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July 30, 2013

MEMORANDUM

TO: Council Members

FROM: Tony Grover, Director, Fish and Wildlife Division

SUBJECT: Staff summary of Fish Tagging Forum recommendations and supplemental information.

The Fish Tagging Forum (Forum) made final recommendations to the Council, which were presented to the Fish and Wildlife Committee at the May 7, 2013 committee meeting in Boardman, Oregon. The Forum's recommendations (see Attachment) cover several tag types. The following recommendations, with near-term, mid-term or long-term time frames for implementation are presented as the Forum's consensus, unless presented as alternatives for those few recommendations that do not have the Forum's consensus. A near term recommendation is meant to be implemented immediately after the Council adopts the recommendation. Mid-term recommendations are meant to be implemented over the next year. Long-term recommendations are designed to be implemented over three to five years to allow implementers time to adjust to the effects of the recommendations.

Table - Consensus recommendations of the Fish Tagging Forum

	Type	Forum Consensus Recommendations	Timeframe
1	Global	Any reduction in funding associated with the recommendations would be available for redirection to other F&W projects.	Near term
2	Global	NOAA to provide guidance in coordination with state, tribal, and other researchers/experts regarding best practices for tagging ESA-listed salmonids.	Mid-term
3	PIT	Implement an annual PIT tag coordination and review forum including federal, state, tribal, utility representatives and other entities for both fish and wildlife projects with the purpose of reviewing short-term and long-term study plans relying on the use	Near term

		<p>of PIT tags to;</p> <ul style="list-style-type: none"> i - Evaluate opportunities to increase efficiency of tag use in a way that minimizes costs and reduces the number of fish tagged; and ii - Provide input and review of the PIT tag forecasting system for the purchase of PIT tags in the Columbia Basin 	
4	PIT	Council sponsor periodic subject matter expert evaluations of rates of PIT tag loss and effects of tagging on fish behavior and survival throughout the life cycle to understand how it affects confidence in critical parameters derived from PIT tag studies.	Long term
5	PIT	Council utilize the IEAB and ISAB to work together with interested regional partners to develop an analytical tool to evaluate trade-offs between PIT tagging levels, detector arrangements and the accuracy and precision of parameters used in making priority management decisions.	Long term
6	PIT	At the completion of the current PIT tag harvest monitoring project (2010-036-00), the Council and ISRP should follow a deliberate and measured approach to evaluate the project.	Long term
7	CWT	Eliminate routine coded wire tagging of steelhead and sockeye because they are not sampled in the ocean at levels significant enough to influence decision making. However, some coded wire tagging of these species will be necessary for specific research projects and hatchery operations and evaluations.	Long term
8	Genetic	Funding of on-going FWP projects developing and evaluating genetic methods (GSI and PBT) should continue consistent with the projects' goals and objectives. After 5-10 years of monitoring have been completed the effectiveness and efficiency of the genetic methods should be evaluated for broader application. The funding of new projects within the FWP should follow a deliberate and measured approach to consider how those new projects would complement existing projects.	Long term
9	Acoustic	Recommends twenty or more year interval between JSATS studies at USACE operated dam(s) unless major modifications to the structures or operations at the dams require updated information about fish survival at the dam(s). Furthermore, before future JSATS studies are implemented the Corps of Engineers, in collaboration with NOAA Fisheries and the Council, should evaluate whether existing, less expensive, tag technologies could be used and if acoustic tags are the appropriate technology for the research objectives, then what is the appropriate data collection required (i.e., presence/absence, two-dimensional or 2D, or three-dimensional or 3D, which provides depth information), to provide adequate information to assess juvenile survival at the dam(s) at a lower cost.	Near term
10	Acoustic	Within one year of date of this recommendation The Corps of Engineers in consultation with NOAA should develop a long term 20 year plan for acoustic tag studies within the Columbia and	Mid-term

		Willamette River basins. This plan should include the purpose of studies, coordination planning to be done with other entities that may be using acoustic tags, locations of the studies, study dates and estimated costs for acoustic tag studies that are envisioned over the next 20 years. This plan should be shared with the Council and the region for comment.	
11	Acoustic	Council should sponsor a public review of the USACE 2014 to 2018 forecast for JSATs performance testing cost and schedule for potential additional efficiencies and associated cost savings.	Near term
12	Radio	Council should continue to support the use of radio tags for specialized purposes to meet the evaluation criteria for specific research objectives and should continue to be used when appropriate for short-term study designs.	Near term
13	Data	Extend PERC process to evaluate potential improvements in the PIT tag and CWT regional databases (PTAGIS and RMIS) that provide important data sharing and analysis, leading to good decision making for our shared salmon resource on the Pacific Coast.	Mid term
14	Data	Implement a regional SNPs genetics database at PSMFC that can be shared in the same manner as the current PTAGIS and RMIS databases.	Underway
15	Data	Link the PTAGIS, RMIS, and SNPs databases to bring more power to these databases, leading to easier and more complete regional mark/tag data analysis (i.e. linking fish with multiple marks or tag in these databases).	Underway
15	Data	Through BPA contracting procedures, provide better documentation of tagging protocols through MonitoringMethods.org .	Near term
17	Data	Evaluate the costs and benefits of incorporating tag-related cost-tracking components into future upgrades to PISCES, and CBfish.Org	Long term

Forum Non-consensus Recommendation

The Forum could not reach a consensus recommendation on the funding responsibility for all Coded Wire Tag (CWT) uses, therefore alternatives have been identified for funding CWT activities. The proponents for each alternative did present their thoughts on merits and consequences of each alternative to the F&W Committee and Council directly and/or in writing.

- i. Alternative 1: Maintain status quo funding [\$7.5 million]
- ii. Alternative 2: Over 3 year transition period, reduce BPA funding for fishery catch sampling and associated analysis [Eliminates \$1.9 million in annual project funding]¹. <http://www.nwcouncil.org/media/6827185/CWT-cost-spreadsheet-by-Bonneville-4-8-13-related-to-recommendation-1b.xlsx>
- iii. Alternative 3: Over a 3 year period, reduce BPA funding for tagging at Mitchell Act Hatcheries [Funding reduction of \$0.6 million]³

¹ These recommendations do not apply to projects funded under the fish and wildlife accords.

- iv. Alternative 4: Increase CWT funding, if necessary, to achieve CWT program objectives (e.g., desired sampling rate at 20%. Cost is uncertain.)

Fish and Wildlife Committee

The Fish and Wildlife Committee discussed the Forum recommendations on July 9th, 2013 at the Seattle Council meeting. The Committee did agree to support the 17 consensus recommendations of the Forum, but did not reach agreement on the non-consensus recommendation from the Forum. The committee did discuss the possibility of a 1% across the board cut in all tagging programs, though committee members believe that concept is impractical to implement when BiOp priorities and accord constraints are considered.

Legal as well as policy and technical issues have been raised with regard to Bonneville funding of the coded-wire tag activities. The F&W Committee asked the Council's legal divisions for its views. What follows is a summary from the legal division as to how it understands the issues and its conclusions:

Legal Issues

One issue out of the Fish Tagging Forum review has been whether and to what extent Bonneville should continue to contribute funding for the coded-wire tag efforts. As we understand it, Bonneville began to contribute funding to this effort more than 30 years ago, in 1982, and currently contributes funding in two areas -- in the recovery of coded-wire tags and the marking of certain production groups. Whether to continue that funding, and at what level, raises a number of policy and priority considerations. But legal issues have been raised as well. Bonneville customer groups, and Bonneville itself, have raised questions about whether this use of Bonneville funds, despite its long tenure, is actually outside of Bonneville's authority to spend funds under the Northwest Power Act, or is in violation of what is known as the "in lieu" provision of the Act, or both.

Conclusions

Continuing these Bonneville expenditures is neither required by law nor clearly prohibited by law. For the activities to be within Bonneville's authority to fund under the Northwest Power Act, it has to be clear that the tagging efforts relate to Columbia River salmon and steelhead adversely affected by the Columbia hydrosystem. This seems clear. It also requires that there be a colorable argument that the information to be gleaned from these tagging and monitoring efforts is relevant in helping the Council and Bonneville evaluate the success of the protection and mitigation efforts funded under the Power Act. It is outside the scope of the legal analysis to make a definitive conclusion about that point -- the information on that question has come from technical staff and outside commenters -- but it possible to understand how coded-wire tag information has some utility for assessing Program-related goals or activities. Finally, for the "in lieu" provision of the Act to be a bar to Bonneville funding, there has to be clear evidence that the Bonneville expenditures are supplanting expenditures required or authorized from others. The facts are not so clear.

Moreover, note that the issues raised now about Bonneville's authority and about the "in lieu" provision with respect to Bonneville's contribution to the funding of the coded-wire tag

projects are not new -- they have been raised and analyzed a number of times before, by the Council beginning in the late 1990s and *including by Bonneville itself*. In the end Bonneville has always decided (and the Council has agreed either explicitly or implicitly) to continue the Bonneville contribution to the funding of these activities. And these questions of the legal appropriateness of the Bonneville expenditures are, in the end, questions for Bonneville to decide. The result has never been a conclusion -- by Bonneville or anyone else -- that a Bonneville funding contribution to these activities is absolutely outside of Bonneville's authority under the Northwest Power Act or constitutes Bonneville expenditures in lieu of or supplanting expenditures authorized or required from other entities under other agreements or provisions of law in violation of the Power Act. Essentially, that is why this Bonneville contribution began and has been ongoing for 30 years.

Instead, from the Council's perspective we are in a gray area of overlapping responsibilities and authorities and expenditures, and not obviously outside the boundaries. In that light this becomes instead what the Council first expressed in 1997 -- a question of policy and priorities in this world of overlapping responsibilities and authorities. A situation in which, as the Council wrote then, "the issue is whether the level of Bonneville funding for coded wire tagging is out of proportion with what could be considered Bonneville's 'fair share' of the coded wire tagging program, whether that share is based on the proportional number of fish from direct program-funded hatcheries that must be tagged *or on the amount of information gleaned from the tags that is relevant to the Council's program*." This does *not* mean that the Council has to arrive at any particular outcome on policy and priority grounds -- the Council could decide on this basis that the Bonneville funding level should stay the same or be reduced or end or increase. Only that the Council is not going to resolve these issues by concluding that a continued Bonneville funding contribution is outside Bonneville's authority or clearly in violation of the in lieu provision and must cease as a matter of law.

Proposed conditions to the Council recommendation:

In deciding whether and to what extent to consider the funding contribution to the coded-wire tag activities, the F&W Committee members suggest the Council recommend to Bonneville the following principles and recommendations:

1. The Council concludes that the use of Bonneville funds for CWT is not obviously outside Bonneville's spending authority under the Northwest Power Act, nor is it a clear violation of the "in lieu" provisions of the Act. Rather, in a situation of overlapping authorities, the question is whether the level of Bonneville funding for coded wire tagging is out of proportion with what could be considered Bonneville's 'fair share' of the coded wire tagging program, based on the amount of information gleaned from the tags that is relevant to the Council's program. This is a policy within the purview of the Council as well as Bonneville.
2. Fish managers rely on CWT as a primary indicator for many management questions, including population status and recovery of endangered species. The Council and Bonneville rely on the fish managers to help develop the Fish and Wildlife Program and to provide Program implementation expertise.
3. The ISAB and ISRP have both endorsed the use of CWT (2009 reports).

4. The IEAB reports that there are inefficiencies in tagging programs across the board. The preliminary fish tagging economic model development reported by the IEAB (June, 2013) indicates this concept is worth further development into a tool by Bonneville. The Council recommends Bonneville, in collaboration with NOAA, the Council, fish managers and appropriate others, develop a Request For Proposals to further refine the tagging model developed by the IEAB, or a similar model, and fund the development of that model to facilitate regional collaborative decision-making regarding programmatic and cost efficiencies in the fish tagging programs funded by Bonneville. The model should be operational in two years.
5. Encouraging efficiency in existing tagging programs and reducing costs in favor of more efficient tagging methods is a goal endorsed by the Council and recommended to Bonneville.
6. A centralized, integrated process that includes evaluating program priorities, as well as costs could play a highly beneficial role in a rationalization process that would improve both cost and program effectiveness of fish tagging (IEAB, June 2013).
7. Implement alternative 1 of the non-consensus recommendation, until the results of conditions 4 and 6 provide a rational alternative that is supported by the Council.
8. The Council recommends that Bonneville and the managers report annually on the number of juvenile fish released each year, and the subsequent number of adults that contribute to harvest, broodstock, and the spawning grounds for all hatchery programs receiving Bonneville funding. Provide this information annually for each hatchery by stock and brood year. The first report should be submitted by December 2013.
9. Regardless of the above conditions, the Council may adjust its recommendations to Bonneville regarding fish tagging as new information regarding technological improvements, efficiencies or tagging opportunities become known.

Attachment:

Background, recommendations and select supporting information from the Fish Tagging Forum, April 30, 2013 memorandum to the Fish and Wildlife Committee.

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[April 30, 2013]

DECISION MEMORANDUM

TO: Fish and Wildlife Committee members

FROM: Tony Grover, Director, Fish and Wildlife Division, members of the Fish Tagging Forum and Kevin Kytola, Forum facilitator

SUBJECT: Background, recommendations and select supporting information from the Fish Tagging Forum.

PROPOSED ACTION: Recommendations of the Fish Tagging Forum

BUDGETARY/ECONOMIC IMPACTS

BPA's costs for fish tagging in the Columbia River Basin exceeded \$60 million in 2012. About \$18.5 million of those costs were short term studies using acoustic and radio tags that vary from year to year. The Council and BPA's direct program makes up somewhat less than \$36 million of the total. Some recommendations have financial effects, which are estimated in the recommendations section.

Significance

Within the Columbia River basin, fish tagging is a costly and complicated endeavor, often going far beyond the modest efforts the ISAB and ISRP referred to in 2009. The Fish Tagging Forum (Forum) was chartered by the Northwest Power and Conservation Council (Council) in July 2011. The Forum was directed to evaluate the fish tagging activities and their cost-effectiveness and program effectiveness under the Fish and Wildlife Program (Program), as well as other issues identified in the March 2009 ISAB/ISRP report (ISAB/ISRP document 2009-1) regarding fish tagging technologies and programs.

The Forum held fifteen in person all-day meetings of the full Forum as well as numerous subgroup meetings and conference calls between November 2011 and April 2013. The meetings have been regularly attended by 15 to 30 subject matter experts from the following entities: Bonneville Power Administration (BPA), United States Army Corps of Engineers (USACE),

National Ocean and Aeronautics Administration (NOAA), Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), Idaho Department of Fish and Game (IDFG), Pacific States Marine Fisheries Commission (PSMFC), Columbia River Inter-Tribal Fish Commission (CRITFC), the Mid-Columbia Public Utility Districts (PUDs), and BPA customer groups (Public Power Council, Northwest River Partners). At times the Forum meetings were also attended by Council members, representatives from the Nez Perce Tribe, the Grand Ronde Tribe, the United States Fish and Wildlife Service (USFWS), the United States Geological Survey (USGS), consultants, equipment vendors, universities, and other interested parties. Council staff participated in all Forum meetings and teleconference calls.

The Forum Charter (<http://www.nwcouncil.org/media/23450/charter.pdf>) defines several specific objectives for the Forum. A synopsis of accomplishments relative to each of the Charter objectives is provided in Attachment 1. Presentation materials, meeting summary notes, and related documentation are available at <http://www.nwcouncil.org/fw/tag/home/>.

A number of information synthesis tools have been developed to support the development of recommendations, including:

1. Tag-specific summaries;
2. Tag infrastructure schematic;
3. Data collection and management schematic;
4. Management Question and Indicator Spreadsheet;
5. Management Question, Indicator, and Tagging Technology Network Diagram;
6. Tag-specific Cost Information (from BPA and USACE).

Background

The ability to mark and tag fish is one of the most important and useful techniques available to fishery managers, researchers and those interested in, or with a legal requirement of, preserving and recovering threatened or endangered fish, particularly salmon and steelhead. Tagging or marking salmon, steelhead and other fish species using tag technologies is a key tool for monitoring and evaluating both juvenile and adult salmon passage from headwater rearing or release areas through the mainstem hydropower projects, into the ocean, and back to the spawning grounds or hatchery broodstock collection areas.

The Council has not previously conducted an effectiveness oriented, policy level review of tagging and marking associated with the Fish and Wildlife Program. However, the Council and the ISRP have reviewed at one time or another all tag related projects within the Fish and Wildlife program.

The Council did request the Independent Science Advisory Board (ISAB) and Independent Science Review Panel (ISRP) to conduct a joint comprehensive review of Columbia River Basin fish tagging technologies and programs, which was completed on March 17, 2009 (ISAB/ISRP 2009-1). That report focused on the scientific and technical aspects of the various tagging technologies and stopped short of a policy level review of tagging. In that report the ISAB/ ISRP stated: *“For proposal solicitations, the ISRP’s technical review is not designed to address cost effectiveness. If project budgets appear unreasonable, either too large or too small, concern is*

often expressed, although this is not a technical review task. This is an aspect of tagging that would be best addressed as part of the Fish and Wildlife Program amendment and program-level decision process... As important as cost effectiveness is program effectiveness. Program effectiveness of tagging activities might be better incorporated into decision management frameworks where reference points from tagging activities trigger management response (e.g., return rates or harvest rates at a fixed limit or threshold).” As a result, the policy issues of cost effectiveness and program effectiveness remained unexplored until the Council created the Fish Tagging Forum.

Since the Council's last review of tagging issues in 1997, several major events have occurred in the Columbia Basin. They include, but are not limited to: several Council reviews of tagging projects, three FCRPS Biological Opinions, in lieu determinations by BPA and numerous tagging technological improvements and infrastructure changes. Because of these events, it is appropriate for the Council to reassess its views on fish tagging under the Council Fish and Wildlife Program.

In June 2010, the Council and Bonneville together began a review of projects in the categories of research, monitoring and evaluation and artificial production (also known as the RME/AP Review).

In June and July of 2011 the Council made following recommendations related to Coded Wire tag projects, which also included the intent to consider chartering a facilitated work group consisting of coded-wire tag project sponsors and Council and Bonneville staff and others to address the need within the Fish and Wildlife Program for coded-wire tag information. In July of 2011 Council members expanded the scope of the facilitated workgroup to include all tagging technologies in the Program, which is the genesis of this Fish Tagging Forum (Forum).

