VI. Adaptive Management and Monitoring:

➢ ADAPTIVE MANAGEMENT AND MONITORING: HOW WILL WE RECOGNIZE SUCCESS?

I. Current Situation: *Where are we now?*

Background

The stated goal of the Statewide Strategy to Recovery Salmon is to: *Restore salmon, steelhead, and trout populations to healthy and harvestable levels and improve habitats on which fish rely."* (See Chapter III. A Road Map to Recovery.)

The strategy is based on a number of guiding principles, one of which states

> *The strategy must be credible, based on best available science and must set priorities and be adaptive. It must also include ongoing data collection, monitoring, and review.@*

This principle is consistent with criteria used by the National Marine Fisheries Service to evaluate conservation plans, which include:

> Establish a comprehensive monitoring and reporting program, including methods that measure whether objectives are being met and detect subpopulation declines and increases in each ESU.

Further, NMFS guidance (See References) encourages conservation plans to utilize an adaptive management approach that actively shapes management actions to generate needed information.

The development of the Statewide Strategy to Recover Salmon has focused on addressing conservation strategies associated with the four Hs (hatcheries, harvest, habitat, and hydropower). There is much we do not understand about fish and how they interact with their ecosystems, and how well our conservation actions will produce the intended effect, both individually and collectively, in each watershed and region. Ecosystems, regions, and watersheds express much variation within and between them that can extend over very short or long time frames. These variations complicate our understanding of how these systems work and how we might improve the probability that our actions on behalf of salmon will not only avoid extinction, but will recover them to healthy levels. Therefore, the strategy commits to

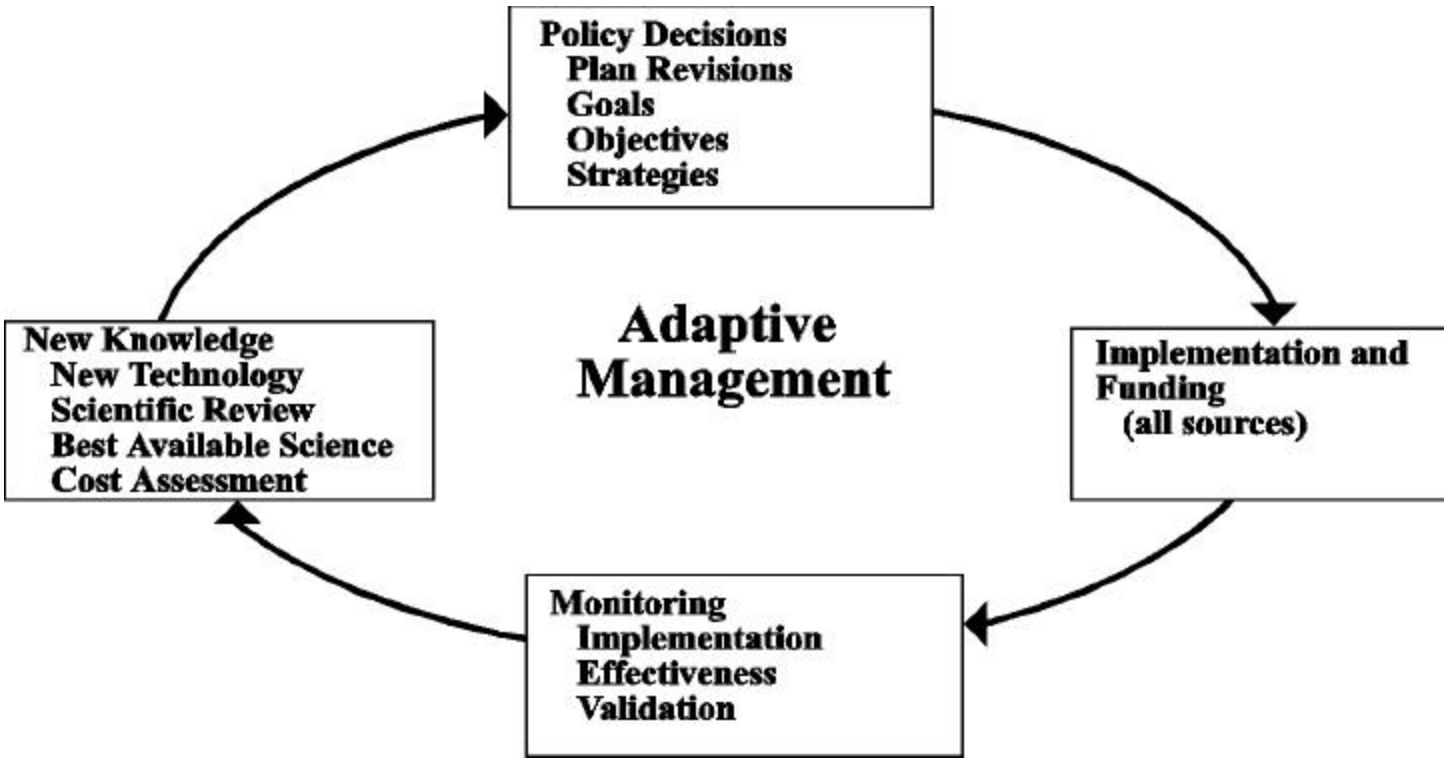
adaptive management, a science-based approach to address how well strategy elements are working and to make changes in the face of uncertainty, based on new information.

What is Adaptive Management?

Adaptive management is a science-based management approach that enables a critical review of how well our actions achieve their objectives and, based on results of monitoring and evaluation efforts, suggests what steps are necessary to increase the chances for successful recovery.

Adaptive management is not simply a matter acting and waiting to see what happens; instead, it requires that activities be taken and purposefully monitored and scientifically evaluated so that management, policy, and actions are more effective in the recovery of salmon. In this manner our understanding of what works and what doesn't is increased.

