6. Recovery Strategy: Adaptive Management Framework and Site-Specific Actions

6.1 Recovery Strategy

The recovery strategy is designed to meet the goal of ESA delisting and to be consistent with broad sense goals that go beyond ESA delisting. Delisting goals and broad sense goals are provided in Chapter 3.

Snake River fall Chinook salmon ESU and Major Population Group
The Snake River fall Chinook salmon ESU has unusual characteristics that pose challenges for both scientific understanding and successful management. The ESU has only one major population group (MPG). The MPG includes three historical populations, two of which are extirpated due to Hells Canyon Complex barriers in the mainstem Snake River. Successfully reestablishing a second population in historically productive habitat upstream of the Hells Canyon Complex would increase the species' geographical distribution and abundance and further reduce risks associated with potential catastrophic events. However, conditions in the habitat upstream of the Hells Canyon Complex are severely degraded and would need to improve substantially in the coming decades before any reintroduction effort could succeed. In addition, providing safe and effective downstream passage for migrating smolts remains a substantial technical challenge that would need to be overcome. It will take decades to restore Snake River fall Chinook salmon above the Hells Canyon Complex. Fortunately, the remaining extant population, Lower Mainstem Snake River fall Chinook salmon (Lower Mainstem Snake population), is well distributed over a large area and has demonstrated substantial increases in natural origin returns since the extremely low spawning levels at the time of listing in the early 1990s. Thus, as presented in Chapter 3 (Delisting Criteria) it may be possible to recover the ESU with only one population, if we are highly confident that it is highly viable.

The general recovery strategy is to protect and improve the status of the Lower Mainstem Snake population while actively pursuing the potential for a second population above the Hells Canyon Complex, all as part of an adaptive management framework. Many of the actions for the Lower Mainstem Snake population, particularly those addressing passage and migration habitat, rearing habitat, and predation in the mainstem Snake and Columbia Rivers, would also create conditions that benefit a potential second population above Hells Canyon.

The Lower Mainstem Snake River fall Chinook Salmon population (extant)
Since multiple causes are responsible for impaired population viability, limiting factors and threats throughout the entire life cycle will need to be addressed in concert. The recovery strategy for the Lower Mainstem population prioritizes specific management actions across sectors (hydropower, habitat, hatcheries, and harvest) and calls for targeted RM&E actions to validate or improve on current working hypotheses. Given the recent increases in natural origin abundance of the Lower Mainstem Snake population, a major focus of the near term recovery strategy is to confirm the driving factors for the increase and to validate or update management provisions to sustain long term population viability.

Comment [EG1]: Note to reviewers:.

NOAA is presently evaluating a range of potential viability scenarios that will be provided in Chapter 3. We also intend to update the status assessment from NOAA's 2010 five- year review for Chapter 4. These chapters will be distributed for co manager review this spring.

We are distributing Chapter 6 now, while Chapters 3 and 4 are in development for an early review opportunity. We expect that the recovery strategy and management actions provided in Chapter 6 would be the same through 2018 for all viability scenarios that we are evaluating for chapter 3. By 2018, we expect additional information from ongoing RM&E that should inform decisions for potential refinement of viability scenarios and for potential adjustments to management actions accordingly.

A high priority element of the strategy is to evaluate the mechanisms leading to the relatively recent increases in apparent survival related to passage through the hydropower system and lower Columbia River mainstem. A better understanding of those mechanisms should identify key actions to maintain as well as elucidate the potential for further survival increases through further adaptations. Ongoing RM&E is evaluating management options that could further increase survivals associated with rearing and migration through the mainstem Columbia and Snake River corridors. An ongoing evaluation of the efficacy of juvenile collection and transport will likely result in modifications to the current juvenile transport strategies. There are potential opportunities for gaining additional survival improvements from actions addressing both the mainstem and reservoir reach immediately upstream of Lower Granite Dam and the federal hydropower system reaches extending downstream to the estuary. Additional opportunities to increase survival may include modifying Hells Canyon Complex operations to further minimize stranding and entrapment in upstream reaches and to improve water quality. Also, there may be opportunities to reduce predation on juvenile fall chinook in the Lower Granite reservoir reach above Lower Granite Dam by reducing predator levels or altering predator 'friendly' shallow water habitats.

