Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP)

Objectives, Performance Indicators & Monitoring Workshop

Pre-Workshop Briefing Package

June 20, 2018

Prepared for the Pacific States Marine Fishery Commission

ESSA

Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP) Task 1.2

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1 Workshop Background & Objectives

1.1 Introduction

We have designed a highly participatory two-day workshop that builds on feedback received at our March 2018 workshop which encouraged providing more time before the workshop to review material, less time working individually on exercise worksheets, and to provide more time for plenary discussions amongst participants. This **workshop briefing document** is accompanied by a simple workshop survey to capture your responses on the pre-workshop questions identified in sections 2, 3 and 4 below. **We thank participants in advance for reviewing this material and completing the pre-workshop questions using this SURVEY LINK: https://www.surveymonkey.com/r/D72BMS5 by June 29 2018.**

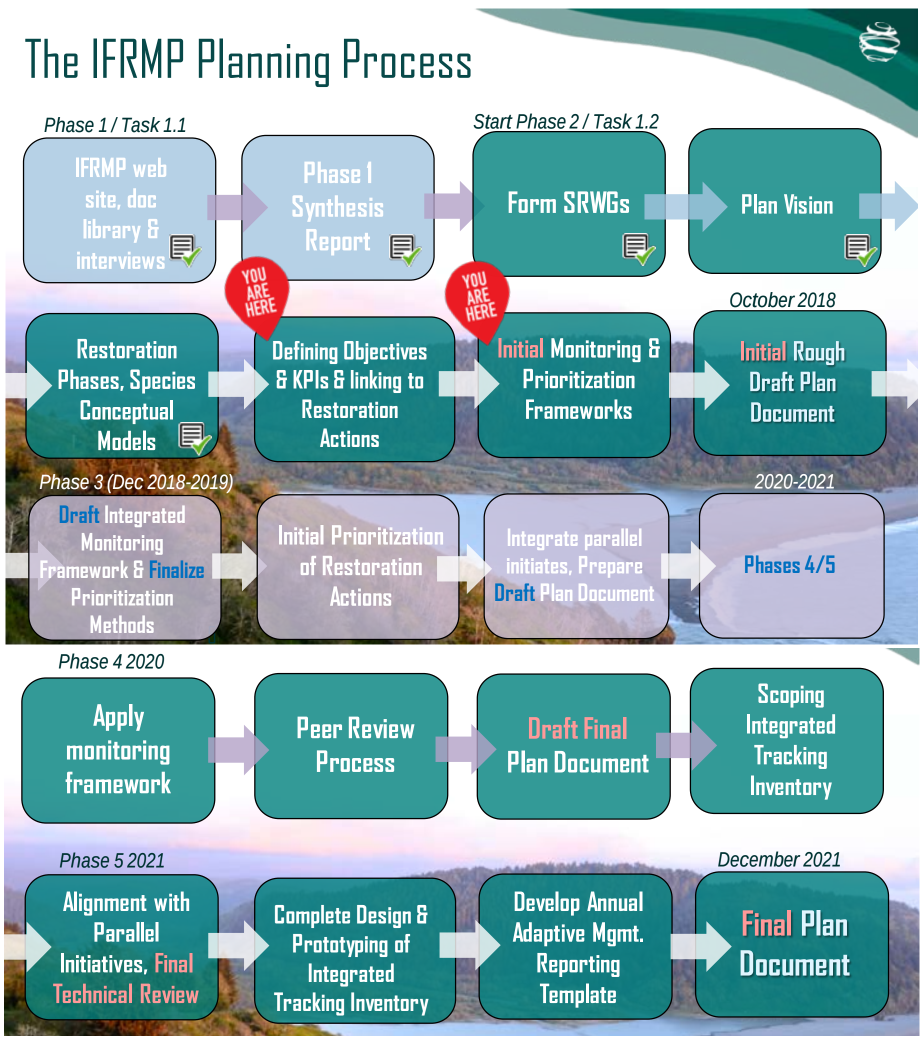

Figure 1. Major phases and tasks in IFRMP planning process 2016-2021. KPI = Key Performance Indicator.

The journey towards restoration of the Klamath Basin, like most journeys, will be accomplished in a series of steps rather than a single leap. We will continue to iteratively provide participants with draft and revised Plan products as we move forward. The project plan has recently been amended to segment the project into additional phases that will be carried out through to **December 2021**. **Figure 1** provides a reminder to participants of where we are in the overall process with "You are Here" symbols flagging specifically topics that are being addressed at the July 2018 workshop.

1.2 Workshop Objectives

1. Review draft goals & objectives hierarchy and assign *candidate* key performance indicators to each objective.
2. Working at a basin-wide scale, review major monitoring needs and uncover gaps in our ability to: a) detect cumulative benefits of *portfolios* of restoration actions, and b) where required, reduce critical uncertainties related to the effectiveness of different *classes* of restoration actions.
3. Review preliminary ideas for methods to help prioritize restoration actions and monitoring activities.

1.3 Workshop Expectations

As illustrated in Figure 1, the July 2018 workshop is only one important step in the planning process with many additional opportunities to provide feedback on the topics that are discussed. Having completed the conceptual model step, our focus now turns to identifying the desired state of the system, key performance indicators for objectives, and beginning to lay out options for how restoration actions and monitoring activities will be prioritized in future phases. As you know, these activities are **highly iterative** and IFRMP development builds in several rounds of peer and technical review.

Our efforts at the July 10-11 2018 workshop are fundamentally about four things:

A. Eliciting your feedback on whether we have captured the appropriate mix of **objectives** to frame the desired state of the system;

B. Getting more of your help to **clarify what performance indicators are truly key** to knowing whether packages of restoration actions are helping to recover focal species;

C. Eliciting your input on some **initial ideas for developing a basin-wide status & trend and action effectiveness monitoring framework**; and

D. Eliciting your input on some initial **ideas for restoration action prioritization** frameworks (but not applying or doing prioritization).

Our pre-workshop questions for you generally boil down to: *(i) are we missing anything 'big' or fundamental? (ii) what is included that shouldn't be (and why) and (iii) what suggestions do you have for us for appropriate considerations to scope and focus the Plan in subsequent phases.*

The workshop is not about identifying highly site-specific actions and indicators, arbitrating the value of different monitoring activities, nor does it pre-determine the precise activities that will and will not be a priority.

As always, please bring to the meeting:

- Your enthusiastic willingness to collaborate in an important process and to follow the agenda;
- Your wisdom, experience, advice and insights;
- Your openness to listen to differing perspectives on major limiting factors, priority restoration actions, monitoring needs, and your recognition that each person brings unique insights and knowledge;
- Your suggestions for key documents and supporting evidence on the topics of objectives, key performance indicators, monitoring and concepts for prioritization (ideally with digital copies on a USB drive)

2 Draft Goals & Objectives Hierarchy

2.1 Introduction & Approach

What We Mean by Goals and Objectives

Restoration goals are statements of broad outcomes to be achieved, while restoration objectives represent specific and measurable tasks that must be completed to attain the related goal (Beechie et al. 2008, 2013). Determining restoration goals and objectives in a workshop process is critical to successful restoration planning because it gives all interested participants a common understanding of management targets and trade-offs (Beechie et al. 2008). While restoration goals and objectives of particular organizations or initiatives may be narrowly focused on a specific area or species, the goals and objectives for the IFRMP are focused on recovery of overall ecological and biological integrity throughout the Klamath basin in support of focal fish populations. Ideally, objectives are specific, measurable, achievable (i.e., recognize socioeconomic constraints), and associated with a timeframe (Beechie et al. 2008, 2013).