The guiding principles of the Statewide Strategy to Recover Salmon reflect that it is an adaptive management strategy. Over time this will require administrative structures using continuous management cycles involving establishing management strategies and objectives, monitoring of management actions linked to objectives, evaluating management actions, and affirming or changing management actions in response to the results of monitoring and analysis - leading to overall improvement in the quality and efficacy of management decisions and actions. The figure below illustrates the adaptive management cycle.



Why Monitor?

Monitoring is a critical component of adaptive management. Monitoring involves deliberate and systematic observation, detection, and recording of conditions, resources, and environmental effects of human and management programs and actions. It allows us to determine trends in fish populations, to determine how well the elements of the strategy are working, and to test key assumptions and resolve important questions. In terms of importance, the National Marine Fisheries Service (NMFS) has identified monitoring, along with substantive conservation actions and implementation certainty, as essential ingredients of conservation plans prepared in response to listings under the Endangered Species Act.

Where Are We Now?

Adaptive management and monitoring have often been low priorities in natural resource management. When attempted they frequently suffer from poorly focused objectives or questions; biological, temporal, and spatial scales that are often too narrow or ill-defined; poor integration due to institutional barriers; incomplete, inconsistent, and/or poor quality information; and inadequate commitment to time scales sufficiently long to produce reliable results. Investment in monitoring is often limited by preferences to commit resources to actions that directly produce more fish or improve habitat. Monitoring may also expose what are perceived as failures, whereas the public and decision-makers desire successes.

Monitoring is currently performed by agencies and others, but it is typically not well coordinated and integrated among involved parties, nor is it well focused on key salmon strategy components and questions. Examples of obstacles that exist include inadequate communication and coordination, conflicting or non-complementary agency interests or mandates, underlying technical issues, data integration and sharing, and funding.

Salmon population and habitat monitoring efforts are typically not organized at regional or ESU spatial scales that take into consideration not just basic needs of fish populations but also the integrity of the watersheds and broader freshwater and marine ecosystems of which they are a part.

The benefits of successful monitoring in an adaptive management context can be substantial. Since more is typically unknown than is known about cause-and-effect relationships, monitoring in an adaptive management context is the most efficient way to take action in the face of uncertainty. Monitoring in this context represents a commitment to accountability and action, while pursuing effectiveness and efficiencies with the biological and fiscal resources available. Adaptive management represents a commitment to change conservation approaches and redirect fiscal resources as warranted by new information, even if such change is difficult or unpopular.

The purpose of this chapter is to provide an overview of general approaches, relationships, and issues related to development of the comprehensive adaptive management and monitoring component of the Statewide Strategy to Recover Salmon. Most components of the statewide strategy focus on individual conservation elements (e.g., instream flow, agriculture, fishery

management, forest practices). However, development of the adaptive management and monitoring components needs to support and integrate monitoring elements of the strategy.

The 1999 legislature enacted the Salmon Recovery Funding Act, Second Engrossed Second Substitute Senate Bill 5595 (2E2SSB 5595) which recognized the need for development of a coordinated and integrated monitoring process to track and assess the effectiveness of salmon habitat projects and recovery activities in the state. In that legislation the Independent Science Panel (See Science as a Guide) is required to:

- recommend standardized monitoring indicators and data quality guidelines;
- recommend criteria for the systematic and periodic evaluation of monitoring data pertaining to critical questions associated with the effectiveness of salmon recovery efforts; and
- by December 31, 2000, prepare a report of monitoring recommendations to the legislature and the Governor.

II. Goals and Objectives: *Where do we want to be?*

Goals:
Develop and implement a decision-making system that is guided by the best available science and that uses new information generated from the monitoring of conservation actions.

Accurately assess the responses of salmon, steelhead, and trout populations and their habitats to specific actions.

Objectives:

- Establish a scientific foundation for the monitoring component of the Statewide Strategy to Recover Salmon.
- Assess and track the status of salmon populations and their habitats.
- Promote the use of and, as necessary, develop appropriate analysis and assessment tools and protocols to support the statewide salmon strategy and related watershed and regional responses.
- Develop means to track conditions leading to changing or modifying restoration actions and for recognizing success.
- Develop and promote complementary, integrated, open, and flexible approaches for the collection, analysis, and sharing of monitoring information (e.g., GIS) within and across sites, watersheds, and regions.
- Provide leadership, coordination, and technical assistance to agencies and other statewide strategy partners.
- Produce a biennial "State of the Salmon" report starting December 31, 2000.

III. Solutions: *What is the route to success?*

Development of the comprehensive adaptive management and monitoring program will be difficult. As stated above, there is much we do not yet understand about how to best recover salmon. There are many differences among salmon species and component stocks, regional/ESU conditions, and watersheds. Monitoring and evaluation technologies themselves may often be limited and/or information from them can be of poor quality. Costs are always a concern.

Scientific Foundation – Understanding what is known and unknown
A strong scientific foundation must underlie the Statewide Strategy to Recover Salmon to assure conservation strategies and actions have the best chance of achieving the desired outcomes. (See Chapter III. A Road Map to Recovery, section on Science as a Guide.) The scientific foundation helps clarify what is known and not known about ecosystem/watershed dynamics and their relationships to salmonid conservation. It provides a way to view needs and issues in a more holistic ecosystem orientation rather than in piecemeal fashion. The scientific foundation provides the platform for adaptive management and monitoring that links conservation strategies, critical uncertainties and related objectives, and risks, to key questions that can be addressed.

Several comprehensive scientific reviews of salmon and their ecosystems (National Research Council 1996: Upstream: Salmon and Society in the Pacific Northwest; Northwest Power Planning Council 1996: Return to the River; and Washington's 1997 Wild Salmonid Policy) have recently been completed that together, provide a strong base of scientific information for the Statewide Strategy to Recover Salmon. (See Chapter VII. C. References.)