Habitat protection and restoration actions are designed to protect and expand on current spawning and rearing habitats in mainstem and tributary reaches. Ongoing juvenile monitoring programs have detected density dependent patterns in growth, survival and timing associated with the recent increases in fall chinook spawning levels above Lower Granite Dam. Studies are underway to evaluate how those patterns are influenced by environmental conditions, exposure to predation and management operations. While mainstem Snake River reaches contain most of the current and potential spawning habitat for the extant population, the strategy incorporates measures to expand natural production in the lower mainstem sections of major tributaries as well.

The recent increases in natural origin returns of the Lower Mainstem Snake population have been accompanied by substantial increases in hatchery origin returns. Another major priority under the recovery strategy involves evaluating and adapting the hatchery program in support of achieving the full range of long term viability objectives for the naturally spawning population, including diversity and spatial structure parameters. Short term studies are underway to determine the homing fidelity and dispersal patterns associated with the range of release locations comprising the current program. Preliminary results indicate that it may be feasible to shift production among release locations to ensure that the bulk of natural production comes predominately from natural origin spawners in one or more major spawning areas. Shifts in release locations could include targeting a component of hatchery returns into underseeded tributary reaches in the Salmon and Clearwater River drainages.

Snake River fall Chinook salmon are subject to harvest in ocean and in-river fisheries. Ocean fisheries impacts on stocks including Snake River fall Chinook salmon are coordinated through the Pacific Salmon Commission and the U.S. regional fisheries management councils. In the Columbia River, mainstem harvest of Snake River fall Chinook salmon is managed according to abundance driven sliding scale schedule. Annual assessments of the performance of these management regimes and periodic reassessments of the efficacy of the overall harvest

management framework in contributing to achieving viability objectives are key components of the overall recovery strategy.

In addition to the specific management actions and their related RM&E in each of these sectors, the recovery strategy also includes elements aimed at factors which are not well understood but may potentially confound progress towards recovery objectives. Chief among these elements are gaining a better understanding of the potential impacts of climate change during freshwater and ocean life stages, the potential for negative impacts of exotic species on fall Chinook salmon survival through competition or predation or alterations in the prey base, and the potential that exposure to toxins may negatively affect production.

The Snake River Middle Mainstem and Snake River Upper Mainstem Populations (extirpated)
The recovery strategy for the population(s) above the Hells Canyon Complex is to undertake and complete feasibility studies for upstream and downstream passage over the Hells Canyon Complex, restoration of historic habitats above the Hells Canyon complex, and for reintroduction of the species. The timing of the feasibility studies and implementation of their results should be determined through the ongoing Hells Canyon Complex relicensing proceedings.[1] In the meantime, actions that protect and restore passage, migration and rearing habitat for the Lower Snake population below the Hells Canyon complex would benefit potential reintroduced populations above Hells Canyon.

6.2 Adaptive Management Framework

This recovery strategy depends on implementation of an adaptive management framework that implements site specific actions based on best available science, monitors to improve the science, and updates actions based on new knowledge. The ESA section 4(f) requires site specific actions "as may be necessary to achieve the plan's goals for conservation and survival of the species." There are two types of site specific actions in this plan: management actions and RM&E actions. Our overarching hypothesis is that the management actions will be effective in improving survival; however, we have substantial uncertainties about whether they will be sufficient to achieve viability. The RM&E actions evaluate the species' status compared to viability objectives; the effectiveness of ongoing management actions in each; and the potential effectiveness of additional management actions for improved survival. The RM&E actions also address issues that are not well understood (critical uncertainties) but may potentially confound progress toward viability.

This recovery plan depends on an adaptive management framework as follows:

1) Establish recovery goals and viability and threats criteria for delisting (Chapter 3).

2) Determine the species present status and the gaps between the present status and viability criteria (Chapter 4).

[1] Reference for the FERC proceedings…

3) Assess the threats and limiting factors in each of the major planning sectors that are contributing to the gaps between present status and viability criteria (Chapter 5). Also, assess the threats in the context of variable ocean conditions and emerging climate change.

4) Implement management actions (Chapter 6) that target the limiting factors and threats associated with each of the major planning sectors.

5) Implement RM&E actions (Chapter 7) to evaluate the status and trend of the species and the status and trend of limiting factors and threats, including action implementation and action effectiveness.

