Fish and Wildlife Program Categorical Assessment, 1980-2022: Habitat Restoration

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This is a staff product and has not been reviewed or approved by the Council. This working draft functions as supplementary documentation for the Categorical Assessment presentations and contains information to inform the upcoming amendment process. While elements within this document were developed in collaboration with the region's state and federal fish and wildlife agencies and tribes, the document itself has not been reviewed by anyone other than Council staff and should be considered preliminary. We welcome feedback and/or corrections for future drafts of this documentation.

Northwest **Power** and **Conservation** Council

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Restoration: Purpose and scope

The Northwest Power and Conservation Council's Fish and Wildlife Program calls for habitat restoration actions as one component of mitigation for hydrosystem effects on fish and wildlife. These actions are designed to address habitat limiting factors and improve ecosystem function for multiple species throughout the basin by increasing habitat quantity, improving habitat quality, addressing water quality issues, and increasing water quantity in tributaries. The Program calls for these actions to be implemented considering the expected effects of climate change on the hydrology and ecology of the basin.

The objective of this assessment is to describe the status of habitat restoration over the last 40 years under the Council's Fish and Wildlife Program, and to identify key topics for the Council and region to consider as we approach the next Program amendment cycle. We describe implementation of habitat restoration at the Program scale by summarizing efforts geographically and over time. This is not a project-scale assessment of implementation; that information is provided by project sponsors in their updates and through Project Review by the Council and the Independent Science Review Panel (ISRP). This is also not an assessment of action-effectiveness. The ISRP and other entities review action-effectiveness in their reporting. Rather, this Program-scale assessment of implementation is designed to characterize the broad types and locations of mitigation that have occurred, and key issues arising in a changing climate and basin.

Changes to the Columbia Basin over 40 years

The Columbia Basin is a diverse landscape with different land and resource uses throughout the basin (Figure 1) and over time. The result of this land use complexity is that different restoration needs exist in different places.

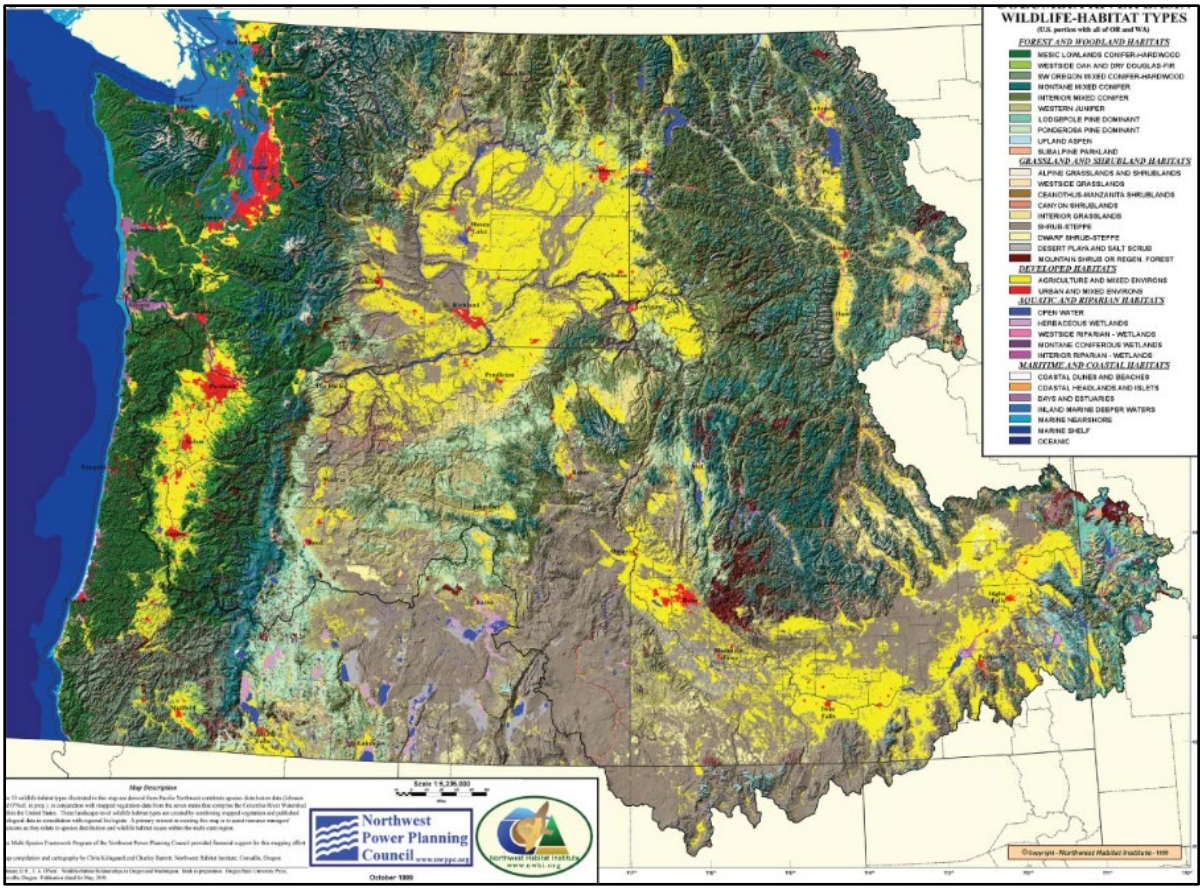

Figure 1. Vegetation and land use in the Columbia Basin. Map produced by the Northwest Habitat Institute

Over the last century, there has been a substantial increase in human population and associated resource uses (e.g., changing energy demands, changes to natural resource extraction and water consumption, and other kinds of impacts). In the Pacific Northwest, census population changes have increased by millions since the 1920's (Figure 2), and those increases have occurred at a faster rate than the United States population as a whole (Figure 3). Taken together, this means that the Columbia Basin is not static- it is always changing. That is the backdrop against which mitigation- in this case habitat restoration- is implemented.

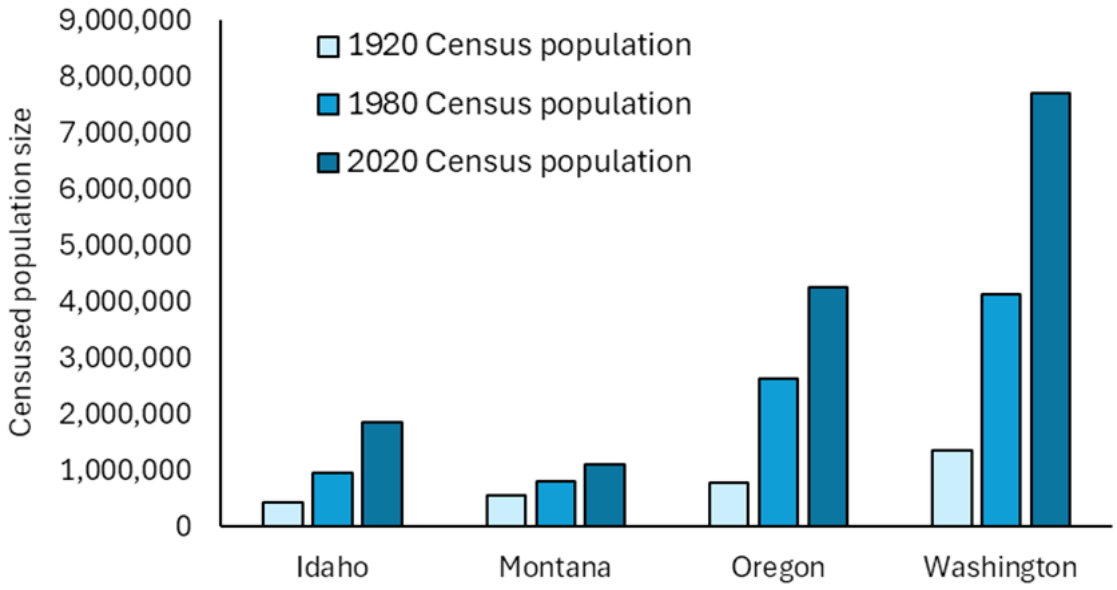

Figure 2. Growth of the U.S. population between 1920 Census, the 1980 Census, and the 2020 Census in Idaho, Montana, Oregon, and Washington

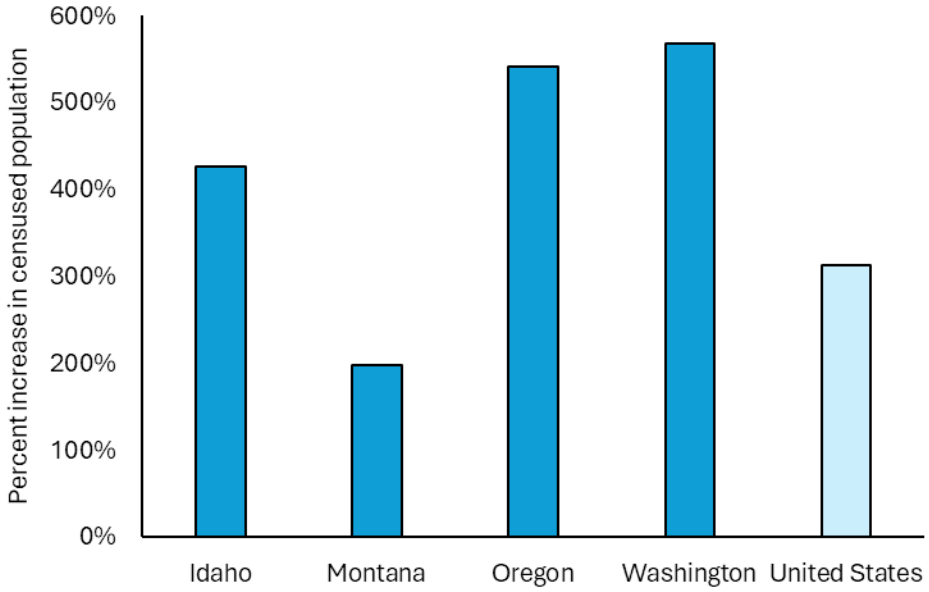

Figure 3. Percent increase in the U.S. population between the 1920 Census and the 2020 Census in Idaho, Montana, Oregon, and Washington, as compared to the United States

Regional efforts to address habitat limiting factors

Restoration is implemented by many organizations in the Columbia Basin, with a focus on addressing limiting factors. Limiting factors describe anything that negatively affects survival or reproduction. There are typically multiple factors. For example, a culvert may block access to a spawning tributary. Removing that culvert creates access, i.e., removes a limiting factor, but if newly accessed habitat is of poor quality, it must also be restored to improve survival or reproductive success. Improving habitat and survival is an iterative process that requires implementation across spatial scales (e.g., local culvert, stream-scale habitat restoration, watershed scale water quantity, basin scale migration corridors), life stages, and habitats used at different points in the life cycle.

The Pacific Northwest Salmon Habitat Project Database (PNSHP) compiled information on habitat restoration actions throughout the basin by project implementors in general and by projects that are part of the Fish and Wildlife Program (Figure 4). The database was developed using information provided by project implementors, so a lack of data does not mean that restoration has not occurred. This map demonstrates how the Program is part of the overall tapestry of restoration in the basin and illustrates why the effects of habitat restoration under the Program cannot be isolated from other restoration efforts in this larger tapestry.

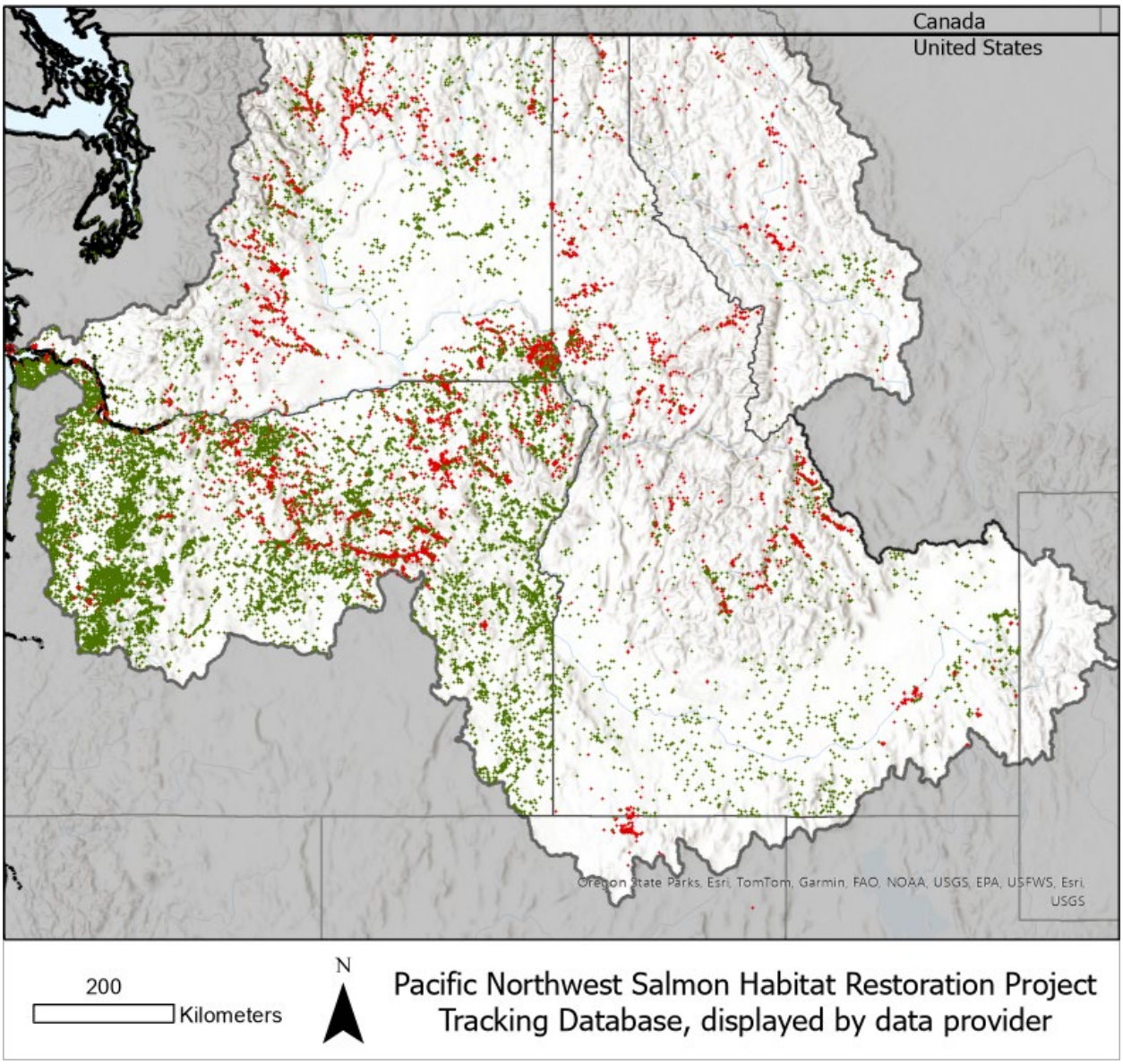

Figure 4. Location of restoration actions within the Columbia Basin submitted by BPA (red dots) and all other organizations (green dots) to the Pacific Northwest Salmon Habitat Restoration Project Tracking Database (PNSHP). Data at https://www.webapps.nwfsc.noaa.gov/apex/f?p=409:13:::::P13_CATEGORY

Habitat restoration under the Fish and Wildlife Program

The Pacific Northwest Electric Power Planning and Conservation Act (Northwest Power Act 1980) specifies that mitigation occur through a combination of (1) onsite (in-kind and in-place) actions related to the hydrosystem, and (2) offsite actions to protect, mitigate, and enhance populations of fish and wildlife affected by the hydrosystem [4(h)(1)(A); 4(h)(5); 4(h)(8)(A)]. These

were designed to function in tandem, with different actions being implemented collectively to achieve goals.

Dam operations and passage structures have been modified to decrease negative effects on fish but the dams remain in place along with associated habitat fragmentation and changes to ecosystem function. To the extent that these onsite actions cannot fully mitigate hydrosystem effects, the Act provides for offsite mitigation, including on related spawning grounds.

Offsite mitigation covers all efforts not directly located in the mainstem or near a dam. Efforts focus on actions to improve survival to offset ongoing mortality due to the hydrosystem. Offsite mitigation, including habitat restoration, has been a substantial part of the Program, particularly since 2000 (Figure 5).

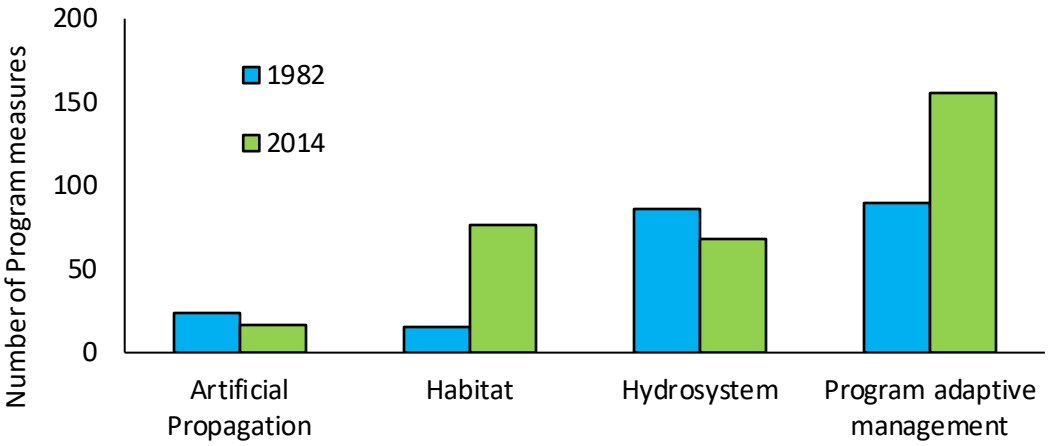

Figure 5. Comparison of the number of measures in each category of the NPCC Fish and Wildlife Program, 1982 and 2014

Habitat restoration is a tool that can be used to recreate some level of lost habitat function following degradation. It is implemented in different environments and for the benefit of individual species, groups of species, or improved ecosystem function. It encompasses restoration of instream habitat, riparian and floodplain vegetation and water quantity and quality, as well as improved physical and hydrologic connectivity along the stream and between the stream and floodplain.

Program measures over time

Over the last 40 years of Council programs, over 500 measures and 59 subbasin plans have called for some kind of action related to habitat. The following is a summary of the habitat program measures by decade. More detailed information can be found in Appendix A.

1980s: Habitat restoration was not a significant component of the Program. Measures focused on a select set of local restoration projects in tributaries or in areas blocked to anadromous species (here after "the blocked areas"). The program specifically called for subbasin plans to be developed. There was also a call to reestablish naturally-spawning runs in the Yakima River basin, particularly by addressing fish passage needs. This basin was selected as a pilot program for tributary habitat and production mitigation because it was "considered by most fishery experts to be one of the areas in the Columbia River Basin with the greatest potential for the production of anadromous fish" (NPPC 1982a).

- Regional policies, guidance, planning
    - Action Plans
    - 1st Subbasin plans
- General restoration
    - System plans for habitat and tributary passage projects
    - Habitat improvement and passage restoration or improvement measures as specified in list of enhancement measures in various subbasins
- Specific restoration
    - Habitat improvement measures in the Columbia River Basin; specific subbasins: John Day, Salmon/Clearwater, a few misc. General enhancement measures, not specific projects
    - Restoration measures in Flathead subbasin to mitigate for habitat loss caused by Hungry Horse Dam
- Fish passage
    - Fish passage improvements at irrigation diversion dams, canals, and ditches in the Yakama basin
- Water quantity
    - Water use efficiency in Yakima Basin
- Water quality
    - Evaluate temperature regimes in Clearwater

1990s: There was a growing emphasis on habitat restoration and numerous measures and principles guiding the kinds of actions, collaboration, and priorities that should be completed in tributaries to aid anadromous and resident fish. The Program identified the need for water conservation and called for implementation of instream leasing and water transactions as a means for improving water quantity. Implementation and evaluation of water transactions was the precursor for the Columbia Basin Water Transactions Program.

