are trying to measure, but never know.

Marvin Shutters   Yeah, it's never known, but things like radio telemetry or

netting and some other tools and videos can all be used...

John Skalski	Yeah, I think that's what Gary is looking at. You might have to cross validate it with other techniques, perhaps to assure yourself of the accuracy.
John Hedgepeth	Possibility of calibrating the model too somehow. I was thinking one way would be to sit it out on a platform, set the transducer out and bring a target down or something and use some high speed rotators and move the beam around as you'd expect the target to move through the beam or you can send some acoustic tags through it.
Marvin Shutters	That is a good idea, to move the transducers through the targets so you can get estimates
Gene Ploskey	Right, the noise level also can be changed in controlled environment, so there are possibilities. Detectability is the key though, if we don't have similar detectability among transducers, then we don't have horizontal distributions of passing fish and FPE begins to break down. I was just wondering what could be done to improve detectability models so we have some tool for knowing how well we're doing.
John Skalski	Another approach depends on how well you believe some of our observations are to reality. We talked at Lower Granite Dam about using a transducer with a rotating head.
Gary Johnson	The scanner.
John Skalski	The scanner. Thanks. You assume that to be reality and then see how biased estimates would have been had you sampled with a single beam. It gives you some feeling under fixed circumstances of the magnitude of the biased obtained. You may not be able to do that under all circumstances but you might be able to under certain circumstances to confirm for yourself hopefully that the problems are not that appreciable. I think we are going to try to use that data later on to see what happens to single beam samples if assume the scanner results to be reality.
Gene Ploskey	The scanning beam shows you the distributions of single targets, but how do you know that those single targets are fish? It seems to me that you get a picture but part of that picture could be noise and not truly the distribution of fish.
John Skalski	That's what I'm saying I mean you have to assume the results to be closer to reality
Gene Ploskey	It may be reality or not

Gary Johnson	Well you can make that statement about anything, but where do you draw the line.
Bob Johnson	A single beam transducer that's in that intake, how do you know it's seeing fish.
Marvin Shutters	Well, you get ping to ping tracks and have a minimum ping criteria. Having four hits certainly filters out a lot of things that having one hit is not going to filter out.
Bob Johnson	Right. I think that a preferable approach to would be to have a single beam or maybe even a split beam transducer on a rotator and rotate to sample for a few minutes at a number of specific stops.
Marvin Shutters	Yeah, I like the sound of that better.
Bob Johnson	When we started that scan head, the question was "can we even do this?"
Gene Ploskey	Right.
Bob Johnson	I think from that standpoint, it's been a good demonstration of capability. Have that type of capability with a more sophisticated instrument. I think you could derive a lot of information from it.
Gene Ploskey	I agree.
Gary Johnson	Just for everybody's information, if you are interested, the scan head stuff is going to be kind of brought together in our draft report coming out in November. That is when we're going to do the stuff that John mentioned about the FGE effects. Don't get me wrong Marvin, I'm not convinced were getting decent data out of the thing either, but to me the jury is still out. We've got some real tough problems sampling the entire intake for one, because the transducer beam was two by thirty degrees and the thirty was just too wide. But it should give decent horizontal distribution from side to side, the thing is they'll be in bands.
Gene Ploskey	That information would be extremely valuable.
Gary Johnson	It is our attempt to get at within slot distribution uncertainty.
Marvin Shutters	It certainly is the kind of stuff we want to be doing. We just want to make sure it's measuring mostly the distribution of fish and not entrained air or other noise.
Gene Ploskey	OK, well let's leave that for now, we'll go on to ratio estimates

like fish guidance efficiency within a single intake. The goal is unbiased sampling of fish in two areas of an intake, above a screen and below a screen so that you have some idea of relative numbers of guided and unguided fish. FGE is number of guided fish divided by the total number that went into the turbine. FGE is done many different ways. You can sample guided fish with an up-looking beam and unguided fish with a down-looking beam or you can use a single beam or multiple beams aimed in one direction. I think John has some information that suggests that using one beam may be superior?

John Skalski   Yeah, I can probably go up to my room and pull out the slide, but somewhere back a couple years ago, when we started the Lower Granite project, we looked at effects of three different transducer deployments within a turbine intake. In one, you have two transducers, one estimating guided and another one estimating unguided fish. In another scenario you had a transducer estimating guided and another transducer estimating guided and unguided (total). In a third scenario, a single transducer took the counts and split it up between guided and unguided. My recollection is that of the three, the method that gives you inherently the least precision is the approach where you have two transducers, one doing guided and the other one doing total. The intermediate situation is where you have two transducers each, one doing the guided and one doing the unguided, and then the most precise, if you have these options, would be to have a single beam that you split up the counts between the guided and unguided fish. And that inherently, if you go through those three options you get better precision, just by the statistics. I think the community over the last couple years is starting to go down the hierarchy, you started off with a two-beam approach estimating total and guided, then doing more two beam sampling of guided and unguided fish separately, and now more conversations about using a single beam approach.

Marvin Shutters   There had been a lot of work before screens were put in using the one transducer, looking to come up with a theoretical FGE for when we put the screen in, what's it going to be? And those, I'm not sure overall, but I know a few examples of when they were way off, what FGE turned out to be, so I agree, it would probably be a very precise estimate, but I wonder what the accuracy would be.

John Skalski   Well, again, assuming that we are getting unbiased counts, you know, that the acoustic equipment is giving us reliable estimates of the fish going through them, those are the methods that will give you the right levels of precision. In my deliberations when trying to come up with a design, I tried to push investigators down that hierarchy, you know, if you have

these three options go further down towards the method that will inherently give you more precision. But that has to be tempered with the circumstance. The way the intake is configured. Not all intakes allow all three options, so I just try to convince the investigators, among the options that they have available, go down the list as far as they can. And, in terms of standardization, I would not be inclined to say everyone do a single beam, split the counts up, because that's not going to work in all situations. My inclination would be, given the three general alternatives, go down as far as you can within the physical limitations of the structure and the hydroacoustics, and then you live with the rest, accomplish additional precision with additional sampling effort. End of my story.

Bob Johnson Good story.

Gene Ploskey Why does the single beam give you more precise estimates?

John Skalski Covariance. When you have a single beam, you have a strong covariance between the fish that are being counted guided and unguided. You get less and less of that valuable covariance, which improves precision, as you get into the two beam situation.

Bill Nagy Suppose you were pinging at the same time with the two beams though.

John Skalski The more covariance you can have, the more that you can take advantage of the better precision that will usually subtract from the variances of the guided and unguided.

Bill Nagy I'm thinking you're always counting two different parts of the water, even with one beam.

John Skalski Yes, but they're correlated.

Bill Nagy The only difference would be whether they're counting at the same time or not.

John Skalski Absolutely, absolutely.

Gene Ploskey Are you saying, Bill, that a fast multiplex between two separate beams is better than a slow multiplex between two transducers in a turbine.

Bill Nagy It would be better provided detectability did not deteriorate because you divided your maximum ping rate between two transducers.

John Skalski Theoretically, there's this relationship, but then again, empirically, from the last few years of study at the dams,

	we've seen a major improvement going from one approach to the other. So it's more than just whimsy, both theory and practice are saying that this is correct.
Marvin Shutters	Were the guided and unguided fish sampled with separate transducers?
John Skalski	Right.
Marvin Shutters	Was that with fast multiplexing between them, or was it with separate time periods?
Sam Johnston	We ought to remove that from the discussion, because you probably can't fast multiplex two transducers in turbine.
Gary Johnson	You can, but you don't get any data out of it. No, we sampled separate times.
John Skalski	Right, separate times.
Bill Nagy	So that, I would think, would account for the difference.
John Skalski	Indeed, because of the covariances, continuous sampling with a single beam is better than a slow multiplex between separate transducers.
Marvin Shutters	But we do sample guided and unguided by fast multiplexing between those two separate transducers. We've done it at John Day two years, and we've done it at Bonneville.
Gary Johnson	Within one given intake?
Gene Ploskey	Within one intake, that's right.
Sam Johnston	Are the transducers at the same location or co-located?
Gene Ploskey	The one that looks up is mounted deep, and the one that looks down is up high and the beams cross in front of the toe of the screen. Therefore, the widest part of each beam is located to count the two classes of fish (guided and unguided).
Bill Nagy	If the total ping rate's the same as the maximum for one transducer, it shouldn't matter.
Sam Johnston	So the transducers beams are crossed.
Gary Johnson	That's good then, I didn't realize you could do that.
Gene Ploskey	We didn't get an appreciable noise increase from reverberation doing that and we were able to run at fifteen pings per second

per transducer.

John Skalski	Well then, that would be comparable to using one transducer and simultaneously sampling both guided and unguided fish.
Gene Ploskey	That may not be possible in all cases, but we were able to do it at Bonneville Dam.
Marvin Shutters	We did it two years at John Day and Gene did it two different years at Bonneville in different intakes.
Gary Johnson	The trouble we have with that, given the gear we use. When you fast multiplex, you don't get the range, you can't do the high ping rates, so we don't do that. We do use high ping rates, get the range we need, and then slow multiplex, but that's an equipment limitation.
Sam Johnston	And a structure limitation too. I think the work you were talking about with these three options that have them both pointing down in the same direction in the intake, if I remember right, as opposed to the up down cross looking out.
John Skalski	It could be either way, I mean, they don't have to be.
Sam Johnston	Well, I was just looking for a fast multiplex case.
John Hedgepeth	Yeah, one has to be aimed up and the other down for it to work.
Gary Johnson	So what kind of range do you get with fifteen pings a second fast multiplex?
Gene Ploskey	I think we're limited to, what was it, 17 or 18 meters?
Gary Johnson	Seventeen or 18 meters. Did you have decent detectability at 15 pings a second?
Gene Ploskey	Yeah, the flow in-turbine is around 4 feet per second.
Bill Nagy	And the ping rate was 15 pings per second for each transducer or 30 overall. Which is really pushing the limit.
Gary Johnson	And you guys have 18 meters of range, that's good.
Gene Ploskey	It may have been 17, it was around 17 or 18. But it wasn't because of the time of travel that we were limited, we were limited by a software setting that wouldn't let you go any higher.
Gary Johnson	Yes, or the switching time of the multiplexer.

Gene Ploskey	Right, but theoretically it would have been possible to have more range.
Bill Nagy	One thing, with the single beam, you ought to be able to ping twice as fast, effectively, as with fast multiplexing two. It didn't work out that way, so if you could get both the counts off a single beam, you could ping faster and that helps.
Gary Johnson	It seems to me though, in making this ratio estimate, you should have equivalent detectabilities with those two parts of the beam. I mean that's why we've decided before that you need to document your detectability.
Gene Ploskey	Right.
Gary Johnson	Maybe it's up on the asymptotic part of the curve that everybody's happy with.
Bill Nagy	What are you saying Gary?
Gary Johnson	Maybe your at the ranges where detectability is nearly asymptotic. I take it you have to use part of each beam to count guided and unguided fish?
Gene Ploskey	That's right, in fact, a lot of them were aimed so that the edge of the beam actually tagged the edge of the screen, so you knew exactly what range you wanted to call guided fish. If you were looking up and you were nicking the edge of that screen, you knew exactly what range to begin counting guided fish. On the down looking one, if you're lucky enough to nick part of the screen, everything below that is unguided. So in that sense, it's pretty clear. They were all mounted at the same distances, so you knew the range to the screen, the tip of the screen, because we had a few transducers that nicked it. And, so the range to the screen tip was very clear. Using 15 pings per second given the flow rate and the passage of those fish provided reasonable detectability.
Gary Johnson	What was the minimum number of hits you required?
Bill Nagy	We had to go three, which is marginal if there is any noise at all.
Bob Johnson	So, getting back to your question about the models for detectability, is this shareware, sounds like your willing to put it out on the web?
Sam Johnston	We can release the old ones, the original ones, yeah.
Gary Johnson	It's all been shared.

Group Laughter

Bob Johnson	I know we've got copies of somebody's.
Gene Ploskey	I guess what I hear is the idea of simultaneous sampling is best for guided and unguided and whether you do that with one beam or …
John Skalski	…or two beams improves the precision appreciably.
Gene Ploskey	Right, as long as your detectability doesn't fall off at some point.
John Skalski	I mean we can go into other aspects, we look at things like rates of sampling, you know, typically we didn't sample all 60 minutes within the hour within the turbine unit, we sub-sampled that through time. Now I can make some comments concerning that, typically, if you have a fixed amount of time allocation to a particular unit, it's better to have frequency of all samples than a few big samples during the hour. Simply improve precision that way, so if you have 12 minutes, just for convenience, it's better to have 12 one minute samples, than it is to have two six minute samples during the hour. That will improve the precision. Then there's also the issue of how do you allocate the sampling within that hour, if you're sampling 12 minutes an hour one minute at a time, every five minutes you take a one minute sample and do that systematically throughout the hour, and that seems to be convenient for the hardware, and more convenient for the people. We drive people crazy if we randomize it. Let's see, in many situations you will get an improved precision with systematic sampling throughout the hour over simple random sampling. The problem with systematic sampling, everyone knows, we don't have a very good variance estimator, there's no consistent variance estimator. So, we end up using typically simple random sampling variance formulas for the systematic sampling. So when you sample systematically but assuming using random sampling formulas, overestimate the variability by applying those simple random sampling formulas to systematic sampling. So in many senses, we're being valid but conservative. Our variances are going to be too large, our standard error's going to be too large, and our confidence intervals going to be too large. Now I guess that's fine if we do enough work, we seem to get enough precision. Maybe I said this before, but I definitely suggest that people do lots of frequent samples during the hour versus a few clumped big ones.
Gene Ploskey	Is that simply just because of the sample size goes up for the hour?

John Skalski	Uh, no. If your sampling 12 minutes an hour you've still got a 1 in 5 or one fifth or 20% sampling fraction, so that doesn't really make a difference, it seems to be in terms of patchiness of the fish.
Gene Ploskey	How frequent would you go?
John Skalski	I've never been in a situation where I've been able to push it down as far as I want. There's a limit because of the bit padding. I mean, we could go down to 24 half minutes samples, but the cost of doing that goes up appreciably because of the bit padding, to my understanding.
Gary Johnson	Our standard is 2 to 3 minutes per sample, we prefer 2 minutes.
Gene Ploskey	I think we used 2 minutes when we slow multiplexed among turbines.
Tim Mulligan	John, there must be some bottom to that, that's dependent on how long the target is resident in the beam. If your looking at long range, like we are in one system, where fish might be in the beam at 200 meters, you might be tracking at the 30 second intervals. You wouldn't want to cut down your tracking interval. Have you ever looked at that end of the spectrum?
John Skalski	Not terribly, I've done some simulations with, you know, having complete 60 minute samples and looked at slices of the pie in many different directions. It does tend to balance out. You get improve precision by getting smaller and smaller samples and then it sort of levels off, indeed it does.
Tim Mulligan	At some point it must get worse and worse. But you're rejecting some because they haven't made it through the time increment.
John Skalski	We've not gotten to such a small interval of time that you're actually cutting into ping time and that situation, I don't think we ever went below a minute.
Marvin Shutters	Four ping samples is probably too short.
John Skalski	Yes, definitely, definitely, definitely. The next thing about turbines is that fish aren't in the beam very long, unlike the river situation.
John Hedgepeth	The equipment has to switch too, and that takes a little bit of time.
John Skalski	Yes.

Sam Johnston	We start losing sample time, when it gets shorter and shorter.
Gary Johnson	Well, we talked about the ratio estimates for FGE on John Day Dam, do you want to talk about any of the other efficiency things we do, like spillway or sluice efficiency. Any considerations there, that have to do with ratio estimation process.
John Skalski	Basically again, it's not inherently different. I mean we do lots of different things like spill effectiveness, which is going to be the fish over the spill versus total fish passing the dam. And again, when we're doing this, as long as you estimate passage on a route specific basis, independently. I think of it as children's ABC blocks, you can add the blocks, put whatever blocks you want in any combination you want to get the kind of ratios you're after. So, we sample each route independently, with the expectation getting independent total passage estimates by route and then we can put the routes together in any ratio combination the sponsor's interested in. And usually they're interested in multiple ratios. Not only FPE, but FGE, spill effectiveness, and all sorts of subsets thereof. And, again, the idea is that they're being sampled independently and treated as blocks. What you want to do is sample each one of those independently, unbiasedly, as much as techniques allow, and precisely. Overall, precision will be a function of the precision of those separate components. It may not be nice and linear, because it's not a linear function, but typically overall precision of your ratio estimator will be a function of the CV's (coefficients of variation) on each of the routes. My recollection, it's the sum of the CV squares. In other words, you have a CV for this route and that route and that route and variance is a function of the sum of the squares of those coefficients of variation. So, if you have one particular route that has a terrible CV, that is where you want to put some more effort into to improve the precision of your overall ratio estimator. So, in that sense, it's very nice. You just tend to design the study so that each route has a small CV, so that sum of them will give you the level of precision you want. Does that help?
Gary Johnson	Yeah, so, I heard a standard. It was to estimate passage on a route specific basis.
John Skalski	They should be independent. Independent sampling allows them to be treated as independent building blocks. You deal with them so that they have adequate precision in and of themselves, and if you're happy with precision for fish passage, you'll also probably be happy with them as being contributors to some of these ratio estimators.
Bill Nagy	How could they be not be independent?

John Skalski	In most cases they will, in the sense that you do have separate transducers and you're sampling at different times at different water aspects, so they will. I guess you could conceive of them, or some reason different transducers at the different locations were being pinged at the same time so they weren't independent. We treat each independently if they are on a different multiplexer.
Gary Johnson	John's first example, where you counted total passage into a turbine and then you counted guided fish was a case where you had a dependency between the two components.
John Skalski	Thank you, that's a good example.
Marvin Shutters	The other thing on ratios, we started to talk about FGE in turbine. I think that's a little bit more of a unique case where perhaps we don't have an unbiased estimate as much because you're taking ratio within the same intake and the horizontal distribution is probably pretty close to the same above and below the screen. So maybe we don't have to worry about those things as much to get an accurate estimate of guidance efficiency.
John Skalski	Again, we've been approaching a topic at Lower Granite and there were two issues with a scan head. First, we were concerned whether the fish were horizontally uniformly distributed. In terms of estimation that's not as important as that the guided and unguided had the same horizontal distribution. So that if there's a bias, they cancel out. Well that's in the case of estimating FGE in a unit. And that's fine.
Marvin Shutters	But, when your ratio is calculated from data for separate routes, that's when you need to have accuracy in the numbers.
John Skalski	Exactly. I think it's a little premature, but I've got the feeling for the couple years of data we have, that it's probably unlikely that the fish are uniformly distributed as well as we'd like, but they are probably more horizontally homogeneous. Is that my recollection? So they don't necessarily satisfy the uniformity, but they do have the same up and down, guided and unguided, so if fish are left biased in the guided they're going to be left biased in the unguided fish, so that even though you put your transducer in one place, both biases sort of cancel each other out. And that probably is a blessing. You had one assumption we thought we needed, we probably didn't fulfill it, on the other hand it was a much more stringent assumption than we needed for the purposes of getting the FGE. And that lesser criteria seems to be more easily fulfilled.
Sam Johnston	The problem comes in when we're trying to get the

denominator of FPE that we're in trouble, using the same data.

John Skalski	Yeah.
Gary Johnson	A perfect example of that in the real world is that at Lower Granite where we do FPE, we don't use the total of the guided and unguided. We use the pier-nose total for the powerhouse estimate. We take that passage distribution and weight the FGE to get the components, guided and unguided.
John Skalski	You weight the unit-specific FGE by fish passage estimated from transducers upstream?
Gary Johnson	So you still end up with the guided and unguided components.
Sam Johnston	You still have those numbers but they're not directly from the transducers.
Gary Johnson	They're not directly, they're not absolute counts.
Marvin Shutters	You believe that your passage estimates are more accurate from your pier nose than in turbine would be.
Gary Johnson	Absolutely.
Marvin Shutters	How did you come up with that?
Gary Johnson	Why? Because we compare our index of passage to other sources of indices, for example, the smolt-monitoring program does an index passage. They call it an index and indeed, it is. They're trying to estimate the number of fish passing the dam each day, so we make our estimate using the various things and compare them. We'd do a cross validation with another tool. We found that the pier nose is the way to go.
Bill Nagy	Any idea why that might be? We are not sure of what you're seeing on deployments upstream of intakes.
Gary Johnson	Right. Yeah, we've talked about this a couple times. One of the things about being on the pier nose, in my opinion, is that, sure you might not know that it's going to go into that hole, right there, right immediately downstream, but the traces that we take are selected such that they are moving directly through. So it's going to go through somewhere, so when we do FPE, we end up combining everything, and the assumption we make of having to go through that hole turns out to be fine if we accept the fact that we have decent data and it's cross checked to other stuff. But detectability for our in turbine transducers, you can see it on the curves, it's just less. We couldn't get equivalent detectability between the pier nose and the guided and unguided transducers in the turbines. We

	couldn't ping fast enough for those 10-degree beams. Nice signal to noise though. Later it was OK in the context of the broader objective, or I should say, set of objectives. I mean the precision on the FPE is fantastic.
John Skalski	And we'll probably bring this up later, but, you know, I think there are other cross validations, just by serendipity and circumstance, I happen to be working on another project trying to pull out FGE and spill effectiveness for pit tag data, which I do a lot of work on, and they seem to track the hydroacoustic estimates closely. So again, very similar results from two very different techniques. It may be foolish luck, or we've done something right.
Bill Nagy	That's tracking daily?
John Skalski	Even daily. Yeah, my model says FGE is going to go down and the hydroacoustics seem to indicate the same thing. The model says it's supposed to go up and hydroacoustic estimates go up.
Gary Johnson	So this experimental pit tag approach is being validated by the well documented conventional approach of hydroacoustics.
Group Laughter	
John Skalski	I thought it was the other way around.
Group Laughter	
Gary Johnson	Along these lines though, the radio telemetry people are still working on their data too. Potentially, they can make FGE estimates also. They have to figure out how to allocate some of their fish for which they don't directly detect exit points. They know the fish went somewhere because they've detected them downstream, and there are some other problems to overcome.
John Skalski	I think it's important, in the sense that, all too often, even within the same project, funded by the same agency, you have different principal investigators and technical representatives doing different programs but not coordinating. They really should cross validate results. We probably would do a heck of a lot better if there was even a smidgen of collaboration. The pit tag stuff just happens to be almost serendipitous too, you know. Two different programs wound up estimating the same thing and it worked. But gosh knows what could have been done purposely. Where you had tag release at different times to help one model, or the rate of telemetry was released concurrently with the pit tags or what have you. It would have been even more fortuitous. So I really encourage that people, when they estimate FGE, is that, don't see these studies as

isolated studies, but as interactive components to a bigger task. It's hard, but it's well worth it, I believe. If you get the same results or similar results from three very diverse techniques, you may start feeling good about it. And if you don't there's a good reason to investigate why.

Gene Ploskey   Does that finish ratio estimator?

Gary Johnson   Not quite, you have your hydraulic considerations that might have something to do with spill efficiency, different spill regimes, different hydraulic flows.

Gene Ploskey   Actually, what I was thinking about screens in a turbine, and how they alter flow fields. Also, different kinds of screens have greatly different effects on flow fields in the turbines, which affects detectability. I wasn't thinking on a broader scale.

John Skalski   I think it's valuable to consider also, again, it's all preliminary, but our work with the pit tagging stuff and FGE, strongly suggests that FGE is not a constant, but is indeed influenced by flow. And, appreciably at times. If that's the case, going out there one season under one small regime is not giving you all the FGE information you want. Again, sometimes it's been fortuitous, we've collected enough data over enough years that we have had different flow regimes, different spill regimes that we can sort of investigate those relationships, but that again tends to be more serendipitous rather than purposeful. And I think it would be real valuable, that in some of these studies, if at all politically, economically feasible is that you may purposely alter dam operations to investigate this process. Otherwise I think we're going to be naive in getting the FGE, which is an FGE for this particular year or that particular flow, and never realize that it doesn't apply to next years after you use it, and we don't know how to change it. There's some comfort in being naive, the world's very simple. The problem is it doesn't conform to reality and people and fish pay for it. I think it's crucially to explore effects of dam operations on FGE but rarely done.

Gene Ploskey   Are you speaking of within a single turbine?

John Skalski   At the dam, you know, what we can do at least with the tag data, is estimate a dam wide FGE. And that definitely seems to be influenced by flow.

Gene Ploskey   And so does that mean that, under certain flow patterns, certain turbines receive more passage?