6) Address critical uncertainties (Chapter 7). There are critical uncertainties about the species status, effects of ongoing and proposed actions, the role of the ocean and climate change, and the best opportunities for further improving survival sufficiently to meet the viability criteria. These uncertainties are described and prioritized in the RM&E Chapter (Chapter 7)

7) Establish a contingency process. We need to be prepared if the species' status does not continue to improve in a timely manner and also if there are significant declines in status. A contingency process should be implemented, as established in the 2010 FCRPS Biological Opinion Adaptive Management Implementation Plan, that incorporates early warning indicators and sets significant decline triggers. Intermediate goals and timeframes could also be incorporated into the framework. As part of this process, additional actions should be developed that are "on the shelf," if needed, to address long term trends toward recovery and to prevent precipitous declines. The need for this contingency process is also addressed in the Implementation Chapter (Chapter 8).

8) Review progress and identify best opportunities for survival improvements. Regular major reviews of implementation progress, species response, and new information are needed. These progress reviews are addressed in the Implementation Chapter (Chapter 9).

9) Adjust actions according to progress reviews. The success of this recovery plan depends on an implementation structure that takes action in response to the results of progress reviews.

10) Repeat the adaptive management cycle. Adaptive management should be a continuous loop of action implementation, monitoring and evaluation, new information, assessment of information and updated actions.

6.3 Prioritizing and Sequencing Site Specific Actions

Prioritization Considerations

Protecting and restoring ecological processes throughout the entire life cycle is essential for conserving the ESU and the productive capacity of its habitat. Conservation of the existing habitat that supports core production and primary life history types as well as quality migration habitats is a critical priority. Given that they are primarily mainstem spawners, Snake River fall Chinook salmon spawning and rearing habitat is affected by large scale hydropower and water management actions more so than other Snake River salmon and steelhead species. Furthermore, Snake River fall Chinook salmon are affected by substantial levels of ocean and river harvest and hatchery production. It is a priority for fishery and hatchery management actions to be consistent with recovery objectives and harmonized with healthy ecological conditions and habitat capacities.

Comment [EG2]: Insert references to scientific principles of prioritization from literature.

This recovery plan includes two types of site specific actions: management actions and RM&E actions. Priority management actions rely on ongoing protective actions across several sectors and provide additional restoration priorities. Priority RM&E actions promote understanding the status of the species; the best opportunities for improving its status; and the biological and management feasibility of the alternative viability scenarios.

The following types of management actions are considered to be the highest priority:

- Actions that protect and/or restore habitat conditions and natural ecological processes that support the viability of the extant Lower mainstem Snake River population and its primary life history strategies throughout its entire life cycle.
- Actions that target the key limiting factors throughout the life cycle and that would contribute the most to closing the gap between current status and viability of the ESU.
- Actions to complete feasibility studies that evaluate reintroduction of populations above the Hells Canyon complex.
- Actions that establish and support a process for implementing the adaptive management framework.

The following types of RM&E actions are considered to be the highest priority:

- Actions that improve our ability to evaluate the status of the ESU.
- Actions that evaluate the feasibility of and potential for achieving alternative viability scenarios.
- Actions that evaluate the effectiveness of actions across the life cycle and provide information about best opportunities for survival improvement.
- Actions that address critical uncertainties about poorly understood or emerging threats.

Sequencing Considerations

The management actions in this recovery plan would promote achievement of all potential viability scenarios described in Chapter 3 and are appropriate through 2018. In 2018, many programs, including the FCRPS biological opinion (NOAA 2014), the *U.S. v. Oregon* Agreement for 2008-2017 (U.S. District Court 2008) and the HGMP biological opinion (NOAA 2012a) are scheduled to be updated. The Hells Canyon relicensing proceedings should also be complete. RM&E associated with those programs should provide results that inform updates to management actions. Furthermore, RM&E results should be available that inform the feasibility of alternative viability scenarios. In summary, further actions and adjustments from those identified here are anticipated in 2018.

Comment [EG3]: Note to reviewers. Between proposed and final recovery plan, we will develop an Implementation Schedule. The Implementation Schedule is a spreadsheet that assigns a recovery priority number, recovery action numbers, duration of the action, implementing entities, and costs.

6.4 Site Specific Management Actions

The management actions below are priorities for addressing the threats and limiting factors across the life cycle for at least the next five years. Many of the actions will continue well beyond that period, but some actions may be adjusted and others added in approximately 2018 through adaptive management.