- **Regional policies, guidance, planning**
    - ESA Listings

- Policies on federal land, including land management, grazing, etc.
- Subbasin plan updates
- Integrated system plan development

- **General restoration**
  - Big expansion in the habitat program, including habitat improvement implementation and monitoring for resident fish
  - Model Watersheds
  - Measures on water quality
- **Specific restoration**
  - Water demonstration projects in Grande Ronde for temperature improvements
  - Restoration projects in Flathead subbasin, Fort Hall Reservation, Malheur subbasin, Lake Roosevelt tributaries, Pend Oreille River tributaries, Duck Valley Indian Reservation, Coeur d'Alene Reservation
- **Fish passage**
  - Feasibility assessments of passage above blockages to fish passage
  - Fish passage facility projects in high priority areas as established by managers and technical work groups
- **Water quantity**
  - Regional assessment of the availability of water for salmon and steelhead spawning, incubation, emergence and migration in the Columbia River and its tributaries
  - States to establish water conservation programs
  - Water conservation plan for Yakama subbasin
  - Water transactions in Snake Basin to aid instream flows for salmon and steelhead
  - Funding for the acquisition and management of critical water rights for rebuilding and maintaining Columbia Basin salmon and steelhead populations
  - Water conservation demonstration projects and water leasing demonstration projects
- **Water quality**
  - Maintain habitat where water quality standards are being met; improve habitat where water quality standards are not being met
  - Study plan to compile and evaluate existing water quality information, identify data gaps and priority problems, and recommend proposals to address gaps and priority problems
  - Establish best management practices under the Clean Water Act to maintain and improve salmon and steelhead production

- Review and, if necessary, seek improvements to mining laws and administrative practices to promote salmon and steelhead productivity
- Review water quality standards and compliance procedures and report on limitations that could impact meeting habitat goals and objectives in the Program

2000s: Restoration was called for throughout the basin, from the blocked areas to the estuary, including in the mainstem and tributaries. There was also a major emphasis on restoring ecosystem function to benefit multiple species (anadromous, resident, and wildlife). The specific details guiding restoration were described in the subbasin plans, and those plans were meant to guide future habitat restoration.

- **Regional policies, guidance, planning**
  - Subbasin plans (2004, 2005, 2009, 2010) are foundation of Program; specific restoration information now contained within subbasin plans
- **General restoration**
  - Protect habitat that supports existing populations that are relatively healthy and productive; next, expand adjacent habitats that have been historically productive or have a likelihood of sustaining healthy populations by reconnecting or improving habitat
  - List of Principles:
    - Restore ecosystems, not just single species
    - Address transboundary species
    - Restoration in estuary and blocked areas
    - Build from strength (strongholds)
  - List of types of habitat protection and improvement activities
    - Removal of passage barriers
    - Diversion screening
    - Riparian habitat protection and improvement
    - Water transactions and conservation activities to increase the amount, timing, and duration of instream flows
    - Floodplain reconnection
    - Acquisitions of and enhancements to terrestrial uplands for wildlife habitat
  - Increase the extent, diversity, complexity, and productivity of mainstem habitat
- **Specific restoration**
  - Actions that create littoral habitat and fish structures along the shores of Lake Roosevelt to diversify food available to fish and provide additional rearing habitat.
  - Actions to stabilize and improve burbot populations in the upper Columbia.

    - Actions to stabilize and improve Columbia River white sturgeon and to recover listed Kootenai River white sturgeon.
    - Most specific restoration details covered in subbasin plans
- **Fish passage**
    - Measures in the BiOps
- **Water quantity**
    - Call for establishment of water transaction program which will continue to use both temporary and permanent transactions for instream flow restoration. The water transaction program to integrate instream water transactions with efforts to set and meet flow targets and habitat restoration goal and with efforts to address other ecological factors that are limiting fish habitat
    - Climate change: Climate change could have significant effects on mainstem Columbia and Snake River flows in terms of runoff timing, water quantity and temperature.
        - Federal action agencies should support advancement of runoff forecasting techniques; assess whether climate change effects are altering or likely to alter critical river flows; evaluate whether alternative management scenarios could minimize the potential effects of climate change on mainstem hydrology; and evaluate the effectiveness and feasibility of possible actions to mitigate the effects of climate change
- **Water quality**
    - In the long-term, implement actions to reduce toxic contaminants in the water to meet state and federal standards
    - Expand the water temperature modeling capabilities
    - Incorporate provisions of various total maximum daily loads (TMDLs) as they are developed and approved

2010s: The shift from isolated restoration actions to more integrated actions continued in the current decade, along with enhanced focus on removing fish passage barriers, restoring and reconnecting floodplain habitat in the tributaries, and restoring mainstem habitat. In the mainstem, new work was proposed to identify and restore thermal refugia as part of a strategy on climate adaptation. Other restoration actions were proposed for specific species (e.g., sturgeon, lamprey). In 2020, there was further emphasis on increasing investment in blocked areas mitigation.

- **Regional policies, guidance, planning**
    - Measures in BiOps, Program principles

- **General restoration**
    - Identify and protect mainstem habitat areas and ecological functions that are relatively productive for spawning, resting, rearing, and migrating native anadromous and resident focal fish species
    - Restore and enhance habitat areas that connect to productive areas to support expansion of productive populations and to connect weaker and stronger populations
    - Protect and enhance ecological connectivity between aquatic areas, riparian zones, floodplains, side channels, and uplands
    - Enhance the connections between the mainstem sections of the Columbia and Snake rivers and floodplains, side channels, and riparian zones
    - Protect and enhance mainstem riparian areas and wetlands to protect aquatic conditions and form a transition to floodplain terrestrial areas and side channels
    - Continue to identify, protect, and restore habitat areas and ecological functions, such as stream channel complexity and function, that are associated with productive spawning, resting, rearing, and migrating lamprey
    - Continue to identify, protect and restore habitat areas and ecological functions that are associated with productive spawning, resting, rearing, and migrating sturgeon
- **Specific restoration**
    - None listed in Program. Specific restoration actions exist in subbasin plans and BiOps
- **Fish passage**
    - Remove fish-passage barriers
- **Water quantity**
    - Continue Bonneville funding to acquire water and pursue water rights in subbasins where water quantity has been identified in subbasin plans as a primary limiting factor and where flow targets have been identified
    - Improve the amount, timing, and duration of instream flows through water rights and acquisitions
- **Water quality**
    - Protect and improve riparian habitats in all areas of the Columbia River Basin to improve water quality, reduce contaminant transport, lower water temperature including creating thermal refugia, and reduce sediments

2014/2020 Fish and Wildlife Program strategies associated with assessment

Table 1. Fish and Wildlife Program strategies and strategy performance indicators (SPIs; NPCC 2020) associated with the restoration portion of the Habitat Assessment

Strategy ***SPI***	**Description**
Ecosystem function	Protect and restore natural ecosystem functions, habitats, and biological diversity wherever feasible consistent with biological objectives in the program.
	• *No specific SPIs*
Habitat	Protect, enhance, restore and connect aquatic and terrestrial habitat. Protecting existing quality habitat is as important as enhancing degraded habitats.
E1-5	• *Acres of habitat improved.*
E1-7	• *Acres improved in riparian areas.*
E2-1	• *Instream flow added (acre-feet of protected water).*
E2-6	• *Instream flow added (cfs)*
E1-3	• *Miles of stream habitat accessed.*
E1-4	• *Miles of stream with improved complexity or improved channel form.*
Water quality	Provide flows and habitat conditions of adequate quality and quantity for improved survival of anadromous and native resident fish populations on the mainstem Columbia and Snake rivers, as well as improving water quality in Columbia Basin tributaries, to promote healthy and productive populations of anadromous and native resident fish and wildlife.
E2-2, E2-4	• *Daily average water temperatures at fixed monitoring sites in the mainstem in reference to water quality targets.*
Climate Change	Better understand how the effects of climate change may impact fish and wildlife populations and mitigation and restoration efforts implemented under the Columbia River Basin Fish and Wildlife Program.
	• *No specific SPIs*
Estuary	Restore ecosystem function to protect and enhance critical habitat and spawning and rearing grounds in the estuary and lower Columbia River.

E1-8	• *Acres of estuary floodplain protected or restored per hydrogeomorphic reach.*
Anadromous fish mitigation in blocked areas	Mitigate through implementation of a variety of actions that may include passage investigation, reintroduction of anadromous fish, habitat improvements, and harvest opportunities for the loss of salmon and in blocked areas of the Columbia Basin that historically had runs of anadromous fish. Flexibility in approach is needed to develop a program that addresses anadromous fish losses.
S5-2	• *Studies completed regarding fish passage, experimental pilot releases and testing interim fish passage facilities, fish reintroduction approaches, upstream/downstream passage options and costs, and habitat suitability.*
S5-4	• *In blocked areas where the program has committed to any or all of these anadromous fish reintroduction activities, track the following: Increase in habitat access for anadromous fish in the blocked waters above the blockage including, but not limited to, miles of fish habitat made accessible and high-head dam interim fish passage facilities in operation.*

Approach to summarizing implementation

For this assessment we utilized data provided by project sponsors in BPA's online program information tool CBFish.org, which has compiled data since 2005. Project sponsors provide information to BPA on the implementation of their contracts using CBFish. Within their contract work statements, they identify actions to be implemented during the contract period and measurements that can be used to quantify implementation.

CBFish contains different levels of information to document project implementation, specifically "Work Elements", "Metrics" and "Measures", as well as location of work sites. A work element is a standardized task or activity implemented under the Fish and Wildlife Program. Examples include "install fence", "collect data", "purchase land", and "submit progress report". A metric is a quantification or qualification of an accomplishment resulting from completing a task (work element). Habitat work elements often have several quantifiable metrics such as # of acres treated or # of stream miles with improved complexity. A measure is a higher-level grouping of one or more metrics. Measures can contain multiple metrics and multiple work elements.

Data on worksites should be provided to CBFish as GIS coordinates. Ideally, the GIS coordinates would document the location of the work site, but for some projects the location provided is the overall project or the sponsor office. The coordinates provided to CBFish are single points, not polygons describing the footprint of restoration.

CBFish is a contract management tool designed to help BPA track where, when and what kind of work is being done by contractors each year. If multiple actions are implemented on the same plot of land, the acreage or length of the area treated is recorded for each of the actions. This is an important feature of CBFish as it allows BPA to track the volume of work that was implemented by contractors each year. It does, however, pose challenges for tracking how much of the landscape was altered due to the restoration actions implemented each year. It also does not provide information on how much habitat change may have occurred due to the implemented action. Reporting the same area or length of work for each action may result in double counting of acreage when summing how much of the landscape has been restored. In addition, since measures often contain multiple metrics and multiple work elements, the data associated with them may reflect double counting.

During the 2020 Fish and Wildlife Program Addendum, we worked with project managers to identify habitat strategy performance indicators (SPIs) that can be tracked to evaluate progress on the habitat measures in the Council's Program. The SPIs were selected to characterize Program-scale efforts and progress and were based on availability of existing data sets. The SPIs provide information on overall habitat restoration by summarizing data geographically and over time. They are not designed to evaluate individual project implementation or action "effectiveness". Information on project-scale implementation and effectiveness can be found in the ISRP project reviews, as well as in action effectiveness reports (e.g., Roni et al. 2023). The SPIs can be found on the Council's Program Tracker tool.

Subsequent to the 2020 Addendum, we worked with BPA to evaluate the data in CBFish and identify what information most closely tracked to the SPIs. In all but one case we utilized measures from CBFish to track and report on the SPIs, similar to many of the reports and data displays provided in CBFish. For one SPI (acres protected by purchase or conservation easement, see below) we used a single metric, based on discussions with BPA staff on the best correspondence between the SPI and the data in CBFish. To provide clarity on the specific actions implemented, we identified the reported work elements associated with each SPI (Appendix B)

Given that the purpose of CBFish is for use as a contract management tool, utilizing this database for evaluating overall improvement on the landscape could at times yield inaccurate or imprecise results. Regardless, we chose to utilize the information from CBFish for the purposes of this assessment since at this time, there is no habitat implementation database available to directly track habitat change or improvement on the landscape.

Description of implementation actions

Habitat restoration is implemented by Fish and Wildlife managers through projects identified under the Council's Program and contracted with BPA. Although we identify these as projects, most are long-term, comprehensive investments in restoration actions in specific watersheds

and subbasins throughout the Columbia Basin. There are currently 143 projects conducting habitat planning, restoration, protection, research, and monitoring, as identified in the Council's Program.

To assess implementation of habitat, we organize the project actions and associated SPIs into four areas of habitat restoration: habitat quality, habitat quantity, water quantity and water quality:

Habitat quality restoration refers to work occurring within areas currently accessible to target species. This includes channel enhancement to increase instream habitat, removal of non-native vegetation and planting of native vegetation, increasing riparian shading and protecting streams through fencing and other enclosures.

Habitat quantity restoration refers to work to increase the longitudinal and lateral amount of available habitat, for example by removing passage barriers or repairing culverts, reconnecting side channels or restoring floodplain connectivity with the main channel.

Water quantity restoration refers to efforts to increase instream flows. This may occur through water conservation or through leasing or acquisitions of water rights in tributaries, or through flow releases from dams in the mainstem or tributaries.

Water quality improvement refers to efforts to improve water temperature or reduce contamination through riparian/floodplain revegetation, protecting or creating cold-water refuges, implementing cold-water releases from storage dams, or addressing sources of contaminants on the landscape.

Data summaries

Habitat quality

Improvements in habitat quality occur through actions taken within the existing available habitat to enhance conditions for fish and wildlife species utilizing those areas. Actions can occur instream or on land, depending on restoration needs. In CBFish, data may be reported for different "zones", including riparian, wetland, freshwater non-tidal, upland, etc. To describe changes in habitat quality, we are utilizing four SPIs:

- Acres of habitat improved (SPI E1-5)
- Acres improved in riparian zone (SPI E1-7)
- Miles of stream with improved complexity or channel form (SPI E1-4)
- Acres of estuary floodplain protected or restored per hydrogeomorphic reach (SPI E1-8).

SPI E1-5 Acres of habitat improved:

This SPI draws on three measures in CBFish: acres improved in various ways (Measure 2), acres improved through channel reconnection or addition (Measure 72), and acres treated (Measure 71). In general, we've seen an increase in acres improved from the beginning of CBFish reporting in 2005 (Figure 6). Figure 6 also shows that there has been a transition from actions being reported under one measure (acres improved in various ways – blue bars) to a different, but related measure (acres treated – green bars).

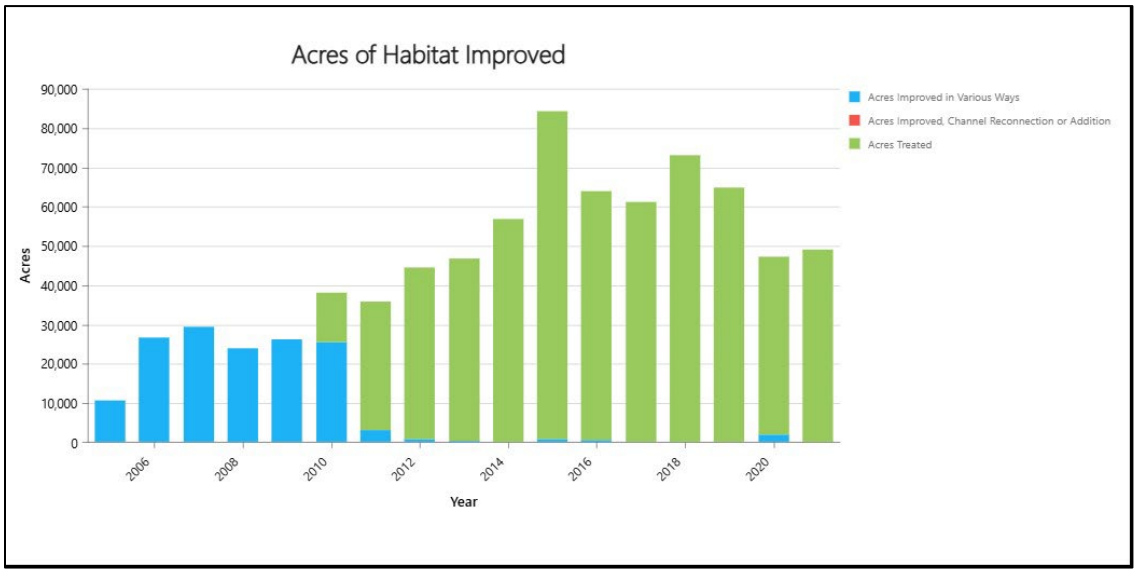

Figure 6. Acres of habitat improved in the Columbia Basin through implementing the NPCC Fish and Wildlife Program, 2005 - 2021. Data reported on Program Tracker as SPI E1-5 and summarized from measures 2, 71, and 72 reported on CBFish

Habitat improvement occurs in different zones and through the application of different techniques. Measures 2, 71, and 72 rely on the metrics in Table 2 to characterize acres improved each year. As with other measures, the values are reported multiple times if an action is implemented in multiple years at the same location. For this reason, annual data on acres of habitat improved cannot be summed over time to determine the total unique acreage improved. Here we report maximum acreage improved in any single year for each metric, and do not provide a value totaled for all years, to reduce potential double counting. It is important to note that in some cases a single action will be reported in more than one zone, another potential source of double counting.

Table 2. Metrics describing how and where acres of habitat are improved (measures 2, 71, and 72), and the maximum annual acreage reported during 2005 – 2022

Metrics describing how and where habitat is improved ***[years when metric used to describe implementation]***	**Max acreage improved in any single year, 2005 - 2022**
Acres of estuarine wetland affected by treatment *[2010 – 2013]*	0
Acres of freshwater wetland affected by treatment *[2010 – 2013]*	2.49
Acres of habitat treated by dike breaching in the Estuarine zone *[2013 - present]*	453
Acres of habitat treated by dike breaching in the Freshwater Non-Tidal zone *[2013 - present]*	10.3
Acres of habitat treated by dike breaching in the Riparian zone *[2013 - present]*	152
Acres of habitat treated by dike setbacks in the Estuarine zone *[2013 - present]*	50
Acres of habitat treated by dike setbacks in the Freshwater Non-Tidal zone *[2013 - present]*	14
Acres of habitat treated by dike setbacks in the Riparian zone *[2013 - present]*	16
Acres of habitat treated by full dike removal in the Estuarine zone *[2013 - present]*	965
Acres of habitat treated by full dike removal in the Freshwater Non-Tidal zone *[2013 - present]*	10.3
Acres of habitat treated by full dike removal in the Riparian zone *[2013 - present]*	38.4
Acres of wetland affected by treatment *[2005 – 2012]*	300
Acres treated *[metric used 2005 – 2012]*	720
Riparian acres treated *[metric used 2005 – 2012]*	1,134
Upland acres treated *[metric used 2005 – 2012]*	3,704

Wetland acres treated *[metric used 2005 – 2012]*	1,800

To better evaluate implementation, we performed some limited quality assurance/ quality control (QA/QC) checks on the data we were reporting. To do so, we sorted data by the size of actual values implemented because this is an easy way to see if large values are repeating under different metrics or subbasins.

We found instances of double counting that would affect the totals reported in a given year. In some cases, a contract may contain work done in more than one subbasin and the totals for work done are applied to each subbasin. Similarly, a project might span multiple habitat zones, e.g., freshwater non-tidal, estuary, riparian, etc. Below is an example where a large number of acres was coded into two habitat zones, meaning that the same action in the same year might be counted twice (Figure 7). Given the limitations of CBFish and its use as a contracting tool describing the amount of work done, there is no simple way to filter out double counting within the database.

