FTF Charter Objectives		Acoustic	Genetic Markers (PBT)	Genetic Markers (GSI)	Pit Tags	Coded Wire tags
3a	What fish are tagged	Acoustic tags are utilized primarily for juvenile Chinook, sockeye, and steelhead. The size of the tag limits use on juvenile species under 85 mm. Some kelt, juvenile and adult sturgeon, bull trout, adult lamprey, walleye, northern pikeminnow, smallmouth/largemouth bass.	Under current BPA-funded project, about 90-95% of Snake River spring/summer Chinook salmon and steelhead hatchery broodstock are successfully genotyped. If sampled and genotyped, any of the parents or offspring can be identified by stock and age.	Genetic markers can be applied to any species of fish to allow for individual or stock identification. Throughout the Pacific Coast, GSI technology has been successfully applied to steelhead and Chinook salmon stocks.	PIT tag technologies available for juvenile or adult salmon, steelhead, sturgeon, bull trout, and lamprey.	Coded wire tags are applied to juvenile salmon and steelhead at hatcheries and to a few wild stocks that are trapped and tagged. These include commercial and sport fisheries, as well as limited use for chum, sockeye, and pink salmon.
3a	Number fish released	About 10,000 Chinook and steelhead are tagged and released each year with acoustic tags. Lamprey and bull trout data very limited (<100 per study). Between 4,000 and 4,500 juvenile fish are tagged per year per species.	Under the current Snake River PBT project, approximately 9 million steelhead are "tagged" each year and approximately 12 million spring/summer Chinook salmon are "tagged" each year.	About 27 million hatchery-origin fish are released in the Snake River Basin, 36 million smolts released in the Columbia River Basin. Programs are currently underway to implement and integrate genetic tagging and sampling of hatcheries and stock of ALL fish.	About 2.5 million Chinook and Steelhead tagged annually, CBFWA tags up to 500 bull trout	ISRP/ISAB recommend marking 100% of Columbia River Basin hatchery salmon and steelhead. Over 50 million fish are coded wire tagged each year.
3a	Number fish or tags recovered	95% detection rate through mainstem, 11 detection sites on Columbia River Dams.	At least 5,000 PBT tagged steelhead and 9,000 spring/summer Chinook salmon are sampled per year.	Thousands of fish are being recovered as part of GSI projects in the Pacific Ocean and in the Columbia River basin. In the Snake River Basin, over 30,000 samples were taken in 2008 and 2009.	Over 1.5 million PIT Tag detections in 2011.	30,000 - 40,000 tags recovered annually.
3a	Entity releasing fish	USCOE; Grant County PUD ; Chelan County PUD, some USGS and USF&WS	IDFG, ODFW, WDFW, USFWS, NPT, IPC	IDFG, ODFW, WDFW, USFWS, NPT, IPC	ODFW, USFWS, WDFW, NPT, CTUIR, Yakama Tribe (47 federal, state and tribal fisheries agencies and other private entities tag fish)	ODFW, USFWS, WDFW, NPT, CTUIR, Yakama Tribe (54 different federal, state and tribal fisheries agencies and other private entities tag fish)
3a	Entity recovering/detecting fish	USCOE; Grant County PUD; Chelan County PUD, some USGS and USF&WS	IDFG, ODFW, WDFW, USFWS, NPT, IPC	IDFG, ODFW, WDFW, USFWS, NPT, IPC	WDFW, UI, USGS, ODFW, USFW, DFO	ADFW, DFO, ODFW, CDFG, WDFW, Northwest Indian Fisheries Commission, IDFG, Nez Perce Tribe, Quinault Nation, Quileute Tribe, Umatilla Tribes (35 different federal, state and tribal fisheries agencies and other private entities)
3a	Purpose of tagging	Acoustic tags address dam passage survival and dam passage behavior in 2-D and 3-D. Tags estimate survival through the estuary, survival of transported fish, and migration and fate of adult fish (as well as lamprey). Acoustic tag studies are able to measure smolt travel time, route-specific passage, and route-specific survival rates.	PBT technology can address tagging report management questions associated with determining the origin of hatchery adult straying, assessing hatchery broodstock composition, reconstruction of runs, predicting adult run abundance, and effectiveness of hatchery operations. In the Snake River basin, PBT determined the origin of straying hatchery steelhead adults in the Deschutes River basin, the origin of hatchery juveniles used in acoustic tagging studies, the origin of hatchery steelhead and Chinook salmon caught in commercial and recreational fisheries. NOAA fisheries has used genetic relationships among populations to establish ESU boundaries for	Used to estimate stock-specific data of wild and hatchery origin fish on ocean abundance, harvest, distribution, survival, and migration timing; estimate direct and indirect harvest of ESA listed salmonids, assess stock-specific temporal and spatial distribution of juvenile salmon and steelhead in the Columbia River estuary; estimate stock-specific harvest rates by commercial, recreational, and tribal fisheries in the Columbia River.	PIT tags are utilized for integrated life-cycle monitoring of hydrosystem survival, hatchery strayin and estuary and tributary restoration effectiveness. In addition to determining survival rates of juvenile fish through Columbia and Snake river reaches, PIT tag data have also been used to determine the status of individual stocks by estimating SAR. Numerous large-scale studies using PIT tags have been undertaken to examine differences in SARs between transported and non-transported fish.	Provide data on stock-specific migrations, ocean distribution patterns, and migration corridors of juvenile salmonids. Currently, CWT data are used in hatchery management to evaluate rearing and release experiments, estimate adult production, and manage broodstock. Additionally, harvest management and natural stock management decisions are augmented by CWT data.
