Independent Scientific Review Panel

for the Northwest Power and Conservation Council; 851 SW 6th Avenue, Suite 1100; Portland, Oregon 97204

Independent Scientific Advisory Board

for the Council, Columbia River Basin Indian Tribes, and NOAA Fisheries

MEMORANDUM (ISRP and ISAB 2009-2) **May 21, 2009**

TO: Tony Grover, Fish and Wildlife Division Director

FROM: Eric Loudenslager, chair ISRP, and Nancy Huntly, chair ISAB

SUBJECT: Comments on the Council's March 2009 Proposed High Level Indicators

Preface

The Council's request to review draft High Level Indicators (HLIs) generated much debate within the Independent Scientific Review Panel (ISRP) and the Independent Scientific Advisory Board (ISAB). On one hand, we wanted to respond promptly to the Council's request to examine the utility of large-scale reporting metrics in the current Columbia River Fish and Wildlife Program. On the other hand, the assignment raised the larger issue of whether the indicators, as they are now constituted, represent the most meaningful measures of progress under the Council's Program. We also felt that the need for a particular type of indicator may be high, but that the indicator presently being used was not the best one. Overall, we agree that there is a strong need for high level indicators of the status and trends of fish and wildlife and their habitats.

The review that follows is our response to the original assignment. However, the ISRP and ISAB feel the topic merits additional examination. Within the time period allotted to this review we were unable to reach full consensus on what the most useful high level indicators of restoration progress might be, and whether such indicators should be many and detailed or few and simple (and how uncertainty can be associated with an indicator). The issues are worthy of further discussion.

The ISRP and ISAB's comments follow, beginning with a table of contents.

ISRP and ISAB Comments on the Council's Proposed High Level Indicators

Contents

ISRP and ISAB Comments on the Council's Proposed High Level Indicators

Background

The Council is developing a list of high level indicators (HLIs) to communicate its Fish and Wildlife Program's progress to the region's Governors and to Congress. The 2009 Fish and Wildlife Program (Program) guides mitigation for impacts on fish and wildlife resulting from the construction and operation of the hydropower system within the Columbia River Basin. This mitigation is for not only salmon and steelhead listed under the Endangered Species Act (ESA) but also non-ESA listed species. On March 13, 2009, the Council requested public comment on a draft list of seventeen possible indicators in an effort to stimulate discussion and to begin the process of aligning the Council's potential HLIs with indicators used by others in the region in reporting the status and trends of the region's natural resources. Concurrent with this request for public comment, the Council asked the ISRP and ISAB to also provide comments.

Currently the Council is considering two broad categories of HLIs: biological and implementation. Ten proposed biological HLIs track the status and trend of fish abundance, fish harvest, fish productivity, hydrosystem survival, and wildlife habitat. The remaining seven implementation HLIs report on actions that are believed likely to contribute to the program's success, such as fish passage, water conservation, land improvements, predation levels, fish screens, and watershed condition.

The Council sought comment on the following questions:

1. What is the potential of the Council's draft indicators to effectively communicate the program's progress?
2. Which indicators, among those suggested by the Council or other indicators used in the region, are the most important to inform Congress, Governors, and other regional decision-makers about Columbia River Basin fish and wildlife?
3. How should these indicators be derived to assure aligning with similar indicators used by the region to report to decision-makers?
4. What is the availability of existing data to support these indicators, and what is the quality of the available data?

The Council also sought input on the potential use of HLIs in assisting with the development of the Fish and Wildlife Program's research, monitoring and evaluation strategies and for prioritizing the Program's biological and environmental objectives (Program, page 20).

The ISRP discussed high level indicators in a previous report (ISRP 2008-7[1]):

> "We acknowledge the need for high level indicators (HLIs) of habitat condition over large geographic scales such as watersheds and subbasins. HLIs are needed to track how well the Fish and Wildlife Program is working to restore habitat over the entire Columbia River Basin and to provide metrics for reporting to Congress. The ISRP agrees that integrated, high level indicators of habitat condition would be very helpful. High level indicators of restoration effectiveness will involve large-scale measures of vegetation, land use, flow, and hydrologic connectivity, as well as multi-species indices of population health. This level of indicator goes beyond the aggregate effect of project level results."

The ISRP and ISAB's previous statement on HLIs still applies (ISAB&ISRP 2006-4[2]):

> "to enable long-term and broad-scale monitoring and evaluation of even the highest priority issues in the Fish and Wildlife Program will require that the list of 'required indicator variables' be relatively short, consisting primarily of attributes that are easy to measure consistently and are revealing of or good proxies for the ultimate biological objectives that are to be evaluated."

These statements by the ISRP and ISAB regarding high level indicators remain germane to our comments below.

Review Summary

In our view, the biological HLIs used to communicate to governors and Congress should be broader indicators than the biological objectives (biological performance and environmental indicators) characterized and identified at province and subbasin levels in the Program (p. 20 *et seq*.). The HLIs should effectively depict how well these province and subbasin biological objectives are being met. These objectives include biological performance, which describes population responses to habitat conditions in terms of capacity, abundance, productivity, and life-history diversity. The HLIs should thus depict the status and trends of fish and wildlife *at the subbasin and basinwide levels,* and be entirely consistent with the province and subbasin biological objectives in the Program. These HLIs should successfully indicate overall Program *performance* which is "the focus of the Program and the Council" (Program, p. 12).

The tightly focused biological objectives (p. 20, Program), in contrast to high level indicators, are the scientific cornerstones of the Program. These biological objectives must be scientifically defensible and implementable. The uncertainty of their respective metrics must also be evaluated. They are typically area-specific. The Program

---

[1] ISRP 2008-7 Metrics Review: Review of Project Reporting Metrics for the Columbia River Basin Fish and Wildlife Program: www.nwcouncil.org/library/isrp/isrp2008-7.pdf

[2] ISAB&ISRP 2006-4: Review of the Draft Monitoring and Evaluation Guidance Document (March 2006 version): www.nwcouncil.org/library/isab/isabisrp2006-4.htm

recommends that where possible, biological objectives should be empirically measurable, based on an explicit scientific rationale, and expressed in quantitative and measurable terms. They are not typically appropriate biological HLIs, but provide data and more localized results useful in developing the HLIs.

For simplicity and impact, high level indicators for reporting to policy-makers should be relatively few in number, yet accurately and parsimoniously convey in quantitative form or quasi- quantitative form (e.g., class or rank) status and trends of critical aspects of the status of the biota (communities, fish runs, populations and species interactions). Although HLIs are at a higher level than the biological objectives of the Program, they should be consistent with them.

High level indicators should indicate progress on four key aspects of the ecosystem. The four measures – *abundance, productivity, diversity, and spatial structure* – are critical aspects for not only fish, wildlife, and all organisms in the basin but also to the natural habitats needed to sustain them. As stated on Page 13 of the Program, "the vision for this program is a Columbia River ecosystem that sustains an *abundant, productive, and diverse* community of fish and wildlife…" (italics added). To this list of indicators, we would add *spatial structure.* Each of the four attributes is distinct. Abundant fish populations might not possess high productivity. Similarly, high abundance or production of a few populations, especially if they are non-native species, in a province does not necessarily mean that overall diversity is high there.