The Council recommends funding for the coded-wire tag projects for two years only, at the requested FY2012 level. The funding recommendation would be conditioned on the project sponsors, within that time, working with the Council staff to develop an overarching plan for ISRP review to coordinate the tagging of salmon throughout the Columbia River Basin, including the recovery of coded-wire tags in the fisheries, on the spawning grounds and elsewhere. In that plan, the sponsors should:

- *address the ISRP's concerns and comments, including evaluating the magnitude of mini-jacks among yearling coded-wire tagged Chinook salmon releases, and recording mini-jack data in the RMIS database);*
- *address the recommendations of the Pacific Salmon Commission's Coded-Wire Tag Workgroup;*
- *provide information identified in RPA 62 of the 2008 FCRPS Biological Opinion explaining how coded-wire tag data helps:*
 - *inform our understanding of survival;*
 - *inform our understanding of straying;*
 - *inform harvest rates of hatchery fish by stock, rearing facility, release treatment, and location;*
- *evaluate the viability of replacing coded-wire tags with newer more efficient tagging techniques, including a transition plan to make these changes;*

- *consider the issues around the use of coded-wire tags in the context of all the tagging of all types of salmon and steelhead in the basin, including the continued review of the use of PIT and related tags described in the next issue below; and*
- *in collaboration with the Council staff and Bonneville, review the appropriate level of Fish and Wildlife Program participation and Bonneville funding of coded-wire tagging. Based on the plan and the ISRP review, the Council will then work with Bonneville and the tagging agencies to revise the coded-wire tag projects for the appropriate level of future funding. The Council may charter a formal facilitated workgroup consisting of coded-wire tag project sponsors and Council and Bonneville staff and others to address the need within the Fish and Wildlife Program for coded-wire tag information, a transition plan to alternative, more reliable tagging technologies, and the appropriate level of Bonneville funding for this work.*

Projects 1982-01-301, 1982-01-302, 1982-01-303 and 1982-01-304, all having to do with coded wire tags, included the following specific recommendations from the Council: *Implement through FY 2013 with condition: Sponsor to participate in developing an over- arching plan on the future of CWT as described in programmatic issue #9. Funding beyond 2013 subject to ISRP and Council review of the plan.*

During the Council's 2010 and 2011 review of all Research Monitoring Evaluation and Artificial Production projects¹ the Fish and Wildlife Committee requested staff develop a charter for a facilitated workgroup to address costs, efficiencies and gaps for all fish tagging efforts that take place under the Council's Fish and Wildlife Program, including expense, capital and reimbursable programs. The Council approved the Forum charter in its' regular July 2011 meeting.

Overview

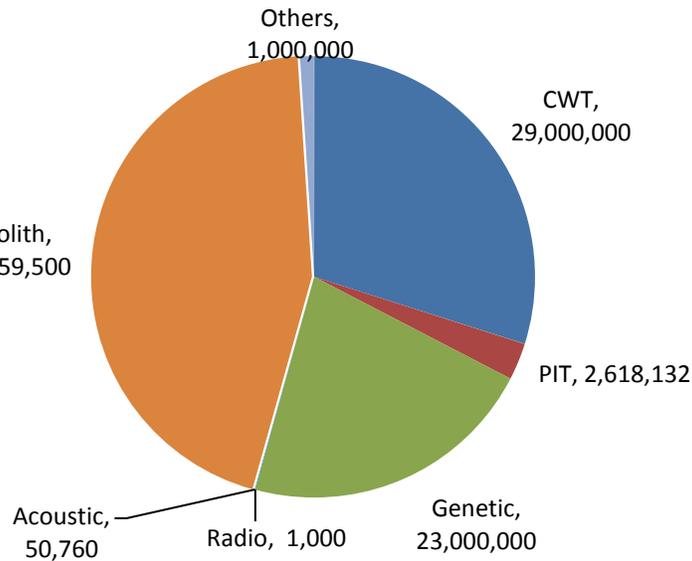
Overall there are few gaps and many overlaps in the tagging systems now in place. Overlapping efforts are not necessarily undesirable, as different tag technologies can often reinforce the level of confidence in results and are often used for multiple projects. In addition, some tag technologies have very specific and limited uses. Tagging coordination is generally well developed and successful throughout the Columbia River basin.

In Fiscal Year 2012 BPA spent over \$60,000,000 tagging or marking fish, detection of fish and analysis of fish tag data. In FY 2012 BPA funded more than 157 projects to carry out tagging, marking, detection or analysis of tag related data (Attachment 3.)

In 2012 in the Columbia Basin, approximately 200,000,000 tags of various types were applied to anadromous fish, sometimes more than one tag type per fish (see Figure 1). BPA funds a majority of the tagging either directly or indirectly, but other entities also fund fish tagging efforts, such as the Mid Columbia Public Utility Districts, federal and state agencies and Columbia River basin Indian Tribes, and investor owned utilities such as Idaho Power and PGE.

¹ Programmatic Issues # 9 (Coded-wire tags) and #10 (PIT tags and related tags) as part of the *RME and AP Category* review by the Council on June 11, 2011

Figure 1: Number of each tag type, not including adipose fin clips, applied during 2011 (or if available, 2012) in the Columbia River Basin.



Most of the fish tagging activity summarized in Figure 1 occurs within the anadromous fish migration and spawning areas of the Columbia and Snake Rivers (Figure 2.) The majority of the fish receiving a tag or mark are hatchery origin Chinook salmon.

Figure 2. PIT tagged fish release and recovery sites. These PIT tag related sites give a sense of the widespread distribution of all tagging activities in the Columbia River basin (Source: PTAGIS).

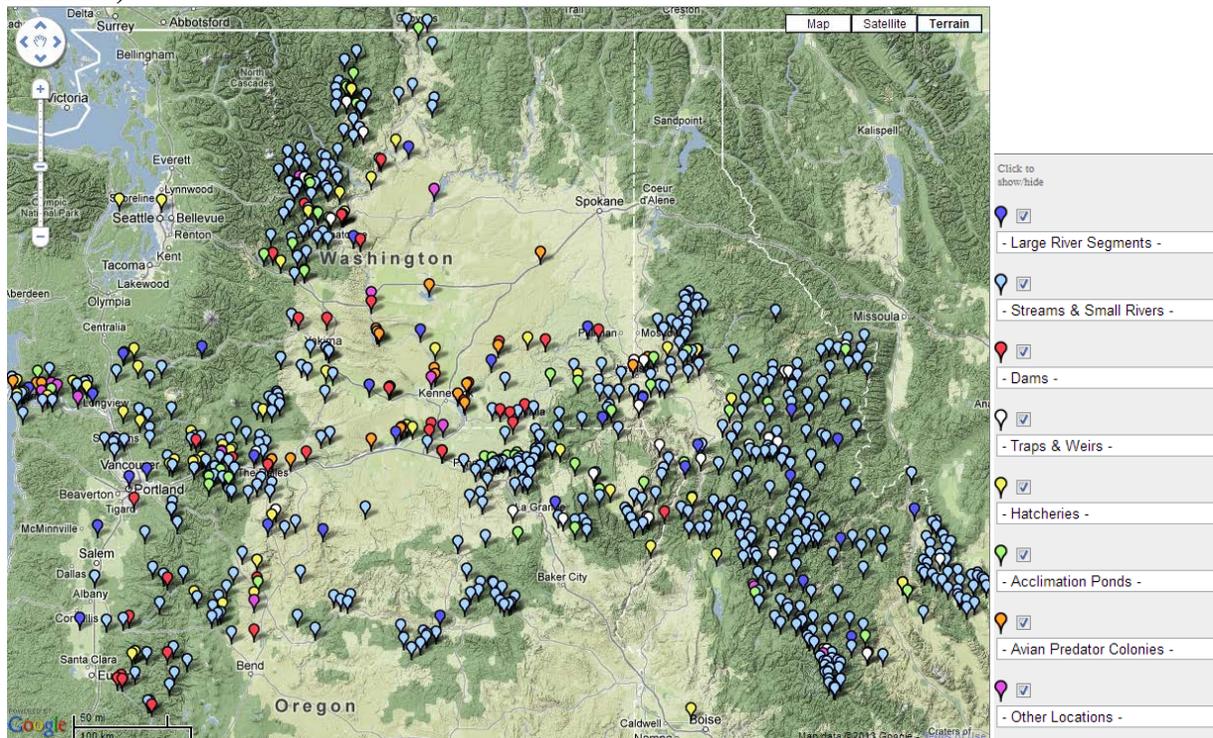


Table 1. Summary of the utility and characteristics of the most commonly used fish tags.

	PIT	CWT	Genetics	Acoustic/Radio	Special Use (Otolith and geochem)
Tag Use	Hydrosystem passage and survival, population status, habitat studies, predation studies and some hatchery studies. Distribution and in season run forecasting.	Stock survival, productivity and distribution. Fisheries composition and harvest rates. Hatchery analyses. Broodstock management.	Population status, some harvest, some habitat, relative reproductive success studies. Broodstock management	Hydrosystem route specific passage studies, some habitat studies, some population status studies	Life history studies, hatchery studies, migration timing, growth rates
Tag-related MortalityRisk	Low to moderate	low	low	high	low
Fish type (wild & hatchery)	Mostly hatchery, some wild populations	Mostly hatchery	PBT: hatchery only GSI: All fish	Mostly larger hatchery fish	Hatchery fish
Fish Size	>60mm	>50mm	Any	>110mm	Any
Geographic Coverage	Entire fresh water anadromous zones to blocked areas	Entire anadromous zone and ocean	GSI: Entire Columbia River Basin for all Steelhead and Chinook. PBT: Primarily Snake basin hatchery Steelhead and Chinook	Primarily at or near hydropower structures and associated reservoirs.	Entire anadromous zone and ocean
Duration of tag	Life of fish or until expulsion, may last long in sediments	Life of fish and some post mortality	Life of fish and some post mortality	Usually weeks, may be longer if low frequency (e.g., up to 1 to 4 years)	Life of fish to mortality

The Fish Tagging Forum

Because fish tagging is a significant and complicated topic, the Fish Tagging Forum (Forum) was chartered by the Northwest Power and Conservation Council (Council) in July 2011. The Forum was directed to evaluate the fish tagging activities and their cost-effectiveness and program effectiveness under the Fish and Wildlife Program (Program), as well as other issues identified in the March 2009 ISAB/ISRP report (ISAB/ISRP document 2009-1) regarding fish tagging technologies and programs.

The Forum Charter defines several specific objectives for the Forum. A synopsis of accomplishments relative to each of the objectives is provided in Attachment 1. Presentation materials, meeting summary notes, and related documentation are available at <http://www.nwcouncil.org/fw/tag/home/>.

A number of information synthesis tools have been developed to support the development of recommendations, including:

1. Tag-specific summaries;
2. Tag infrastructure schematic;
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6. Tag-specific Cost Information (from BPA and USACOE).

Management Questions and Indicators:

Nineteen key Management Questions and one hundred seventeen Indicators related to fish, mostly anadromous salmon and steelhead and supported by information gathered through fish tagging in the Columbia Basin were a principal element of the Forum's assessment (Attachment 2). Typically, a management question is answered through the use of a tagging program that quantifies the indicator. For example, a Hydro related *management question*, such as “*Are hydro passage conditions providing safe and effective passage for adults that contribute to meeting the performance standards and targets?*” may be partially informed by measuring an *indicator* such as “travel time” using PIT tags.

In addition to the technology focused presentations and discussions, the Forum members identified what Management Questions and Indicators are supported by the tagging efforts in the Basin. This understanding provides an important context for evaluating the tagging technologies by capturing how information from each tagging technology is used to inform Columbia River Basin management questions and their indicators.

Not all the legal and policy drivers that give rise to tagging related Management Questions are of equal priority under the Council's Columbia River Basin Fish and Wildlife Program. The Council's responsibilities are primarily driven by the mitigation requirements of the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act). The Northwest Power Act directs the Council to “protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries ...affected by the development, operation, and management of [hydropower projects] while assuring the Pacific Northwest an adequate, efficient, economical, and reliable power supply.” Under the Northwest Power Act, the Council's Fish and Wildlife Program is not intended to address all fish and wildlife problems from all sources.

Throughout the basin, NOAA's National Marine Fisheries Service (NOAA Fisheries) and the U.S. Fish and Wildlife Service are administering the Endangered Species Act, which requires information gathering, planning, and mitigation actions. The four northwest states and all of the Columbia Basin's Indian tribes also have fish and wildlife initiatives under way.

The Program is not intended to pre-empt the legal authorities of any of these parties. The Council's Program is designed to link to and accommodate the needs of other programs in the

basin that affect fish and wildlife. Measures implementing this Program are funded primarily by Bonneville through revenues collected from electricity ratepayers. Although Bonneville has fish and wildlife responsibilities under the Endangered Species Act and the Northwest Power Act, both responsibilities can be met in the same set of actions. The Council will address both sets of responsibilities wherever feasible.

The Fish and Wildlife Program activities related to increasing the total adult salmon and steelhead runs in the Columbia River basin, particularly those that originate above Bonneville Dam, are intended to complement regional harvest agreements. Examples of those harvest agreements are the Columbia River Compact, the U.S. v Oregon Agreement and the Pacific Salmon Treaty.

The Management Questions and Indicators have been organized around the following categories: Hydro, Hatchery, Harvest, Habitat, Predation, and Species Recovery decision making. The Forum established a clear connection between management questions and tagging efforts, including instances when more than one tag technology is being, or can be, used to support decision making and instances when only one technology can gather the necessary information. For the purposes of conducting analyses and developing recommendations for the Council to consider, the management questions and associated indicators the Council has identified in previous decisions and in the Fish and Wildlife Program are helpful to focus the discussions within the broader context. Visual aids and spreadsheets have also been developed to document and communicate the relationships between questions, indicators, and tagging technologies.

Tagging Technologies: The Forum has received presentations from subject matter experts on the following tagging technologies:

- Acoustic Tags
- Passive Integrated Transponder (PIT) Tags
- Genetic Markers (PBT and GSI)
- Coded Wire Tags (CWT)
- Otolith Marks and Scales
- Fin Clipping
- Radiotelemetry Tags
- Data systems used to manage tagging data

For each technology, the Forum has discussed the basic design, function and use of the tags; associated detection, recovery, and data management infrastructure; costs; relevance to specific management questions, application limitations, and potential for technological advancement.

The regions fish managers, action agencies and policy makers rely primarily on three long-term tags and one short-term tag to provide the majority of information needed to address management questions important under the Fish and Wildlife Program. These long term tags are PIT tags, coded wire tags (CWT) and genetic markers. Genetic Stock Identification techniques are increasingly being used to monitor wild salmon and steelhead populations throughout the Columbia River basin. Parentage Based Tagging primarily involves the genetic tagging of

hatchery stocks and is most developed in the Snake River basin. The short term tag is an acoustic emitter and detection methodology primarily used by the US Army Corps of Engineers.

PIT Tags The number of PIT tags inserted into various species of fish in 2011 and 2012 appears in Table 2. The table provides insight into how the fish species and tagging mix varies somewhat from year to year, but can be viewed as relatively stable overall.

Table 2. Total number of PIT tag insertions for 2011 and 2012.

Year	2011	2012
Chinook	1,811,529	2,036,438
Steelhead	556,677	562,157
Coho	136,066	118,131
Sockeye	79,365	81,162
All others	32,484	12,663

Source: PTAGIS

Coded Wire Tags (CWT) CWT information is still coming in for 2012, but 2011 information of insertions by species is shown in Table 3.

Table 3. Total number of CWT, by species, inserted in 2011, for the Columbia Basin and Pacific region.

Species	Columbia Basin CWT	Other CWT	Total CTW
Chinook	23,383,741	28,352,968	51,736,709
Coho	3,592,384	4,777,031	8,369,415
Steelhead	2,616,073	329,135	2,945,208
Sockeye	415,567	25,548	441,115
TOTAL	30,007,765	33,484,682	63,492,447

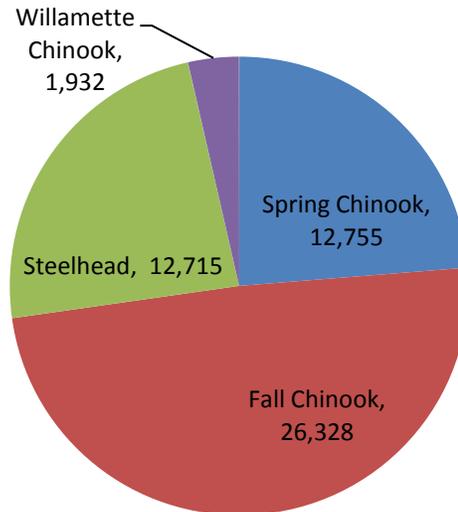
Condensed from a table provided by: Dan Webb, Regional Mark Processing Center

The data in the above two tables (Table 2 and 3) show clearly that Chinook salmon is the species subject to the greatest amount of tagging with PIT or coded wire tags. The greater number of tags, and often higher tag rates, result in Chinook salmon being used more widely to inform management questions. Steelhead are not subject to commercial harvest in the ocean and thus are CWT'd less intensely than Chinook and coho, which are targeted by ocean salmon fisheries. The geographic distributions of species, ESA listings, and focus of Program projects drives a higher level of PIT tagging for steelhead than coho.

Acoustic Tags During 2012 a total of 53,730 acoustic tags were deployed by the US Army Corps of Engineers. Most of these tags were inserted into Chinook salmon. The purpose of these tags was to provide data for route specific dam survival studies. Of the total number of

acoustically tagged fish in 2012, less than thirteen thousand were steelhead, and the remainder were Chinook salmon. Figure 3 shows the species and geographic mix of fish used for the acoustic tag studies.

Figure 3. Species and geographic distribution of acoustic tags in U.S. Army Corps of Engineers studies in 2012.



In the Mid-Columbia River, Grant and Chelan PUDs have used acoustic tags over the past decade to measure survival performances standards at dams and reservoirs of downstream migrating juvenile salmon and steelhead. In these studies, acoustic tags were used to monitor behavioral changes associated with modifications in dam operations and bypass structures to increase non-turbine passage efficiency and overall survival.

Radio Tags Additionally, radio tags have been used in the region to answer specific fish passage questions during a given life cycle phase, such as have ladder modifications increased upstream fish passage guidance and/or efficiency of adult salmon, steelhead, or lamprey at a given dam or a series of dams in the Columbia and/or Snake River basins. Radio tags are well suited for large-scale movement studies in freshwater and at shallow depths (less than 10 m). Acoustic tags are best suited for estuary based studies as radio signals cannot be detected in saline or brackish waters.

Genetic Tags For genetic tagging, GSI baselines have been completed for wild steelhead and Chinook salmon for the entire Columbia River basin, effectively tagging these species at the ESU or MPG level throughout their entire range in the basin. These baselines are used to report on the genetic diversity of these species throughout the CRB and to perform GSI at Bonneville and Lower Granite Dams to estimate VSP parameters associated with abundance and productivity of wild stocks. These baselines have also been used to estimate the stock composition of wild Chinook salmon and steelhead caught in the lower mainstem treaty fisheries.