A Draft Goals and Objectives Hierarchy

To avoid reinventing the wheel, we have drawn on the most commonly recurring goals and objectives within a range of existing basin-specific species recovery plans available for focal fish species of the IFRMP (**Table 1**) to produce an *early draft* basin-wide goals and objectives hierarchy (**Table 2**) for your input at the upcoming workshop. This hierarchy is organized into sections that correspond to the major tiers of watershed organization that served as an organizing framework for our Synthesis Report. In this framework, fisheries goals are at the top and restored watershed inputs at the bottom to reflect that objectives higher up in the hierarchy are closer to the overall goal in the cause-effect chain. To illustrate consistency with existing recovery plans mentioned in Table 1, ***we compiled a cross-walk of basin-wide goals and objectives with corresponding species recovery plan goals and objectives which can be downloaded via this LINK***.

These goals and objectives are not intended to supersede the original species-specific goals and objectives within existing recovery plans, but instead offer a common framework of goals and objectives for planning and tracking overall watershed recovery. While we anticipate that the relative emphasis on each of these goals and objectives will vary by subregion, subbasin, and species this hierarchy provides an organizing framework at the whole-basin scale.

It should be noted that this hierarchy *does not take into account* the goals and objectives of two key restoration plans that are still under development and thus not yet available for consultation, namely the **ODFW's Draft Implementation Plan for Reintroducing Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin** (draft anticipated by the end of 2018) and the **KRRC "Definite Plan"** (anticipated July 2018)[1]. As these documents or components thereof become available, the IFRMP will align and integrate features of these parallel initiatives.

[1] Timelines provided are as reported in the Overview of Klamath River Dam Removal and Salmon Reintroduction to the Upper Klamath Basin symposium at the Annual Salmonid Restoration Conference held in Fortuna, California from April 11 – 14, 2018. Available via this LINK.

Linking Goals and Objectives to Actions, Performance Indicators, and Suitability Thresholds

Each of these goals and objectives (see Table 2) should be linked to specific types of actions, the stressors they address, and the associated performance indicators that can be used for tracking progress in a way that is consistent with the major monitoring and management questions. **While the objectives may be largely qualitative, the associated performance measures need to be *specific* and *measurable*.** Suitability thresholds or triggers for performance indicators should be developed that can indicate broad changes in status and the degree of progress towards particular objectives/goals (e.g., poor vs. high quality habitat).

One way that watershed restoration programs can track their overall strategic effectiveness over time is by determining how well the cumulative suite of restoration projects carried out in the region aligns with the original program goals and objectives (e.g., for a single basin like the Russian River as in Christian-Smith and Merenlender 2010, or an entire region like the Pacific Northwest as in Barnas et al. 2015). Mismatches between projects and restoration objectives might indicate a need for realignment of project prioritization schemes (see Section 3.1) or building capital, capacity, and local buy-in to reduce barriers preventing certain types of restoration.

Table 1: Species Recovery Plans Consulted to Develop Basin-Wide Goals and Objectives

Species	Key Recovery Plans Consulted
Coho salmon	• NOAA NMFS. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*). National Marine Fisheries Service. Arcata, CA. 1841 pp. • California Department of Fish and Game. 2004. Recovery strategy for California coho salmon. Report to the California Fish and Game Commission. 594 pp. Copies/CDs available upon request from California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, 1416 9th Street, Sacramento, CA 95814, or
Chinook salmon	• NONE (recovery outlines exist only for central California distinct population)
Steelhead	• McEwan, D. and T. A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game. 246 pp. NOT RECENT (recent recovery outlines exist only for central California distinct population)
Bull trout	• USFWS. 2015. Recovery Plan for the Coterminous United States Population of Bull Trout (*Salvelinus confluentus*) Prepared by U.S. Fish and Wildlife Service, Portland, Oregon. 195 pp. • USFWS. 2015. Klamath River Recovery Unit Implementation Plan for Bull Trout (*Salvelinus confluentus*), Oregon. 39 pp. Prepared by U.S. Fish and Wildlife Service Klamath Falls Fish and Wildlife Office, Klamath Falls, OR. • USFWS. 2002. Chapter 2, Klamath River Recovery Unit, Oregon. 82 p. In: U.S. Fish and Wildlife Service. Bull Trout (Salvelinus confluentus) Draft Recovery Plan. Portland, OR. *(this version retained for more specific language)*
Redband trout	• Interior Redband Conservation Team. 2016. A Conservation Strategy for Interior Redband (*Oncorhynchus mykiss subsp.*) in the states of California, Idaho, Montana, Nevada, Oregon, and Washington. 106 pp.
Suckers	• USFWS. 2012. Revised recovery plan for the Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. xviii + 122 pp.
Pacific lamprey	• USFWS. 2012. Conservation agreement for Pacific lamprey (*Entosphenus tridentatus*) in the States of Alaska, Washington, Oregon, Idaho, and California. 57 pp. • Goodman, D.H. and S.B. Reid. 2015. Regional Implementation Plan for Measures to Conserve Pacific Lamprey (*Entosphenus tridentatus*), California - North Coast Regional Management Unit. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2015-21, Arcata, California.
Green sturgeon	• NONE (recovery plan exists only for southern distinct population)
Eulachon	• NOAA NMFS. 2016. Recovery Plan for Eulachon (*Thaleichthys pacificus*). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, OR, 97232. 120 pp.

2.2 Pre-Workshop Questions for Participants

- Q1: Do the high-level goals and objectives in Table 2 reflect the full suite of issues and activities required for whole-basin recovery? If not, provide feedback on missing whole-basin goals and objectives.
- Q2: To help contextualize the initial goals and objectives and assist us in ground-truthing and developing our prioritization framework (see Section 4),
    - Please list your input on your "Top 3" *specific actions at specific locations* that would have **disproportionately high benefit** for some or all of these objectives in the sub-basin(s) for which you have the most experience. Some examples heard at the last workshop are included in Table 2.

Table 2: Early rough draft of Klamath IRFMP Goals and Objectives Hierarchy and Example Performance Indicators for discussion at the workshop.

Klamath Basin IFRMP Overall Goal:

Restore and sustain viable, naturally self-sustaining native fish populations in the Klamath Basin to facilitate enhanced harvest opportunities for dependent Tribal, recreational and commercial fisheries, while improving Basin flows, water quality, habitat and ecosystem processes.