John Skalski   That we haven't looked at, because there's certainly going be a high correlation between flow and turbine operation, and

	which turbine units are on and very, very strongly on a unit. We have not tried to break it down, but, I suspect we can't, because again, we'd be using opportunistic observations that no one really assisted to see what's driving it. It is not as simple as we would like, spill efficiency is not 1:1 and FGE is not a constant. We can't just get one number and go off and do good things with it. Things are a lot more dynamic than that, it seems. The pit tag data suggests so, and so do the differences in FGE at Granite over two years. It's also a function of flow and also predictable by the flow regime model we've come up with. FGE varied from the 50-60-70% level one year to 80-90% the other year.
Gary Johnson	Well, yeah, but you can't compare those numbers because they were two very different sampling regimes. In '97 we sampled 6 of 18 intakes, in '96 it was 2 of 18 and the unguided transducers were mounted in a less than desirable orientation.
John Skalski	Pushing it, perhaps.
Gary Johnson	Do the same thing again in '98 or something like that, to see if you can detect differences.
Bill Nagy	What usually happens though is just the opposite, where they try to control operations in order to control conditions over the fish passage season, in order not to confound whatever manipulations they are doing.
Marvin Shutters	One or the other, you know, if we have surface collector tests going on or something in the turbine, we try to maintain constant loading on these units. Or conversely, we alter, drastically alter, operations to test the effect of it whether it's two levels of spill or two very different upper and lower limits and 1% efficiency of a turbine.
John Skalski	In every study there are bound to be conflicting needs for operations. It's very hard to please and appease everyone.
Marvin Shutters	That's certainly one of our District's goals is spill efficiency by spill levels. We want to get that response curve.
John Skalski	And you have to vary it to get that curve, yes.
Marvin Shutters	And getting that done politically, at John Day because of gas and at Bonneville because of adult fallback, is probably not going to happen, but at The Dalles we were able to do it to some degree.
John Skalski	I know, again, within my limited constraints of trying to pull that out from the pit tag data that we can do nicely at Granite. There was a very fairly big range of flows and spill levels over

the course of the last few years. At Little Goose, however, the spill range was much more contracted, it's very hard, if not impossible to sort out those two factors. You know, the fact that you know that, in the end it's an important goal, it might suggest that you have to do a particular spill regime. I guess my argument is, maybe with all these different investigations sometimes at a project we need to coordinate with multiple investigators with multiple projects and say OK- this is what I liked, this is what I needed. The goal is to optimally design, not studies, but programs, at a site. I think might get more information out of them. I don't think, again the costs, you know, all of these studies are megabucks each one of them spending a day together comparing notes may not be a bad investment.

Bill Nagy   Do you think that it is reasonable to design a surface collector and evaluate it in a year or two, given real world variability.

John Skalski   I have those concerns. (Group laughter) I've had those concerns, especially given that within a year or two they were trying to view it in very limited conditions compared to what nature might impose. Then the system and the politics impose other criteria. Even if we could alter spill within a year, we don't because of other environmental policies going on, you know, fish protection and what have you, while the science begs, please do.

Marvin Shutters Lots of tradeoffs.

John Skalski   Yeah, always. And I think the thing I'm arguing is, quite often you don't know the costs of the tradeoffs until it's after the fact.

Bob Johnson   Do the authorities know about this, or are they just oblivious to the concern that you're voicing?

John Skalski   We're sitting around and just talking about hydroacoustics, which is technically complex and hard to come to a consensus, and now you want to do this across, hydroacoustic, pit tag, and radio telemetry studies. For any one person, like a bureaucrat, to absorb that all is impossible. I just think that to ask one person to do it is impossible, and I don't think it's malicious or intentional, it's just overwhelming.

Marvin Shutters Regional funding mechanisms and policies really drive a lot of this stuff. However, you know, at the Corps level, and certainly, you know, the people in here, you know, we do try to keep it as programmed. All types of studies at Lower Granite were designed around what they were testing on the surface collector that year. At the Dalles, we have adult radio telemetry, survival studies through the spillway,

hydroacoustics, every study is evaluating spill efficiency. We do try to organize programs, but when it gets to multi-agency agendas, things get muddled and mucked up and funding for a project is yanked one year and shifted to another project.

Gary Johnson   There also are different priorities at the river operations level, and this is not a high priority.

John Skalski   Don't read it as a criticism. I just, think of it as a recommendation that the Army Corps or BPA try to coordinate things. It's still very rarely that the principal investigators across these projects get to sit down and- ahead of time- it's extraordinarily rare. It might be invaluable.

Bob Johnson   I think you make a very good point that's a source of frustration.

Marvin Shutters   That's something we've been talking about for a couple years, and it never seems to happen.

Gene Ploskey   It takes a lot of effort. I know Gary Johnson has been active in pursuing coordination, but in order to make it happen, you have to dig down deep. Higher level interest is needed to assure that coordination becomes a reality, because few researchers can unilaterally assume the responsibility.

I want to back up to the little building blocks that we can add together. (Group laughter) Should we weight individual FGE estimates by the passage of fish. I guess that is understood, right?

John Skalski   Well, you know, again, I'll use my learning curve as an example. When we started doing it at Granite this year, actually, the project team was somewhat in a quandary. I mean, we had several options and we talked about them, but as soon as the season got on, it became obvious that that was the way to do it, the only way. Nature told us how obviously dumb we were not to think of that, since that at Granite, roughly, FGE was inversely related to fish passage. You know, the highest units of fish passage had the lowest FGE's and visa versa. And if you didn't also take that into account, you could have a very different project wide FPE than what reality would have. And like I said, in this case, nature sort of had a wake up bell for us. But yeah, I think it's extremely natural.

Gene Ploskey   Essentially FGE estimates for each intake is weighted by the number of fish going through that intake.

John Skalski   Exactly, and then that becomes the project wide FGE. And that's what I was saying earlier. When you go from trying to estimate FGE at a unit to a project, it becomes an order of magnitude more difficult. Not only do you have more turbine

units being sampled, but you also have to have estimates of fish passage going through those units. So now you have another level of study. You're getting FGE and passage concurrently.

Gary Johnson   But if the transducers you used to estimate the in-turbine passage, to get your FGE's, if you use those to take your data and essentially lump it together for the guided and lump it together for the unguided, and you've accounted for horizontal distribution, if indeed that reflects anything. So we did that initially, but then we looked at the pier nose and we thought, perhaps, it gave us a better estimate of total project FGE. So that's why we went with the pier nose, so I don't know. I'm agreeing with John, I'm just not saying we weren't as…

John Skalski   Naive? Well, I just remembered my own experience in trying to write up the statistical synopsis. I remember there were several pages in terms of having options that the committee was going to look at in terms of how to get project-wide FPE. And a week within the course of the study, it became apparent that the natural way to do it was the right way to do it. And, you know, I was embarrassed by that.

Gary Johnson   Yeah, one of the ways people do it though, is they average the FGE's across the intakes, that's definitely not a good idea. Or average FGE's across the days to get a estimates.

Marvin Shutters   That's how it is typically done for fyke-net data. We need a biologically based measure really. The probability of any one fish being guided is what's meaningful, and that's what Gene's question was I think.

Gary Johnson   Another one of John's standards is that you sum across locations to get a total, and then make your estimate, as opposed to making your estimate and them averaging the estimates. Does that make sense?

John Skalski   Yeah, don't average ratios, you take ratios of averages.

Gary Johnson   Exactly.

Bill Nagy   You said that FGE was correlated with fish passage?

John Skalski   It was, inversely.

Bill Nagy   So, that when there were more fish…

John Skalski   there was lower FGE.

Bill Nagy   Is there any possibility that you may be counting noise? You are always counting some noise when the fish passage is low,

that amount of noise that's getting counted starts dominating the FGE estimates.

John Skalski	My impression, using the pit tag model that we came up with, not only is it intuitively correct, but we also had a cross validation that suggests it's right.
Bill Nagy	So it wasn't just acoustics then?
John Skalski	No, it wasn't just acoustics. It was interesting, we did it strictly from an acoustic point of view, and then I had a separate study and then it dawned on us to cross validate. The pit tag data was from '93 to '96 and the hydroacoustic data was from '97. So, we had two independent data sets in different years and it's probably as good a way to have independent cross validation as you can. You know, two techniques, two different whole years, and it seems to work well. Again, concurrently, it matches too well to be wrong. Or God had a very keen sense of humor, to lead us down the primrose path this way. But then again, I think also, just from logic and the theory that you'd want it weighted by fish passage. What about the issue of forebay versus total guided and unguided, you are convinced one way is apparently better?
Gary Johnson	I just know that we didn't make a very good estimate of total powerhouse passage from the within-intake transducers.
Gene Ploskey	How did you determine that Gary?
Gary Johnson	Because, we took the way we made an index of passage and we compared that to the smolt monitoring index and it fit, and we used the pier nose. If we would have used the unguided, which were an order of magnitude less than the pier-nose passage rate, it wouldn't have worked.
Gene Ploskey	So you felt confident enough in the smolt monitoring index that it reflected run timing.
Gary Johnson	Well that's an issue in itself. I guess for run timing it probably does a good job, this is a question for Tim. What do you think of the smolt monitoring programs index of passage at Lower Granite.
Tim Wik	It's probably pretty good.
Gary Johnson	How much do they sample, like, give us some of the details of the sample it's taken.
Tim Wik	Sampling is six times an hour, ranging anywhere from six seconds on up.

Gary Johnson	So they change the sample time based on passage?
Tim Wik	Right. To get a reasonable number of fish.
Marvin Shutters	Again that's expanded for the unguided fish. Is there just a straight FGE constant?
John Skalski	Water volume.
Gary Johnson	It is still water volume. They make that an assumption for FGE.
Gene Ploskey	The Fish Passage Center?
Gary Johnson	Yeah.
Gene Ploskey	They do this same thing at most of the dams that have a bypass. I think that they sample from a few minutes to 10 minutes out of an hour until they get enough fish and then however long they sample was their effort. But to expand that by flow, is back to having your 'I don't know' measurement and then making an expansion with it. Your passage estimates apparently were real good in the spring. You had a good correlation between your estimates of passage and their estimates of passage.
Gary Johnson	Except for the last two weeks.
Gene Ploskey	John, don't you have problems using two estimates, one that has a measure of precision and another that does not? For example, the smolt monitoring sampling with a variance and then the guided and unguided flow ratio that may or may not be related to FGE.
John Skalski	It's expanded by fixed constants, that we probably know to be wrong. In other words, you're assuming 1:1 spill effectiveness. I think our estimates of spill effectiveness for Lower Granite are not one to one, they're something better than one to one typically over the range of most spill conditions. But it seems to track reasonably well. What convinces me more is the correlation between FGE and spill effectiveness that we get from pit tag and acoustic databases. Together, you know, all three together convinces us that we're probably close. I hope this would convince the community that maybe things are different than preconceived notions of spill effectiveness and what have you. If we just had the hydroacoustics, which was an extensive, well-documented study, I think, given the Columbia River community, people would have been doubtful. Everything's always questioned, questioned by five ways more than necessary.

Marvin Shutters	But that was hydroacoustics data.
John Skalski	Right, exactly. And I know what hydroacoustic data are. However, I think it's going to be much harder for the community to discount this as all accidental serendipity because it was also observed in the radio-telemetry and pit-tag data. Again, I think that's one of the values of having collaborative, if not cross validating, studies going on concurrently.
Gene Ploskey	Yeah, and that leads us right into the next section which is validation by non-acoustic methods and questions such as how often should that be required?
Gary Johnson	Always.
John Skalski	Next topic.
Gary Johnson	No seriously..
Marvin Shutters	Always, but specific, you know, like calibration checks on acoustics with other gears should be done occasionally too, to check the assumptions of your passage estimate's accuracy for a turbine route or a sluiceway. Especially at places that are hard to sample with acoustics, like The Dalles sluiceway and the second powerhouse sluice chute at Bonneville. But certainly hydroacoustics and telemetry should be used in any of these large-scale studies to get the kind of back ups like John's talking about. Like at the Dalles, the split between fish going to the powerhouse and spillway were within a couple percent in '96, between hydroacoustic and radio telemetry. And it gives you a good feeling.
Gene Ploskey	Well, certainly there are other methods being used out there. It's a matter of analyzing the data to do that. I was thinking more in terms of specifically designing study checks to verify a correlation between methods.
Gary Johnson	Well there should be overlap in the program, in the total study, unless you want to duplicate everything. On the other hand, you just get some of this stuff, depending on where you're at in the system, it just falls out, and Lower Granite is a perfect example. We get a lot of pit tag fish go through Lower Granite more than any other spot probably, right? So you use that. Bonneville, you're not going to be able to do that like that, but, like you say Marvin, you can do the radio telemetry maybe when your looking at the passage of yearling chinook specifically, look at what their spill efficiency was or something, you know, whatever.
John Skalski	Also just trivial things, which aren't so trivial, is like timing,

	having radio telemetry the first part of spring and the hydroacoustics at the latter part. They should overlap in time.
Marvin Shutters	We tried to schedule how the researchers overlap radio telemetry and mobile hydroacoustics.
John Skalski	Yeah, some of these things are obvious, but only after the fact sometimes. Gosh, if we only had told them to do it. If they were totally overlapping, we'd have gotten twice as much information. It's funny how those important things get skipped because there are so many details in any one program. Cross validation across is very, very difficult.
Bob Johnson?	Your point about coordinating is really a significant one here too, because we've encountered situations where we're sampling with acoustics looking back at the dam and find someone else had mobile hydroacoustic transects right in front of us.
John Skalski	Screws that up.
Bob Johnson	That doesn't help that. So there's a point where you start tripping over each other and that information is really important.
John Skalski	I think the telemetry studies that are coming out of the mid-Columbia may , I haven't analyzed, but it looks like a very, very, very good chance- the way they were designed partially on purpose and partially by serendipity again, was that not only will telemetry releases estimate some gross things about movement and timing and disposition, but there's a darn good expectation that they may get reach survival, FGE, spill effectiveness, turbine survival, and spill survival, if designed properly. But again, you have to know the potential capabilities and want to do the overlap and it's going to cost more but…
Marvin Shutters	The techniques are evolving more and more with underwater antennas and estimates of passage routes.
John Skalski	In the past three years, looking at what's happened to radio telemetry studies on the Columbia, it's gone an order of magnitude more sophisticated. I don't think we've quite tapped out yet. So I think there is some real possibility of getting potentially FGE and spill effectiveness from those data, if we wanted to. But that would take some front end coordination and maybe some research and development. But, it's shocking. I was real surprised at what was being generated or potentially generated from mid-Columbia tag releases this year. And I think they could have generated more if the different PUD's had coordinated.

Marvin Shutters	And another thing, on your list here of other methods for verification, pit tags should be added.
Gene Ploskey	OK.
Marvin Shutters	Not only what John's been talking about, but also trying to use pit tagging detectors in sluiceways to help us get estimates of passage on the routes that hydroacoustics does not do a good job at. Where we have the high noise levels and structures and all the other problems of surface collection and sluiceway monitoring.
Gary Johnson	So what range are we looking at for these new extended pit tag detector.
Marvin Shutters	A four-foot diameter pit detector is being built.
Gary Johnson	A four-foot diameter.
Marvin Shutters	Two feet diameter is the biggest one in existence right now.
Gary Johnson	Where two foot is the range of detection?
Marvin Shutters	We need to determine what the detectability will be, and we're kind of going at it with the idea of not only getting a 90% read efficiency, like they typically get in bypass systems. John's done a couple write ups on kind of precision's that we could try to get. I think it's good. Of course it's going to be a bear to get something like that to hold together in a sluiceway, and I don't know how practical it is.
Gene Ploskey	First log that passes may take it out unless trash is excluded upstream during testing by placing log booms across the opening. So back to our list, we have fyke netting, sluiceway netting, purse seining, underwater video, pit tags, and radio telemetry. Does anyone have any other things to add?
Gary Johnson	We talked about the smolt monitoring.
Gene Ploskey	I guess that's a reliable thing to look at.
Marvin Shutters	Just like any of the other methods, it has its biases.
Gary Johnson	There's another index they use upriver and that's a transportation index. That would be helpful for comparing to estimates of guided fish.
Gene Ploskey	How does that work? I'm somewhat naive about this, but if you want to estimate fish passage efficiency at Bonneville or any of the lower dams, don't you also have to account for what

was barged past the dams? Are those not guided fish? (extended Group laughter) Well, they didn't go through the turbines and they made it down to the tailrace right?

Marvin Shutters   Actually, I heard the same comment from James Thorne at John Day this year as a barge was entering the navigation lock. "Aren't those guided fish?" (more Group laughter)

Gene Ploskey   I told you I was naive.

Bob Johnson   Don't discount the locks as a passage route. Densities are high and patchy.

Gene Ploskey   Are you ready for a break?

Group Yeah.

Bob Johnson   Gene, do you have radio telemetry on that list?

Gene Ploskey   I have it now. I've got pit tags added, radio telemetry, smolt monitoring, transportation. How would I use transportation as a method of assessing the value-

Bob Johnson   It's kind of tied in to the smolt monitoring.

Tim Wik   It's just a guided- guided fish. Out of the collector- out of the collector.

Marvin Shutters   It's like the smolt monitoring. Guided fish are barged. If you're sampling McNary, you want another estimate of how many fish were screen guided, you can go to transportation folks and see how many fish they collected.

Gene Ploskey   Is that not the same as the smolt monitoring?

Tim Wik   It's part of that.

Tim Wik   The rest is just an estimate. The Fish Passage Center comes up with that (Group laughter)

Marvin Shutters   But it's only the guided fish that are collected or sampled.

Gene Ploskey   So it is a good estimator?.

Tim Wik   It's a very good estimate of guided fish numbers.

Gene Ploskey   But transportation is not used at The Dalles or Bonneville dams.

Tim Wik   John Day has a new monitoring procedure. I don't know how they're going to operate it, but it may be operated similar to

those upstream.

Gene Ploskey   Which would be helpful. Then that would become a good number for John Day.

3:00 P.M. - 5:00 P.M. Tuesday, 9/16/1997

Gene Ploskey   Get started again on targets. Cliff brought up an interesting point, that is non-target species that we count; where we have trouble with them, non-salmonids, and as much as noise or anything else, that's a huge problem, especially in the summer. So, question is how do we know we're on track? How do we know that we're monitoring the juvenile salmonids with the acoustics? The way we do that is by using other methods to calibrate, essentially. We might use a fyke net and gatewell dipping as the basis for saying, "yes this FGE pertains to salmonids." However, in the case of the smolt monitoring, where you begin to have disagreement, then you almost have to attribute the differences to being related to non-target species, I would guess. Is that, is that reasonable? I brought something to share with you. These are some fyke-net data from John Day Dam in 1996. The acoustic data were collected by BioSonics and the netting data by the NMFS. The r^2 on this regression is about .59.

Gary Johnson?   The slope changes nicely too. (Group laughter)

Gene Ploskey   And this is the fyke net catch of unguided fish and then those are acoustic counts of unguided fish. About 60% of the variation is explained. These were based upon concurrent sampling. The bottom plot is of acoustic counts as a function of gatewell catch. The r^2 was 0.63. These two elements go into calculating the FGE. This plot shows acoustic FGE on the y-axis and fyke net FGE on the x-axis. Actually, the best regression had an r square of 0.85. So 85% of the variation in acoustic FGE explained by the fyke net. In the best regression, the acoustic FGE ran longer than the fyke net sampling. Fyke netting was done from 2000 to about 2130, or when they got this 100 fish and quit. But the acoustic FGE actually tightened up, the regression tightened up when acoustic sampling continued until midnight. I think your acoustic estimates improve with increased sampling duration because we spatially sampled such a small part of the intake. The longer you sample, the better the ratio estimate. These data suggest that the ratio estimate for acoustic FGE is actually better than the estimates of the component parts, perhaps because of offsetting errors.

Marvin Shutters The slopes are pretty close also.

Gene Ploskey	Yes, the slopes here is about 1.01. This is based upon a couple 6 degree transducers in a 21 foot wide intake, and I was impressed, pretty impressed. So one would guess that when we get correlations like that, we're mostly sampling salmonids. And if for some reason we deviate from some of the other methods, one explanation could be that we have non-target species involved. Well, what do we do about non-target species. I know Bill's told me for years and years at Bonneville that we struggle with shad in the summer time. And they do, the adult shad deteriorate and they fall back into intakes. They are usually larger than the smolts, so I guess having some estimate of the size of the fish might be helpful.
Tim Mulligan	Could I just interject a comment before those slides disappear on my mind. The first two that you showed were a bit overpowered by one point that had a lot of leverage to it. I wonder if you had looked at some sort of saturation effects?
Gene Ploskey	As a matter of fact I had log transformed both the x and y variables to reduce the influence of that one point. Actually, the explanation of variance didn't go up substantially when you fit a curve to it or something like that. It certainly didn't go up enough to justify going away from the linear model. The best regression could not be improved upon using a curvilinear function.
Tim Mulligan	Yeah, it actually looked like it might, the points looked like they might have been reasonably well described by that, which suggests some sort of saturation in whatever your vertical axis was. I don't remember if it was the acoustic or the net count.
Gene Ploskey	Yeah, I'll put that back up here, especially the top one is I think. The top one looks like it could be saturation. On the other hand, there's so few points up in this range that it's hard to tell.
John Hedgepeth	I think that Bryan McFadden mentioned to me that it's possible to tell that you have shad in the system just by looking at the echograms.
Gene Ploskey	How do you tell they're there?
Bill Nagy	Wallowing traces in the beam.
Gene Ploskey	You could look at the ladder counts too to see numbers of adult shad coming up. It's very clear that in June that they're on their way, and by the end of June, they are beginning to fall back into passage routes.
Bill Nagy	You get swamped.

Gene Ploskey	Especially at the lower dams.
Marvin Shutters	Is there any way that you can separate out shad from salmonids in the passage estimates? Saying that you can tell they are there suggests that you might.
John Hedgepeth	You may get longer tracks from shad and the echo target strengths were different.
Sam Johnston	Has anybody looked at the target strength variability.
Gene Ploskey	It's almost hopeless if you're single beam in turbine to separate the two. Because a shad off axis can look just like a smolt.
John Hedgepeth?	It definitely takes a split beam to make sure that you have nice tracks and to evaluate differences in target strengths.
Gary Weeks	I noticed that when shad were falling back, they stayed in the beam longer. It seemed to be that we were getting longer traces in the beam.
Sam Johnston	And your velocity in the beam to see if there is a bimodal distribution of velocities.
Gene Ploskey	Because they're either fighting the flow, you're saying that shad duration in beam would even be higher.
Gary Weeks	That's what I'm saying.
Gene Ploskey	Bigger, stronger fish for the most part.
Gary Weeks	So, you know, maybe you could use the maximum number of pings to discriminate.
Marvin Shutters	Bryan McFadden's comment, I know that's one thing we determined. At the spillway at Bonneville, that's how he described it. He thought he was starting to have shad problems. They were seeing more hits on the fish all of a sudden in mid July, when there's a lot of shad fallback.
Gene Ploskey	It's interesting, when you start getting more hits than he did in the spring on yearling juvenile and your into the summer with smaller salmonids, you'd expect even fewer hits, because they have even less ability to fight the flow.
Marvin Shutters	Perhaps you can weed out some individuals, but that's kind of truncating off the problem because there is still going to be a lot of false detecting. Does anyone have any other ideas on how to deal with it? Split beam would be important.

Sam Johnston	Well, when you see a target with not very many hits, with split beam you can tell why it doesn't have very many hits. Maybe it doesn't have very many hits because it's smaller, it is off axis and then it kind of tells you if it was big or small. If you know positions in the beam, you can actually measure the velocity, not necessarily number of hits. Just counting hits you can actually estimate the positions and get some sort of measurement of speed. If your willing to use split beam then there's at least a couple other pieces of information that you can use.
Gary Weeks	Do they, do they keep species composition from the bypass channel?
Gene Ploskey	I don't know. What we've always gotten was just been strictly juvenile salmon, but that would be of use. But as far as I know, it doesn't exist.
Bill Nagy	One thing has convinced me that you can't use single beam in that situation. You know that you can look at split beam data as single beam data. And looking at an echogram from split beam data in that kind of situation where there were a lot of non-target fish in the beam. I was a total fool, you know, about what to count. Because you look at it and see where those things are that you're counting, and they're way outside the beam.
Gene Ploskey	Because they're big?
Bill Nagy	Yeah, so that just doing that convinced me single beam, in that kind of situation, doesn't give you enough information to sort out the larger fish from salmonids.
Tim Mulligan	What's the size, excuse me. What's the mean size difference between the two species.
Bill Nagy	Pretty good actually. The shad are adults and typically, at that time Bonneville, the smolts that were coming through are age zero, about 100 mm long.
Tim Mulligan	So you are looking at as much as a three or four fold difference in average length.
Sam Johnston	We used to, sort of as a rule of thumb, talk about if the two species of interest or groups of interest are two times different in length, then you have a pretty good shot at it.
Tim Mulligan	Yeah, and you're probably talking about this ping to ping. If you do it off of mean target strength per tracked animal, then you could tighten it up a bit.