Adequacy of geographic and species coverage.

Tag technology use is not evenly distributed throughout the Columbia basin (Tables 4, 5 and 6). The Forum was tasked to review issues related to fish tagging, such as the adequacy of geographic coverage, span of species diversity, adverse biological impacts or completeness of life cycle tracking. We have summarized tables for the CWT, PIT, and genetic PBT tagging release data to examine geographic coverage, species, and life cycle monitoring

CWT For CWT there is a broad geographic and species coverage, but it is predominantly used for Chinook and coho, due to the existence of coast wide sampling programs for tag recovery. CWT tagging coverage is lacking for chum salmon because they are too small to tag with CWT and they are relatively rare in the Basin. Otolith marks are typically used instead for chum salmon. Sockeye and chum are not CWT'ed in large numbers because CWT sampling programs for them are very limited in general. Wild stocks such as wild steelhead are typically not CWT'ed because of the logistical difficulties. The other zeros in the table generally reflect the few populations, low abundance, or lack of CWT needed for harvest information.

Table 4. 2011 CWT releases by region and species.

Description	Region	Spring CK	Summer CK	Fall CK	Coho	Sockeye	Chum	S. Stlhd	W. Stlhd	Totals
Below Bonneville	L Col	1,998,146	NA	1,565,700	1,998,194	NA	0	0?	20,491	5,582,531
Bonneville - McNary	M Col	1,412,129	NA	3,192,336	208,684	0	NA	62,146	0	4,875,295
Snake R Basin	Snake	3,128,425	527,219	3,702,296	121,547	184,198	NA	2,019,140	NA	9,682,825
Above McNary	U Col	2,437,495	3,321,622	2,098,373	1,263,959	231,369	NA	514,296	NA	9,867,114
Totals:		8,976,195	3,848,841	10,558,705	3,592,384	415,567	0	2,595,582	20,491	30,007,765

PIT tags The PIT tagging data is presented in Table 5. There is relatively good representation of PIT tags in all geographic areas except below BON. Only 2% of the PIT tagged fish in the Columbia basin are released below BON. This is because the infrastructure needed to recover PIT tags is concentrated and most effective at mainstem Columbia River dams above BON. Therefore, unless PIT tag infrastructure is installed below BON, this technology will have limited application in this area. CWT will remain the most cost effective tag technology to answer management questions downstream of BON. However, our ability to answer some management questions will be less effective in this area without PIT tags.

Table 5. 2011 PIT tag releases by region and species.

	Region	Spring CK	Summer CK	Fall CK	Coho	Sockeye	Chum	S. Stlhd	W. Stlhd	Totals
Below Bonneville	L Col	33,574	NA	11,917	7,891	NA	0	0	4,083	57,465
Bonneville - McNary	M Col	120,325	NA	60,274	661	760	NA	44,768	6,222	233,010
Snake R Basin	Snake	391,091	148,049	656,956*	14,981	68,147	NA	329,520	NA	1,608,744
Above McNary	U Col	189,207	141,023	59,113	112,533	10,458	NA	172,084	NA	684,418
Totals:		734,197	289,072	788,260	136,066	79,365	0	546,372	10,305	2,583,637

* In FY 2013 PIT tagging of Snake River Fall Chinook has been reduced to 92,000.

Genetic Tagging Parentage Based Tagging technology is less developed throughout the CRB, with only one large basin (Snake) implementing 100% PBT tagging of steelhead and Chinook salmon hatchery stocks (Tables 6a and 6b). However, CRITFC began PBT sampling programs for all Chinook salmon and steelhead hatchery stocks above Bonneville Dam in 2011, and is planning to initiate PBT sampling of all hatchery stocks below Bonneville Dam in 2013.

The Snake River PBT baselines for Chinook salmon and steelhead are currently being used in conjunction with GSI baselines to estimate the stock composition of wild and hatchery Chinook salmon and steelhead caught in zones 1-10.

Table 6a. Number of steelhead hatchery broodstock sampled and successfully genotyped for PBT in the Snake River basin (2008 – 2011). Tagging rate, number of smolts produced and number PBT tagged.

	Spawn Year			
	2008	2009	2010	2011
Broodstock sampled	5,151	5,761	5,282	5,931
Genotyped	5,070	5,636	5,198	5,765
“Tagging” Rate of Offspring	96.9%	95.7%	96.9%	94.5%
Smolts Produced *	~9.01 mil	~10.08 mil	~9.24 mil	~10.38 mil
Smolts “Tagged”	~8.74 mil	~9.65 mil	~8.96 mil	~9.81 mil

Table 6b. Number of Chinook salmon hatchery broodstock sampled and successfully genotyped for PBT in the Snake River basin (2008 – 2011). Tagging rate, number of smolts produced and number PBT tagged.

	Spawn Year			
	2008	2009	2010	2011
Broodstock sampled	10,836	8,849	8,290	8,410
Genotyped	10,630	8,493	8,235	8,329
“Tagging” Rate of Offspring	96.2%	92.1%	98.7%	98.1%
Smolts Produced *	~19.0 mil	~15.5 mil	~14.5 mil	~14.7 mil
Smolts “Tagged”	~18.3 mil	~14.3 mil	~14.3 mil	~14.4 mil

Tagging Effects It is generally accepted that there are adverse affects from tagging. However, these affects vary greatly depending on the tag type, fish size and condition, biological and environmental factors, tagging procedures, etc. For ESA listed populations, NOAA issues annual “take” permits to allow tagging and co-managers have permitting process for capture and tagging of non-listed fish.

Data Systems: The Regional Mark Information System (RMIS) is a database for coded-wire-tags (CWT). It stores CWT tagging, recovery, and sampling data. In addition, it stores fin mark data such as the mass mark data, and provides age data. The Passive Integrated Transponder (PIT) tag data is stored in PTAGIS. It stores tagging and recovery data along with biological data from individual fish. It does not store sampling data so to estimate abundance sampling data from other sources is used. For genetic markers there has been a switch from microsatellites to single nucleotide polymorphisms (SNPs). CRITFC and IDFG are working toward developing a publicly accessible SNPS data repository. An otolith marking data repository is kept by the Working Group on Salmon Marking of the North Pacific Anadromous Fish Commission. The goal is to coordinate otolith marking strategies between member countries (US, Canada, Russia, Japan, Korea) to decrease overlap in patterns and to facilitate an improvement in the method overall. Scale databases are maintained by management agencies.

Coordination: There is generally good tagging and tag recovery coordination within the various agencies and tribes. This coordination occurs for management decision or local coordination for population monitoring. The F&W program is primarily organized around subbasin plans and individual projects, which does not promote programmatic tagging coordination. However, from a cost-effective perspective increased programmatic coordination of both PIT and Acoustic tagging could be valuable. Examples could include the annual purchase of PIT tags, and linkage between tagging, recovery and reporting costs. Given the flexibility in answering multiple questions with PIT tags this may be a natural area to improve coordination, along with cost information.

Shared Infrastructure/Efficiencies: Tagging and recovery of salmon and steelhead tags to address multiple management questions benefits from the shared infrastructure of the Fish and Wildlife program. One example of the shared infrastructure to support multiple tag technologies is the current fishery sampling program. For example, fishery samplers collect biological data, genetic marker, CWT, and PIT tags, along with recover of radio and Floy tags. Another example of the shared infrastructure is PIT tagging juveniles to estimate trap efficiency for smolt abundance estimates. These PIT tagged fish are used by others to estimate juvenile and adult hydro-system reach survival, smolt to adult returns (SAR), bird predation rates, PIT tag based harvest estimates, etc. This opportunistic detection/recovery of PIT tags is considered a positive externality by economists, where the tagging costs by one entity benefits another party that did not incur this cost. In this case the benefits from the juvenile tagging at a smolt trap are a benefit to the entire Fish and Wildlife program. This may be considered as strength of the PIT tag or other tagging program, where multiple management questions may be answered by single tag technology. However, due to these positive externalities, care must be taken if tagging is restructured in the Fish and Wildlife program, because we have not linked all of the positive externalities in the program. For example, if there was a decision to stop PIT tagging juvenile salmon, we would not have bird predation estimates because they depend on juvenile PIT tagging by others.

Effectiveness Evaluation: Consistent with the Charter, the Forum considered effectiveness in terms of Program Effectiveness and Cost Effectiveness. The considerations for these components of effectiveness are defined below, followed by a discussion of outcomes of the Forums evaluation.

Program Effectiveness: An assessment of how well the tag/mark serves the technical/decision-making needs associated with the Bonneville funded F&W Program. Primary considerations include:

1. Ability to support Management Questions and Indicators
2. Geographic Coverage
3. Species Diversity
4. Life Cycle Tracking
5. Reliability (e.g., tag loss and detection/recovery rate)
6. Biological Effectiveness (e.g., handling, tag/mark-related mortality)
7. Data Management and Coordination

Short versus Long-Term Applications: Fish tagging technology can be categorized as short- and long-term for the purposes of analyzing their utility. Radio and acoustic tags are primarily used in short-term (a few weeks) fish passage and migration studies as they are active tags relying on an internal battery to power either a coded radio signal or a coded sound pulse on a repeating, intermittent basis. After a period of time the batteries run down and the tag is no longer capable of transmitting a signal, e.g., not detectable.

Long-term tags last the lifetime of the fish, unless they are expelled somewhere along the way, which occasionally happens for a low percentage of fish. Long-term tags in common use in the Columbia River basin are PIT, CWT, otolith marks, and fin clips. Fish scales can also be used as tags to address some questions. Genetic markers, while not strictly a tag, function very much like a tag to identify fish at various levels of resolution (ESU, population, hatchery, off spring). Genetic stock identification (GSI) is increasing in use in the CRB and allows determining the stock of origin of a fish. When genetic data on adult spawners are available then the use of Parental Based Tagging (PBT) can identify the origin of a fish.

Support of Management Questions and Indicators: The Forum has also identified which tags are considered Not Applicable, Primary, Secondary, Specialized Use or Future use technology to answer a specific management question and the consequences of not having specific tag types available to support decision making (REF Indicator Analysis Spreadsheets/Spider Chart).

The majority of the 117 indicators of interest can be informed through tagging technologies. Nearly all of the indicators are monitored with multiple tag technologies. Multiple tags to assess indicators or even within a single fish are not necessarily considered redundant. Often multiple tags serve to validate information or serve different purposes. Some indicators are only currently monitored with one tag type, although some other tag types could be used in the future if adjustments are made. For instance, ocean harvest indicators could be monitored by either Coded Wire Tags (CWT) or through genetics, but as a Pacific Salmon Treaty condition, only CWT are currently being used for monitoring treaty compliance.

For instance, the CWT system is currently the only methodology available to produce estimates of stock and age specific ocean fishery mortality that are required to determine survival, recruitment and productivity of each stock, partly because there is no coast wide sampling program for any other tag types, like PIT tags or genetic samples. In the future, investments could be made to implement a coast wide genetic sampling and data management system similar to that for CWT, and genetic methods could be used to obtain stock composition of ocean harvests. However, GSI alone does not provide the age-specific estimates required, and PBT is applicable only for genetically "marked" fish (such as from hatcheries), so it is likely both would have to be implemented in conjunction with each other.

Cost Effectiveness: An assessment of how the relative life-cycle costs of tagging/marketing technologies (from application to detection/recovery and associated data management) compare when addressing similar management questions or indicators. Considerations include:

1. proportion of technology/infrastructure investment versus labor investment,
2. least-cost data collection strategies (see IEAB model),
3. coordination/consistency on methods and data reporting.

Annual Cost Benchmark: For the purposes of estimating costs, direct, indirect and reimbursable costs to BPA are included. BPA and US Army Corps of Engineers staff have estimated cost-related information for each tagging technology that includes all activities, including tag insertion costs, tag detection costs and analysis of data generated from the tags. The estimated tagging costs in FY2012, shown in Table 7, below, are considered generally accurate, though not precise. Acoustic tag costs will vary quite a bit from year to year depending on how many US Army Corps of Engineers dam passage performance standard studies in Columbia/Snake River or Willamette Basin studies need to be conducted. BPA costs include direct costs, indirect costs and reimbursable costs (Table 8).

Table 7. BPA’s best estimate of all BPA funded 2012 tagging costs for insertion, detection and analysis of the tagging data.

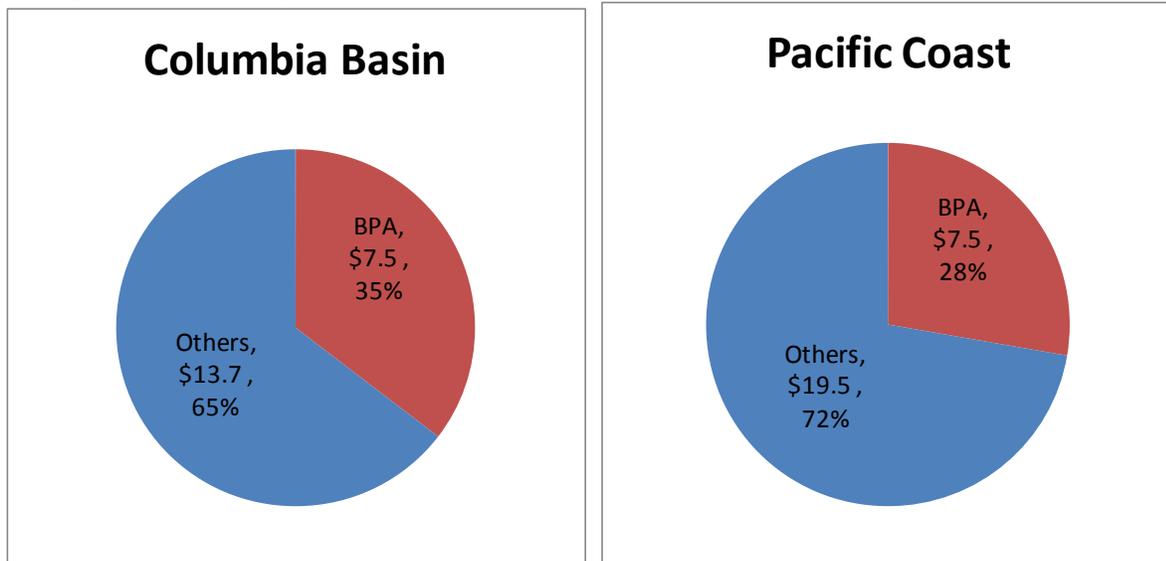
Tag Technology	Bonneville Cost	
CWT	\$ 7,500,000	
PIT	\$ 23,800,000	
Genetic	\$ 7,800,000	Only \$5.5 Million is strictly genetic tagging
Radio	\$ 2,100,000	
Acoustic	\$ 18,500,000	Varies significantly year to year
Others	\$ 1,700,000	
Total	\$ 61,400,000	

Table 8. BPA’s best estimate of all BPA funded 2012 tagging costs for insertion, detection and analysis of the tagging data for direct, indirect and reimbursable costs.

Funding Source	Tag Technology						TOTALS
	CWT	PIT	Genetic	Radio	Acoustic	Other	
Fish & Wildlife Program	\$5,434,900	\$18,219,745	\$7,780,782	\$1,897,782	\$951,585	\$1,474,317	\$35,759,111
LSRCP	\$1,218,287	\$1,909,000					\$3,127,287
COE	\$858,903	\$3,663,546		\$234,600	\$17,559,502	\$219,000	\$22,535,551
TOTALS	\$7,512,090	\$23,792,291	\$7,780,782	\$2,132,440	\$18,511,087	\$1,693,317	\$61,422,007

CWT - Cost Share. There are limitations in available data that make it difficult to precisely estimate the CWT cost share. The Forum considers these estimates to be a reasonable representation. The current CWT program is about \$21.2M, with the BPA cost share to \$7.5M or approximately 35% of the funding for the CWT tagging and recovery program. The remaining \$13.7M of the CWT program is funded by others. This represents a minimum because CWT data analysis cost from co-managers were not included.

Figure 4. BPA estimated funding for CWT tagging, recovery and data management for salmon and steelhead fisheries, compared to other agencies’ funding for only CWT tagging and recovery. There are additional substantial expenditures by other agencies on CWT data management and analysis that are not included above.



For species sampled for CWT in ocean fisheries, the tag recovery rates, taken in proper context, can provide additional insight into information returns resulting from investments in tagging technology. The following Table 9, shows ocean recoveries of CWT in Columbia River origin fish. Steelhead, sockeye and chum recoveries are very low due to lack of sampling and because chum are not CWT'd.

Table 9. Ocean CWT Recoveries

Year	Chinook	Coho	Sockeye	Chum*	Steelhead	Totals
2011	6,958	2,577	1	0	4	9,540
2010	8,832	1,472	0	0	1	10,305
2009	5,364	4,364	2	0	9	9,739
2008	4,941	692	2	0	7	5,642
2007	4,502	2,763	4	0	1	7,270
Totals:	30,597	11,868	9	0	22	42,496

*Chum are generally not CWT due to small size

A similar analysis for PIT tags may not yield meaningful information. For example in 2011 about 2.8 million fish were PIT tagged in the Columbia basin. Of those tagged fish over 1.1 million survived release to be detected somewhere else. The total number of detections of these 1.1 million fish exceeded 15 million. While these numbers may be interesting they do not reflect the utility of the detections. For example, if a group of fish was PIT tagged for the purpose of calculating SAR from Lower Granite Dam juvenile to Lower Granite Dam adult, then the many in between tag detections, while interesting, do not help inform the LGR to LGR SAR.

Cost-Effectiveness Modeling Tool: The Independent Economic Analysis Board (IEAB) is developing a linear programming model to assist the Forum in structuring the cost-effectiveness evaluation. This linear programming (LP) fish tagging model is an optimization model of the Columbia River system, fish populations, migration, harvest, hydropower, hatchery, and fish tagging objectives. The model characterizes a representative set of fish life cycles, normalized to a one-year scale for the number of smolts, their migrations, returns, etc. Tagging activities are introduced to produce the indicators that answer management questions related to these fisheries. The model simulates juvenile and adult migrations, ocean survival and fishery harvests. Tagging options in the model include PIT tags, coded wire tags (CWT), and genetic markers of two types, Parentage Based Tagging (PBT) and Genetic Stock Identification (GSI). This analytical tool was informed by the Forum process, but not available at the time the Forum developed the recommendations provided below.

Emerging technology, particularly the future use of genetics

GSI can be used to determine origin and stock composition of mixed samples of both wild and hatchery fish, but not by age, while PBT can provide fish origin by age, but only for genetically "tagged" fish." PBT can identify the origin of a fish only if at least one of its parents were genetically sampled ("tagged"), and is therefore most practicable for identifying hatchery fish. Therefore, PBT and GSI are most effectively applied together to assign individual fish (hatchery or wild) to stock of origin.