More specific scientifically-based principles have been drafted for protection and restoration of ecosystems in the Puget Sound region these include:

$ *Maintain and restore the freedom of rivers and streams to move and change, especially during floods.*
The ability of rivers to move and change is an essential process for forming habitat. Areas where rivers still have the potential to move in their flood plains often provide the most productive habitats for fish and wildlife. Whenever possible, the ability of streams and rivers to roam should be protected and restored. This allows them to create braided channels for spawning, as well as oxbow lakes and wetlands for rearing, and provides places to store their floodwaters.

$ *Allow time for natural regenerative processes to occur and provide recovery of river and stream integrity.*
Once riverine habitat has been damaged it can take several decades to recover, if it can recover at all. Too often we try to recover natural habitat functions by demanding an

immediate fix and not allowing the natural regenerative process to work. This can lead to conflicts with the natural dynamics of the river or stream. Restoration actions must be designed to work with natural processes, providing some immediate benefits but also with consideration of how they will change and improve over time.

- *Protect the natural diversity of species and restore the natural diversity of habitats within river channels and riparian zones.*
  River systems and salmon are like human communities: their richness increases with diversity. The habitat diversity of rivers needs to be protected and restored whenever possible. We must understand what diversity in species and habitat was historically supported by each river system, then work to protect and restore that historic diversity.

- *Support and foster the interaction and connections between the diverse parts of the aquatic ecosystem, including estuaries, rivers, streams, and uplands.*
  It is not enough to preserve only some parts of a system; all of the components need to interact and connect. Replacing culverts or other barriers to passage are obvious reconnections that can improve habitat. In addition, improvements to water quality and drainage from developed areas can increase system integrity.

- *Tailor actions locally and to the whole watershed in the proper sequence of time and place. Match the system's potential and long term human commitment to stewardship of the system.*
  Many restoration efforts have been unsuccessful because they focused on a local part of a river or stream without understanding how it is affected by processes that may be occurring upstream or upland. For example, logs and other habitat structures have been placed in streams to improve habitat, only to be covered by sediment caused by unstable areas in upstream areas of watersheds. It will be critical to take actions in a manner that is consistent with the upstream and upland processes of the whole watershed. Also, successful actions will require an ongoing commitment to stewardship and monitoring. The more intensive the restoration and changes to the natural character of a watershed, the more commitment will be required.

- *Integrate the needs of human communities with the long-term dynamics of rivers and streams.*
  Human actions have a dominant effect on the character and function of rivers and streams in the state, and rivers are essential to human needs. In protecting rivers and streams, we protect ourselves; we will not be successful if we just try to make the remaining best habitat into nature preserves and lock people out. We need to find ways to allow people to enjoy healthy habitats without damaging them. We also need to restore damaged rivers and streams to provide human and ecosystem benefits in cities and towns where people live.

The principles outlined above recognize that the biological communities in which salmon, steelhead, and trout live have evolved in highly complex and dynamic environments, that natural

processes are key in shaping variation in salmonid populations and their ecosystems, that human activities can influence ecosystems, and that there is much uncertainty in human understanding of salmonids and their ecosystems. These features point to the need to use an adaptive and experimental approach, while emphasizing the need for recovery actions in the face of this acknowledged uncertainty.

Principles such as those listed above will help guide a wide range of monitoring planning needs and decisions. The principles will influence identification of key questions and the relative priority of their answers to salmon recovery, will shape the appropriate scale(s) of monitoring and evaluation efforts, and will guide the selection of appropriate methodological and analytical approaches.

Adaptive Management/Monitoring Development Process

Before an effective and efficient monitoring program can be fully established it will be necessary to clarify what is known and not known and to develop specific management objectives and benchmarks associated with each component of the strategy. A review of risks and uncertainties associated with strategies and objectives will lead to specific, answerable questions. Answerable questions can then be reviewed and prioritized (e.g., by species, regions, watersheds, habitats, strategy components, human activities). Questions can then be reviewed in the context of available funding to ensure that the highest priority questions are sufficiently addressed. Finally, detailed monitoring plans outlining what, where, when, how, and who can be developed and implemented, and coordinated and integrated information management systems can be developed. Questions that are not technically or economically feasible to answer will be reviewed to assess acceptable levels of risk and/or alternative courses of action.

In summary, steps in development of the monitoring program should be:

1. Understand what is known and unknown (scientific foundation),
2. Identify strategies/key actions for implementation (conservation actions),
3. Develop measurable objectives associated with the elements of the Strategy,
4. Identify key questions (technical/policy) and risks associated with measurable objectives,
5. Review and prioritize the key questions,
6. Match priorities to level of available funding,
7 Develop detailed monitoring plans to answer priority questions consistent with funding availability.

The adaptive management approach for the statewide strategy will require an ongoing commitment to review and possibly redirect objectives and actions for the core elements as information on critical questions becomes available. Key checkpoints and triggers for adaptive management decisions will be developed. Monitoring activities themselves will be expected to change over time as conservation strategies and related objectives and questions change.

The statewide strategy commits the state to collaborative processes involving state, federal, and local governments, tribes, and other parties. These processes will also lead to increased coordination and efficiencies with respect to the adaptive management and monitoring component.

In general, a two-tiered model could be used to evaluate how well elements of the strategy work over time. The first tier would involve evaluation of conservation measures with respect to meeting the measurable resource objectives that are tied to management issues. The second tier would involve looking at the resulting trend in resource condition. Quantifiable targets are needed to evaluate and communicate the expected performance outcomes. The following depicts an approach related to monitoring of outcomes and responses anticipated under adaptive management:

Outcome A: *The target has been reached and a positive resource trend has been realized.*

Response: The plan is working as designed.