Gary Johnson	Have we done any laboratory work on the target strength of adult shad? Is that in Carlson's experiment?
Gene Ploskey	It was his intent to do that, but it was not part of the scope of work. He wants to do it.
Marvin Shutters	Does he have the apparatus now to do those kind of studies so hopefully we can start expanding the base of information on that kind of stuff. Have different aspects, different species?
Gene Ploskey	The setup now handles different aspects for juvenile salmon and could be used for other species as well.
Gary Johnson	I've been curious as to what the group thought about a target strength distribution from the split beam and in one spot where you had, say, one split and five single beams. Could you use the target strength distribution from the split beam to correct counts in the singles.
Marvin Shutters	Sounds like a reasonable approach, but you have to be careful of whether shad are falling back more through one route than they are another. You've got to make sure that the split-beam sample is applicable.
Bill Nagy	If you're worried about the overall distribution of fish in general, you have to be worried about the individual distribution of a species. Especially when they're very different.
Marvin Shutters	I certainly wouldn't want to take data from one turbine and apply that ratio all the way across the powerhouse.
Gene Ploskey	Sounds like one of Skalski's brute laws. (Group laughter)
Marvin Shutters	Every species different, in every slot, in every turbine, in every dam. (Group laughter)
John Skalski	As measured by our main investigator. (Group laughter)
Bill Nagy	No. What you said though, that's probably the best you could do if you had to continue counting smolts. That's what you'd have, probably have one split beam and many single beams.
Don Degan	Yeah, I was involved in the mobile surveys, the one thing we noticed was that the fall back occurred, started by the fish ladder and then progressed downstream from there and across the face of the dam. I'm not certain, but if seems like at John Day we saw once the shad were there, the distribution of fish was shallower, so it seems like the shad were possibly up closer to the surface than the smolts. I'm sure the composition would be different based on that. There might have to be a

	split beam in each of those areas that has a different vertical component to it as well.
Gene Ploskey	Could Tim Wik or Marvin check to see whether species composition information is available from bypass systems? Is there something we can do on your scale or at some level to figure out what it would take to estimate that composition? I don't believe it's done now in the bypasses. There is a by-catch but I believe it is not summarized.
Marvin Shutters	Well, I'm not sure what's recorded now, but certainly some could be.
Gene Ploskey	It could be tremendously important to summer acoustic studies to have an idea of the composition of guided fish. I mean, the estimate would have problems like every other measure we make, but we would have a species composition estimate that went beyond just juvenile salmonids.
Tim Wik	Smolt monitors record everything they get.
Gene Ploskey	Everything?
Tim Wik	In the Snake at least.
Gene Ploskey	They do? So you do have species composition for guided fish.
Gary Johnson	The problem we ran into was species composition is different between fish in the bypass, intakes, and surface collector.
Gene Ploskey	So that's a whole another problem.
Gary Johnson	So you need to really have species composition by passage route.
Gene Ploskey	Do we have special considerations for sluiceways and overflow weirs that we need to address, or is that just all the same problem? We even use acoustics at the shallow surface openings. Some of them are only open three feet, some of them are open six feet.
John Hedgepeth	Sampling close to surfaces is possible if it's not too windy. But once it gets windy, especially at a place like the Dalles, I remember, my experience there is with 120 kiloHertz split beam. You lost a lot of detectability in the near surface under windy conditions. The 420 kHz system was a lot better than the 120 kHz system.
Bob Johnson	120 had minus 17 dB side lobes.
John Hedgepeth	Yeah, that doesn't help.

Bill Nagy	We had the same thing at 420 at the Dalles, with the wind.
Marvin Shutters	A lot of the time it is very noisy. It comes and goes with the wind and everything. There's a large proportion of the time we can't track fish at the Dalles, but they have been able to monitor it and get, you know, over a couple different years, get kind of similar estimates to what the old netting studies indicated for fish passage efficiency. So, perhaps, it's being sampled effectively, but there is a lot more background scatter from air entrained and even structure noise at all the sluiceways. The sluice chute at Bonneville also is a problem. In 1997, BioSonics gave up on sampling it when it was wide open, but when it was closed up to six feet they were able to get reasonable estimates. I don't know how accurate they were, but at least there seems to be daily variation. Before that, Gene tried to monitor for a few days and found noise levels were so high and so constant that sampling was deemed ineffective. Is there any other approach we should be taking? What was your experience with the Lower Granite collector monitoring?
Gary Johnson	Lower Granite's on the lee side of the wind, so the wind wasn't quite the problem. As far as turbulence off the structures, the surface bypass has three instances: one of which has a log boom, because it has an overflow portion and there was some turbulence came off that. There's some turbulence that comes off trash sheer boom but none of it is such that it just precludes sampling like at the sluice chute at Bonneville, which is a horrible environment to sample. Maybe it is just serendipity, isn't John's word law? (Group laughter)
Sam Johnston	We've seen the same thing at the sluice of Wanapum Dam. When it's windy, you just can't sample. Noise gets into those first two meters and that's what you're interested in.
Gary Johnson	And we have that, we just make sure we account for how much we can sample so when we do the expansion, it is accounted for.
Sam Johnston	That's the special consideration.
Marvin Shutters	So you, you take blocks of time and you say it's not effectively sampling. And then that's not sampled, you know, it's treated as missing, but...
Gary Johnson	Well, we don't treat it as a missing value. What we typically do is, we sample half the time there anyway or process half the time of the sample. And so, there's a proportion of noise, we skip to the next interval and take that one, like you're taking every other interval.

Marvin Shutters	OK, because what I've always wondered is if in processing data like this there's a point; it's a continuum from absolute quiet to too noisy that no one would try to track it. And you're making a yes/no decision on that. Track this and assume we're getting every fish in there and not counting noise, there's no fish hidden in it. And just a little bit more noise and you are saying you can't do it. How is that decision made?
Gary Johnson	Well, I'll tell you how we make it. If you can't see any fish and it's all cloudy and noisy and horrible, you make a note and then the person that analyzes the data tallies up all the notes and makes the appropriate adjustments in the time expansion.
Marvin Shutters	So if you can see one thing that's clearly a fish track? You'd use that sample period?
Gary Johnson	No, of course not. No, if the sample is anyway tainted we throw it out.
Marvin Shutters	I'm not trying to put you on the spot.
Gary Johnson	That's OK. I'll answer the question. (Group laughter)
Marvin Shutters	That's the kind of stuff we could be more consistent on, is how do we handle these kinds of problems?
Sam Johnston	Like one of the things they do at Wanapum is if there's a question about the noise, they throw it out for the real time and they only use the very best data for that. And then, later on in the season go back and look at those noisy portions and make better discriminations. Can we really use this? Is the noise in an area where we've seen many fish before? If we missed the first, you know, foot or so of the surface, do we see fish in that area based on the time before and after when they're, when the fish are there. And then we want to use that sample and improve our variance estimate. That's, you know, one way we do it, we try to use the very best of the stuff right now.
Gary Johnson	We don't have, I guess you'd call, set criteria, quantitative criteria, because for the passage stuff at Lower Granite we use a visual person. Now with the automatic trackers and stuff, then that's a different situation or maybe some sophistication could be added in and would be very beneficial to the objectives. I think most people notice you can see fish in the noise, so it's kind of like 'well I can see that one but maybe they were on axis.' There is a level of subjectivity, but people are trained to throw it out when in doubt.
John Hedgepeth	I wonder if we could make correlations with wind speed.

Gary Johnson	Acoustic noise measurer?
Marvin Shutters	I think what might be more direct, direct measure of the problem is you have some kind of a noise density, like electronic data processing that will give so many echoes within this space and range and number of pings, that we can count that.
Sam Johnston	There's a number of practical applications for that besides just noise, like in oceanographic things. One of the things a number of people have asked us for is for simultaneous echo integration so you can get a signal to noise ratio and tell just what the noise component is through time. That's certainly possible. Some people do simultaneous echo integration. In most cases, the individual fish traces are very small proportion of the total integrated signals so you can just look at the integrated values and throw out the noisy parts of echograms.
Gene Ploskey	With the auto tracker, noise is the biggest problem we have. Last year, one of the things we tried to do was to identify air bubbles or noise. We had a bubble detector and the autotracker was told not to track when you hit an area where the noise was too high. It wasn't echo integration, it was simply echoes on a ping, summed over time. We finally decided that we couldn't make good decisions, because when it threw out parts of the echogram it left bubble cloud remnants, little pieces. Those remnants often looked like fish traces and the auto tracker would track them.
Bill Nagy	False targets.
Gene Ploskey	We now have an index to noise. It is not echo integration, although I like that idea. It is the fraction of pings that have more than some threshold number of echoes, allowing for some expected number of pings from fish. You simply count those loaded pings to estimate the fraction of pings that are too noisy. It is rare to see three smolts coming through the beam at the same time. The noise index then can be used as a covariant and to index trackable time to determine expansion factors for sample periods.
Bill Nagy	We were talking about doing a regression of a visual count and automatic counts and using that noise index as a variable in multiple regressions to see how important it might be.
Gene Ploskey	Yeah, the dilemma is that the automatic tracker tends to give higher counts than a visual tracker, and that's almost always due to noise in which the auto tracker will track but the visual tracker won't. So if you knew what fraction of the total time was too noisy for tracking, then you might adjust automatic counts to better correlate with visual counts.

John Hedgepeth	I just want to get back to my little wind meter or flotsam meter. It might be nice having an independent estimate of noise. I'm sure you can create false targets, especially in post processing when you are manually tracking or electronically tracking, whatever you want to call it. If you had somehow incorporated into that electronic record some other environmental information, it might give some clues on how to better process the data.
Tim Mulligan	I have a question. When you're looking at tracked data and auto data that's been tracked by machine, do you look only at the tracked data, or do you look simultaneously at the tracked and the raw data itself from which it was taken?
Gene Ploskey	Simultaneously.
Tim Mulligan	Then why isn't picking out noise trivial for an operator?
Bill Nagy	That's the thing, it doesn't always come in clouds of noise. I mean it grades from clouds of noise to just thin lines of noise or even an individual air bubble coming through the beam which appears as a perfectly good target. And when there's tons of them coming through that's no problem in a way, it when it grades down to pretty much individual air bubbles coming through the beam you detect false target. And a manual tracker might look at the whole echogram and say "ok, I'm seeing this cloud of bubbles and it kind of fades out into these few traces coming through, I'm not going to count those. That's the tailing end of a noise event." But an automatic tracker at that stage of development we have it now, can't see that whole context.
Tim Mulligan	What we do, in automatic track, but then we have an editing procedure where a human interacts with what's happened and he judges whether or not to accept that. So if there's a lot of background noise, says "no, I've got to cut out this whole two minute section there, because there was a boat wake responsible for that." And he adjusts the sampling time and blah, blah, blah. He just removes something with a mouse and goes on with the next section. So we use the automatic tracking with the human interaction post tracking to a sort of grade the events before the automatic tracker is used.
Gene Ploskey	Yeah, we may very well wind up there.
Tim Mulligan	You might, what we found is that's the most effective, you know, human is fantastic at pattern recognition and much more powerful than the tracker by itself, because it doesn't have a global perspective, as you pointed out.

John Hedgepeth	Sometimes you have short noise events where it gets noisy. You know, for fifteen minutes, and if you have a short sample in that fifteen minutes, you might pick up the tail of one of these events. And so it looks like you have a couple fish to track. Then you don't have the records because the processor doesn't look at the other transducers to determine the noise background. You know, your records are continuous for long periods of time.
Tim Mulligan	No, not really, when you're switching the transducer, where it's aimed, so we have very similar to what you're talking about.
Bill Nagy	I think he was talking about counting the echoes on each beam, that's recognizing having a bubble cloud. That works real well. And then we even have smoothed that and expanded that to try to get rid of the edges where it kind of trails off into false traces. The only thing I can think of is to get real conservative about what you're willing to count as a fish and know that you may be underestimating, but in the case of a ratio, you would not want to count fish in a clean beam of an unguided transducer if you had a lot of bubbles coming though on your guided transducer. So you have to be real conservative. That's the kind of tactics we're are using.
Tim Mulligan	We auto track but throw in one more level of editing which is human interaction. In the final edits, a human checks the automatic tracker by screening it simultaneously with the raw data.
Bill Nagy	Essentially he identifies good and bad times for the auto tracker. He doesn't have to actually count and recognize traces, he just has to recognize a bad time.
Tim Mulligan	Yeah.
Gene Ploskey	Well, that would certainly go faster than bit padding fish. Even if it came back to that, it would be still an improvement. John, you're point's well taken, I mean some other independent measure of noise would be useful. Maybe you could echo integrate. For surface sampling, like in sluice chutes, rain is a big factor. When it rains you've got a lot more air in the water near the surface. It rains a lot in spring at Bonneville Dam.
Bob Johnson	We have another sort of rain that happens at Lower Granite, from acres of debris from terrestrial vegetation in the springtime.
Gene Ploskey	So there are a lot of non-targets near surface because all of that stuff floats or nearly floats.

Bob Johnson	This can be a really subversive type of noise because you can maybe get double the number of targets. Maybe you've got nice fish tracks moving through your thing, but they're not fish. It's become real apparent looking at the stuff, the multi-beam while the activities were going on. We might not have seen that, that large volume of stuff moving through a single six- degree transducer. A six dB increase in target strength might be normal, but that might not be from a fish.
Gene Ploskey	Isn't that also an advantage of a split beam, that you can see three dimensional objects that are obviously not point source reflectors.
Sam Johnston	Well, yeah, in the split beam, if the target is not a point target, then the angle estimates are very variable. We were involved in a project in England, where we were trying to distinguish downstream migrating salmon from mats of weeds. It was pretty clear that downstream salmon had a nice tracks through the beam, but these weeds, every other echo was from all over the beam and there was variability in the target position in the beam.
Tim Mulligan	We've had floating debris, it was not large but easily recognizable because it is near the surface and all the tracks are parallel moving with the current. Fish never have those beautiful parallel tracks. Once again, a human looking at the echogram, or two dimensional projection can pick that up quite readily.
Bob Johnson	Yeah, I think this is complicated in the forebay of the dam however, because you have, first, a large component of the water moving down towards the turbines. So you entrain debris into the water column, so they are no longer surface oriented. Second, you also have vortices and structure. So maybe that can actually start having traces that look very much like a fish traces. (Group laughter)
Gene Ploskey	My indoctrination into that was the leaf fall at Richard B. Russell Dam where we had a huge full recovery net over the penstock opening and pump turbines were pumping water upstream. We were not catching any fish, but the acoustics showed millions of beautiful targets all parallel going through the beams. It was obvious that there was no correlation between acoustic counts and fish catch in fall. We did not try to estimate fish passage for October through December.
Bob Johnson	You see a lot of that information, then you can say something about it, if you only see a little bit of it, it could be, perhaps, enough to cause severe problems with your extrapolations.

Gene Ploskey	Some of the guys on the barge were talking about a leaf index as an independent measure of noise.
Bob Johnson	One thing that you found out, Gary, when looking at some of the new data was some, some pulse width criteria that you could deal with to eliminate some of the debris issues.
Gary Johnson	We had a bad cross-correlation with the smolt monitoring index and our acoustic stuff in the spring at Lower Granite. As Bob mentioned, the river was loaded with a lot of debris. We were doing preliminary weekly reports. It was only after we'd accumulated quite a bit of data and had done this cross-check that it appeared there was a significant problem, most likely due to debris. So we took a hunk of data from a 5-day period before debris and a hunk of data from about five days when the debris was present and we compared the distribution of various echo statistics. It was quite interesting, but before debris showed up the pulse widths were quite tight, but the after they were a lot wider. Our accepted range for pulse width during collection was 0.4 to 0.6 milliseconds. And so we did some post processing where we squeezed that down to 0.40 to 0.45 or so, and really got rid of a lot of erroneous targets and improved the acoustic and smolt monitoring correlation. I wish I had the curve to show you. It went pretty good, but we still probably were counting stuff that were not fish the last part of the study. The idea being of course, that the stuff would have multiple, overlapping, point sources that we could then look at a multiple target type situation and exclude based on pulse width. Still that improves the data but doesn't correct the data.
Sam Johnston	Actually, one of the things that somebody looks at when they try to look for a single target, even if the pulse width is narrow, is to see if the phases are correlated between the targets.
Gene Ploskey	We've already finished up, near as I can tell, the day's agenda and a good chunk of tomorrow's as well. I think John gave us a good idea of how best to allocate sampling effort; put it where the fish are. So I think there's no need to cover that, unless anybody has a comment on it. John said that he brought some of his reprints with him, so I for one am going to hit him up for whatever ones I don't have.
John Skalski	I'll bring them down tomorrow morning to the room.
John Skalski	Most of the studies deal with how we would sample in time and space using a unit hour as a fundamental sampling block. In other words, a physical location during a particular hour would be a time and space cell, and then we sample within that, randomly or systematically, to come up with an estimate of passage and variance. We can then add those estimates in

any way. If you want a daily passage for that particular location, we can just take 24 point estimates and variances and sum them up. If you want to start sampling, or collecting estimates of passage across the turbine units, just sample those time/space blocks across the units for the days that you're interested in. It works very nicely. I think also it works reasonably well even if you have missing data. If it's a few missing data points, we can estimate those missing cells fairly readily if you have to. What we tried to do is get not only a point estimate, but a variance estimate for each one of these time/space cells for all possible locations in hours and process these and add them up. Some of the exceptions to that are, for example, slots within a turbine unit, you know, where we don't have enough transducers to sample every turbine slot in every turbine unit. In which case we have a nested type design, where you will, or two-stage sampling. First, we'll randomly select two out of three slots within a unit and then sample temporally given the slots we had selected. And then that estimation has two sources of variability, not only the sampling within the hour but also the extrapolation from two to three turbine slots. That tends to be the only exception to that rule.

Gene Ploskey   I have a question about the hour unit. So to estimate a variance within the hour, you've got some increment of time that you sample within the hour.

John Skalski   Yeah, take for example, we sampled six one minute intervals during the course of a 60 minute period, so you'll have six estimates of fish passage during those six one minute time slots. We will use those again to get an estimate of total passage during that hour within that location, and then also use the variability among those six one minute intervals to get an estimate of the variability associated with that extrapolation. That variance will typically include not only the temporal variability but most of the measure error associated with the technique. Then we store those two numbers, estimate of total passage and the variance associated with the estimate of total passage within that unit hour. Then whatever statistics we're going to do beyond that in terms of estimating days or weeks or passage through locations then become a simple function in a spreadsheet summing to calculate point estimates as well as variances. Variances sum, standard errors and confidence intervals don't. So we always work out the variance level in the last step and then do your confidence interval calculations.

When making combined ratio estimates for different structures, we get an estimate of overall variance of that ratio by the Delta method, which is just a way of trying to estimate the variance for non-linear functions.

John Skalski   The way you do that, in terms of analysis, you will first

estimate total passage for spill, total passage for guided, total passage for unguided. Get those point estimates, those variances, and then use this final calculation to get the variance of that ratio estimator. Up to that point it's largely a spreadsheet operation.

Gene Ploskey   So before that the variances add.

John Skalski   Exactly, all right, to get total passage at the spill, for example, you'd just be summing up all those spill bay hours over time to get an estimate of total passage, and similarly summing up all the variances for each of those time/space cells. That would give you total variance. And only then, once you sum them all up, will you say, for example, square root that to get a standard error for fish passage through the spill. The hours are not magical, it just seems that for most dam operations all the operational changes have occurred on the hour. So it just became a natural unit to use.

Gene Ploskey   We're already up to 9:45 tomorrow.

John Skalski   We can sleep in then. (Group laughter)

Gene Ploskey   Let's see, we've talked about periodic noise in tracking, when should tracking be avoided? We didn't get an answer, but I heard the question. When do you not track? Do you stop tracking? When it looks like crap I guess. (Group laughter)

Marvin Shutters   I think that was Gary's answer.

Gene Ploskey   That's kind of subjective, can we nail that down?

Sam Johnston   One thing I'd like to add about when you don't track and a measure of noise, if you're using a system that selects echoes, so basically you have processor that's thinking, "OK, this second line comes from a fish." And then either manually or automatically tracking these echoes that did come from a fish. If you do an edited version and actually say these came from fish, you can look at the number of echoes that were tracked versus not tracked and get some sort of ratio. And as that ratio starts to increase then you have less and less confidence in your data. Because more and more of the echoes are not together into a tracked fish, and that's one thing that we used at Wanapum as a noise index.

John Skalski   So it's sort of a QA/QC kind of thing where you track that ratio to see if it's stable or not.

Gene Ploskey   One of the things that's always overwhelmed me, the amount of data you can collect when you have thirty some transducers out. You can sub-sample what you collect, but you give

something up when you do that. If there was only a way to process all of it and not kill everybody on your staff. It seems you would gain a lot in terms of the precision of your estimate, especially when we sample a small part of an intake. If you have no noise, an auto tracker like ours performs well. It does just what a visual tracker does. Remember of course that a human tracker is not perfect. Correlations of counts from different human trackers can be poor, particularly in noisy situations. If you have many human trackers trying to keep up with gigabytes of data, you need to worry about quality control.

John Skalski   I don't want to have the implication that if you had a choice between sampling more minutes within the hour or more locations at the dam that you would tend to go for the more time. You always sample more at the high level of variance again. If you had a choice between sampling two of three turbine units a third more time or sampling all three units, you do the three turbine units. Because that will decrease the variance and improve the precision much more than adding a little bit extra time to the sampling within an hour. We have a tendency as biologists, because the techniques are so laborious, and we know how much measurement error we have with the techniques and that Mother Nature is even noisier. It's surprising that you don't have to sample, 30 minutes an hour, or 45 minutes an hour. You can sample and get away with 5 or 6 minutes an hour and over the course of the season and get very tight estimates of FGE. You know, it's sort of like you can only sample 1200 people in the nation to get a pretty good estimate of an opinion poll. You know, although we have 200 million people, at some point there's a diminishing return.

Gene Ploskey   But in order to estimate your hourly variance, you have to have…

John Skalski   at least two! (Group laughter)

Gene Ploskey   One five minute shot is not going to give you an estimate of your within-hour variability.

John Skalski   Oh, it hurts you. (Group laughter) At least two 2 half minutes, or preferably, you know, five 1 minutes or something like that so we can estimate that variability within hour. Because that is really key, because that captures not only within hour variability but some of that measurement error associated with technique. Not the random measurement error, but the systematic error which we'd call bias.

Gene Ploskey   We're supposed to have removed all bias.

John Skalski   Once I have the data it is perfect, isn't it. (Group laughter)

Gary Johnson	Of course.
Bob Johnson	So is there an incremental benefit then? Say you've got 18 intakes that you want to sample, and historically we've been kind of limited by transducers and equipment, so we say "well let's just do one of three intakes per unit. If we could do all three, for all units, even if you didn't collect data from them all the time, what would your strategy be?
John Skalski	Again, since you sample and can estimate all the variability associated with the study. If you're only sampling a fraction of the slots within a turbine unit, you have to be able to estimate that variability, and you can't do it with one slot out of three. You need at least two out of three. Three out of three is even better, then we don't have to worry about the slot-to-slot variability. It goes to zero. So if you're going to sub-sample a level, you have to have at least two things going on twice. So I would definitely, if I wanted valid variances and new confidence intervals, which the community and our peers are pushing more and more for. I think we've gone beyond the days where we can avoid that now. I strongly emphasize that if you had the choice between more time and a few locations versus where you allocate those transducers, I would definitely spend less time and put those transducers at those, at least two of the three intake slots per turbine unit.
Bob Johnson	Take it the next step, you go all three?
John Skalski	And what I would do then, if I still had some left over transducers, I'd hook that third transducer in those locations where I expect the highest fish passage. Because that's where I'd also expect the highest slot to slot variability to be. So a few extra transducers will knock down that extra source of variability substantially. Like I said, at Wells Dam, one of 30 transducers, put strategically from one place to another, cut the variance in half.
Marvin Shutters	Ok John, when you're allocating these transducers, would it be better to get all of your turbines monitored before you start going within turbines?
John Skalski	Yes, cover the higher order variances first. The highest order is your turbine to turbine variability, and the next level is the slot to slot variability, and then within slots there is temporal variability. So yes, if you want to make inferences to a project, probabilistically, you don't have to sample all say six out of six turbine units, if that's what you have.
Marvin Shutters	We have 23 turbines. (Group laughter)

John Skalski	But certainly, the first thing I would do though, would be to allocate to the turbine level.
Marvin Shutters	Typically done by every second, or every third turbine.
John Skalski	Yes.
Marvin Shutters	That's what we've been doing the last few years.
John Skalski	I sample first as many turbine units as I can, then if I have transducers left over, then I start replicating or sub-sampling the slots within turbines. Next, I'm going to sample more time at the slots I selected.
Marvin Shutters	Yeah, so if I can't completely monitor every turbine, would it be better then to randomize ABC slots?
John Skalski	I think so.
Marvin Shutters	Among the turbines?
John Skalski	Yep, I probably would randomly select the turbines and then probably randomly select the slots within the turbines. You know, in one study we were told to sample all B slots. Yeah, we did a very expensive study that only has valid inferences to FGE at B slots. We could as easily randomly sample slots within units for no additional cost.
Marvin Shutters	We have often done that on the assumption that you have more flow through A and less flow through C, so …
John Skalski	B is the average.
Marvin Shutters	Closer to the average.
John Skalski	Yeah, I don't believe it. Life isn't that simple.
Marvin Shutters	I thought it was. (Group laughter)
Gene Ploskey	In 1996 at Bonneville, we monitored all slots in Units 3 and 5, each slot with a pair of transducer and the A slots tended to have more passage fish than the other slots.
Don Degan	My experience has been that slots with the highest intake volume always have the highest fish passage.
Gene Ploskey	I don't know, that's the way it turned out for the two we looked at, but that's a small sample of all of the turbines that are out there.
Marvin Shutters	I think you're talking about B1.

