Appendix A: RM&E Management Questions, Information Needs, and Cost Sharing Agencies (BPA 11/14/05)

RM&E Framework Component	Management Questions	Subordinate Questions	Regional Information Needs					
			Metrics	Data Required	Survey or Experimental Design	Spatial Scale	Temporal Scale	Agencies[1] with Cost Sharing Responsibilities
Tributary Habitat Status and Trend Monitoring	Are Columbia Basin fish populations meeting population level objectives (abundance, productivity, and diversity)?							
		What is size of adult salmonid and resident fish populations?	Numbers of adult fish	Numbers of adults, spawners, or redds	Census or spatially balanced survey[2]	Columbia Basin, ESU, Population, Core Area, or Sub-population	Annual sampling	1st: FR, S, T 2nd: AA, LU
		What is the distribution of salmonid and resident fish populations??	Presence/absence of adult fishes	Presence of adults, spawners, or redds	Census	Columbia Basin, ESU, Population, Core Area, or Sub-population	Sampling every 3 to 5 years	1st: FR, S, T 2nd: AA, LU
		What is the growth rate of adult salmonid and resident fish populations??	Returns/Spawner, Lambda, Temporal Trends	Numbers of adults, spawners, or redds	Census or spatially balanced survey	Columbia Basin, ESU, Population, Core Area, or Sub-population	Annual for at least 3 generations	1st: FR, S, T 2nd: AA, LU

[1] FR= Fish Regulatory Agencies (NOAA and/or USFWS); AA= FCRPS Action Agencies (BPA, COE, BOR); LU= Land Management Agencies (USFS, BLM); EPA= Environmental Protection Agency; S = State Agency; T= Tribe
[2] Spatially-Balanced Survey Design (e.g., EMAP-GRTS design; see Stevens and Olsen 2004)

		What is the freshwater productivity of these populations?	Smolts, fry or parr produced per adult, spawner, or redd	Number of smolts, fry or parr	Census or spatially balanced survey	Columbia Basin, ESU, Population, Core Area, or Sub-population	Annual sampling	1st: FR, S, T 2nd: AA, LU
		What is the age structure of these populations?	Age of returning adults or spawners	Otolith, scale, or length of adults or spawners	Census or spatially balanced survey	Columbia Basin, ESU, Population, Core Area, or Sub-population	Annual sampling	1st: FR, S, T 2nd: AA, LU
		What fraction of the spawners of these populations is of hatchery origin?	Ratio of hatchery to total fish abundances	Number of hatchery produced adults or spawners	Census or spatially-balanced survey	Columbia Basin, ESU, Population, Core Area, or Sub-population	Annual sampling	1st: FR, S, T 2nd: AA, LU
	Are aquatic, riparian, and upland ecosystems of the Columbia Basin being degraded, restored or maintained relative to desired conditions or objectives?							
		What is the biological condition of spawning and rearing habitat for Columbia Basin fish populations?	Macro-invertebrate and fish assemblages		Spatially-Balanced survey	Stream, watershed, subbasin	Annual sampling	1st: FR, EPA, S, T 2nd: AA, LU
		What is the physical condition of spawning and rearing habitat for Columbia Basin fish	Valley characteristics (valley bottom types, valley widths and gradients, valley		Spatially-balanced survey [1]	Stream, watershed, subbasin	Annual sampling	1st: LU, S, T 2nd: AA, FR

		populations?	containment, road density, land ownership, land use); Channel characteristics (bed-form types, channel types, gradient, width/depth ratio, stability); Riparian vegetation (structure, disturbance, canopy cover); Habitat access (dams and diversions); Stream flows; Habitat quality (substrate, embeddedness, large woody debris, pools, off-channel habitat, fish cover)					
		What is the water quality in spawning and rearing habitats for Columbia Basin fish populations?	Temperature, Turbidity, Conductivity, pH, Dissolved Oxygen, Nutrients, Toxic Pollutants and Heavy Metals		Spatially-balanced survey	Stream, watershed, subbasin	Annual sampling	1st: EPA, S, T, LU 2nd: FR, AA
Tributary Habitat Action Effectiveness Research	What actions are most effective at addressing the limiting factors preventing achievement of habitat, fish or wildlife performance objectives?							