180: Enhance Floodplain/Remove, Modify, Breach Dike	1674: # of acres of habitat treated by full dike removal in the Freshwater Non-Tidal zone	0.10	9.00	0.40	4.90	11.00	0.00
	1675: # of acres of habitat treated by dike breaching in the Riparian zone	0.00	0.00	0.00	28.78	0.00	0.00
	1676: # of acres of habitat treated by dike breaching in the Estuarine zone	90.00	100.00	0.00	0.00	0.00	0.00
	1677: # of acres of habitat treated by dike breaching in the Freshwater Non-Tidal zone	0.00	0.00	0.00	0.00	0.00	0.00
	1678: # of acres of habitat treated by dike setbacks in the Riparian zone	0.00	16.00	0.00	0.00	1,199.50	1,187.00
	1679: # of acres of habitat treated by dike setbacks in the Estuarine zone	0.00	0.00	0.00	0.00	0.00	0.00
	1680: # of acres of habitat treated by dike setbacks in the Freshwater Non-Tidal zone	0.00	0.00	14.00	0.00	1,199.50	1,187.00

Figure 7. Example of duplicated data values (same value reported under two habitat zones) for Habitat acres improved in various ways, which resulted in double counting

SPI E1-7 Acres Improved in Riparian Areas

Acres of habitat improved in riparian areas is reported under Measure 83 and draws on work elements including

- Realign, connect, and/or create channel
- Conduct controlled burn
- Plant / maintain/ remove vegetation
- Erosion and sedimentation control
- Enhance floodplain/remove, modify, breach dike
- Create, restore, and/or enhance wetland

- Practice no-till and conservation tillage systems
- Remove mine tailings

Figure 8 shows the annual total of acres improved in riparian areas. After subbasin plans were adopted in the early 2000s, we saw an increase in restoration that peaked in 2013. Sixty-eight projects conducted some kind of restoration action that contributed to acres improved in riparian areas that year. Since then, there has been variable acreage improved each year.

Many factors influence how much work is implemented over time including availability of willing landowners, changing infrastructure, funding, legal and permitting requirements and other factors. Funding is especially critical, as costs have risen over time, but funding levels may not have kept pace with market values and/or inflation. These factors interact with changing priorities and changing biological and physical conditions, including additional habitat loss, climate change and land development.

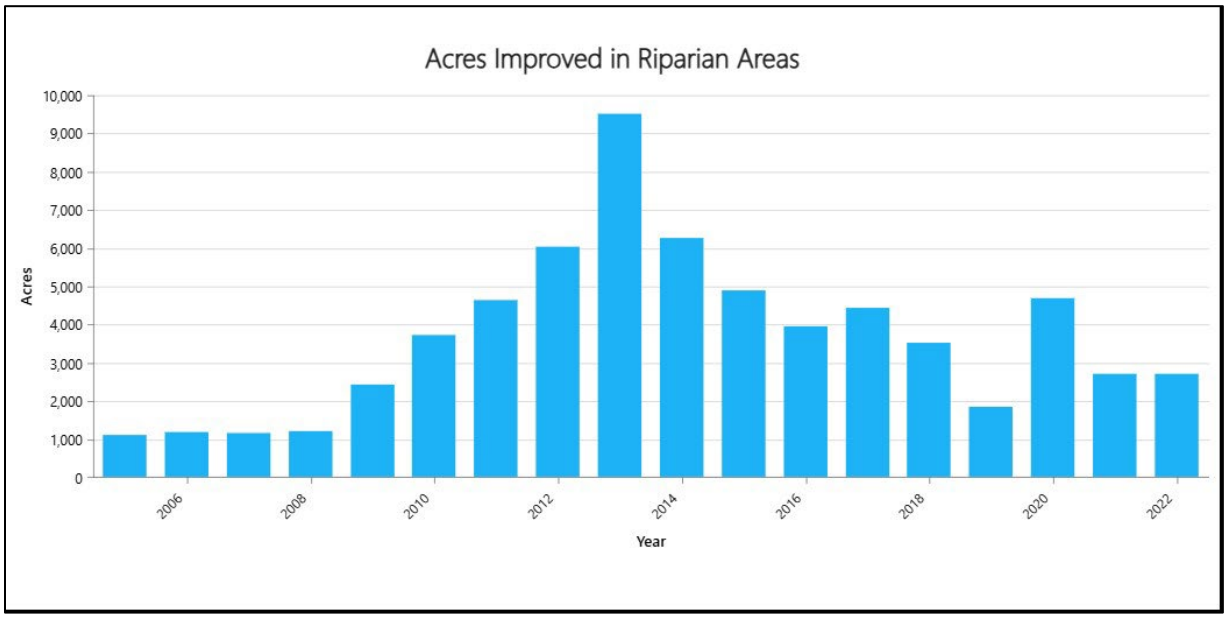

Figure 8. Acres of habitat improved in riparian areas in the Columbia Basin through the NPCC Fish and Wildlife Program, 2005 - 2022. Data reported on Program Tracker as SPI E1-7 and summarized from measure 83 reported on CBFish

Habitat improvement in the riparian zone (measure 83) relies on multiple techniques, occurs in different habitats (e.g., estuarine, freshwater, tidal, non-tidal), and is described using a large set of metrics (Table 3). As with other measures, the value is reported multiple times if an action is implemented in multiple years at the same location. Here we report maximum acreage improved in any single year for each metric, and do not provide a value totaled for all years, to reduce potential double counting.

Table 3. Metrics contributing to acres improved in riparian areas (measure 83), and the maximum annual acreage reported during 2005 – 2022 for each metric

Metrics contributing to acres improved in riparian areas	Max acreage improved in any single year, 2005 - 2022
# of acres of estuarine habitat rehabilitated/enhanced	45
# of acres of estuarine habitat restored/re-established	130
# of acres of estuarine non-wetland habitat treated	59.5
# of acres of estuarine wetland affected by treatment	0
# of acres of estuarine wetland habitat treated	163
# of acres of freshwater non-tidal habitat created	2.5
# of acres of freshwater non-tidal habitat rehabilitated/enhanced	200
# of acres of freshwater non-tidal habitat restored/re-established	110
# of acres of freshwater non-wetland habitat treated	290
# of acres of freshwater wetland affected by treatment	2.49
# of acres of freshwater wetland habitat treated	1,800
# of acres of habitat treated by dike breaching in the estuarine zone	453
# of acres of habitat treated by dike breaching in the freshwater non-tidal zone	10.3
# of acres of habitat treated by dike breaching in the riparian zone	152
# of acres of habitat treated by dike setbacks in the estuarine zone	50
# of acres of habitat treated by dike setbacks in the freshwater non-tidal zone	14
# of acres of habitat treated by dike setbacks in the riparian zone	16
# of acres of habitat treated by full dike removal in the estuarine zone	965
# of acres of habitat treated by full dike removal in the freshwater non-tidal zone	10.3

# of acres of habitat treated by full dike removal in the riparian zone	38.4
# of acres of riparian habitat created	22
# of acres of riparian habitat rehabilitated/enhanced	720
# of acres of riparian habitat restored/re-established	1,200
# of acres of riparian habitat treated	100
# of acres of riparian non-wetland habitat treated	850
# of acres of riparian wetland habitat treated	1,800
# of riparian acres treated	828

In Table 3, the 1,800 acres of riparian wetland habitat treated occurs in the same location (i.e., same latitude/longitude coordinates) as the 1,800 acres of freshwater wetland habitat treated, but the actions are implemented in different years. Summing the total work conducted in any single year would not result in double counting, whereas summing across years, even across metrics, would result in double counting. In this instance, the metric should have been the same both years- either acres treated in riparian wetland habitat or acres treated in freshwater wetland habitat.

SPI E1-4 Miles of stream with improved complexity or channel form

Some types of restoration projects, like reconnecting channels, adding large wood, or placement of other physical structures can change the form of the river channel. It may transition from a channelized river to one with more side channels, and/or to a range of habitat types (like pools, riffles, alcoves, undercut banks). On the Program Tracker, we report on miles of stream with improved complexity or improved channel form using data from CBFish. Over the last 20 years, there has been a general increase in the miles of stream with improved complexity or channel form (Figure 9).

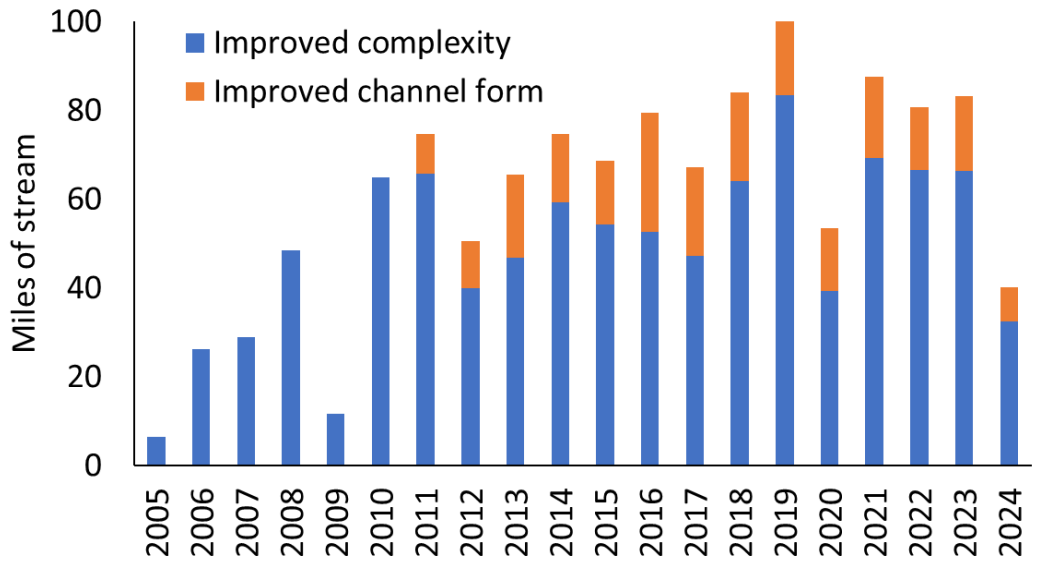

Figure 9. Miles of stream with improved complexity or improved channel form in the Columbia Basin through implementing the NPCC Fish and Wildlife Program, 2005 - 2024. Data reported on Program Tracker as SPI E1-4 and summarized from measures 6 and 70 reported on CBFish. Note: 2024 data is preliminary and subject to change.

Stream complexity and channel form (measures 6 and 70) are improved using multiple techniques, in different habitats, and are described using a large set of metrics (Table 4). As with other measures, the values are reported multiple times if an action is implemented in multiple years at the same location. Here we report maximum acreage improved in any single year for each metric, and do not provide a value totaled for all years, to reduce potential double counting.

Table 4. Metrics contributing to miles of stream with improved complexity or improved channel form (measures 6 and 70), and the maximum miles reported during 2005 – 2022 for each metric

Metrics contributing to miles of stream with improved complexity or channel form	**Max miles improved in any single year, 2005 - 2022**
Measure 6	
Miles of stream with improved complexity	25
Measure 70	
# of miles of main channel created in the estuarine zone	0
# of miles of main channel created in the freshwater non-tidal zone	2.81

# of miles of main channel treated in the freshwater non-tidal zone	3.5
# of miles of side channel created in the estuarine zone	1.7
# of miles of side channel created in the freshwater non-tidal zone	2.35
# of miles of side channel treated in the estuarine zone	1.2
# of miles of side channel treated in the freshwater non-tidal zone	5

SPI E1-8 Acres of estuary floodplain protected or restored per hydrogeomorphic reach

One habitat SPI is specifically focused on estuary habitat. The data were provided directly to the Council by the Lower Columbia Estuary Partnership (LCEP) and not obtained through CBFish. This SPI tracks the acres of land affected by restoration, acquisition, or a refuge. The Lower Columbia has been divided into geomorphic reaches (Figure 10) and the data are summed for each geomorphic reach independently, therefore there is no double counting of acres.

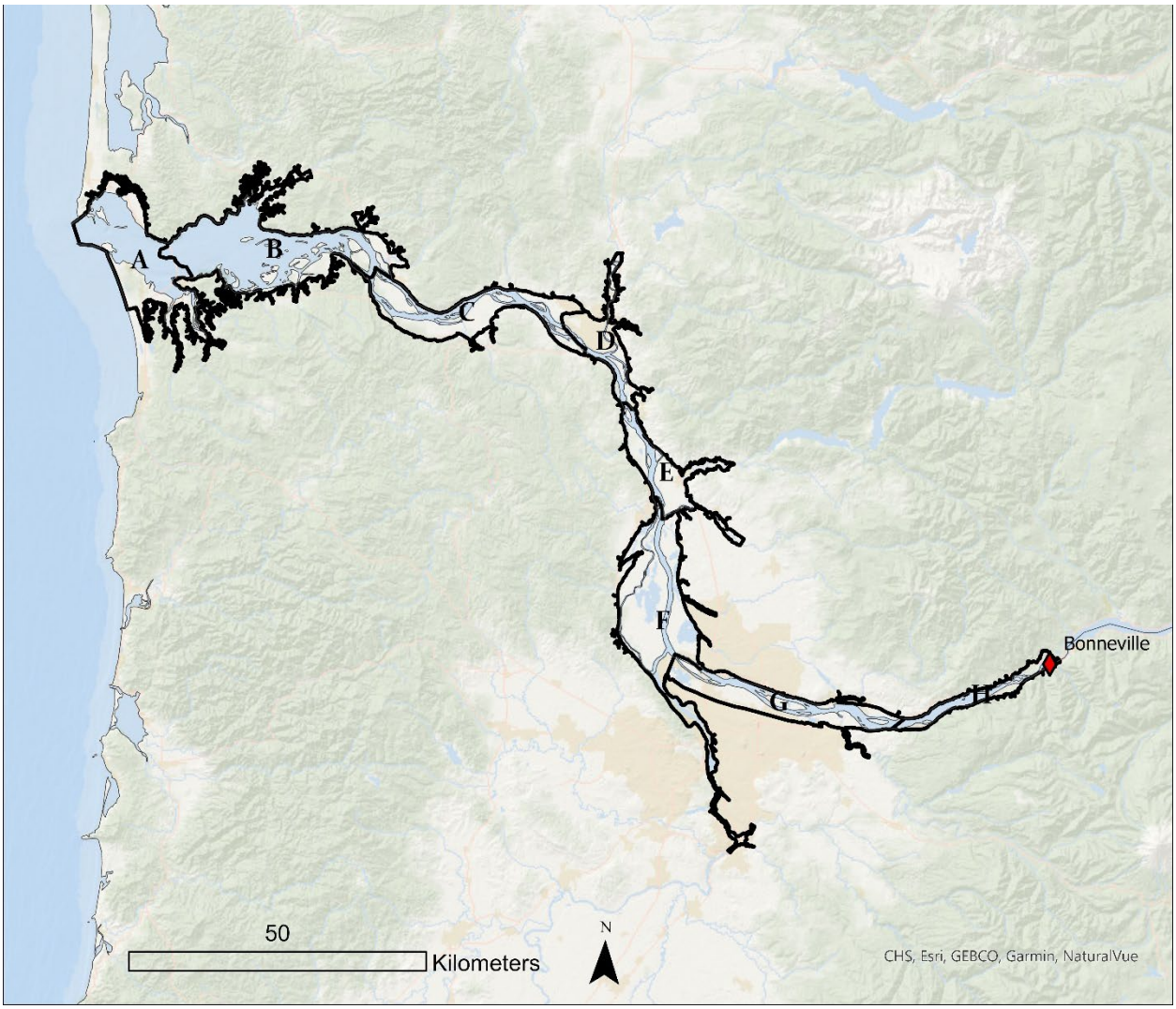

Figure 10. Geomorphic reaches in the Lower Columbia River and estuary

The initial target set by LCEP and partners was to protect and/ or restore 25,000 acres of habitat by 2025. That target was met in 2016 (Figure 11) and updated to 1) no-net loss of native habitats as of 2009; 2) recover 30% by river reach of historic extent for priority habitats by 2030; and 3) recover 40% by 2050. In total 44,796 acres have been protected or restored, with emphasis on reaches B and F.

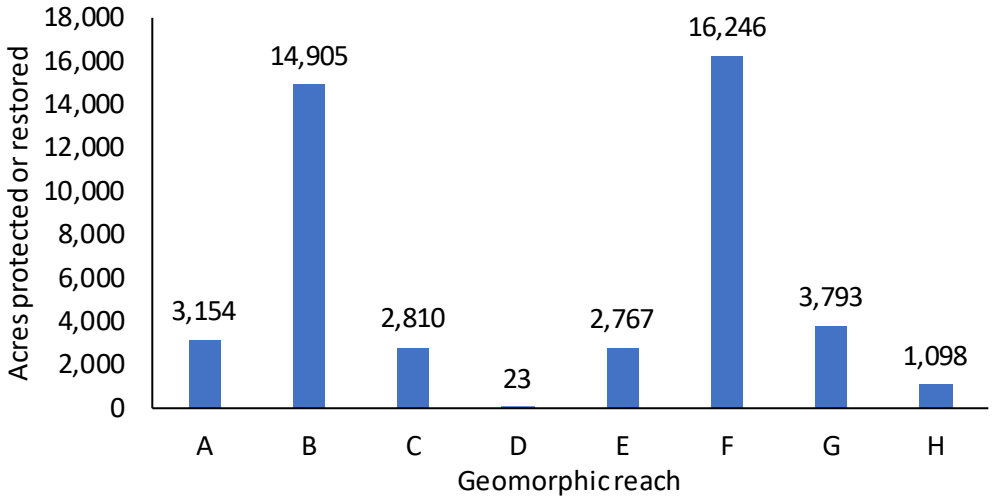

Figure 11. Total acres of land impacted by restoration and/or acquisition projects or protected by a refuge (no double counted areas). Data compiled by Lower Columbia Estuary Partnership and reported on Program Tracker as SPI E1-8.

Habitat quantity

Improvements in habitat quantity occur through actions taken to increase the amount of accessible habitat by removing passage barriers to upstream habitat, restoring access to multiple channels, or reconnecting the stream with its floodplain. This work occurs in tributaries, the mainstem, and the estuary. To describe changes in habitat quantity, we report on one CBFish measure and one SPI:

- Number of barriers removed (CBFish Measure 69)
- Miles of stream habitat accessed (SPI E1-3)

Number of Barriers Removed (CBFish Measure 69)

Measure 69 covers the following kinds of barriers: culverts, large-scale hydropower and diversion dams, mine tailings, natural dams, small scale hydropower and diversion dams, small-scale push-up or diversion dams, tide gates, and weirs (Table 5).

Table 5. CBFish metrics associated with measure 69- Barriers Removed, and values reported for 2011-2024

Metrics describing type and location of removed barriers	Barriers removed (measure 69)
Culvert full passage barriers in the estuarine zone	1
Culvert full passage barriers in the freshwater non-tidal zone	11

Culvert partial passage barriers in the estuarine zone	21
Culvert partial passage barriers in the freshwater non-tidal zone	51
Large-scale hydropower and diversion dam full passage barriers in the freshwater non-tidal zone	1
Large-scale hydropower and diversion dam partial passage barriers in the freshwater non-tidal zone	1
Mine tailing partial passage barriers in the freshwater zone	258
Natural dam full passage barriers in the freshwater non-tidal zone	1
Natural dam partial passage barriers in the freshwater non-tidal zone	4
Small-scale hydropower and diversion dam full passage barriers in the estuarine zone	4
Small-scale hydropower and diversion dam full passage barriers in the freshwater non-tidal zone	7
Small-scale hydropower and diversion dam partial passage barriers in the estuarine zone	1
Small-scale hydropower and diversion dam partial passage barriers in the freshwater non-tidal zone	23
Small-scale push-up or diversion dam full passage barriers in the freshwater non-tidal zone	26
Small-scale push-up or diversion dam partial passage barriers in the freshwater non-tidal zone	82
Tide gate full passage barriers in the estuarine zone	4
Tide gate partial passage barriers in the estuarine zone	2
Weir full passage barriers in the freshwater non-tidal zone	1
Weir partial passage barriers in the estuarine zone	2
Weir partial passage barriers in the freshwater non-tidal zone	65

From 2011 to 2024, a total of 576 barriers were removed in the Columbia Basin (Figure 12). The value reported in 2014 is highly influenced by a single contract, which reported that 250 barriers were removed from one site in one year.