Gene Ploskey	It also was true at B2. All the A intakes at B2 that year also had the highest passage, and they also had the highest flow, but they also tended to all be toward the south side of the powerhouse which also had the most fish. We randomized but wound up with more A's on the south end of the powerhouse than anywhere else, so there were confounding factors.
John Skalski	You know, there's a lot of discussion in the literature about randomization in a particular study, and I think people probably fallen down. If you end up with a peculiar randomization, don't stick with it. (Group laughter) You don't have replication of the study and can't do it over again. So at least set up some rules so that you have restrictions on your randomization such that it will spread those samples out more uniformly.
Don Degan	Have you not sampled across all intakes and units at any place?
John Skalski	Oh, at Wells we've had a majority, yeah.
Marvin Shutters	On the upper, on the Snake, but not on the lower Columbia.
Don Degan	On all the ones I've been involved with, the turbine direction, the movement of the flow of the turbine dictates where the highest intake flows are going to be. And in almost all cases you have the, except for contributing problems with near a shoreline or something like that, or other structures, in all cases, the highest velocity of the intake, at an intake, had the highest passage across all of the units. And there was more variability there, there was more variability within the unit itself on one intake versus the second intake than there was among units.
John Skalski	At Wells, a majority of the turbine units were sampled three out of three slots. It looked like you had tremendous variability in fish passage through the various turbine units. Furthermore, I don't think we ever saw real systematic differences. There was no ABC rhyme or reason to it. That's why we went to the randomization, after years of trying to figure it out. We just threw up our hands and said "Let's just use randomization, let the laws of average, you know, play that out." We did not see the kind of consistency that you're implying.
Gary Johnson	But you say you have that distribution.
John Skalski	We have a graph of that data upstairs, yeah. I can bring it tomorrow morning.

John Hedgepeth	John, once you allocate your transducers across your turbines and spillways, you're left with sampling within the hour now. That is something that you cannot change. Is there any reason to fill up every little time slot that we can within the hour, or should we start thinking about being more efficient. Considering that processing is so labor intensive. So let's say we could fill up 100% of the hour, versus 50% of the hour, and just have 50% of blank space where we didn't look at anything.
John Skalski	Yeah, certainly, again, if you have enough transducers and manpower, I would fill up the locations first, and then worry about the sampling effort for within hour sampling.
John Hedgepeth	Usually, once we allocate a transducer, that's the hardest thing. We could get multiple computers and echo sounders and so forth, and hook them up so we can sample 100% of locations
John Skalski	And that will cut down your variance to the level of within-hour variability.
John Hedgepeth	Right. So there's a trail in cost here. Are there some guidelines for us to look for?
John Skalski	Well, I remember when, a couple studies we looked at the issue of sampling so many transducers in this particular spatial array versus how much time at the locations. And it always came out to sample spatially as much as you can and then with the time you have left over, sample within the hour. If that's answering your question.
John Hedgepeth	Not really.
Gary Johnson	I'll answer. Let me try. One of the things we've done is, we'll sample, just for the purpose of discussion, ten of ten spill bays. So that gives you when you do, oh, that's six minutes each, we'll do three 2's, but we won't just say you only need two 2's. So we wouldn't just leave the thing off for a period of time since the machines are out there and everything, we go ahead and collect the data, but then only process and analyze two thirds of it. And then a statistician will come along and say, "that looks like pretty decent precision on that estimate and I think we can live with that." Or they say, "no, or we've talked it over with the sponsors, we need to come up with some more money to handle this data." (Group laughter) Actually, we've never gone the step of the more money thing, because the precision's usually been decent.
John Hedgepeth	That's what it sounds like. Maybe you only need one sample per hour.

John Skalski	Two for variance please.
Gary Johnson	But you wouldn't ever leave your machines off.
John Skalski	Thank you Gary. I think that's exactly what happens. If you're squished for time then sample actual transducer time, and you can always go back, once you've collected it. But if you don't collect it, you can never regenerate it.
Bill Nagy	Yeah, fast multiplexing too. It ends up a lot of time, you have several transducers out there, and you can effectively sample all of the time. Which, you know, that's kind of the extreme of collecting as much as you can. There are some problems with it.
John Skalski	Yes. And even if you can do that, cost effectively it's not worth doing that. In other words, you can get enough precision not reading 100% of the hour. You can, like I said, get away with a smaller fraction, because you're doing a lot of hours across a lot of locations, and ultimately, you know, it builds up the precision that way.
John Hedgepeth	Like the two one-minute samples. (Group laughter)
John Skalski	You have to consider the expectation of the sponsor with regard to how you want to slice and dice the data. If all they're interested in is a season-wide FGE or FPE, then you can really get away with very small sampling within the hour and day. But they change their minds and start asking for weekly or daily estimates, then things go to hell in a hand basket. Now the precision for that particular day is not as good as it could have been because you only have the couple of minutes per hour. I think, part of it has to be a real good understanding among everyone, contractor and sponsor about how you are going to slice the pie. You don't ever go back and slice it thinner than you really expected, without realizing there's going to be a real penalty in precision. That happened a couple years ago to a project, you know, I think the expectation was to get seasonal FGE's and then someone started looking at daily FGE's and got so scared by the poor precision that it upset people. And it wasn't a function of acoustics or design. There was no real expectation that precision was going to be that good on a daily basis. And so, I think people have to say, "OK, where are we going to stop?" and then don't go any finer than that. You can design a very fine daily FGE if you want, but you're going to be sampling a heck of a lot. But you can sample very little daily and get a very decent seasonal estimate.
Gary Johnson	The lesson from that is the need to get together ahead of time and go over what the statistics are going to be, before the study

starts.

| Bob Johnson | Sounds like a standardization issue. |

Marvin Shutters   That is a very much a needed standardization.

John Skalski   But there's also, it's interesting. We've talked about wanting these seasonal and project wide FGE's, but if we're also believing that FGE is a function of flow or something, then down the pipe people will want to say, "Well, could you plot for me, the daily FGE's against daily flow conditions." Now if that comes down the pipe then the fact that we sacrificed daily precision for seasonal performance, all the sudden comes back to haunt you. So if there really is in back of your mind, one way or the other, that sometime you're going to want to investigate these relationships between dam operations and river operations and FGE or spill effectiveness, then we're probably getting down to smaller units of time and that requires higher precision for those daily estimates. You know, so if that is a clear objective, that you want to do relationship kind of studies, as well as just point estimates for a project, then you probably are going to be forced to have more within-hour sampling and better daily precision than you would just to get a good seasonal estimate of FGE. And unfortunately, I think there's also a move to look at all those things.

Gene Ploskey   Well, I'd hope so. I mean, I'd hope that we're not just trying to generate one magic percentage for the whole year, and then all of that effort, those dollars go into say, "Well, you made your passage goal or you didn't."

John Skalski   Well, I think so too. So you say, "OK, I am now interested in the seasonal FGE's and the relationship stuff", but then it says, "well, maybe we should be concerned about the conditions in which we're going to be estimating these FGE's, we have to keep the flows at 40%, spills at 40%", and such and such. It's not going to be real useful. It's going to, you're going to have daily FGE's over a flat environmental condition you're interested in. So that gets you back, "well maybe we need to have different spill regimes". And then you know you get into a whole other level of policy and political mess, but there's absolutely no reason to look at daily FGE's against spill fraction, if you can't vary spill fraction. I really encourage coordination of those things, because different programs and different people have different objectives that counteract and counter balance things. And we can design a very good daily FGE study, but it's all going to be nullified if you can't vary the conditions.

Gene Ploskey   Well, I'm still didn't get an answer to when tracking should be avoided. (Group laughter) Maybe that can't be answered

today.

Gary Johnson	Let us sleep on that.

Gene Ploskey   We make assumptions when we track or don't track, about whether or not fish are correlated with noise, like these vortices at Bonneville. Vortices I've seen in the past where we actually netted a unit, there are definitely more fish in the vortices than there are when vortices aren't present. That was my early experience. But we make assumptions when we look at an echogram and say, "Wait, we've got to track." and track 50% of it and here's the count we got, and our effort was this. And so our number of fish per unit of effort can be adjusted among transducers. That's what you should do, because if you don't do that then you don't ever have horizontal distribution. You can't estimate horizontal distribution unless you know what your effort was at each location along the gradient. Even when you do that, you only track the good parts, your assuming, and so that's like catch per unit effort, you're assuming that fish are uniformly distributed.

Marvin Shutters   The approach Gary was saying they take, you know, with two minute sample sizes, whatever they are, they use that two minutes or they don't. Am I right? Whereas, you, you know, with the PAS systems, when you've got so many targets into the system, it writes a file, you know you can't do that. That's when you get into that problem. Then if you can take the data set and make it somehow time based.

John Hedgepeth   I think the guidelines that we used in the past was if you count half an interval, you can extrapolate it.

Gene Ploskey   OK, so that you avoid tracking when over one half of an interval is noisy.

Sam Johnston   Half the interval from a temporal standpoint or a spatial?

John Hedgepeth   Temporal, I think. Our assumption is that there are fish in the noise and we extrapolate into that noise.

Gene Ploskey   Right, but what if densities are higher in noise than when it is clear.

John Hedgepeth   Right, right, that's your problem.

Gene Ploskey   Or fewer fish in the noise than in the other part. How could we test that assumption?

Marvin Shutters   Critical uncertainty.

John Hedgepeth   Just raise the voltage threshold. Fish should have sufficient

	targets above some high threshold, then compare their voltages. I think that is one answer.
Sam Johnston	Yeah, I think you are right, just keep bumping up.
Tim Mulligan	If your noise is mainly bubbles, from entrained air, you might have a characteristic pattern of target strengths from bubbles without fish, if you depend on the presence of fish on top of that. Often times, at least my experience with boat wakes, typically the target strengths from the bubbles are low. And, the target strengths in the adult fish we're looking at are going to stick out, so we'll know if there's a target.
John Hedgepeth	Target strengths of bubbles at the same range of fish add to those of fish on average. So the target strengths of fish in the bubbles are larger than the target strengths outside the bubbles?
Tim Mulligan	Bubble clouds just look flat; they are just not that dense.
John Hedgepeth	You know with our DT sounders, we have this digitized color background so the targets kind of stand out of the noise better than in a monochrome display. So that's another way to get at fish in noise.
Tim Mulligan	So the trick is, that there has to be a fair distinction between strength of the targets and the strength of the background, at least for adult salmon.
Don Degan	If you have that, then we've used echo integration to do that to separate fish from Chaoborus or silt at Russell during pumpback when there was a fairly constant, low level, background noise. When you look at the echo integration over time you can pick out the fish as they came through because the voltage was much higher at that point than it was with the background noise there.
Bill Nagy	In most tracking to count small fish, amplitude differences between fish and noise are not large enough to allow tracking to consistently distinguish between them.
Gene Ploskey	Well, is there some way we could test the assumption of fish density being independent of noise?
Sam Johnston	Well there's one thing that sort of used to happen to us when we were using dual beam. We had a wide and narrow beam, and many times the wide beam was very noisy and target strength estimates would be terrible. So we'd have to use just the narrow beam. So if you had a wide beam and a narrow beam, you'd have this wide beam that took up lots of noise, but the narrow beam wouldn't, and then you could look at the

ratios of echo strengths to see if you could detect any difference. This is a way to estimate numbers when there was a lot of noise, through this narrow beam. And you could probably do something similar with a couple of different frequencies just to get differences in the noise and then test whether or not fish were in the noise per se or not.

Gary Weeks   So, you're saying use a lower frequency and subtract the higher frequency ping count from that to get an index of noise?

Sam Johnston   Hopefully you'd have periods of no noise and then periods of high noise in one of the frequencies. And so then as you're going through, make sure that you get a good correlation when there's no noise, and then when the noise happens, you find out if there are more fish in the noise than outside the noise, because you haven't measured how many fish are in the noisy area.

Gene Ploskey   The something that just popped into my head is the turbine intake extensions (TIES) that are at Powerhouse 2 at Bonneville. The FGE of slots between TIES is generally higher than at slots with TIES. There also happen to be huge vortices between the TIES. Bill informs me that bubbles are less dense than water and vortices likely are guided above screens. I know it's true that the up-looking beams always had more noise on them than the down-looking beams.

Bill Nagy   I think it's just that the vortices are generated at the surface, and so the up-looking transducer is subject to more noise.

Gene Ploskey   But if fish densities are substantially higher in vortices and noise than elsewhere, you likely will substantially underestimate FGE at the second powerhouse.

Bill Nagy   I think, when they put those TIES in, the idea was that it would break up lateral flow and create vortices between the ties and that would actually bring water down into the unit instead of coming by the unit and that it would bring the fish down. So I think that was a conscious effort to create a vortex to bring the fish down into the unit.

Gene Ploskey   So there might be something that can be tested there. I mean, there are years of FGE data, I believe they show that higher guidance occurs at the slots between the ties.

Gary Johnson   How much higher guidance though? This is a personal question.

Gene Ploskey   I just remember reviewing all of the FGE's from fyke and gatewell netting at Bonneville and it is very clear. We also found higher FGE at the intakes between the TIES with

acoustics, in spite of the fact that we couldn't track when it was noisy, which was a fair amount of the time. I'm not certain what that tells you. This is something that ought to be explored further.

So there are some acoustic ways we might look at whether fish densities are independent of noise. I guess anytime we net something and acoustically sample an intermittently noisy intake, we potentially can test the assumption of fish density being independent of noise. Any other ideas on how we test those assumptions?

I want to talk about data processing quality control tomorrow, and also what the outputs are of data processing, in the morning. And the quality control, if you have all original trackers, how much tracking and re-tracking of the same data should be done as a quality control measure? Should you have double blinds? What is satisfactory, what should be reported, if anything? Are there any potential standards there that, you know, we should look at, look for? Same thing for automated tracking. And I assume that eventually a lot of this will be automated tracking, maybe with human bubble cloud filters, but, nevertheless, that also has, we have to have quality control on it, you know. So we might just talk about schemes for reporting that and making sure that the numbers have some meaning. So we'll do that in the morning, and then John's already done all the data analysis for us. But we might just go through that, and if there's anything that we haven't touched, or hasn't sunk in, we'll ask him to do it again, and hit him up for his reprints. We likely will finish by noon tomorrow, or we can keep going now until about nine o'clock.
(Group laughter and comments)

| Gary Johnson | Well Gene, one thing you didn't have on your agenda was a block of discussion about reporting. |

| Gene Ploskey | You're talking about in terms of the short-term reporting and then the final reporting? |

| Gary Johnson | All of it. Weeklies, preliminaries, drafts, peer review. What to include, when, how fast you turn around. We're all under pressure now to do more and more reporting, and frankly it's becoming kind of pain… |

| Bob Johnson | Thanks to Gary. (Laughter and comments) |

| Marvin Shutters | You Battelle guys are giving people unreasonable expectations; it just feeding back to you. |

8:00 A.M. - 10:00 A.M., Wednesday, 9/17/1997

Gene Ploskey	I made up a sampling scheme for a single transducer last night. I want John to go over it with me. Sample duration is 0.5 minute, 1 minute, 2 minutes, 2.5 minutes, or 5 minutes. Adjacent to sample duration is the fraction of an hour that you would be sampling and it seems to say that shorter is better. However, would that always be the case if the expectation of getting a fish is really low. You might have lots of zeroes in your data set. I seem to recall that some bad things happen when you get lots of zeroes in your data set for estimating variance.
John Skalski	When they are all zero.
Gene Ploskey	I read somewhere that you have to go through special data handling processes when the number of zero observations is high.
John Skalski	A lot of the analysis that we've done has been to use finite-sampling theory. Typically, finite-sampling theory is nonparametric in the sense that it doesn't assume any distribution properties associated with the data at all. The point estimates and variances are independent of how the data themselves are distributed. The only time you have to make a distribution assumption is when you start making confidence intervals. When you're sampling thirty different orifices several times per hour, twenty four hours per day, that probably is looking at normality faster than you can believe anyhow. We've never really worried about the underlying distribution. Typically, you don't in finite sampling theory; that's one of the nice things about it.
Marvin Shutters	So you used like a Kruskal-Wallace test ?
John Skalski	We don't test, we just estimate. Sometimes we'll do comparisons between different configurations, but a big chunk of the work we've done in the past has been to estimate parameters. What's the FGE, what's the FPE here and there. Once in awhile there are particular tests for surface collection configurations and what have you. Again, usually the sample is over at least a day's unit of kind. There's going to be multiple observations per hour. Summed over twenty-four hours, it tends to become normal pretty quickly.
Gene Ploskey	Suppose, for example, we're just at the low end of the scale and we've got a sample duration of five minutes and we go and we sample ten times an hour. Does that not give you a lower variance for that hour than if you had a longer duration and fewer samples.

John Skalski	You have to be careful of how you speak in terms of you're just looking at the mean number of fish per interval and its variance. That's one thing. Or are we estimating total fish passage during that interval time, an hour for example, and its variance.
Gene Ploskey	Right.
John Skalski	It's usually the latter that we are interested in. You extrapolate up to the whole hour. That's total passage within the hour. Then, of course, what we're interested in is the variance of that estimate and what we want is a design that gives us the smallest variance for that hour of passage. Let me be more specific. In the first line in your table you have one-half minute intervals and you take ten of them during the hour. That would be one slot for one hour you took those ten observations of a half of a minute duration. What we would do would be to take that mean of those ten observations and expand it up by one hundred and twenty. That would be our estimated total passage during the hour. Similarly, we would calculate the variance associated with that hourly estimate, but take into account the empirical variation among those ten replicate one-half minute observations. Then there are some scalars to expand it up to the hour. There's another scale to correct for what is called finite population correction. You sample one-twelfth of the whole time so you get some benefit for having sampled an appreciable fraction of that universe. What happens is that, typically, there is some small advantage to doing more short intervals. I'm sure there is a diminishing return when you go from ten one-half minutes to twenty quarter minutes and so on. I think definitely you are probably losing some effect. But certainly that would be preferable to the two, five minutes, as far as we know, in our experience.
Gene Ploskey	What are the tradeoffs? How do you make that decision.
John Skalski	What we've done in the past in some instances has been a few locations at a site. Continue the sixty-minute observations at a few portals and then once you have that continuous data, play the game. Go back and sub-sample that as if it was actually ten one-half minute intervals. Look at all possible combinations and see what the variances would be. We've been very fortunate in some instances where I've been involved where PI's had done that historically. They had those kind of data sets in abeyance and just went back and looked at those to give us some guidance.
John Skalski	Apparently, what seems to happen, and you wouldn't think so, but there seems to be some patchiness of fish going through these units. You wouldn't think there would be any fish

saying, hey, Charlie, let's not go. Having smaller intervals tends to eliminate some of that patchiness which in turn reduces the relative variance. Typically, too, if you want to get on with the story is that we find that if I had my preference, would be to have people literally randomly sample within that hour interval. If you have one hundred and twenty one-half minute potential intervals in the hour sampled, I'd let the multiplexers randomly select those ten. The random sampling does a couple of nice things. First of all, the formulas are correct. They are valid and reliable. Furthermore, they are much more predictable. In other words, you say, well, I'm going to take ten one-half minute intervals, but tell me what the advantage would be if I took fifteen or twenty. I could absolutely tell you theoretically what you should be getting in terms of additional performance. When you do systematic sampling there are time spacings such that you can actually increase the number of samples and the amount of effort that actually increases the variance. That's the problem I have with systematic sampling, it's unpredictable to a degree. I think it screams lots of samples look better than a little. In the middle zone, where most of us work, we're taking several too many. I can't necessarily guarantee that if you take a random systematic sample of one-minute intervals every 20th then do every 15th that you necessarily are going to have better precision. Some of the stuff we saw in mid-Columbia data, there were strange things, like with every 13th minute the samples were just terrible. If you sampled during those intervals the variances just went skyrocketing. There's no reason that you would think that fish are thinking on thirteen-minute intervals. There is no reason operationally or biologically that you think that would happen, but there seems to be cases. All sampling I've ever done in biology you will find frequencies that are less desirable, and you can't predict them. You don't have to worry about that if you do truly random sampling. Furthermore, what happens is that even if we do systematic sampling we end up using simple random sampling formulas because there aren't very reliable variance estimators for systematic sampling. We have a true variance formula, but we don't have a variance estimator.

Gene Ploskey   Sometimes you might have different control files for your sounder for on a different day you alter the sequence at which you sample transducers.

John Skalski   We'll do that at least randomize daily with the initial sequences so that you are not always starting at the first of the hour that we first sample.

Gene Ploskey   But ideally, do it every hour you would randomize.

John Skalski   Yes. Historically, the multiplexers were incapable of doing

    Chapter 2 – Workshop Transcript

that. I think they have evolved to the point where if you really wanted them to they can. It seems to be the limitation is people-wise in terms of it keeps the people more mixed up.

Gary Johnson   That's part of it, John, but the main reason why is that we sample so many places at a given time you have to worry about the cross talk. If you have multiple systems and they are all randomly going you are going to get yourself in a big mess fast.

Sam Johnston   There have to be rules to your randomness. (Group laughter)

Gary Johnson   If you have one system with a string of transducers…

John Skalski   Then you are fine.

John Hedgepeth   John, if you sampling is continuous, are variances still able to be estimated?

John Skalski   That's a very good question and an important one. Let's just look at unit hour. The variability of trying to estimate fish passage through a unit for an hour. There are at least two sources of variability that we need to contend with. First of all, there is temporal variability within the hour of which we are only sub-sampling. Then there are true measurement errors, random and non-systematic errors associated with the technique irregardless of potential systematic bias. Those two sources are there. Sampling error and measurement error. If you sample all sixty minutes out of sixty minutes in an hour you've eliminated the sampling error, but you have not eliminated the measurement error of the technique itself. Unfortunately we do not have very good models to independently propagate or estimate that measurement error. What we have done in the projects I've been involved with is simply to calculate the empirical variance among the observations within an hour. That will then capture both measurement error and sampling error. But once you sample all 60 minutes within an hour, you don't have a variance yet, you do have noise. We've been fortunate in situations in that we've never had enough luxury that we could sample 60 minutes out of 60 minutes. It's always been a real small set so we've never had that issue. I think we encountered that in a project up in Alaska.

Tim Mulligan   We don't sample the same. We move the transducers so any particular geometry is a different sample.

John Skalski   You do, that's right. You still have sub-sampling going on, but I think my impression is some of the riverine stuff up in Alaska, they basically keep it on continuously…

Tim Mulligan	Yeah, it's a difficult application.
John Skalski	Applying this finite sampling theory and trying to have that incorporate both measurement errors and sampling error, this doesn't work.
Cliff Pereira	I guess if you were being real conservative you could presumably solve measurement error and just not be concerned about population error. That's an upper bound and the lower bound is zero.
John Skalski	What happens is all these finite sampling formulas, as Cliff has alluded to, have a finite population threshold to correct for the fact that you for instance... The first line you sample $1/12^{th}$. So $1/12^{th}$ of the empirical variance you see is eliminated because you sampled that much of the population. That is then cutting the measurement error by $1/12^{th}$ where it shouldn't have occurred. So it will underestimate the true variance. If you totally eliminate the finite sampling correction it will over estimate the variance. You have an upper bound in that situation. To further complicate the matter, because you probably sample systematically by using simple random sample formulas, those simple random sample formulas almost always grossly over estimate the variance as well. I'm pretty confident even with little measurement error problems and the finite population correction, the way we're doing it now, we're typically doing systematic sampling but using finite random sampling formulas, our confidence intervals are probably valid but pretty conservative in terms of being probably wider than they ought to be in most cases.
Cliff Pereira	Most of the time your finite population correction isn't very large because your only sampling $1/20^{th}$ or something.
John Skalski	Right. It's not a huge thing.
Cliff Pereira	So it's not making much of a difference.
John Skalski	Yeah, using a simple random sampling formula in a systematic case probably ups that variance by a factor of 10 or more.
Cliff Pereira	Yeah, it's hard to say, because as you said, as you got to certain frequencies when you did an empirical study, you found that systematic sampling did very poorly. But those also are the cases where you underestimated the variance at the same time. So it could go either way.
John Skalski	Either way, yeah. It could go theoretically either way, or in cases it kind of tends to go on the high side. And so, I think most of the time when we record a point estimate and confidence interval zero, I think that confidence interval is

probably quite reliable, if not real healthy.

Cliff Pereira   Yeah, I guess when you started sampling a really large fraction of the hour then you might start to wonder about it.

John Skalski   Yes. Rarely do you sample more than probably a 10th of the hour, a 20th of the hour, or you know, 20 % of the hour.

Gene Ploskey   Well, the right half of that table that I handed out is effort in terms of tracking hours based upon a variety of assumptions, assuming a tracker can track say 5 minutes of data in 5 minutes of his or her time. The next column assumes that trackers are twice as fast. The middle column is man-days of tracking required. Effort's really important if you go to do a big project in terms of how many people you have to bring on. The 1 to 1 tracking rate, you're looking at 12 trackers required to turnaround the data in a day. So it makes a huge difference in manpower, how much of every hour is processed. If you collected 10 1-minute samples but only processed 5, you cut tracking effort in half. So, it is very important how you approach sampling to provide a balance between turn around, precision, and cost.