Outcome B: *The target has been reached and a positive resource trend has not been realized.*

Response: Determine why the trend has not been realized. Is it the conservation measure? Past influences (e.g., sediment from pre-plan mass failures)? Natural conditions? If conservation measure, then re-assess target and look for ways to reduce impacts from conservation measure.

Outcome C: *The target has not been reached and a positive resource trend has been realized.*

Response: Determine the role of conservation measure in development of the positive trend. Is the positive trend primarily due to re-equilibration from disturbance prior to plan management (natural or past influences)? If current management is slowing the recovery of resource then look for ways of meeting the target. If the positive trend is primarily due to the implementation of conservation measure, review why the target has not been met. Was the target set too high? Re-adjust target.

Outcome D: *The target has not been reached and a positive resource trend has not been realized.*

Response: Determine why the positive resource trend has not been met and the role of conservation measure in failure to develop a positive trend. Re-adjust measure to achieve outcomes A, B, or C.

Types of Monitoring

Monitoring associated with protection and restoration activities is commonly broken down into several categories, each of which is essential to an effective comprehensive adaptive management approach.

Implementation monitoring addresses the extent to which conservation measures have been taken as planned and target has been reached**.** It should be a part of every conservation element. The earlier it is started in the recovery process the better, since often mid-course corrections will be necessary as design specifications are improved. This type of monitoring provides a basis for quality assurance and accounting for recovery measures.

Strategy effectiveness monitoring addresses how well completed actions or programs are effective in meeting explicit objectives, criteria, or desired future conditions. This is a very complex type of monitoring because it requires an understanding of the multiple factors that influence aquatic ecosystems at various spatial and temporal scales.

Trend monitoring involves tracking changes in fish populations and habitat conditions over time. Trend monitoring should encompass all aspects of the ecosystem, including those conditions over which we have no direct influence (e.g. ocean conditions). Trend monitoring is critical to the interpretation of effectiveness and validation monitoring activities at project, program, watershed, and regional scales.

Validation monitoring involves specialized activities to evaluate the appropriateness of assumptions that are critical to conservation components of the strategy itself. This type of monitoring is usually associated with research efforts focused on key priority questions linking relationships between strategy components and fish populations, or the relationships between changes in habitat/ecosystem parameters and fish populations. It is usually the best approach to use to assess cause-and-effect relationships. Effectiveness and validation monitoring are key steps to assess adaptive management activities.

Key Monitoring Questions

An effective adaptive management approach to the Statewide Strategy to Recover Salmon will require a comprehensive monitoring program that focuses on key questions associated with the objectives of actions undertaken. However, regardless of the specific strategy component, a fundamental objective of the monitoring program will be to detect changes and trends in basic characteristics of fish populations, such fish size/age structure, stock abundance and distribution in time and space, life history variation, and survival. Information on fish populations was used to make listing determinations and this same type of information will have a strong influence on salmon recovery and delisting decisions in the future.

The comprehensive monitoring framework should address the following central question:

Are the actions and processes represented by the Statewide Strategy to Recover Salmon effectively protecting and restoring naturally reproducing salmonid populations across suitable ranges of abundance, spatial and temporal scales, and diversity of habitats and life history types, to ensure persistence in dynamic and unpredictable environments?

The central question can be further partitioned into the following sub-questions:

1. What are the trends in fish population abundance and habitat conditions (including ocean conditions) over time? (**Baseline/trend monitoring**),
2. Are strategy elements being implemented correctly? (**Implementation monitoring**),
3. Are the strategy elements, actions, and programs achieving their objectives? (**Effectiveness monitoring**), and
4. How sound are key assumptions underlying conservation actions and strategies, and what are the cause-and-effect relationships? (**Validation monitoring**).

Elements of the Comprehensive Adaptive Management and Monitoring Strategy

Development of the comprehensive adaptive management and monitoring strategy that sufficiently accommodates all types of monitoring will be an extremely complex endeavor.

The Joint Natural Resources Cabinet expects that **each** agency/partner will commit to monitor the *implementation* of its respective conservation actions. Through the development of the comprehensive monitoring program, needs and priorities will be clarified, and a phased approach to *effectiveness* and *validation* monitoring will be developed to direct available funding and cooperative partnerships. At the minimum, the Joint Natural Resources Cabinet stresses the need for coordination, integration, and where possible, reprioritization of existing agency/partner monitoring activities to meet priority needs. (See Early Action Plan and Performance Measures – referred to as "Balanced Scorecard")

Although the monitoring strategy continues to undergo active refinement and will benefit from recommendations provided by the Independent Science Panel and others as required in the 1999 Salmon Recovery Funding Act (2E2SSB 5595), several basic needs have been identified in support of the comprehensive monitoring program, with particular emphasis on effectiveness monitoring. These include:

- *Trends in escapement and overall abundance of fish populations at the stock and ESU level must be tracked over time.*

  Wild salmonid populations must be regularly monitored in order to measure their health and to determine whether protection and restoration effects are having their desired outcomes. It is not enough to simply collect fish population information; monitoring and assessment data must be effectively summarized and communicated to managers and public so that performance of protection and restoration efforts can be analyzed. Subsequent refinements

and modifications to resource management priorities, strategies, and activities can then be made that accurately reflect the changing condition of salmon populations.

Monitoring the status of fish stocks over time is the responsibility of the Department of Fish and Wildlife (WDFW) and tribal fishery co-managers. Information is obtained from ongoing and new juvenile and adult monitoring activities. A statewide Salmon and Steelhead Stock Inventory (SASSI) was prepared by the Department and western Washington treaty tribes in 1993. In 1997, this effort was expanded to include bull trout and Dolly Varden char and re-titled Salmonid Stock Inventory (SaSI), reflecting the intention to include all salmonids. A SaSI appendix is in preparation for coastal cutthroat trout and a status review for westslope cutthroat trout that will form a basis for an appendix on this species was recently completed. These efforts will continue to form a foundation of information for stock status assessments.