Comment [EG4]: Note to reviewers. One of the first steps of implementation will be to apply an implementation schedule, which is a table that provides details like priority numbers , recovery action number, action duration, responsible entities and cost estimates. We will develop the implementation schedule either with the final recovery plan or shortly following the plan.

The management actions below address the threats and limiting factors from Chapter 5. Very brief summaries of the threats and limiting factors accompany each section. The management actions include Existing Protective Actions and Additional Restorative Actions. Many of the management actions are part of programs already underway that were overviewed in Chapter 2.6 (Recent History and Programs Since Listing). All of these programs include RM&E for implementation compliance and effectiveness and for addressing areas of critical uncertainties. Key RM&E activities from these programs are highlighted in the RM&E Chapter 7 and we consider those RM&E activities to also be priority site specific actions. As described in the adaptive management framework, as we learn more from RM&E about the status of the species and the best opportunities for achieving viability, site specific management actions should be updated accordingly.

6.4.1 Snake and Columbia River Habitat Including Hydropower and Tributaries

6.4.1.1 Above the Hells Canyon Complex

Threats: Hydropower projects; reservoirs, land uses that alter river habitat: irrigated and dryland agriculture, livestock grazing, confined animal-feeding operations, mining, timber harvest
Related Limiting Factors: Fish passage, blocked and inundated habitat, total dissolved gas levels, reduced velocities, excessive nutrients, sedimentation, toxic pollutants, low dissolved oxygen in water and gravel, and altered flows.

- Complete the Hells Canyon Federal Energy Regulatory Relicensing Proceedings and develop biological and engineering fish passage and migration feasibility studies.[2]

- Encourage local governments and stakeholders to implement actions to reduce nutrients and sediment to improve mainstem habitat.

- Complete and implement plans to meet Total Maximum Daily Loads (TMDLs) to improve water quality in the mainstem Snake River to support adequate spawning and rearing habitat.

[2] Once completed, Idaho Power Company would be expected to implement FERC license articles and NOAA and USFWS biological opinion requirements (and potentially additional requirements in a settlement agreement) which together, should maintain or enhance survival and habitat function in extant (and potentially blocked historical habitat) and specify actions and timelines for assessing (and potentially implementing) actions to restore the passage to and from upstream spawning and rearing areas

6.4.1.2 Mainstem Snake and Columbia River Habitat and Tributary Habitat from Hells Canyon Complex to Bonneville Dam, including Hydropower.

Threats: Hydropower projects; load following; reservoirs; predation; channel maintenance; and land uses adjacent to the mainstem and tributaries.

Limiting factors: Blocked habitat; inundated habitat; fish passage; reduced velocities; stranding and entrapment of juveniles; reduced water quality -altered thermal regime; low dissolved oxygen; total dissolved gas; altered flows – on a seasonal, daily, and hourly basis; interruption of geomorphological processes resulting in reduced turbidity, higher predation, and potential reduction in spawning gravels.

Continue Existing Protective Actions:

Mainstem Habitat

- Idaho Power Company's fall Chinook salmon spawning program to enhance and maintain suitable spawning and incubation conditions
- Cool water releases from Dworshak Dam to maintain adequate migration conditions (for adults and juveniles) and juvenile rearing conditions (temperatures) in the lower Snake River.
- Summer flow augmentation (Dworshak Reservoir, Brownlee Reservoir, and upper Snake River Bureau of Reclamation projects) to maintain adequate summer migration conditions. (NOAA 2014; other cites, implementation plans)
- Summer spill at mainstem Lower Snake River and Lower Columbia River dams (as per the 2014 Supplemental FCRPS Biological Opinion) (Cite Action agencies implementation plan and NOAA 2014) to maintain adequate passage conditions for substantial numbers of actively migrating fish.
- Management actions to reduce juvenile losses to predacious fish and birds.

Tributary habitat

- Protection actions in tributary habitats to maintain spawning and rearing potential. These actions are described in the Southeast Washington Snake (cite); Northeast Oregon (cite) and Idaho Management Unit plans (cite). Even though the actions in these management unit plans tend to be higher up in the tributaries than where Snake River fall Chinook salmon spawn and rear, the actions have cumulative beneficial effects on downstream habitats

Implement Additional Restorative Actions

Mainstem habitat

- Upon completion of the fall Chinook salmon transportation study, modify the Corps of Engineers' transportation program to enhance adult returns of migrating juvenile salmon, including consideration of terminating or modifying transport at one or more collector projects.
- Evaluate, and install, if feasible, a passive integrated transponder (PIT) tag detector in the removable spillway weir at Lower Granite Dam to enhance understanding of smolt to adult returns and the contributions of alternative life history strategies.