John Skalski   And again, this really depends on what your end point is. You know, if you're trying to get very precise FPE or FGE estimates for a particular day, then you have to sample fairly intensely during that day. However, you can get away with much less sampling per hour if you really are interested in longer intervals like a week or season. Sometimes I think it's almost surprising how precise you get, and I think that's really important. In other words, are those dailies important enough that you have to expend double the effort or triple the effort in terms of manpower.

Cliff Pereira   Right, and you shouldn't bother to report those dailies

John Skalski   Yeah, if the objective was to give a seasonal estimate, then I would be real hesitant to look at the shorter intervals and have someone get very upset when they discover the variance associated with shorter intervals are noisier than heck. It will be.

Gene Ploskey   Based upon my experience, I can't imagine wanting to look at project FPE on a scale finer than a one week. Do you guys agree with that?

Gary Johnson   I agree with that. (Group laughter)

Tim Mulligan   I have a comment on the entire discussion this morning, and that is you're zeroing in only on the variance component and not on the bias. Bias is a much more insidious of the pair, and

it's the part that's usually overlooked because it's more difficult to deal with. I would emphasize putting in as much effort into looking at the bias of your measurements as you do the variance, like comparing them with other measurements or trying to do some sort of additional studies to amplify where your measurements might not be subject to error

Cliff Pereira

So that might be where you spend some of that money you got from not sampling so much in the day.

Gene Ploskey

Yeah, I agree. We're supposed to have the bias out by the time we get the data to John.

John Skalski

Yes, absolutely right. (Group laughter) But I think, I think it's a good point.

Cliff Pereira

John can say, "whatever it is you're measuring, this is your variance."

John Skalski

Yes, right. (Group laughter and comments) Whatever that parameter is, you might think it's this, it may be that…

Tim Mulligan

One of the points that John made the other day was comparing acoustic estimates with estimates from pit tags or other methods. Certainly ancillary measurements deserve a lot of attention to convince yourself that you haven't spent a lot of time arranging the deck chairs on the Titanic. Concentrating only on one of the components.

Gary Johnson

Tim, to follow up on your first point, John mentioned it when he started off, when he explained that in the variance that comes out of the formulas that we use, the measurement error and the sampling error kind of combine together. But you mentioned you need better models for the measurement error. I guess the question would be then, how do we measure measurement error?

Tim Mulligan

Yeah, certainly it boils down to doing some comparisons vs. some other techniques. You can have theories on how acoustics works and that's one of the strong points of acoustics is it follows certain physical laws. In addition, fish behavior isn't completely random, they follow certain laws too, particularly when they are entrained. At the end of the day, to make sure those models and your ideas all gel, you've got to compare your data vs. some other technique. You have to keep going back repeatedly. One of the things that we were talking about at breakfast though was, you can model the detection process, and you can keep examining your own data for inconsistencies. Acoustics is very strong in that you can predict many properties of the data. They shouldn't have certain anomalies imposed by the measurement instruments.

You can check, and if they do that tells you something's going on that you haven't accounted for and you need to look at it more seriously. I think those kind of things go into models for detection. A true model for acoustic detection will predict many things about the data, and you should continue to examine it as it comes in to make sure it satisfies those assumptions. You want to make sure your data isn't beginning to drift into some region where it would indicate that something is going on that you haven't accounted for. I'm not trying to downplay what John does, what I'm trying to say is an equal amount of emphasis should go into examining the credibility of the data before it goes to statistical analysis.

Gary Johnson   John would be the first to say garbage in, garbage out.

John Skalski   Yeah, it's analogous with mark and capture theory. We're tagging animals, doing recapture or estimated parameters from a model, and those estimates have two inherent sources of variability, natural variability as well as measurement error associated with the estimation model. One of the nice things about some of the mark and captures, if you believe the models then you get independent estimate of measurement error associated with that process that we can sort of partition out overall noise into how much is nature, how much is contributed by our technique. There isn't quite that counterpart in the acoustics I don't think. You read papers where people tried doing it, but I haven't seen anyone really apply those models.

Gary Johnson   So you guys could quantify the measurement error of the mark and capture studies.

John Skalski   Yeah, for example, you know pit tag studies that we do daily release of pit tag fish for a month and estimate monthly survival, we get daily estimates of survival and the variability will include not only the temporal variability of survival, but also the measurement error associated with the mark and capture process. And we can partition those out to see how much is God-given, how much is man driven. And we can't do much about nature, but we can say, "Hey, we can reduce our measurement error by increasing tagging size or capture rates. Unfortunately, there's not quite that same analog in acoustics.

John Hedgepeth   What about using two transducers in one intake.

John Skalski   That's possible, yeah.

John Hedgepeth   You know you're only sampling part of the intake, so if you had multiple transducers in one intake…

Bill Nagy	Even two transducers that are supposed to be seeing the same fish. You could put one transducer in front of the other to sample the same fish.
John Skalski	And then you would think that the differences between those two is giving some indication of the measurement error of the technique itself.
Bill Nagy	Right.
John Skalski	Right. And all that really does in some ways is tell you, "OK, now I've partitioned out overall noise into these two sources, Mother Nature and me. What can I do to reduce my part so that the overall noise of the study is reduced?" But again, it doesn't give to the other type of error, systematic error, or bias.
Gary Johnson	In the two transducer approach, they may have the same bias?
Sam Johnston	The same bias, like they're in the middle of the intake and most of the fish are on the edges?
Bill Nagy	That's sampling. I'm saying you ought to be coming up with the same number and they're not, that's if they're not, you don't know why. But that's an indication that there's a measurement error. That isn't a matter of sampling because, unless your model about how fish are coming into this intake is totally wrong.
Gary Johnson	But if they both have the same kind of measurement error.
John Skalski	You have to be real cautious here, the same systematic error. Then the bias will be cancelled and you will get an estimate of measurement error, you won't get any feeling for the systematic bias. Because both are there, and both cancel each other out when you look at the comparison.
Gary Johnson	That's what I was pointing out.
Bill Nagy	But you have two transducers, supposedly measuring the same thing, you get the same answer, that's fine. If you don't, then you've got some indication that there's a measurement error involved. You don't know what it is, but at least you know it's there.
John Skalski	And it's there all the time.
Marvin Shutters	Every time I've seen that, where you had two transducers supposedly measuring the same thing, they often track the pattern fairly well, but the absolute estimate is usually a fair amount off.

Bill Nagy	Outside, well outside the confidence intervals...
John Hedgepeth	There are a number of problems using two transducers to sample the same volume. Like you have to trigger them at the same time and then you have cross talk. You could use different frequencies but then would when you introduce other problems.
Marvin Shutters	Well, just, the example I'm thinking of is John Day extended screens in '96. BioSonics had two different transducers looking up and counting guided fish. They were side by side and sampling slightly different volumes of water. The estimates of guided fish were different depending on if you're using transducer A or transducer B.
John Hedgepeth	They were not on the same guideline?
Marvin Shutters	I'm not sure, I don't remember that. And then also...
Bill Nagy	For assessing measurement error and not bias the transducers would have to be fast multiplexed and staggered so that one beam was just behind the other.
Marvin Shutters	Even if they are slow multiplexed, you know, over the season, those side by side transducers should have provided pretty close estimates.
Bill Nagy	Unless, you had the kind of bias that Tim was talking about. Even minor variation in aiming of the beam could lead to big differences in detectability.
John Skalski	Yeah, the repeated measurements on the same unit is a classic way of estimating measurement error. The problem we have in fisheries and wildlife, nothing's ever static in space or time. You can get close, I mean the closer they are in time and space the more of what you're seeing is truly measurement error and less of it is natural variability out there. And that's what you were talking about. It's a reasonable approach. Again it could simply be estimating measurement error in terms of the random error, not any systematic error. If you saw two transducers however, they always tracked, but they were always offset, now there's some obvious difference. One or both of them would have some bias in it. If it's all measurement error, you would expect over time to just randomly flip-flop. And that random flip-flop is truly measurement error. But if they're tracking like this, the ups and downs may be harmony but the difference may be an accumulation of systematic bias.
Bill Nagy	There's another, maybe, instance where that would be of value, is when there's noise present, and the noise is affecting one

Marvin Shutters	And that's what, at the sluice chute at B2 this year, there was a 6 and a 12 degree transducer side by side, couple degree difference in aiming angle, but the 12 degree, which would have more volume reverberation, consistently had lower estimates of passage than the 6 degree.
Gene Ploskey	Did that account for time they could actually track? I mean, was it the number of tracked fish per trackable time.
Marvin Shutters	I don't know exactly how the noisy data was handled.
Gene Ploskey	Because that makes a huge difference. I mean if you can only track half the time on one transducer, and you can track 100% of the time on another…
Marvin Shutters	But it was Brian's feeling that it was appropriate use of that data.
Gene Ploskey	And he probably did, I'm not saying that he didn't. I'm just pointing out to the group that how you process the data makes a huge difference. You can't estimate horizontal distributions of passage unless you account for effort, and effort is not just defined by how long your transducer was on, it's defined by how much of the data was usable and expanded.
John Skalski	I guess I have a question. In my original field studies of mark and capture theory, again you have these two sources of potential error You have the measurement error model and you also have the potential bias associated with some systematic departure from the assumptions. The model will estimate the measurement error, but then we use tests of assumptions and different goodness of fit tests to determine whether the data are conforming to the theoretical model for the tagging study. And so we use two types of analysis to confirm for ourselves that we know how much systematic error vs. how much random error is going on. In line classic theory, we know that the sign of the flush angle should be uniformly zero one, if the model is correct. I'm hearing from you yesterday, theoretically the fish should be uniformly distributed in the beam. I know you can't do that with a single beam, but do you think with a split beam you could be able to look at the horizontal distribution and see if it is indeed at least uniform. Do people use some of these measures?
Tim Mulligan	They're beginning to now, yeah. And it doesn't have to be uniform. If you know where the signals came from within the beam you have a chance for correcting for the non-uniformity of the detection. So it gives you a much better tool for

	recovering a better estimate of number of fish that were truly there.
John Skalski	It sounds like a two step process, first you can see whether it's uniform, if it's not uniform you can adjust for it. Is that what I'm hearing, sort of?
Tim Mulligan	No. No matter what the distribution is, you always adjust for the fact that although it appeared uniform, then the fish distributions were not uniform. The detection probabilities are not uniform across the beam.
John Skalski	Right, right.
Tim Mulligan	And what you see is a product of what was there times the probability of you seeing it. So it's like you're seeing the result of a convolution process. But you can measure one of those components in the product, which is the detection probability as a function of your instruments. You can do it in the lab or you can do it in the field or what not, either controlled or semi-controlled circumstances. Then it gives you the chance, when you look at the data which is a convolution, you can now deconvolve because you know what one of the products is.
John Skalski	So there are some diagnostics that help you to assess whether you have some sort of systematic error versus random error.
Tim Mulligan	That's right.
John Hedgepeth	So let's say the result of your analysis was that you had a skewed distribution of to one side of the beam then you extrapolate outside the beam?
Tim Mulligan	If you have to, yeah. But hopefully you don't, yeah, hopefully it's an interpolation problem rather than an extrapolation problem.
Sam Johnston	Fortunately for the river case outside the beam is bottom, you just can't go there.
Gene Ploskey	OK, does anybody got anything else to say on that? I want to talk about quality control processing. Should there be a standard of any kind? Or should we leave that up to every group to police themselves. I think Gary told me he had 8 visual trackers all going full time to turn the data around on a one week basis for Lower Granite last year, is that right?
Gary Johnson	Yes.
Gene Ploskey	So it was 8 folks and we've had, well at different times, up to 6

people tracking, and anybody whose taking on a big project is going to have lots of people tracking fish. And when the data is noisy, we found that you don't always get the same counts from different human trackers. How much should we worry about that? Should some of the data be tracked by two people the same day with some indication of how well they agree?

Don Degan   Did Sandy send you the verification data for Richard B. Russell?

Gene Ploskey   I did. Sandy sent me that information and for the most part, counts of pairs of trackers agreed pretty well. But I think that was after they had resolved their differences.

Don Degan   Didn't it have the preliminary data and then the final resolution?

Gary Weeks   No, it just had the fish counts and the percent difference. I thought it was after resolution.

Gene Ploskey   Can you, can you describe what you did?

Gary Weeks   What we had actually, was two different groups tracking with more than one tracker in each group. I think data from one transducer per nightly pump was re-tracked by a different person. We decided that differences >20%, required that the two trackers would get together and resolve the difference, and if was < 20% then things just went on as they were.

Gene Ploskey   Gary, was that required by the states or the committee, or was that just something you did?

Gary Weeks   No, we thought we were at risk if we didn't do it. So if we had some sort of QA/QC in place then it would never be questioned, and if we didn't we might have to go back.

Gene Ploskey   The Richard B. Russell project was under litigation, and it still could go to court. So that was maybe an extreme measure. Is tracking QA/QC something that we need to worry about on a routine basis? I guess it's something that people should worry about in their own shops. What about a standard?

Gary Johnson   Gene, I would suggest that maybe the minimum standard have something to do with the fact that people need to document in their reports what the QA/QC was for processing. Whether or not everybody does it the same way is another story. We found that the first part of any season is the worst of course, and so we've taken old data and we go in training for a couple weeks before we actually start sampling. This last year we were fortunate enough to have the gear in the water before the start flag went down. We gave trackers some real data to practice

on, but it wasn't used in the study. We monitored everybody kind of in a sweatshop (Group laughter), and they're all lined up in a row and they cranked away, but there was a foreman, a foreperson, answering questions. PI's also were there a lot and helped out. Then, we also had the leader of the group go in and do spot checks and see how the trackers performed. He doesn't actually retrack the data, but he'd go in and look at the file and say, "How come there are 6 fish there?" He won't actually match them up one to one. If we suspect something is amiss, we retrack it by someone more senior. We think it's a real complicated problem. If we don't think someone did a very good job, then we go back and redo it.

Bill Nagy   Do you randomly assign tracking jobs.

Gary Johnson   No, we don't, but we give the hardest environments to track to the best people.

Bill Nagy   I think maybe that it would be better if that was randomized. For one thing, you could look at analysis of variance to quantify tracker bias.

Gary Johnson   Yeah there's certainly some unknown bias, but because of QA/QC I'm fairly confident that it is not very large. I mean most of the data we get are reasonable, it's not like there are lots of hours to retrack. We look for anomalous spikes in data patterns and maybe say that transducer was always tracked by John Martinson.

John Skalski   Thank you. (Group laughter)

Gary Johnson   I think randomizing is a good idea though. We just put the best people on the hardest stuff.

Bob Johnson   I also think that's a good approach. Aren't there other ways you can estimate the tracking variance?
              There is the issue of moving through this data too. You don't want some guy that's struggling with it, just working his little heart out while the guy next to him is better and working on the real easy data set. Some practical considerations.

Bill Nagy   But the fact that there are good guys and bad guys does sort of raise the issue of…

Gary Johnson   No, they're all good, it's just that some are better. (Group laughter) No really, it really gets to one of the advantages of automatic tracking. Gene, I don't know whether we're going to talk about that, but I'd be interested if we had time to discuss automatic vs. manual tracking.

Marvin Shutters   I'd like to continue the discussion on quality control on manual

	stuff and then get to using automated or manual tracking later.
Gene Ploskey	Yeah, that's fine.
Sam Johnston	Just, I can talk about our quality control on the mid Columbia which is sort of similar. There's a three tiered organization of people. There are people that enter the data, and a foreman that oversees those people and does spot checks. We do at least a week's worth of training ahead of time. And we always plan, although doesn't always work, to get the gear in as soon as we can so that we have at least a few days of data that they can play with and track before we're into the daily, you know, numbers generation. Finally, there's the final level that looks at the numbers before the whole data set is analyzed. If you see a giant spike someplace or if there's any anomaly in the data, then you go back to it and take a look at it. A lot of times it's pretty easy to tell when things are not quite right. It seems like a subjective thing, but, the people who are doing this work know which units have a lot of noise. So they're going to be looking for high volumes of fish that might be noise, and when they see a lot of fish at that unit they'll examine the data more carefully. There are lots of times when we go and we retrack certain sections of data.
Marvin Shutters	Sounds like everybody relies on up front training and then only looks for anomalies in the data sets.
Gary Johnson	We do spot-checks too
Sam Johnston	Right.
Marvin Shutters	What do you mean by spot checks
Gary Johnson	Just go into a hunk of data and…
Marvin Shutters	Retrack it?
Gary Johnson	The foreman typically looks at the tracked data. If he sees 6 fish in a brief period he goes to the file and checks to see if 6 fish were correctly tracked.
Marvin Shutters	But it's, you're retracking the data, as quality control?
Gary Johnson	Mentally you're retracking the data. The foreman will write it down a number from the data set and the revisit the echogram to spot check the tracking. He is not changing the data set unless discrepancies are discovered.
John Skalski	He's not altering the database.
Gary Johnson	Does that make sense?

Marvin Shutters	Your just doing quality control checks. Ok, you're not, unless there's a big problem, going to change what the first guy's result was. Right. So do you have a standard or protocol for determining how often this is done or what percent of the data is checked or anything like that?
Gary Johnson	We don't use a set program.
Marvin Shutters	Or is it just when you don't have a lot of fires to put out and you're sitting around bored? (Group laughter) I'm sure there's a lot of that.
Gary Johnson	Each day they go in and do a little bit. It would be a good thing for us to put in a report -- what the final QA/QC program was.
Sam Johnston	I think they do, I think there is a minimum number they'll do each day, but I don't know what that number is right now.
John Skalski	Is there a criteria in terms of when bad is bad, in other words when the average deviation is more than 20% or something?
Gary Johnson	Yeah, about 20% and then you know you're really off. That actually happens fairly rarely, when you get some sort of a weird event. The good part about having everybody together is that a data entry person can ask for help from other trackers. They don't just plow through it because no one is around to help.
Marvin Shutters	Bill and I've done stuff where we had everyone sitting in the same room and when there was a question, you could always turn around and tap somebody on the shoulder. You sort of had a group consensus, pushing everybody towards the same interpretation.
Gary Johnson	Yeah, that helps a lot.
John Skalski	In terms of, you know, estimating parameters, I don't think it's as much of a problem. When we were doing tests like surface-collector configurations or baffle configurations, would a particular configuration, that typically yielded more fish always be given to the same reader?
Gary Johnson	No, we had one person do the surface prototype collector (SPC).
John Skalski	The whole thing?
Gary Johnson	Yeah, they're the SPC person.

John Skalski	OK, so there isn't going to be any systematic bias between treatments and readers.
Gary Johnson	No.
John Skalski	Good.
Marvin Shutters	And that's something that should be considered, is how having one person tracking certain routes can cause biases.
Gary Johnson	Yeah, practically speaking, I say the guideline is we give the harder stuff to the best person, but a given entry person, except for us on the Lower Granite SPC, pretty much will have done all of the other systems. They are not assigned completely to one location.
Sam Johnston	Yeah, the data's usually organized by systems. One system controls all the spill transducers and that block of data comes to a data entry person and they just work on it.
Don Degan	Seems like there ought to be a standard for that. I'm not sure whether it's something that needs to be done across the board, but it seems like there ought to be at least a minimum amount of QA/QC that's performed on data.
Marvin Shutters	Yeah, I think it probably should be a certain percent of data that's double-checked by the best trackers or supervisors.
Gary Weeks	I have a question for Cliff or John. If your data's thin and you're getting say 5 fish an hour, and one fish makes a good 20% difference, how does that compare if you're getting 100 fish an hour? If you were going to set some sort of QA/QC limit to compare trackers, one fish is still one fish, but it's not necessarily a big percentage.
John Skalski	I think I'd be concerned about percent difference. In other words, if you're off by more than 20%, not by two fish.
Gary Weeks	No matter how may fish there are?
John Skalski	Yes, I think it's a percentile kind of error rather than an absolute error. I think you'd be more concerned. Because, right, I mean one fish out of 100 probably isn't going to make a whole lot of difference but one out of 5 could make a big difference. So I'd base a QA on the fractional error, rather than absolute.
Don Degan	That was the biggest problem we had when we were sampling. When we had low passage rates of less than 10 fish per hour, oftentimes we see a 20% difference. For example, you might have 4 fish instead of 6 fish, and you had to spend a lot of time

resolving those differences.

Gene Ploskey   Well, does that suggest that your block that was tracked was too short? Like choosing increments in a histogram?

Don Degan   It was based on the amount of time that you wanted to devote to something. I guess if you allowed a differential block, you could set it up so you can compared counts per 100 fish or something rather than going by the amount of time. I don't know. Because you get variations from a thousand fish an hour to five fish an hour.

John Skalski   I think it may also depend on the objectives. Our studies tend to be just estimating these major performances of the project, but on the other hand, we do some trials like the different configurations of surface collector. A 20% change in fish passage at different baffle configuration would be probably enough to peak people's interest. So now, you know, detection of that one fish out of 5 is to the point where we're talking about a treatment effect that is of people's interest. So I think in that case, yeah, I'd be real concerned that you got that one out of five fish resolution resolved. When it came to fish passage at the dam, it's probably not going to amount to a hill of beans. So I think it also depends on scenario.

Gene Ploskey   So, what's the percentage? What percentage do we retrack?

Gary Weeks   Well, I guess what seems to be almost as good a case would be double blinds, where you just cross files. If you've got, as Gary so eloquently put it, a sweatshop full of trackers... (Group laughter)

Gary Johnson   I didn't say that. (Laughter and comments)

Marvin Shutters   I think we have that on tape.

Gary Johnson   Let me see that tape.

Gene Ploskey   Our taping will only be used to summarize this workshop, not for blackmail. (Group laughter)

John Skalski   That won't be in the summary. (Laughter and comments)

Gary Weeks   So anyhow, it seems like if you just swapped files among trackers, it might be about as good for detecting differences as randomization in a real practical sense. That would be my preference.

John Skalski   I guess I still have a question, in this whole area, typically when you're counting things, we tend to have one-sided error. We're more likely to miss things than to make things up, in

	many cases. Is that also the case with your...?
Everyone	No. (Group laughter and comments)
John Hedgepeth	You can count one fish two times-
John Skalski	Or count some blip as a fish-
Bill Nagy	As far as counting jobs go, it's a problematic one.
John Skalski	Yes, in fact I prefer that. It's the, it's the one-sided error that causes more problems than the two sided error, where you can overestimate or underestimate, and on the average you may be OK. I guess in terms of QA considerations, in which case I would not only be concerned about the percent error, but whether there's one person systematically always underestimating or always over counting relative to the QA person.
John Hedgepeth	Right, it seems to be there's different philosophies. Some conservative people, "I want to make sure there's a fish there, and so I'm very conservative." That would be the one-sided error, and I think that might be typical to, to something to look for.
John Skalski	So I might consider in the QA not only the model error, but whether you're seeing some systematic one-sidedness to the error.
Sam Johnston	Yeah, you do the double blind test and then one person's always higher than the other, then you have something to worry about.
Don Degan	Well, just for reference, when we had about six people actually tracking the fish, and we would randomly select one transducer hour per pump. That was one out of 32 hours of data that was re-tracked so the counts could be compared. That's what we ended up doing just because of time considerations.
Gene Ploskey	How did you pick the transducer hour?
Don Degan	Random. The hour and the transducer were picked at random.
Gene Ploskey	Out of every day?
Don Degan	Every day they pumped.
Gene Ploskey	I think the noisier, unless they're completely noisy, the noisier files tend to be the hardest ones. Is that some minimum standard that might be considered? One transducer hour per day, or the equivalent of that maybe from several transducers

	or something?
Gary Johnson	I'd do a system hour.
Gary Weeks	Yeah, that's what I was thinking, what I was going to say. Maybe a system hour.
Gary Johnson	Assuming you sample all your transducers in an hour.
John Skalski	And all spill bays, that kind of thing?
Gene Ploskey	So all transducers on one transceiver?
Gary Johnson	Essentially, one hour sample, just go through whatever you sample, whether it's 2 or 3, 4, 5, 6 times a location an hour, and do all of it.
Gary Johnson	Just an hour's worth of data per system.
Marvin Shutters	So 1/24th of the data collected?
Gary Johnson	Right. Quite a bit shy of what Don said. At least you cover all the transducers.
Gary Weeks	The other thing you could do is if, if you're worried about bias in one of your trackers, is to check one tracker, one hour's worth. So if you have 6 trackers, swap files, three from each of them. Then you run a check on each tracker instead of a system.
Don Degan	That's what you're checking for, people error.
Gary Weeks	And not system error. Because it seems to me to be a little bit more reasonable approach.
Gene Ploskey	Do you want to vote? We're really looking for differences among trackers I guess, to try to understand the differences.
John Skalski	I think you're less concerned about the random as much as the systematic differences. Because it's sometimes high, sometimes low, and that's fine, but if a particular tracker is one-sided, then you've got a problem. Because then you're back into systematic errors vs. random errors, and at least the system can handle the random aspects, but it cannot recognize the systematic biases that may be induced by a person or group of people.
John Hedgepeth	Could there be an alternative of just randomizing the people and having them just kind of shift chairs each day?
John Skalski	That's possible...