		Did all tributary habitat actions in aggregate for a sub-population increase juvenile survival or adult abundance, compared to a similar sub-population with few or no habitat actions?	Type, location, timing and intensity of habitat actions, and juvenile survival or adult abundances	Depends on management actions	Large-scale Before-After (BA) Studies[3]	Watershed, Subbasin	Depends on management action(s)	1st: AA, S, T 2nd: FR, LU
		What contribution did all tributary habitat actions for an ESU make toward increasing the ESU-level population growth rate?	Type, location, timing and intensity of habitat actions, and ESU population growth rates	Depends on management actions	Large-scale Before-After (BA) Studies	ESU scale	Depends on management action(s)	1st: AA, S, T 2nd: FR, LU
		Did a single tributary habitat action increase local fish abundance or distribution, or improve local environmental conditions, compared to a similar control or reference site?	Type, location, timing and intensity of habitat action, local fish abundance or distribution, and/or habitat conditions	Depends on management actions	Project-scale Before-After Studies[4]	Stream, Watershed	Depends on management action(s)	1st: AA, LU, S, T 2nd: FR
		Did some classes of actions (e.g., riparian restoration actions) perform better than other classes (e.g., passage improvement	Type, location, timing and intensity of habitat actions, and local habitat conditions and/or juvenile fish survivals	Depends on management actions	Project-scale Before-After Studies	Stream, Watershed	Depends on management action(s)	1st: AA, S, T 2nd: FR, LU

[3] Intensive BA, BACI, or Staircase designs; see Roni et al. 2005
[4] Intensive BA, Extensive BA, or replicated BACI; see Roni et al. 2005

		actions) in improving localized conditions or sub-population juvenile survival rates?						
Tributary Habitat Uncertainty Research	What are the limiting factors or threats preventing the achievement of desired habitat, fish or wildlife performance objectives?							
		What is the relationship of habitat processes and functions of upslope, riparian, and aquatic systems to biological and environmental habitat attributes?	Watershed condition metrics identified above.	Watershed condition data identified above.	Depends on correlation or experimental approach	Stream, watershed, subbasin	Depends on correlation or experimental approach	1st: LU, S, T, EPA 2nd: FR, AA
		What is the relationship of habitat attributes, processes, and/or functions to fish and wildlife abundance, productivity, and diversity?	Watershed condition and fish population metrics identified above.	Watershed condition and fish population data identified above.	Depends on correlation or experimental approach	Stream, watershed, subbasin	Depends on correlation or experimental approach	1st: FR, S, T 2nd: AA, LU, EPA
Hydro Status and Trend Monitoring	Are salmon and steelhead meeting juvenile and adult hydro passage objectives?	Are smolts achieving survival standards prescibed in the NOAA BOs?	Smolt survival estimates through impounded reaches of the Snake and lower Columbia System survival estimates reflecting delayed effects	PIT tag detection histories through the FCRPS Tagging ample # of fish at hatcheries as	Cormack-Jolly-Seber single release model	LGR to BON tailrace, when possible	Annual	1st: AA 2nd: FR

			of transported smolts	surrogates for wild ones. Annual estimates of D				
		Are adults achieving survival standards prescribed in the NOAA BOs?	Survival indices of adult salmon and steelhead through the FCRPS. *NOTE- AFEP funds some, but not all, data elements required under this objective. Close coordination with AFEP required*	PIT detection histories at ladder-based detectors, for known source fish. Estimates of stray rates Estimates of	Accounting of fates for returning PIT tagged fish.	BON to uppermost dam as applicable to an ESU	Annual	1st: AA 2nd: FR

				harvest removals of PIT tagged fish in the Mainstem. Estimates of incidental harvest mortality, e.g., net drop out rates, catch and release related mortality, etc.				
Hydro Action Effectiveness Research	*NOTE- AFEP funds elements required under this objective. Close coordination with AFEP is required.*							
Hydro Uncertainty Research	What is the magnitude of delayed effects associated with transporting smolts?	Under what conditions does inriver passage yield higher SARs than transport?	Estimates of D for wild and hatchery fish	PIT tag detections juveniles and returning adults SAR for transport and inriver groups, i.e. TIR estimates Inriver survival estimates Direct transport survival estimates	Empirical estimates & model derived estimates for populations of some inriver migrants	Individual transport sites to designated return site.	Annual	1st: AA 2nd: FR