- Evaluate and implement structures or operations at Lower Granite Dam to address adult passage blockages caused by warm surface waters entering the fish ladders.
- Implement actions to reduce September water temperatures for adult migration and passage at Lower Granite Dam.
- Implement actions to improve the quality of water discharged from the Hells Canyon Complex (dissolved oxygen, total dissolved gas) - as called for in NMFS recommendations for the Hells Canyon FERC Relicensing (NMFS 2006).
- Evaluate whether current September and October temperatures significantly affect pre-spawning survival rates or the viability of gametes or egg to parr survival rates.
- Develop and implement a gravel monitoring and management plan in the Hells Canyon reach of the Snake River (as called for in the Hells Canyon FEIS) (FERC 2007).
- Continue evaluations of how patterns in juvenile production, growth, survival and timing are influenced by environmental conditions, exposure to predation, and management operations.
- Evaluate and restore edge and side channel habitats used by rearing and migrating juvenile fall Chinook salmon.
- Continue to evaluate the effects of water management strategies on mainstem rearing capacities and adapt as appropriate given consideration for requirements for other migrating species (e.g., sockeye, spring Chinook salmon, and steelhead).
- Evaluate whether the Hells Canyon Complex of dams could be operated to improve egg and juvenile survival and growth in the mainstem Snake River major spawning areas.
- Evaluate whether increased cold water discharges and reduced temperatures from upstream dams would decrease predation on juvenile fall Chinook salmon in Snake River reservoirs.
- Reduce impacts of reservoir and river channel maintenance dredging and disposal; in particular the impacts of predator bird colonies that could establish on dredge spoil islands. Also reduce impacts of winter dredging and in water disposal and do more winter studies on the impacts of these actions on fall Chinook and their habitats.
- Implement Clean Water Act Total Maximum Daily Loads (TMDLs) to improve water quality in the mainstem Snake and Columbia Rivers.[3]

Tributary Habitat

- Complete and implement TMDLs to improve water quality in tributary habitats that affect Snake River fall Chinook salmon spawning and rearing habitats.

Tributary Major Spawning Areas (Clearwater, Grande Ronde & Tucannon Rivers)

[3] The Idaho and Oregon Departments of Environmental Quality (IDEQ and ODEQ) are jointly developing plans to implement (TMDLs) in mainstem segments of the Snake River and its tributaries. These plans indicate that without additional funding to address nutrients entering the Snake River from non-point sources, the nutrient standards will be met in 70 years (IDEQ and ODEQ 2004). NMFS supports the implementation of these TMDLs because they are likely to ultimately increase the likelihood of successful reintroduction of anadromous fish in the Middle Snake Mainstem, as well as provide substantial benefits to a host of resident species in future decades, thereby enhancing the historical habitat for anadromous fish. However, the TMDL time frame is not sufficient to address the adverse impacts stemming from low dissolved oxygen levels entering extant Snake River fall Chinook salmon critical habitat.

- Evaluate and prioritize opportunities to restore side channel rearing habitats to increase natural production capacity for fall Chinook salmon (all systems).
- Evaluate opportunities to mitigate for declining flows by protecting and restoring wetlands, floodplains, or other landscape features that store water.
- Evaluate potential spawning and rearing habitats in the lower reaches of the Selway, Lochsa and South Fork Clearwater tributaries and target high priority opportunities in support of restoring October spawning life history patterns.
- Evaluate whether water quantities and quality could be increased and whether sediment delivery could reduce in the lower Grande Ronde to improve spawning and rearing conditions and survival.
  Evaluate the potential to reduce sediment impacts on lower Tucannon River mainstem historical spawning and rearing area.

Small Tributaries Minor Spawning Areas

- Help alleviate both elevated temperatures and low stream flows in affected streams during autumn by increasing shade through riparian restoration and managing water withdrawals to maintain as high a flow as possible.
- Provide mitigation for declining flows by protecting and restoring wetlands, floodplains, or other landscape features that store water.
- Evaluate opportunities to mitigate for naturally declining flows during spawning by protecting and restoring wetlands

.