Gary Weeks	I'd think you'd want to identify any problems trackers too
Marvin Shutters	So you can take them behind the woodshed? (Group laughter)
Gene Ploskey	So you have an even number of trackers, and you pass a one hour file to the right every day, is that where we're headed? I wouldn't think you'd want to do more than 1/16th of a day's tracking as quality control.
Marvin Shutters	Sounds reasonable.
Gene Ploskey	Yeah, 16, if it's an 8 hour day, that's one half hour out of 8, you're going to spend having people retracking files.
Gary Johnson	I thought we said 1/24th?
Gene Ploskey	I'm talking about work hours for the people, how much time they're going to spend. Not transducer hours or sample hours, but how much time do you want each tracker spending per day. Your throughput of data will drop by the same amount.
Marvin Shutters	But Gary runs a sweatshop, so 8 hours is out the window. (Group laughter)
Gary Johnson	You guys are too funny. (Group laughter)
John Skalski	When a person falls below performance level, what happens typically?
Gary Johnson	You don't want to know. (Group laughter)
John Skalski	I know some programs where they do zooplankton counts and a person has to go back and do a couple more days of training or something, and then goes on probation or something, and if it happens too often they go on unemployment.
Gary Johnson	We have to keep caught up, so we just keep tracking.
Don Degan	We were in different parts of the country. When two people had differences in counts, we talked on the phone about the file to find out what the differences were and why they were different. We were able to identify systematic errors that way, where one person was always counting some traces but not others.
Gary Johnson	The guidance from the foreman was really important along those lines. Because people have different work habits, and some people like to put their headphones on and just sit there and concentrate, and other people concentrate for a bit and then get up and talk. So you kind of got to work with them

and make sure they know what's expected.

Gene Ploskey   Yeah, I agree. That's probably more important than any quality control plan that you could put in effect, is to have them together and work with them. However, when you pick up somebody's report, it would inspire confidence to read about a QA/QC program, but that is more related to reporting needs. The same thing comes out of independent checks with other gears. It seems like we are close to a consensus, but just can't quite extract it. What I hear is that something should be done, maybe that's two trackers tracking each other's data for a half hour of data a day. In the summary, I'll list all of your good suggestions. Maybe we don't need to nail it down now. I do hear a consensus that something needs to be reported, and we need to be concerned about quality. Is that close enough?

Marvin Shutters   I think so.

Gene Ploskey   Go back to automated tracking now, is that all right?

Marvin Shutters   Yeah.

Gene Ploskey   I know that Tim's group's been working with that, and we've also been building an automated tracker. Bill's done all of the programming on it.

Gene Ploskey   I think probably Gary's the best one to describe the calibration process. Bill can best describe the automated tracker. Essentially the calibration we refer to is changing filters within the automated tracker so that you get concordant results with the visual tracker. Gary, would you please describe calibration for us?

Gary Weeks   Basically the way the calibrator part of the tracker works is you have a choice of several different levels of filtering. The screen is split into two parts so you can view any two filtering levels simultaneously. You can look at raw data, data that's filtered for echo amplitude, data that's filtered for structure and amplitude, and finally line extracted fish tracks. I was using the calibrator to determine whether filters were appropriate or needed fine tuning.

I've worked closely with Bill, and he would give me the program and I would track some data, or he would track data and look at it and then make decisions about autotracker performance. He would give me a program and I would track data and look to see if I saw any problems, and we would go back and forth. Finally, I worked up a data set about a month ago and ran it and looked at a number of parameters output from that data set and visually tracked sub-samples of the data set. When I felt we had a pretty good concurrence between counts from visual

tracking and calibrated autotracker for that data set, we tried the tracker on a new data set. I also regressed visual tracker counts on autotracker counts. Bill can tell you more about the different parameters.

Bill Nagy   Basically, it is a single beam tracker, but it would be ten times easier if it was a split-beam tracker. The ease of tracking alone almost justifies split beam. The biggest problem in tracking, of course, is noise, because the autotracker usually performs well on a clear echogram. The huge advantage of the split beam is three-dimensional tracking through noise. But anyway, when tracking a single beam echogram, the tracker has to be tuned for each deployment, because the conditions tend to be site specific. Well this year, I guess, the object was to try different deployments and see which one might be best to go with this year. So we had a lot of data from different deployments with a lot of different conditions, different noise. My feeling is that even the single beam tracker is worth a lot of attention and certainly can be made to function as consistently as a visual tracker. I mean that's one of their great advantages, they are very consistent, more consistent than human beings. However, they are not as sophisticated as human beings. A human tracker can take in a lot of information, look at the whole picture, see the context, and make better decisions than an automatic tracker can now. You can keep putting more and more sophistication into the automatic trackers, but it's not there yet. Obviously, that is part of the reason why any automatic tracker, at this point in its development, has to be verified by manual tracking.

John Skalski   Do any of these programs use artificial logic? Are they a program algorithm that actually learns from its mistakes?

Bill Nagy   I wouldn't say that yet.

Sam Johnston   Yeah, that's where the problem is, you have a set of parameters that you use to track, you know maximum velocity, whatever it is, and when conditions change, it's incorrect. If the behavior of the fish changes, or whatever.

Bill Nagy   The learning process in our tracker involves a split screen so you can see how it's performing in its various stages in the tracking process. Therefore, it works through the data in stages gradually. It obviously pays to filter out stuff that is not fish in the beginning so that you don't get bogged down trying to track a lot of garbage. But you can watch what the program's doing at each stage. So the process of teaching the tracker involves getting some data, running the program, looking at what it's doing, and then making adjustments to tracking filters. Then you see whether it does better with that data set. You can usually do pretty good getting it to count the

Chapter 2 – Workshop Transcript

fish you want it to count out of that data. Then the test is to get some novel data from the same deployment and see how it performs. The ultimate test is how does it deal with the variety of data that you're going to get in a season. And my feeling now is that you're going to be doing some…

John Skalski   Handholding

Bill Nagy   Yeah

John Hedgepeth   How often do you anticipate changing parameters you set up for one transducer, would it be on a weekly, daily, or seasonally?

Bill Nagy   I would change it if noise conditions changed. It ought to be able to deal with, you know, big fish and little fish.

John Hedgepeth   At Wells Dam, we automatically track to obtain an index. I think that initially there was a lot of looking at verifying automatic tracking and manual tracking. Once that was accepted, it's run since then with some infrequent checks.

Bill Nagy   I think it mainly is if the noise conditions change, which they tend to do in some places.

Gene Ploskey   I think the key is getting a good deployment and detectability in the first place to avoid noise. If you get a real good, clean deployment, then the automatic tracker could run through the spring and summer with just a few checks. If an echogram is free of noise, tracking is easy for a person and for an auto tracker.

Bill Nagy   One thing that happens is the shad run. When the shad started falling through, and the tracker was presented with a totally different problem once that occurred. In that situation, you might have to change parameters.

Marvin Shutters   You could still need the same kind of quality control checks as you had for different manual trackers to periodically take certain amounts of the data and make sure that it's still automatically tracking accurately.

Gary Weeks   Bill's actually working on a tool now that will allow us to readily check performance of the tracker. Whoever's doing the check gets a full screen view and not a tracked fish view, and enters the number of fish screen by screen. The number of fish visually tracked is matched up with autotracker counts to generate a data set for comparison.

Cliff Pereira   It sounds like the sort of thing where you wouldn't want to randomly select times, but from what you said it's more

watching for changes.

Gene Ploskey — This version of the tracker is a quality control tool where the autotracker is tracking the same fish as the visual tracker. The tracker pairs visual and auto-track counts and writes them to the disk so you can do a regression analysis. By processing some data from every transducer, each point in the data set could represent a transducer. By examining outlying points, you should be able to tell what transducers are giving you problems. Problem transducers might be re-deployed, re-aimed, or have to be visually tracked.

Bill Nagy — I guess one kind of danger is things can happen invisibly when you're doing automatic tracking. You want to have somebody regularly looking at echograms. Because nowadays you can have a site that's collecting automatically and feeding the data files into an automatic tracker. You want to, at some point, look and see what it is seeing.

Sam Johnston — That's right, and even at mid-Columbia, where we have projects where we have a processor and it's processing data and selecting raw echoes, those raw echoes are the ones that the manual trackers see. There's still a whole step there they need to check. So you also have, you know, just base echograms and you have to compare the echograms to the echo collection, make sure that you're not throwing out a bunch of fish because their echoes don't meet some criteria. It's very important to go all the way back.

Marvin Shutters — Yeah, like you can see in your chart recorder stuff that, you know, there was some kind of a noise event, that most of that's being filtered out by the digital data collection. The stuff that is getting through is quite likely an aberration of that noise, but it would appear like fish.

Sam Johnston — That's right.

Gary Weeks — Right now one of the other outputs in Bill's tracked fish analysis, the noise index, sort of based upon the number of echoes on pings. I think that would be real beneficial in helping identify noisy data and maybe point you toward files that need to be more closely examined.

Sam Johnston — That's number of echoes vs. number of echoes that are tracked fish?

Bill Nagy — Right now because it used to be more sophisticated, but all it does now is it looks at each ping, counts the number of echoes and you can set a threshold. We've got it set for three, but if there are three or more echoes on a ping, and this is after structure filtering that is tallied as a noisy ping. Noisy pings

are just tallied and the index is the number of noisy pings vs. the total number of pings for the location. I don't know what we're doing with that index right now, right now it's just an indicator for someone to see how noisy a location was associated with the fish counts.

Gene Ploskey
If it proved to be meaningful somewhere down the road, then you might adjust counts on different transducers with the noise index. I mean it would have to reflect trackable time. Right now, it is simply an index that we're going to put out so we can later look at statistically to see if it bears some relationship to trackable time.

Marvin Shutters
The approach that BioSonics uses at Wells and what you guys are trying to develop is fully automated tracking with some quality control. Yesterday I heard both Tim and Sam mention automatic tracking with human intervention. Can you go through that again? What is the trade off between manual, hybrid visual and automatic, and fully automated tracking?

Sam Johnston
Well, I can tell you the direction that you're going. It's sort of, the challenge is, we know that people are sort of the best signal processors around. They can decide what a fish is better than anything. But we can get close with these trackers. So the challenge is to only use people to do the little parts that the automatic tracker can't and to do that in a real graphical way. So it's not like, you don't have to take a data set and rerun it with different parameters 10 times until you hone in on the right number of fish. You show the person on one screen what the automatic tracker did vs. the raw data and use the person to fix things and go on. He's not retracking the data; he's just fixing little problems.

Marvin Shutters
Adding.

Sam Johnston
Yeah, adding or subtracting or, you know, whatever the automatic tracker is doing incorrectly. Hopefully someday we could also have a program that would learn from the user so the next time the autotracker wouldn't make those same mistakes. But, you know, like Bill says, I don't think it's there yet. Certainly it's there to be able to show raw data and then on top of that different colors. I think ours uses different colors and then a couple lines through echoes and things that tells you which echoes were selected for target tracking and which weren't. It has mostly been applied to rivers. The problem the tracker has is that fish are free to behave, change aspect, and undulate, so you get echo gaps. One of the biggest parameters is what echo gap you are willing to accept. You know, as Bill says, if it's a split beam tracker, it's easier because you can tell if the next echo is on the whole other side of the beam, or if there are linear segments going through the

	beam. At any rate, all those little problems a user can very easily just make changes and examine the data more carefully.
Marvin Shutters	So Gary, what you are doing at Lower Granite, is it somewhat automated or are all the decisions being made by the individual trackers?
Gary Johnson	Zero automation.
Marvin Shutters	Why?
Gary Johnson	I haven't had time to apply tracking, although that's something that we'd be interested in this winter.
Marvin Shutters	I've wondered if that is something you've looked at and rejected, or if you think there's a problem.
Gary Johnson	No, it's just that I have not had time to do it. No, I'd like to investigate it. I just was making a tally to answer my question from earlier. In comparing manual vs. automatic tracking parameters, it seems like the automated tracking is better for consistency and the processing turnaround, but that the manual is better for pattern recognition and perhaps handling of noise. One of the main things I've learned this morning is that even when you do automatic tracking, you have to do the QA/QC. Whether it's going through echoes or using the WES approach, you still have to use some manual tracking with your automated tracking. So, we will never get away from manual tracking.
Gene Ploskey	Yeah, I don't see how you could.
Marvin Shutters	John, I know you have a couple projects, Wells is one of them, where you have the black box system going. Do you know how closely accuracy is checked?
John Hedgepeth	I don't really run the Wells project, but I know that they do check it. I get the impression that it's very infrequent. They may check it one hour per week or something like that but not one hour per day. The system I'm more familiar is in New York State. It uses echo integration. Those are checked on a daily basis. It is a black box system but voltage thresholds are checked regularly. There's no double blind, or no one checking me when I look at this stuff. It's a little bit different than the sweat shop philosophy. (Group laughter) Somebody probably should be checking me.
Gene Ploskey	The hope I see for auto trackers is that you could take on a big project, but have two visual trackers tracking to provide a continuous check on the autotracker instead of 8-10 trackers working full time. If the autotracker is performing adequately,

you'd have it track all of rest of the data. I see saving resources and money.

Tim Mulligan   Yeah, to add to that, we do all our tracking automatically, but it involves looking at the entire set of data. So a typical time investment for that would be, to do 48 hours worth of tracking from two transducers brought in continuously for 24 hours. It might take one man two hours if there are only 50,000 fish passing per day or 5 hours if there are 500,000 fish passing. He double-checks the output from that, and we go ahead. So he's looking at stuff that's passed the signal processing, but we also do echogram generation from the raw signal, sub-sampling through the day. We have those counted manually, and compare those to autotracker counts. So we have a quality sort of assurance program going on simultaneously so we aren't way off the deep end with the automatic tracker. It certainly cuts down the manpower by a significant fraction. We can't afford to have hand tracking when we have that many events…

John Hedgepeth   So it sounds like that kind of system just relieves the tedium of identifying the fish. It sounds like it's very similar to manual tracking in that you might need to have the checker checked. The person that is just using the automatic tracker is doing the kind of thing that a manual tracker does. Look at all the data and then you change this and this and then you get an output.

Tim Mulligan   Yeah, it's not really, it's even more distant than that. He doesn't check each track. He first gets a visual impression of most of what he would have tracked and the physical properties picked up by the tracker. But this is based on a fair amount of experience, he doesn't check to see if a single track has been broken into two and he would have called it one. We did a lot of that to build up confidence. And yes it does split one into two and sometimes it coalesces two into one, that's OK. What we're interested in is the number for some given unit, is it about what he would do by hand. Basically it's very, very close. The other thing the automatic tracking does is it brings your attention to what it is having trouble with. So you don't have to look with the same intent at the entire record. It will bring to your attention those areas where it's having trouble deciding what's going on. So it sort of optimizes the human interaction. The other real service that the human does is handling noise and systematic features that are very difficult. So we haven't attempted to do that in the automatic tracker. It is much easier to have human interaction take care of those problems. We can put filters in for gross noise events and those are easy. Other types of noise aren't easy to characterize. There the human factor recognizes the Y spectrum or scenario quite readily, so it speeds the whole operation up.

John Skalski	What about recommendations concerning cross validating with methods other than hydroacoustics, like fyke nets. We've had an instance recently where less than 1% of the recognized targets were actually fish and half of those were salmonids. I know there is quite a bit of opposition to using fyke nets, but on the other hand, that's probably one of the closer things to reality. Is there any reason for periodically cross checking.
Gene Ploskey	It is done occasionally. The data from John Day that I showed yesterday is an example.
Marvin Shutters	Active capture is much less likely now. Fyke netting days probably are over on the Snake. Gary probably knows more about that. It also is very difficult to get fyke netting approved for the lower Columbia. I would like to see us be able to do some, some netting as cross checks, but we would have to do a lot of convincing of fisheries managers and tribes.
John Skalski	I mean it's a damned if you do, damned if you don't. Do it and you kill fish, don't you may go astray once in awhile. It's a very touchy kind of situation.
Gary Johnson	It's just good species composition for a hydroacoustic study, you think there could be some reason there.
Marvin Shutters	The agencies asked us to do fyke netting for screen evaluations next year to provide species-specific guidance efficiencies, so we are doing that for FGE studies at Bonneville.
Gene Ploskey	Well, why don't we take a 10-minute break. Everybody stretch their legs, and then we'll continue. When we come back, I'd like to talk about applying species composition data to counts from acoustics.

10:27 AM TO 12:25 PM, Wednesday, 9/17/1997

Gene Ploskey	Well, are you ready to start again? This probably is the last segment. Is there any more discussion on automated processing?
Gary Johnson	Gene, I want to make another run at my list. Does anybody have any other characteristics than the four I mentioned earlier to compare manual to auto tracking. We have consistency, pattern recognition, ability to handle noise, and processing time. Are there any others? These might be advantages or disadvantages, however you want to characterize it. I don't think we've done a very good job comparing the two, although I understand that autotracking really is a mesh of both.

Sam Johnston	One of the things that Tim pointed out was that, a lot of times the auto tracker points out areas where you should look, where the data should be reexamined. A manual tracker, especially an inexperienced manual tracker, would just go along and do the best they could but not be aware of a problem. An automatic tracker would blow up and say this is completely wrong, and you could at least go back and check that data.
Gary Johnson	So, perhaps, with the automated approach in combination with quality control you'd have higher quality of data.
Sam Johnston	Yeah, because you would identify all areas where potential problems might occur or where tracking was difficult, rather than randomly select areas.
Bill Nagy	I suppose the automatic tracker could plug into your data processing a little more smoothly. The numbers would be passed right on to the next stage of data analysis.
Gene Ploskey	It'd be good for beating those one week deadlines for posting that preliminary data. Just slap that stuff out there and quality control it later. (Group laughter) After all, speed is the most important measure of quality! (Group laughter and comments)
Gary Johnson	Don't hold back; tell us how you really feel.
Marvin Shutters	I have less confidence in autotracking, until I see it well proven out with a lot of quality control. I've seen Bill's tracker as it developed, and it is getting quite good. But when they first started working with it and running into the problems, you see that you can get off base pretty bad.
Cliff Pereira	You might add black box to your list. I've heard several of you say that the function of the autotracker may not be fully understood or controllable.
Tim Mulligan	Part of the difficulty with many trackers is that they all have some set of parameters that control the algorithm that they use for tracking. Part of the difficulty with many of them is that they're proprietary property and there's not a very good description either textually or mathematically of how these parameters work. There's a large set of combinations that potentially control how the thing tracks. A real step forward is to be public and open with what your algorithm is so users can apply their intelligence to adjust the parameters, rather than blindly groping to figure out how to get the thing to improve its performance.
John Hedgepeth	I think the algorithms are certainly available. They are not hidden intentionally. Wouldn't that be fair to say?

Sam Johnston	Yeah, access to algorithms is pretty simple.
Tim Mulligan	I have yet to see, of the two commercial ones that I have tried, a thorough description, either mathematically or textually of how they work. So maybe the definition of thorough needs to be looked at. (Group laughter) Estimating what a parameter is doesn't necessarily tell you how it works. The one I'll pick on, because I'm the most familiar with it, is from HTI. Their volume expansion coefficient, we know that you adjust that and the volume it searches in to find the point increases. But we don't know mathematically, you know, is that a curvilinear function or is it a linear function, or what? You know, that was never made clear to me, so you don't, and that's only one of half a dozen of parameters that you can adjust and many of them are correlated so that the search for effects becomes very convoluted.
Gene Ploskey	Well that's precisely why we began building our own tracker. We didn't know how the others were working exactly, and when it wouldn't track something, we couldn't adjust it to pick up those fish that we thought it should be tracking. It obviously was time to start building your own.
Marvin Shutters	I think that is important, especially if you started relying on the automatic tracking, to scientifically document the methods thoroughly.
John Hedgepeth	We documented the algorithms. I think the problem was that sometimes the algorithms didn't work the way you thought they should work and then you wanted to add algorithms and couldn't.
Gene Ploskey	Yeah.
John Hedgepeth	From what I remember, we had several pages of user documentation.
Marvin Shutters	I know BioSonics described some of those clearly in the past. There are explanations of traditional criteria for identifying fish traces off of paper, but is there the same kind of documentation available for automatic tracking programs, without having a BioSonics or HTI manual on the shelf.
John Hedgepeth	Well, I think the manuals can be cited as long as you list the source, although it is kind of gray literature.
Sam Johnston	I sort of get the impression that one of the main reasons to make your own tracker is that you can actually change the algorithms, not just the parameters. I think in most cases, most of the algorithms will probably work. I'm just saying that it takes a while to fiddle with those parameters to do it. And

also, as John says, I think it's sometimes surprising, even if you know what it means and what a parameter is supposed to do, when you make a small change, it has an effect that you can't anticipate. And that's just something that goes with experience and it may not be any good to know whether it's an exponential function. I don't suppose it matters now, but...

Tim Mulligan   Actually we wrote our own tracker sort out of frustration. And for the same reason as everybody else, because then we would know exactly what the algorithm is. We also found that a very simple algorithm does quite well. Where the effort's needed is not in the tracking algorithms so much, as in the external stuff, the graphics that it presents. Graphics that let the operator see not one but several presentations simultaneously. That is particularly important when you have split beam data, where you are looking at three dimensional space through time, rather than a two dimensional space. So our effort has focussed upon the graphical environment for editing and quality control, not so much with the tracking algorithms.

Sam Johnston   Our target tracking code is maybe two or three pages. The rest of the program is thousands.

Tim Mulligan   Yeah.

John Skalski   I guess you could add one more characteristic of human trackers and that is that even a very good tracker can become complacent. So the tracker can be working real well, but the transducer has been shifted and he is producing erroneously high counts. Then three days later when you finally check on data you find you suddenly have a high level of passage in that slot. We need routine higher level checks to assure that we catch problems as soon as possible.

Tim Mulligan   Yeah, I think that's an excellent point. Certainly what we've found is that we need to spend a lot of time every day, looking at higher and higher levels of data presentation to make sure that there's consistency and not some anomaly. It gives you the opportunity to correct it in real time, rather than trying to do so post-facto.

Marvin Shutters   That's my motivation for asking for rapid turnaround of data at the Portland District. I don't want it for regional reporting. I want to make the researchers and me aware of problems in the equipment, tracking, or interpretation so they can be fixed before it is too late.

John Skalski   And it may be simply a matter of training our personnel to go to the next level rather than looking at blips on a screen, but looking at outputs of summary data to make sure that it's consistent with what we expect. And we can do that regularly

	rather than weekly, just because the thing's working well.
Bill Nagy	Sounds like the emphasis needs to be on the data acquisition process. The information that you're looking at has to do with the data acquisition and not the numbers that people get later.
John Skalski	Yes. But sometimes we get lax in that middle part, where, you know, it's working real well up here and we have number crunching there, but we don't keep, sort of, our finger on the intermediate part. And it's just a matter, I think, of retraining to include this next level of attention. It's not a problem with the system itself, it's just the personnel and educational system.
Gene Ploskey	Does that do it for automated processing? Did you get finished Gary?
Gary Johnson	Yes I did, thank you.
Marvin Shutters	Are you going to write your table onto a big piece of paper now? (Group laughter)
Gene Ploskey	We've already talked about expanding acoustic counts to the whole cross section of a passage route, whether that's a turbine intake or a spill gate. Sometimes we express counts on a per unit volume basis. What are the advantages in doing that?
Marvin Shutters	So you can extrapolate to unmonitored intakes and spill bays.
John Hedgepeth	They're weighted by volume.
Gary Johnson	What? Passage rates? In some cases that is useful but that is after you get passage rates.
John Skalski	If you want number of fish per minute, per cubic meter of water, you wouldn't analyze that per sampling period and then average it. You would instead calculate the total fish passage and then divide that by the total volume of water that went through the orifice at the same time. You don't take averages of ratios; you take ratios of averages.
Gary Johnson	And that's what we do, we actually call that a fish density. It's the number of fish per hour per cubic meter.
Gary Johnson	We did it for five minute periods, but we used an hourly rate. I have another question. What do people do when the turbine is off?
John Skalski	Not missing data, but functionally just off?
Gary Johnson	Just off.

Marvin Shutters	Then that is zero passage.
John Skalski	Zero passage, yeah.
Gary Johnson	So would you, when you estimate passage per hour for 24 hours, do you include that hour as a zero or not include it because the turbine was off?
Gene Ploskey	You can't estimate an hourly rate for that hour.
John Skalski	You still say there were 10,000 fish that went through the turbines this last hour, the fact that there's one less turbine isn't going to matter.
Gary Johnson	That reflects the actual sum of passage, but that does not take into account dam operations then, if say you're taking these data and doing a horizontal distribution.
Sam Johnston	You do have to weight them by operational time to get a horizontal distribution.
John Skalski	Operational times, yeah.
Gary Johnson	So if you present the data as a total you're ok because an off or a zero are the same thing in the total.
John Skalski	But if you express it as a rate or something on a horizontal distribution, you would want to prorate that by operational time.
Marvin Shutters	It comes back to John's earlier comment that if all of your estimates are hourly by route, then it's how you arrange those building blocks for each hourly estimate.
Gary Johnson	In that case, it doesn't make any difference if you treat it as a zero or not.
John Skalski	Right. So far, we've not had any problems with treating these things as little hourly building blocks. You can build estimates anyway you want once you have those building blocks. Just make sure you're defining your parameter correctly. You know, if you want horizontal distribution, under functional conditions or non-operating conditions, you can find it either way. You're going to put your building blocks together associatively, correctly.
Gene Ploskey	So, you have to define the condition under which you're looking at the horizontal distribution. You could have a different horizontal distribution for every imaginable combination of operational units.