For GSI, there have been rapid advancements in the development of single nucleotide polymorphism (SNP) genetic baselines for Chinook salmon, steelhead and sockeye salmon throughout the entire Columbia River basin (projects 2008-907-00 and 2010-026-00). These baselines, along with non-lethal sampling programs at Bonneville Dam and Lower Granite Dam are increasingly being used to report on the VSP parameters of diversity and abundance of wild stocks as they migrate from the ocean back to native spawning areas in the basin. Genetic Stock Identification appears to be the only technology that can "tag" wild salmon and steelhead at the ESU or MPG level across the entire Columbia River basin and allow non-lethal tag "recovery" through their entire life-cycle.

A genetic sampling and genotyping program for Chinook salmon has been in place for the mainstem Columbia River fisheries (zones 1-10) since 2009 (CRITFC; 2008-907-00). A similar pilot program was initiated in 2011 for steelhead (IDFG & CRITFC). Recently, both of these programs have been able to demonstrate the benefit of integrating Parentage Based Tagging (PBT) technology for hatchery stock assessment. Parentage Based Tagging is an emerging technology for permanently genetically tagging hatchery stocks of steelhead and Chinook salmon and it has the potential of addressing many of the same management questions currently being addressed with CWTs in the Columbia River basin. Some of the primary advantages of PBT include: low per sample tagging costs, no tag related mortality, non-lethal recovery of tags, and the ability to address data needs associated with measuring genetic diversity, effective population size and relative reproductive success. At the time of this review, the Snake River basin is the only large basin that has initiated 100% PBT sampling and genotyping of steelhead and Chinook hatchery broodstock (2010-031-00), and thus only Snake River hatchery stocks can be identified via PBT when sampling lower mainstem CRB fisheries. CRITFC has initiated the sampling of all Chinook salmon and steelhead hatcheries in the CRB in anticipation of extending PBT technology outside the Snake River.

PST funding has been used to develop the coast wide microsatellite baseline for Chinook, improve baseline genetic samples and further develop SNPs and analytical methods for using genetic data. However, the use of GSI and PBT coast wide requires development of the rest of the "system", including a coast wide genetic sampling system, increased lab capacity, analytical tools to turn the data into useable information, standards for data sharing, and database systems.

Recommendations:

The following recommendations, with a near-term, mid-term or long-term time frames for implementation are presented as the Forum's consensus, unless presented as alternatives for those few recommendation that do not have the Forum's consensus. A near term recommendation is meant to be implemented immediately after the Council adopts the recommendation. Mid-term recommendations are meant to be implemented over the next year. Long-term recommendations are designed to be implemented over three to five years to allow implementers time to adjust to the effects of the recommendations. The Forum recommends that any reduction in funding associated with the recommendations below would be available for redirection to other F&W projects.

Over arching Recommendation:

There are potential risks to natural spawned juvenile fish during the process of capture, sedation, handling and tag insertion. The Forum recommends that NOAA provide guidance in coordination with state, tribal, and other researchers/experts regarding best practices for tagging ESA-listed salmonids. This is a mid-term recommendation.

1. PIT Tags

PIT tag technology is heavily used within the Columbia River Basin, perhaps more so than anywhere else in the world. PIT tags are the preferred tag type for freshwater life cycle monitoring. The Forum does not envision any substantial immediate changes in the use of PIT tags, though a few important issues need to be addressed prior to federal or BPA funding of additional PIT tag activities and systems as described in the following recommendations.

Recommendations

- a. In the near-term, implement an annual PIT tag coordination and review forum including federal, state, tribal, utility representatives and other entities for both fish and wildlife projects with the purpose of reviewing short-term and long-term study plans relying on the use of PIT tags to;
 - i - Evaluate opportunities to increase efficiency of tag use in a way that minimizes costs and reduces the number of fish tagged; and
 - ii - Provide input and review of the PIT tag forecasting system for the purchase of PIT tags in the Columbia Basin.
- b. Unaccounted for PIT tag loss and other tag effects may bias results of studies (e.g., reach survival or smolt-to-adult return estimates) that rely on this technology for their conclusions. Currently, the rate of PIT tag loss and other tag effects beyond a short holding period following tagging is not well understood. The Forum recommends the Council sponsor periodic subject matter expert evaluations of rates of PIT tag loss and effects of tagging on fish behavior and survival throughout the life cycle to understand how it affects confidence in critical parameters derived from PIT tag studies. This is a long-term recommendation.

- c. By increasing the number and geographic distribution of detection sites, it is possible to use fewer PIT tags to monitor multiple indicators. The Forum recommends the Council utilize the IEAB and ISAB to work together with interested regional partners to develop an analytical tool to evaluate trade-offs between PIT tagging levels, detector arrangements and the accuracy and precision of parameters used in making priority management decisions. This is a long-term recommendation.
- d. PIT tag monitoring of harvest has only been recently initiated in the basin. At the completion of the current PIT tag harvest monitoring project (2010-036-00), the Council and ISRP should follow a deliberate and measured approach to evaluate the project. This is a long-term recommendation.

2. Coded Wire Tags

The Forum recognizes the use of CWT to answer multiple management questions considered by the Forum, in particular harvest and hatchery management (see Attachment 2, 5 and indicator analysis spreadsheet.). The CWT system (tagging, sampling and database) is the only tagging methodology under current sampling programs to distinguish fishery mortality from natural mortality in the ocean, and to provide age and stock specific ocean and Columbia River Basin exploitation rates that are required to calculate overall survival and productivity. The Forum evaluated the current use of CWT to determine where efficiencies might be gained

Recommendation:

- a. The Forum recommends that we eliminate routine coded wire tagging of steelhead and sockeye because they are not sampled in the ocean at levels significant enough to influence decision making (see Table 9). However, some coded wire tagging of these species will be necessary for specific research projects and hatchery operations and evaluations. [Funding reduction is uncertain but may be up to \$500,000] This is a long-term recommendation.
- b. However, the Forum could not reach a consensus recommendation on the funding responsibility for all uses, therefore alternatives have been identified for funding CWT activities. The proponents for each alternative may present their thoughts on merits and consequences of each alternative to the F&W Committee and Council directly and/or in writing.
 - i. Alternative 1: Maintain status quo funding [\$7.5 million]
 - ii. Alternative 2: Over 3 year transition period, reduce BPA funding for fishery catch sampling and associated analysis [Eliminates \$1.9 million in annual project

funding]². <http://www.nwcouncil.org/media/6827185/CWT-cost-spreadsheet-by-Bonneville-4-8-13-related-to-recommendation-1b.xlsx>

- iii. Alternative 3: Over a 3 year period, reduce BPA funding for tagging at Mitchell Act Hatcheries [Funding reduction of \$0.6 million]³
- iv. Alternative 4: Increase CWT funding, if necessary, to achieve CWT program objectives (e.g., desired sampling rate at 20%)

3. Genetic Tags

The use of genetic tagging (GSI and PBT) for monitoring and evaluating wild and hatchery stocks continues to increase throughout the CRB. BPA funded projects have constructed extensive SNP GSI baselines for wild steelhead and Chinook salmon for the entire Columbia River basin. These baselines, along with non-lethal sampling programs at Bonneville Dam and Lower Granite Dam are increasingly being used to report on the VSP parameters of diversity and abundance of wild stocks. Parentage Based Tagging technology is more developed in the Snake River basin than elsewhere in the Columbia River basin and now most Snake River hatchery Chinook salmon and steelhead returning to the Columbia River are PBT tagged. Efforts to sample hatchery stocks outside the Snake River basin were initiated in 2012.

Recommendation: The funding of on-going FWP projects developing and evaluating genetic methods (GSI and PBT) should continue consistent with the projects' goals and objectives. After 5-10 years of monitoring have been completed the effectiveness and efficiency of the genetic methods should be evaluated for broader application. The funding of new projects within the FWP should follow a deliberate and measured approach to consider how those new projects would complement existing projects. This is a near-term recommendation

4. Acoustic Tags:

Acoustic technology is being used by the US Army Corps of Engineers on the Willamette and Columbia rivers to address performance standard testing requirements from 2008 and 2010 Biological Opinions as well as to gather behavioral information to support identification and evaluation of fish passage technologies, operations and techniques. The technology allows the Corps and NOAA to understand Fish Passage Efficiency, Spill Passage Efficiency, route-specific survival and dam passage survival. In the Columbia and Snake Rivers the Corps of Engineers is using the Juvenile Salmon Acoustic Telemetry System (JSATS) tagging technology. JSATS is very precise, data rich and expensive which leads the Forum to make the following two recommendations, which should be implemented consistent with the FCRPS BiOp.

² These recommendations do not apply to projects funded under the fish and wildlife accords. The NW Power Act prohibits BPA from funding state or federal agencies "in lieu" of their own sources of funding. In other words, state or federal funding cannot by law be replaced by BPA funding and this practice should be discontinued.

JSATS is very helpful in understanding dam specific fish survival characteristics. However, with the exception of lamprey passage needs, few, if any, major structural or operational modifications are being considered by the Corps of Engineers for implementation at its dams on the Columbia and Snake Rivers. The following recommendation pertains to listed salmonids, not to lamprey and other non-listed species.

Recommendations:

- a. The Forum recommends a twenty or more year interval between JSATS studies at USACE operated dam(s) unless major modifications to the structures or operations at the dams require updated information about fish survival at the dam(s). Furthermore, before future JSATS studies are implemented the Corps of Engineers, in collaboration with NOAA Fisheries and the Council, should evaluate whether existing, less expensive, tag technologies could be used and if acoustic tags are the appropriate technology for the research objectives, then what is the appropriate data collection required (i.e., presence/absence, two-dimensional or 2D, or three-dimensional or 3D, which provides depth information), to provide adequate information to assess juvenile survival at the dam(s) at a lower cost. This is a near-term recommendation.
 - b. Also, within one year of date of this recommendation The Corps of Engineers in consultation with NOAA should develop a long term 20 year plan for acoustic tag studies within the Columbia and Willamette River basins. This plan should include the purpose of studies, coordination planning to be done with other entities that may be using acoustic tags, locations of the studies, study dates and estimated costs for acoustic tag studies that are envisioned over the next 20 years. This plan should be shared with the Council and the region for comment. This is a mid-term recommendation.
 - c. The Council should sponsor a public review of the USACE 2014 to 2018 forecast for JSATs performance testing cost and schedule for potential additional efficiencies and associated cost savings.
5. **Radio Tags:** Radio technology is being used by the US Army Corps of Engineers on the Columbia and Snake Rivers and associated tributaries to evaluate adult salmon and steelhead upstream passage performance per the requirements from 2008 and 2010 Biological Opinions. The Council should continue to support the use of radio tags for specialized purposes to meet the evaluation criteria for specific research objectives and should continue to be used when appropriate for short-term study designs. This is a near-term recommendation.

6. **Recommendations regarding the systems used to organize and track tagging data**

The Regional Mark Processing Center maintains the Regional Mark Information System (RMIS) which is the shared database for coded-wire-tags (CWT). RMIS stores CWT tagging, recovery, and sampling data. In addition, it stores fin mark data such as the mass mark data, and provides age data. The Passive Integrated Transponder (PIT) tag data is stored in PTAGIS. It stores tagging and recovery data along with biological data from individual fish.

Recommendations

- a. Extend PERC process to evaluate potential improvements in the PIT tag and CWT regional databases (PTAGIS and RMIS) that provide important data sharing and analysis, leading to good decision making for our shared salmon resource on the Pacific Coast.
- b. Implement a regional SNPs genetics database at PSMFC that can be shared in the same manner as the current PTAGIS and RMIS databases.
- c. Link the PTAGIS, RMIS, and SNPs databases to bring more power to these databases, leading to easier and more complete regional mark/tag data analysis (i.e. linking fish with multiple marks or tag in these databases).
- d. Through BPA contracting procedures, provide better documentation of tagging protocols through MonitoringMethods.org. This is a near-term recommendation.
- e. Evaluate the costs and benefits of incorporating tag-related cost-tracking components into future upgrades to PISCES, and CBfish.Org. This is a long-term recommendation.

List of Attachments:

- Attachment 1: Fish Tagging Forum objectives and information organization tools
- Attachment 2a: Management Questions and Indicators
- Attachment 2b: SARS - Smolt to Adult return rate
- Attachment 2c: Spider chart
- Attachment 3: Council questions to the ISAB and ISRP
- Attachment 4. BPA projects that fund tagging efforts in the Columbia River basin.
- Attachment 5. Analysis of the objectives of each tagging effort.
- Attachment 6: Indicator Analysis spreadsheet

Additional tables, diagrams, analytical products, presentations and documents can be found at:
<http://www.nwcouncil.org/fw/tag/home/>

Attachment 1: Fish Tagging Forum objectives and information organization tools.

Objective	<u>Tag Summary Table</u>	<u>Tag-specific Cost Information</u>	<u>Management Question Spreadsheet</u>	<u>Tag-specific Presentations³</u>	<u>Indicator Analysis Spreadsheet</u>	<u>Network Diagram/Spider Chart</u>	<u>Infrastructure Schematic</u>	<u>Data Collection and Management</u>	<u>IEAB Cost Model</u>
Objective A: Develop and recommend a commonly accepted description of fish tagging funded by BPA	X			X			X	X	
Objective B: Recommendations on ways to improve the cost effectiveness of fish tagging		X			X		X	X	X
Objective C: Recommendations to improve the program effectiveness of fish tagging to address key management questions	X		X		X	X	X	X	
Objective D: Recommend “fair share” allocation of responsibilities for funding fish tagging relative to each management question	X	X	X		X	X			X
Objective E: Respond, as appropriate, to 2009 ISRP/ISAB recommended actions									
Objective F: What is the objective of each tagging effort and are the right tags being used, or proposed to be used, to accomplish that objective	X		X	X	X	X			
Objective G: Review issues related to fish tagging, such as the adequacy of geographic coverage, span of species diversity, adverse biological impacts or completeness of life cycle tracking	X		X	X	X	X	X		

³ The following are the meeting dates where each technology was discussed: December 2011 –Acoustic, February 2012 – Genetics, March 2012 – PIT, May 2012 – CWT, August 2012 – Otolith, Mass Marking, Scales, and October 2012 – Radio.

Attachment 2a.

Management Questions and Indicators

Nineteen key Management Questions and one hundred seventeen Indicators related to fish, mostly anadromous salmon and steelhead and supported by information gathered through fish tagging in the Columbia Basin, were a principal element of the Forum's assessment. Typically, a management question is answered through the use of a tagging program that quantifies the indicator. For example, a Hydro related *management question*, such as "Are hydro passage conditions providing safe and effective passage for adults that contribute to meeting the performance standards and targets?" may be partially informed by measuring an *indicator* such as "travel time" using PIT tags

Population Status and Indicators

Are the populations (trending towards) meeting the goals of the viability parameters?

- A) Abundance
- B) Diversity
- C) Spatial distribution
- D) Productivity

What are survival rates through various life stages?

- A) Fry-to-smolt
- B) Fry/Parr/Smolt Tributary to estuary
- C) First year ocean survival
- D) First year ocean survival to maturity
- E) Adult spawning migration
- F) SAR
- G) Parr to Smolt

Hydro-System

Are salmon and steelhead meeting juvenile and adult hydro passage performance standards and targets for the HCP, FCRPS BiOP and Accords?

- A) Hydrosystem Survival juvenile
- B) Hydrosystem Survival adults
- C) Project (Dam and reservoir) Survival (juvenile fish)
- D) Fish Guidance Efficiency (assume both spill passage efficiency and fish guidance efficiency)
- E) Forebay Delay

Are hydro passage conditions providing safe and effective passage for adults that contribute to meeting the performance standards and targets?

- A) Dam Passage Delay
- B) Dam Passage Fallback and reaccension
- C) Travel Time
- D) Migration timing(between dam migration=PIT, radio; run-timing arr at BON = PIT)
- E) SAR (specific to studies re: in-river vs. transported; project and passage survival)

Are hydro passage conditions providing safe and effective passage for juveniles that contribute to meeting the performance standards and targets?

- A) Fish Condition (health, growth rate and bioenergetics)
- B) Bonneville through Estuary (Lower Columbia River) Survival, Behavior and Travel Time
- C) Route-Specific Survival (through individual dam passage routes - e.g., turbine, spill, bypass)
- D) Reach Survival

- E) Travel Time
- F) Juvenile Dam Passage Delay
- G) Migration timing (overwintering, residence time, in-season)
- H) SAR

What conditions affect the relative benefit of in-river passage versus transport?

- A) Juvenile survival
- B) Smolt-to-Adult Return Rates
- C) Measuring physiological stressors & environmental conditions
- D) Tributary Survival, Straying Rates
- E) Post-hydrosystem juvenile behavior, survival and travel time
- F) Predation rate

What are effective configurations and operations to reduce impacts on sturgeon and lampreys?

- A) Age one recruitment for sturgeon
- B) Passage numbers and directions for sturgeon and lamprey
- C) Entrainment rates for sturgeon and lamprey
- D) Number of sturgeon trapped in draft tubes and in fishways (not normally assessed with tags)
- E) Impingement rates of lampreys on fish bypass screen (not addressed by tag studies)
- F) Adult lamprey passage

Habitat

Are tributary habitat actions achieving the expected benefits?

- A) Juvenile production in tributary habitat (NOF, parr abundance and survival)
- B) Relationship of tributary habitat actions and productivity (out-migrating)
- C) Spawning distribution (gross distribution info, specific spawning distribution relies on snorkeling, redd count etc)
- D) Fish in - escapement / spawning ground
- E) Fish out - outmigrant
- F) Post-Hydrosystem Adult Survival (i.e., survival from last dam to tributaries)
- G) Rearing distribution (reach scale within trib including abundance & movement)
- H) Juvenile salmonid growth rates
- I) Patterns of movement (juveniles/adults)
- J) Patterns of timing (juveniles/adults)
- K) Residency (in trib, reservoirs,)

Are Estuary habitat actions achieving the expected benefits?

- A) Life history diversity index
- B) Salmon and steelhead smolt survival from Bonneville Dam through the estuary
- C) Juvenile salmonid growth rates
- D) Migration timing
- E) Patterns of movement
- F) Patterns of timing
- G) Residency
- H) Estuary distribution and habitat associations by stock
- I) Fish density
- J) SAR
- K) Estuarine life histories among returning adults

What is the ocean's /plume effect to population status / recovery?

- A) Length of time
- B) Growth rate
- C) Predation
- D (ii) Ocean

- D(i)plume
- E) Productivity
- F) Maturation (maturation rates and age structure)

Hatcheries

Are mitigation hatchery programs meeting their specific production goals?