6.4.1.3 Estuary (below Bonneville Dam), Plume, and Nearshore Ocean Habitat

Comment [EG5]: Possibly Add details from FCRPS BiOp Implementation Plan

Threats: Dikes and other agricultural uses of the estuary; FCRPS flow management; predation; ocean conditions

Comment [EG6]: Update with excerpts from Ocean Module when ready

Related limiting factors: Lack of access to estuary habitat; altered food web; altered flow regime.

Continue Existing Protective Actions:

- Protect recent gains in land acquisitions and ---summary from FCRPS document

Implement Additional Restorative Actions

- Evaluate how juvenile Snake River fall Chinook salmon are using the estuary and plume.
- Improve quantity and quality of shallow water estuary habitat for migrating or overwintering SRFC. Improve food web in estuary and plume.
- Review mechanisms for timing arrival of smolts in the estuary and plume to avoid a mismatch with marine predators and prey.
- Evaluate effects on early ocean survival of conditions in the estuary and the plume.

6.4.2 Actions to Address Harvest

Threat: Fisheries.

Related Limiting Factors: Mortality.

Continue Protective Actions

- Implement abundance-based harvest regimes according to Pacific Salmon Treaty, U.S. v. Oregon Management Agreement, and fishery management frameworks authorized under the ESA.
- Ensure accuracy of reported estimates of harvest of natural-origin Snake River fall Chinook salmon in both ocean and river fisheries as required by the existing biological opinions (add cites).

Implement Additional Restorative Actions

- Develop harvest management frameworks and complete ESA regulatory reviews for Snake Basin fisheries that result in direct or incidental take of Snake River fall Chinook salmon.
- Ensure that potential changes to downriver fisheries in response to the John Day mitigation program do not result in harvest of natural Snake River fall Chinook salmon that is inconsistent with recovery objectives.
- Consistent with results of the evaluations described in RM&E update harvest management plans through negotiations with appropriate fishery management forums.

6.4.3 Actions to Address Predation, Prey Base, Competition, and other Ecological Interactions

Threats: Dam operations; reservoirs; alterations to estuary; channel maintenance; high proportions of hatchery fish in spawning and rearing habitats; increased abundance of nonnative species.

Related Limiting Factors: Bird predation; non-native fish predation; competition for space in spawing and rearing areas; competition for food; increased predation.

Implement Ongoing Protection and additional Restorative actions

- Continue efforts to reduce or disperse bird colonies that prey on juvenile Snake River fall Chinook salmon in both the interior Columbia and the estuary.
- Improve states of Oregon and Washington fishery management of non-native fish predator populations including pike minnow, smallmouth bass, channel catfish and walleye.
- Continue pike minnow bounty program.
- Evaluate plume/nearshore ocean conditions that influence predator fish populations and predation rates during the early ocean life stage.
- Based on results of evaluations described in the RM&E Chapter, take actions to reduce impacts of competition, and density dependence on Snake River fall Chinook salmon.
    - Evaluate potential competition or food web alterations resulting from non-native juvenile American shad in mainstem reservoirs where juvenile fall Chinook salmon rear; and, if beneficial to juvenile fall Chinook salmon, develop and implement actions to reduce or remove shad from these areas.

- Take actions to prevent the rapidly expanding ranges of zebra mussel, quaga mussel, NZ mudsnail, Siberian prawns and other invasive species from extending into Snake River fall Chinook salmon habitat and deplete available nutrients in the rivers.

6.4.4 Actions to Address Other Natural or human made factors

6.4.4.1 Hatcheries

Threats: High proportion of hatchery fish as adults and juveniles.

Related Limiting Factors: Genetic change; loss of fitness; competition for prey resources; spawning densities; higher mortality from incidental harvest; hatchery operations, including methods of broodstock collection and selection for traits not beneficial in natural environment.

Continue Existing Protective Actions

- Continue to implement best management practices at Snake River fall Chinook salmon hatcheries as reviewed in the ESA biological opinion on those programs (NMFS 2012).
- Continue current actions to minimize fish from outside the ESU spawning in the wild.
- Continue to improve estimates of natural- and hatchery-origin fish over Lower Granite Dam.
- Continue to validate and improve estimates of hatchery/natural composition of adult fish on the spawning grounds, both overall and in specific major spawning areas.