Abundance, productivity, diversity, and spatial structure are clearly embodied in the Program's Objectives for Performance, which include the following specific objectives:

1. Halt declining trends (especially for salmon and steelhead populations above Bonneville) (abundance and productivity)
2. Significantly improve smolt-to-adult survival rates (SARs) resulting in productivity well into range of positive population replacement (abundance and productivity)
3. Restore the widest possible set of healthy, naturally reproducing and sustaining populations of salmon and steelhead in each relevant ecological province (diversity and spatial structure).
4. Increase total adult salmon and steelhead runs, especially above Bonneville in a manner supporting harvest (abundance and productivity)
5. Increase salmon and steelhead runs to average of five million annually by 2025 (abundance)
6. Achieve SARs of 2-6% (minimum 2%, average 4%) for listed Snake and upper Columbia River salmon and steelhead" (abundance and productivity)

(Program, Pages 21-22)

These four measures are also clearly embodied in the Program's eight scientific principles summarized on pages 17-19. From the eight scientific principles guiding application of the scientific method in the basin, we extract these critical aspects of the biota and habitat:

1. *abundance* of organisms and habitat
2. *productivity* of organisms and habitat
3. *diversity* of organisms and habitat
4. natural, dynamic character of ecosystems
5. resilience of ecosystems
6. *spatial* complexity, including hierarchical organization of ecosystems, landscapes, communities, and populations
7. habitat creation, alteration, maintenance by physical, biological processes over a range of *spatial* scales
8. role of species in developing and maintaining ecological conditions
9. *diversity* of species, traits, life histories contributing to ecological stability
10. connectivity, and
11. role of humans in the ecosystem.

The implementation HLIs, in contrast, can be viewed as measures of activities. For example, how much passage was achieved, how many fish screens were installed, how many acres of land acquired to improve habitat diversity, complexity, connectivity and ecosystem function. All seven draft implementation HLIs reflect actions taken, rather than ecosystem responses. The implementation indicators are, in general, surrogate indicators of more productive habitat. Most of the implementation HLIs, which "report on actions that are likely to contribute to the program's success such as fish passage, water conservation, land improvements, and fish screens (T. Grover, letter to N. Huntly and E. Loudenslager, p.1)," are similar to environmental characteristics of the biological objectives on Page 20 of the Program. No HLIs for aspects of habitat quality such as diversity, ecological connectedness, or ecosystem function are included among the draft implementation HLIs (although the scientific community has not reached consensus on how these attributes should be quantified). The assumption is that implementation HLIs can be directly linked to improvements in habitat quality and ultimately to improvements in biological HLIs.

In the Fish and Wildlife Program, implementation HLIs correspond approximately to measures of improvements in environmental characteristics at various spatial levels (including ecosystem, landscape, or more localized habitat), which describe the environmental conditions (such as habitat diversity, complexity, connectedness, and ecosystem function) necessary to achieve desired population levels. It is imperative that monitoring and evaluation activities are undertaken to show the effectiveness of implementation actions in eliciting the desired biological responses. In many cases the linkages between implementation HLIs and biological HLIs have not been established, but have only been assumed based on hypotheses of ecological cause and effect from various studies inside and outside the basin.

In our review of the 17 draft HLIs, number 10 (Wildlife) as described (wildlife units lost and acquired) and measured (habitat units) was not a biological indicator, but rather an implementation indicator. All of the implementation HLIs were associated with some form of habitat improvement, if one concedes that predator abundance in the context of the Program is seen mainly as an aspect of habitat. Similarly, number 8 (survival rates through the hydrosystem), while a biological measure, is actually an important indicator of habitat improvement, i.e., a true habitat HLI for wild fish.

If high level indicators are to be simplified, careful selection of HLIs for status and trends becomes especially critical. We suggest that the optimal mix of biological HLIs is a combination of (1) simply and consistently measured indicators and (2) mapped depictions of provincial, subbasin, or population-specific indicators. For HLIs depicting status and trends across a range of provinces and subbasins, useful measures would be simple basinwide population parameters that have been measured over the long term, simply, and consistently, with known variability and uncertainty.

For anadromous fish abundance, we recommend the use of dam counts, including counts above Lower Granite and Priest Rapids as indicators of regional status and trends. These dam counts, while a simple number, help track the outcomes of basinwide as well as regional restoration implementation. They can be depicted on basin maps with demographic trends displayed at different locations.

For HLIs depicting status and trends of biological diversity and aspects of spatial structure of ESUs, we recommend maps of trends at the provincial and subbasin levels. For example, for depicting fish population status and trends for each evolutionarily significant unit (number 3), we recommend the use of a map such as Figure 3, p. 57 of the Program. For each subbasin, green (increasing), red (decreasing), grey (stable), or white (unknown) colors could correspond to status of each species. Listed species can be in bold borders. Such maps would convey the spatial and diversity aspects of salmon recovery efforts and needs (one figure/map for each listed species).

For HLIs depicting fish abundance and productivity, we recommend a similar mapping approach, with different colors indicating whether the species is achieving subbasin objectives (one figure/map for each species for abundance and for productivity). This approach requires that abundance and productivity objectives be set for each subbasin, and that sufficient monitoring is conducted to assess status and trends. It is important to note that uncertainty in abundance and productivity estimates can be, and should be, expressed in maps to better communicate the level of confidence in current knowledge.[3]

For implementation HLIs, we also recommend a combination of simple indicators and map depictions, similar to the approach used in the Interior Columbia Basin Ecosystem Management Project (ICBEMP http://www.icbemp.gov/). The simple indicators are intended to show broad regional trends in habitat improvement activities. Province and subbasin level maps can depict provincial and subbasin habitat efforts (i.e., loss or gain of some specific aspects of habitat such as accessible distance of streams). The implementation HLIs will not, however, necessarily translate into clear measures of

[3] Kardos, J., Moore, A. and Benwell, G. 2006. Expressing attribute uncertainty in spatial data using blinking regions. In 7th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences, Lisbon, Portugal, Edited by M. Caetano and M. Painho.

overall habitat quality or improvements. In our view, more effort will be needed to link the implementation HLIs, which tend to be very specific actions, to broad, measurable HLIs for habitat. The proposed habitat HLIs are broader than the typical implementation HLIs as proposed in the draft and will require more development using landscape-level methods.

For each biological or implementation HLI, whether a fish count index or a mapped basinwide habitat depiction, specific data must exist, be available, and have been evaluated so that the presented HLI is scientifically defensible (i.e., with adequate rationale and data supporting it). The degree of uncertainty associated with each HLI must also be evaluated based on the accuracy and precision of data contributing to it. We suggest a fourth column in the section below providing some narrative or explanation of the uncertainty associated with each HLI. If data are not available, the shortfall should be identified.

For provinces and subbasins, a few examples of representative studies leading to demonstrated benefits should also be presented as evidence that restoration efforts are clearly linked to changes in indicators. In part, this is being addressed through intensively monitored watershed research. In addition, the variable environmental conditions in the estuary and ocean, while not typically habitat factors that can be manipulated, nevertheless can greatly affect HLIs (Program, p. 60). They must be considered in indicators of progress, perhaps through uncertainty assessment, at least for anadromous species.

The biological and implementation high level indicators summarize success at achieving provincial, subbasin, and watershed objectives. Therefore, they should provide top-down guidance to monitoring and evaluation activities outlined in the Program. For example, provincial or subbasin data gaps should become readily apparent in mapped HLIs, indicating where more restoration is needed or where monitoring is inadequate. By superimposing patterns of gains and losses of biological HLIs with patterns of implementation HLIs, areas may be identified where habitat actions are not producing desired ecosystem responses. By mapping provincial and subbasin status and trends in relation to established provincial and subbasin objectives, areas needing increased attention also can be clarified.

The Program recognizes that data gaps exist and on page 22 states, "Within one year of adopting the amended program, the Council will work with the fish and wildlife agencies, tribes, and others to initiate a process specifically aimed at assessing the value for the Program of quantifiable biological objectives at the basinwide level (or at any level above the subbasin and population level and, if determined to be useful, develop an updated and scientifically rigorous set of such quantifiable objectives." Good examples of provincial and subbasin objectives and metrics related to abundance and productivity trends in salmon ESUs are found on pages 28-30 of the 2008-2017 U.S. v. Oregon Management Agreement, May 2008.[4]

[4] www.fws.gov/Pacific/fisheries/hatcheryreview/Reports/snakeriver/SR--079.2008-2017.USvOR.Management.Agreement_042908.pdf

Specific Comments

We address each individual Council proposed HLI or set of related HLIs below. The HLIs in the tables are the Council's proposed indicators, not ours. The first column in the tables below is the proposed indicator, the second column is the description, and the third column is the presumed data source. We recommend that a fourth column be added to indicate the uncertainty associated with each indicator.