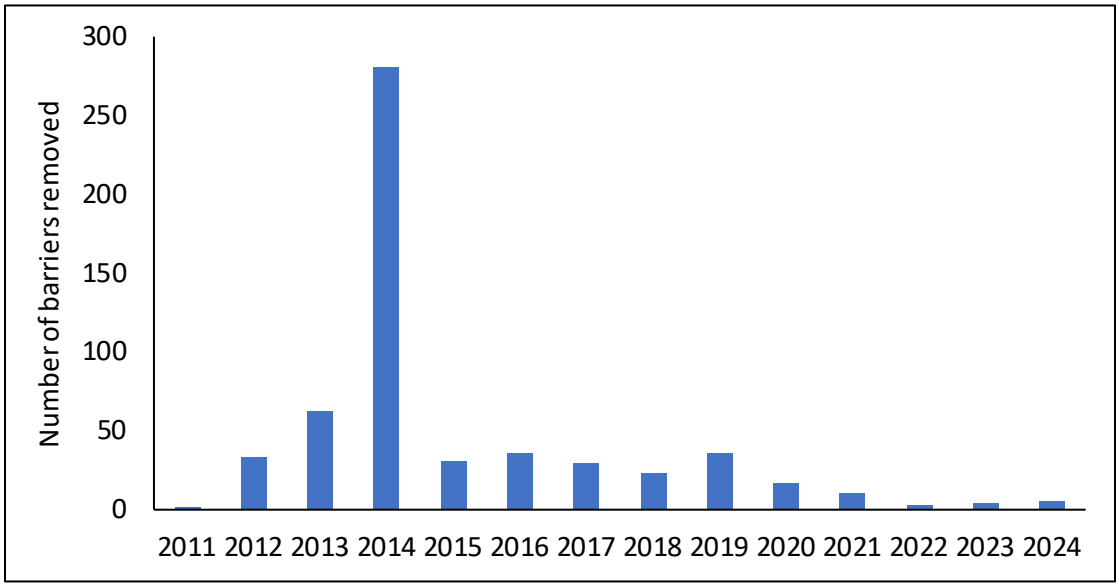

Figure 12. Number of barriers removed in the Columbia Basin through implementing the NPCC Fish and Wildlife Program, 2011 - 2024. Data reported as measure 69 on CBFish,

The value of 250 barriers in one year, and more specifically in one contract, was anomalously high. To better understand the data, we compiled information from CBFish on the contract summary associated with this work (Figure 13). In the section reporting on implementation metrics, we observed the following:

Metric	Planned	Actual	Contractor Comments	Measures	HLIs
1408. Did the tailings create a fish passage barrier?	No	No			
1441. # of miles of habitat accessed to the next upstream barrier(s) or likely limit of habitable range	0.00	0.00		miles of habitat accessed	Passage Barriers
1634. # of mine tailing partial passage barriers addressed in the freshwater zone	250	250	The tailings piles are NOT a fish migration barrier to any life stage.	barriers removed	
1638. # of acres of riparian habitat treated	3.90	3.90		acres treated acres treated instream acres improved in riparian areas	Habitat Acres

Figure 13. Example of incongruous data entry in CBFish related to removal of mine tailings- an observation that they are not barriers to migration, but still coded under “barriers removed.”

The sponsor noted that the tailings were not a fish passage barrier and did not create increased habitat access, but then entered data showing that 250 mine tailing barriers were addressed. The comments make clear that these tailings were not a barrier, but when data on individual metrics is summarized, the “actual” value reported is tallied, regardless of any contractor comments. As

a form of QA/QC, the answers provided to metric 1408 should provide an error flag associated with the answers provided for metric 1634.

The data reported for this specific project is not the concern here. Rather, it is that data associated with a straightforward measure like barriers removed cannot be taken at face value. As we highlight these different data challenges in CBFish, we also need to highlight the complexities of trying to obtain a lot of data in a large basin. CBFish works well for its intended purpose. Because there is not a separate habitat database, we are attempting to use these data to answer questions for which the database was not designed. To utilize CBFish for the purposes of reporting on habitat improvement requires a user to have enough familiarity with the database to be able to flag potential issues like double counting, data accuracy, program coding and more. These issues may seem isolated, but they influence the ability to do higher level spatial analysis or comparisons between barrier removal and stream access provided.

SPI E1-3 Miles of stream habitat accessed

Data on the miles of stream habitat accessed are tracked in CBFish using Measure 10 and also reported on the Council's Program Tracker as SPI E1-3. Because these data include values that may be repeated annually, such as from trap and haul programs, they cannot be summed over years to determine the total amount of stream access that has been provided through barrier removal. Instead, we can report the range, year-to-year, of increased access for fish. From 2004 to 2022, stream miles made accessible each year through barrier removal ranged from 2.5 – 639.4 (Figure 14; Table 6).

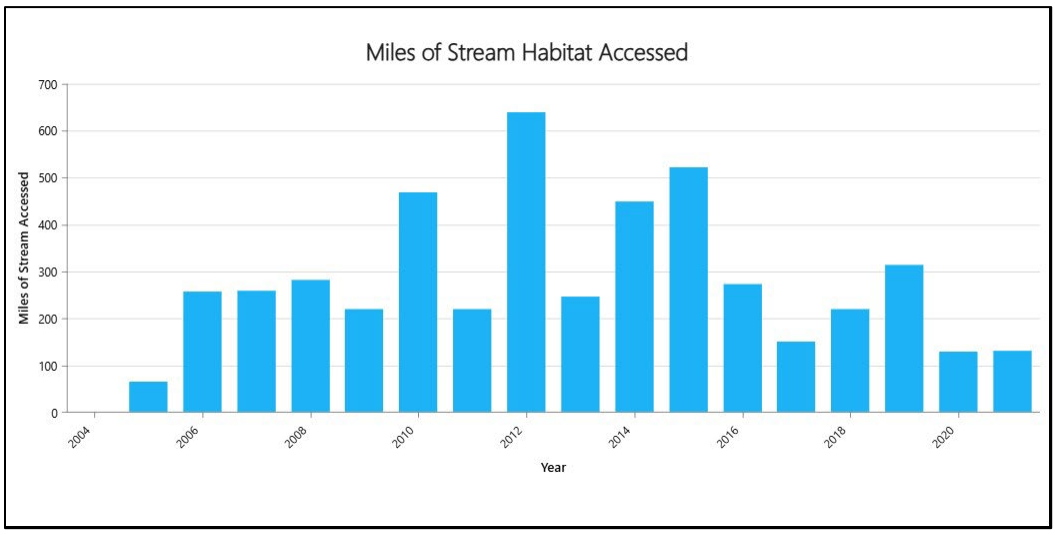

Figure 14. Miles of increased stream habitat access in the Columbia Basin through implementing the NPCC Fish and Wildlife Program, 2005 - 2021. Data reported on Program Tracker as SPI E1-3 and summarized as measure 10 on CBFish.

Two metrics are summed to produce the increase in stream access reported in Measure 10 (Table 6)

Table 6. CBFish metrics that contribute to Measure 10 and range in annual implementation values observed, 2005 – 2021

Metrics summed	Range of miles of increased stream habitat access (measure 10)
Miles of habitat accessed to the next upstream barrier(s) or likely limit of habitable range	2.5 – 639.43/ year
Miles of habitat accessed	0.75 – 2.8 / year

There are locations (latitude/longitude coordinates) associated with each of the locations where stream mile access has increased. Each of these locations has a worksite ID code that is generated each time a coordinate appears in a contract. Some projects use the same worksite ID to describe different kinds of actions all taking place in one location and other projects generate unique worksite IDs for the same location- even when the same kind of work is done in the same place in multiple years. This is problematic because if the worksite ID were unique to the coordinates, it would be possible to filter out where multiple actions are being implemented in the same locations and generate a spatial understanding of where barriers have been removed and stream access increased, relative to where the need for increased habitat exists.
As an example, a trap and haul project is correct in reporting the access in stream habitat provided for every year that fish are released upstream of the blockage. However, it would not be correct to sum those annual totals and report the total access provided within that subbasin, because that would result in repeat counting over time.

Water quantity

Water quantity may be improved by conserving water (e.g., lining irrigation ditches, improving irrigation practices, etc.), and through leasing or acquiring water rights. Water transactions under the Council's Program is managed by the National Fish and Wildlife Foundation through the Columbia Basin Water Transactions Program (CBWTP). Under the CBWTP, the types of water right transactions include:

- Permanent acquisition
- Lease/lease markets
- Source switch
- Irrigation efficiency
- Forbearance agreements

- Diversion reduction agreements
- Stored water releases

In this document we report on two SPIs related to water quantity as well as on data provided directly by NFWF for the CBWTP. The data provided by the CBWTP is a more updated source of information on water transactions than CBFish, from which we obtained the SPIs.

- Instream flow (cubic feet per second or CFS) protected or conserved (SPI E2-6)
- Instream flow (acre-feet) protected or conserved (SPI E2-1)
- CBWTP CFS protected
- CBWTP acre-feet protected

Water rights are described in two ways, the instantaneous rate of water to be diverted or to be protected instream (cubic feet per second), and the total volume of water available for beneficial use under the water right, termed the "duty" (acre-feet). Water rights can have different allowed rates and duties on different streams, therefore geographic comparisons do not always yield meaningful results. In addition, a small instream water right may provide significant benefit in a small stream, and much less benefit in a larger stream or river.

Investment in water transactions has resulted in significant improvements in instream flows, habitat and water quality across the basin. Figure 15 shows the subbasins that are included in the CBWTP and Figures 16 through 20 show the results of water transactions since the initiation of the program. Since the inception of the program there has been a steady increase in the amount of water acquired for instream purposes, particularly the amount of water permanently protected instream. This can be clearly seen in the cumulative graphs (Figures 18 - 20). Both the amount of water in cubic feet per second and the total volume of water have increased over time. Additional information on the CBWTP and the water right transactions can be found in the NFWF annual reports (CBWTP 2023).

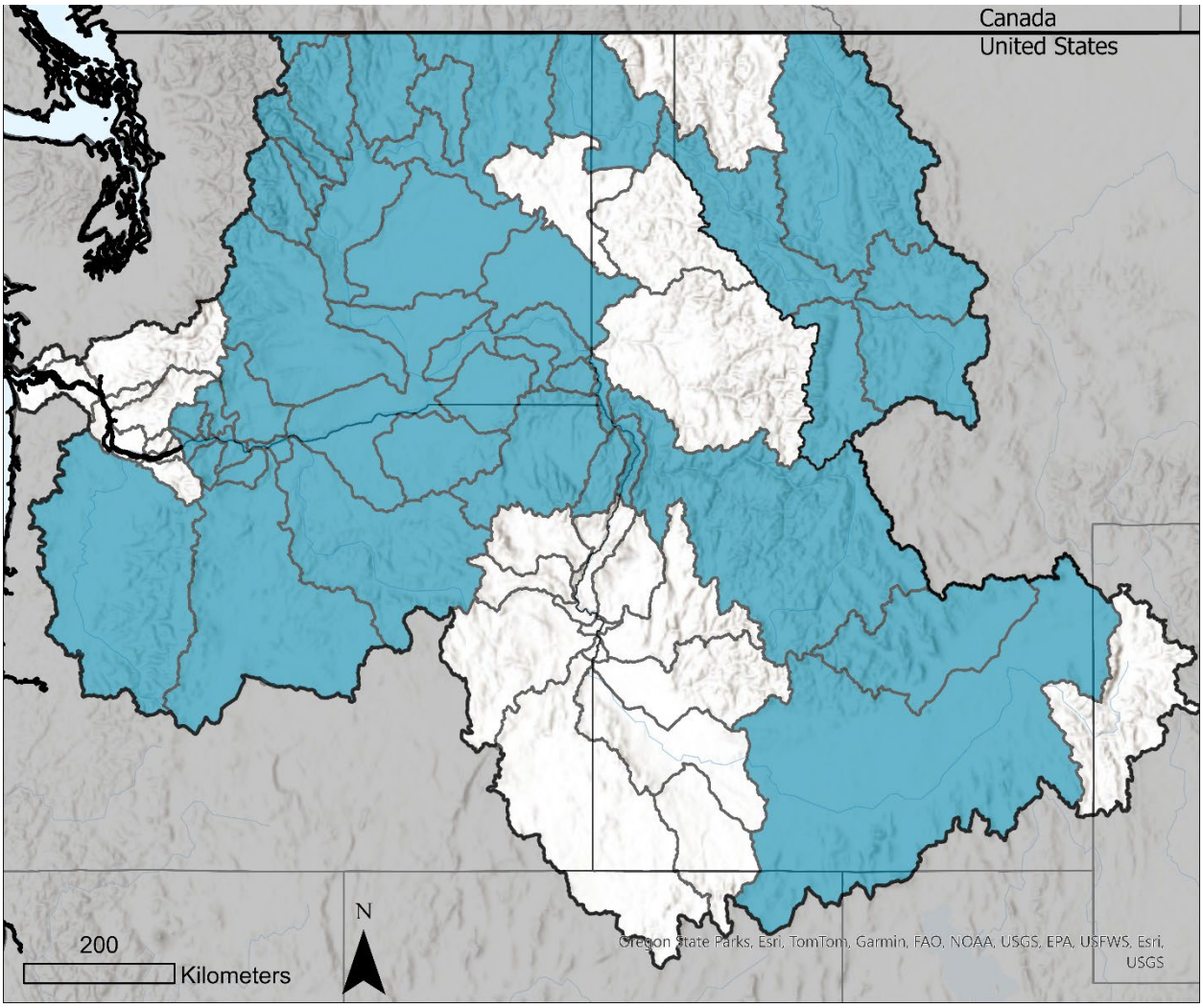

Figure 15. Subbasins (blue) that are part of the Columbia Basin Water Transactions Program

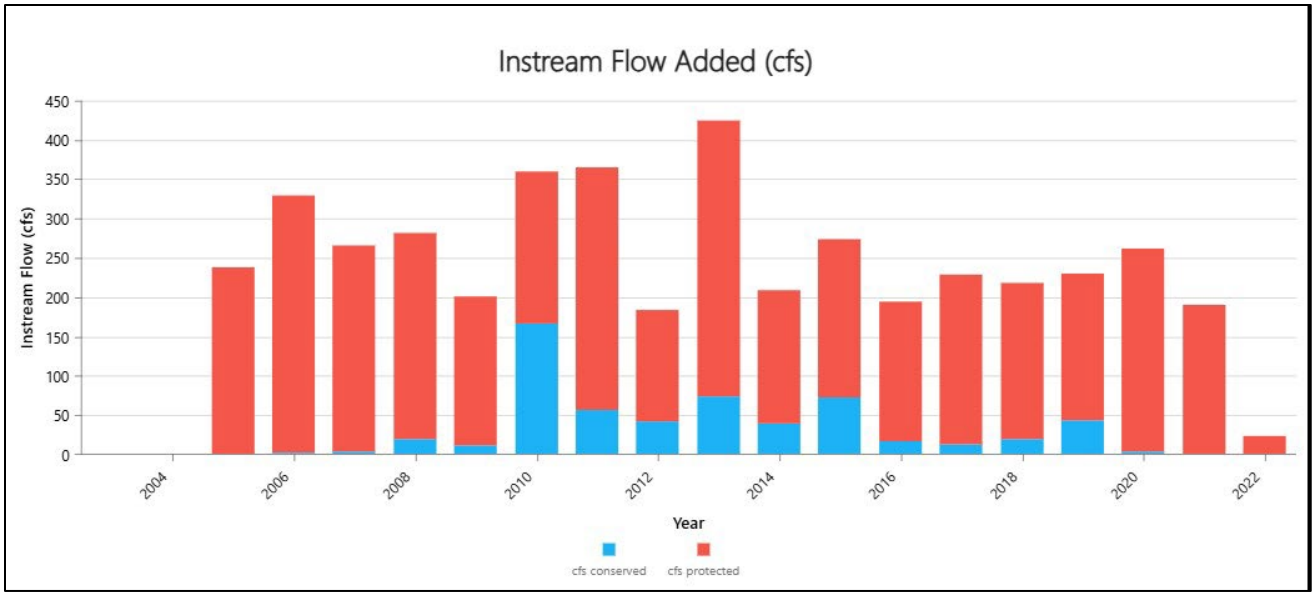

Figure 16. Instream flow (cfs) added through conservation or protection. Data reported on Program Tracker as SPI E2-6 and summarized from Measures 15 and 17 reported on CBFish

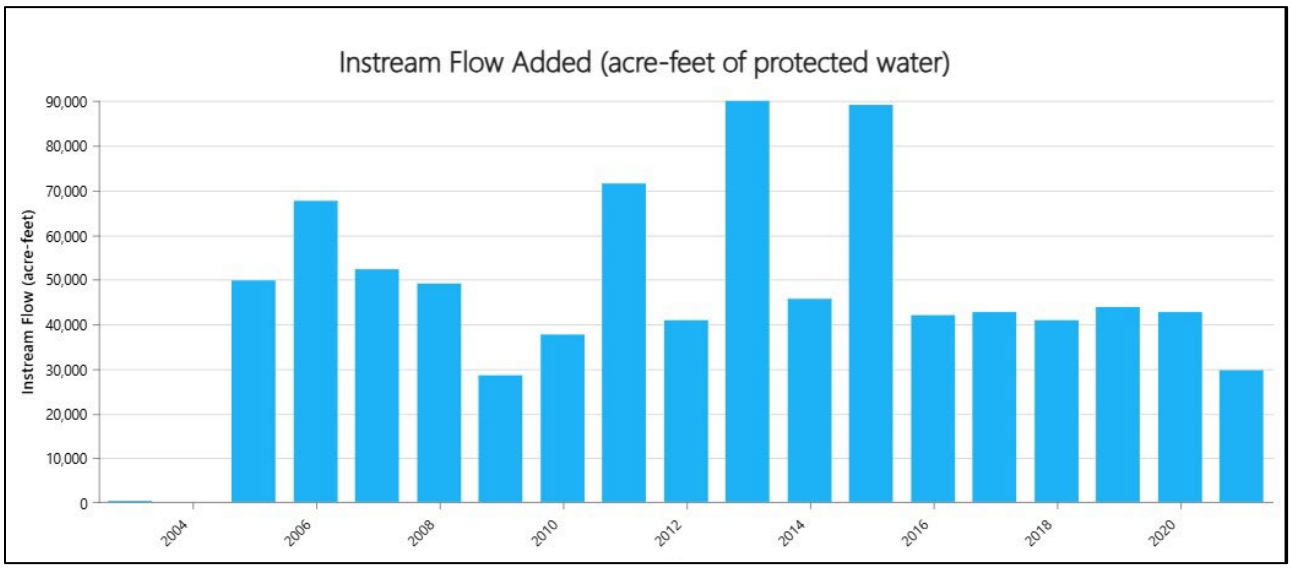

Figure 17. Instream flow (acre-feet) added through protection. Data reported on Program Tracker as SPI E2-1 and summarized from Measure 55 reported on CBFish

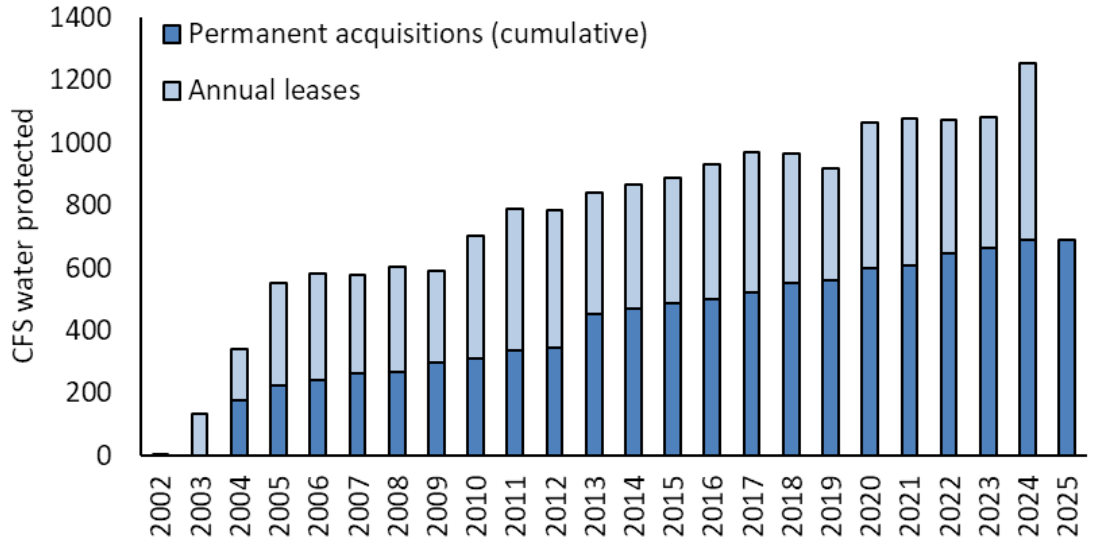

Figure 18. Instream flow (cfs) protected through permanent acquisitions (shown cumulatively) and through annual leases (shown for each year lease active) as part of the Columbia Basin Water Transactions Program. Note: 2025 data are preliminary and subject to change.