Whole-Basin Scale Nested Goals	Whole-Basin Nested Core Objectives	Examples of Candidate Restoration actions	Examples of Candidate Performance Indicators
Fish Populations 1. Prevent further declines of Klamath fish populations and produce naturally self-sustaining populations with healthy demographic traits and trends that exceed escapement objectives to provide harvest opportunities.	1.1 Increase juvenile production	• *Reduce habitat and harvest stressors via actions below* (objectives 1.1–1.3)	• Index of juvenile/larval density Egg to fry survival rate
	1.2 Increase juvenile survival and recruitment to spawning populations		• Fish growth rate; Smolt to adult survival rate
	1.3 Increase overall population abundance and productivity		• Population size by species and age class by stream/subbasin
	1.4 Maintain or increase life history and genetic diversity	• *Improve fish passage conditions via actions below, reintroduction* (objectives 1.4–1.5)	• Diversity of migration, spawn timing
	1.5 Expand spatial distributions		• Length of streams where sp. present
Fisheries Actions 2. Regulate harvest so as to support achievement of goal #1.	2.1 Improve management and regulations/enforcement of harvest, bycatch and poaching of naturally produced fish such that populations do not decline and can recover	Direction related to fisheries and harvest management and monitoring is not within the scope of this plan, and will be provided by the NMFS, USFWS, and state agencies. This objective is presented here only for completeness.	
Biological Interactions (BI) 3. Support goal #1 by reducing biotic interactions (ecological, genetic) that could have negative effects on native fish populations	3.1 Conduct hatchery supplementation, rearing and re-introduction (as needed) to meet fish restoration objectives without generating adverse competitive or genetic consequences for native fish	• Improve and ultimately reduce salmon hatchery production; juvenile sucker rearing programs	• pNI/pHOS; Index of genetic integrity
	3.2 Minimize disease-related mortality by reducing vectors and factors known to lead to fish disease outbreaks	• Restore natural flow regimes, increase scour to pre-dam levels	• Diseased fish/day; Polychaete / C. shasta densities
	3.3 Reduce impacts of exotic fish species on native fish	• Electrofishing brown trout	• Index of abundance of exotic/invasive aquatic species
	3.4 Reduce impacts of predation on native fish	• Predator culls or exclusion	• No. predators/competitors removed

Whole-Basin Scale Nested Goals	Whole-Basin Nested Core Objectives	Examples of Candidate Restoration actions	Examples of Candidate Performance Indicators
Habitat (H) 4. Support goal #1 by improving freshwater habitat access for fish and the quality and quantity of habitat used by all freshwater life stages	4.1 Restore fish passage and re-establish channel and other habitat connectivity	• Complete planned removal of Iron Gate, Copco 1 & 2, J.C. Boyle dams; improve fish passage at other dams	• No. fish passage blockages removed or mitigated; Length of stream made accessible (km)
	4.2 Improve water temperatures and other local water quality conditions for fish growth and survival	• Restore, protect, and connect thermal refugia (springs); improve land mgmt, minimize WQ barriers	• Temperature, pH, DO by vs. target values by reach / species; % stream length within thresholds
	4.3 Enhance and maintain food availability	• Riparian planting, LWD addition, small dam removal	• Index of biotic integrity for macro-invertebrates; marine nutrients
	4.4 Reduce fish mortality due to entrainment, scour, stranding	• Screening diversions, channel reconfiguration, BDAs	• No. screened water diversions; water screened (acre-feet)
	4.5 Enhance and maintain habitats for all freshwater life stages of resident and anadromous fish	• Instream restoration, small dam removal, creating off-channel habitat, restore fringe wetlands	• Acres of habitat mechanically created or rehabilitated; Durability of restored habitat over time
Fluvial Geomorphic Processes (FG) 5. Support goal #1 by creating and maintaining spatially connected and diverse channel and floodplain morphologies	5.1 Increase and maintain coarse sediment recruitment and transport processes	• Prepare mainstem mined/degraded bars and floodplains to capture sediment post-dam removal, LWD	• Amount of coarse sediment augmented by reach per year (tons/year by reach)
	5.2 Increase channel and floodplain dynamics, stability and interconnectivity	• Levee setback or removal, channel reconfiguration, bank stabilization	• Floodplain arear; Rate of channel migration (m bank retreat/year)
	5.3 Promote establishment of diverse riparian and wetland vegetation that contributes to complex channel and floodplain morphologies	• Riparian planting, riparian fencing, restoring natural fire regimes	• Total length of streambank rehabilitated and/or planted (km);
Watershed Inputs (WI) 6. Support goal #1 by improving water quality, quantity, and ecological flow regimes	6.1 Improve instream ecological flow regimes for the Klamath River mainstem and tributary streams	• Dam removal, irrigation improvements, co-management of flows, water right acquisition	• Selected set of Indices of Hydrological Alteration
	6.2 Reduce fine sediment inputs	• Management of upland agriculture, forestry, and roads to minimize inputs	• Fine sediment delivered per key tributary (tons)
	6.3 Reduce external nutrient and pollutant inputs	• Land mgmt, tailwater treatment, reduce mobilization of contam. sediments	• Area treated for manure management (km^2), no. DSTWs
	6.4 Minimize the impact of harmful algae blooms	• Reduce agricultural nutrient inputs	• Index of extent and frequency of lake harmful algal blooms

3 Monitoring Framework

3.1 Introduction

Monitoring plays a key role in understanding how various stressors cumulatively affect the overall status and trends of fish populations and also in gauging how successful management actions are at reducing these stressors and improving fish survival. For the purposes of this briefing document, we delineate two main categories of monitoring: (1) status and trend monitoring and (2) action effectiveness monitoring.

Status and Trend (ST) monitoring provides information about changes in anthropogenic and natural stressors, habitat attributes, and fish populations, and can be divided into **Habitat Monitoring** and **Population Monitoring**. Action Effectiveness (AE) monitoring tracks how well specific classes of restoration projects are meeting their desired goals, objectives and outcomes. Action effectiveness monitoring can be further divided into five sub-types: (1) **Baseline Monitoring**; (2) **Implementation Monitoring** (which may also include associated compliance monitoring) (3) **Physical Effectiveness Monitoring**; and (4) **Biological Effectiveness Monitoring**. **Figure 2** demonstrates the relationship between these four sub-types and how they are used together to assess OVERALL action effectiveness.

Both categories of monitoring may be relevant at local, sub-basin, or basin-wide spatial scales (**Figure 3**). For example, action effectiveness monitoring might focus on a single local scale restoration project or on the combined result of many projects at the basin scale.

Status and trend monitoring programs tend to be long-term consistent monitoring programs while action effectiveness monitoring programs often change over time depending on the phase of the restoration and speed of the response. Effectiveness monitoring is eventually phased out in favor of status and trend monitoring. **For the purpose of the IFRMP, we envision the focus will be on basin-wide status and trends and action effectiveness monitoring.**

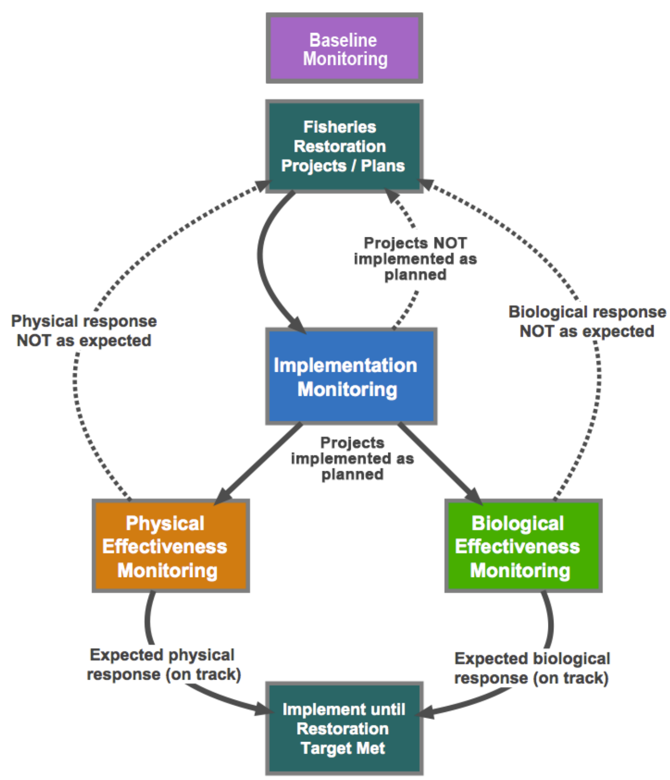

Figure 2: This figure illustrates the relationships between the different components of effectiveness monitoring.

