1. **Synthesizing Vital Signs Data from Klamath and San Francisco Bay Area Networks: Analysis of Linkages and Trends in Climate, Stream Flow, Vegetation, Salmon, and Ocean Conditions**

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4. Overview

The Klamath (KLMN) and San Francisco Bay Area (SFAN) networks of national parks span the Pacific coast of northern California and Oregon. In this region, daily, seasonal, and decadal variation in abiotic drivers (e.g., precipitation, fog, stream flow, and temperatures of air, ocean, and streams) regulate many ecological processes, including the distribution of vegetation and wildlife and frequency of disturbances from fires, floods, landslides, and biotic pests. However, the exact nature of the linkages between abiotic drivers and the direct and indirect effect of these drivers on species of concern and their habitat are not well understood. Specifically, abiotic drivers are commonly analyzed as individual elements (i.e., calculating mean annual precipitation) and the linkages between drivers (such as the influence of changes in stream flow on stream temperature) are poorly defined.

In addition to understanding the basic linkages between abiotic and biotic ecosystem elements, the question of climate change is of increasing concern to land managers in the national parks. They need to understand how climate change has already affected natural resources and whether other changes may be looming. Without this understanding it is increasingly difficult to judge the effects of management efforts (e.g., stream restoration), evaluate the resilience of existing habitats, or plan future management actions. Climate change has been linked to more rain and less snow in the Sierras (Cayan and others 2008), identifying the need for management to address long-term water storage. In contrast, there has been a paucity of information depicting the effects of natural climatic cycles and anthropogenic climate change, aside from sea level rise, in coastal California and Oregon including KLMN and SFAN (Suffling and Scott 2002, Hayhoe and others 2006).

Complicating a manager's ability to respond to climate change effects is the common assumption of stationarity – the idea that natural systems fluctuate within an unchanging envelope of variability (Milly et al., 2008). The stationarity assumption is being compromised by major shifts in background environmental conditions. As a result, the timing, magnitude and intensity of critical abiotic elements in national park units may be changing. In addition, the common assumption that restoration planning can use historical reference conditions as a goal may not be

valid if extrinsic drivers in national parks display non-stationarity. Consequently, the understanding of trends, variability, and interactions among abiotic drivers is needed to inform and prioritize restoration sites or activities and to implement scenario planning to foster strategic thinking about future conditions and management alternatives.

Numerous long-term data sets are being collected by SFAN and KLMN as part of the vital signs monitoring program. They represent management concerns and ecologically important constituents of park ecosystems. In discussions with NPS staff, we identified the NPS data sets, other data sets available from other agencies, and created a conceptual model of their linkages (Figure 1) as the basis for designing an integrative data analysis. Further discussion of network priorities and concerns led us to salmon-related data and linkages as a feasible subset for focus.