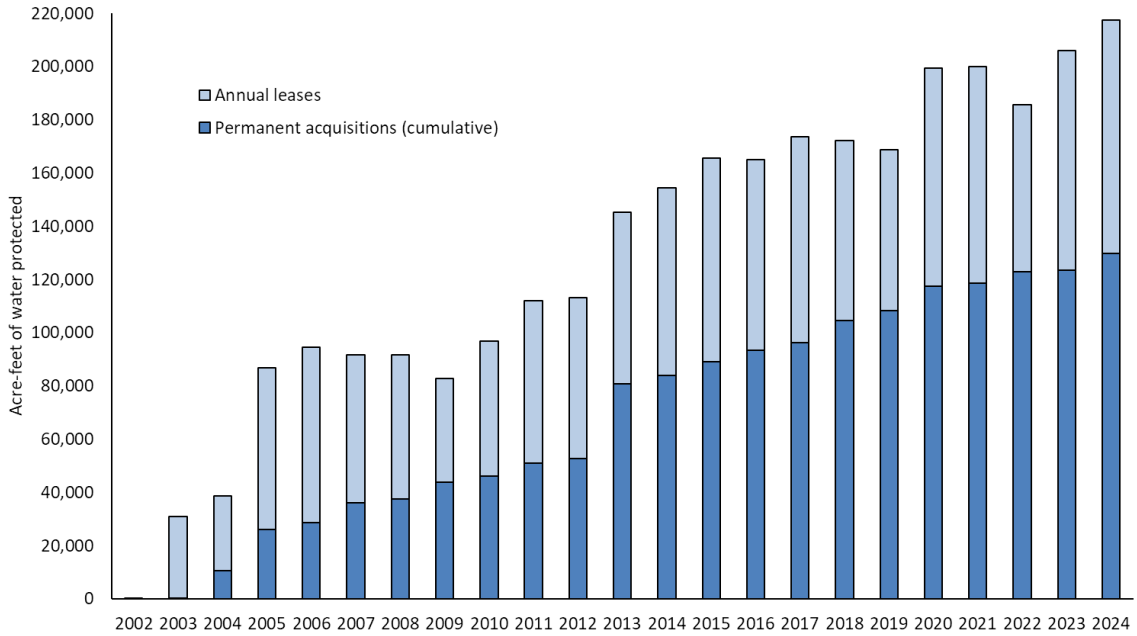

Figure 19. Instream flow (acre-feet) protected through permanent acquisitions (shown cumulatively) and through annual leases (shown for each year lease active) as part of the Columbia Basin Water Transactions Program

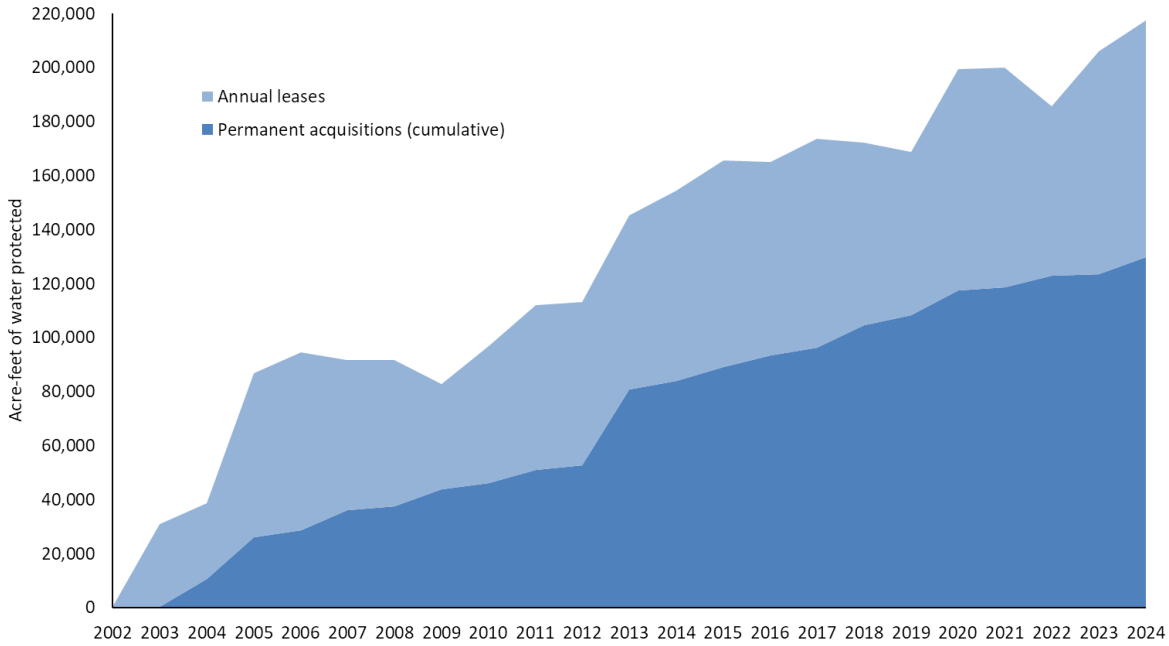

Figure 20. Instream flow (acre-feet) protected through permanent acquisitions (shown cumulatively) and through annual leases (shown for each year lease active) as part of the Columbia Basin Water Transactions Program

Water quality

Water quality measures call for maintaining water temperatures relative to species thresholds and standards, and reducing toxics including those released at dams or from other activities in the basin. This can be done through:

- Planting riparian vegetation in tributaries (water temperature and erosion control)
- Protecting or creating cold water refugia
- Implementing cold water releases from storage dams
- Addressing sources of toxics in mainstem and tributaries

We report on two SPIs related to water quality as well as on data from the Environmental Protection Agency (EPA) and the United States Forest Service (USFS):

- Toxic contaminants (EPA)
- Daily max water temperatures at fixed monitoring sites in the mainstem in reference to water quality standards. (SPI E2-2; E2-4)
- Tributary temperature data (USFS NorWeST stream temperature models- baseline, 2040, 2080)

Toxic contaminants

There are various sources of toxic contaminants in the Columbia Basin. Within the 2014 Program Water quality strategy, a general measure called for "the federal action agencies to partner with and support ongoing federal, state, tribal, and regional agencies' efforts to: monitor, assess and map high priority toxic contaminant hot spots in the Columbia River Basin and evaluate their relationship, if any, to the development and operation of the hydrosystem."

At the time of the 2014 Program, there existed an EPA-led workgroup, the Columbia Basin Toxics Reduction Workgroup. In 2016 and 2017, the Columbia River Toxics Mapping subgroup was assembled and tasked with mapping locations of toxic contaminants as part of the Council Program strategy. The focus was on polycyclic aromatic hydrocarbons (PAHs), which are a class of chemicals that occur in coal, crude oil, and gasoline, and are toxic when released to the environment. These maps show locations of PAHs in water and sediment samples produced through this workgroup (Figure 21).

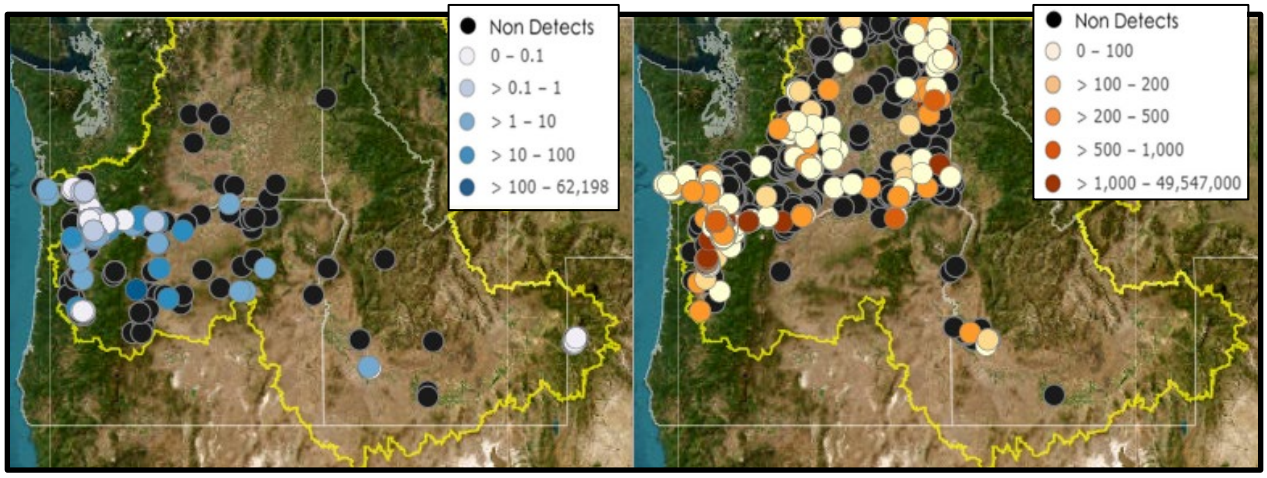

Figure 21. Sample sites and detection levels for polycyclic aromatic hydrocarbons (PAHs) in water samples (left; 514 sites, PAHs detected at 69% of sites) and sediment samples (right; 3,606 sites sampled, PAHs detected at 81% of sites) as reported on the Council's Toxics Toxics story map on Program Tracker

More information on these can be found in the Councils' Toxics story map on the Program Tracker. Measures in the Program also focus on oil and lubricant leaks occurring at Columbia and Snake River dams and call for switching to more natural lubricants that break down in nature. The Council Program has limited habitat projects focused on toxics as the EPA is the primary entity that manages and remediates toxics.

Temperature

Water temperature affects fish habitat in both the mainstem and the tributaries. Water temperature in any given location in a stream is driven by solar radiation and air temperature as well as the temperature of water from upstream sources. In the mainstem, impoundments behind dams increase the surface area of water bodies, thus increasing the effect of solar radiation and air temperature on stream temperature. The temperatures in the mainstem are an important component of the conditions fish experience as they navigate the hydrosystem. Here we report on mainstem temperature SPIs for major dams on the Columbia and Snake Rivers (Figure 22).

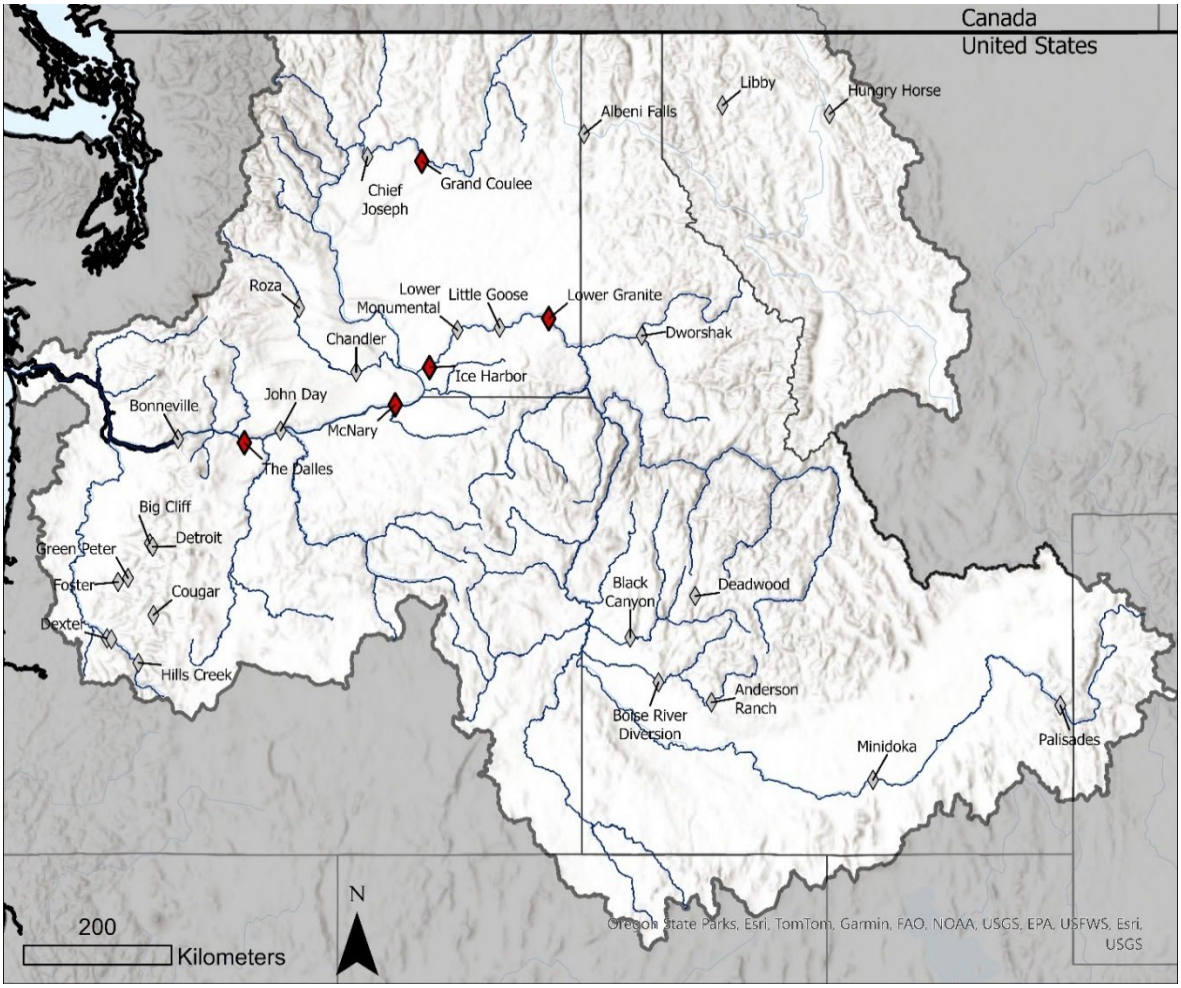

Figure 22. Federal Columbia River Power System Dams. Daily maximum temperature data were summarized at the tailraces for dams highlighted in red

For these SPIs, we compare daily maximum temperature data to water quality temperature standards (Table 7). Water quality temperature standards have been developed which establish

the designated use of a water body- including for fish- and a level above which impairment occurs (CWA 1972).

Table 7. Temperature standards (daily maximum; °C) and source of standard at a selection of mainstem hydropower dams in the Columbia Basin

Dam	Standard(s)	Source(s)
Grand Coulee Dam	17.5 °C; 16°C; 18 °C	State of Washington; Colville Tribe [class I; class II]
McNary Dam	20 °C	State of Washington
The Dalles Dam	20 °C	State of Washington
Lower Granite Dam	20 °C	State of Washington
Ice Harbor Dam	20 °C	State of Washington

In a recent document, the EPA developed tables documenting the average number of days/month where the maximum daily temperature exceeded the water quality standard from 2011-2016 for each of the dams shown in Figure 22. We compare those data to contemporary data from 2017 - 2022. Additionally, we plotted daily maximum temperature for each year from 2017 to 2022 at a selection of dams, relative to the water quality standard at those dams.
At Grand Coulee Dam, there is a trend toward more days exceeding temp standards in 2017-2022 relative to 2011-2016, with significant increases later in the summer (Figure 23).

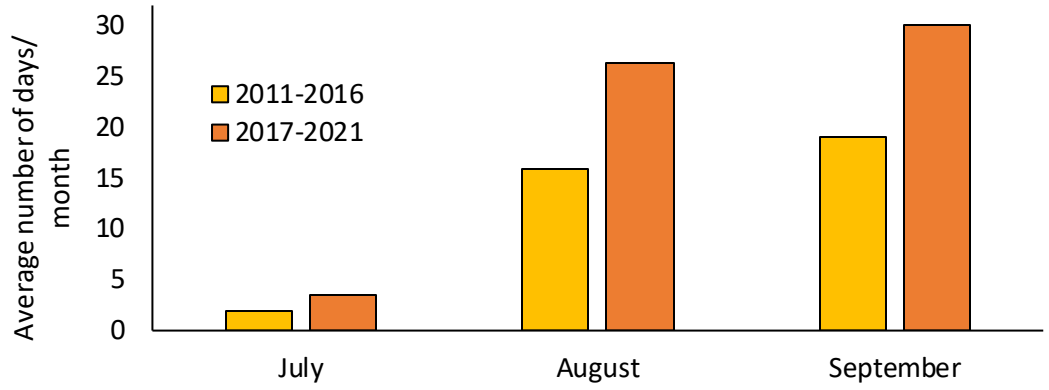

Figure 23. Comparison of the average number of days in July, August, and September when the maximum daily temperature at Grand Coulee Dam exceeded the water quality standard of 18 °C between 2011-2016 (EPA 2021) and 2017-2022

When looking at the individual years in Figure 24, the effect of the "heat dome" in 2021 can be clearly seen. Warming began earlier that year, and the maximum temperatures were higher than other years; however, the effect of the heat dome decreased over the season and was undetectable by the end of August.

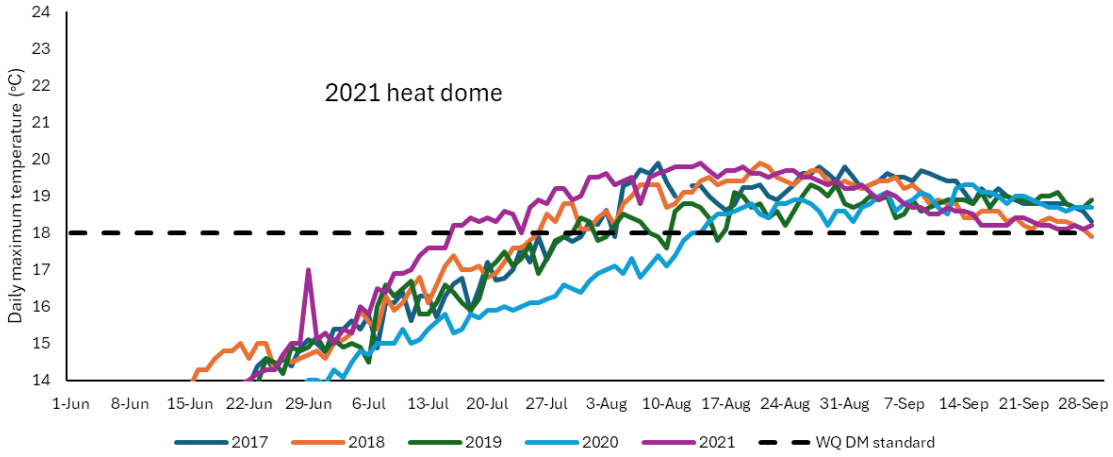

Figure 24. Daily maximum temperatures (°C) recorded at the tailrace of Grand Coulee Dam, Jun – Sep, 2017-2021, relative to the water quality standard for daily maximum (DM) temperature (18 °C).

At McNary Dam, most of the temperature exceedances occur in August. This pattern is increasing over time (Figure 25).