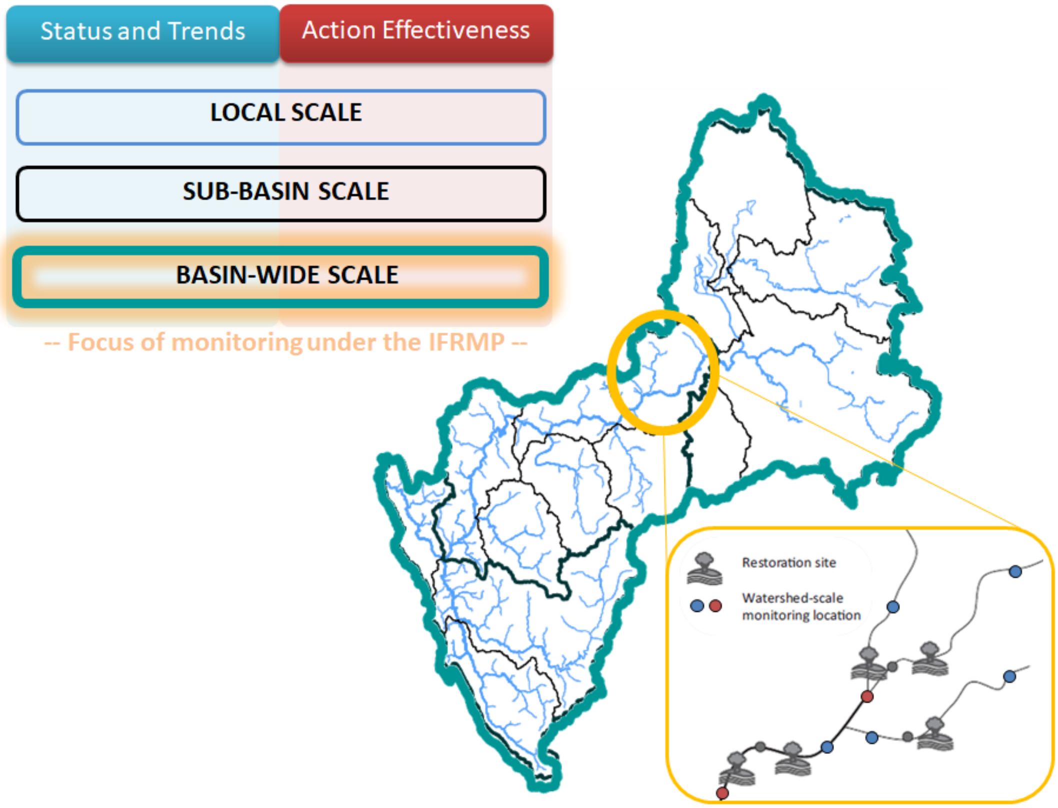

Figure 3: Both status and trends monitoring and action effectiveness monitoring may be used to answer questions at multiple spatial scales.

3.2 Approach

3.2.1 Monitoring Framework

The basic components of any monitoring program include:

- the decisions / questions (i.e., the **why**);
- the indicators (i.e. the **what**);
- the sampling design which describes **where** and **when** measurements are to be made, as well as the process by which those locations and times are selected; and
- the response design which describes **how** data will be collected (i.e., the field protocol) and subsequently analyzed and reported (**Figure 4)**.

Designing an effective monitoring system requires thorough consideration of each of these components. However, these components are not independent of each other and while there is a natural sequence, it is often necessary to step back and revisit an earlier step before converging on an optimum design.

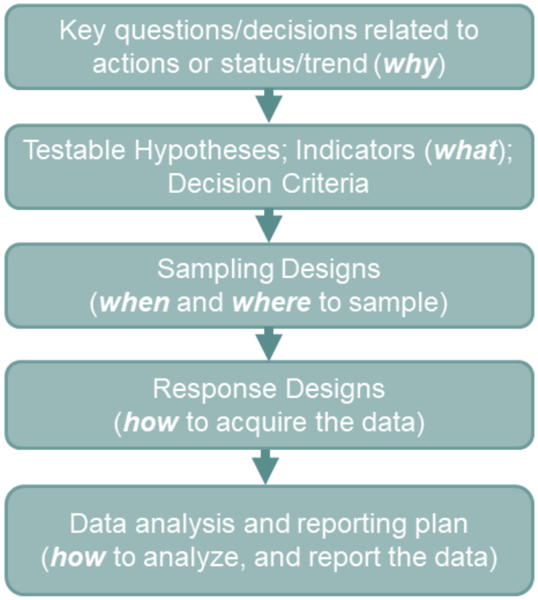

Figure 4: Components of the monitoring framework, including: why, what, when, where, and how data are collected and analyzed.

Developing an effective monitoring design is relatively simple if the problem is well defined. Many monitoring programs fail or are inefficient (i.e., waste money) due to poor problem definition (Reynolds et al. 2016). Data are collected which don't end up being used or are inadequate to answer the questions of interest with sufficient precision in a useful timeframe at the right spatial scales. It is absolutely critical to think through how the data will be used to answer the questions of interest (Section 2) and inform management decisions at the outset. This is a fundamental concept recommended by the Environmental Protection Agency's Data Quality Objectives approach (EPA 2006).

Developing a **sampling design** requires an understanding of the spatial and temporal aspects of the study, both in terms of the decisions being made and the variability of the data. In general, key components include: (1) target population, (2) sample frame (the complete list of sampling units from which a sample is selected), (3) sample unit(s); (4) strata; (5) selection of sites (e.g., probabilistic sample, census, convenience sampling); (6) timing and frequency of sampling, both within a year and across years; and (7) allocation of effort across time and space. Development of the **response design** must consider the cost and feasibility. The level of sampling effort (number and frequency of samples) required depends on the desired precision and statistical power as well as the response design itself. A typical trade-off occurs between spatial coverage and precision, a less precise assessment (e.g., aerial photo interpretation) is possible at a broad spatial scale where more precise assessments (e.g., vegetation plots) are too costly to complete at a large number of sites.

In general the same considerations are applicable to both status & trends monitoring and action effectiveness monitoring. The key difference with action effectiveness studies is that there is a manipulative component, in other words there is some degree of control over the treatment (i.e., restoration action). This allows for the potential to involve experimental design principles such as randomization and replication. However, river restoration projects are somewhat constrained in their inherent connectivity. Before-After or Before-After Control-Impact designs are the most common experimental design approach employed in river restoration with controls typically occurring upstream of treatment sites (Roni et al. 2013a). The other typical difference with action effectiveness monitoring programs is that the nature and intensity of monitoring may change over time.

The IFRMP Phase 1 Synthesis Report (ESSA 2017) proposed a simple organizing framework starting with Watershed Inputs and working down through the ecosystem to Biological Responses. Development of detailed conceptual models in the earlier part of Phase 2 builds on this simple framework. Conceptual models provide a systems perspective of the linkages among physical, chemical, and biological components / processes in an ecosystem along with natural and anthropogenic stressors. These conceptual models can then be used to help identify what appropriate performance indicators best capture the pathways of effects between ecosystem stressors, potential management actions and related decisions. The current step in Phase 2 and the focus of this workshop is to **refine the goals and objectives, identify key performance indicators for each, and develop a monitoring framework which outlines the path forward for the IFRMP.** The detailed monitoring plan will be developed as part of implementation (Phase 3).