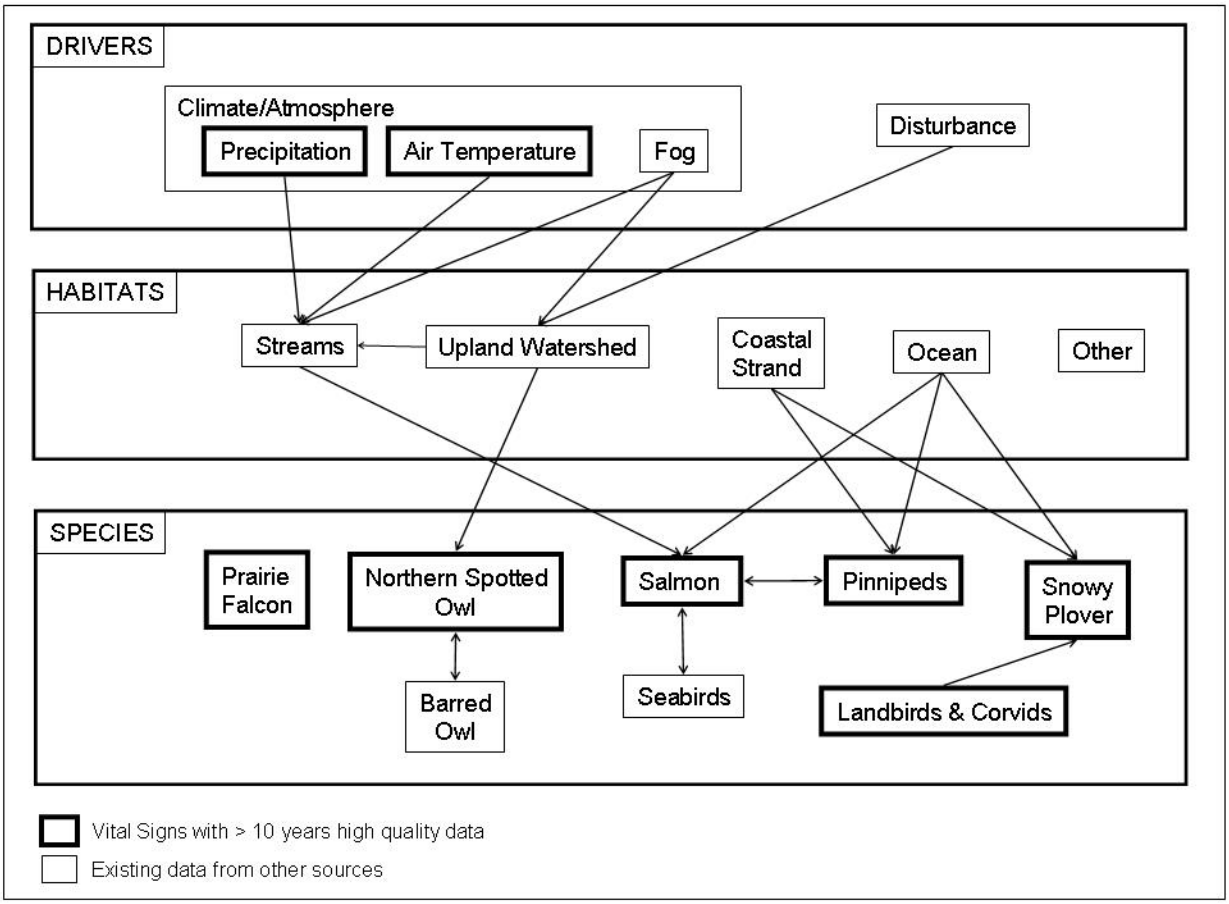

Figure 1. Conceptual model of linkages among long-term data sets available from both NPS and other sources for the SFAN and KLMN area. Note that many linkages are not represented in this conceptual diagram, such as disturbance effects on streams, ocean effects on fog, and habitat changes on the prairie falcon.

In central and northern California, several salmon populations have been in decline for years. In 1997, coho salmon *(Oncorhynchus kisutch)* were federally listed as threatened in the Southern Oregon/Northern California Evolutionary Significant Unit, including Redwood National Park, and as endangered in the Central California Coast Evolutionary Significant Unit, including SFAN parks. Millions of dollars are being spent in coastal parks on watershed and stream

restoration projects. As the NPS plans salmon restoration activities in coastal watersheds, it is critical to understand the abiotic factors and interactions that affect salmonid populations (MacCall and Wainwright 2003, Battin and others 2007).

The proposed analysis will help park managers prioritize restoration activities that have a high probability of success. Linking abiotic data to biological information on riparian habitats and salmon will enhance park management by providing insight into some of the subtle changes influencing the ecosystem. Specifically, managers will be able to understand local salmon population trends within a context of regional salmon population patterns, habitat restoration efforts, anthropogenic modifications (i.e. dams), stream flow, ocean conditions, and climate change including extreme climatic events. The results, for example, could provide some insight regarding whether habitat restoration is enough to counteract the trends imposed by climate change. Similarly, by linking climate change with riparian habitats, we may also be able to tease out current and expected habitat changes due other large scale disturbances such as Sudden Oak Death (SOD), prevalent at both Golden Gate National Recreation Area and Point Reyes National Seashore and recently detected near Redwood National Park.

In addition to influencing management decisions, evaluating short and long-term effects of climate variability on park vital signs and analyzing the effects on biotic indicators will serve as a model for synthetic data analysis. The long-term monitoring programs being established at KLMN and SFAN focus on a variety of vital signs with protocols detailing how measures are collected and how data will be analyzed to detect trends (Sarr and others 2007, Adams and others 2006). Although it is a goal, a synthetic approach for analyzing multiple datasets has not been developed. This project will provide a statistical framework for analyzing datasets from multiple vital signs within and across networks.

National Parks are also recognized by adjacent jurisdictions and other agencies as an important resource of monitoring data representing protected ecological systems. Creating institutional linkages that enhance ongoing research and monitoring in parks and elsewhere will not only provide a larger landscape context for site specific actions but also increase the value of a vital signs warehouse. This synthesis can therefore augment other efforts to build linkages with other agencies such as the Bay Area Early Detection Network (BAEDN) which was formed among private and public land management agencies in the San Francisco area to share data and information relating to invasive plant species.

5. Objectives

Objectives of this project include:

- Identify trends in climate drivers and disturbance regimes that may be having local and regional effects on salmon populations in relevant units of KLMN and SFAN using multivariate statistics and structural equation modeling.
- Exploit the latitudinal gradient of environmental conditions and variety of management contexts among park units to discern relationships and provide a regional view.
- Inform management decisions, including restoration planning, in the face of potential non-stationarity of system drivers by the response of multiple salmon life-history stages to novel ranges of variability.
- Identify gaps in NPS data sets and recommend modifications to the vital signs monitoring program.

- Continue an interactive relationship with NPS staff at all stages of the project: data sets acquisition, data analysis, interpretation of results, development of potential structural equation models, and dissemination of results.
- Provide NPS with tools and a framework for synthetic analysis of multiple sets of monitoring data from NPS while also taking advantage of other sources.