Biological indicators and descriptions

In an effort to clearly answer the Council's four questions regarding HLIs, we examine (1) the type of HLI (biological or implementation), (2) what biological attributes the HLI is intended to indicate (i.e., abundance, productivity, diversity, spatial structure), (3) the best forms for reporting the HLI to governors and Congress, (4) the priority importance of using the HLI, and (5) the availability and quality of existing data to support the HLI.

Answering the last question (data availability and quality) completely would require considerably more time and effort of the ISRP and ISAB than is possible in the response time frame. Most of the database on, for example, adult fish abundance are very large and exist in files of numerous agencies. Although database information may be available (see ISRP-2000-3 Review of Databases Funded through the Columbia Basin Fish and Wildlife Program), establishing quality control standards would be a long-term effort.

One question asked of us was how these indicators should be derived to assure alignment with similar biological indicators used in the region to inform decision-makers. Convening a workshop would be one way to start the process to ensure that the selected HLIs are represented clearly and accurately. Such a workshop could help develop provincial, subbasin, and population-specific biological objectives, and monitoring protocols that are natural outcomes of the HLIs. This process also would encourage consistent use of monitoring metrics among diverse agencies, which would improve the accuracy of the HLIs. Such a workshop would be consistent with the Program, page 22: "Within one year of adopting the amended program, the Council will work with the fish and wildlife agencies, tribes, and others to initiate a process specifically aimed at assessing the value for the Program of quantifiable biological objectives at the basinwide level (or at any level above the subbasin and population level) and, if determined to be useful, develop an updated and scientifically rigorous set of such quantifiable objectives."

Abundance		
1. Total adult salmon and steelhead returns to the Columbia	Adults & jacks passing Bonneville Dam (1938-present): Excel (30k) or PDF (20k) Smolt counts, Lower Granite and McNary to Bonneville: Excel (60k) or PDF (10k) Will include returns to mouth of the river and lamprey if available.	Fish Passage Center
2. Abundance of adult fish in the Council's program	Number of salmon, steelhead, lamprey, resident fish in streams, rivers and lakes.	Status of the Resources, CBFWA
3. Fish population status and trends for each ESU, especially listed ESUs	Based on NOAA definitions and USFWS (Bull trout and sturgeon)	NOAA, although data are not yet available, with the possible exception of TRT, recovery plans

HLI 1 – Total adult salmon and steelhead returns to the Columbia
Type: ***Biological***
Indicator of: ***abundance, productivity.***
Form: ***simple numbers, trends***
Priority: ***very high***
Availability and quality of data: ***Long term-records with consistent and well-documented protocols overall.***

Long-term data for this indicator are available and reliable, based on Bonneville Dam counts. But the data provide only a very broad benchmark, and results are clearly affected by ocean conditions and harvest in the ocean and below Bonneville Dam. Moreover, the data provide almost no measure of province or subbasin restoration efforts, i.e., no information on variation in success among regions or fish stocks. It is conceivable that increasing counts at Bonneville could mask serious declines in some areas of the basin.

We suggest it would be useful to use at least two other dam count indicators to more adequately indicate large scale patterns and trends of regional salmon runs. We recommend dam counts at Lower Granite and Priest Rapids as additional regional indicators. It is better to assess total salmon and steelhead returns to different portions of the basin, to show any differences in success between upriver and lower river restoration efforts, and major species differences by area. Data on non-salmonids (e.g., lamprey) can also be depicted by these simple counts, but there are many other species that will not be included with this approach.

It would also be important to provide estimated numbers of each species, as well as numbers of hatchery-reared as opposed to wild salmon.

HLI 2 – Abundance of adult fish in the Council's program
Type: ***Biological***
Indicator of: ***abundance, productivity; spatial structure***
Form: ***Map depictions of status and trends by subbasin***
Priority: ***Very high***
Availability and quality of data: ***Good overall, but variable and perhaps not up-to -date in all provinces and subbasins.***

This HLI would be best depicted using a basinwide map. CBFWA's Status of the Resource provides data on abundance by province and subbasin, which when consolidated can show overall trends and abundance. It is not clear how often data from each subbasin are updated; current results only provide information up to 2005. This HLI should provide a reasonable overview by province and subbasin, depicted visually for different stock sizes and for increasing, decreasing, stable and unknown trends. This metric serves to direct agencies to collect more reliable data at the subbasin level and to report the data more consistently and promptly. We suggest that this is an excellent topic to be addressed in the biological objectives effort proposed in the Program. Trends will be greatly affected by variations in ocean survival.

A similar metric could be used for some wildlife species for which the states collect data. This could include flyway data and bird counts.

HLI 3 – Fish population status and trends for each ESU, especially listed ESUs
Type: ***biological***
Indicator of: ***diversity, spatial structure.***
Form: ***Simple statistics and map depictions***
Priority: ***Very high***
Availability and quality of data: ***Good overall, but variable and perhaps not up-to-date in all provinces and subbasins.***

An HLI related to ESU status could convey the evolutionary and ecological importance of stocks, the need to maintain the diversity, and progress toward restoration goals. This is a good indicator given the major recent efforts that have been put into developing it with scientifically defensible contemporary modeling and genetics methods.

For each ESU, it might be best to graphically depict status as increasing, decreasing, stable, or unknown with corresponding uncertainty levels also depicted. This approach could be accompanied by simple statistics about the percentage of ESUs increasing, decreasing, or stable by region or basin/subbasin. Key endangered ESUs that indicate regional problems (e.g., Stanley Basin) could be addressed separately as needed. For this indicator, metrics used for other major salmonid rivers have included escapements (number of fish on the spawning grounds, by species). These types of data would be especially useful for each ESU. They too could be used to report on status of listed wildlife and even plants where they are important factors in land acquisition or management.

Fish Habitat Productivity (we suggest re-titling "Wild Fish Production")		
4. Productivity of wild fish in select watersheds targeted by Council's Program.	Juveniles/spawner for anadromous and resident fish. Will focus on adult fish in and juvenile fish out.	Focus on adult fish "in" and juvenile fish "out." Juvenile fish counts could be added to Streamnet and Status of the Resource

HLI4: Productivity of wild fish in select watersheds targeted by Council's Program
Type: ***biological***
Indicator of: ***abundance, productivity, diversity, spatial structure***
Form: ***Simple numbers, maps***
Priority: ***very high***
Availability and quality of data: ***Fair to good overall, but sporadically collected in many locations and not up-to-date in all provinces and subbasins.***

We suggest that *production* (a performance measure) of wild fish is a better word choice than *productivity* (a capacity) for this important indicator. The production of wild fish from selected key watersheds is unfortunately not simply an indicator of how well the habitat in the subbasin is being maintained or improved, but is also a function of passage in both directions through the hydrosystem, harvest, and estuary/ocean conditions (including potential climate change). For that reason, the status and trends of wild fish is truly a high level indictor. It is not, however, easily shown in most instances to result from particular habitat or passage actions taken under the Program. Changes in status and trends at the province or subbasin scales should therefore be specifically linked to important actions undertaken to restore habitat.

Maps for each species depicting status and trends for mature wild fish in the basin would best depict this HLI. The spatial distribution and diversity aspects of the wild fish can then be best appreciated. A model for this work might be something like the Atlas of Pacific Salmon developed by the Wild Salmon Center.[5] Their approach was on a broad scale (the entire Northwest Pacific coast). A similar atlas could depict status and trends in the Columbia Basin. The 2008 Washington "State of Salmon in Watersheds" report gives some very good examples of how trends can be depicted.