We use a combined top-down and bottom-up approach to begin developing the basin-wide monitoring framework. The IFRMP goals and objectives (Section 2) and associated monitoring questions / management actions will enable us to define the IFRMP monitoring needs. The needs can then be compared to the current monitoring initiatives across each sub-basin (**Figure 5**). In some cases the basin-wide monitoring needs may be adequately addressed through existing monitoring programs. In other cases gaps may be identified.

During the workshop participants will use a simple monitoring design template to summarize the broad sampling considerations and response design options for a sample of priority indicators and associated basin-wide questions. Part of the exercise will involve identifying next steps required to finalize and actually implement the design. For example, it may be necessary to complete GIS analyses or digitally capture expert opinion to define strata boundaries.

3.2.2 Basin-Wide Questions and Management Decisions

The focus of the IFRMP is principally on **basin-wide status & trend and action effectiveness monitoring questions that address key uncertainties or management decisions at the basin scale**. While they may rely on many of the same monitoring activities and performance indicators as local or sub-basin scale monitoring programs they will differ in terms of the required spatial and temporal scales, desired precision, allocation of effort, data analysis and interpretation.

Even when limited to a single (basin-wide) scale, there can be a long list of potential monitoring questions. For example: Are the suite of restoration actions in the upper basin resulting in an improvement in water quality? Is rearing habitat for coho increasing at the basin-scale? Our experience with large monitoring programs involving multiple stakeholders is that it is usually easier to get agreement on the **high-level goals and objectives and core KPIs** than to try and agree on all possible sub-objectives and hypotheses. Where there is general agreement on objectives and KPIs, one goal for the July 10-11 2018 workshop will be to begin to articulate some of the broader core basin-wide monitoring questions. These initial core monitoring questions will be used as examples to demonstrate the structure and utility of the proposed monitoring framework going forward.

Monitoring if the dams are removed…

A restoration example of particular interest is the scenario where the dams are removed. What basin-wide questions might be of interest under that state of nature and how might the monitoring requirements differ? We conjecture that assessment of dam removal impacts ("action effectiveness") will likely focus on the following major system-wide changes that would otherwise not be a focus of long-term monitoring:

1. Direct habitat effects of dam removal and elimination of existing reservoir dynamics as they impact:
   - **Dynamics of channel "redevelopment"** (including at least transport of sediments, gravels, reconfiguration of channel) from below the existing dams to whatever location below Iron Gate Dam past which no significant effects are evident (assuming such location exists); and
   - **Dynamics of changing "water quality" parameters** from the uppermost removed dam to the mouth of the Klamath including at least presence of algae/algal blooms, nutrient loads, DO, mean temperatures and spatial distribution of cool water "refugia", polychaete/disease presence.
2. Effects of dam removal on distribution and abundance of fish species, with special concern for:
   - **Reintroduction of native anadromous species** including at least Coho, fall Chinook, spring Chinook, and Steelhead (possibly also Pacific Lamprey, Green sturgeon) above Iron Gate Dam; and
   - **Possible unintended introductions of non-native species** populations (Large and Smallmouth Bass, Bullhead, Yellow Perch, Bluegill, new non-natives, etc.) below Iron Gate Dam and **possible establishment of viable non-native populations** in the restored mainstem channel above Iron Gate Dam.

In contrast to many of the candidate performance indicators that have been thus far proposed, many of the anticipated system-wide changes identified above **(a) focus on the mainstem Klamath River, (b) focus on species that are currently not present above Iron Gate Dam, and (c) would require long-term monitoring programs with broad rather than localized spatial coverage.** Also, as for the Elwha River restoration plan (Ward et al. 2008), it would be logical to tie certain restoration actions to achievement (or failure to achieve) clearly specified restoration targets by pre-specified dates. This requires further development of the IFRMP adaptive management framework to illustrate what would trigger certain restoration actions based on data collected in monitoring programs.

3.2.3 Klamath IFRMP Performance Indicator Selection Criteria

Deciding what indicators to measure is a critical part of any monitoring framework. Careful thought at this stage ensures best use of the often limited funds available to collect and analyze data. A commonly used approach is to develop a set of indicator selection criteria and then objectively review the candidate indicators against the criteria. Numerous examples of this approach exist. The rationale for selection of particular indicators for basin-wide monitoring may vary as there is a potential wide range of objectives that may need to be considered when selecting and prioritizing the indicators to be used. Examples of different rationales for indicator selection that could be considered include:

1. Are representative of well understood and key system linkages/responses of concern
2. Have defined benchmarks of concern so status can be clearly interpreted
3. Provide early warning of potential system distress
4. Support (tactical) short-term decision making
5. Support (strategic) long-term decision making
6. Provide broad information across a suite of issues and can inform multiple questions/objectives
7. Are tangible, easily understood and useful for communicating underlying issues to the community

Our recommendation is to keep the assessment of potential performance indicators relatively simple but to be explicit about the approach. Based on a review of indicator selection approaches used within other projects (i.e.; Kurtz et al. 2001; Nelitz et al. 2007; Kershner et al. 2011; Uuma Consulting 2013 – unpublished; Pickard et al. 2015; Martone et al. 2016) we suggest **12 indicator criteria for consideration**, grouped into 5 broad categories of indicator assessment: Science, Management, Analytical, Data, and Feasibility (Table 3).

Table 3: Potential criteria to be considered for selection of Klamath IFRMP performance indicators. The 12 suggested criteria are organized into 5 broad categories and definitions of each are provided.

#	Category	Criteria	Definition
1	Science	**Scientifically valid**	Scientific, peer-reviewed findings should demonstrate that indicators can act as surrogates for ecosystem component(s), activities, or stressors.
2	Science	**Reflects ITK**	Indigenous or Traditional Knowledge indicators or information that can act as surrogates for ecosystem component(s).
3	Science/ Management	**Benchmark(s) exists for indicator**	It should be possible to link indicator values to quantitative or qualitative limit reference points (beyond which irreparable damage is done to the ecosystem) and/or target reference points (which imply positive progress toward ecosystem goals).
4	Management	**Relevant to policy or management**	Indicator should serve as proxies for evaluating ecosystem status & progress related to specific goals & strategies
5	Management	**Reflects community concerns**	Indicator relates to a community concern or priority, such as food security or community health.

#	Category	Criteria	Definition
6	Analytical	**Sensitive to change**	Management actions or other human-induced pressures should cause detectable changes in the indicators, in a theoretically- or empirically expected direction, and it should be possible to distinguish the effects of other factors on the response.
7	Analytical	**Narrow range of natural (process) variability**	The process variability (or noise) should be relatively small compared to the expected change.
8	Analytical	**Widely used across agencies**	Indicator should be comparable to those used in other geographic locations, in order to contextualize ecosystem status and changes in status.
9	Data	**Supporting data available, meets database requirements**	Indicator should have readily available data to support
10	Data	**Time series data available**	Indicator should have existing time series date available to support
11	Feasibility	**Technical feasibility**	The methods for sampling, measuring, processing, and analyzing the indicator data should be technically feasible.
12	Feasibility	**Cost effective data collection**	Sampling, measuring, processing, and analyzing the indicator data should make effective use of limited financial resources.

3.2.4 Summary of Current Monitoring in the Klamath Basin

The collection of data relevant to fish restoration in the Klamath Basin is a multi-organizational effort that began as early as 1904 with the first U.S. Geological Survey (USGS) flow gage placed at Keno, OR (USDI et al. 2013). While during these early years many organizations worked independently in isolated 'silos' this has been shifting in recent years from a fragmented collection of projects toward a more integrated approach that seeks to derive 'benefits of scale' by improving cooperation among all participants.