3a	Cost of tagging	Costs vary by manufacturer, tag type, and quantity. JSATS costs for tags is currently around $200 per tag with a goal to get tag price down to around $100. Receivers: $3,000 to $9,000 each, $19,000 each for cable arrays.	Genotyping costs will vary slightly depending on the lab. The average per sample charge of the current BPA-funded Snake River PBT project for spring/summer Chinook salmon and steelhead is approximately $45/sample. This includes consumable costs, biologist and technician salaries, sample and genetic data management, analyses, etc. Genotyping costs associated with sampling of "tagged" fish (not broodstock) are lower (~$40/sample).	No direct tagging costs, but reference genetic baselines are needed for GSI. Genotyping costs will vary depending on the lab and type and numbers of genetic markers used. Generally most labs charge $35-$55/sample for GSI related projects.	Cost of PIT tagging, including the tagging, data management, and analysis, averages out to $1.60 per PIT-tagged fish. The PIT tag budget in 2012 was $2,616, 917.	$0.10 per CWT fish; however, there are additional labor costs in implanting and recovering CWT. Total tagging cost exceeds $9 million annually and ranges between $0.15-$0.20 per fish.
3b	Cost effectiveness of tagging	Typical studies cost about $6.5 million to assess survival of three species across three dams (e.g. from John Day to Bonneville). The studies follow a standard protocol. Full program cost for Lower Columbia survival studies is about $13 million per year. Willamette program cost is about $2 million to $3 million per year.	PBT is highly cost efficient as millions of smolts are genetically tagged by genotyping their parents and juveniles do not need to be handled. Further, tag recovery rates for PBT would be very high relative to other methods for similar overall costs.	Genetic baselines are not very costly since they can typically be used to represent genetic signatures of stocks for several years with occasional updates.	PIT tags are highly retentive and require minimum maintenance while continuously providing data collection. Reductions in fish capture and handling saves field crew time and labor costs, while at the same time reducing deleterious impacts on fish growth and survival.	Sampling rates vary based on the catch rates, but is generally around 5%. 100% of hatchery releases should be tagged to maximize the accuracy and precision of the CWT system. Currently, the cost is over $9 million annually.
3c	Program effectiveness relative to key FW Program mgmt questions	Mainstem strategy & Council draft mgmt question & Council HLI, recovery data integrated into VSP or escapement monitoring				

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3d	Data system for organizing and tracking tag data (release and recovery)	Standardization of data collection and formatting is being developed for JSATS tagging studies so that all data will be in a single database. JSATS data is currently stored in TAGVIZ (Tag Visualizer) to store spatial and temporal information about the river environment. ATLAS (Active Tag-Life-Adjusted Survival) provides survival estimates from acoustic tag data. ATTracker (Active Tag Tracker) offers 3-D acoustic tag tracking.	Progeny databases for tracking sample and genetic data. IDFG and other agencies are working with PSMFC to develop Snake River hatchery database that would allow efficient tracking of family groups from spawning to release. A permanent genetic database repository of PBT genotypes is needed to implement PBT across the Columbia River Basin.	Progeny or similar databases for tracking sample and genetic data are available in most PNW genetic labs. Standardized microsatellite genotypes for coastwide steelhead and Chinook salmon populations have been developed (i.e. GAPS and SPAN), although they are designed for a finite numbers of samples/populations. A permanent genetic database repository of sample and genetic data is needed to more efficiently use GSI across the Columbia River Basin.	PITAGIS serves as a database to store data related to PIT tags. The data is available to everyone and can be accessed using a variety of tools on the website.	Regional Mark Information System (RMIS) serves as a coordinated coastwide database. Recovery data integrated into VSP or escapement monitoring. RMIS is utilized for international coordination of tagging efforts between the United States and Canada.