[5] Augerot, X. 2005. Atlas of Pacific salmon. University of California Press, Berkeley, California.

In addition, data from key wild stocks having long-term records should be used to indicate province-level trends. Streamnet format is a good source and format for these key indicators. Data sets from Streamnet could be screened and evaluated for quality as indictors of subbasin and provincial trends. These trends should where possible, be linked to actions under the Program. Production of wild fish should be focused on measurements made in the Intensively Monitored Watersheds where the most reliable data are being obtained. These stocks should also be evaluated for their usefulness as indicator stocks for other adjacent populations in the subbasins and provinces. For example, on pages 28-30 of the 2008-2017 U.S. v. Oregon Management Agreement, abundance indicator stocks are listed. Some of these indices will better depict trends by region (e.g., returns to Priest Rapids, returns to Lower Granite). Others will more clearly depict abundance and trends by species (e.g., sockeye and summer steelhead). Others indices will be good representatives of several stocks in the basin or province.

For wild fish, one possibility would be to assume a positive relationship between habitat improvement and wild fish production and then compare efforts (expenditures) under the Fish and Wildlife Program relative to other programs or funding sources. This could be misleading if great expenditures were directed at restoring wild stocks that are almost gone, and similarly misleading in less dramatic, but comparable situations.

For each province, the proportion of total fish that are wild versus hatchery-produced should also be depicted, along with trends.

The use of juveniles per spawner can be a good indicator but like all ratios, it must be used cautiously. For example, low levels of spawners can lead to high levels of juveniles per spawner, even though the stock status is poor. Similarly, a large stock can theoretically have comparatively few juveniles per spawner but still be healthy. Similar data (number of offspring per adult) are available for some wildlife species, especially carefully managed game species such as elk or those that are the subject of intensive population research, such as cougar.

Harvest and Hatcheries		
5. Harvest number and rate	Totals for all spring, summer, fall Chinook, sockeye, steelhead, lower river sturgeon and for each listed ESU and by fishing type as well as hatchery and natural	In-river harvest and rate information from the ODFW and WDFW Joint Staff Report on the stock status and fisheries for fall Chinook salmon, coho salmon, chum salmon, summer steelhead, and white sturgeon; ODFW and WDFW Joint Staff Report stock status and fisheries for spring Chinook, summer Chinook, sockeye, steelhead, and other species, and miscellaneous regulations; ODFW and WDFW Joint Staff Report concerning stock status and fisheries for sturgeon and smelt Ocean harvest estimated from PSMFC's coded wire tag database
6. Harvest of hatchery fish in the Council's Program	Number by species and by hatchery. For all hatcheries receiving BPA funds.	PSMFC's coded wire tag database
7. Relative fitness of supplemented stocks from hatcheries in the Council's Program	Possible measures may include relative reproductive success (RSS), percent natural influence (PNI), or the number of natural origin spawners compared to control streams.	Being developed by the Ad Hoc Supplementation Workgroup and ISRP. May include number of natural origin spawners. Completion goal: 2009.

HLI5: Harvest number and rate for hatchery-reared and wild fish.
Type: ***biological***
Indicator of: ***abundance, productivity***
Form: ***simple numbers and trends; map with different sized circles depicting different harvest levels***
Priority: ***high***
Availability and quality of data: ***very good*****.**

Harvest numbers should be depicted mainly at the province level. Exceptions would be for endangered or threatened ESUs. For naturally produced fish, harvest rates *per se* will have little if any interpretive value for decision-makers unless they can be related to levels shown to be excessive relative to what can be tolerated for a particular stock.

HLI 6: ***Harvest of hatchery fish in the Council's Program***
Type***: biological/implementation***
Indicator of: ***abundance***
Form: ***map with different sized circles depicting different harvest levels; map showing hatcheries with levels of harvest by species resulting from their activities.***
Priority: ***high***
Availability and quality of data: ***very good***

This HLI is a fairly direct measure of Program actions. A map can depict which hatcheries are contributing most to the harvest, with larger circles indicating a larger contribution. This map may be complemented with key statistics of total harvest of hatchery fish produced by BPA-funded hatcheries and trend charts of harvest. It is also important to know how significant the harvest from BPA-funded hatcheries is compared to the total harvest of all hatchery fish in the province. Maps could depict this information. Important sources of these data are annual reports of state fisheries agencies.

We recommend that this metric indicate total hatchery harvest, not harvest per fish released. The latter indicator, if used, is more of a survival indicator. If used, it should also be depicted graphically with codes corresponding to increasing harvest per fish released – a broad indicator of hatchery and provincial differences in survival to harvest. To separate Program results from results of efforts of all the other agencies in the Basin for hatchery fish, the smolt output from Council-supported hatcheries can be compared with non-Council supported hatcheries. It is also important to depict oceanic harvest of the stocks by region to show which stocks are contributing regionally or locally, versus outside of the region. This information is also available.

HLI 7: Relative fitness of supplemented stocks from hatcheries in the Council's Program
Type: ***biological***
Indicator of: ***abundance***
Form: ***map with different colors depicting different fitness ranges***
Priority: ***high***
Availability and quality of data: ***unknown***

This metric would best be depicted as a map showing the relative fitness of naturally spawning fish for each supplemented stock of salmon and steelhead. The measure of fitness must be clearly and specifically defined. It is not evident at this time how the three potential candidate indicators; relative reproductive success, PNI, and number of natural spawners compared to reference streams will be used to develop an index of fitness. Maps showing straying rates of non-local hatchery fish and the proportions of supplementation and total hatchery fish in the naturally spawning population for each population and ESU could serve as an initial indicator of potential hatchery influence.

Life-cycle mortality		
8. Life stage survival for representative wild populations of Chinook and steelhead	Mortality rates at each life stage: egg to smolt, freshwater passage (reservoirs, dams), estuary, ocean, harvest, freshwater return. Include SARs.	To be determined. It will incorporate data from other HLIs. SAR data are available from several sources.

HLI8: Life-cycle mortality
Type: ***biological***
Indicator of: ***productivity***
Form: ***basinwide mapping of SARs and temporal trends***
Priority: ***very high***
Availability and quality of data: ***Well-documented limitations and subtleties in interpretations of SARs apply.***

The use of SARs is highly recommended under this HLI, but SARs are obtained from dam counts of smolts vs. returning adults and do not provide estimates of mortality at all life stages. Data similar to SARs are available for some focal wildlife species. Survival or mortality estimates for other periods in the life cycle (e.g. egg to smolt) are often more limited and imprecise. It is not clear that meaningful data would be available, but a review of the information generated in intensively monitored watershed projects could provide a useful perspective.

Hydro survival		
9. Survival rates through the hydrosystem for adult and juvenile fish passing in-river and barged, wild and hatchery.	From Lower Granite to Bonneville and McNary to Bonneville, total system survival and individual hydroelectric facility	NOAA

HLI9: ***Survival rates through the hydrosystem for adult and juvenile fish passing in-river and barged.***
Type: ***High-level habitat indicator***
Indicator of: ***abundance, productivity***
Form: ***Numerical survival rates depicted past successive dams for upstream and downstream migrants (separate maps) and cumulative total mortality from beginning of migration to the end.***
HLI Priority: ***very high***
Availability and quality of data: ***good.***

A measure would be mortality rates of salmon smolts and adult migrants through the successive dams and passage facilities. This is an important HLI of in-river migration restoration efforts for both hatchery-reared and wild fish (separately).