We have attempted to characterize the current state of fish restoration and monitoring in the Klamath Basin based on extensive document review, existing online databases, input received via key informant interviews, prior IFRMP workshops, and responses to information requests as part of the development of the Klamath Basin IFRMP Synthesis Report (ESSA 2017). While the level of metadata information available to our team was highly variable across different organizations we nevertheless attempted to define as best as possible the spatial and temporal aspects of past/current monitoring across Basin agencies. **Presented below is a coarse metadata overview of composite past/current monitoring efforts in the Klamath Basin (Figure 5) and support your input helping us identify and resolve monitoring gaps.** More specific monitoring metadata by organization will be provided in an accompanying **Excel worksheet that has been distributed as an attachment with this Briefing Document**, and summarized at the workshop.

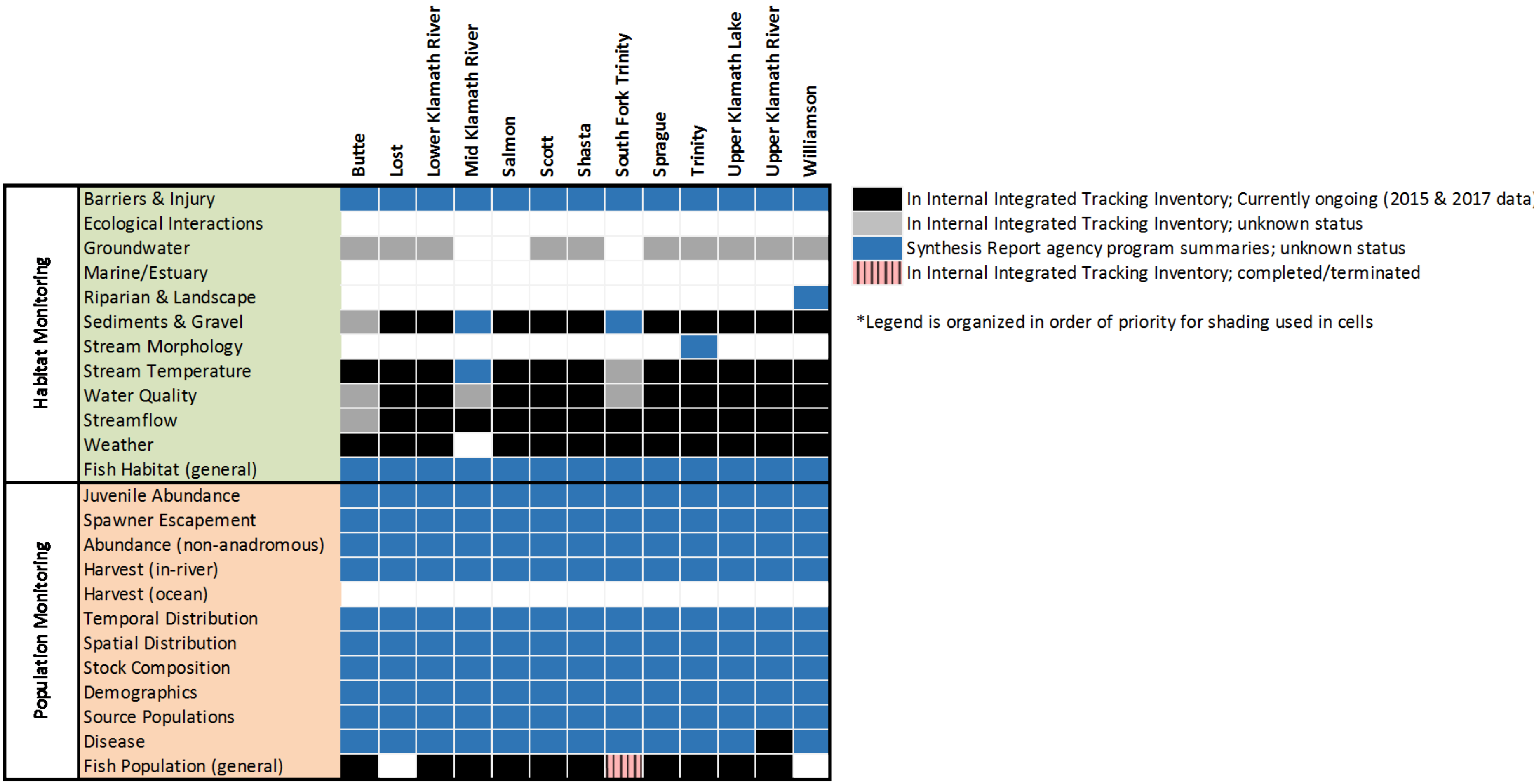

Figure 5: Synthesis of past/current monitoring activities in the Klamath Basin across monitoring agencies. Figure rows indicate general types of information collected (for habitat and population monitoring) within each sub-basin. More detailed information on agency monitoring by monitoring type and species will be provided in a supporting Excel table available at the workshop. Our full understanding at this time of the information collected by each agency is variable (as represented in the accompanying figure legend), and this figure will be updated with information solicited through the pre-workshop survey. This summary does not provide any detail in terms of the quality of the assessments.

3.2.5 A Note on Prioritization of Monitoring Activities

Optimization of monitoring is a complex decision analysis problem. **Generally, the priority management decisions/monitoring questions should drive the prioritization**. However, a single indicator or monitoring activity may often inform multiple questions. Therefore, given limited budgets it is possible to be faced with choosing between monitoring one high priority question well and monitoring multiple medium priority questions quasi-adequately.

Our approach is to first consider prioritization from several different perspectives independently and then collaboratively determine what trade-offs are preferable. For the purpose of the IFRMP three different prioritization lenses are proposed in no particular order. First the suitability of different indicators as evaluated through a set of systematic and transparent evaluation criteria described in Section 3.2.3 above. Second, involves considering the degree of certainty of restoration action effectiveness (as in **Figure 6**). The outcomes of restoration action prioritization will have some influence on monitoring activities, particularly those associated with action effectiveness monitoring. Given limited resources, it may be desirable to defer monitoring for "no-brainer" restoration actions with clear benefit and low uncertainty (e.g., restoring fish passage at a road crossing) and instead monitor effectiveness only for projects with the highest uncertainty in project effectiveness and/or magnitude of effect. For high benefit, low uncertainty projects the scope of monitoring could alternatively be limited to simply the implementation component, rather than the more expensive physical and biological effectiveness monitoring. Third, considers how many questions/objectives each monitoring activity supports. This overall approach to prioritization can be summarized in a simple monitoring activity-by-question matrix (as illustrated in the approach used for prioritizing monitoring activities within the Missouri River Recovery Program - **Figure 7**).