		Is transport appropriate for some locations and not others?	TIR estimates for wild and hatchery fish					1st: AA 2nd: FR
	Do smolts migrating through the FCRPS incur delayed effects?	What is the magnitude of such effects?	SARs linked to different smolt passage fates or experiences	PIT tag detections as juveniles to describe migratory experience PIT detections of returning adults	Compare SAR among treatment groups	Variable	One to several years	1st: AA 2nd: FR
		What are the causes and can they be rectified?	Localized smolt survival rates (Identfiy zones of particularly intense mortality that could depress SAR)	Variety, e.g. PIT, acoustic tag or radio telemetry data from smolts.	Compare survival with reference areas.	Geographically localized, e.g. bird predation centered at islands	One to several years	1st: AA 2nd: FR
Estuary Habitat Environmental Status and Trend Monitoring	Are aquatic, riparian, and upland ecosystems of the estuary (from Bonneville Dam to the mouth of the Col. R.) being degraded, restored or maintained relative to desired conditions or objectives?	Using a hierarchical habitat classification system based on existing hydro-geomorphology, to what quantitative extent are we avoiding further loss to existing shallow water wetland habitat and restoring degraded habitats, in particular for listed salmonids?	Characterization of Vegetation cover, Geology/ soils, Floodplain topography, Bathymetry	Habitat classification	Census (mensurative) or spatially balanced survey	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What is the amount of habitat in absolute acreage, by habitat type,	Measurements of Area affected	Habitat classification Habitat condition	Census (mensurative) or spatially	BON to mouth	Annually	1st: FR 2nd: AA, S

		that was restored annually and by proportion of the total lost historically for each habitat type for each reach of the CRE?			balanced survey			
		What is the index of habitat connectivity by reach and its status/trend?	Connectivity -- Inventory of Passage barriers and Total edge, density and sinuousity of floodplain and tidal channels.	Habitat connectivity	Census (mensurative) or spatially balanced survey	BON to mouth	Annually	1st: FR 2nd: AA, S
	What are the status/trends in attributes of the CRE, plume, and ocean ecosystems?	What are estuary habitat physical properties?	Habitat -- Characterization of Vegetation cover, Geology/ soils, Floodplain topography, Measurements of Bathymetry	Habitat condition and classification	Statistical (mensurative) or Spatially balanced survey	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What are estuary fish population properties, especially with respect listed salmonids?	Fish – Estimates of Species composition, Age/size-structure, Stock identity, Temporal distribution, Spatial distribution, Migration pathways, Growth rate, Residence time, Prey availability, Foraging success, Survival rate, Predation index	Life history diversity, spatial distribution, growth, survival	Statistical (mensurative) or spatially balanced survey	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What are estuary hydrograph and water quality properties?	Water -- Measurements of Hydrograph, Temperature, Salinity, Dissolved oxygen, pH,	River discharge, water quality	Statistical (mensurative) or spatially balanced survey	BON to mouth	Depends on metric	1st: FR 2nd: AA, S

			Turbidity, Nutrients, Toxics					
		What are invasive species properties?	Invasives -- Invasive species list, Invasive spatial distribution, Invasive abundance	Invasive species assessment	Statistical (mensurative) or spatially balanced survey	BON to mouth	3 yrs	1st: FR 2nd: AA, S
		What are the environmental conditions and salmon ecology in the Col. R. plume and ocean relative to salmon production and survival?	Plume and Ocean -- Estimates of Juvenile salmon usage, Growth, Survival, Zooplankton prey base, and Anchovy/ herring index in the plume and Measurements of Sea surface temperature, Northern oscillation index, Upwelling index, chlorophyll	Ocean and plume conditions, Growth, residence time, survival,	Statistical (mensurative) or spatially balanced survey	Plume and N. Pacific Ocean	Depends on metric	1st: FR 2nd: AA, S
Estuary Action Effectiveness Research	What actions are most effective at addressing the limiting factors preventing achievement of habitat, fish or wildlife performance objectives?	What is the cumulative effect of multiple habitat restoration projects on the CRE ecosystem?	See "Connectivity", "Habitat" and "Fish" above	Habitat cond's, habitat connectivity, fauna, life history diversity, spatial dist., growth, survival, predation, water quality physical cond.,	Effectiveness (mensurative) or Large-scale Before-After (BA) Studies	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What are the effects of hydrologic reconnection projects (e.g., dike breaches, new tide gates and culverts) and	See "Connectivity", "Habitat", "Fish" and "Invasives" above	Habitat connectivity, life history diversity, spatial dist., growth, survival,	Effectiveness (mensurative) or Project-scale Before-After Studies	BON to mouth	Annually	1st: FR, AA 2nd: S