Gary Johnson	That's why we treat it as off, so that there's no ambiguity, or no misconception in the horizontal distribution; It is passage when these units were on. This was the distribution.
Sam Johnston	Yeah, it's great if you have the luxury of having them on all the time.
Marvin Shutters	So, you base your horizontal distribution on a time period when all units are on.
Gary Johnson	Yeah. If a unit is off for an hour, there is no hourly estimate for that unit.
Gary Weeks	From that unit. But you use other units?
Gary Johnson	Oh yeah.
Sam Johnston	You just have fewer samples from that unit than you do from the other units.
Gary Johnson	You have a missing value when a location is on, but you don't collect any data from it.
Gene Ploskey	A count is zero when a unit is on and you don't have any fish going through it.
Gary Johnson	Right that's the third condition.
John Skalski	Yes. I think you're right. There are probably three types of quasi zeros.
Marvin Shutters	Expressing counts as fish per volume of water for each route also can help sort that out.
Gary Johnson	Right.
John Skalski	Right.
Gary Johnson	We did that in '96 at Lower Granite in horizontal distribution, but since our original, or the first approach, was to do horizontal distribution not including the "offs". So OK, that's the horizontal distribution, so that's the distribution of passage when the units were all on. Then, we took the same data and then factored in the volume of water through each hole. The distributions were the same. But if we would have incorporated the "offs" as zeros, then there would have been a big difference.
John Skalski	Big difference. I think the lesson of this, be careful what you ask for, because you'll probably get it. (Group laughter)

Gene Ploskey	Ok, we covered expanding variances yesterday.
John Skalski	Pretty much so. Most of it's very straightforward if you use the unit hour as a sampling block. Then those variances add as you add the blocks of fish passage very nicely. And that occurs whether it's different hours within the same turbine slot or whether your adding turbine slots to slots, or even spill bays to turbine slot passages. The only two minor tricky parts are when you start doing these composite parameters with ratios and stuff, you need to use a Delta method, just go see your friendly statistician. The second complication sometimes arises is when we sub-sample spatially. We're only looking at two out of three turbine slots, and how you make inference to all three slots and what's the variance associated with that extrapolation from two to three. Now you have not only the temporal variability, but you also have some spatial variability, and that's not overwhelming, but you can see a friendly statistician to do that.
Gene Ploskey	Yeah, OK. I think yesterday we also talked some about using the data from juvenile bypass channels. Gary had used it as a method to see that his acoustic estimates were on track at Lower Granite. Tim Wik had said that they kept track of all species of fish at least upriver. We are not sure about that for the lower Columbia, maybe they do, and I just haven't seen the data. This might be a good time to talk about what happens when you partition a total acoustic count into counts by species using species composition information from netting or another source. This is sometimes done in mobile surveys. I know Don did it when he worked with Duke Power for years. They would get a total count from acoustics and species composition data from purse seining and then partition that acoustic total among species. They could then say they had so many largemouth bass, so many gizzard shad, and so on. How is the combined variance calculated?
John Skalski	Yeah, I'll take a simple example. You estimated a million fish passing a dam and the species composition suggests that 30% of the fish are chinook, so your best estimate of chinook passage would be 300,000. Now the variance associated with that estimate should have the uncertainty associated with the passage number as well as the species composition proportion. So, again, we simply use the Delta method, or the variance for a product. Since those two data would probably be independent, you'd be using very different techniques. If they're independent, you don't have to worry about co-variances. Again, it's a fairly simply way of propagating the error of that product.
Gary Johnson	What if there's no variance estimate for species composition?

John Skalski	Then, you have a hard time with propagating the error. I mean one could potentially do something as naive as to say sample binomially, in other words, all fish had equal probability of selection across species and use a binomial PQ over n type variance. That would be the simplest, maybe most naive approach. If you have, for example, in collecting species composition, taken the number of dip nets, you could look at how that species composition varied from net to net when you use the empirical variance among that composition to get an estimate of the variance. So it depends how you collected the data and what assumptions you might want to make in terms of how you would construct that variance for that species composition estimate of 0.3 Chinook. You would need both variances to be able to propagate the overall error. Again, the variance of that product is going to depend on the precision of those two elements. You can get a very precise estimate of fish passage number, and a very, very poor estimate of composition, expect your product to have a very poor overall variance.
Gene Ploskey	The fyke net data that I showed yesterday from John Day at '96. The NMFS had species composition information from one 1-2 hour of fyke net sample each day. Therefore, if I wanted to look at error propagation by day, I would have to have more daily net samples to estimate within-day variance in species composition.
John Skalski	You would, yes, you'd need to have daily estimates of species composition along with daily estimates of that sampling error associated with that species composition estimate.
Marvin Shutters	I'd be leery of using the smolt bypass data for species composition; it is a biased estimate of species composition because every species guides with a different efficiency.
Gene Ploskey	No, I agree. I was just thinking about fyke-net data where sampling is almost concurrent.
Marvin Shutters	No, that would be reasonable.
Gary Johnson	What would you use instead of bypass data? …Bingo. There's nothing else out there.
Marvin Shutters	It's probably the best.
Gary Johnson	Its all we've got.
Marvin Shutters	Well, we got it, it gives you an idea of composition. For example, ammocoetes of lamprey never guide. What region really want us to do is start estimating FGE of lamprey. But, you know, they never show up in the bypass systems, but fyke

nets catch lots of them.

Gary Johnson   We used to catch tons of them.

Tim Wik   They show up in our bypass system.

Marvin Shutters   They do?

Gary Johnson   Well, the first dual-beam experiments were on tethered lamprey. Janusz Burczynski did it. About −72 dB target strength, as I recall. (Group laughter and comments)

Don Degan   Gene, when we did the population estimates and mobile surveys, generally we had to go to a purse seine sampling because the variance within the gill net catches is so high that we didn't get a very good variance estimate for the population. I've always used the product of variances calculations. I don't know if there's a better way or not. But, that's always been, that was always the big problem I had with sampling with gill nets where I was catching a small number of fish, you know, relatively speaking. Less than 100 versus thousands of fish purse seining, so I could come up with a much better idea of what species composition was and the variance from the few purse seine samples than I could get with many gill net samples. This past year at Bonneville Dam the biggest problem I saw with the data we were collecting in mobile surveys was that at certain times the majority of the fish we were seeing along the face of the dam were not salmon. But how we separate those out and make a somewhat accurate estimate of what's out there.

Gene Ploskey   Yeah, I know that's particularly true once you get into June.

Marvin Shutters   You're concerned about squawfish or adult shad? I think they would be the fish you would be most likely to run into. If you're using split beam, your target strength data might be used to limit an upper end of the size of fish that you would accept?

Don Degan   I don't think it would be helpful.

John Skalski   One comment you could make with regard to species composition is if, for example, you tried to get total passage of chinook across the season, it would not be appropriate, necessarily, to get an overall passage for all the fish that went past the dam for that season, and then multiply it by the average, or a point estimate of species composition. If species compositions varied across the season, you'd want to make those corrections on a finer scale. You know, weekly or daily, and you won't get the same estimates. And so if you're worried about species composition and you know it's changing

through time, I'd be sampling species composition in the, in the scale that it's probably changing. You know, you may not have to worry about hourly or even daily, but maybe weekly or something like that. Go out and then make your adjustments on that scale. But to assume that taking the total passage multiplied by some overall seasonal guess is going to give you a crude estimate. And by that, I mean more in terms of bias than precision.

Gene Ploskey | Well, a couple of criticisms that you hear from resource agencies about acoustics is (1) what is the species composition, and (2) "Oh, that is hydroacoustic data, which is somehow tainted." This is part of the reason for this workshop. Some of them have a knee jerk reaction to acoustics as being inferior, and yet we know it correlates with other methods. So it's probably an education issue. We do a good job of educating each other; I've certainly learned a lot in this workshop. People with resource agencies and the public usually are not users of acoustics. Maybe that will change in time. I don't know that we have done a good job of educating them. They think "Counting fish is easy," right? Anybody can count, and yet this is really a complicated methodology.

Don Degan | When we use another gear type to sample species composition and partition total counts among species, we include the variance on that sample. However, if we use a threshold for smaller or larger fish and only count a portion of the total, then we probably should use the same approximate threshold for lengths of netted fish.

John Skalski | Probably so. If I understand your question right. You set a minimum threshold for a larger size fish, then when you come to species composition, hopefully you know what that threshold is in terms of fish length, and you're estimating the composition above that threshold. Otherwise, you definitely have a bias. So, and I think that's a very good point. You should know what threshold sizes are, so that when you start doing species composition you know what domain you should be sampling. Not all fish in the fyke net, but all fish above some target strength size.

Tim Mulligan | I was just going to amplify the discussion relative to the comments you make about the variance. Certainly, what our data is used for is not by itself, it's multiplied by species composition, sometimes a stock composition. Therefore, the total error is much larger for the number of fish-like objects that were moving upstream. And insignificant attention, in my mind, is paid to the latter, which is species composition. We've done all kinds of things about trying to have systematic or random sampling of the one, but the other you throw a net in at one place at one time and you get a composition, then

	people sense that it is accurate. If it's the final answer that is really important, equal care should be taken in estimating species composition, and how representative the sampling is from there as in the other, since the answer is the product of the two.
John Skalski	The variance is as well.
Tim Mulligan	That's right.
Don Degan	But those are real fish, I mean there's no question that those are real numbers. (Group laughter)
Tim Mulligan	Certainly. Certainly the one great advantage acoustics has is that it is much, much, much more reproducible than most types of catching. And, you can talk about acoustic detection probabilities versus size, or where the fish are. You can't even talk about those kinds of things in terms of most catching type scenarios. So if the final product you guys are interested in is the product of those two things, you need to equally emphasize netting.
John Hedgepeth	Well not equally but according to their variability.
Tim Mulligan	That's right, right.
John Hedgepeth	You have a lot of variability in your species estimates.
Tim Mulligan	Yeah, even the time and location in which samples are taken, and for you guys it's the time of passage. For us where they're all coming by the river, it's the time and where in the river they're caught. We had some evidence that lead us to believe that species will migrate the same places in the river. Yet test fishing assumes there's a uniform distribution over the entire river cross section. I have a real problem for that. I guess I would just emphasize that the catching needs to have the same types of attention brought to it about spatial distribution, temporal distribution, and catchability that we apply to the acoustics.
John Skalski	Yeah, your bottom line is no stronger than your weakest link. A number of us were at a riverine acoustic study up in Alaska, where they're trying to get counts by species and having this two phase process, hydroacoustics estimating passage numbers and sampling to estimate composition. They could not differentiate how much of the overall certainty or uncertainty was associated with the two aspects of the study. So it was very, very hard to then say how to improve the study. Which component should you go after to obtain an overall better estimate?

Tim Mulligan	Yeah, it's often true they do the fishing at one particular time during the day at one particular spot. So it's all the bad things we try to avoid with hydroacoustic samples. You're now lumping all those bad features into your final answer, because you haven't taken the same care with the catching as with the acoustics.
John Skalski	Unfortunately the blame is smeared across the whole.
Tim Mulligan	No, it is focused on the acoustics.
John Skalski	The acoustics! (Group laughter) More often than not you are correct, it's going to be blamed on the acoustics, because that's not real fish in hand.
Tim Mulligan	Yeah, anything that's remotely sensed has that taint about it.
Bill Nagy	I think what we do is we do our studies when the passage is presumed dominated by the species of interest and quit when it's not. Like an FGE study where most of what's coming through is juvenile salmonids. When that's no longer the case, it's time to stop.
John Skalski	I think we've been very fortunate that we can play that game, and play it successfully and estimate sufficient information to date.
Bill Nagy	It is, but it isn't. I mean, people really do want to know what's the FGE for sockeye.
John Skalski	This is a moving envelope. You give me an FGE, now tell me a species specific FGE.
Marvin Shutters	Its like you said, the seasonal FGE we can do pretty well and get some good precision on it. But when you get down to the sockeye coming through, you only have a week or so, maybe two weeks. It is a much shorter run than summer chinook. The run in the first couple of weeks of the spring is dominated by steelhead. You don't have many days to sample when the composition is dominated by one species.
John Skalski	In those situations like that, where there's going to be pressure to try to get the species specific estimates and you know you have different windows, there's absolutely no problem in sampling theory that says you can't sample more minutes during the hour or more time during that window to get better precision. You can still combine these data with the other data from the other weeks to get an overall seasonal estimate. Don't worry about having equal sample sizes, things you are harped on when you want to do t tests test. That doesn't count here. If there's more importance, put more effort there, and

you aren't penalized at all. So I think you could differentiate your effort if you had these different windows. You know that for one species you have a two or three week window to get an overall estimate, while for another you've got one week, you might want to inherently move effort within the hour or places during that period of time. There is absolutely no statistical penalty at all for doing that. We will not slap your hands for unequal sample sizes.

Marvin Shutters	Because you're making an estimate.
John Skalski	We're making an estimate, not a hypothesis test, yes. (Long pause) I think we're ready for a break. (Group laughter and comments)
Gene Ploskey	Before we go, can we think of an index that accounts for the efficiency of acoustic detection among transducers so they are equalized.
Gary Johnson	Gene what did you have in mind for how we measure detection efficiency? Maybe I misunderstood what you're getting at.
Gene Ploskey	I was thinking of detection modeling, before you start and throughout the year. Then presumably, if you have a certain number of expected echoes from a fish and a certain trajectory, you would hope that it would be observed in your data to provide feedback that your modeling effort was accurate. Does that make any sense?
Gary Johnson	Yeah that does. But how would you measure detection efficiency?
Marvin Shutters	Gary wants an answer to the question.
Gary Johnson	It's a question to the group.
Gene Ploskey	That's why all of your giant brains were brought in here (Laughter and comments)
Bob Johnson	So this is a QA/QC thing where you've determined the detectability of your system and presumably you're checking this. I guess, if I understand, what you're saying is that this efficiency should be some comparison with that predicted detectability?
John Hedgepeth	So you want to measure the average number of pings per fish and see if that relates to the average chord through your detection cross section.
Gene Ploskey	Some correlation there would be desirable. You'd know that your detection was on track.

Bob Johnson	And this should feed back into your, your processing steps in a key way... I think that's a good point because I think there needs to be a loop in there. The detectability is probably the most important thing that's been talked about here.
Gary Johnson	Well Gene, when I was asking about detection efficiency and measuring it, I was thinking like in a pit tag system where you have multiple readers, multiple coils all in a line, and they come up with an efficiency, and they like that to be really high usually. That's what I was thinking of in terms of detection efficiency, that type of idea.
Gene Ploskey	I'm focussing on uneven detectability among transducers deployed to measure horizontal distribution for example. Differences in the actual detection among transducers is important.
Gary Johnson	Right. If they do not have equivalent detectabilities then you've got a problem, and you have to account for that somehow. So you set them up so they do.
Gene Ploskey	I guess if modeling shows that detectability is not equal among transducers, you could expand counts by the ratio of the slot width to each transducers effective beam width at range, as determined from detectability modeling and empirical data collected to verify the model.
Gene Ploskey	Tim did you have something...
Tim Mulligan	Yeah, you made a statement that triggered the following comment I'm going to make. I'm going to change the subject. Talking in terms of detectability and looking for evidence of consistency, there are certainly some checks that you can make even with a single beam system. You have models that talk about mean number of echoes per depth interval or something like that. Actually, what's important is the distribution of echoes per trajectory. You can make a model that will give you a distribution of expected echoes per trajectory, assuming that fish have a uniform distribution over the beam cross section. You can check your data to see how close to the distributions that you get come to that. When the fish are non-uniformly distributed, what you'll find is a significant departure from that. For example, if they're largely near one edge of the beam, you'll find a lot more low numbers per fish trajectory than you would otherwise. So that your data can be examined to give you an indication of some sort of failure to meet the assumptions.
John Skalski	I have seen literature somewhere that talks about how you can use the data internally to check the validity of some of the

models.

Gary Johnson   What are some other ways? (Group laughter)

Sam Johnston   If you had a split beam you can take it to a different level.
                 There are a lot more variables you can look at that actually
                 position across the beam.

John Hedgepeth   Yeah, with a split beam you can do it on an individual chord,
                 and with a single beam you can do it with an expected chord.

Tim Mulligan   Yes, certainly the other thing you were talking about is
                 detectability. One of the nice things about acoustics is the
                 many features can be isolated. So that you can measure under
                 one set of circumstances, say, typical signal to noise regime
                 and typical target you're going to look at. You can figure out
                 what detection is under somewhat controlled conditions. That
                 will apply usually in the field, unless something different was
                 going on. It is much more repeatable than many other types of
                 measurements. So that you can isolate those types of events
                 and you have a chance to measure. That's what we've done, is
                 measure fish detection probability while hanging a fish on a
                 frame and moving it around within the beam right at the site
                 where we're doing the measurements, so the signal to noise is
                 very typical. You have a lot going for you in the ability to
                 model and partition many of the features of the measurement
                 process. Certainly that should be applied and then checked for
                 consistency versus the data. Was the data actually meeting
                 these assumptions? Does it show the characteristics the model
                 assumes.

John Skalski   Just to add to that, at least in my mark recapture field you'll do
                 that. If it the model assumptions hold, then you're reasonably
                 certain you're getting correct absolute abundance estimates.
                 Conversely, if you show a systematic bias off the norm, you
                 show that to be the same in two different places, you can at
                 least use those as valid indices relative to one another. Which
                 may be adequate for FGE, guided and unguided. So whether
                 you have a model violation or five model violations, as long as
                 they are the same for guided and unguided, you're still in good
                 shape in terms of getting the ratio, and that might be adequate
                 in some situations. But I think that it would be very nice to see
                 more of that coming out in the analysis.

Tim Mulligan   And with so much of the data electronically amenable now,
                 you have the ability to examine those things in much more
                 detail than you used to in the past.

Gene Ploskey   Bill, you have a detectability program that plots the beam
                 pattern and then you shoot fish through that beam. Can you
                 describe how that works?

Bill Nagy	It's Monte Carlo. It modeled the acoustic beam and then we had fyke net distributions of fish at the Dalles one year. So we drew fish randomly out of those distributions in a noise free model. You put in mean target strength and then you randomly drew target strength from a Rayleigh distribution of target strengths centered on the mean. You also could change the velocity of fish moving through the beam.
y John Hedgepeth	Except your TS varied. Your have an independent sample of TS?
Bill Nagy	Right, it was a random sample from a Rayleigh distribution.
John Hedgepeth	Per ping or per fish?
Bill Nagy	All the fish were assumed to be of one size. No, that might have even been in there too. The fish size came from a normal distribution centered on some fish size. Then the echo strengths or target strengths came from a Rayleigh distribution, and then that was per ping as it was going through, you would give it a different echo strength. We took different configurations of beams in the turbine intake and looked to see how it counted. It was graphical. So you'd see where, like at short ranges, if you made certain assumptions, like fish speed and number of pings, that it was missing fish.
Marvin Shutters	What we used it for was to get an idea of the sampling accuracy and variance during the time concurrent with fyke net sampling or taking the same distribution of fish and running the model for an extra two or six hours beyond the end of fyke net sampling. We also tested a 12 degree beam, or using three up-looking 12 degree beams and two down looking beams and seeing how the accuracy and variance changed.
Bill Nagy	The thing it didn't have was noise. So, it unrealistic in that sense.
John Hedgepeth	You need to have at least random noise.
Bill Nagy	Random noise, yes.
Tim Mulligan	I certainly applaud that very type of approach. I think that's the real strength of the acoustic method. The measurement process is a stochastic process and can be modeled with many of the techniques that are currently available. You used those models to examine the data for consistency to make sure that the fish indeed are behaving and your instruments are behaving the way you supposed they were.
Bill Nagy	I think certain consistency checks would work better in a

mobile environment than in a fixed aspect deployment. Like for example, the velocity of the fish coming through the beam can usually be controlled better in mobile sampling. Just like you talked about doing in a laboratory. But that's another possibility, that you could fix some of the…

Tim Mulligan   Yes.

Don Degan   Is anybody trying to inject anything into an intake? We were validating fish passage on Buzzards Roost. We tested net efficiencies using the potatoes, putting them through the turbines and using hydroacoustics at the same time. We counted potatoes with the acoustics and the nets. Couldn't you do the same thing with the noise levels, if you had a surrogate for a fish, replicate samples several times at different noise levels.

Don Degan   Fish don't work at all, dead fish don't work at all with, in that situation with hydroacoustics, because they tumble and the aspect changes dramatically, which is not a natural situation. But potatoes seem to work pretty good.

Gene Ploskey   What kind of an echo do you get off a potato?

Don Degan   A pretty good one.

John Skalski   Potatoes are better.

John Hedgepeth   Baked potatoes or raw? (Laughter and comments)

Don Degan   We basically sent, you know, we put in 50 potatoes into the turbine and counted what we saw in hydroacoustics and what came out the nets under different flow velocities.

Gene Ploskey   My interest was in the standardization of detection among transducers to facilitate accurate estimates of horizontal distribution. If I understood Gary Johnson correctly, they don't worry about trackable time because they expand numbers for the time they could count to a full hour.

Gary Johnson   Yeah, we had different scales.

Gene Ploskey   Do you account for the volume of water going through the structure?

Gary Johnson   Well, like I said, we don't use the volume, we use a time basis. For example, if we expect to sample three intervals in an hour, but one was completely filled with noise, then we'd note that we only did two, and we expand temporally accordingly. And then, on a larger scale with respect to noise, if you have five hours in a row, I'll use this as an example, where you just

sampled noise, that's no data. Then afterwards we may go back and estimate counts for the missing hours by regression or interpolation.

Tim Mulligan   So you're extrapolating on a volume average, you're extrapolating to an hour.

John Skalski   Right. If you used two slots to correlate the passage between two slots and then used the slot that had continuous data to fill the holes for the slot that had missing data, something of that nature.

Don Degan   That would be the easiest thing to do if we could show the fish density was independent of noise.

Gene Ploskey   That's the assumption that underlies the way we handle temporal expansions, that fish density is independent of noise.

Marvin Shutters   When you have unmonitored turbines or spillways, how do you get the estimates for passage through those for the entire structure?

Sam Johnston   Traditionally, it's been done to interpolate between the ones that are monitored.

Marvin Shutters   By volume of water?

Sam Johnston   Generally it's by time because there isn't a lot of variation in the volume of water. Turbines are on or off.

Marvin Shutters   Ok, so if they're on, they are interpolated between the adjacent units?

Sam Johnston   Yeah.

Marvin Shutters   Ok, I wasn't sure if that was the approach, or if you're saying you're randomly sampling the spill bays so your mean rate for the, for the structure would be applied to what you didn't monitor.

John Skalski   I think it's important depending on how you did the selection. If it were a random sampling, then you would just take the average and blow it up proportionately.

Marvin Shutters   I guess what I would think, what would want to look at is the horizontal distributions you see in the monitored ones and see if there is a pattern.

John Skalski   You could, if there is, and certainly that's another piece of information that you would think would improve on the extrapolation or interpolation, absolutely.