Implementation indicators and descriptions

Passage Barriers		
10. Instream passage improvement. Additional habitat made accessible	number of miles of habitat accessed, number of barriers removed.	Bonneville Power Administration's Pisces database. Specifically combining work elements 84, 85, and 184

Type: ***Implementation***
Indicator of: ***improvements in passage and increased habitat leading to (indirect) increased abundance and productivity in the short term, (indirect) diversity and spatial structure in the long term.***
Form: ***Mapped number of miles added by province and subbasin; number of barriers removed by province.***
Implementation indicator priority: ***high***
Availability and quality of data: ***Good for larger projects; fair for many smaller ones***

The number of barriers to fish passage that have been removed or modified to allow passage should be fairly easy to obtain from Pisces. This information is valuable, but it does not necessarily reveal the quantity or the quality of the habitat that has become available as a result of barrier removal or modification. The more difficult question of the amount of newly available habitat probably cannot be adequately addressed through infrequent field surveys, since both the recruitment of adults (i.e., number of adult salmon and steelhead passing the former barrier) and the flow characteristics of the streams will vary from year to year. The uncertainty associated with estimating newly available habitat should be characterized, at the least qualitatively. In some years, large escapements and/or relatively robust flows will allow penetration of fish farther into the watersheds than in years when weak escapement or unusually low flow limit the upstream movement of adults. Likewise, the upstream movement of juveniles is rarely documented, and the extent to which they make use of newly available upstream habitats is often poorly known. Upstream movement of juveniles is known to occur when fish seek cooler water during summer, and there may be other instances where upstream movement by juveniles is favored.

Known natural barriers (e.g., waterfalls) upstream from an anthropogenic barrier removal project can be used in some cases as putative boundaries for delineating additional habitat. Also, some models can predict upstream limits to the distribution of species based on channel gradient, stream size, and water temperature. However, in most cases there will be some uncertainty associated with estimates of miles of newly accessible habitat. Nevertheless, the tally of barrier removal projects and estimate of newly accessible habitat constitutes a useful high level indicator.

Fish passage improvement is an important high level indicator. Although a comprehensive inventory of all actual or potential anthropogenic barriers does not yet exist for the Columbia River Basin, it should be possible to assemble a reasonably accurate measure of sites with improved passage, although the actual number of stream miles made available will always have inherent uncertainty. Records of passage improvement projects should also be available from other regional salmon enhancement programs such as Washington's Salmon Recovery Funding Board, Oregon's Watershed Enhancement Board, and the Forest Service Regions 1, 4, and 6. The Columbia Basin Tribes should also maintain a useful inventory of passage improvement projects, and Washington State has an inventory of culvert barriers resulting from recent legal action by Tribes.

There are a variety of types of barriers to fish movement. The most numerous are road crossings involving culverts or other means of water conveyance that completely or partially block either or both adult and juvenile passage. Other barriers include low or high dams; debris screens or racks meant to protect water intakes; and natural barriers such as falls, rapids, or cascades. It is unlikely that any single current database includes data on all known fish barriers, and the task of consolidating the information will require considerable cooperation between federal, state, and local organizations. However, with increasing use of on-line environmental databases, data sharing should become easier. The quality of existing data, i.e., the accuracy of descriptions of passage improvement projects, is likely to be adequate. However, for the reasons stated above, the miles of stream available as a result of the projects will be somewhat uncertain.

Though not hydro-related, there are also wildlife passage and habitat connectivity issues that could be included here. These would include improvement of highway passages, reconnection of wetlands, or other habitat corridors that restore natural movement or migration routes and reduce genetic isolation of focal species.

Water		
11. Water conservation and irrigation improvement and water transactions. Additional water available for fish, anadromous and resident	Acre-feet/yr., number of miles of primary stream reach improvement, including in-stream water rights purchased or leased	Bonneville Power Administration's Pisces database. Specifically combining work elements 82, 149, 150, 164

Type: ***Implementation***
Indicator of: ***(indirect) abundance, productivity, diversity, and spatial structure.***
Form: ***mapped***
Implementation indicator priority: ***highly variable by province and subbasin***
Availability and quality of data: ***very good for water quantity; poor and disorganized for water quality.***

Unfortunately, our knowledge of water quantity and quality is limited in the Columbia Basin. A few streams have strong monitoring programs, but many drainage systems are inadequately sampled.

Water conservation is also an important high level indicator. Metrics of how much water formerly was withdrawn from streams for agriculture and other human uses but now is left in streams and rivers are useful in communicating the Fish and Wildlife Program's progress. While the suggested metrics (acre-feet/yr., number of miles of primary stream reach improvement) can be quantified, they would benefit from being placed in the broader context of streamflow conditions in the Columbia River Basin. Thus, it would be helpful to relate water conservation estimates, e.g., acre-feet/yr, to the total amount of water available for natural flows and human uses. The indicators should convey the relative contribution of conservation measures to the overall water budget of a subbasin. For instance, a water transaction program could result in a potential increase of 5% of the total water budget dedicated to increased streamflow. This would require, however, that annual water budgets be estimated for each major subbasin. Data on acquisition of in-steam water rights are readily available from states and local governments. However, seniority of these rights is important as they may be junior to irrigators/municipalities. Irrigation districts will have this information in some areas, and areas undergoing adjudication may have available data soon. Entities such as the National Fish and Wildlife Foundation and Washington Water Trust may also have data that are relevant to this issue.

Streamflow information is available for many streams, but budget cutbacks have closed many gauging stations and most project sponsors do not have the materials or skills to conduct direct measurements of increased streamflow before and after implementing water conservation agreements. This will make estimates of annual water budgets difficult and highly uncertain.

Restoring stream access to floodplains and re-flooding wetlands have implications for flow and are common strategies for wetland wildlife projects, as documented in Pisces.

The suggested indicators in the HLI table contain a potentially serious oversight: a high level indicator is not proposed for water quality. Water quality indicators are currently underrepresented among the habitat metrics used to track progress in the Columbia Basin. It is important to include measures of water quality impairment beyond 303(d) criteria (e.g., pesticide and herbicide concentrations, fire retardants, and other persistent organic pollutants) in order to demonstrate that progress is being made to assure that the water being returned to streams is clean and will not harm aquatic ecosystems. For example, a recent NOAA Biological Opinion (dated 04-20-09) indicates that 3 modern pesticides (carbaryl, carbofuran and methomyl) are likely to jeopardize the continuing existence of 22 listed salmonid species.

Water quality and water quantity are closely related, and increased water quantity generally results in improved water quality. Water quality metrics can be obtained from existing monitoring programs within federal and state water quality agencies. Many streams in the basin are 303(d) listed, mainly for temperature or suspended sediment. Trends in status of the 303(d) list would be instructive, but 303(d) listings by themselves are not sufficient to capture all of the important trends in water quality.

For the most part, Pisces will have to rely on existing water quality data from others. Relatively few BPA-sponsored projects include provisions for water quality testing, although there are a few fish and wildlife projects that are examining the presence of toxic compounds in target species. Water quality should be more closely examined in proposed projects that use irrigation return water and other water that is likely to be contaminated. Watershed councils are also monitoring water quality and quantity. The Forest Service program tied to the PacFish/InFish Biological Opinion has an extensive (basinwide) network of stream temperature monitoring.

Many streams are periodically surveyed, but overall the amount and quality of data on water quality (especially for persistent organic compounds, metals, and other toxic compounds) is far from complete. There is a need for more testing of toxic substances, including endocrine disruptors. We learn about toxins when a public health alert is issued, and this could be one component of an indicator of extreme problems.

Water temperature is a key habitat variable and could be a stand-alone indicator in habitats where its effects are clear (e.g., on spawning grounds in tributaries where pre-spawning or juvenile salmonid mortality is an issue). The majority of 303(d) listed streams in the basin are listed because of high temperatures, the most easily measured metric for water quality. Trends for delisting or new listing of salmonid rearing streams due to water temperature problems could be instructive.