3e	Degree of coordination within tagging efforts	Fair. The Corps is now using a uniform acoustic telemetry system (JSATS) throughout the Columbia River Basin. VEMCO technologies are utilized in the Pacific Ocean Shelf Tracking project (POST).	High among CRITFC and IDFG labs with respect to standardization of genetic marker sets, broodstock sampling and tag recovery projects. Inter-lab (CRITFC/IDFG) SNP standardization and accuracy checks have demonstrated >99.8% genotyping concordance.	High among CRITFC and IDFG labs with respect to standardization of genetic marker sets, broodstock sampling and tag recovery projects. Inter-lab (CRITFC/IDFG) SNP standardization and accuracy checks have demonstrated >99.8% genotyping concordance.	Overall coordination among tagging efforts is excellent. Archiving and sharing of PIT tag data are coordinated by the PSMFC. When tagging project designs are robust, tagged fish from one project can be used by others. (e.g. NOAA fisheries using Comparative Survival Study data when appropriate)	The Regional Mark Processing Center (RMPC) provides essential services throughout the Pacific region to help coordinate regional tagging efforts and fin marking programs.
3e	Degree of coordination among tagging efforts	Poor. Tags are not compatible across tag detection platforms. VEMCO technologies (used by the Pacific Ocean Shelf Tracking project) and JSATS (incorporated into Basin studies) require unique acoustic receivers.	High among PNW fish genetics labs with regard to genetic marker standardization, collaboration on publications, and interest in standardized, coastwide genetic database development. Although there is good coordination at the level of data compatibility and exchange, information is not publicly available through a regional database.	High among PNW fish genetics labs with regard to genetic marker standardization, collaboration on publications, and interest in standardized, coastwide genetic database development. Although there is good coordination at the level of data compatibility and exchange, information is not publicly available through a regional database.	A regional database system and standardized tag detection allows data collection and database accessibility among tagging efforts to be highly successful at a Basin-wide scale.	Coordination among agencies has been remarkable despite the complications of management by the international treaty, councils, and statistical demands of the process. Management for CWT overseen by PSMFC.
3f	Best tag suited for a given objective	Acoustic tagging best for 3D tracking purposes, such as passage route and timing measurement through a dam and reservoir or tracking movement of fish in a complex environment. Allows for use of run-of-river fish due to small population requirement to get a high level of precision in the study.	Allows for non-lethal sampling when recovering tag information. Allows for the identification of sex at any age non-lethally. PBT tagging is the only method that can address issues associated with relative reproductive success or heritability of specific traits. Able to determine relative reproductive success of hatchery fish spawning in the wild, and evaluate hybridization between introduced and native resident trout.	GSI is the best method for evaluating stock-specific data of wild and hatchery origin fish on ocean abundance, harvest, distribution, survival, and migration timing.	Using separation-by-code, researchers can most effectively identify route-specific passage information and monitor how physiological changes occur as the salmonids migrate downstream. The long lifespan of PIT tags allows for SAR estimates.	Best suited for coastwide application to salmon fisheries and species with significant ocean fisheries. Currently, the best infrastructure in place for monitoring ocean harvest.