- *A system of "index" watersheds or areas (including associated estuarine/nearshore marine areas) should be developed where comprehensive and integrated effectiveness and validation monitoring efforts can be accommodated (includes integration of juvenile and adult fish population data with habitat information).*

  Some effectiveness questions (e.g., barriers to fish passage) can be answered relatively straightforwardly, but most questions will be difficult to answer. Questions about how habitat conditions are responding to implementation of strategy elements at watershed scales will be difficult because of the complexity of simultaneous interacting factors, and the long assessment time frames required to separate effects of strategy implementation from background levels of natural variation. Therefore, it will not be practical or possible to monitor the effectiveness of all strategy elements in all watersheds.

  A system of index or representative watersheds among regions will be identified within which coordinated and integrated long term monitoring and evaluation activities would be performed to address critical strategy effectiveness questions and assumptions (validation monitoring). An approach to identification of these systems will first seek locations where quality fish and/or habitat databases already exist, that could be enhanced to increase efficiencies and effectiveness. The Departments of Fish and Wildlife, Ecology, and Natural Resources, along with Indian tribes and other partners will participate in cooperative monitoring to collect the necessary data in these systems.

  This intensive monitoring program will be designed to evaluate the cumulative effectiveness of salmon recovery strategies and projects on salmon populations and indicators of salmon habitat, land use, water quality/quantity, and stream health. Specific aspects of this program will include: smolt/adult population monitoring, instream habitat monitoring, landscape features monitoring, and water quality/quantity monitoring.

- *Priority "indicators" will be identified and monitored to track trends in ambient conditions over time and at appropriate spatial scales.*

  Similar to the ongoing efforts to track long term trends in fish stock abundance on a statewide basis, a system of key indicators is needed to assess trends in ambient habitat quality and quantity for salmon at the appropriate spatial scales. Where applicable, protocols will be identified or developed to help ensure that monitoring of these indicators is of sufficient quality and reliability for use at project, watershed, and regional scales. As mentioned previously, the Salmon Recovery Funding Act, passed in 1999, directed the Independent Science Panel to develop recommendations for monitoring indicators and related data quality guidelines.

- *Coordinated data and information management systems must support a diversity of adaptive management and monitoring efforts at various scales (e.g., site, watershed, region, state).*

  Coordinated data and information management systems must support the adaptive management and monitoring effort. A wide range of data systems and standards are currently in use by agencies and other entities. A key challenge of the strategy will be to identify, coordinate, and develop information management and sharing systems focused on information needs for the statewide strategy, regional responses, watershed, and project-level efforts.

  To at least partially address this challenge, the 1999 Salmon Recovery Funding Act (2E2SSB 5595), addressed the need for a coordinated and integrated monitoring process by stipulating that salmon monitoring data provided by lead entities, regional fisheries enhancement groups, and others shall be included in the data base of SASSI and the Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP). SSHIAP was initiated in 1995 by the Northwest Indian Fisheries Commission and cooperatively implemented by the western Washington Tribes, WDFW, and other partners. The objective of SSHIAP is to assess and document current conditions and trends of salmon habitat in WRIAs 1-23, and to incorporate these data into a GIS-based information management system.

  In addition, the Salmon Recovery Funding Act stipulated that information pertaining to habitat preservation projects funded through the Washington Wildlife and Recreation program, the Conservation Reserve Enhancement Program, and other conservancy programs related to salmon habitat shall be included in the SSHIAP database.

- *A monitoring planning structure is needed to resolve general direction, technical issues, and information integration and sharing needs and approaches.*

A means of encouraging communication and cooperative planning is proposed to facilitate coordination of monitoring among agencies and partners. A monitoring steering committee would guide statewide monitoring policy planning, in collaboration with scientific and technical assistance would identify key management questions, and identify statewide monitoring priorities for the salmon strategy. A technical committee would provide technical support and coordination for implementation of the monitoring strategy; seek resolution of issues, and coordinate with monitoring steering committee on unresolved issues. A data/GIS support services committee would provide guidance and support for distributed integrated information systems development and implementation; facilitate interagency/partner standardization, data sharing, retrieval, and long term synthesis.

It is not intended that these committees would force burdensome new layers of planning, but that they would draw together involved agencies and interested parties to add value and assistance to monitoring programs.

Initial Guidance on Monitoring Indicators and Protocols

Development of indicators and protocols for monitoring the implementation and effectiveness of salmon recovery activities will need to be developed to meet multiple needs. These needs will exist to support watershed planning forums, volunteer groups, government agencies and tribes, and many others. The development of standardized indicators and protocols, and their use, will allow information to be collected and shared among multiple levels, to address multiple monitoring and evaluation needs. As mentioned previously, the 1999 legislature requested the Independent Science Panel to assist with this task.

What follows below is an initial overview of rationale and information about monitoring indicators and related protocols.

Salmon and the ecosystems on which they depend are extremely complex and diverse. It will not be practical to monitor all aspects of these ecosystems for each species of concern, or in every area. Nor will it be practical to monitor the effectiveness of each and every protection and restoration strategy to the same extent. This requires that a set of surrogates for key features, termed *indicators*, must be chosen and measured. Concepts, issues, and details associated with identification of appropriate indicators are still being refined; as additional details are available they will be included in the salmon strategy and related implementation plans.

Efforts to protect and restore healthy wild salmon populations and their ecosystems will require new indicators of salmon performance. Traditional indicators typically emphasize relatively straightforward harvest and economic measures. These will still be needed, but alone will be insufficient. Restoring wild salmon populations and healthy watersheds will require measures that more fully depict ecosystem variables, processes, and dynamics of not only individual populations or stocks, but groups of populations (e.g., metapopulations).