Bill Nagy	Do you avoid covering the ends?
Sam Johnston	Yes, whenever possible.
John Skalski	In my experience we have done that as well. Because, again, people want these estimates and confidence intervals to include the whole uncertainty associated passage with that project. Therefore, you can't make inferences to part of the dam you didn't sample.
Marvin Shutters	That's right and in most cases, the ends usually have higher rates. If you start applying rates from the middles to the end, you're going to be off base.
John Skalski	Way off base, yes. That's why I tend not to want to average or extrapolate. I'd rather sample those end intakes, particularly if fish densities are high. If I have a unit with high fish passage, I'd rather put a transducer in each of the three slots, because that appreciably decreases the amount of uncertainty associated with that extrapolation. Slot to slot variance often is huge, even within the same unit. It's amazing.
Don Degan	Does net data show the same thing, higher passage rates of salmon smolt on the shoreline?
Gary Johnson	I think typically that they sampled an intake, and so it wasn't as if they could get a real comprehensive horizontal distribution.
Marvin Shutters	Yeah, in most netting studies it is only done one or two intakes a year.
Gary Johnson	From, gatewells though, they have indication of horizontal distribution of passage, for what that's worth.
Marvin Shutters	And radio telemetry also can show that too.
Gary Johnson	Like south shore at John Day Dam has high rates.
Marvin Shutters	Right.
John Skalski	In terms of sampling, you use simple random sampling in one or two instances. Either where the environment's uniform or when you know very little about it. But as you get increasingly informed about the system, you can always improve upon the performance of your study. Therefore, simple random sampling is the naive person's fall back. What we know is that units are different so we block on units, we know that spill bays are going to be different, so we block on those. We take into account as much information as possible

	to try to improve those estimates. When we learn that there is higher fish passage in some areas than others, we have reason to put more sampling effort in those high passage areas.
Marvin Shutters	One thing we've done some of is, the first year of a study at a location, outfit almost everything so you can get an idea of the variability, and you can get your sampling schemes for future years.
John Skalski	You can back off later. When we moved a transducer or two at Wells Dam, we still had building blocks that were very additive. It wasn't as if we had to scrap the first week's data because we redesigned it from the second week. It just happened that the first week's numbers had more noise that the subsequent weeks. The study was improved subsequently. Don't be frightened to adjust in season. I think the only thing worse would be that know you have a noisy program and you know that you can improve upon it, but you don't do anything about it.
Marvin Shutters	Yeah, we've certainly done that when we weren't getting data.
John Skalski	The thing is there's a lot of motivation for that latter scenario, because so often people slap our wrists and say, you know, "We're doing monitoring, don't change it, because otherwise we won't be able to compare." We aren't trying to look for trends, we're trying to get overall best estimates over a season or something, so adjust. It is a different goal from long-term monitoring, so respond appropriately or accordingly.
Marvin Shutters	Another thing that we haven't touched on really, is monitoring passage into sluiceways or surface collector openings, equipment is deployed upstream of a near surface opening in a forebay. How do you take your counts of what's passing? Gene used a split beam at a sluice opening. He assumed that fish passing within ±45 degrees of straight downstream were headed toward the opening and any passing within ±45 degrees of straight upstream were passing upstream. He subtracted numbers moving upstream away from the opening from numbers moving downstream to estimate the downstream flux of fish. Should you be using one half of the beam to look at the flux? Do you any comments on that?
Gary Johnson	Comments on how to do it?
Marvin Shutters	How it should be done?
Gary Johnson	From what I've heard in the last two days, you need to put a split beam in. Seriously, seriously, a split beam would be a better way to go. I guess I'd add to that, in a place like Lower Granite where we have vertical slots you need both up-looking

Chapter 2 – Workshop Transcript

and down-looking transducers. Especially with those narrow beams. Getting back to Gene's idea of the down river site with the vertical distribution not being as surface oriented as it is upstream…

Marvin Shutters   Because the surface is so close to the bottom.

Gary Johnson   Because you don't have as much water column, right. Then you need to sample up and down with something, something that gives you some sort of directionality in the hole. You put the thing as close to the hole as you can of course.

Gene Ploskey   When we used that split beam, you had to have a model of how fish would pass. What I finally wound up with was the flux of fish headed in the downstream direction, because there were smolt sized fish, going upstream, downstream, and laterally across the beam, which was a single up-looking split beam. Unfortunately, we could not aim the beam any closer than about 4-5 m upstream of the weir opening because the project had placed a trash rack in the slot 3 m upstream of the weir for the safety of the mobile hydroacoustic crew. We simply couldn't tuck the beam up close to the surface opening, which varied from 1-m deep. We also happened to have four underwater cameras with 52-degree, wide-angle lenses mounted on the upstream side of the weir. We could not correlate the split beam estimates with the camera counts of fish going over the weir. I think that the dilemma was that the beam was too far away from the opening. The downstream flux of fish was always positive. There were always more fish going downstream than upstream, but the flux was not accurate relative to intensive camera counts.   So even a split beam can be unreliable if the beam is not close to the opening.

John Hedgepeth   It's a pretty small opening right?

Gene Ploskey   It was 6.4-m wide and averaged 1 m deep. We had the split beam down 12 m deep on a pier nose looking back up toward the surface so the beam diameter was only about 1.5 m relative to a 6.4 m wide intake.

Marvin Shutters   Two things on that. Not only were they upstream, but video cameras showed that there wasn't a uniform lateral distribution; it was skewed two to one toward the piers. So, if you use a split beam in that situation and didn't have cameras, you would be assuming a uniform lateral distribution and would be incorrect.

Gene Ploskey   The biggest problem was that we needed to place the beam closer to the opening and couldn't because of the upstream trash rack.

Sam Johnston	Wouldn't the split beam show you that the distribution wasn't even across the beam?
Gene Ploskey	I don't believe we looked at that.
Bill Nagy	We didn't look at it.
Gene Ploskey	Fish were going every which way through that beam. Bill has a barrel display and a vertical display. In these, you can watch fish going every which direction through that beam.
Sam Johnston	At one project we sampled, we had transducers looking up at what are called fish portals. The portals are only about eight feet wide and six feet deep, and there are four different transducers. Operators turn the portals on and off with different flow conditions. We actually use the trajectories of fish to catch errors in operations records of portal status. Fish generally move along the dam and when one of these things is open, you can actually see the fish going through, and you can watch those trajectories. Sometimes they don't tell us when they turned a portal off, but you see fish going past it into the slots. We do have enough range that we can get the beam to cover most the opening and we can get very close to the opening which has a very smooth wall. So in those situations, you know, it can really say something. But that has more to do with just pure deployment issues. Can you cover the thing and get close to it. Something else that is nice is that you can tell how close you really are by sticking an object out there until you see it and know how far off axis it was.
Gene Ploskey	We tried to take some flow measurements at that location to see…
Sam Johnston	how far up the flow that extends.
Gene Ploskey	If I had to do it over again, I might try to do it from the side, although the beam would have been very narrow. But you get something that's 21 feet wide and three to six feet deep. They are just hard to sample effectively. Also, the trash rack upstream of the weir would have to be removed because it generated a lot of entrained air near the surface.
Sam Johnston	You might also try an elliptical beam to increase your detectability. But there are limits, that's for sure.
Marvin Shutters	In any case, we had the cameras there. This was a good example of how we got information even though it was difficult to get your beam where you want it. Anything you can think as a backup technique to lend support to your data needs to be done. Perhaps it's up to hydroacoustic folks to point out to people like me that they might not be nailing it.

Can you help us come up with another technique? Maybe find some other study to back up monitoring or maybe you need to do some video sampling or something like that.

Another thing we mentioned a few times but haven't really talked much about is reporting. People moaned about reporting but also brought up instances where getting quick data turnaround, you know, help relieve some problems or some bad data. Everyone probably agrees that getting your, your first cut of data analysis done pretty quick helps you catch errors or problems creeping into your data. What I'm more interested in is what is a realistic reporting schedules? How quick is it possible to have data that is really hammered out and accurate before we put it out and make decisions on it. But you know, on the other hand, we have to be making decisions to meet the regional demands in fish protection and keep on schedule. I'd like to get some input on just what is a reasonable time frame for reporting.

John Hedgepeth   What do you need? What would you like?

Marvin Shutters   People are in the process right now in designing a corner collector for B2 powerhouse, it'd be awful nice to have all the final report with all of the mobile, sluice chute, and Unit 11, if you guys were comfortable with it, two months ago, while you were still collecting data?

John Hedgepeth   I thought, I thought you were talking about daily versus weekly.

Marvin Shutters   No, I think that's scale of daily or weekly is just a quality control issue. I've probably talked with several of you personally in the past about demands from the agencies for weekly reports or daily estimates of passage. I just say that leads to bad science. What are you going to do with the data and try to avoid distributing it. However, my boss has been known to take preliminary reports and distribute them to the region with bad results on a couple occasions where studies were killed. So that is one issue. What my real interest is just what is kind of reasonable time frames to be asking for preliminary reports and final reports.

Sam Johnston   I think at least a part of that has to deal with cost. I mean if you only have to write a final report, that is going to cost a lot less than if you have to produce daily or weekly reports. That's because you have to have more people scrutinizing the data, and you have to have to do quality control on an ongoing basis. This requires more people out on the site at the same time. That's something you look at pretty hard when you look at what the reporting schedule is. What the manpower requirements are going to be, and that translates into cost.

	Daily reports are not unreasonable, but it costs more.

Bill Nagy	I think if the methods are well established or you've ironed out the problems in data acquisition that makes a difference. I think a lot of times we encounter new problems that weren't anticipated that end up slowing down the analysis.

Gene Ploskey	It also makes a difference how long you've been doing something in one place. Because I know when we go in and we do a study some place for the first time, all of the programs for analyzing the data, SAS programs or whatever they are, have to be written and tailored to that area. So actually, it takes weeks of programming to get set up for one project. Then if the next year, you are off on a different project, you're again adapting all of those programs to the new project.

Bill Nagy	One thing we talked about is that we can collect more data than we can analyze quickly. Considering more sub-sampling and using automated tracking feed into the equation to keep cost down. Autotracking is much, much faster that visual tracking; it just needs to be developed to the point where it is reliable.

Gary Johnson	Right. Marvin, I think you have to ask yourself what level of risk of having some bad data is reasonable when they're asking for rapid turn around times.

Marvin Shutters	None.

Gary Johnson	We don't like to do dailies. It is not logistically feasible, unless your doing a study on weekdays. It doesn't work on weekends, you start running into all sorts of problems. But weekly, a week's turnaround, seems to be reasonable. I wouldn't want to do it any sooner and actually would prefer a little longer. But when you do in season reporting, there are going to be errors in it. We explained that to the Walla Walla District. We do everything we can in this basically real time and do the best job we can. But as we've talked about here today, often times you don't see something until you have 3, 4, or 5 weeks worth of data, and then you start to see something that doesn't look right. So as long as the sponsor understands that errors can occur and frankly probably will, then those weekly reports can be useful. In other words, if they're taking them with a grain of salt.

Marvin Shutters	Right, and why I don't like them distributed to the region, because if they see spill efficiencies are lower than expected, they're going to be wanting to increase spill levels the next week.

Gary Johnson	Well, that's something that the sponsors and the Corps of

Engineers need to have set up with other agencies too. I mean, are these data going to be used for operational decisions. They haven't typically done that at Lower Granite. They have not operated Lower Granite Dam based upon our data in real time during the season.

Marvin Shutters   There's certainly pressure to but I don't know about Lower Granite.

Gary Johnson   In the old days we used the spill efficiency and spill gates were opened and closed on hourly basis.

Marvin Shutters   Right, right it used to be that John Day was operated that way.

Gary Johnson   But, that's a different situation. But then another aspect of the reporting comes up with the, with the so called preliminary reports. Again, it's farther out in time, but there's a point where you need to be cognizant, as Sam pointed out, of the cost of those. We understand that there are some major decisions to be made by certain dates in summer at Lower Granite. So our reporting was tailored around that schedule, and so they have got to make a decision, do they want the best information we have at that date, and that's what happens. So that's not driven by any researcher; that's driven by the process that these structures are being designed in. And so we do the very best job we can. But frankly, we put out a report July one, then we had another one due August one. In the course of that July time period, we reanalyzed all the data and now I tell people to literally discard their July one report because it's no good. So that's, I mean that's part of the risk. The trends were still there, but the magnitudes of some of these numbers shifted. I don't think any bad decisions were made. I'm not sure any decisions were made, probably. But I think was part of the process, but it was well understood between the contractor and the sponsor what the deal was, so there wasn't a bad scene in the sense of hard feelings or anything, it's just part of the deal. These reports at truly preliminary. The July report was just a mess of data, and we say we put transducers here, here, and here, but we don't describe any methods to speak of; there's no interpretation; it's just the data. The next report was more of a rehash of the data, but it includes a statistical analyses.

John Skalski   The means, and graphs, and that kind of stuff.

Gary Johnson   The confidence intervals get put in, add some more detail about what you did, and maybe a little bit of interpretation. It's only the, the big report for Lower Granite this year will be the November 17 draft final report, which is a nice time frame. I mean we stopped collecting data in August and produce a draft final report in three months. From a research point of

view that's not a lot of time, but on the other hand, it's doable. I guess one aspect of that is since we've done the previous reports, we have kind of have a leg up on the draft final report, so to speak. So it costs more to do the preliminary reports, but frankly I think you might get a little bit better product in the end.

Marvin Shutters   You might get a little better product in the end because you did the preliminary?

Gary Johnson   Every one of us, I'll bet, in this room has done the crash and burn to do a report. And we'll probably do it again, it's just that the crash and burn aren't as severe if you've already done a couple of preliminary reports.

Marvin Shutters   OK.

Sam Johnston   Preliminary crash and burns. (Group laughter)

Gary Johnson   Yeah, mini crash and burns.

Marvin Shutters   Ok, so you've said they help you get a higher quality final report, and they provide some input into the process. However, in season reports do add to costs and maybe some headaches and frustrations.

John Skalski   They provide a lot of feedback though too. You're getting a lot of internal feedback during the whole process, so hopefully that last report or semifinal report, you aren't getting major surprises.

Gary Johnson   Yeah, we used statistical review after one but before another.

John Skalski   And that helps. My experience after 20 years of research is that you need at least as much time in analysis as it took for you to collect the data in the field. So if you have a months worth of data, the very bottom line for me is, I need a month to get the report out. And that's the fast track. And I usually like another multiple, and two months would be much better. A factor of three would be a leisurely and rarely observed luxury.

Gene Ploskey   Well, I think a good example is last year, they had the, the annual review in early September? In preparing for that, which is generating graphs and making interpolations and for not just acoustic work but other work that we did is time consuming. In rushing to meet that early deadline, we found a lot of our results changed between the preliminary and the final report. Most of the preliminary analysis was done in an absolute frenzy. I can see how preliminary reports of data that have been processed without a lot of interpretation could keep you moving toward a timely final report and may help identify

	anomalies in the data. However, it may be a waste of time and money to ask for a preliminary report with data interpretation that's not likely going to be consistent with the final interpretation. We have to allocate everybody on our staff to generate those kinds of reports, and we obviously cannot handle incoming data at the same time. It is a huge drain on resources.
Gary Johnson	That needs to be communicated and decided upon between the sponsor and contractor way up front. Not "by the way we're having this General coming in for this review with the agencies and tribes. Could you just give us everything you have up to this point." That doesn't work. If you decide on what the reporting schedule is you're far better off in terms of management.
Sam Johnston	And what goes into those reports.
Gary Johnson	Right. Another thing that we've done to expedite the reporting process, since there's a lot of information goes into these reports, we've done what we call an automatic reporter. We automatically generate the reports. We do that using the internet or I should say internet tools. Basically some scripts are written that go to an FTP site and look for a set of files. Each week we send over these analyzed files. The scripts grab those files and formats output for a web site. The Corps of Engineers in Walla Walla used that site to receive their reports. If they wanted hard copy, they could use a feature called a report generator which consolidates the various pages and prints them for you as a post script file or whatever. The CE was concerned about people getting the data that shouldn't be getting the data, so we had to institute a password protection program. Basically, what Walla Walla wanted to do was to look at it themselves and let NMFS, Portland look at it. The web site was good because we didn't have to FAX and Federal Express a lot of paper around, but the biggest advantage to us was reduced time to compile and assemble reports. I mean, when you start doing weekly reports it really gets monotonous. So the automatic reporter really helped.
John Hedgepeth	What did the site contain?
Gary Johnson	A giant set of files; a lot of stuff.
Bob Johnson	A lot of graphics and...
Gary Johnson	A lot of big intense graphics.
Marvin Shutters	So you had macros or something written that just took your data set and generated the plots based on the new data set.

Gary Johnson	Right, I think they're called CGI scripts.
Sam Johnston	Just threw them on a graphic template.
Bob Johnson	Some of them; others were passed to the site.
Gary Johnson	It seemed to help in the reporting. We had 13 or 14 weekly reports over the 96 day study at Lower Granite. By the end of the study, it was just kind of automatic. What we did was have someone go through the data, and then I'd look at the data and send it to be posted. Then, the Corps looks at the data, and they decide what they want to do with it. By the end of the study, they went ahead and opened up the pages for everybody to look at.
Bob Johnson	Dan Kenny initially had password control, and could limit access to the site.
Gary Johnson	Yeah, it was a policy decision on Walla Walla's part. He'd go home and look at it at night after work, because he could tell by looking who tracked it. (Group laughter and comments) I guess I had a question. Is this a trend that we want to…
John Skalski	foster?
Gary Johnson	We've pushed our limit. It's been good because the Corps has understood there could be errors in the preliminary data reports. But I guess I have a philosophical question that I'd appreciate you guy's input on. Is that a good idea?
Bob Johnson	Are you talking about the reporting?
Gary Johnson	The reporting. The fact that there's going to be, there's going to be some things wrong.
John Skalski	Well I philosophically have a problem reporting anything less than 100% of the time it took to generate. At least a one to one factor, anything less than that I think is unrealistic and dangerous. You know, a week's worth of work takes at least a week's worth of analysis. Anything less than that I think is dangerous and irresponsible and unreasonable on the sponsor's basis. Two weeks is more, I think, more close to what's humane and probably closer to all the time you need to have, i.e., a two to one analysis to generation time. That's just my philosophy. My repeated observations of your projects and other projects I did myself suggests that pushing those time limits creates problems. Personnel problems, quality problems, and I would not work for a sponsor that wanted something less than a one to one ratio of data collected to analysis. It is dangerous.

Gary Johnson	It may be better to collect a weeks worth of data and then have two weeks to report it?
John Skalski	I think so. That seems to make it easier for the personnel to do in the long run. I think it also has a better chance of receiving better quality controls. You get time to not only do the crunch, but think about the crunching and go back and look at anomalies.
Gary Johnson	One pretty important feature that I failed to mention is that the weekly report was accumulative. So if in week one we do something and report it, and then in week two we're going through it and say, "Uh oh, we found that little problem with week one." We don't go back and send out errata sheets. In the cumulative report, we present the data we currently believe to be accurate.
Marvin Shutters	Each weekly report is accumulative?
Gary Johnson	Right, so that it's not a big hassle to go back to earlier data.
John Hedgepeth	Do you leave week one data there?
Gary Johnson	All the reports are archived to what I call the information center so people can go back and actually read it. There's text that goes along with each one, not just data. So the accumulative is the most up to date stuff, and it includes the corrected data from earlier weeks. What we send to the FTP site is the week and the cumulative.
John Hedgepeth	Then you put the revised week on there once you revise it.
Gary Johnson	No, there is no revised week. That is what I'm saying. We don't go back and revise that week, we just revise it as it adds into the cumulative.
John Hedgepeth	Oh.
John Skalski	The cumulative is always being revised.
Gary Johnson	The cumulative is always being revised. So you do get to do corrections during the season.
John Skalski	I think there's going to be more pressure to do it sooner. You know we work with HTI on the Columbia, we use daily results. We need to have yesterday's results today to predict run timing. But, that is a stress on the staff. I know it is. They need to have their numbers from yesterday by 9 or 10 am the following day so we can start doing run timing predictions for meetings that afternoon. People call up on a daily basis looking at these things to see what's going on. The only

benefit is that we've limited it to one number, so we need totals. The sponsors are realistic in terms of what actual information they need for the decision process. When you're limited to that in the short term, then it's tractable. If you don't just want the bottom line but want all the superfluous side numbers and summaries and graphs that you are not going to use during the time period, then I think it becomes an unnecessary burden. It is dangerous for everyone in terms of the quality of the product and health of the staff. But I see it as having few recourses. More people are going to want more information sooner, but we have to get it to the point where they just tell us exactly what you're going to use.

Sam Johnston Focus it there.

John Skalski Yeah, very focused pieces of information that are focused to the time frame they're going to use it and can use it. It's foolish to give a person a tome each week if they don't even have time to read the tome. And that then becomes a babysitter to make sure you're doing your work, which I think is insulting. If they really need this information, I don't think there's anyone who's not going to try to break their butt to deliver it. The thing is to hone it down to those particular pieces of information that are essential. If the decision process doesn't need confidence intervals and five different ANOVAS to get through that decision process, don't do it at that point in time.

Bill Nagy I knew a guy at John Day who was reading the echograms, getting on the phone at 15 minutes before the hour and calling for spill. He was just kind of adding up a few numbers and getting one number.

John Skalski That becomes palatable or tractable. But if you start plotting the dailies and have to decide whether to split it this way or that way, you couldn't keep up and no one would use it anyway. I think as information systems get faster, people are going to want data on a more timely basis. We will have to tailor to the decision process.

Sam Johnston Yeah, I think Gary's point is that there are some things we can't really detect until we have a back log of information. That sort of error is something that having couple weeks' data collected before producing a weekly report is very important. Generating daily reports won't tell you if a transducer is going out gradually over the season. So those kinds of errors require a look at the whole picture. That's this whole idea about risk, how much risk are you willing to accept in the preliminary numbers.

Bill Nagy Sounds like what you're doing is essentially allowing certain

	people to look over your shoulder as you're doing your preliminary data reduction.
Gary Johnson	Yeah, well mostly from sponsors. We didn't get much feedback from the NMFS. We got a lot from Dan Kenny.
John Skalski	Sometimes it's good in the sense if you're doing sequential testing and changing configurations daily to update test statistics daily. You might find that you don't have to run this test for 30 days. If it is significantly different after 20 days, we might stop and look at another test or save costs. That is real useful. But if you really aren't going to use the information in a timely process, and I don't think you should be generating reports until you have met QA requirements.
Sam Johnston	Yeah, if you take that to the extreme, at Rocky Reach they would do fyke-net tests and use acoustics to determine when to pull the nets. "Well, how many fish do you think we have in there?"
John Skalski	Yeah, I think I've seen most databases with disclaimers. "This is very preliminary."
Marvin Shutters	The problem is that no matter what disclaimers there are, when someone reads the numbers, the first number they hear on the study is the one they recall forever. That's why releasing data before quality control stuff is a mistake.
Marvin Shutters	And I think this, this is a good input from you guys.
John Skalski	And this is where people come to problems before, you know our studies have been purposely designed to do seasonal FGE's, but then the sponsor later asks for dailies, and the dailies are going all over the place. Sponsors become worried that someone's going to grab on the highest or lowest FGE and run with it. Well, don't ask for those types of numbers. Don't make them available, if you know they are unreliable.
Bob Johnson	Don't release them.
John Skalski	Yeah, don't release them nor even get concerned about them.
Bob Johnson	The sponsor has control of that. That's the whole thing, it is a communication device.
Marvin Shutters	Also, you mentioned the program review dates being too early in 1996. In my opinion, very few people presented results because they just didn't have time to analyze their data. Most people presented data from the year before. In 1997, the program review is going to be like six weeks later than it was 1996, the last week of October.

Gene Ploskey	That is much better. When you know you've got to make a presentation on a year's results, my tactic is to take some small percentage of all the data that we know we can process in time and analyze it. Well that is a lot different than processing all of the data when it comes to comparing treatment effects. I remember giving a preliminary presentation on effects of blocked trash racks. I stood up and said that based upon 10% of the data that "Blocked trash racks had no effect." When I got to the annual program review in early September, I also said that blocked trash racks had no effect, based on about 20% of the data. However, in the final report, which was based upon all of the data collected, damned if blocked trash rack didn't have a significant effect. The risk is that the answer only applies to the subset of data processed and analyzed.
Gary Johnson	What was the effect? Did it increase sluice passage?
Gene Ploskey	Probably. We found considerable evidence that blocking trash racks, which lowered the zone of flow separation, was beneficial. For example, standardized turbine passage (passage under blocks) was significantly less for blocked treatments than for unblocked treatments at Unit 3 in spring (50% less) and summer (70% less). Sluice passage efficiency (SPE) did not differ significantly between blocked and unblocked treatments, probably because tests lacked sufficient power to reject the null hypothesis of no difference. The mean ratio of blocked to unblocked mean sluice passage was about seven for Unit 3 and two for Unit 5 in spring.
Gary Johnson	With the racks blocked?
Gene Ploskey	Right. I believe we are finished. After lunch, Deborah and I will be glad to help you fill out of your travel vouchers. Thank you so much for participating. I certainly learned a lot. After lunch, Deborah and I will be glad explain how you should fill out your invitational travel vouchers.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
September 2000	Final Report	

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Workshop on Standardizing Hydroacoustic Methods of Estimating Fish Passage for Lower Columbia River Dams	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
Gene R. Ploskey, Deborah S. Patterson, Carl R. Schilt, Michael E. Hanks	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
U.S. Army Engineer Research and Development Center AScI Corporation Environmental Laboratory 1365 Beverly Road 3909 Halls Ferry Road McLean, VA 22101 Vicksburg, MS 39180-6199; Dyntel Corporation 3530 Manor Drive Vicksburg, MS 39180;	ERDC/EL SR-00-10

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
U.S. Army Engineer District, Portland 333 SW First Avenue Portland, OR 97204-3495	
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The U. S. Army Engineer District, Portland, funded this research to evaluate possibilities for standardizing hydroacoustic methods for estimating fish passage through U. S. Army Corps of Engineers dams on the lower Columbia River, Washington and Oregon. The effort included this standardization workshop involving experts with fixed-aspect hydroacoustics, statistics, or fish passage. The goal of the workshop was to increase the consistency and comparability of fish-passage estimates by different researchers among sites and years by identifying important considerations and guidelines for hydroacoustic sampling, data processing, and data analysis. The 2-day workshop was held in Cascade Locks, OR, on 16 and 17 September 1997.

15. SUBJECT TERMS

Columbia River	Fixed-aspect hydroacoustics	Juvenile salmon
Fish-passage efficiency	Hydroacoustic detectability	Spill efficiency

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT UNCLASSIFIED	b. ABSTRACT UNCLASSIFIED	c. THIS PAGE UNCLASSIFIED		207	19b. TELEPHONE NUMBER (include area code)

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18