3g	Adequacy of geographic coverage	Willamette River, Columbia River, Snake River. Stream passage projects at Cougar and Detroit.	Currently, only the Snake River basin is under a PBT sampling/genotyping program for all hatchery steelhead and Chinook salmon stocks. Of the 14.9 million hatchery steelhead released in the Columbia River basin each year, 9.1 million are Snake River origin (~61%). Of the 36.2 million hatchery spring/summer Chinook salmon released in the Columbia River basin each year, 12.4 million are Snake River origin (~34%).	SNP baselines with up to 192 markers are in place for steelhead and Chinook salmon in the Columbia River. Coastwide baselines for both species using standardized SNP markers are being developed. Coastwide microsatellite baselines are in place for Chinook and coho salmon coastwide.	PIT tagging activities occur on or at more than 550 rivers and streams, dams, traps, and hatchery rearing and release facilities throughout the Basin within the range of anadromous salmon and steelhead, including the Okanogan River in British Columbia above Osoyoos Lake.	Columbia River Basin CWT sampling is coordinated between entities to provide spatial and temporal coverage (also coordination on other multi-state rivers such as the Snake and Grande Ronde)
3g	Span of species diversity	Broad applicability, though variability of location, cost of detectors and tag life and range is significant. There is a reservoir study for adult Lamprey that has a tag designed to last 400 days (greater time between pulses).	Genetic markers can be developed in any fish species to provide for parentage and tagging studies. Single Nucleotide Polymorphic marker sets have been developed for PBT tagging in Snake River steelhead and spring/summer Chinook.	GSI methodologies can be applied to any species of fish. In the Columbia River Basin genetic markers and baselines are available for Chinook salmon, steelhead, sockeye, and coho.	PIT technology used for Chinook, steelhead, sturgeon, and bull trout. Current studies aim to identify a suitable PIT tag for juvenile lamprey.	Available for salmonids and non-salmonid fish, lobsters, crayfish, prawn, and Molluscs, Amphibia, Reptilia and Annelids
3g	Completeness of life cycle tracking	Short, typically just over a month. Juveniles limited to two projects at most, depending on reservoir length.	Complete for the life of the fish, intergenerational and non-lethal at any life-stage beyond fry.	Complete for the life of the fish.	Complete lifecycle tracking; smolt abundance, freshwater productivity, juvenile migration rate, SAR, adult spawner migration.	Tags provide a start and end point to a fish's movement over a defined period; however, they can't provide information on the path taken by the fish between two points.

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3c	Limitations	Limitations of technology include: life of transmitter, interference from ambient noise (requires higher frequency of signal), and code space. Surgical implantation is required. Too big for smallest subyearlings. Range of detection is about 75 to 300 meters, less in noisy environments. Shallow water results in low signal-to-noise ratio, which limits the tag usefulness due to echoes, false positives, poor 3D geometry, etc. Tag life is dependent upon the ping rate (pulses per second) chosen, frequency of signaling and battery performance. Technology possible limited by number of unique tag codes (~60,000 in the JSATS).	PBT does not provide "real-time" tracking of fish. PBT tagging requires that adult broodstock are sampled at the time of spawning and tissue is preserved correctly. Progeny from adults that are not sampled are not PBT tagged. Progeny from adults that are sampled, but not successfully genotyped are not PBT tagged. The current BPA-funded PBT project in the Snake River has successfully genotyped >90% of all hatchery broodstock spawned in the Snake River basin over the last 2 years. PBT requires a huge genotyping workload and standardization among labs.	Stocks that are genetically similar will not have highly accurate GSI assignment (e.g., fall Chinook salmon from Snake R. and Hanford Reach). Precision and accuracy is dependent on the baseline samples being representative of the genetic characteristics of all the stocks that could contribute to the mixed stock sample.	Potential difficulty in tagging small fish (<55mm in length); PIT Tag readers have a limited range of effectiveness in the water (<3m); detection rates appear to be affected by weir design and adult swimming behavior in avoiding weirs; require surgical implant. Currently, the antenna width is the most limiting factor in expanding the applications where PIT-tag technology can be incorporated. Installation is expensive and detection interference normally requires the removal of all rebar from the area.	CWT information can only be obtained when the fish is dead; removal of snouts to extract CWTs can affect market value of fish and make processors and fishermen reluctant to participate in recovery efforts; tags only offer information on beginning and end point of fish lifecycle.
3d	Data availability	Limited due to technically challenging post-processing required before raw information can be used. UW retains the data in an archive.	Standardized PBT parental genotype databases are housed on Progeny software and available upon request. A permanent genetic database repository of PBT genotypes is needed to implement PBT across the Columbia River Basin.	Standardized SNP genotype databases are housed on Progeny software and available upon request. A permanent genetic database repository of SNP genotypes for Columbia Basin GSI is needed.	PITAGIS serves as a database to store data related to PIT tags. The data is available to everyone and can be accessed using a variety of tools on the website.	Data accessible in various formats and summary reports in online relational databases (StreamNet, DART). CWTs are a major data contributor to StreamNet and provide information to state, federal, and tribal agencies, consultants, and the general public.