Land		
12. Land acquisition/conservation easement. Additional land acquired or leased for fish habitat	number of riparian miles protected, number of acres.	Bonneville Power Administration's Pisces database. Specifically combining work elements 5 and 92

Type: ***Implementation indicator***
Indicator of: ***(indirect) abundance, productivity, diversity, spatial structure.***
Form: ***three to four simple numbers in basin plus mapping by province and subbasin***
Implementation indicator priority: ***high***
Availability and quality of data: ***good***

These indicators (number of riparian miles protected, number of acres) are useful, but the linkage between land acquisition or conservation and actual improvement in fish habitat is often obscured by other limiting factors. In other words, documenting that some number of miles of stream has been fenced to exclude livestock can give us some indication that the streambank and riparian vegetation will be protected, but other factors may strongly limit aquatic productivity in a stream reach of interest. Therefore, caution should be exercised in assuming that the carrying capacity for target fishes will always be increased in streams where fencing or land acquisition has occurred. As with many other implied improvements, the primary value may be in slowing the *rate* of loss, thus the numbers are misleading without some reference to the level of threat or other contextual information.

The project plans in the Pisces database should provide improved accuracy when combined with accomplishment reports.

Information on fencing and land acquisition should be readily available. Likewise, similar data from other restoration programs can be obtained from annual BPA reports. Often missing is an expression of what percentage of the overall stream system has benefited from the actions. The information that links fish and wildlife objectives to show something more akin to an ecosystem perspective is also lacking in these indicators.

Habitat Improvement		
13. Habitat	Miles, Acres, Increased instream habitat complexity, Realign, Connect, and/or create channel, Create, restore, and/or enhance wetland, Enhance floodplain, Install fence, Plant vegetation, Manage weeds, Practice no-till & conservation tillage systems, Upland erosion & sedimentation control…)	Bonneville Power Administration's Pisces database. Specifically combining work elements 29, 30, 40, 55, 180, 181

Type: ***Implementation***
Indicator of: (*indirect) abundance, productivity, diversity, spatial structure*
Form: ***mixed***
Implementation indicator priority: ***high***
Availability and quality of data: ***variable***

Of the high level indicators describing progress in improving fish habitat, this category contains the greatest uncertainty. Most of the metrics describe actions that we *think* will increase the carrying capacity or survival of target species, but our assumptions are too often not accompanied by effectiveness monitoring that could document real improvements. Thus we are usually left with lists of habitat restoration projects that have been implemented but with little direct evidence that the productivity of a restored site has actually been increased. Intensively monitored watersheds (IMWs) with experimental restoration programs offer the greatest opportunity to document habitat restoration success, but many IMWs are just beginning to track the long-term effects of restoration actions.

Furthermore, this category includes no measures of the rate of habitat loss in the Columbia Basin. The Fish and Wildlife Program is currently set up to track habitat improvement but does not have a dedicated monitoring component that tracks habitat loss to development or other natural factors such as climate change. This is problematic because the current reporting structure describes only gains, but does not complete the picture by describing simultaneous habitat losses.

We continue to believe that the most effective indicator of habitat improvement in response to restoration efforts is the performance of target species themselves, for example, the rate of production of smolts per returning adult in a watershed. This is a biological metric, not a habitat metric, but it still is the best way of answering the question "Overall, is habitat getting better or worse?" This question is best addressed using an IMW approach, and Council may wish to consider incorporating the results of IMW biological monitoring in their list of indicators.

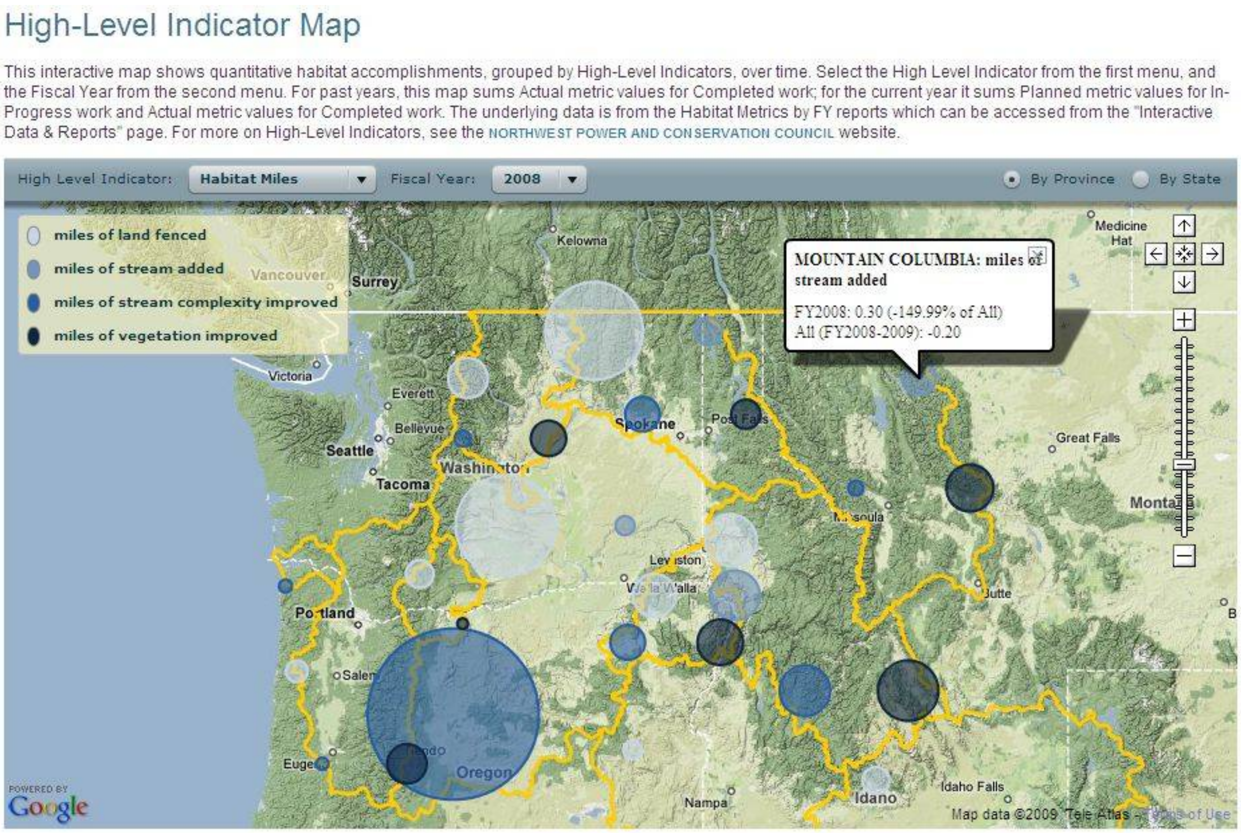
The indicators given in the table are *implementation indicators*, and as such are appropriate metrics of the types of habitat restoration actions being undertaken through the Fish and Wildlife Program. Some of the metrics included under this category (enhance floodplain, install fence, plant vegetation, practice no-till & conservation tillage systems, upland erosion & sedimentation control) could easily be included under the "Land" category. Habitat improvement will presumably include estuarine projects such as length of rejuvenated tidal channels and number of culverts/floodgates upgraded to provide access.

There is no easy answer to this question, "How should these indicators be derived to assure alignment with similar indicators used by the region to report to decision-makers?" because the habitat restoration projects are diverse. Several widespread habitat monitoring programs (e.g., Pacific Northwest Aquatic Monitoring Partnership; PacFish/InFish Biological Opinion monitoring program) could potentially provide indicators of improvement trends, but coordination and standardization of habitat data collection are very challenging. It will take time to develop a coordinated, region-wide habitat monitoring effort, but given the centrality of this question to the Program's ultimate success, the effort is justifiable.

The availability and quality of habitat data vary widely. For some metrics the scientific community has not settled on a consensus measure (e.g., how does one characterize habitat "complexity" or "connectivity"?). This is one reason why the habitat category contains so much uncertainty. Synthesis of meaningful metrics of habitat quality will require careful and critical thinking over the coming years. Biological surrogates of habitat quality (e.g., biotic integrity indices) have some utility, but many limitations.