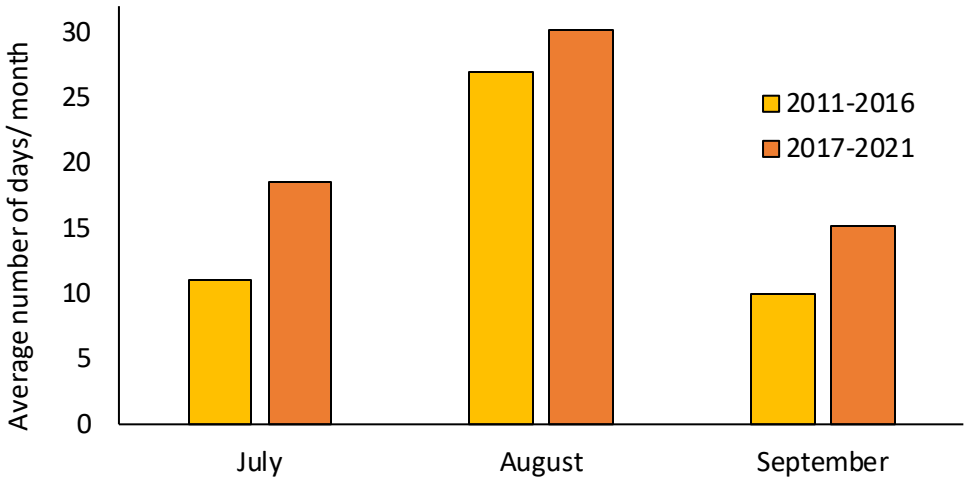

Figure 25. Comparison of the average number of days in July, August, and September when the maximum daily temperature at McNary Dam exceeded the water quality standard of 20 °C between 2011-2016 (EPA 2021) and 2017-2022

Daily maximum temperatures are typically above the standard from mid-July through mid-September, although the 2021 heat dome caused this to begin in June (Figure 26).

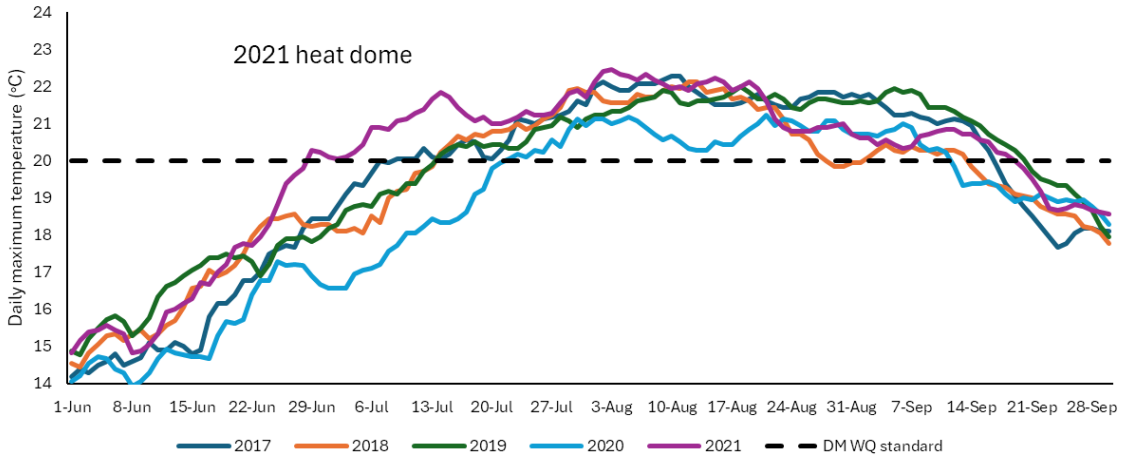

Figure 26. Daily maximum temperatures (°C) recorded at the tailrace of McNary Dam, Jun – Sep, 2017-2021, relative to the water quality standard for daily maximum (DM) temperature (20 °C).

Temperature patterns at The Dalles are similar to McNary but warmer- both in terms of number of days exceeding standards (Figure 27) and the degree to which standards are exceeded (Figure 28).

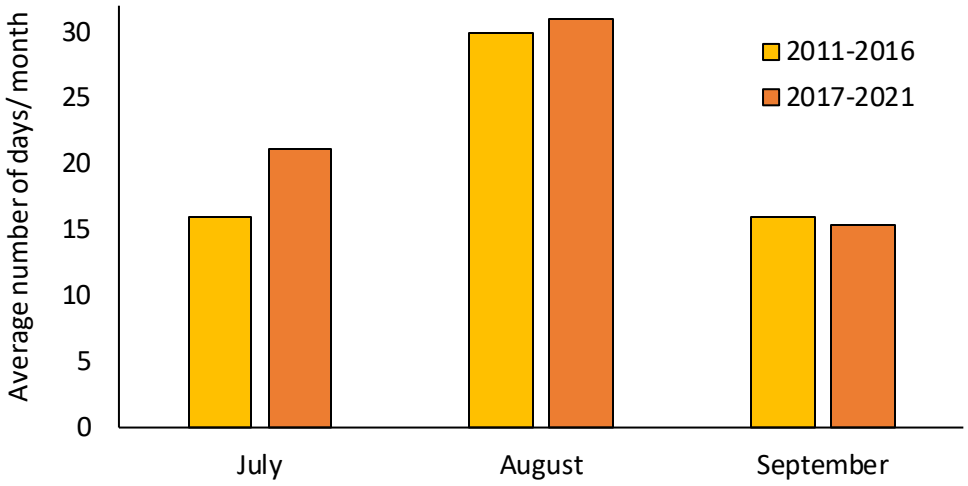

Figure 27. Comparison of the average number of days in July, August, and September when the maximum daily temperature at The Dalles Dam exceeded the water quality standard of 20 °C between 2011-2016 (EPA 2021) and 2017-2022

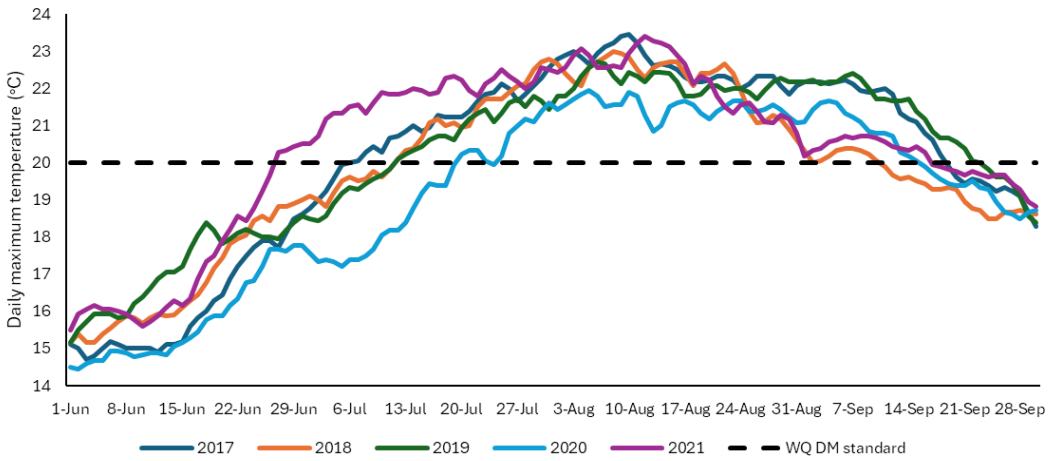

Figure 28. Daily maximum temperatures (°C) recorded at the tailrace of The Dalles Dam, Jun – Sep, 2017-2021, relative to the water quality standard for daily maximum (DM) temperature (20 °C).

Temperature effects are somewhat different at the Snake River Dams than the Columbia River dams. At Lower Granite Dam, we tend to see fewer summer days when temperatures exceed water quality standards (Figure 29). Lower Granite Dam temperatures are affected by cold-water flow releases from Dworshak Dam, designed to benefit migrating salmon.

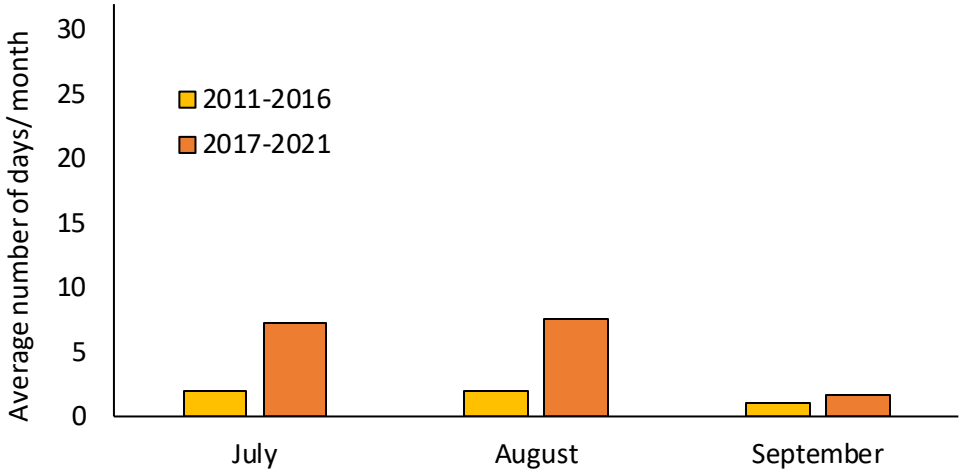

Figure 29. Comparison of the average number of days in July, August, and September when the maximum daily temperature at Lower Granite Dam exceeded the water quality standard of 20 °C between 2011-2016 (EPA 2021) and 2017-2022

Although temperatures are typically below the standard, we can still see the effect of warm events. Figure 30 shows the 2021 heat dome, which rapidly warmed temperatures earlier than normal. By later in the summer, the effect of that warming event was not detectable.

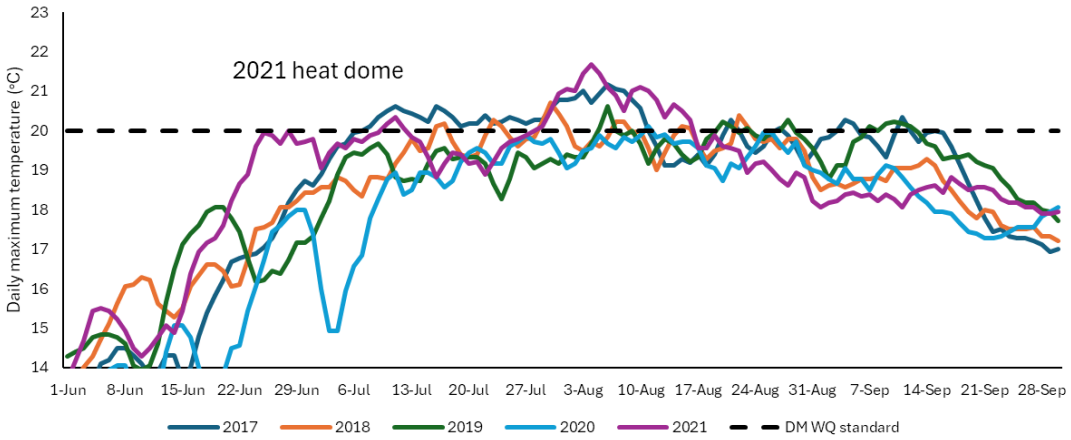

Figure 30. Daily maximum temperatures (°C) recorded at the tailrace of Lower Granite Dam, Jun – Sep, 2017-2021, relative to the water quality standard for daily maximum (DM) temperature (20 °C).

At Ice Harbor Dam, we see much warmer temperatures than Lower Granite Dam and a trend toward more days above the standard over time (Figure 31).

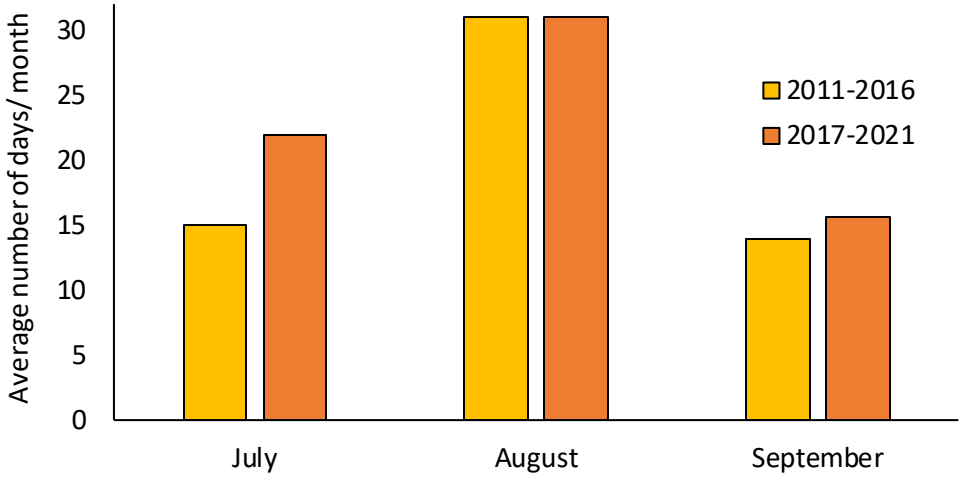

Figure 31. Comparison of the average number of days in July, August, and September when the maximum daily temperature at Ice Harbor Dam exceeded the water quality standard of 20 °C between 2011-2016 (EPA 2021) and 2017-2022

All of August is above the maximum temperature standard by several degrees (Figure 32). The effect of the heat dome is particularly significant at this location.

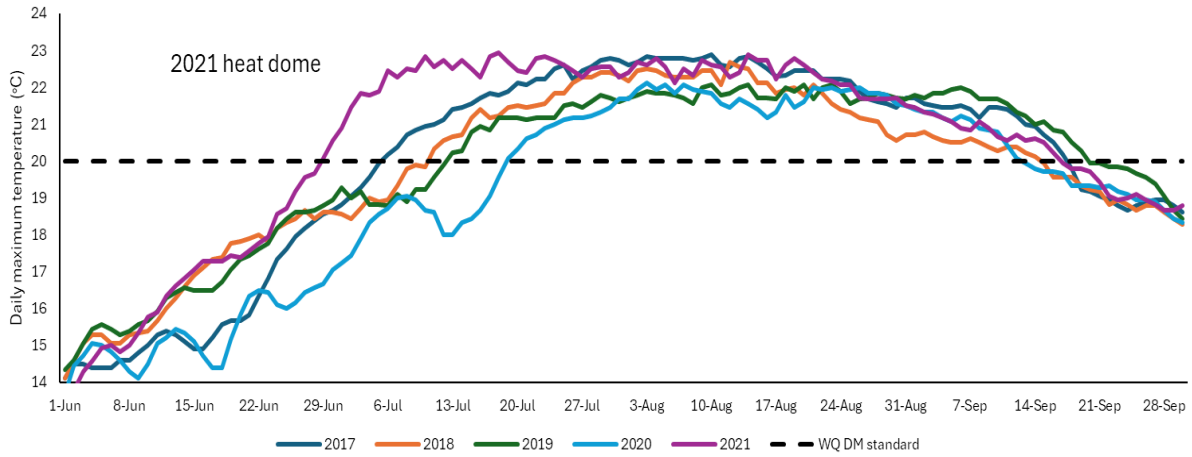

Figure 32. Daily maximum temperatures (°C) recorded at the tailrace of Ice Harbor Dam, Jun – Sep, 2017-2021, relative to the water quality standard for daily maximum (DM) temperature (20 °C).

We can also examine the temperature conditions that fish and wildlife are experiencing in tributaries. We do not have a tributary temperature SPI because the Columbia basin is quite large with varying geography, elevation, precipitation, and other factors that cause changes in temperatures over large and small spatial scales. To better understand stream temperatures in the tributaries we rely on patterns provided by modeled data.

The U.S. Forest Service Rocky Mountain Research Station developed a comprehensive model of stream temperatures called NorWeST (Isaak et al. 2017). The NorWeST stream temperature map was created using a large dataset of recorded August stream temperatures from dataloggers placed by biologists throughout the basin for their individual projects. The data were modeled to predict temperatures in stream reaches where loggers were not present. Then the data were fit to climate models to estimate mean August temperatures in 2040 and in 2080, relative to a contemporary baseline (Figure 33).

The baseline conditions show colder temperatures in higher elevation areas of the Cascades and Rockies, particularly in Northern Washington, Idaho, and Montana (Figure 33). By 2040, temperature models predict growing warm areas in valley bottoms, along the Snake River above Hells Canyon and where it approaches the Columbia, and in the Columbia Plateau region. Further warming is anticipated to occur by 2080, reducing the overall availability of cold-water habitats, fragmenting current habitats, and affecting flows. This information could be useful when planning or prioritizing restoration projects or to identify where monitoring and research should occur.

For information on a specific geographic area or stream, users can zoom in on the modeled temperature maps on the NorWeST website. The information describes the current conditions, as well as providing expectations for temperature patterns in the future.

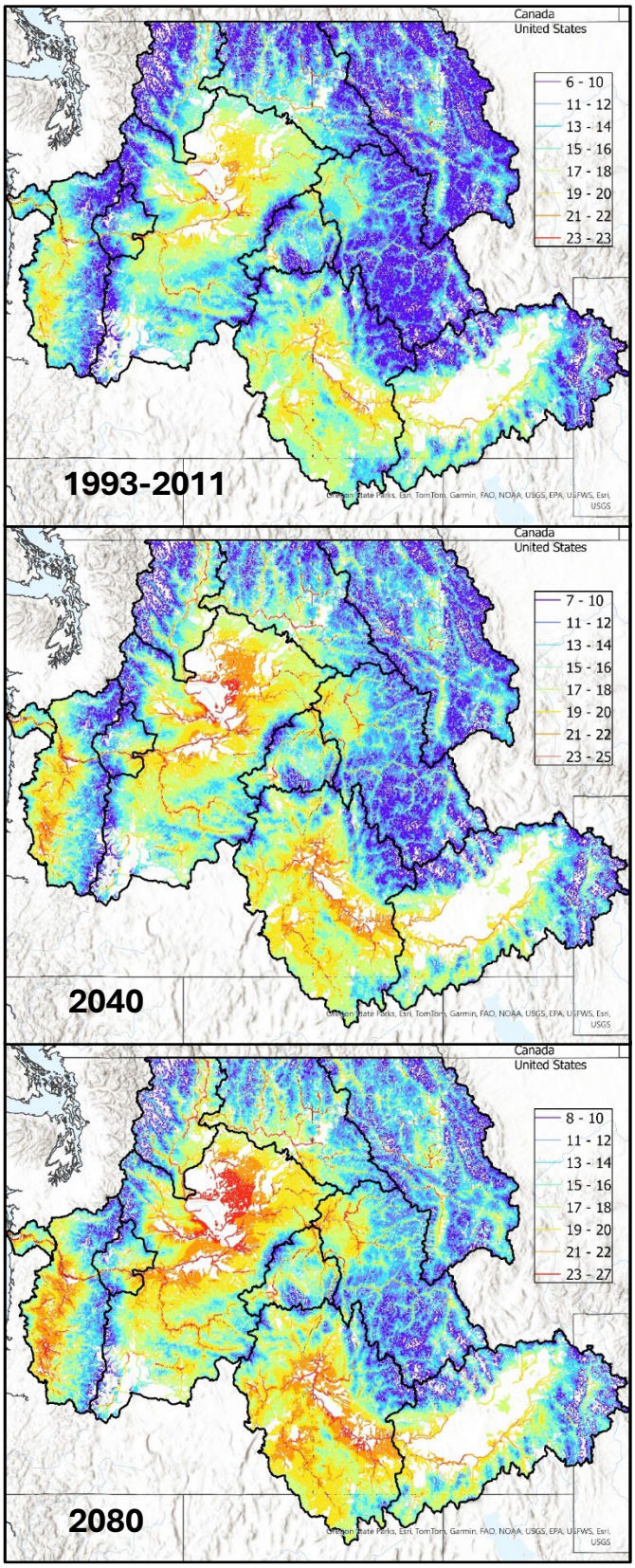

Figure 33. Mean August stream temperature models created by the USFS RMRS NorWeST Stream Temperature map for 1993-2011 (baseline conditions), 2040, and 2080. Bluer colors are cooler temperatures, and redder colors are hotter temperatures – exceeding conditions that are suitable for salmonids

Climate change effects

Beginning in the early 2000's and continuing through the present, the Council Programs have identified climate change as a significant concern and called for actions to better understand and address the effects of climate change on fish and wildlife. The 2020 Addendum identified climate change as a near-term priority for the Council, specifically to "Consider the implications of climate change in all aspects of the program –program planning, project development, and project and program implementation and assessments". Some of the potential impacts from climate change include:

- Transition from snow to rain hydrographs
- Change in timing and volume of precipitation and runoff
- Increased water temperatures
- Higher peak flows and lower summer flows
- Increased frequency, duration and severity of weather events like heat domes
- Increased intensity of wildfire and more extreme fire behavior
- Changes in species composition in response to climatic changes

Examples of changes in natural conditions under climate change can be seen in Figures 34 and 35. Figure 34 shows the shift from snow dominant to rain dominant watersheds across the Columbia Basin. In the West, mountains act as natural reservoirs by collecting snow in the winter and releasing it in the spring as temperatures increase. As the basin shifts toward more rain dominant behavior in response to warming temperatures, both flood and low flow conditions will change in response.