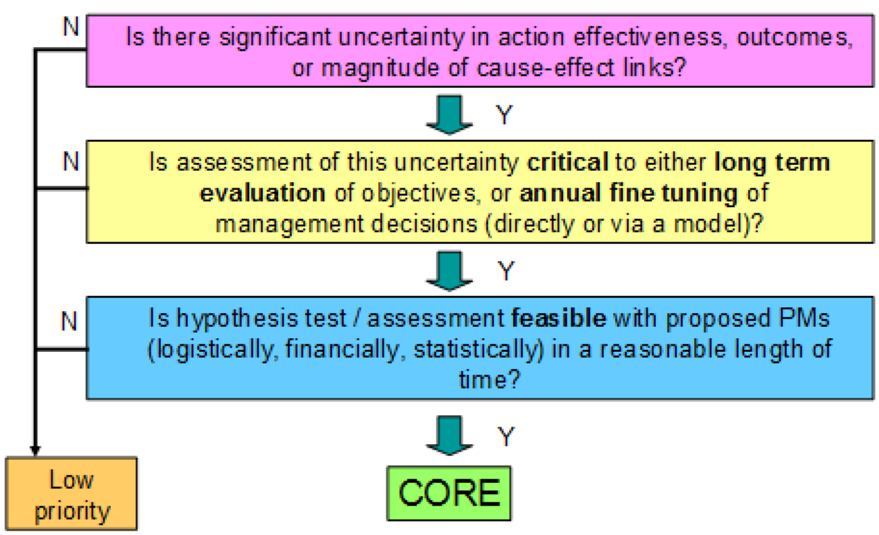

Figure 6: Summary of the criteria for prioritizing monitoring, and determining the core monitoring activities, as used in the Trinity River Restoration Program (TRRP and ESSA 2009).

Monitoring activity	E.1 IRCs		E.2 SWH		E.3 Spawning habitat projects				E.4 Level 2 spawning flows				E.5 Translocation / passage at Intake				
	Q1	Q2	Q1	Q2	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q5
Age-0 population sampling	X		X					X				X				X	X
Physical monitoring of food producing and foraging habitat		X		X													
Plankton net surveys and genetic analysis								X				X				X	X
Radio tagging, genetic analysis of motivated adults						X	X		X	X	X		X	X	X		
Passive telemetry network (and/or aerial surveys)						X			X	X			X	X			
Mobile tracking by boat						X	X			X	X			X	X		
Physical monitoring of spawning habitats					X										X		
DIDSON acoustic video						X	X			X	X				X		
3D telemetry						X	X								X		
Adult capture (e.g., trammel net) to assess size of aggregation or confirm spawning (ultrasound or pre/post weight)							X			X	X				X		
Macro-scale in-river monitoring									X	X	?	?		X			
Experimental release of reproductively ready hatchery primed but natural origin sturgeon						X	X										
Acoustic Doppler Current Profiler (ADCP) at Intake													X				
Experimental release of hatchery free-embryos above Intake Diversion Dam																	X

Figure 7: Example of a monitoring activity by monitoring question matrix as applied to the Missouri River Recovery Program. Each "x" in the matrix represents a monitoring question that can be addressed through the particular monitoring activity.

3.3 Pre-Workshop Questions for Participants

- Q1: Status quo monitoring summary – are we missing any ongoing monitoring activities by agency, monitoring type or focal fish species in our Basin-wide summary (included as an ***attachment*** in the email distributing this Briefing Document). Are there types of monitoring that you think are particularly effective or deficient?
- Q2: Having considered the objectives hierarchy, identify the top 3 basin-wide monitoring questions from your perspective?
- Q3: Are any important KPI selection criteria missing from our current subset (Table 3)? Which criteria are most important to you and why?
- Q4: Monitoring if the dams are removed – are the four proposed categories of major system-wide changes valid from your perspective? Are there any additional categories to add?

4 Preliminary Prioritization Framework

4.1 Introduction & Approach

What We Mean by Prioritization

When developing a restoration plan encompassing an entire river basin, an organizing framework is necessary to move beyond regionally-oriented restoration and prioritize those activities that will most effectively contribute to recovery of overall ecosystem function at the basin-wide scale (Beechie et al. 2008). Prioritization in this sense refers to the process of scoring or ranking potential types of restoration actions to determine the most beneficial *sequencing* to inform funding and implementation decisions. Prioritization can take place at the level of the basin, watershed, sub-watersheds, or reaches, or alternatively by habitat type. Initiatives at a regional scale may also choose to take a multi-level approach involving prioritization across watersheds followed by prioritization of projects within watersheds (Beechie et al. 2008, Roni et al. 2013b).

Effective prioritization frameworks provide a systematic, repeatable, and transparent rationale for making restoration decisions given limited funding, capacity, and time (Beechie et al. 2008, Roni et al. 2013b). Structured frameworks help to clarify the decision-making process for funding agencies, proposal reviewers, project proponents, and other stakeholders that will be affected by these decisions and facilitate reprioritization on a regular, often annual, basis as projects are completed, new opportunities are identified, and new information becomes available.

Selecting a Prioritization Approach

Many approaches to prioritization are possible depending on restoration objectives, spatial scale, and level of information available and each comes with trade-offs (Roni et al. 2013b, **Table 4**). Many of the characteristics of the Klamath River Basin exclude most of these methods outright (i.e., multiple species of conservation interest, varying levels of data availability across regions, and a wide range of interested participants and socioeconomic considerations at play). In consideration of the pros and cons of alternative methods, we recommend that the IFRMP develop a **Multi-criteria Decision Analysis (MCDA)**[1] framework. Multi-criteria scoring approaches are transparent, repeatable and highly adaptable.

Applying multi-criteria scoring involves the following key steps:

- selection of criteria,
- identifying the scoring and weighting method,
- data collection and inventory analysis to assist with scoring, and finally
- scoring and ranking.

[1] We prefer the term “multi-criteria scoring” over MCDA.

Table 4: Common approaches for prioritizing restoration (adapted from Beechie et al. 2008, Roni et al. 2013).

Approach	Description	Pros	Cons
Logic-Based Approaches			
Project Type & Effectiveness	Ranks projects based on general understanding of effectiveness from literature review.	Helpful interim approach if no or limited data available on physical habitat conditions.	Ignores local influence of local contexts on effectiveness of a given project type.
Refugia	Prioritizes protecting refugia first, and then restoration near refugia.	Useful approach for single species dependent on a specific habitat type.	Challenging to implement for multiple species with different habitat requirements. Doesn't encourage process and function rehabilitation in highly degraded environments.
Multi-criteria Decision Analysis (MCDA)*	Also known as multi-criteria scoring. A rubric where projects or watersheds are scored on multiple criteria (e.g., effectiveness, cost, extent) to determine overall rank.	Widely used, transparent and easy to document, incorporates multiple information types, and adaptable to varying spatial scales and data availability.	Scales and weightings used for criteria imply some level of subjectivity in prioritization. Priorities are influenced by 'who' is asked to participate in the scoring.
Analytical Approaches			
Scale of Effect	Ranks projects by area restored and/or projected increase in fish production	Based on habitat-abundance relationships derived from empirical data.	Data may be unavailable in all regions, challenging to predict benefit to fish populations for specific projects with much certainty.
Capacity or Life-Cycle Computer Models	Estimates population benefits at each life stage to predict overall population benefit from a given project. Other types of computer models use statistical approaches to predict restoration outcomes.	Based on empirical data for specific life stages, and species, can handle complex data types.	Complex, time consuming, requires detailed habitat and fish population data by life stage, and difficult to draw conclusions at the project scale. Often many assumptions with rankings sensitive to these assumptions. One of the least transparent approaches for some stakeholders.
Cost-Benefit	A strictly cost or cost-benefit approach to ranking projects.	Provides a common currency for comparing across projects.	Many benefits are hard to translate in economic terms. Costing data difficult to obtain or compare across project types, and economic benefits of restoration challenging to estimate, omits other factors contributing to project effectiveness.