Habitat improvement will presumably include estuarine projects such as length of rejuvenated tidal channels and number of culverts/floodgates upgraded to provide access.

BPA's new Taurus project tracking system provides some utility in examining the expenditures and other quantitative metrics related to various types of habitat improvements. These are quite useful for providing snapshots in time of the general location and relative effort devoted to different types of projects at a very large scale. An example is shown in the map below. However, we caution that one can not necessarily infer effectiveness from implementation, which is what the map shows. This is a general limitation of implementation indicators.



Screens		
14. Installed fish screens	Quantity of water protected in acre-feet.	Bonneville Power Administration's Pisces database. Specifically, work element #69

Type: ***Implementation***
Indicator of: ***(indirect) abundance, productivity***
Form: ***simple number of screening projects total and by province; map by province and subbasin***
Implementation indicator priority: ***high***
Availability and quality of data: ***very good***

This is the most straightforward of the proposed habitat indicators. It might benefit from indicating (1) what fraction of the existing unscreened water withdrawals have been screened in the current cycle, and (2) what target species or subbasins will most likely benefit from the screening projects. The availability and quality of existing data should be reasonably good.

Predators		
15. Number of juvenile salmon saved from predators	Include pikeminnow, avian predators, sea lions, and others as appropriate	BPA reports on pikeminnow control program; USFWS reports on tern predation

Type: ***Biologically-based, but in Program an implementation (habitat) index***
Indicator of: ***(indirect) abundance, productivity***
Form: ***mixed***
Implementation indicator priority: ***unknown***
Availability and quality of data: ***variable***

This category of high level indicator will require further development. The assumptions need to be examined. At present the actual number of juvenile salmon lost to predators in fresh water and the estuary is highly uncertain. However, estimates of tern and cormorant predation are available in the estuary based on recovery of tags found at nesting colonies. Newer insights regarding the interaction of predators and other species, and dynamics of predator populations, suggest that counterintuitive indicators are possible. Also, there are relatively few studies of predation losses in the nearshore marine environment. Climate change and trends in water temperatures and flows are relevant to the invasion of warm-water predators into fresh waters and the estuary.

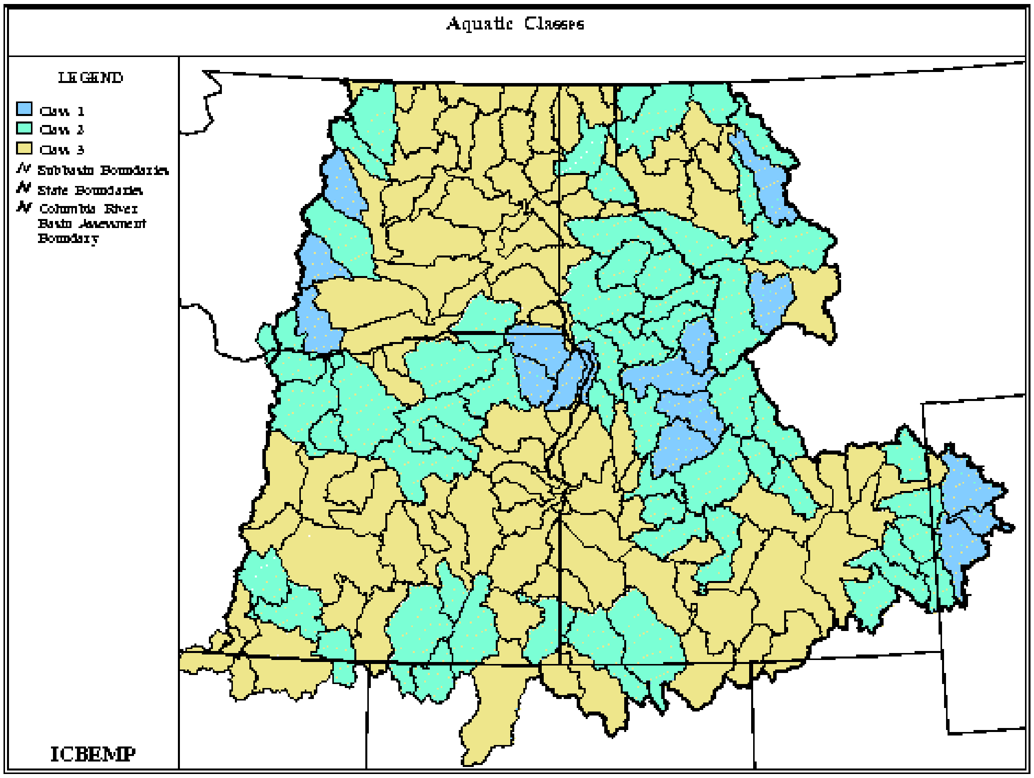
Watershed Health Indicator		
16. Number and percentage of targeted watersheds that provide adequate fish habitat	Need to develop watershed health indicator for fish. Should include measures of water quality.	Being developed through Executive Summit, Task 3.

Indicator of: ***(indirect) abundance, productivity, diversity, spatial structure***
Form: ***mapped by HUC-6 watershed***
Implementation indicator priority: ***high***
Availability and quality of data: ***unknown (maps have not been updated since mid-1990s)***

We agree that there should be indicator(s) of watershed health, but this will take some time. The efforts of the Interior Columbia Basin Ecosystem Management Project (ICBEMP http://www.icbemp.gov/) which included assessments of watershed condition and the status of various fish and wildlife species is an example of one attempt. The map below depicts their expert-opinion assessment of overall aquatic ecosystem integrity. There are many existing indices of ecosystem "health" including some specific to fresh water, e.g., the Index of Biotic Integrity that includes the community composition of aquatic invertebrates and abundance of pollution tolerant species and the measures of watershed condition used by the Aquatic and Riparian Effectiveness Monitoring Program (AREMP http://www.reo.gov/monitoring/reports/watershed/aremp/Welcome.htm). However, there is little scientific consensus on what constitutes a generally useful measure of watershed health, and in any case the metric would need to be carefully tailored to the Columbia River Basin. We recommend that if indicators of watershed health are really desired, development of appropriate metrics should be given additional thought. For example, the ICBEMP project created maps that represented snapshots in time but did not thoroughly characterize trends. Given the very general nature of the data used in that process, it is unlikely that these measures would be sensitive to implementation of the Program except over long time frames. See the section above on water quantity and quality.

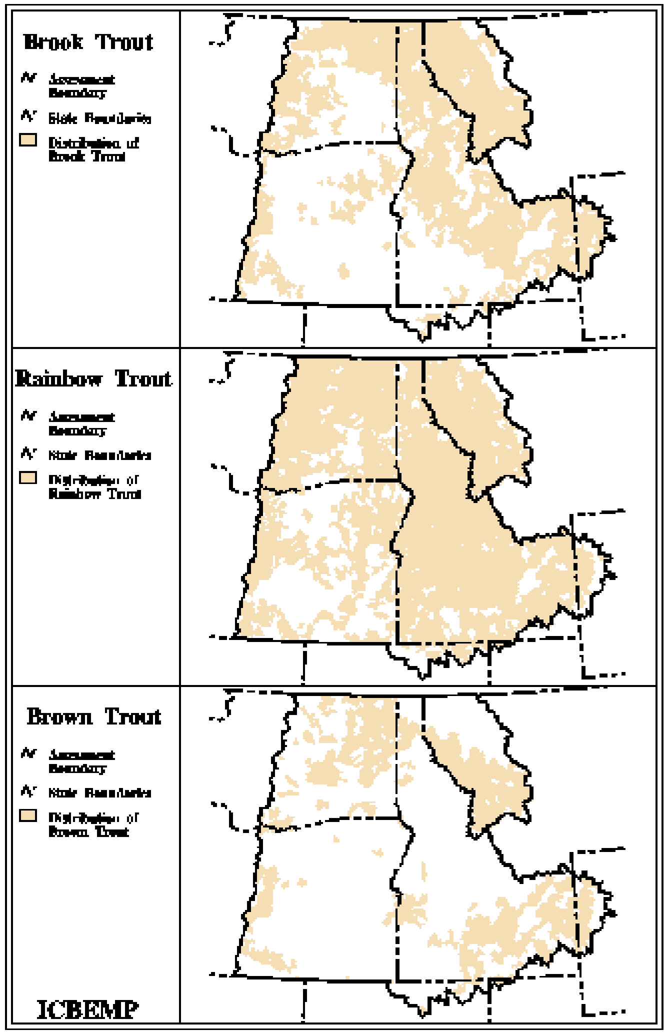
Indices of watershed health will likely need to include large-scale measures of vegetation, land use, streamflow, and hydrologic connectivity, as well as multi-species indices of population health. New and emerging technologies in remote sensing can provide measures of land and riparian cover and channel characteristics relevant to streams and are being implemented in some watersheds. Other agencies like the Forest Service are pursuing similar objectives to characterize the condition of forests and upland communities and wilderness conditions.