Implement Additional Restorative Actions

- Continue RM&E activities established for the HGMP Biological Opinion (cite). The results of these activities should inform further opportunities for improving viability of the Lower Mainstem Snake population.
    - Determine the relative homing fidelity and dispersal patterns among spawning areas of hatchery origin returns from reach specific releases.
    - Evaluate the potential for shifts in release locations to ensure that the bulk of natural production comes predominately from natural origin spawners in one or more spawning areas.
    - Consider seeding underseeded tributary reaches, for example, the Salmon and Clearwater River drainages, with hatchery fish that are part of the Snake River fall Chinook ESU.
    - Determine the relative reproductive success of hatchery origin spawners.
- Determine the impacts of increased numbers of juveniles because of the hatchery program on natural origin juvenile growth and productivity. Investigate the nature of potential mechanisms, e.g. interactions in the natal rearing areas and during the downstream migration and estuary phases.
- Based on results of RM&E implement adaptive management and take actions that:
    - Increase the proportion of natural origin spawners in important habitats for natural production.

  - Improve genetic and spatial substructure to be consistent with or trending towards levels associated with a natural functioning population.
  - Improve ability of hatchery programs to meet production and supplementation needs without limiting natural productivity.
- Ensure that adult returns from new hatchery programs, i.e. the John Day mitigation program do not stray into the Snake River.

6.4.4.2 Climate Change

In Mainstem Snake/Columbia Corridor

- Continue cool water releases from reservoirs during critical time periods.
- Maintain surface passage routes that improve juvenile passage through warm dam forebays.
- Reduce warm-water predators.
- Monitor changes in temperatures and flows that result from climate change and implement adaptive management by taking actions that respond to changing conditions.

In the Estuary

- Remove dikes to open backwater, slough, and other off-channel habitats to provide refuge habitats and increased food production for migrating juvenile Chinook salmon.

6.4.4.3 Toxins

- Continue and expand toxics monitoring efforts to collect information on contaminant exposure and accumulation in Snake River fall Chinook salmon for chemicals and critical habitats where data are lacking.
- Evaluate effects of contaminants of concern on individuals and spawning aggregates where key data are lacking (e.g., unregulated contaminants of emerging concern; impacts in mixtures or in combination with other stressors).
- Identify sources of toxics and evaluate where Snake River fall Chinook salmon are being exposed.
- Develop actions to reduce toxic contaminants at the sources.
- Revise water and sediment quality criteria as needed to ensure they are protective of listed salmonids.
- Evaluate legacy effects of banned pesticides, PCBs, PBDEs, PAHs and DDTs on individuals and spawning aggregates.
- Evaluate effects of copper and mercury on individuals and spawning aggregates.
- Implement National Pollution Discharge Elimination System permit programs to address point source pollution.

6.5 Potential Effectiveness of Management Actions

The abundance of Snake River fall Chinook salmon natural origin returns has increased substantially since listing. Thus, the working hypothesis is that the combination of management

actions since listing has been effective at improving abundance of the natural origin population. These management actions are identified by sector as Existing Protective Actions in sections above. In sum, they include actions that improved abundance survivals through the hydropower system, reduced overall ocean and mainstem harvest, especially in relatively low return years, and increased natural production from hatchery supplementation. There is, however, substantial uncertainty about the status of the natural origin population's productivity and diversity viability parameters and about whether the increases in natural origin spawners would be sustainable over the long term. These uncertainties need to be addressed and additional management actions may be needed beyond those provided above.

It is important to determine which individual actions in each management sector are most effective and to also understand the relative effects of actions in different sectors throughout the life cycle. In the individual sectors, the effects of ongoing protective actions and additional restorative actions will be, for the most part, evaluated through ESA biological opinions, (which are overviewed in Chapter 2, section 2.6) and in the modules, which are appendices to this recovery plan.

The combined effects and also the relative effects of actions in different sectors across the life cycle are not well understood. Multi stage life cycle models are under development for Snake River fall Chinook salmon. Those models incorporate empirical information and working hypotheses on survival and capacity relationships at different life stages. The models provide a valuable framework for systematically assessing the potential response of fall Chinook salmon to alternative management strategies under alternative climate scenarios. In addition to informing decisions about near term management strategies, the fall Chinook salmon life cycle modeling can also be used in identifying key research, monitoring and evaluation priorities to improve future decision making.