- A) Juvenile/Smolt production
- B) Adult harvest/returns/escapement
- C) Juvenile to adult survival rates

Are mitigation hatchery programs being managed to meet conservation objectives?

- A) Proportion and origin of hatchery fish within natural spawning populations (pHOS)
- B) Reproductive success of hatchery-origin fish compared to natural origin fish

Are conservation hatchery programs reducing the extinction risk of certain listed populations?

- A) Adult abundance (harvest returns and escapement)
- B) Juvenile productivity (of the listed population ; also need adult information), natural origin fish from supplementation
- C) SAR
- D) Proportion and origin of hatchery fish within natural spawning populations (pHOS, pNOB)
- E) Reproductive success of hatchery-origin fish compared to natural origin fish

Harvest

Are harvest management actions effective in meeting conservation responsibilities?

- A) Run size forecasts
- B) In-season updates (abundance-based management)
- C) Post season run reconstruction FCRPS BiOP Limited to specific stocks
- D) Stock-specific (ESU, MPG etc) harvest by fishery (includes CRB and ocean fisheries)
- E) ESA-listed population impact rate as well as FCRPS BiOP for selective fishery research projects
- F) Non ESA-listed population harvest rate
- G) Area-specific harvest accountability (e.g. harvest sections below BON, sections above BON, or areas in Ocean fishery)
- H) Release mortality
- I) SAR (at least six definitions of SAR)

Are harvest programs being managed to contribute to recovery of ESA listed populations?

- A) Direct and indirect harvest of ESA-listed salmon - required by harvest BiOps
- B) ESA-listed population impact rate - required by harvest BiOps
- C) Run size forecasts (abundance based management)
- D) In-season updates (abundance based management)
- E) Post season run reconstruction
- F) SAR

Is harvest effectively managed to meet Treaty Indian/non-Indian allocation requirements and other management responsibilities?

- A) Total Treaty and non-treaty harvest by stock in the Columbia River
- B) Total Treaty and non-treaty harvest by stock in U.S. ocean (South of Canada)
- C) Tributary Harvest
- D) Run size forecasts
- E) In-season updates (abundance based management)
- F) Post season run reconstruction
- G) Stock-specific (ESU, MPG etc) harvest by fishery

H) Other state management catch objectives (e.g., sport fisheries, state management objectives/policies)

Is harvest managed to meet the requirements of International treaties? (PST)

- A) Pre-season abundance forecasts for U.S. and Canadian stocks
- B) Total harvest by stock in U.S. ocean
- C) Total harvest by stock in Canadian fisheries
- D) Harvest impact on wild stock indicators
- E) Escapement accountability of wild stock indicators (status of PST wild stock Indicators)

Predation

Are predator management actions providing expected survival rate improvements?

- A) Caspian tern predation rates on juvenile fish populations
- B) Double-crested Cormorant predation rates on juvenile fish populations
- C) Other combined avian predation rates on juvenile fish populations
- D) California and Steller sea lion predation rate on fish in the lower Columbia River
- E) Northern Pikeminnow annual predation rate on fish
- F) Other aquatic predator species (e.g., smallmouth bass, walleye, etc.)

What is the effect of alternatives/actions used to reduce the impact of predators?

- A) Distribution and population size of No. Pikeminnow in Columbia and Snake basins
- B) Distribution & population size of other major fish predators in Columbia/Snake basins
- C) Annual exploitation rate of No. Pikeminnow removed in sport-reward program

Attachment 2b

SARs - Smolt to Adult Return Rate

The Forum identified several instances, at least six, where SAR (Smolt to Adult Return rate) was an important Indicator that various tagging technologies were intended to inform in different situations. Despite its' importance, SAR is not an Indicator that can be easily defined in a single manner; rather, it is a generic term for a 'family' of similar Indicators. The Forum convened a subgroup to explore SAR in more detail. The results of the subgroup discussions are summarized below.

SARs are referenced in the 2009 Fish and Wildlife "...*Program continues to include a set of quantitative goals and related timelines for anadromous fish. These include, among others, increasing total adult salmon and steelhead runs to an average of 5 million annually by 2025 in a manner that emphasizes the populations that originate above Bonneville Dam and supports tribal and non-tribal harvest, and achieving smolt-to-adult return rates in the 2-6 percent range (minimum 2 percent; average 4 percent) for listed Snake River and upper Columbia salmon and steelhead.*"

Smolt to adult return rates (SARs) are a measure of survival from smolt outmigration to adult return. Depending upon the species, tag type, and research/management question, smolt outmigration and adult returns may be enumerated at various locations (e.g., Bonneville to Bonneville, Dworshak Hatchery to Lower Granite, or tributary to tributary). Therefore, SARs must therefore be explicitly defined based on the enumeration points. The SAR indicator incorporates all sources of mortality between the smolt and adult life stages. In the Tagging Forum, we noted that SARs are used for NPCC program goals as an indicator for management questions and as data input for management decisions. Therefore, SARs can be found in many of our management categories. For example in the population status and recovery management category, SAR is a key parameter for extinction risk, regardless of the source of mortality. This was the rationale for including SARs as a high level indicator in the Columbia Basin Anadromous Coordinated Assessments (CA) project. For other analyses, such as the effectiveness of management actions taken to improve survival by reducing hydro, hatchery, or harvest impacts, SARs remain an important indicator of overall success. However, to accurately assess the effectiveness of specific management actions, it may be necessary to separate river and ocean mortality with additional information, such as in-river PIT tag survival, or CWT information on ocean and in-river exploitation rates. Predicted SAR can also be used as data input for management decisions. For example, the Pacific Fisheries Management Council (PFMC) adopted amendment 13 in 2000, which regulates coho salmon fishery impacts based on the escapement estimates and forecasted SARs. Given the importance of SARs, their widespread use, and variable measurement points it is important to document the data and methods used to estimate SAR. The CA project has developed data exchange standards for efficient, consistent, and transparent data-sharing for SARs.

The Forum participants identified a number of ways that tag data derived SARs are used to answer Management Questions relating to Columbia River basin salmon and steelhead:

Management Question	Indicator SAR
Are harvest management actions effective in meeting conservation responsibilities (PST, FCRPS relies on data e.g., RPA 62 , US v OR)?	Smolt to adult return (multiple measurements): Survival from beginning of downstream migration, typically hatchery release or tagging and release of in river migrants, to return as adults to the point of origin or other specified point. This measurement accounts for mortalities occurring during the juvenile migration, ocean, and adult return phases of the life cycle. To parse specific causes of mortality, or mortality during specific life stages, different geographic start and end points may be used. For example, harvest impacts are one of the components used to assess exploitation rates on stocks of concern and are an essential element in the total mortality estimate.
Are harvest programs being managed to contribute to recovery of ESA listed populations?	Smolt to adult return (multiple measurements): Survival from beginning of downstream migration to return as adults. Metric includes harvest-related mortality occurring during the ocean and adult return phases of the life cycle and is used to estimate the effect of harvest regulation on escapement.
What are survival rates through various life stages?	Smolt-to-Adult Return Rates: Multiple and varied points of measurement including: trib-trib, trib-BON, BON-BON, 1st dam encountered by juvenile to BON, 1st dam encountered by juvenile to last dam
Are hydro passage conditions providing safe and effective passage for adults that contribute to meeting the performance standards and targets?	Smolt-to-Adult Return Rates (multiple and varied points of measurement): a relative comparison metric specific to studies re: inriver vs transported fish; project and passage survival)
What conditions affect the relative benefit of in-river passage versus transport?	Smolt-to-Adult Return Rates (multiple and varied points of measurement): a relative comparison metric specific to studies re: in-river vs transported fish.
Are conservation hatchery programs reducing the extinction risk of certain listed populations?	Smolt to adult return (multiple measurements): Survival from beginning of downstream migration to return as adults. Metric is used to assess the effect of broodstock and adult escapement reform measures on captive rearing programs and stock rebuilding programs that contribute to the growth of genetic resources and promote recovery of listed populations.

Attachment 2c - Management Questions, Indicators and Tag use and priority -- Spider Chart

[Insert 11" x 17" Spider chart here]

Attachment 3

Council questions to the ISAB and ISRP

It is worth briefly looking at the Council's intent when questions about tagging arose in 2008. The Council requested that the ISAB and ISRP address six questions which resulted in the 2009 ISAB/ISRP report on Tagging. As a result of information gathered over the last year and a half during the Fish Tagging Forum, those questions could be concisely answered in the following manner:

1. *Can the coordination of fish tagging projects and programs, both within and outside of the program, be improved?*

There is generally good tagging and tag recovery coordination within the various agencies and tribes. This coordination occurs for management decision or local coordination for population monitoring. The F&W program is primarily organized around subbasin plans and individual projects, which does not promote programmatic tagging coordination. However, from a cost-effective perspective programmatic tagging coordination could be valuable. Examples could include the annual purchase of PIT tags, and linkage between tagging, recovery and reporting costs. Given the flexibility in answering multiple questions with PIT tags this may be a natural area to improve coordination, along with cost information.

Acoustic tagging is short in duration, intermittent and expensive. As a result, substantial efficiencies may be realized if entities coordinated acoustic tag studies to maximize the amount of information derived from the release point of each tagged fish by having detection arrays deployed downstream at their facilities simultaneously.

2. *Can the compatibility between the results of different tagging studies be increased?*

Given the relatively high degree of coordination, the use of well developed public tagging data bases and the agreements on tag coding sequences among all parties, it is uncommon to encounter incompatibilities in tagging studies.

3. *Can the Council, through its Fish and Wildlife Program, best encourage the development and use of innovative tagging technologies relevant to program RM&E needs?*

There are a wide variety of fish tagging technologies available to researchers and managers, resulting in few management questions that cannot be answered through tagging. Genetic techniques are being well tested now and hold the promise of being more widely used for a variety of purposes, with the advantage that genetic sampling is non-lethal. A vexing problem that still lacks a good solution is how to get good, frequent detections of any tag in the lower Columbia River, estuary and plume below Bonneville Dam.

4. Do gaps exist in the Basin's capacity to collect life history information at the project or program scale because of lack of relevant technology?

No significant gaps exist due to a lack of tag technology. However, non-BPA funding of tagging efforts is generally on the decline throughout the range of Columbia River salmon and steelhead, making maintenance of existing infrastructure and systems problematic.

5. Can criteria be developed for determining the most cost-effective tagging technology during the project review process?

See the section on the efforts of the IEAB to model cost effectiveness..

6. How can this element of the program be made more cost-effective?

Greater cost efficiency can be realized through continuous efforts to align BPA funding of fish tagging with Fish and Wildlife Program priority goals and objectives.

Attachment 4.

BPA projects that fund tagging efforts in the Columbia River basin in whole or in part.*

CWT Tagging Projects (not including Lower Snake Compensation Program)

1982-013-01	PSMFC CWT (PSMFC)
1982-013-04	WDFW CWT (WDFW)
1982-013-02	ODFW CWT (ODFW)
1982-013-03	USFWS CWT (USFWS)
1988-053-07	Parkdale Hatchery (Warm Springs Tribe)
1988-053-08	Hood River Production Program (ODFW)
1985-038-00	Colville Hatchery Ops (Colville Tribe)
1983-350-03	NPT Hatchery RM&E (Nez Perce Tribe)
2010-036-00	Columbia R. CWT Recovery & Analysis (WDFW)
1990-005-00	Umatilla Hatchery RM&E (ODFW)
1993-060-00	S.A.F.E. (ODFW)
1995-063-25	Yakima River RM&E (Yakama Tribe)
1995-063-35	Klickitat River RM&E (Yakama Tribe)
1996-040-00	Mid-Columbia Reintroduction Feasibility Study (Yakama Tribe)
1996-043-00	Johnson Creek Artificial Propagation Enhancement (Nez Perce Tribe)
1998-010-04	Monitor and Evaluate (M&E) Performance of Juvenile Snake River Fall Chinook Salmon from Fall Chinook Acclimation Project (Nez Perce Tribe)
2007-402-00	Snake River Sockeye Captive Propagation (IDFG)
2008-306-00	Deschutes River Fall Chinook Research and Monitoring (Warm Springs Tribe)
1989-098-00	Salmon Studies in Idaho Rivers (IDFG)
2010-057-00	B run steelhead

PIT Tagging Projects

2008-508-00	Power Analysis Catch Sampling Rates (CRITFC)
2008-502-00	Expanded Tribal Catch Sampling (CRITFC)
1990-080-00	Columbia Basin PIT Tag Information (PSMFC)
1991-028-00	PIT Tagging Wild Chinook (USFWS)
2007-406-00	Lower Snake River Compensation Plan PIT Tag Reimbursement (USFWS)
2010-042-00	Tucannon Expanded PIT Tagging (WDFW)
2001-003-00	Adult PIT Detector Installation (NOAA)
2010-035-00	Abundance, Prod, Life History of 15mile Creek Winter Steelhead (ODFW)
2007-299-00	Investigation of RRS of Hatchery Stray SH in Deschutes (ODFW)
1988-053-03	Hood River RM&E (Warm Springs Tribe)
1988-053-04	Hood River RM&E (ODFW)
1988-064-00	Kootenai River White Sturgeon Aquaculture Conservation Facility (Kootenai Tribe)
1988-053-08	Hood River Production (ODFW)
1983-319-00	New Marking and Monitoring Technologies (NOAA)
1983-350-03	Nez Perce Tribal Hatchery RM&E (Nez Perce Tribe)
1986-050-00	Evaluate Sturgeon Populations in the Lower Columbia River (ODFW)
1987-127-00	Smolt Monitoring by Non-Federal Entities (Fish Passage Center)
1989-024-01	Evaluate Umatilla Juvenile Salmonid Outmigration (ODFW)
1989-098-00	Salmon Studies in Idaho rivers (IDFG)
1990-005-00	Umatilla Hatchery M&E (ODFW)
1990-005-01	Umatilla Basin Natural Production Monitoring and Evaluation (Umatilla Tribe)
1990-044-00	Coeur D'Alene Reservation Fisheries Habitat (Coeur D'Alene Tribe)

- 1990-055-00 Idaho Steelhead Monitoring and Evaluation Studies (IDFG)
- 1990-077-00 Development of Systemwide Predator Control (PSMFC)
- 1991-019-01 Hungry Horse Mitigation/Flathead Lake Restoration and Research, Monitoring and Evaluation (Salish & Kootenai Tribe)
- 1991-029-00 Research, monitoring, and evaluation of emerging issues and measures to recover the Snake River fall Chinook salmon ESU (USFWS)
- 1992-026-04 Grande Ronde Early Life History of Spring Chinook and Steelhead (ODFW)
- 1993-029-00 Survival Estimate for Passage through Snake and Columbia River Dams and Reservoirs (NOAA)
- 1993-056-00 Advance Hatchery Reform Research (NOAA)
- 1994-042-00 Trout Creek Operations and Maintenance (ODFW)
- 1995-004-00 Libby Reservoir Mitigation Restoration and Research, Monitoring and Evaluation (MFWP)
- 1995-027-00 Lake Roosevelt Sturgeon Recovery (Spokane Tribe)
- 1995-063-25 Yakima River Monitoring and Evaluation-Yakima/Klickitat Fisheries Project (Yakama Tribe)
- 1995-063-35 Klickitat River Monitoring and Evaluation-Yakima/Klickitat Fisheries Project (Yakama Tribe)
- 1996-019-00 Data Access in Real Time (University of WA)
- 1996-020-00 Comparative Survival Study (Fish Passage Center)
- 1996-035-01 Yakama Reservation Watershed Project (Yakama Tribe)
- 1996-040-00 Mid-Columbia Reintroduction Feasibility Study (Yakama Tribe)
- 1996-043-00 Johnson Creek Artificial Propagation Enhancement (Nez Perce Tribe)
- 1997-004-00 Resident Fish above Chief Joseph and Grand Coulee Dams (Kalispel Tribe)
- 1997-015-01 Imnaha River Smolt Monitoring (Nez Perce Tribe)
- 1997-030-00 Chinook Salmon Adult Abundance Monitoring (Nez Perce Tribe)
- 1998-007-02 Grande Ronde Supplementation Operations and Maintenance and Monitoring and Evaluation on Lostine River (Nez Perce Tribe)
- 1998-010-04 Monitor and Evaluate (M&E) Performance of Juvenile Snake River Fall Chinook Salmon from Fall Chinook Acclimation Project (Nez Perce Tribe)
- 1998-016-00 Escapement and Productivity of Spring Chinook and Steelhead (ODFW)
- 1998-019-00 Wind River Watershed (WDFW)
- 2000-039-00 Walla Walla River Basin Monitoring and Evaluation (CTUIR/WDFW)
- 2001-003-00 Adult PIT Detector Installation (NOAA)
- 2002-053-00 Asotin Creek Salmon Population Assessment (WDFW)
- 2003-017-00 Integrated Status and Effectiveness Monitoring Program (NOAA)
- 2003-039-00 Monitor and Evaluate Reproductive Success and Survival in Wenatchee River (WDFW)
- 2003-041-00 Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams (NOAA)
- 2003-063-00 Natural Reproductive Success and Demographic Effects of Hatchery-Origin Steelhead in Abernathy Creek, Washington (USFWS)
- 2006-008-00 Mainstem Columbia Amendments Research at Libby Dam (MFWP)
- 2007-156-00 Rock Creek Fish and Habitat Assessment (Yakama Tribe)
- 2007-157-00 Bull Trout Status and Abundance on Warm Springs Reservation (Warm Springs Tribe)
- 2007-401-00 Kelt Reconditioning and Reproductive Success Evaluation Research (CRITFC)
- 2007-402-00 Snake River Sockeye Captive Propagation (IDFG)
- 2008-306-00 Deschutes River Fall Chinook Research and Monitoring (Warm Springs Tribe)
- 2008-308-00 Willamette Falls Lamprey Escapement Estimate (Warm Springs Tribe)
- 2008-311-00 Natural Production Management and Monitoring (Warm Springs Tribe)
- 2008-471-00 Upper Columbia Nutrient Supplementation (Yakama Tribe)
- 2008-503-00 Studies into Factors Limiting the Abundance of Okanagan and Wenatchee Sockeye Salmon (CRITFC)
- 2008-518-00 Upstream Migration Timing (CRITFC)
- 2008-718-00 Non-Native Fish Hot Spots (ODFW)
- 2008-724-00 PIT Purchase for COE (discontinued after FY 12)