Ultimately an integrated (i.e. upland, riparian, stream network) perspective of watershed condition could prove quite useful, but likely will require thoughtful development and collaboration with others.



In this graph the overall aquatic integrity of watersheds in the Columbia River Basin is assigned to three classes with Class 1 watersheds having the most intact aquatic ecosystems and Class 3 watersheds having the least intact systems. (http://www.icbemp.gov/spatial/pubdoc/stars/html/ch4stars.shtml)

The number of non-indigenous species should be considered an aspect of watershed health. This can be measured and is generally interpreted as an indicator of decline. More non-native species indicates movement away from sustainable productive native plant and animal communities, independent of whether each non-native has any particular known effects or not. Initial biotic inventories would be patchy at best, but this is tractable to measure and clear to interpret and has attributes of a high level indicator. Some information is currently available on the distribution (actual or potential) of introduced fishes that could act as predators or competitors, but the number of non-native invertebrate and plant species has increased in recent years. The ICBEMP provided a snapshot of several widely distributed species and general occurrence of many others. More recent information available from the E-map effort could refine and update this information on a more routine basis.



These graphs depict the distribution of three introduced salmonids in the Columbia River Basin. The shaded areas represent locations where species presence has been verified or inferred from older distribution records. Rainbow trout in the middle graph are non-indigenous stocks from outside the basin.
(http://www.icbemp.gov/spatial/pubdoc/stars/html/ch4stars.shtml)

Wildlife		
17. Wildlife habitat units by dam: lost and acquired	Measured in habitat units.	Bonneville Power Administration's Pisces database

Type: ***Implementation (as described)***
Indicator of: ***(indirect) abundance, productivity, diversity, spatial structure***
Form: ***Totals in basin; mapped by province and subbasin.***
Implementation indicator priority: ***moderate to high***
Availability and quality of data: ***readily available for HU increasingly available for biological indicators.***

This is an implementation indicator, rather than a biological indicator of progress in improving the abundance, productivity, or diversity of wildlife.

Many, including some project sponsors, view HUs (habitat units) or HEP (the habitat evaluation procedure used to calculate HUs) as effectiveness monitoring. However, HEP is an outdated approach in part because the data and statistics that went into deriving the HSIs and HUs for most species are outdated and in part because we also understand now the limitations of many assumptions of the approach (e.g., no clear relationship of a species' abundance with productivity or habitat quality, and large costs to following all individual species of interest in detail). Further the newer HAB and CHAP processes proposed by the Northwest Habitat Institute magnify the problems of HEP. The money and effort expended repeating HEP (to count HU) every five years fail to give useful information on either wildlife or habitat, relative to goals of recovering and sustaining wildlife in the basin. The problem is that many, including some project sponsors, view HEP as effectiveness monitoring.

If HEP were universally recognized as an accounting tool *only*, mitigation progress could be approximated and reported with this metric. However, another approach is needed to report on biological accomplishments. In many cases, actual biological monitoring of focal species might be less expensive and would certainly be more informative as to effects of management than is HEP. We recommend either adding a *biological* indicator, and using HU as an *implementation* indicator, or simply substituting a biological indicator. There are several possibilities.

For biological effectiveness monitoring, one alternative is following what the ISAB and ISRP have said in the past about M&E approaches in general, though these have not been considered to be about wildlife. The paper published by the ISAB and ISRP in Fisheries[6]

[6] McDonald LL, Bilby R, Bisson PA, Coutant CC, Epifanio JM, et al. (2007) Research, Monitoring, and Evaluation of Fish and Wildlife Restoration Projects in the Columbia River Basin: Lessons Learned and Suggestions for Large-Scale Monitoring Programs. Fisheries: Vol. 32, No. 12 pp. 582–590: http://afs.allenpress.com/perlserv/?request=get-abstract&doi=10.1577%2F1548-8446(2007)32%5B582%3ARMAEOF%5D2.0.CO%3B2

advocated development of a background, low-level, inexpensive monitoring program, with many sites chosen probabilistically and simple direct metrics taken and used for status-trend evaluation. This could work for wildlife too. The background monitoring, such as a MultiSpecies Indicator Monitoring (MSIM) approach based on presence-absence information at many sites would be a much better approach than HEP and HUs. A basinwide multi-species indicator monitoring approach could give valuable status and trend data at low cost. Detailed wildlife census or productivity indicators from all wildlife property in the Program seem unattainable – too much time and money to do in all but unique cases such as the Western Pond turtle reintroduction. The Fisheries paper also advocated for watershed experiments to be used to evaluate the contributions of strategies for improving habitat or increasing fish and wildlife, with effective strategies generalized to use in other similar areas. Intensively monitored watersheds could be useful for species with small home ranges and the ability to generate a rapid population response to management. There are also logical links to some fish habitat indicators as identified above.

Breeding bird survey data could be used now to evaluate trends in the basin or sub-regions. These data are not entirely or directly linked to Program actions, but are relevant and perhaps linkable indirectly. These data are not perfectly interpretable, as breeding bird surveys are influenced by many external factors and success of birds that nest might be more site-specific. However, extensive data are available now and these data have been used effectively by others to relate bird population status and trends to habitat, land-use, and other environmental factors.

For a high level indicator of wildlife habitat, a composite-type index might be created using data already reported to Pisces and other simple categorical data such as habitat type, rarity, and value to designated species, as well as landscape metrics such as acreage and contiguity or access to other nearby secure habitats. For instance, land acquisition that links areas of habitat for a sensitive amphibian would score higher than acquisition for expanded mule deer hunting. All existing projects could be rather quickly rated this way. For maintenance, operations and enhancement, scores could be based upon mutually agreed effectiveness monitoring criteria. New parcel scores could increase with completion of a management plan that includes mutually agreed monitoring criteria, followed by some points for implementation monitoring until such time as biological response could be expected. This is simplistic, but has a biological basis. It is transparent, and it could be modified with new knowledge or opportunities. Further it could be aggregated across the basin and integrated with population monitoring work the states, tribes or other groups may be doing.

Other population and habitat data can be sought from State fish and game agencies, USFS, BLM, NRCS, NRI, USGS, Gap Projects, TNC, National Resource Assessment and Plan, State Wildlife Conservation Plan's monitoring efforts. Data for a biological index are available. Acreage and habitat-type data are available and can be acquired fairly easily. Data on listed species are also accessible. Existing population survey data vary in quality and accessibility. Focal species can be retrieved from subbasin plans, and project proposals. Habitat contiguity or proximity and conservation status can be derived from government records and GIS. Land management planning status and monitoring progress can be derived from project progress reports.

Habitat unit data are available in Pisces, but the ISAB and ISRP recommend that these be used only for implementation monitoring. Additionally, because of the high cost to obtain HUs and their unclear relation to biological responses, we recommend that HUs not be considered high priority HLIs in some instances, even as implementation indicators.