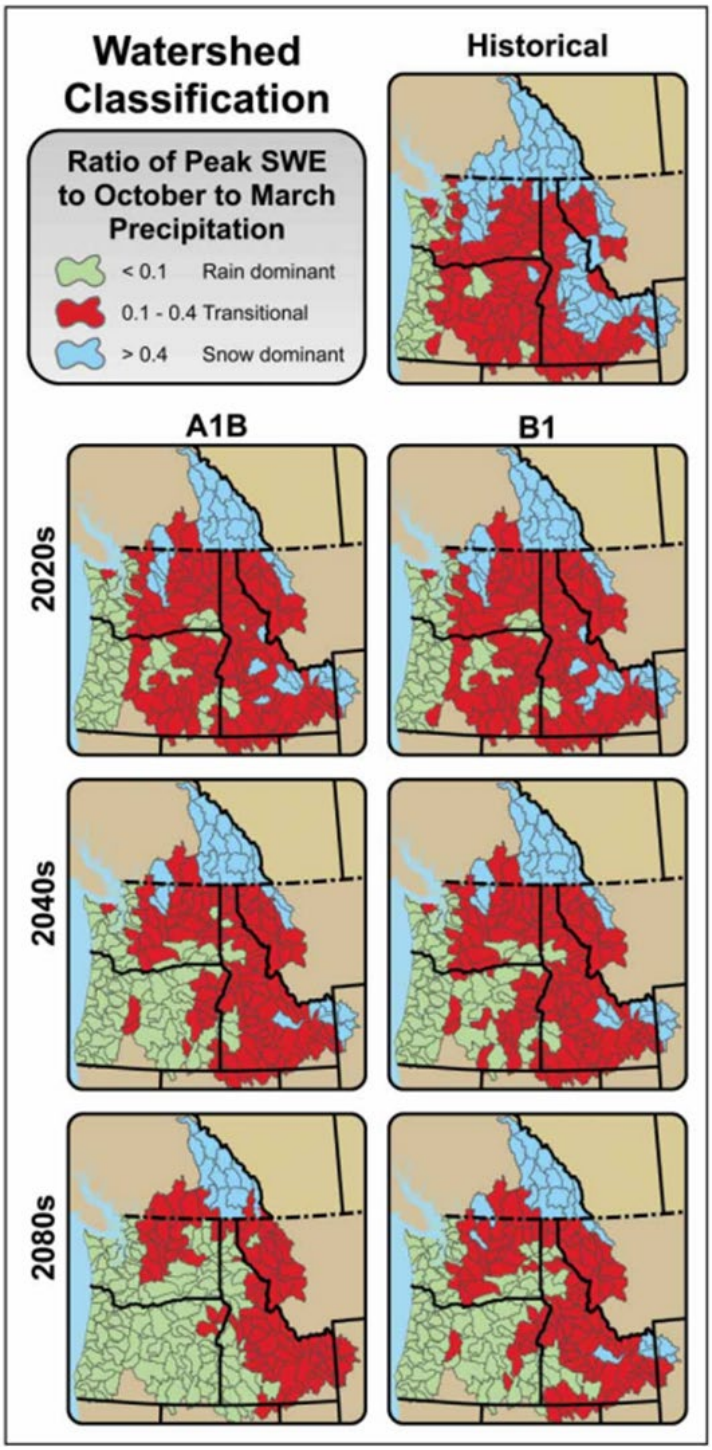

Figure 34. Ratio of Peak Snow Water Equivalent (SWE) to total March-October precipitation for the historical period (1916-2006) and at three future time periods, under two different climate emissions scenarios (Figure from Hamlet et al. 2013). SWE is a measure of the water content of the snowpack, which is influenced by temperature and type of storms.

Figure 35 shows projected streamflow hydrographs under different climate change scenarios compared to historical non-regulated flows. It can be seen in these graphs that peak flows will be higher and occur earlier in the season while summer flows will occur earlier and drop lower than under historical conditions (Hegewisch et al. Future Streamflows web tool; accessed on 3 Jan 2025).

Figure 35. Projected non-regulated stream flows (2040-2069) under lower emissions (light blue, RCP 4.5) and higher emissions (orange, RCP 8.5) climate scenarios, compared to the historical non-regulated baseline streamflow (purple) on the Columbia River at The Dalles Dam (upper figure) and the Snake River at Little Goose Dam (lower figure). Data and figures accessed from https://climatetoolbox.org/tool/Future-Streamflows

Adaptation of project work for climate change

In response to potential climate change impacts on habitat, the sponsors of habitat restoration projects have begun to incorporate climate adaptation and climate resilience in project implementation. This includes more comprehensive analysis of climate impacts, as well as

changing restoration priorities and approaches to consider climate change. Specific types of analyses include:

- Identifying broad-scale analyses and adapting them to local areas and conditions
- Utilizing existing tools such as the Climate toolbox, NorWeST, etc. to understand climate effects
- Developing local-scale models of climate, hydrology and ecosystem response
- Developing Climate Adaptation Plans

Examples of restoration approaches include:

- Prioritizing resilient habitats
- Designing for higher flood stages
- Revising planting regimes for future climate
- Identifying and connecting cold-water sources
- Ensuring connectivity under altered hydrologic conditions

Figure 36 shows an example of cold-water refuge locations in the lower mainstem Columbia River. Fish and Wildlife managers have identified additional cold-water refuges in other sections of the mainstem rivers, as well as in small streams and rivers throughout the Basin. Tools such as NorWeST are particularly helpful in identifying these cold-water refuges.

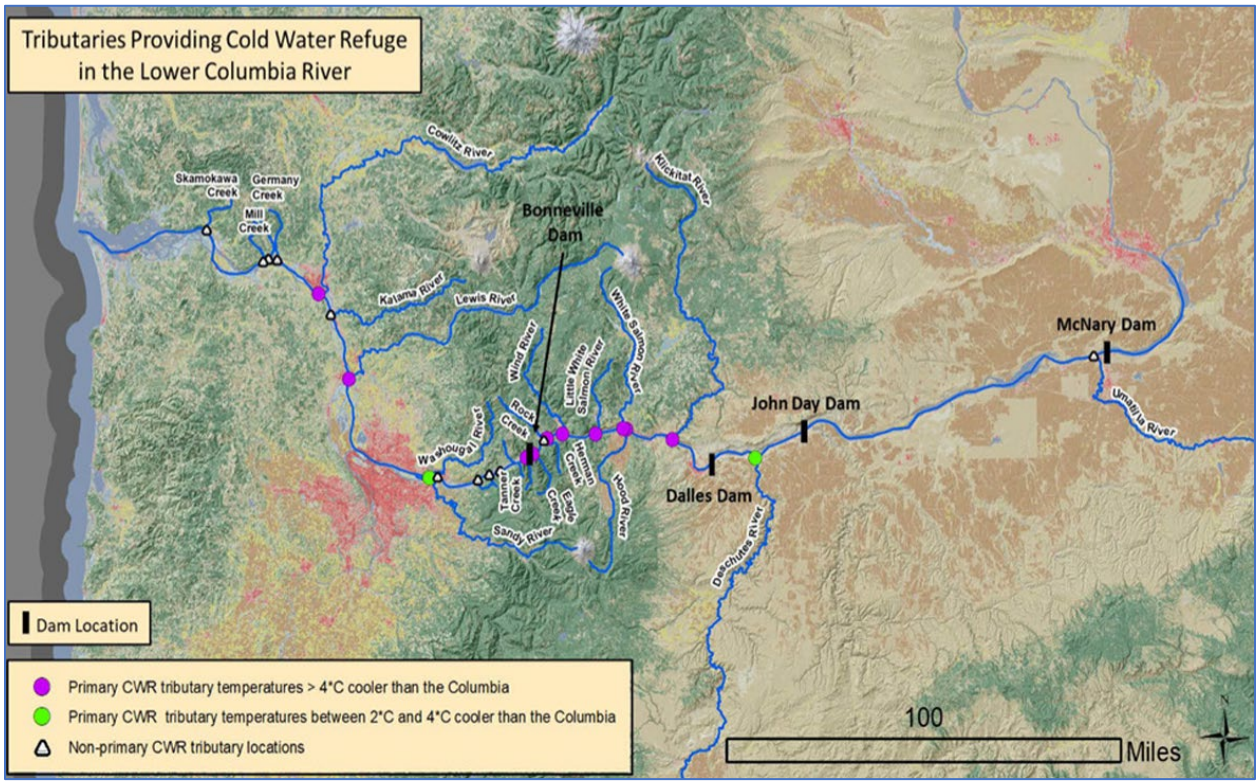

Figure 36. Tributaries providing cold water refuge in the Lower Columbia River. Available at https://www.epa.gov/columbiariver/columbia-river-cold-water-refuges-plan

Discussion

The objective of this assessment is to describe the status of habitat restoration under the Council's Fish and Wildlife Program, and to identify key topics for the Council and region to consider as we approach the next Program amendment cycle.

General Observations

The data summaries show general increases in habitat restoration actions since the beginning of data management through CBFish. However, the trends are not consistent, and in some cases the amount of restoration activity has decreased in the past few years. There are many factors to consider when evaluating the status and trends in habitat restoration.

Over time, there has been a shift to more comprehensive, landscape-scale restoration projects. Many project sponsors have recognized the need to focus on specific watersheds or river reaches and are designing projects to recreate complex riverine systems with well-connected floodplains. This requires more time spent on planning, coordination and environmental compliance, as well as sustained, multi-year funding. In some cases, individual sponsors are implementing small projects that, in coordination and connection to other projects, create a larger restoration footprint. These planning, coordination and funding horizons can influence the amount of restoration action implemented on a year-to-year basis. While there is an increasing focus on projects with a larger landscape footprint, most projects depend on the availability of willing landowners, and support of the surrounding community. This may limit the ability to implement projects or require longer timeframes in which to cultivate landowner partnerships and address potential risks. At the same time, changing conditions including land development, water use, and climate change may lead to additional habitat loss.

Key questions:

- If restoration actions are not keeping pace with additional habitat loss, what changes in Program priorities are needed?
- Do habitat goals and objectives need to change?
- Do we need to further prioritize the type or location of habitat restoration work?
- What new or additional strategies can be employed to increase habitat restoration or limit habitat degradation?
- How do we deal with the need for multi-year funding?
- Is there a need for better coordination/collaboration so that larger scale projects or projects of a given type can be implemented throughout the basin?

- What do the mainstem and tributary temperature data tell us about habitat conditions, and how do we use those data?

Data Challenges

Descriptions of implementation draw on information from CBFish. Staff encountered numerous issues with both data availability and data quality. Some of these issues were due to the design of CBFish as a contract management tool, some were due to QA/QC issues, and some were due to missing or inaccurate data reporting (e.g., accurate data on work site locations). Specific examples of challenges include:

- Many-to-many structure of database- makes it extremely difficult to query data
- Many issues with double counting
- No way to determine the footprint of project- prevents additional analyses on things like connectivity, risk, effectiveness, etc.
- Use of office location or the center point of the organization's purview instead of work site
- Work sites as a point instead of a polygon- limits spatial analysis of work
- Incorrect location data – affects summaries by subbasin and province

Key questions:

- CBFish is a very large database that was designed and functions as a contract management tool. Is it feasible to adjust that database to accommodate other purposes?
- Could we develop a database specifically designed to track implementation and spatial attributes of restoration efforts? This could be designed to focus on a small subset of actions that could be reported annually for each on-the-ground project, and that could link to the recommended monitoring data in the Tributary Habitat RM&E strategy.

Detecting change

We currently lack comprehensive tools and information for detecting habitat change across the Columbia Basin. Detecting change in either habitat or biological response depends on the spatial and temporal scale of the restoration actions. If we are looking for effects at larger spatial scales, we need to consider the work done under multiple projects, both within and outside of the Program. For effects at smaller spatial scales, we may be able to evaluate single projects or a small number of connected projects to determine change. In all cases, consistent, comprehensive and cost-effective data are needed to evaluate habitat change over time.

Key questions:

- Can we use existing databases to evaluate habitat change in subbasins or across the Basin?
- Are we collecting the appropriate data to evaluate habitat change?
- What additional monitoring data is needed?
- How do we use the guidance from the Columbia Basin Tributary Habitat RM&E strategy to inform assessment of habitat change or improvement?

Targets

In general, we report on changing habitat conditions or monitoring results to inform progress towards some kind of objective or target. The Program does not contain basin-scale targets for restoration due to the size and complexity of the Columbia Basin. The Program also does not have specific targets for the amount or type of restoration work that is required to achieve outcomes at local, watershed or biological scales. These targets are generally provided in planning documents such as subbasin plans, watershed plans, recovery plans, etc., which results in different approaches across the basin. The Program also does not specifically define the scope of problem that needs to be addressed through offsite mitigation. It provides principles, but not targets, except resident fish in Montana where specific habitat targets have been developed. Although mitigation does not have a habitat target, it does have a biological purpose of increasing survival and production.

Key questions:

- What does offsite mitigation mean in the context of habitat restoration? Do we need to better define it, or provide specific targets?
- Where habitat is severely degraded, any amount of appropriate restoration is an improvement. How do we identify these needs without over-spending resources on defining targets? Can we use simple targets like “no-net-loss” or interim targets to begin improving habitat in these areas?
- How do we better incorporate planning and prioritization into the process of determining where to invest resources given the variability in setting targets?
- Is the amount of restoration sufficient to make gains under current conditions? Given potential future landscape changes, if we were to continue on the current trajectory of restoration, would we make gains? Do we need to increase the amount of restoration over time due to changing conditions?

Climate Change

Climate change is already affecting conditions on the landscape and these effects will continue or accelerate in the future. Adapting habitat restoration for future climates will be critical. Many

complex restoration projects can require decades to realize landscape changes that result in the intended ecosystem benefits. During the intervening decades, climate change may cause impacts that affect the outcome of a long-term project.

Key questions:

- Do the principles in the Council Program (e.g., build from strength, focus on ecosystems, not individual species and populations, etc.) hold under projected climate change impacts? Do we need to adjust Program and strategy principles?
- Will contemporary projects be beneficial under different climate regimes?
- How do we incorporate climate change into planning and prioritization? This could include changing restoration locations, focusing on connectivity, identifying and expanding cold-water refuges, etc.
- How do we implement projects today in consideration of that future environment? Are there particular techniques that should be explored?
- Can we incorporate changing precipitation or temperature patterns or species distributions in our planning?

References

Clean Water Act (CWA). 1972. The Federal Water Pollution Control Act of 1972. 33 U.S.C. §1251 et seq. (1972).

Columbia Basin Water Transactions Program (CBWTP) website: https://www.nfwf.org/programs/columbia-basin-water-transactions-program?activeTab=tab-3

CBWTP. 2023. Columbia Basin Water Transactions Program 2023 Annual Report. Available online at: https://www.nfwf.org/sites/default/files/2024-10/cbwtp-2023-annual-report.pdf

Hamlet, A. F., M. M. Elsner, G. S. Mauger, S. Lee, I. Tohver, and R. A. Norheim. 2013. An Overview of the Columbia Basin Climate Change Scenarios Project: Approach, Methods, and Summary of Key Results, Atmosphere-Ocean, 51:4, 392-415, DOI: 10.1080/07055900.2013.819555

Hegewisch, K.C., J. T. Abatzoglou, and O. Chegwidden. 'Future Streamflows' web tool. Climate Toolbox (https://climatetoolbox.org/) accessed on 3 Jan 2025.

Isaak, D., S. Wenger, E. Peterson, J. Ver Hoef, D. Nagel, C. Luce, S. Hostetler, J. Dunham, B. Roper, S. Wollrab, G. Chandler, D. Horan, S. Parkes-Payne. 2017. The NorWeST summer stream temperature model and scenarios for the western U.S.: A crowd-sourced database and new geospatial tools foster a user community and predict broad climate warming of rivers and streams. Water Resources Research, 53: 9181-9205.

Lower Columbia Estuary Partnership (LCEP) restoration inventory website: https://www.estuarypartnership.org/our-work/habitat-restoration/lower-columbia-regional-habitat-restoration-inventory

Northwest Power and Conservation Council (NPCC). 2014. Columbia River Basin Fish and Wildlife Program. October 2014. Document 2014-12. Portland, Oregon.

NPCC. 2020. Addendum to the 2014 Columbia River Basin Fish and Wildlife Program. October 2020. Document 2020-9. Portland, Oregon.

NPCC Subbasin Plans available online: https://www.nwcouncil.org/subbasin-plans/

Northwest Power Planning Council (NPPC). 1982. Columbia River Basin Fish and Wildlife Program. November 1982. Portland, Oregon.

NPPC. 1987. Columbia River Basin Fish and Wildlife Program: A debt to the past… an investment in the future. February 1987. Portland, Oregon.

Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act), Pub. L. No. 96-501, Sect. 4(h) (codified in part at 16 U.S.C. §839b).

Pacific Northwest Salmon Habitat Restoration Project Tracking Database (PNSHP). Data available online at: https://www.webapps.nwfsc.noaa.gov/apex/f?p=409:13:::::P13_CATEGORY:

Roni, P., J. Kvistad, S. Burgess, and K. Ross. 2023. Action effectiveness monitoring. 2022 Annual and Final Report. Project Number 2016-001-00. Available online at: https://nwcouncil.app.box.com/s/2yh61cbnoq0psv1vmpgburxe98tl9het

U.S. Environmental Protection Agency (EPA). 2021. Columbia and lower Snake Rivers Temperature total maximum daily load. Available online at: https://www.epa.gov/system/files/documents/2022-06/tmdl-columbia-snake-temperature-errata-update-05102022.pdf

U.S. Forest Service (USFS) Rocky Mountain Research Station (RMRS) NorWeST Stream Temperature website: https://www.fs.usda.gov/rm/boise/AWAE/projects/NorWeST.html

Appendix A. Specific Measures from Programs

1980s

- **Regional policies, guidance, planning**
    - Action Plan- beginning in 1984
    - 1st Subbasin Plans- not adopted in Program
    - Benefit resident and anadromous fish
    - Some general principles

- **General restoration**
    - Habitat and tributary passage projects described in action item 4.2. Upon approval of system plans, Bonneville shall fund habitat and passage restoration or improvement measures in those plans, including those measures identified in the plans that are listed in Appendix A Table: Planning Inventory of Enhancement Projects (general list of enhancement actions in various subbasins)
    - Habitat improvement and passage restoration or improvement measures in the Columbia River Basin, as specified in Table 2 (general list of enhancement measures in various subbasins)
- **Specific restoration**
    - Habitat improvement measures in the Columbia River Basin; specific subbasins: John Day, Salmon/Clearwater, a few misc. general enhancement measures, not specific projects
    - Placement of spawning-sized gravel downstream from Big Fork Dam
    - Design, construct, operate, and maintain spawning channel along the Flathead River to supplement propagation of natural fish in the river as mitigation for habitat loss in the South Fork and Flathead rivers caused by drawdown of and discharges from Hungry Horse Reservoir
    - Design, construct, operate, and maintain mitigation projects in the Flathead River and Flathead Lake system to supplement natural propagation of fish in the river
- **Fish passage**
    - Yakima - implement needed fish passage improvements at irrigation diversion dams, canals, and ditches in the basin
- **Water quantity**
    - Use water efficiently in Yakima Basin
- **Water quality**
    - Evaluate temperature regimes in Clearwater

1990s

- **Regional policies, guidance, planning**
    - Immediately begin implementing the procedures outlined in the Anadromous Fish Habitat Policy and Implementation Guide and seek means to accelerate the Anadromous Fish Habitat Plan. By September 1, 1992, all land management activities should be designed to at least maintain the quantity and quality of existing salmon and steelhead habitat.
        - Report annually to the Council by March 15 on the effectiveness of federal land management actions to protect and improve anadromous and

resident fish populations and habitat on federal lands in the Columbia River Basin.