- 2009-001-00 Expanded Multi-Species Acclimation in the Wenatchee/Methow Basins (Yakama Tribe)
- 2010-030-00 Provide VSP Estimates for Yakima Steelhead MPG (Yakama Tribe)
- 2010-032-00 Imnaha River Steelhead Status Monitoring (Nez Perce Tribe)
- 2010-034-00 Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring (WDFW)
- 2010-042-00 Tucannon Expanded PIT Tagging (WDFW)
- 2010-057-00 B-run steelhead supplementation effectiveness research (Nez Perce Tribe)
- 2008-307-00 Deschutes River Sockeye Development (Warm Springs Tribe)
- 2010-076-00 Characterizing migration and survival for juvenile Snake River sockeye salmon between the upper Salmon River basin and Lower Granite Dam (IDFG)
- 2008-109-00 Resident Fish Research, Monitoring and Evaluation (Colville Tribe)
- 2003-007-00 Lower Columbia River Estuary Ecosystem Monitoring (LCREP)
- 2011-014-00 Evaluate Status & Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River Subbasins (Warm Springs Tribe)

Acoustic Tagging Projects (not including Army Corps JSATS studies)

- 1988-065-00 Kootenai River Fishery Investigations (IDFG)
- 1994-043-00 Lake Roosevelt Data Collection (Spokane Tribe)
- 2003-114-00 Coastal Ocean Acoustic Salmon Tracking (Kintama)
- 2008-004-00 Sea Lion Non-Lethal Hazing (CRITFC)
- 1994-047-00 Lake Pend Orielle Kokanee Mitigation (IDFG)

Genetic Projects

- 2010-031-00 Snake River Chinook and Steelhead Parental Based Tagging (IDFG)
- 2008-907-00 Genetic Assessment of Columbia River Stocks (CRITFC)
- 2009-005-00 Influence of Environment and Landscape on Salmonid Genetics (CRITFC)
- 2010-026-00 Chinook and Steelhead Genotyping for Genetic Stock Identification at Lower Granite Dam (IDFG)
- 2003-063-00 Natural Reproductive Success and Demographic Effects of Hatchery-Origin Steelhead in Abernathy Creek, Washington (USFWS)
- 1989-096-00 Genetic Monitoring and Evaluation (M&E) Program for Salmon and Steelhead (NOAA)
- 1989-098-00 Salmon Studies in Idaho Rivers (IDFG)
- 2003-039-00 Monitor and Evaluate Reproductive Success and Survival in Wenatchee River (NOAA/WDFW)
- 2003-054-00 Evaluate the Relative Reproductive Success of Hatchery-Origin and Wild-Origin Steelhead Spawning Naturally in the Hood River (Oregon State University)
- 1991-073-00 Idaho Natural Production Monitoring and Evaluation (IDFG)
- 2002-030-00 Salmonid Progeny Markers (CTUIR)
- 1990-055-00 Idaho Steelhead Monitoring and Evaluation Studies (IDFG)
- 1991-019-01 Hungry Horse Mitigation/Flathead Lake Restoration and Research, Monitoring and Evaluation (Salish and Kootenai Tribes)
- 1991-019-03 Hungry Horse Mitigation Habitat Restoration and Research, Monitoring and Evaluation (MFWP)
- 1993-056-00 Advance Hatchery Reform Research (NOAA)
- 1994-049-00 Kootenai River Ecosystem Restoration (Kootenai Tribe)
- 1995-063-25 Yakima River Monitoring and Evaluation-Yakima/Klickitat Fisheries Project (Yakama Tribe)
- 1995-063-35 Klickitat River Monitoring and Evaluation-Yakima/Klickitat Fisheries Project (Yakama Tribe)
- 1998-016-00 Escapement and Productivity of Spring Chinook and Steelhead (ODFW)
- 2002-037-00 Freshwater Mussel Research and Restoration (CTUIR)
- 2003-007-00 Lower Columbia River Estuary Ecosystem Monitoring (LCREP)
- 2007-246-00 Restoration of Bull Trout Passage at Albeni Falls Dam (Kalispel Tribe)
- 2007-299-00 Investigation of Relative Reproductive Success of Stray Hatchery & Wild Steelhead & Influence of Hatchery Strays on Natural Productivity in Deschutes (ODFW)

2007-156-00	Rock Creek Fish and Habitat Assessment (Yakama Tribe)
2007-401-00	Kelt Reconditioning and Reproductive Success Evaluation Research (CRITFC)
2009-009-00	Basinwide Supplementation Evaluation (CRITFC)
2007-404-00	Spring Chinook Captive Propagation-Oregon (NOAA/ODFW)
2008-306-00	Deschutes River Fall Chinook Research and Monitoring (Warm Springs Tribe)
2010-030-00	Project to provided VSP Estimates for Yakima Steelhead MPG (Yakama Tribe)
2008-504-00	Sturgeon Genetics (CRITFC)
2010-028-00	Estimate Adult Steelhead Abundance in Small Streams Associated with Tucannon & Asotin Populations (WDFW)
2007-402-00	Snake River Sockeye Captive Propagation (IDFG)
1988-053-04	Hood River Production Monitor and Evaluation (ODFW)
1996-043-00	Johnson Creek relative reproductive success

Radio Tag Projects

1990-005-01	Umatilla Basin Natural Production Monitoring and Evaluation (CTUIR)
1992-026-04	Grande Ronde Early Life History of Spring Chinook and Steelhead (ODFW)
1994-026-00	Pacific Lamprey Research & Restoration Project (CTUIR)
1995-063-35	Klickitat River Monitoring and Evaluation-Yakima/Klickitat Fisheries Project (Yakama Tribe)
2002-030-00	Salmonid Progeny Markers (CTUIR)
2002-032-00	Snake River Fall Chinook Salmon Life History Investigations (USGS)
2007-246-00	Restoration of Bull Trout Passage at Albeni Falls Dam (Kalispel Tribe)
2008-109-00	Resident Fish Research, Monitoring and Evaluation (Colville Tribe)
2010-076-00	Characterizing migration and survival for juvenile Snake River sockeye salmon between the upper Salmon River basin and Lower Granite Dam (NOAA)
1995-027-00	Lake Roosevelt Sturgeon Recovery (Spokane Tribe)
2010-030-00	VSP Estimates for Yakima Steelhead (Yakama Tribe)
2010-057-00	B Run steelhead

Other Tagging and Marking Projects (otolith, floy, scales, spaghetti, calciem, jaw tags, etc.)

1991-051-00	Modeling and Evaluation Statistical Support for Life-Cycle Studies (University of WA)
2002-030-00	Salmonid Progeny Markers (Umatilla Tribe)
1991-073-00	Idaho Natural Production Monitoring and Evaluation (IDFG)
1994-033-00	Fish Passage Center (PSMFC)
1995-027-00	Lake Roosevelt Sturgeon Recovery (Spokane Tribe)
2008-307-00	Deschutes River Sockeye Development (Warm Springs Tribe)
2007-405-00	Rufus Woods Habitat/Passage Improvement, Creel and Triploid Supplementation (Colville Tribe)
2007-403-00	Spring Chinook Captive Propagation-Idaho (IDFG)
1990-077-00	Development of Systemwide Predator Control (PSMFC)
1991-046-00	Spokane Tribal Hatchery Operations and Maintenance (Spokane Tribe)
2002-032-00	Snake River Fall Chinook Salmon Life History Investigations (USGS)
2003-007-00	Lower Columbia River Estuary Ecosystem Monitoring (LCREP)

*Does not include the Lower Snake River Compensation Program or the USACOE studies on the Columbia, Snake and Willamette Rivers.

Attachment 5.

Analysis of the objectives of each tagging effort.

What is the objective of each tagging effort and are the right tags being used, or proposed to be used, to accomplish that objective.

In the Tagging Forum, a total of 117 management questions were identified that relied on tagging. The appropriateness of tag type is a qualitative categorical variable based on its ability to provide an adequate answer to the management question. Based on the January and February 2013 meeting notes and spreadsheet comments the categories are: 1) Primary (P), which indicates it is the current primary tag technology used in decision making, 2) Strong Secondary (SS), which indicates this current tag technology is a secondary source of information critical to current decision information or an emerging primary technology, 3) Weak Secondary (WS), which indicates this current tag technology is a secondary source of information not critical to current decision information, 4) Specialized (SP) indicates that this tag technology currently has limited application, 5) Future (F) indicates that this technology is not currently being used to address the management question but that a future application is being explored, and 6) Not Applicable (NA) indicated that this tag technology is not appropriate to answer the management question.

The primary tag type that answered the most predation management questions was the PIT tag (33%). For predation no other tag types were considered primary (Figure 1). Acoustic tags types are currently are weak secondary or specialized application.

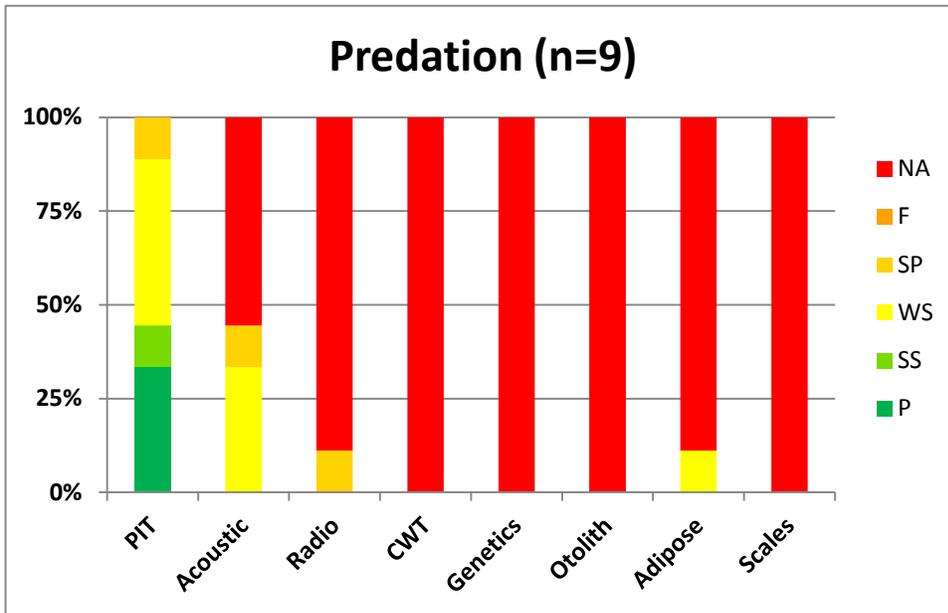


Figure 1. Ability of tagging types to answer predation Tagging Forum management questions not including SAR. Abbreviations in the figure for tag type are (Primary=P, Strong Secondary=SS, Weak Secondary=WS, Special Project=SP, Future=F, and Not Applicable = NA).

For harvest estimates, CWT were the primary tag type for 100% of the management questions, while the PIT tags and genetic markers were the primary tag types for 19% and 4%, respectively. Genetic and PIT tags cannot currently answer all harvest management questions (Figure 2).

However, continued advances in genetic markers show it is a strong secondary tag and has a high potential.

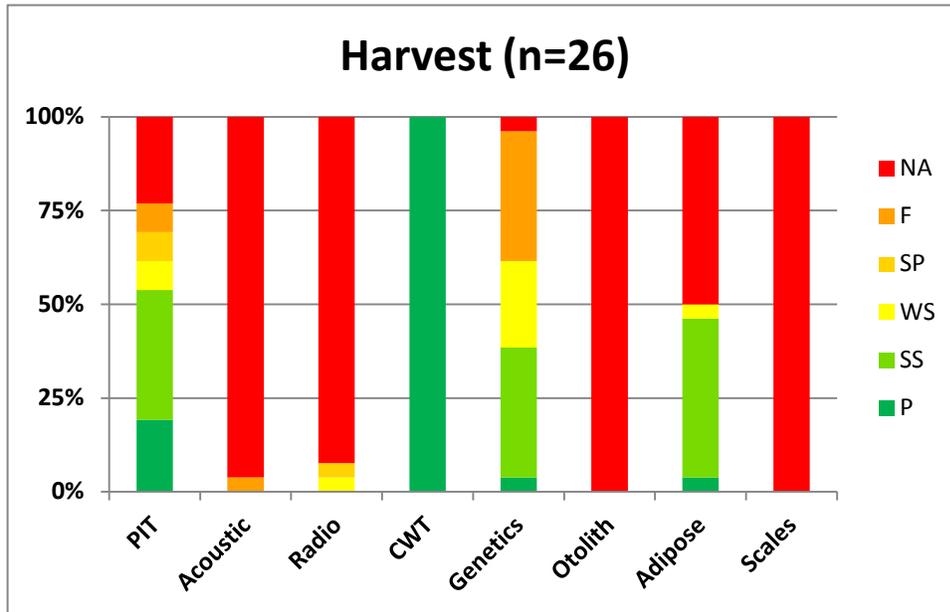


Figure 2. Ability of tagging types to answer harvest Tagging Forum management questions not including SAR. Abbreviations in the figure for tag type are (Primary=P, Strong Secondary=SS, Weak Secondary=WS, Special Project=SP, Future=F, and Not Applicable = NA).

PIT and CWT were the primary tag types for population status monitoring answered 30% or the management questions (Figure 3). Other tag types were the primary tag type of less than 10% of the management questions.

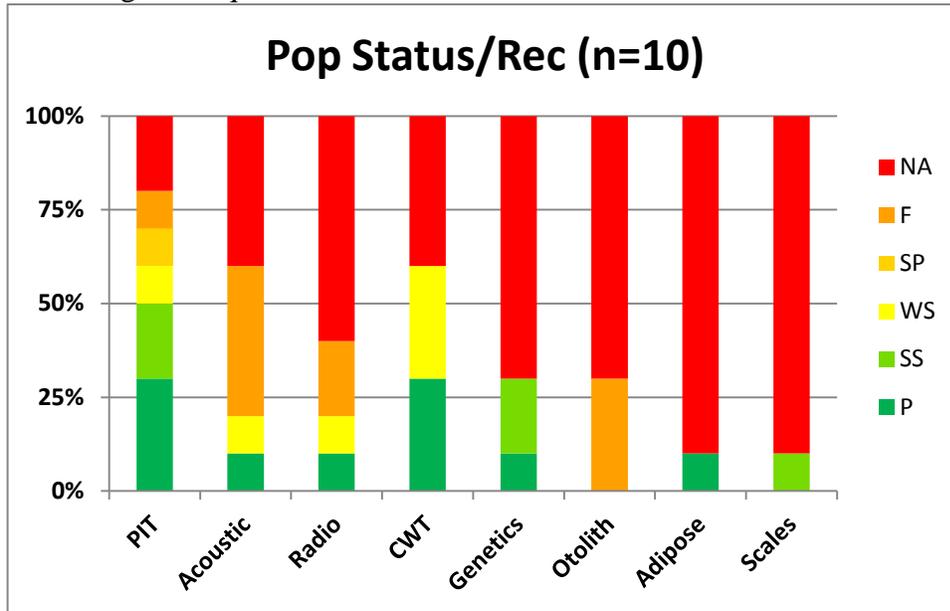


Figure 3. Ability of tagging types to answer population status Tagging Forum management questions not including SAR. Abbreviations in the figure for tag type are (Primary=P, Strong Secondary=SS, Weak Secondary=WS, Special Project=SP, Future=F, and Not Applicable = NA).

The primary tag type to address hydro management questions is the PIT tag (Figure 4) . However, acoustic and radio tags are the primary tag type to assess specific project passage routes and survival using those routes.

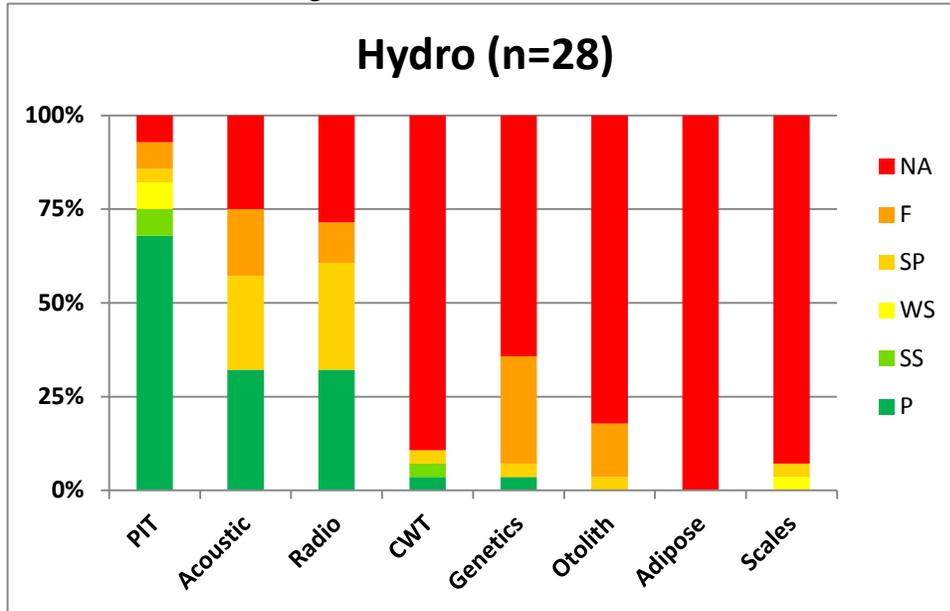


Figure 4. Ability of tagging types to answer hydro Tagging Forum management questions not including SAR. Abbreviations in the figure for tag type are (Primary=P, Strong Secondary=SS, Weak Secondary=WS, Special Project=SP, Future=F, and Not Applicable = NA).

PIT tags were the primary tag type to answer ~ 75% of the habitat management questions (Figure 5). Other tags types were the primary tag type for less than 10% answered of the management questions. For high interest management question, PIT tags were the primary tag type for 90% of the management questions and radio tag types for 10%.

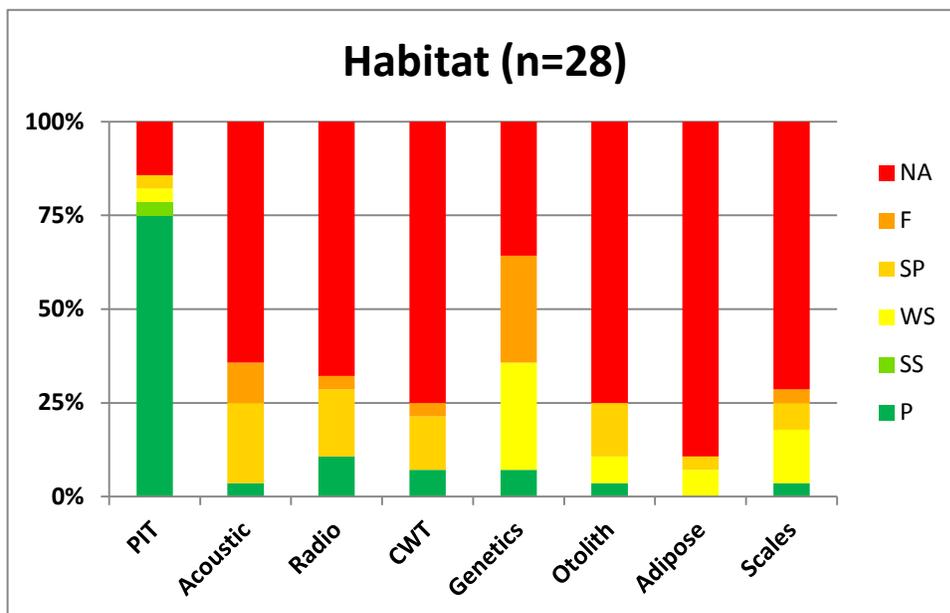


Figure 5. Ability of tagging types to answer hydro Tagging Forum management questions not including SAR. Abbreviations in the figure for tag type are (Primary=P, Strong Secondary=SS, Weak Secondary=WS, Special Project=SP, Future=F, and Not Applicable = NA).