Traditional indicators used to assess salmon in the context of consumptive uses include:

- Catch/harvest
- Angler days
- Economic value of catch
- Licenses sold
- Pounds of fish released from hatcheries
- Number of habitat projects completed
- Spawner escapement
- Stock status

In general, indicators related to ecosystem health from which measures could be identified include:

- Condition of riparian zones, flood plains, and nearshore habitats
- Habitat complexity and connectivity
- Patterns of variation in stream flows and temperatures
- Life history and genetic diversity
- Establishment of reference species composition and abundance
- Values of environmental integrity (e.g., indices of biotic integrity)
- Long-term recruit per spawner ratios for key species
- Stock status at metapopulation scales
- Marine trophic conditions (e.g., forage fishes, predators)

Indicators of ecosystem health should also be used in the context of the range of habitat and ecosystem components that salmon interact with over their life histories in time and space. For example, the following outlines examples of potential indicators organized by various aspects of the salmon ecosystem continuum.

Headwaters and smaller tributaries

- Conditions of flood plains and riparian zones
- Habitat complexity, connectivity, and diversity
- Patterns of variation in stream flow
- Water quality (e.g., temperature, dissolved oxygen)
- Biological communities (e.g., predators, prey, competitors, vegetation)
- Salmonid distribution, productivity, and mortality

Larger tributaries and mainstems of rivers

- Conditions of flood plains and riparian zones
- Habitat complexity, connectivity, and diversity
- Patterns of variation in stream flow
- Water quality
- Biological communities

Salmonid distribution, productivity, and mortality

Estuarine deltas, tidal flood plains, and marine shorelines

Conditions of flood plains and riparian zones, and nearshore habitats
Habitat complexity and connectivity
Patterns of variation in estuarine flow and tidal inundation
Water quality (e.g., salinity, dissolved oxygen, toxics)
Biological communities: structure and function
Salmonid distribution, productivity, and mortality

Offshore

Patterns of variation in circulation and marine productivity
Water quality (e.g., salinity, dissolved oxygen, toxics)
Biological communities: structure and function
Salmonid distribution, productivity, and mortality

Indicators and associated measures should be used that are appropriate for relevant goals and objectives. They should address elements of salmon and related ecosystem composition, structure, and function. Identifying appropriate indicators may be fairly straightforward in some cases, and extremely difficult in others. For example, monitoring measures of salmon abundance can be useful indicators to address some objectives and questions; however, abundance is often a poor indicator of broader and more complex objectives or questions. Ecosystem concerns such as disturbance regimes, hydrological or climate cycles, habitat connectivity, or ecosystem health require indicators other than abundance. In addition to their basic relevance to specific goals or objectives, indicators should ideally be:

1. Good measures or surrogates of the element of concern.
2. Able to detect a problem before it is too late to solve it.
3. Amenable to experimental controls (where possible).
4. Aimed at relevant biological scales in time and space (e.g., genetic, population/species, watershed/community, and ecosystem/landscape).

As mentioned above, although more work will be done to refine indicator concepts and approaches, several general categories of indicators have been identified that are related to the frameworks noted above (e.g., salmon ecosystem continuum, scale of organization [population, watershed, landscape]). These general categories are ***fish***, ***physical habitat***, ***water quantity, water quality***, *and* ***land use/cover***.

Fish: The category of indicators pertaining to *fish* includes: life history variation and genetic diversity, variation in size and age structure, stock and ESU/metapopulation distribution and abundance, juvenile/smolt production, freshwater survival rates (e.g., spawner to juvenile recruit survival rates), marine survival (e.g., smolt to adult survival rates), and the structure and function of involved biological communities (e.g., non-salmonid fishes, predators, aquatic invertebrates,

vegetation). In general, use of these indicators and related monitoring measures over time and space would support a wide range of conservation objectives.

Physical habitat: The category of indicators related to *physical habitat* ranges across the entire salmon ecosystem continuum, including headwaters, mainstems, estuaries, and ocean environments. At this time, this section emphasizes physical instream habitat at the watershed scale; as additional information is available on indicators related to the other components of the continuum, it will be considered in the state performance indicators.

Physical habitat in freshwater develops in response to inputs of wood, water, sediment and solar energy. Land use and management has changed the input rate of these factors. Through restoration, improved land-use, and better overall management, the input rates of these factors should assume a pattern that is closer to the natural disturbance levels, leading to an improving trend in habitat condition.

Different land uses effect input processes in distinctly different ways. For example, forest land management has substantially altered the input rate of large wood and coarse/fine sediment, and to a lessor extent, the input rates for solar energy and water. Agriculture has altered the input rates for wood, fine sediment, and solar energy; and through diking and the use of flood gates has considerably altered flood plain functioning and the movement of water. Urbanizing landscapes have greatly affected the input rates for all of these factors. In addition, these land-uses often occur in different parts of the watershed. The response of channels to a change in the rate of an input is much different in a steep gradient headwater stream compared to a low gradient, low elevation channel.

Similarly, fish tend to use different habitats and channel types for various freshwater life history stages. Their habitat needs change in response to fish growth and environmental conditions. An effective physical habitat monitoring program needs to consider the influence or response of habitat to input processes, land use, lithology and channel morphology in the design of a monitoring program. Selection of physical habitat indicators should also be determined by species distributions and uses of the watershed. It is recommended that a base set of indicators be collected during all habitat surveys.

Additional (optional) indicators should be used in certain channel types, areas of the watershed, for certain life history stages, or to answer monitoring questions related to specific management actions or restoration projects.