		revegetation projects?		invasive species				
		What possible changes to FCRPS operations might improve habitat conditions in the CRE for Columbia basin salmonids?	Ibid.	Ibid.	Effectiveness (mensurative) or Large-scale Before-After (BA) Studies	BON to plume	Depends on metric	1st: FR, AA 2nd: S
Estuary Uncertainties Research	What are the limiting factors or threats in the estuary preventing the achievement of desired habitat, fish or wildlife performance objectives in the Col. Basin?	What is the ecological importance of the Columbia River estuary and oceanic plume to the viability and recovery of salmonid populations in the Columbia Basin?	See "Connectivity", "Habitat", "Fish", "Invasives" and "Plume and Ocean" above	Habitat cond's, habitat connectivity, fauna, life history diversity, spatial dist., growth, survival, predation, water quality physical cond., river discharge, plume conditions	Effectiveness (mensurative) or Large-scale Before-After (BA) Studies	BON to plume	Depends on the metric	1st: AA 2nd: FR, S
		What are the effects of toxics on salmonids?	See "Fish" above, plus estimates of concentrations and distributions of Toxics	Water quality, life history diversity, spatial distribution, growth	Depends on correlation or experimental approach	BON to mouth	Depends on metric	1st: FR 2nd: AA, S
		What are the causal mechanisms affecting survival of juvenile salmon during their first months in the ocean?	See "Fish" and "Plume and Ocean" above	life history diversity, spatial dist., growth, survival, predation plume conditions	Depends on correlation or experimental approach	BON to plume	Depends on metric	1st: FR 2nd: AA, S
		What is the survival rate by species of juvenile	Estimates of smolt survival rates, predation	Survival	Cormack-Jolly-Seber single	BON to mouth	Seasonally	1st: FR 2nd: AA, S

		salmonids migrating downstream from Bonneville Dam to the mouth of the Columbia River?	indices		release model			
Hatchery Status and Trend Monitoring	What is the relative proportion of hatchery spawning salmon and steelhead compared to wild fish populations?		Ratio of hatchery fish to total fish abundance	Numbers of hatchery-origin and natural-origin fish on spawning grounds	Develop requisite marking guidelines and proceed with the marking of remaining groups of unmarked fish released from hatcheries to facilitate monitoring of hatchery-origin fish in natural spawning areas	Census or spatially balanced survey	Annual sampling	1st: AA 2nd: FR
Hatchery Action Effectiveness Research	Can hatchery reforms reduce the deleterious effects of artificial production on listed populations, thereby contributing to a reduction in extinction risk for affected natural populations?		Returns/spawner, lambda, temporal trends, or other metrics as determined by experimental design	Numbers of adults, spawners, or redds, or other data as determined by experimental design	Studies of modifiied hatchery practices (“reforms”) that involve controlled experiments designed and replicated sufficiently to provide statistically and	As required by experimental design	As required by experimental design	1st: AA 2nd: FR

					biologically meaningful results pertinent to multiple programs.			
	Can properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations?		Returns/spawner, lambda, temporal trends	Numbers of adults, spawners, or redds	Treatment and control studies using existing safety-net programs intended to reduce extinction risk of targeted populations.	Selected populations	Annual	1st: AA 2nd: FR
Hatchery Uncertainties Research	What is the reproductive success of hatchery fish spawning in the wild relative to the reproductive success of wild fish?		Number of offsping produced by hatchery x hatchery, hatchery x wild, and wild x wild matings in natural spawning areas and subsequent adult returns from each type of cross	DNA pedigree analysis	Hatchery/wild reproductive success studies	Selected populations	Annual for 2 or 3 generations	1st: AA 2nd: FR
Harvest Status and Trend Monitoring	What are the boundaries of uncertainty around harvest point estimates?	What are the harvest rates on listed wild fish?	Numbers of adult fish harvested and numbers of adult fish escaping	Dam Counts; harvest estimates; PIT tag detections at dams	Census at Dams; sub-sample in fisheries	Columbia Basin; ESU	Continual during fishery	1st: FR 2nd: AA
Harvest Action Effectiveness Research	Are new selective gear types effective at harvesting?		Catch Per Unit of Effort; Catch related to capital and operating expense	Standardized measures of catch and effort		Columbia Basin, ESU	Continual during fishery	1st: FR 2nd: AA
Harvest Action Effectiveness	What is the post-release survival of salmon		Survival rates	Tagging for fish that are caught	Treatment/control	Columbia Basin, ESU	Continual during	1st: FR 2nd: AA