For hatchery management questions, CWT were the primary tag type for 54% of the management questions (Figure 6). The adipose fin clip, genetic, and PIT tags were the primary tag types for 27%, 18%, and 18%, respectively of the hatchery management questions.

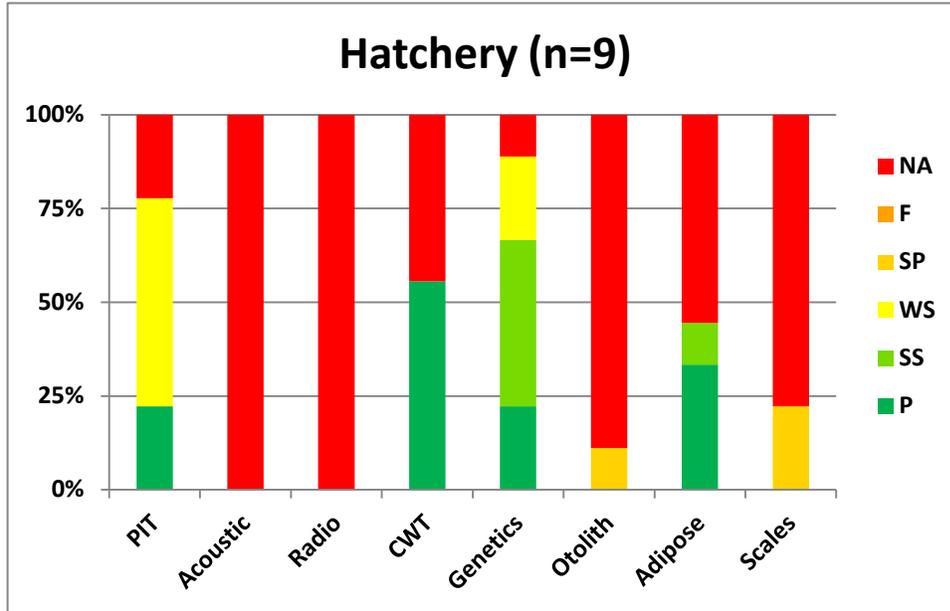


Figure 6. Ability of tagging types to answer hatchery Tagging Forum management questions not including SAR. Abbreviations in the figure for tag type are (Primary=P, Strong Secondary=SS, Weak Secondary=WS, Special Project=SP, Future=F, and Not Applicable = NA).

In summary, the all management questions cannot be answered by a single tag type. Each tag type has areas in which it is currently the only tag type to provide sufficient information to an answer a management question (primary or strong secondary). For example, acoustic and radio tags excell at identifying dam passage routes and survival using those routes. PIT tags are the only technology to answer predation questions. CWT are the only technology to answer some harvest and hatchery. Genetic is the only technology available to assess mitigation hatchery programs conservation responsibility (i.e. relative reproductive success). The primary tag type that answered the most management questions were the PIT tag (48%) and the CWT (33%). Other tag types were considered primary for less than 13% of the management questions (Figure 7). Genetics markers currently are not a primary tag type but have the most future potential.

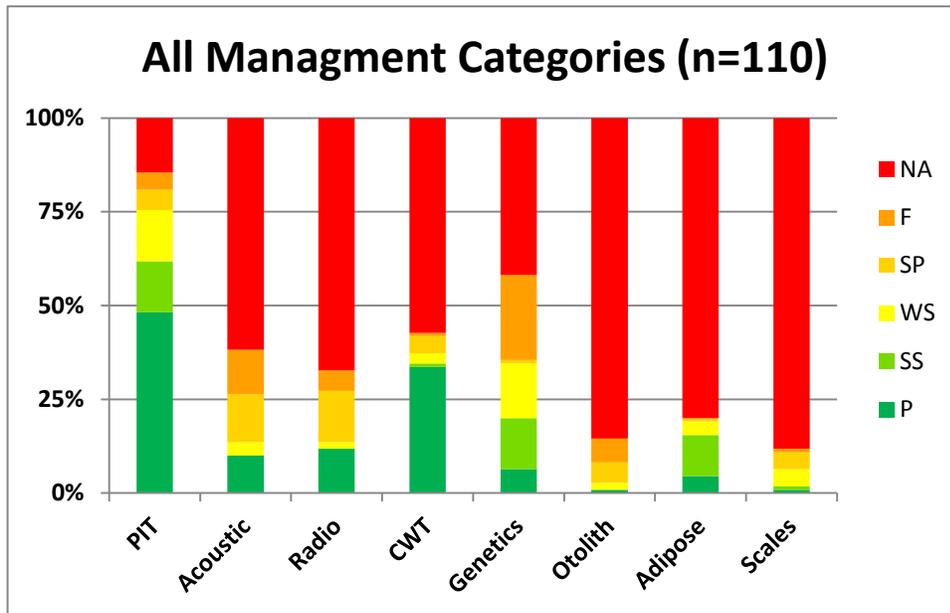


Figure 7. Ability of tagging types to answer all and high interest Tagging Forum management questions not including SAR. Abbreviations in the figure for tag type are (Primary=P, Strong Secondary=SS, Weak Secondary=WS, Special Project=SP, Future=F, and Not Applicable = NA).

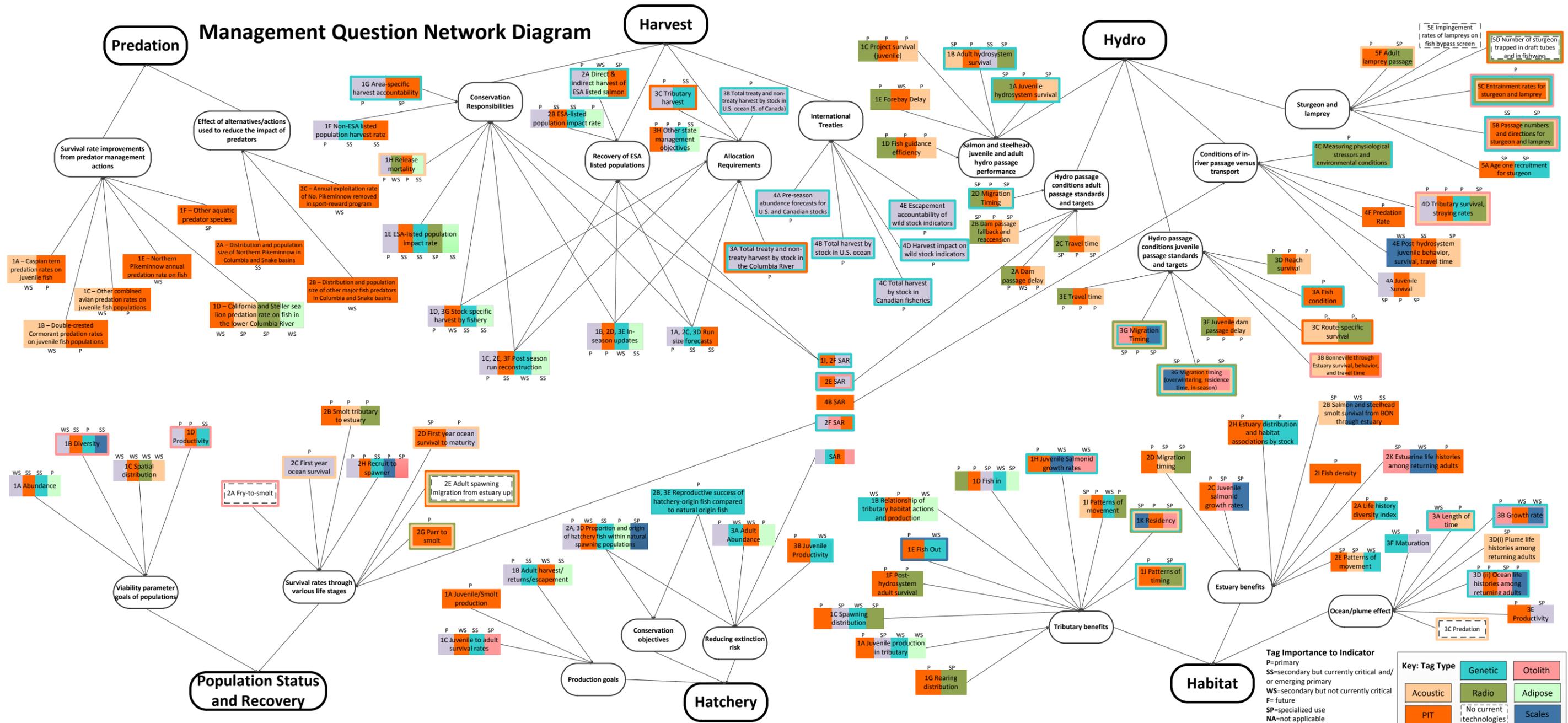
Attachment 6: Indicator Analysis spreadsheet

[Insert Indicator Analysis Spreadsheet here.]

Attachment 6.

c:\users\grover\desktop\ff decision memo committee 29april2013 final.docx (Tony Grover)

Management Question Network Diagram



Tag Importance to Indicator
 P=primary
 SS=secondary but currently critical and/or emerging primary
 WS=secondary but not currently critical
 F=future
 SP=specialized use
 NA=not applicable

Key: Tag Type

Acoustic	Genetic	Otolith
PIT	Radio	Adipose
CWT	No current technologies	Scales
	Colored band indicates future application opportunity	

Management Category	Management Question	Indicator	Tag Type and Importance to Indicator (P=primary; SS=strong secondary (e.g., currently critical and/or emerging primary); WS=weak secondary (e.g., not currently critical); F= future; SP=specialized use; NA=not applicable)																	
			Is more than one technology applicable? (1=No; 0=Yes)		PIT		Acoustic		Radio		CMT		Genetics		Otolith		Adipose		Scales	
Predation	1) Are predator management actions providing expected survival rate improvements?	A) Caspian tern predation rates on juvenile fish populations	0	P	WS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Predation	1) Are predator management actions providing expected survival rate improvements?	B) Double-crested Cormorant predation rates on juvenile fish populations	0	P	WS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Predation	1) Are predator management actions providing expected survival rate improvements?	C) Other combined avian predation rates on juvenile fish populations	0	P	WS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Predation	1) Are predator management actions providing expected survival rate improvements?	D) California and Steller sea lion predation rate on fish in the lower Columbia River	1	WS	SP	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA	WS	NA	NA	NA	NA
Predation	1) Are predator management actions providing expected survival rate improvements?	E) Northern Pike minnow annual predation rate on fish	0	WS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Predation	1) Are predator management actions providing expected survival rate improvements?	F) Other aquatic predator species (e.g., smallmouth bass, walleye, etc.)	0	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Predation	2) What is the effect of alternatives/actions used to reduce the impact of predators?	A) Distribution and population size of No. Pike minnow in Columbia and Snake basins	1	SS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Predation	2) What is the effect of alternatives/actions used to reduce the impact of predators?	B) Distribution & population size of other major fish predators in Columbia/Snake basins	1	WS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Predation	2) What is the effect of alternatives/actions used to reduce the impact of predators?	C) Annual exploitation rate of No. Pike minnow removed in sport-reward program	1	WS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Harvest	1) Are harvest management actions effective in meeting conservation	A) Run size forecasts	0	SS	NA	NA	NA	NA	NA	NA	NA	P	SS	NA	NA	NA	NA	NA	NA	NA
Harvest	1) Are harvest management actions effective in meeting conservation	B) In-season updates (abundance-based management)	0	P	NA	NA	NA	NA	NA	NA	NA	P	WS	NA	SS	NA	NA	NA	NA	NA
Harvest	1) Are harvest management actions effective in meeting conservation	C) Post season run reconstruction FCRPS BIOP Limited to specific stocks	0	SS	NA	NA	NA	NA	NA	NA	NA	P	WS	NA	SS	NA	NA	NA	NA	NA
Harvest	1) Are harvest management actions effective in meeting conservation	D) Stock-specific (ESU, MPG etc) harvest by fishery (includes CRB and ocean fisheries)	0	WS	NA	NA	NA	NA	NA	NA	NA	P	SS	NA	SS	NA	NA	NA	NA	NA
Harvest	1) Are harvest management actions effective in meeting conservation	E) ESA-listed population impact rate as well as FCRPS BIOP for selective fishery research projects	0	SS	NA	NA	NA	NA	NA	NA	NA	P	SS	NA	SS	NA	NA	NA	NA	NA
Harvest	1) Are harvest management actions effective in meeting conservation responsibilities (PST, FCRPS relies on data e.g., RPA 62, US v OR)?	F) Non ESA-listed population harvest rate	0	SS	NA	NA	NA	NA	NA	NA	NA	P	SS	NA	NA	NA	NA	NA	NA	NA
Harvest	1) Are harvest management actions effective in meeting conservation responsibilities (PST, FCRPS relies on data e.g., RPA 62, US v OR)?	G) Area-specific harvest accountability (e.g. harvest sections below BON, sections above BON, or areas in Ocean fishery) -- this may be redundant with question 1D	0	SP	NA	NA	NA	NA	NA	NA	NA	P	F	NA	NA	NA	NA	NA	NA	NA
Harvest	1) Are harvest management actions effective in meeting conservation	H) Release mortality	0	P	F	WS	NA	NA	NA	NA	NA	P	NA	NA	SS	NA	NA	NA	NA	NA

Management Category	Management Question	Indicator	Tag Type and Importance to Indicator (P=primary; SS=strong secondary (e.g., currently critical and/or emerging primary); WS=weak secondary (e.g., not currently critical); F= future; SP=specialized use; NA=not applicable)																	
			Is more than one technology applicable? (1=No; 0=Yes)		PIT		Acoustic		Radio		CWT		Genetics		Otolith		Adipose		Scales	
Harvest	1) Are harvest management actions effective in meeting conservation	I) SAR-Survival from beginning of downstream migration, typically hatchery release or tagging and	0		NA	NA	NA	NA	NA	NA	NA	WS	NA	NA	NA	NA	NA	NA	NA	NA
Harvest	2) Are harvest programs being managed to contribute to recovery of ESA listed populations?	A) Direct and indirect harvest of ESA-listed salmon - required by harvest BIOps	0	SP	NA	NA	NA	NA	NA	NA	NA	F	NA	NA	WS	NA	NA	NA	NA	NA
Harvest	2) Are harvest programs being managed to contribute to recovery of ESA listed populations?	B) ESA-listed population impact rate - required by harvest BIOps	0	SS	NA	NA	NA	NA	NA	NA	NA	SS	NA	NA	P	NA	NA	NA	NA	NA
Harvest	2) Are harvest programs being managed to contribute to recovery of ESA listed populations?	C) Run size forecasts (abundance based management)	0	SS	NA	NA	NA	NA	NA	NA	NA	SS	NA	NA	NA	NA	NA	NA	NA	NA
Harvest	2) Are harvest programs being managed to contribute to recovery of ESA listed populations?	D) In-season updates (abundance based management)	0	P	NA	NA	NA	NA	NA	NA	NA	WS	NA	NA	SS	NA	NA	NA	NA	NA
Harvest	2) Are harvest programs being managed to contribute to recovery of ESA listed populations?	E) Post season run reconstruction	0	SS	NA	NA	NA	NA	NA	NA	NA	WS	NA	NA	SS	NA	NA	NA	NA	NA
Harvest	2) Are harvest programs being managed to contribute to recovery of ESA listed populations?	F) SAR - Survival from beginning of downstream migration to return as adults. Metric includes harvest-related mortality occurring during the ocean and adult return phases of the life cycle and is used to estimate the effect of harvest regulation on escapement.	0		NA	NA	NA	NA	NA	NA	NA	WS	NA	NA	NA	NA	NA	NA	NA	NA
Harvest	3) Is harvest effectively managed to meet Treaty Indian/non-Indian allocation requirements and other management responsibilities?	A) Total Treaty and non-treaty harvest by stock in the Columbia River	1	F	NA	NA	NA	NA	NA	NA	NA	F	NA	NA	NA	NA	NA	NA	NA	NA
Harvest	3) Is harvest effectively managed to meet Treaty Indian/non-Indian allocation requirements and other management responsibilities?	B) Total Treaty and non-treaty harvest by stock in U.S. ocean (South of Canada)	1	NA	NA	NA	NA	NA	NA	NA	NA	F	NA	NA	NA	NA	NA	NA	NA	NA
Harvest	3) Is harvest effectively managed to meet Treaty Indian/non-Indian allocation requirements and other management responsibilities?	C) Tributary Harvest	0	F	NA	NA	NA	NA	NA	NA	NA	SS	NA	NA	NA	NA	NA	NA	NA	NA
Harvest	3) Is harvest effectively managed to meet Treaty Indian/non-Indian allocation requirements and other management responsibilities?	D) Run size forecasts	0	SS	NA	NA	NA	NA	NA	NA	NA	SS	NA	NA	NA	NA	NA	NA	NA	NA
Harvest	3) Is harvest effectively managed to meet Treaty Indian/non-Indian allocation requirements and other management responsibilities?	E) In-season updates (abundance based management)	0	P	NA	NA	NA	NA	NA	NA	NA	WS	NA	NA	SS	NA	NA	NA	NA	NA