Water quantity: The category of indicators pertaining to *water quantity* preliminarily includes instream flow (e.g., percent of stream miles with instream flow meeting seasonal requirements for salmonids) and flow hydrology (e.g., percent of streams with flows that, over time, closely mimic natural conditions). Similar indicators were recommended by a workgroup of salmon habitat specialists from the Pacific Northwest (PNSHIWG 1998) and are being considered for

use by the state. The recommended monitoring protocols for instream flow indicators is in Buchanan and Somers (1969).

Water quality: The category of preliminary indicators (from PNSHIWG 1998) and protocol references pertaining to water quality includes temperature (Rashin et al.1994), biological water quality index (Plotnikoff 1994), and chemical water quality index (Ehinger 1995). These indicators are being considered by the state.

In addition, Cusimano (1994) provides a general guidance manual for developing water quality assessment programs, including technical methods for conducting water quality studies. It includes information on survey planning, report writing, and data management activities, as well as assessment techniques for water, biota, and sediment quality.

Land use/cover: The category of indicators pertaining to *land use/cover* may include: land use conversion (e.g., number of acres in a watershed converted from one land use/cover classification to another over time, with emphasis on the flood plain to riparian area); transportation impacts (e.g., miles of road and number of road crossings within one mile of salmon streams, flood plains, or marine shorelines); and impervious surface (e.g., percent of watershed covered by impervious surfaces [roads, roof tops, etc.]). This suite of indicators was recommended by a workgroup of salmon habitat specialists from the Pacific Northwest (PNSHIWG 1998).

A Model for Sustainable Information Management

A wide range of monitoring efforts and databases currently exist or are being planned by a wide range of entities to address various implementation, effectiveness, and validation monitoring issues and priorities associated with salmon, restoration projects, watersheds, regions, and ecosystems. Some of these may be directly relevant to the Statewide Strategy to Recover Salmon whereas others may not. Relatively few monitoring efforts have been designed for the purpose of monitoring conservation strategies and their effectiveness in an adaptive management context. Thus a key challenge of the comprehensive adaptive management and monitoring strategy will be to identify, coordinate, and develop information sharing approaches (e.g., GIS, analyses, modeling) with existing and new efforts at site, watershed, and regional scales. This will lead to creation/use of effective synthesis and reporting processes for the state and other salmon strategy partners.

As discussed earlier, part of the data and information management required for salmon recovery will be provided by entities receiving habitat project funding and will be incorporated into a GIS based information management system (part of SSHIAP)

The type and extent of comprehensive and integrated information management systems will, however, take considerable work to develop and implement. A model information management strategy should address the following considerations:

- Information management needs to be an integral part of any monitoring or data collection effort. Left as an afterthought, it will not meet the needs or be adequately funded, and ultimately be the reason for needing to collect more data in the future.

- Information and data are owned by the public and are not the property of any program or agency (a few exceptions do exist).

- Information should be managed and maintained in one location as close to the point of origin as possible, and by the group having the primary interest. Primary users have a vested interest in the ongoing quality and will do the best job of maintaining their mission critical information.

- Agencies should be data/information stewards and have a responsibility as stewards to make the information available to the public and any secondary data user. Data stewards have an obligation (and need the resources) to maintain the information they keep. They must have the ability and commitment to make improvements in the quality of the data set as users (primary and secondary) provide value added feedback.

- Data need to be documented such that a secondary user coming in 20 years later can determine why, how, and where data were collected. Most data sets today are inadequately documented and do not meet the 20-year criterion. Increased documentation will cost more but it is an investment in the future and secondary uses.

- Data misuse is a concern but the real issue is that misuse will be greatly minimized if documentation is present and the appropriate use can be determined. Misuse will always occur but with documentation it can be discussed on merit.

- Secondary users should be able to obtain the most current information available to make their decision or do their analysis. When done, the secondary user discards the data knowing that the next time an analysis requires it, they can return to the steward and easily obtain the most current information again.

- Data collection methods will never be the same within or across agencies, as the primary collector's purpose will always dictate their approach/methods. However documentation standards, (metadata = data about the data) should be consistent.

- Data quality is a concern with all data sets. It will only improve if the information is made available for many to see and use, and there is a willingness to evaluate and incorporate (as appropriate) the corrections noted by others.

- Known and consistent standards within a data set are required for sharing information. Standardization for some things is possible given management direction and attention. Consistency and adequate documentation within a historical data set is the first step. In

other words, there is a known standard within a data set, and standards between similar data sets will be adopted and migration to a more universal standard would occur over time.

$ The concept and purpose behind old data sets may be very valuable today; however a realistic evaluation needs to be made about the investment required and the resulting value from any older, poorly documented and maintained system/data set.

$ Efforts to agree on standards for the future data collection efforts need to be supported. The cost of uniqueness is too high when future access costs are considered.

Recommended Adaptive Management and Monitoring Approach

The comprehensive adaptive management and monitoring component of the Statewide Strategy to Recover Salmon is briefly summarized below. It is intended to guide further development of implementation approaches to be used by state agencies and other partners. Agencies and other entities routinely perform many appropriate and related monitoring activities that are outside the strict scope of the salmon strategy.

Monitoring programs are expensive and needs are typically greater than resources allow. At the minimum, coordination, integration, and where possible, reprioritization of existing agency monitoring activities will be stressed to meet priority needs. The Joint Natural Resources Cabinet expects implementation monitoring will be the responsibility of each agency/partner, within existing resources (although the 1999 legislature appropriated additional resources for monitoring and data management – See Early Action Plan).

The monitoring program needs to be developed at three geographic scales:

- Project implementation and effectiveness monitoring.
- Watershed-scale effectiveness and validation monitoring.
- Regional-scale effectiveness and validation monitoring.