Research	caught in a mark-selective fishery compared to fish that were not harvested?			compared to those not caught			fishery	
Predator Status and Trend Monitoring	What is the impact of predators on juvenile salmonids within the Columbia River Basin?							
		What are the nesting distribution, colony size, and colony productivity for the major avian predators within the Columbia River Basin?	Presence/absence of avian predator colonies, colony size, number of nesting pairs, reproductive chronology, reproductive success rates	Colony location, colony size, number of nesting pairs, timing of reproductive events, reproductive success	Census; statistical sample	Columbia Basin or colony	Annual sampling	1st: AA 2nd: FR
		What are the juvenile salmonid consumption rates of major avian predators within the Columbia River Basin?	Diet composition, consumption rates	On-colony PIT tag deposition rates and detection efficiency, diet samples, bill load observation	Statistical sampling of targeted populations	Columbia Basin or colony	Annual sampling	1st: AA 2nd: FR
		What are the consumption rates of major pisciverous predators in the Columbia River Basin?	Abundance, distribution, diet composition, fecundity consumption rates	Abundance, distribution, diet composition, consumption rates	Statistical sampling of targeted populations	Columbia Basin	Annual sampling	1st: AA 2nd: S
	What is the impact of predators on adult							

	salmonids within the Columbia River Basin?							
		What are the consumption rates of mammalian predators (marine) in the Columbia River Basin?	Abundance, distribution, consumption rates, diet composition	Abundance, distribution, consumption rates, diet composition	Census or statistical sampling	Columbia Basin (BON to estuary)	Annual	1st: FR 2nd: AA, S
Predator Action Effectiveness Research	What are the most effective management alternatives/actions that could be used to reduce the impact of predators?							
		What is the effect of alternative management alternatives/actions used to reduce the impact of avian predators?	% Change in Juvenile Salmonid Survival, % Change in Avian Predation Rate	Colony location, colony size, number of nesting pairs, timing of reproductive events, reproductive success, On-colony PIT tag deposition rates and detection efficiency, diet samples, bill load observation	Large-scale Before-After (BA) Studies[5]	Columbia River, alternate habitat location, or colony	Depends on management action(s)	1st: AA 2nd: FR
		What is the effect of management alternatives/actions used to reduce the impact of	% Change in Juvenile Salmonid Survival, % Change in pisciverous Predation Rate	Abundance, distribution, diet composition, fecundity	Large-scale Before-After (BA) Studies	Systemwide Columbia Basin	Depends on management action(s)	1st: AA 2nd: S

[5] Intensive BA, BACI, or Staircase designs; see Roni et al. 2005

		pisciverous predators?		consumption rates				
Predator Uncertainty Research								
Wildlife Status and Trend Monitoring								
Wildlife Action Effectiveness Research	What are the species response to the various protection/restoration efforts?	How has the mitigation target species responded to fee title versus conservation easements?	Target species abundance for pre/post protection measure	Numbers of adults by target species	Large-scale Before-After (BA) Studies[6]or Project-scale Before-After Studies[7]	Columbia basin	Depends on management action(s)	1st : S,T 2nd : LU
		How has the mitigation target species responded to various habitat enhancement efforts?	Target species abundance for pre/post enhancement measure	Numbers of adults by target species	Large-scale Before-After (BA) Studies or Project-scale Before-After Studies	Columbia basin	Depends on management action(s)	1st : S,T 2nd : LU
Wildlife Action Effectiveness Research								

[6] Intensive BA, BACI, or Staircase designs; see Roni et al. 2005
[7] Intensive BA, Extensive BA, or replicated BACI; see Roni et al. 2005