3f	Benefits	Reservoir survival, and dam passage survival that is route specific and can observe 3D fish behavior in forebay. Tag maintains performance in saline environments. Acoustic tag tracking requires smaller sample sizes to produce reliable result.	All fish whose parents are genotyped are tagged. PBT tagging requires no handling of juveniles and lethal sampling is NOT needed to recover information from tagged fish. Genetic tags are passed on to offspring following standard parental inheritance. In addition to determination of stock and cohort identification, PBT can be used to address many other questions related to life history, ecological and quantitative genetics.	Can be used for both wild and hatchery origin fish. With GSI, the time and place of sampling can be chosen more freely and precisely than with external tagging because it is not dependent on tagging and release programs. In addition, genetic data can be combined with non-genetic data (e.g. scale characteristics and smolt age). Genetic stock structure information can be used to define management units based on genetic similarities between stocks.	PIT tags can be read without killing the host fish, opportunities to gain information of migration patterns and rates, and growth rates through lifecycle.	Tags can be inserted into very small animals (or half-tags), minimal effects to survival and migration, high retention rates from juvenile to adult ages, large code capacity, and inexpensive tags ($0.10 each).
3b	Cost of receivers	Receivers costs depend on technology. JSATS autonomous receivers are $3,000 (Lotek) to $8-9,000 (ATS, Teknologic) and cables receivers are about $19,000.	No receivers required. Lab work is about $35 per sample.	No receivers required. Lab work is about $35 per sample.	Minimum cost of stationary receiver = $1,000 Portable antennas are also available.	Recovering tags requires lab work that costs an average of $20 per tag.
3c	Confidence interval	Confidence interval for the USACE survival studies is 95% +/- 2 to 3%; Chelan and Grant County PUDs have 2.5% standard error.	The precision of stock contribution estimates are directly related to the number of tagged fish recovered in fisheries or escapements. Under a PBT program, any hatchery fish recovered would be genetically tagged if its parents have been genotyped.	Stock resolution and accuracy of GSI assignments depends on the underlying genetic structure of the species, the accuracy to which allele frequencies are estimated in populations and reporting groups, and the number and variation of the loci used.	Confidence interval for FPC survival studies incorporating PIT tags is 90%.	Prince William Sound survival study confidence interval for coded wire tagging is 95%.
3f and 3g	Alternative tagging technology	PIT and acoustic tags can be used for similar measurements (e.g., dam passage survival), but they do not allow for 2D and 3D tracking. Acoustic telemetry is detectable in brackish and salt water and has a higher detection range than PIT tags.	Depends on the question of interest. PBT should provide same information as CWTs (stock and cohort) and could be used to address similar types of research and management questions as those currently addressed using CWTs. However, PBT does allow for non-lethal sampling when recovering tag information as opposed to CWT. PBT tagging would be only method that could address issues associated with relative reproductive success or heritability of specific traits.	Depends on the question of interest, but no other technology is readily available for assignment of wild origin fish.	PIT tags provide SAR data more rapidly than CWT data, which has a long-term delay before the data is available, allows for tracking of live fish. Once installed, these tags require no handling to transmit data.	CWT tags are an alternative source of SAR information to PIT tags and genetic studies. Genetic studies are an alternative estimation of ocean fishery impacts, but are computationally very intensive and take longer to obtain results
3c	Tag loss (shedding) rate	Tag shedding <10% (Cadigan, Brattey).	Cannot shed genetic tag.	Cannot shed genetic tag.	PIT tag loss in steelhead and salmon is less than 100th of 1%.	Retention rates in excess of 95% between parr and adult.
3c	Tag failure rate	JSATS tag failure rate generally less than 1%; tag life rated at 33 days at 3 second pulse rate at 417 dB.	Approximately 1-5% of samples fail genotyping due to poor storage of tissue.	Approximately 1-5% of samples fail genotyping due to poor storage of tissue.	PIT tag failure is estimated at less than 1%.	Carson National Fish Hatchery (2009) failure rate <1%.
3c	Increased mortality due to tagging	Some (0-4.5%), decreasing with shrinking tag size; additional tag-induced vulnerability to predators unknown.	Tag is intergenerational and non-lethal for any life stage beyond fry.	Tag is intergenerational and non-lethal for any life stage beyond fry.	Variability of mortality rate between studies (1%-36%); average five year rate was 10%.	Very low, less than 1% (Munro & McMahon). Tag recovery is lethal, and it takes several minutes for a lab technician to dissect the tag from a snout and decode the tag under magnification.