The recommended approach is to focus on fish and priority habitat, implementation, and effectiveness monitoring. Effectiveness monitoring will be focused on the highest priority components and questions related to the Statewide Strategy to Recover Salmon at the project, watershed, and regional scales. A limited set of the highest priority habitat/ecosystem indicators will be monitored, tailored to priority strategy components across marine systems (nearshore/estuarine), urban, rural, and forested areas. This approach will entail substantial costs. However, it provides for all types of monitoring and creates efficiencies by emphasizing the highest priority issues for effectiveness and validation monitoring. Federal and other funding sources will be pursued to complement state investments in the salmon recovery monitoring program. A phased approach will be developed to direct available funding and cooperative partnerships.

The recommended approach focuses adaptive management on the top priority strategy components, objectives, and questions, as determined by the Joint Natural Resources Cabinet

and informed by the best available scientific advice. It seeks efficiencies and attempts to optimize funding and infrastructure needs.

The recommended approach is expected to be more compatible with potential funding availability than more comprehensive options. However, it does not preclude modification or expansion over time to address a broader range of strategy components and objectives as resources allow.

Overview of recommended option:

Activities and outcomes:
- Gather and assemble information on the status of fish populations and their habitats.
- Document changes in fish populations and habitat conditions over time.
- Produce and synthesize information regarding current conditions and assess cumulative effects on fish resources on a priority basis.
- Document whether conservation and regulatory compliance activities were implemented as intended (all agencies).
- Perform effectiveness monitoring at the appropriate spatial scales on a priority basis.
- Coordinate focused validation monitoring efforts on a priority basis.
- Analyze information on a schedule for use in the "State of the Salmon" report, and for feedback to the adaptive management process.

State services provided:
- Technical assistance and study design support to agencies/partners.
- Standard monitoring methods and protocols.
- Quality assurance support.
- Database and information services support.
- Leadership and coordination for strategy effectiveness, validation, and project monitoring.
- Watershed, regional, and statewide information syntheses.

Design elements:
- Ensure adequate monitoring of fish stock status over time.
- Complement fish status monitoring with monitoring of key habitat indicators at regular intervals.
- Utilize a system of reference and "index" areas/watersheds for focused, multi-disciplinary integrated effectiveness and validation monitoring efforts.
- Coordinate with the Independent Science Panel and other appropriate scientific teams to ensure scientific quality and integrity.
- Implement sector-oriented adaptive management and monitoring systems such as in the Forests and Fish report.
- Submit monitoring data from habitat projects and other recovery activities to the Salmon and Steelhead Inventory and Assessment Project.

Potential implementation structure:

- Monitoring steering committee - guides statewide monitoring policy planning and sets statewide monitoring priorities for the salmon strategy in coordination with the Joint Natural Resources Cabinet; creates and administers the formal adaptive management and monitoring process for the Cabinet.
- Technical monitoring committee - provides technical support and coordination for implementation of the monitoring strategy; seeks resolution of issues, coordinates with monitoring steering committee on unresolved issues.
- Data/GIS support services - provides guidance and support for distributed integrated information systems development and implementation; facilitates interagency/partner standardization, data sharing, retrieval, and long term synthesis.

IV. Adaptive Management and Monitoring: *Are we making progress?*

As stated earlier, performance monitoring associated with the Statewide Strategy to Recover Salmon must encompass multiple levels of monitoring (i.e., implementation, fish/habitat trends and strategy effectiveness, validation). A diverse array of monitoring efforts will be associated with different core elements of the strategy, which need to be meaningful and applicable at different scales and levels of effort (e.g., restoration projects, watersheds, regions, statewide).

Each agency partner will be expected to monitor the implementation of its respective conservation actions.

The design and results from monitoring should also be oriented to and interpreted in the context of the salmon ecosystem life cycle continuum (e.g., ocean, estuaries, mainstems of rivers, and small headwater streams). The biological organizational structure of fish populations should be used in developing and coordinating appropriate monitoring programs.

The 1998 Salmon Recovery Planning Act calls for preparation of a biennial State-of-the-Salmon report which will be prepared and submitted to the Legislature by the Governor beginning in December, 2000. The emphasis of this report will be on aspects of implementation monitoring, as noted by the elements drawn from the legislation identified below.

The report will also contain recommendations on monitoring from the Independent Science Panel, including the level of effort needed to sustain monitoring of salmon projects and other recovery efforts. The report should serve as a platform from which to address key salmon population and habitat trend information, and key strategy effectiveness and validation monitoring issues and results. It will help focus on issues and adaptive responses that might be addressed in subsequent biennia. The report may include implementation monitoring information such as:

1. The types and level of funds expended on salmon recovery in response to actual, proposed, or expected listings.
2. A summary of habitat projects, such as barriers removed, restoration efforts, volunteer initiatives, and habitat protection efforts.
3. A summary of collaborative efforts with adjoining states or Canada.
4. A summary of harvest and hatchery management activities affecting salmon recovery.
5. Information on impediments to success of salmon recovery efforts.
6. A summary of the types, extent, and sanctions imposed due to violations of existing laws regarding: (1) water quality, and (2) salmon.
7. Information on estimated carrying capacity created associated with habitat restoration projects.
8. Recommendations that would improve the likelihood of successful salmon recovery, including (1) the need to expand or improve non-regulatory programs and activities, and (2) the need to expand or improve state and local laws and regulations.

The report could also include other strategy effectiveness and validation monitoring information, as well as information on trends in key fish and environmental indicators (e.g., ocean productivity).

More specific implementation, effectiveness, and validation monitoring activities will be performed in conjunction with the Joint Natural Resources Cabinet work on performance indicators/measures being developed – referred to as Salmon Recovery Balanced Scorecard.

Given the central need for credible and reliable monitoring and decision management systems, if a comprehensive monitoring program is not developed the state would likely lose support for its conservation strategies and actions, increasing the risk of federal intervention and involvement and reduction in funding support.