Selecting Prioritization Criteria

Multi-criteria scoring is transparent and relies on a set of criteria associated with simple scales and weighting systems (Roni et al. 2013b). This type of prioritization framework is widely used in restoration programs, for example:

- By agencies setting project priorities for Species Recovery Plans (e.g., for SONCC Coho, Table 6-3 in NMFS 2014; for Pacific lamprey in Appendix B of Goodman and Reid 2015).
- By programs setting project priorities for a specific type of restoration action with multispecies benefits (e.g., prioritizing fish passage projects in Oregon, ODFW 2013).

- By grant programs selecting among project funding proposals that best meet their program's regional restoration priorities (e.g., the Oregon Watershed Enhancement Board's Prioritization Framework, OWEB 2005).

The criteria within a multi-criteria scoring framework generally fall into one of the following broader categories:

- **Technical/Scientific Benefit**
- **Feasibility**
- **Social Considerations**
- **Cost**

On July 10, **we would like discuss the general level of support for developing a multi-criteria scoring approach and solicit your input on whether our preliminary ideas for criteria in each of these categories are suitable**. In preparation for this discussion, we have prepared a *very early, rough draft* of some of the types of criteria that may eventually be defined and included (**Figure 8**). These early draft criteria were drawn from key references cited in this section, as well as from the suggestions provided in the March 2018 workshop for this project.

The criteria that are ultimately included will eventually be associated with a clear scoring scale, and if different scoring ranges are necessary there will also be rules for normalization to a common scale. If the approach is scored my multiple people, scores are typically averaged or summed, or otherwise rolled up to arrive at a final ranking for each project. While there are numerous ways of weighing and calculating scores, the more complicated the method, the more difficult it will be for a broad audience to understand. Note that **the development of specific scales and weighting factors for each criterion selected would be determined in a future IFRMP phase** once the prioritization framework is fully developed (it is premature to address this issue at the July 2018 workshop).

Where the number of projects and/or prioritization criteria to consider is large, **inventory approaches are usually necessary to automate / streamline the process**. For example, in the Columbia River Basin, a spatial GIS database is used to store criteria data and carry out prioritization in two tiers. In Tier I Prioritization, the database helps carry out scoring on stressor criteria to prioritize sites, and in Tier II, the database helps carry out scoring on effectiveness, feasibility, and cost criteria to prioritize specific project proposals at high-priority sites, and displays prioritization outcomes on a map for consideration by a decision-making committee (Thom et al. 2011). At the workshop, we will present this and possibly one or two other case studies of prioritization frameworks in action.

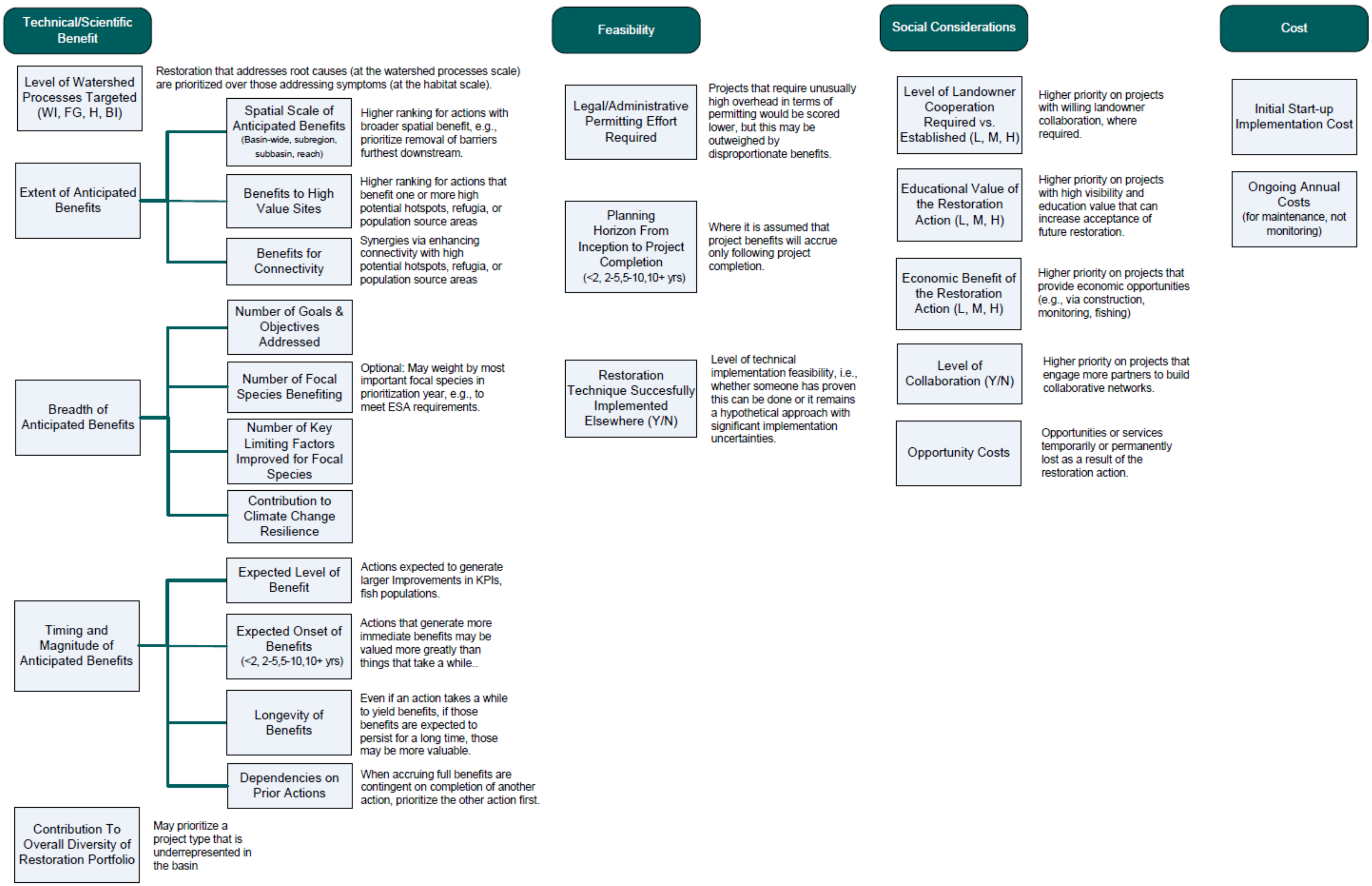

Figure 8: Early rough draft of potential restoration project prioritization criteria for the Klamath River Basin IFRMP for discussion at the workshop.

Interpreting Prioritization Outcomes

It is very important to understand that a low prioritization rank for a project does *not* necessarily mean it should *never* be implemented. For example, some projects may have greater benefit if implemented later in the restoration sequence after other tasks have already been completed, and other projects scoring high on potential benefit but low on proven effectiveness may be candidates for research studies coupled with effectiveness monitoring before they are widely implemented. Finally, we should always remember that prioritization frameworks provide guidance, but groups of people will ultimately make the ranking final decisions. In practice, lower ranking projects are sometimes implemented first because they are either easy to implement or less expensive.

4.2 Pre-Workshop Questions for Participants

Recognizing the draft criteria in Figure 8 are only preliminary ideas to initiate a discussion…

Q1: What are your general likes and dislikes for the criteria listed in Figure 8?

Q2: Do the overall categories and criteria capture the range of values embodied by your agency/group? What else should be added? What should be removed? Please include your rationale.

Q3: Comment on which if any criteria should be given greater weight than others, and if you can, provide a brief rationale.

Q4: Do you think the scoring system should be applied and updated annually? Every 2-3 years? Other? Why?

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