- As a condition for ratepayer funding of habitat protection or improvement projects on federal lands, demonstrate that federal land management activities are consistent with and, therefore, will not undermine the benefits of any project implemented through this program.
- Immediately initiate development, updating and implementation of livestock management plans and provide adequate staffing and funding to monitor and supervise all livestock permits in salmon and steelhead production areas. By December 31, 1992, revise all livestock management plans, as necessary, and address enhancement of riparian areas and compliance with state water quality standards and best management practices.

- Section 703 (c)(l) of the 1987 fish and wildlife program will continue to guide the implementation of habitat improvement projects (Action plan)
- Subbasin plans, as the foundation of the fish and wildlife program, must reflect the provisions of Section 4.1. Implementing an ecosystem approach requires knowledge of the Columbia River ecosystem and its ability to support salmonids
  - Expeditiously update the subbasin plans. Particular attention should be directed to sections addressing considerations, objectives, alternative strategies and recommended strategies. Submit the updated subbasin plans to the Council by December 31, 1995. Thereafter, update the subbasin plans as needed. Once it is operational, use the subregional process to update subbasin plans.
- Integrated system plan
- Explore expanding scope of the Columbia River Estuary Bi-State Study to include all of the Columbia River Basin. If feasible, this would be more effective in addressing comprehensively all interrelated water quality and quantity aspects of the basin.

- **General restoration**
  - Implement, monitor and evaluate resident fish habitat improvement and protective measures. Include the following: stream riparian zone restoration by planting vegetation, fencing overgrazed areas, and stream bank stabilization
  - Because the region places a very high priority on protecting existing habitat, manage activities to restore and maintain the quality and quantity of existing habitat. In so doing, take all steps necessary to comply with the following regionally adopted habitat objectives, or with locally adopted objectives that are consistent, in terms of biological consequences, with these regional objectives in perennial and intermittent streams supporting salmon and steelhead. Provide

sufficient funding to support needed watershed restoration activities and schedules.

- Established and described model watersheds. By the second year, begin implementation of priority on-the-ground actions that address key limiting factors for salmon and steelhead production through the implementation planning process (see Section 3.1B). In addition, initiate procedures for filling gaps and addressing conflicts.
- Explore alternatives to provide permanent erosion control for lands in the Columbia River Basin that are currently enrolled in the Conservation Reserve Program. (soil conservation program)

- **Specific restoration**
  - Implement habitat improvement projects in the implementation plan to be consistent with maintenance of the genetic integrity of native fishes and protection of species that are endangered, threatened, or of special concern that occur in the improved or newly accessible habitat. This concern is critical where passage over natural barriers is considered. In addition, implement fish health monitoring. (In the Flathead Basin)
  - Implement habitat restoration and enhancement activities in Spring Creek and Clear Creek along the Fort Hall Bottoms located on the Fort Hall Reservation.
  - Implement habitat improvement measures to enhance redband trout and smallmouth bass in the Malheur River Basin.
  - Operate and maintain pilot projects for improving habitat [in] Lake Roosevelt tributary streams for rainbow trout.
  - Design, construct, operate and maintain water control structures and repair dikes on the Pend Oreille wetlands wildlife mitigation project for the purpose of creating a bass nursery slough.
  - Operate and maintain habitat improvement projects to enhance bull trout and cutthroat trout in three demonstration tributaries of the Pend Oreille River: LeClerc, Cee Cee Ah and Skookum creeks.
  - Construct and place artificial cover structures to increase the amount of bass fry winter cover in the Box Canyon Reach of the Pend Oreille River.
  - Implement, monitor and evaluate resident fish habitat improvement and protective measures at the Duck Valley Indian Reservation.
  - Implement habitat restoration and enhancement measures in Lake, Benewah, Evans and Alder Creeks located within the Coeur d'Alene Indian Reservation including: 1) construct, operate and maintain water storage facilities adjacent to streams for water recruitment and to provide juvenile rearing habitat (trout refugia); 2) restore stream riparian zone through plantings, fencing and stream bank stabilization; 3) provide for off-site livestock watering areas; 4) construct

lateral/side channels for juvenile rearing habitat and provide overflow or "flood" channels to help relieve peak flow increases; and 5) place large woody debris in channels to increase instream cover. Also, 1) purchase critical watershed areas (riparian corridors, sensitive wetland and upland areas) for protection of fisheries habitat

- Fund test vegetation plantings at appropriate reservoirs and evaluate results. Appropriate reservoirs might include Hills Creek, Dworshak, Libby, Hungry Horse and others.

- **Fish passage**
  - … determine the feasibility of providing passage above blockages to habitat caused by human development activities … where weak stocks … would benefit from additional habitat (e.g., parts of the Willamette, Yakima, Grande Ronde and Deschutes basins).
  - Operate and maintain pilot projects for improving passage into and out of Lake Roosevelt tributary streams for rainbow trout.
  - Fund the construction of fish passage facility projects included in the two highest-priority groups established by the Yakima Passage Technical Work Group approved by the Council.
  - The Confederated Salish and Kootenai Tribes shall provide a prioritized list of adult and juvenile fish passage needs and accomplishments on the Flathead Indian Reservation annually …. Bonneville and the Bureau of Indian Affairs shall fund an accelerated program to accomplish screening and passage work.
  - Study the feasibility of reestablishing runs of anadromous fish above Cle Elum Dam. If results indicate that restoration is feasible, Bonneville shall fund the construction of fish passage facilities at Cle Elum Dam.
  - Design, construct, place and evaluate shoreline habitat in C.J. Strike Reservoir, in consultation with Idaho Power Company, to provide for improvement of resident fish populations.

- **Water quantity**
  - Develop a regional assessment of the availability of water for salmon and steelhead spawning, incubation, emergence and migration in the Columbia River and its tributaries, given current and projected water use and plans to provide secure flows for salmon and steelhead.
  - The Council urges the states to … call for establishing water conservation programs, with a goal of 25 percent more water conservation regionwide by 2005.
  - Review the adequacy of existing law and administration to protect enhanced instream flows for fish
  - Yakima Basin- develop water conservation plan

- Snake River - facilitate water transactions to aid instream flows for salmon and steelhead by allowing water bank prices to achieve market levels, eliminating obstacles to downstream use for instream flows and developing expedited water transfer procedures.
- Provide funding for the acquisition and management of critical water rights for rebuilding and maintaining Columbia Basin salmon and steelhead populations. These acquisitions should be on a willing-seller and willing-buyer basis.
- In 1991, initiate a cooperative effort with the states of Idaho, Oregon and Washington, and with irrigators, to select and design at least four demonstration water conservation projects to provide additional instream flow and enhanced water quality for production of weak stocks.
- Fund and implement four water leasing demonstration projects; one in the Yakima River Subbasin, along the lines proposed in the Environmental Defense Fund's March 1994 report, and three in the Snake River Basin. Work with the states, the Council and other parties to demonstrate and evaluate the use of water leases and transfers to increase stream flows for salmon and steelhead.
- Identify all cases of water spreading on reclamation projects in the Columbia River Basin. Propose alternative approaches for addressing this issue.
- Report annually to the Council regarding the amount of water provided by pumping, the amount of exchanged water and the disposition of the exchanged water.
    - Studies to determine the biological effectiveness of interim and long-term pumping.

- **Water quality**
    - In streams where either water quality objectives or federal land management plan objectives for fish habitat and water quality are not being met, initiate actions needed for recovery.
    - Coordinate development of a study plan to compile and evaluate existing water quality information, identify data gaps and priority problems, and recommend proposals to address gaps and priority problems.
    - Where water quality standards are being met, retain existing shade, vegetation, standing and down large woody debris, and small woody debris. Where water quality standards are not being met, initiate action to increase shade, re-vegetation, standing and down large woody debris, and small woody debris.
    - Coordinate design of a demonstration project to evaluate and address water temperature problems in the Grande Ronde Subbasin
    - Establish best management practices under the Clean Water Act to maintain and improve salmon and steelhead production.

- Review and, if necessary, seek improvements to mining laws and administrative practices to promote salmon and steelhead productivity
- Review state water quality standards and compliance procedures by June 30, 1995, and report to the Council findings and any limitations in resources to programs that could impact meeting the habitat goal, policies and objectives of the program
- Establish a mechanism to facilitate coordination of water quality activities relating to Columbia River Basin fish and wildlife resources.

2000s

- **Regional policies, guidance, planning**
  - Subbasin plans (2004, 2005, 2009, 2010) are foundation of Program and where specifics on restoration now found
  - 2000- For purposes of the program a subbasin level plan must include the following three general components in order to be eligible for adoption into the fish and wildlife program:
    - A subbasin assessment providing a description of historical and existing conditions;
    - A clear and comprehensive inventory of existing projects and past accomplishments;
    - A 10-15 year management plan.
- **General restoration**
  - 2000 Program: Identify the current condition and biological potential of the habitat, and then protect or restore it to the extent described in the biological objectives.
  - 2000- where to work: Efforts to improve the status of fish and wildlife populations in the basin should protect habitat that supports existing populations that are relatively healthy and productive. Next, we should expand adjacent habitats that have been historically productive or have a likelihood of sustaining healthy populations by reconnecting or improving habitat.
  - Principles:
    - Restore Ecosystems, Not Just Single Species
    - Address Transboundary Species
    - Restoration in Estuary and Blocked Areas
    - Build from strength (strongholds)
  - Habitat Protection and Improvement Activities to Address Biological Objectives:
    - Removal of passage barriers
    - Diversion screening

        - Riparian habitat protections and improvements (fencing, vegetation planting, erosion control, best land management practices, easements, and other acquisitions) largely intended to improve water quality, especially with regard to temperature and sediments
        - Water transactions and conservation activities to increase the amount, timing, and duration of instream flows
        - Floodplain reconnections, passive and active improvements in channel structure and geomorphology and the re-establishment of natural river processes
        - Acquisitions of and enhancements to terrestrial uplands for wildlife habitat
    - Through system operations and investments in mainstem habitat improvements, increase the extent, diversity, complexity, and productivity of mainstem habitat by protecting, enhancing, and connecting mainstem spawning, rearing, and resting areas. Actions to consider include, but are not limited to:
        - providing appropriate spawning, rearing, and resting flows in the mainstem
        - excavating backwater sloughs, alcoves, and side channels
        - reconnecting alcoves, sloughs and side channels to the main channel
        - dredging/excavation of lateral channels that have silted in
        - enhancement of wetlands
        - creating islands and shallow- water areas
        - adding large woody debris to these systems
        - stabilizing the water levels of the rivers and reservoirs to the extent practicable
        - planting riparian and aquatic plants at appropriate locations
        - acquiring and protecting lands adjacent to the mainstem
- **Specific restoration**
    - Develop and implement actions that create littoral habitat and fish structures along the shores of Lake Roosevelt to diversify food available to fish and provide additional rearing habitat.
    - Implement actions to stabilize and improve burbot populations in the upper Columbia.
    - Implement actions to stabilize and improve Columbia River white sturgeon and to recover listed Kootenai River white sturgeon.
- **Fish passage**
    - Measures in the BiOps
- **Water quantity**
    - Water transaction program

- Bonneville established a water transactions program in response to the 2000 Columbia River Basin Fish and Wildlife Program and the 2000 FCRPS Biological Opinion. Bonneville shall fund the continuation of the water transaction program to pursue water right acquisitions in subbasins where water quantity has been identified in a subbasin plan as a primary limiting factor. The water transaction program will continue to use both temporary and permanent transactions for instream flow restoration. The water transaction program will coordinate with the fish and wildlife agencies, tribes, and project sponsors to:
    - Integrate instream water transactions with efforts to set and meet flow targets and habitat restoration goals;
    - Integrate instream water transactions with efforts to address other ecological factors that are limiting fish habitat;
    - Coordinate with Bonneville on other funding efforts addressing flow restoration to ensure consistency; and
    - To the extent possible, consider the potential impact of climate change while making water transaction recommendations. … The water transaction program will seek closer integration of land and water protection acquisition activities.

- **Water quality**
    - In the long-term, implement actions to reduce toxic contaminants in the water to meet state and federal standards.
    - Continued development of the Corps' CE-QUALW2 model for estimating mainstem Snake River temperatures and cold-water releases from Dworshak Dam on the North Fork Clearwater River to assist in real-time decision-making for Dworshak summer operations
        - Expanding the water temperature modeling capabilities to include the Columbia River from Grand Coulee to Bonneville dams to better assess the effect of operations or flow depletions on summer water temperatures
        - Incorporating provisions of various total maximum daily loads (TMDLs) as they are developed and approved, particularly TMDL provisions containing allocations affecting federal action agencies
    - 2009 Program: Climate change could have significant effects on mainstem Columbia and Snake River flows in terms of runoff timing, water quantity and temperature. Possible changes in regional snowpack, river flows, and reservoir elevations due to climate change could have a profound impact on the success of restoration efforts and the status of Columbia Basin fish and wildlife populations.
        - The Federal action agencies, in coordination and collaboration with others, should:

- Support the advancement of runoff forecasting techniques. Continue to encourage, monitor, and promote public awareness of pertinent climate change research and information and assess how it should influence Program mitigation efforts.
- Assess whether climate change effects are altering or likely to alter critical river flows or other habitat attributes in a way that could significantly affect fish or wildlife important to this Program, either directly or by affecting the success of current mitigation efforts.
- If so, evaluate whether alternative water management scenarios, including changes in flood control operations, could minimize the potential effects of climate change on mainstem hydrology. Evaluate the effectiveness and feasibility of possible actions to mitigate effects of climate change, including selective withdrawal from cool/cold water storage reservoirs to reduce water temperatures or other actions to create or protect cool water refugia in mainstem reaches or reservoirs.

2010s

- **Regional policies, guidance, planning**
  - Measures in BiOps, Program principles
- **General restoration**
  - Identify and protect mainstem habitat areas and ecological functions that are relatively productive for spawning, resting, rearing, and migrating native anadromous and resident focal fish species and manage these areas to protect aquatic conditions and form a transition to floodplain terrestrial areas and side channels.
  - Restore and enhance habitat areas that connect to productive areas to support expansion of productive populations and to connect weaker and stronger populations so as to restore more natural population structures.
  - Protect, enhance, restore, and connect freshwater habitat in the mainstem and tributaries.
  - Protect and enhance ecological connectivity between aquatic areas, riparian zones, floodplains, side channels, and uplands.
  - Where feasible, reconnect protected and enhanced tributary habitats, especially in areas with productive populations.
  - Enhancing the connections between the mainstem sections of the Columbia and Snake rivers and floodplains, side channels, and riparian zones
  - Reconnecting floodplains through passive and active improvements in channel structure and geomorphology and re-establishing natural river processes

Mainstem Habitat:

- Enhancing the connections between the mainstem sections of the Columbia and Snake rivers and floodplains, side channels, and riparian zones
- Continuing actions to reconnect the river to its floodplains wherever possible in the mainstem, with special emphasis on the estuary and lower Columbia River
- Protecting and enhancing mainstem riparian areas and wetlands to protect aquatic conditions and form a transition to floodplain terrestrial areas and side channels

2014: Lamprey, Sturgeon

- Continue to identify, protect, and restore habitat areas and ecological functions, such as stream channel complexity and function, that are associated with productive spawning, resting, rearing, and migrating lamprey
- Continue to identify, protect and restore habitat areas and ecological functions that are associated with productive spawning, resting, rearing, and migrating sturgeon.

- **Specific restoration**
  - None listed in Program. Specific restoration actions exist in subbasin plans and BiOps.
- **Fish passage**
  - Removing fish-passage barriers
- **Water quantity**
  - Continuing Bonneville funding to acquire water and pursue water rights in subbasins where water quantity has been identified in subbasin plans as a primary limiting factor and where flow targets have been identified
  - Improving the amount, timing, and duration of instream flows through water rights and acquisitions
- **Water quality**
  - Protecting and improving riparian habitats in all areas of the Columbia River Basin to improve water quality, reduce contaminant transport, lower water temperature including creating thermal refugia, and reduce sediments through fencing, vegetation planting, erosion control, best land-management practices, and acquisition of land through conservation easements and other types of acquisition

Appendix B. Measures and Work Elements Associated with Council SPIs.

SPI	Name	Measure	Work Element ID	Work Element Name	Years (if no longer in use)
E1-1	Acres protected by purchase or conservation easement	Metric 1772	5	Land Purchase and/or Conservation Easement (internal BPA)	
E1-2	Miles of stream protected by purchasing or leasing land	18	5	Land Purchase and/or Conservation Easement (Internal BPA)	
			92	Lease Land	
E1-3	Miles of stream habitat accessed	10	52	Remove Mine Tailings	
			84	Remove/Install Diversion	2005-2020
			85	Remove/Breach Fish Passage Barrier	
			180	Enhance Floodplain/Remove, Modify, Breach Dike	
			184	Install Fish Passage Structure	
			208	Irrigation Infrastructure Construction or Replacement	2021-present
E1-4	Miles of stream with improved complexity or improved channel form	6	29	Increase Aquatic and/or Floodplain Complexity	
		70	30	Realign, Connect, and/or Create Channel	
E1-5	Acres of habitat improved	2	30	Realign, Connect, and/or Create Channel	

SPI	Name	Measure	Work Element ID	Work Element Name	Years (if no longer in use)
			31	Conduct Controlled burn	2005-2010
			47	Plant Vegetation	
			48	Practice No-till and Conservation Tillage Systems	
			52	Remove Mine Tailings	
			53	Remove Vegetation	2005-2011
			55	Erosion and Sedimentation Control	
			180	Enhance Floodplain/Remove, Modify, Breach Dike	
			181	Create, Restore, and/or Enhance Wetland	
	Acres of habitat improved.	71 (2010-present)	30	Realign, Connect, and/or Create Channel	
			31	Conduct Controlled burn	2005-2010
			47	Plant Vegetation	
			48	Practice No-till and Conservation Tillage Systems	
			52	Remove Mine Tailings	
			53	Remove Vegetation	2005-2011
			55	Erosion and Sedimentation Control	
			180	Enhance Floodplain/Remove, Modify, Breach Dike	
			181	Create, Restore, and/or Enhance Wetland	
			197	Maintain/Remove vegetation	2012-2013
			198	Maintain Vegetation	2014-present

SPI	Name	Measure	Work Element ID	Work Element Name	Years (if no longer in use)
			199	Remove Vegetation	2014-present
	Acres of habitat improved	72 (2010-2011 only)	30	Realign, Connect, and/or Create Channel	
E1-7	Acres improved in riparian areas	83	30	Realign, Connect, and/or Create Channel	
			31	Conduct Controlled burn	2005-2010
			47	Plant Vegetation	
			48	Practice No-till and Conservation Tillage Systems	
			52	Remove Mine Tailings	
			53	Remove Vegetation	2005-2011
			55	Erosion and Sedimentation Control	
			180	Enhance Floodplain/Remove, Modify, Breach Dike	
			181	Create, Restore, and/or Enhance Wetland	
			197	Maintain/Remove vegetation	2012-2013
			198	Maintain Vegetation	2014-present
			199	Remove Vegetation	2014-present
E2-1	Instream flow added (acre-feet of water protected or conserved)	55	82	Install Well	2005-2020
			92	Lease Land	
			149	Install Pipeline	2005-2014

SPI	Name	Measure	Work Element ID	Work Element Name	Years (if no longer in use)
			150	Install Sprinkler	2005-2014
			151	Line Diversion Ditch	2005-2014
			164	Acquire Water Instream	
			203	Install Water Conservation Measure	2015-present
			208	Irrigation Infrastructure Construction or Replacement	2021-present
E2-6	Instream flow added (cfs)	15	82	Install Well	2005-2020
			149	Install Pipeline	2005-2014
			150	Install Sprinkler	2005-2014
			151	Line Diversion Ditch	2005-2014
			203	Install Water Conservation Measure	2015-present
			208	Irrigation Infrastructure Construction or Replacement	2021-present
		17	5	Land Purchase and/or Conservation Easement (internal BPA)	
			92	Lease Land	
			164	Acquire Water Instream	