Management Category	Management Question	Indicator	Tag Type and Importance to Indicator (P=primary; SS=strong secondary (e.g., currently critical and/or emerging primary); WS=weak secondary (e.g., not currently critical); F= future; SP=specialized use; NA=not applicable)									
			Is more than one technology applicable? (1=No; 0=Yes)	PIT	Acoustic	Radio	CMT	Genetics	Otolith	Adipose	Scales	
Harvest	3) Is harvest effectively managed to meet Treaty Indian/non-Indian allocation requirements and other management responsibilities?	F) Post season run reconstruction	0	SS	NA	NA	P	WS	NA	SS	NA	NA
Harvest	3) Is harvest effectively managed to meet Treaty Indian/non-Indian allocation requirements and other management responsibilities?	G) Stock-specific (ESU, MPG etc) harvest by fishery	0	WS	NA	NA	P	SS	NA	SS	NA	NA
Harvest	3) Is harvest effectively managed to meet Treaty Indian/non-Indian allocation requirements and other management responsibilities?	H) Other state management catch objectives (e.g., sport fisheries, state management objectives/policies)	0	P	NA	NA	P	P	NA	SS	NA	NA
Harvest	4) Is harvest managed to meet the requirements of International treaties? (PST)	A) Pre-season abundance forecasts for U.S. and Canadian stocks	1	NA	NA	NA	P	F	NA	NA	NA	NA
Harvest	4) Is harvest managed to meet the requirements of International treaties? (PST)	B) Total harvest by stock in U.S. ocean	1	NA	NA	NA	P	F	NA	NA	NA	NA
Harvest	4) Is harvest managed to meet the requirements of International treaties? (PST)	C) Total harvest by stock in Canadian fisheries	1	NA	NA	NA	P	F	NA	NA	NA	NA
Harvest	4) Is harvest managed to meet the requirements of International treaties? (PST)	D) Harvest impact on wild stock indicators	1	NA	NA	NA	P	F	NA	NA	NA	NA
Harvest	4) Is harvest managed to meet the requirements of International treaties? (PST)	E) Escapement accountability of wild stock indicators (status of PST wild stock Indicators)	1	NA	NA	NA	P	F	NA	NA	NA	NA
Pop Status/Rec (ESA listed stocks)	1) Are the populations (trending towards) meeting the goals of the viability parameters?	a) Abundance	0	SS	NA	NA	WS	SS	NA	P	NA	NA
Pop Status/Rec	1) Are the populations (trending towards) meeting the goals of the viability parameters?	b) Diversity	0	SS	NA	NA	WS	P	F	NA	SS	NA
Pop Status/Rec	1) Are the populations (trending towards) meeting the goals of the viability parameters?	c) Spatial distribution	0	WS	WS	WS	WS	NA	NA	NA	NA	NA
Pop Status/Rec	1) Are the populations (trending towards) meeting the goals of the viability parameters?	d) Productivity (derived indicator based on abundance and diversity data)	0	P	NA	NA	P	SS	F	NA	NA	NA
Pop Status/Rec	2) What are survival rates through various life stages?	a) Fry-to-smolt (NOAA prefers fry to smolt)	1	NA	NA	NA	NA	NA	F	NA	NA	NA

Management Category	Management Question	Indicator	Tag Type and Importance to Indicator (P=primary; SS=strong secondary (e.g., currently critical and/or emerging primary); WS=weak secondary (e.g., not currently critical); F=future; SP=specialized use; NA=not applicable)										
			Is more than one technology applicable? (1=No; 0=Yes)	PTT	Acoustic	Radio	CWT	Genetics	Otolith	Adipose	Scales		
Pop Status/Rec	2) What are survival rates through various life stages?	b) Fry/Parr/Smolt Tributary to estuary (consider clarify if mainstem aspect, trib to BON, or something else) - FCRPS is directly responsible for trib to estuary	0	P	P	P	NA	NA	NA	NA	NA	NA	NA
Pop Status/Rec	2) What are survival rates through various life stages?	c) First year ocean survival (FCRPS BIOP does not have a direct requirement to monitor first yr ocean condition)	1	NA	F	NA	NA	P	NA	NA	NA	NA	NA
Pop Status/Rec	2) What are survival rates through various life stages?	d) First year ocean survival to maturity	1	SP	F	NA	NA	P	NA	NA	NA	NA	NA
Pop Status/Rec	2) What are survival rates through various life stages?	e) Adult spawning migration (USVOR DR responsible for collecting adult spawning migration) - from estuary up including: trib-trib, trib-BON, BON-BON, 1st dam encountered by juvenile to BON, 1st dam encountered by juvenile to last dam encountered by adult.	1	F	F	F	NA	NA	NA	NA	NA	NA	NA
Pop Status/Rec	2) What are survival rates through various life stages?	f) Parr to Smolt (added Nov. 26th by subgroup))	0	P	F	F	NA	NA	NA	NA	NA	NA	NA
Pop Status/Rec	2) What are survival rates through various life stages?	g) Recruit to Spawner: is the population growing? (derived indicator based on abundance, diversity, and harvest)	0	P	NA	NA	NA	P	SS	SS	SP	NA	P
Hydro	1) Are salmon and steelhead meeting juvenile and adult hydro passage performance standards and targets for the HCP, FCRPS BiOP and Accords?	A) Hydrosystem Survival juvenile	0	P	SP	SP	NA	SP	NA	F	NA	NA	NA
Hydro	1) Are salmon and steelhead meeting juvenile and adult hydro passage performance standards and targets for the HCP, FCRPS BiOP and Accords?	B) Hydrosystem Survival adults	0	P	SP	SP	SS	SP	SS	F	NA	NA	NA
Hydro	1) Are salmon and steelhead meeting juvenile and adult hydro passage performance standards and targets for the HCP, FCRPS BiOP and Accords?	C) Project (Dam and reservoir) Survival (juvenile fish)	0	P	P	P	NA	P	NA	NA	NA	NA	NA
Hydro	1) Are salmon and steelhead meeting juvenile and adult hydro passage performance standards and targets for the HCP, FCRPS BiOP and Accords?	D) Fish Guidance Efficiency (assume both spill passage efficiency and fish guidance efficiency)	0	P	P	P	NA	P	NA	NA	NA	NA	NA
Hydro	1) Are salmon and steelhead meeting juvenile and adult hydro passage performance standards and targets for the HCP, FCRPS BiOP and Accords?	E) Forebay Delay	0	WS	P	P	NA	P	NA	NA	NA	NA	NA
Hydro	2) Are hydro passage conditions providing safe and effective passage for adults that contribute to meeting the performance standards and targets?	A) Dam Passage Delay	0	WS	P	P	NA	P	NA	NA	NA	NA	NA

Management Category	Management Question	Indicator	Tag Type and Importance to Indicator (P=primary; SS=strong secondary (e.g., currently critical and/or emerging primary); WS=weak secondary (e.g., not currently critical); F= future; SP=specialized use; NA=not applicable)												
			Is more than one technology applicable? (1=No; 0=Yes)	PIT	Acoustic	Radio	CWT	Genetics	Otolith	Adipose	Scales				
Hydro	2) Are hydro passage conditions providing safe and effective passage for adults that contribute to meeting the performance standards and targets?	B) Dam Passage Fallback and reaccension	0	P	SP	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	2) Are hydro passage conditions providing safe and effective passage for adults that contribute to meeting the performance standards and targets?	C) Travel Time	0	P	SP	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	2) Are hydro passage conditions providing safe and effective passage for adults that contribute to meeting the performance standards and targets?	D) Migration timing (between dam migration=PIT, radio; run-timing arr at BON = PIT)	0	P	SP	SP	NA	NA	NA	F	NA	NA	NA	NA	NA
Hydro	2) Are hydro passage conditions providing safe and effective passage for adults that contribute to meeting the performance standards and targets?	E) Smolt-to-Adult Return Rates (multiple and varied points of measurement): a relative comparison metric specific to studies re: inriver vs transported fish; project and passage survival)	0	P	NA	NA	NA	NA	NA	F	F	NA	NA	NA	NA
Hydro	3) Are hydro passage conditions providing safe and effective passage for juveniles that contribute to meeting the performance standards and targets?	A) Fish Condition (health, growth rate and bioenergetics) - not associated with tagging; but have used PIT tagged fish to understand migration history and measure these condition variables	1	P	NA	NA	NA	NA	NA	F	NA	NA	NA	NA	NA
Hydro	3) Are hydro passage conditions providing safe and effective passage for juveniles that contribute to meeting the performance standards and targets?	B) Bonneville through Estuary (Lower Columbia River) Survival, Behavior and Travel Time	0	P	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	3) Are hydro passage conditions providing safe and effective passage for juveniles that contribute to meeting the performance standards and targets?	C) Route-Specific Survival (through individual dam passage routes - e.g., turbine, spill, bypass)	0	F	P	P	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	3) Are hydro passage conditions providing safe and effective passage for juveniles that contribute to meeting the performance standards and targets?	D) Reach Survival	0	P	P	P	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	3) Are hydro passage conditions providing safe and effective passage for juveniles that contribute to meeting the performance standards and targets?	E) Travel Time	0	P	P	P	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	3) Are hydro passage conditions providing safe and effective passage for juveniles that contribute to meeting the performance standards and targets?	F) Juvenile Dam Passage Delay	0	P	P	P	NA	NA	NA	NA	NA	NA	NA	NA	NA

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			Is more than one technology applicable? (1=No; 0=Yes)		PIT		Acoustic		Radio		CMT		Genetics		Otolith		Adipose		Scales	
Hydro	3) Are hydro passage conditions providing safe and effective passage for juveniles that contribute to meeting the performance standards and targets?	G) Migration timing (overwintering, residence time, in-season)	0	P	F	F	F	NA	NA	NA	NA	F	SP	NA	NA	NA	NA	NA	NA	SP
Hydro	4) What conditions affect the relative benefit of in-river passage versus transport?	A) Juvenile survival	0	P	SP	NA	NA	NA	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	4) What conditions affect the relative benefit of in-river passage versus transport?	B) Smolt-to-Adult Return Rates (multiple and varied points of measurement): a relative comparison metric specific to studies re: in-river vs transported fish.	1	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	4) What conditions affect the relative benefit of in-river passage versus transport?	C) Measuring physiological stressors & environmental conditions	1	NA	NA	NA	NA	P	NA	NA	NA	F	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	4) What conditions affect the relative benefit of in-river passage versus transport?	D) Tributary Survival, Straying Rates	0	P	F	SP	SP	P	P	P	P	F	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	4) What conditions affect the relative benefit of in-river passage versus transport?	E) Post-hydrosystem juvenile behavior, survival and travel time	0	SS	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	WS
Hydro	4) What conditions affect the relative benefit of in-river passage versus transport?	F) Predation rate	0	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	5) What are effective configurations and operations to reduce impacts on sturgeon and lampreys?	A) Age one recruitment for sturgeon	1	SP	NA	NA	NA	NA	NA	NA	NA	SP	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	5) What are effective configurations and operations to reduce impacts on sturgeon and lampreys?	B) Passage numbers and directions for sturgeon and lamprey	0	SS	F	SP	SP	NA	NA	NA	NA	F	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	5) What are effective configurations and operations to reduce impacts on sturgeon and lampreys?	C) Entrainment rates for sturgeon and lamprey	0	P	F	F	F	NA	NA	NA	NA	F	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	5) What are effective configurations and operations to reduce impacts on sturgeon and lampreys?	D) Number of sturgeon trapped in draft tubes and in fishways (normally results in draining and removal of all sturgeon; if not drained then might rely on tags to detect if had a detector in the draft tube/fishway)	1	F	NA	NA	F	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	5) What are effective configurations and operations to reduce impacts on sturgeon and lampreys?	E) Impingement rates of lampreys on fish bypass screen (not addressed by tag studies)	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydro	5) What are effective configurations and operations to reduce impacts on sturgeon and lampreys?	F) Adult lamprey passage	0	P	F	SP	F	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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			Is more than one technology applicable? (1=No; 0=Yes)	PIT		Acoustic		Radio		CMT		Genetics		Otolith		Adipose		Scales	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	A) Juvenile production in tributary habitat (NOF, parr abundance and survival)	0	P	NA	NA	NA	NA	SP	WS	NA	NA	WS	NA	NA	WS	NA	NA	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	B) Relationship of tributary habitat actions and productivity (out-migrating)	0	P	NA	NA	NA	NA	NA	WS	NA	NA	WS	NA	NA	WS	NA	NA	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	C) Spawning distribution (gross distribution info, specific spawning distribution relies on snorkeling, redd count etc)	0	P	NA	NA	SP	SP	SP	WS	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	D) Fish in - escapement / spawning ground	0	P	NA	NA	P	SP	SP	WS	NA	NA	SP	NA	NA	SP	NA	NA	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	E) Fish out - outmigrant	0	P	NA	NA	NA	NA	NA	WS	NA	NA	NA	NA	NA	NA	NA	F	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	F) Post-Hydrosystem Adult Survival (i.e., survival from last dam to tributaries)	0	P	NA	NA	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	G) Rearing distribution (reach scale within trib including abundance & movement)	1	P	NA	NA	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	H) Juvenile salmonid growth rates	0	P	NA	NA	NA	NA	NA	F	NA	NA	WS	NA	NA	NA	NA	WS	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	I) Patterns of movement (juveniles/adults)	0	P	SP	SP	P	NA	NA	WS	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	J) Patterns of timing (juveniles/adults)	0	P	F	SP	NA	NA	NA	F	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	1) Are tributary habitat actions achieving the expected benefits?	K) Residency(in trib, reservoirs,)	0	P	F	F	F	NA	NA	F	NA	SP	NA	NA	NA	NA	SP	NA	
Habitat	2) Are Estuary habitat actions achieving the expected benefits?	A) Life history diversity index	0	P	NA	NA	NA	NA	NA	P	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	2) Are Estuary habitat actions achieving the expected benefits?	B) Salmon and steelhead smolt survival from Bonneville Dam through the estuary	0	SS	SP	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	WS	
Habitat	2) Are Estuary habitat actions achieving the expected benefits?	C) Juvenile salmonid growth rates	0	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	SP	
Habitat	2) Are Estuary habitat actions achieving the expected benefits?	D) Migration timing	0	P	SP	SP	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	2) Are Estuary habitat actions achieving the expected benefits?	E) Patterns of movement	0	SP	SP	SP	NA	NA	NA	WS	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	2) Are Estuary habitat actions achieving the expected benefits?	F) Patterns of timing	0	P	SP	SP	SP	NA	NA	F	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	2) Are Estuary habitat actions achieving the expected benefits?	G) Residency (R.G. -- How is this different from E?)	0	P	NA	NA	NA	NA	NA	F	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	2) Are Estuary habitat actions achieving the expected benefits?	H) Estuary distribution and habitat associations by stock	0	P	NA	NA	NA	NA	NA	P	NA	NA	NA	NA	NA	NA	NA	NA	
Habitat	2) Are Estuary habitat actions achieving the expected benefits?	I) Fish density	1	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

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			Is more than one technology applicable? (1=No; 0=Yes)	PTT	Acoustic	Radio	CMT	Genetics	Otolith	Adipose	Scales				
Habitat	2) Are Estuary habitat actions achieving the expected benefits?	K) Estuarine life histories among returning adults	1	P	NA	NA	NA	NA	NA	NA	NA	SP	NA	NA	WS
Habitat	3) What is the ocean's /plume effect to population status / recovery?	A) Length of time	0	NA	P	NA	NA	NA	NA	NA	NA	WS	NA	NA	NA
Habitat	3) What is the ocean's /plume effect to population status / recovery?	B) Growth rate	0	WS	NA	NA	NA	F	F	F	NA	P	NA	NA	WS
Habitat	3) What is the ocean's /plume effect to population status / recovery?	C) Predation	0	NA	F	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Habitat	3) What is the ocean's /plume effect to population status / recovery?	D (ii) Ocean life histories among returning adults (number of yrs at sea; or determining time spent in plume requiring tagging within plume - or do we want to know how a fish spends its time in ocean/plume if so we need to tag fish within the plume, scale and otolith only marks transition between salt-fresh)	0	P	NA	NA	NA	NA	P	P	F	SP	NA	NA	P
Habitat	3) What is the ocean's /plume effect to population status / recovery?	D(i)plume		NA	SP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Habitat	3) What is the ocean's /plume effect to population status / recovery?	E) Productivity	1	P	NA	NA	NA	SP	NA	NA	NA	NA	NA	NA	NA
Habitat	3) What is the ocean's /plume effect to population status / recovery?	F) Maturation (maturation rates and age structure)	0	NA	NA	NA	NA	NA	P	P	WS	NA	NA	NA	NA
Hatchery	1) Are mitigation hatchery programs meeting their specific production goals? (R.G.--DR if BPA-funded tribal hatcheries=mitigation.)	A) Juvenile/Smolt production	1	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hatchery	1) Are mitigation hatchery programs meeting their specific production goals? (R.G.--DR if BPA-funded tribal hatcheries=mitigation.)	B) Adult harvest/returns/escapement	0	WS	NA	NA	NA	P	P	SS	SS	NA	SS	NA	NA
Hatchery	1) Are mitigation hatchery programs meeting their specific production goals? (R.G.--DR if BPA-funded tribal hatcheries=mitigation.)	C) Juvenile to adult survival rates	0	WS	NA	NA	NA	P	P	SS	SS	SP	NA	NA	NA
Hatchery	2) Are mitigation hatchery programs being managed to meet conservation objectives?	A) Proportion and origin of hatchery fish within natural spawning populations (pHOS)	0	WS	NA	NA	NA	P	P	SS	SS	NA	P	NA	SP
Hatchery	2) Are mitigation hatchery programs being managed to meet conservation objectives?	B) Reproductive success of hatchery-origin fish compared to natural origin fish	1	NA	NA	NA	NA	NA	NA	P	P	NA	NA	NA	NA

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Management Category	Management Question	Indicator	Is more than one technology applicable? (1=No; 0=Yes)									
			PTT	Acoustic	Radio	CWT	Genetics	Otolith	Adipose	Scales		
Hatchery	3) Are conservation hatchery programs reducing the extinction risk of certain listed populations?	A) Adult abundance	WS	NA	NA	P	WS	NA	P	NA	P	NA
Hatchery	3) Are conservation hatchery programs reducing the extinction risk of certain listed populations?	B) Juvenile productivity (of the listed population ; also need adult information)natural origin fish from supplementation	P	NA	NA	NA	WS	NA	NA	NA	NA	NA
Hatchery	3) Are conservation hatchery programs reducing the extinction risk of certain listed populations?	C) SAR - Survival from beginning of downstream migration to return as adults. Metric is used to assess the effect of broodstock and adult escapement reform measures on captive rearing programs and stock rebuilding programs that contribute to the growth of genetic resources and promote recovery of listed populations.	SS	NA	NA	P	WS	SP	NA	NA	NA	NA
Hatchery	3) Are conservation hatchery programs reducing the extinction risk of certain listed populations?	D) Proportion and origin of hatchery fish within natural spawning populations (PHOS)	WS	NA	NA	P	SS	NA	P	NA	P	SP
Hatchery	3) Are conservation hatchery programs reducing the extinction risk of certain listed populations?	E) Reproductive success of hatchery-origin fish compared to natural origin fish	NA	NA	NA	NA	P	NA	NA	NA	NA	NA