6. Prior Year's Report for Subtasks (not applicable)

7. Next Year's Proposal for Subtasks

7.1 Need

The SFAN and KLMN haves limited technical expertise to synthesize complex data sets, and data analyses such as those proposed here would typically have to be outsourced. This proposal provides a unique opportunity to develop a long-term relationship with USGS to conduct the types of analyses that are highly desired but are currently beyond the means of the networks. The products developed through this project would also build capacity for the networks by serving as a model for conducting future data syntheses. The network coordinators, data managers and aquatic biologists from both KLMN and SFAN have vested long-term interests in the NPS I&M Program and will be very involved in his project and learn synthetic approaches, modeling, and analytical techniques from USGS professionals that could be applied to future projects. This project will also address a national need for examples of synthetic analyses.

7.2 Procedures and Methods

Close consultation with NPS staff determined that the subset of vital sign measures that had the greatest potential for synthesis was the climate-stream-salmon system (Figure 2). A brief description of the important relationships in this system begins with climate, a high priority vital sign for both KLMN and SFAN, which has strong direct linkages to stream condition by determining water input. Variation in precipitation modulated by land cover, is an indirect geomorphic driver throughout the watershed determining stream flow which in turn affects channel erosion, sedimentation, and water quality. Air temperature variations are strongly linked to stream temperatures, which have been shown to be correlated to summer survival of salmonids. Water temperature and flow are also influenced by shade and input of large woody debris from riparian vegetation. Many forms of disturbance (e.g., fire, flooding, diseases, timber harvest) cause abrupt changes in land cover, including riparian and upland vegetation, as well as in physical attributes of stream habitat. An important driver of more gradual change in upland vegetation is fog, which determines the distribution of redwood forests. Fog, in turn, is a function of air temperature, ocean temperature and precipitation. Finally, various stage of the salmon life cycle are affected by the characteristics of freshwater and ocean habitats (Laufle and others 1986 and Bettelheim 2000). This complex system cannot be understood using univariate or correlational analysis alone.

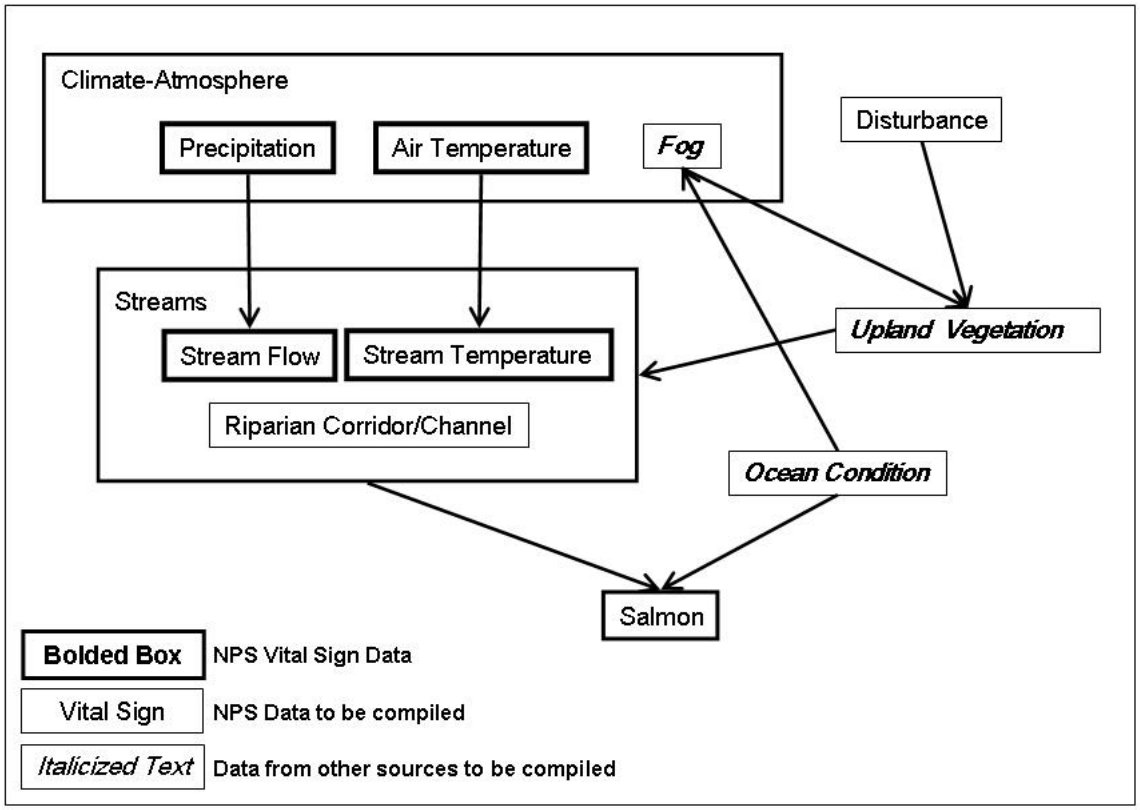

Figure 2. Simplified representation of the climate-stream-salmon system. The Climate-Atmosphere box has three strongly interacting sub-components, precipitation, air temperature and fog. Likewise the Streams box has three interacting sub-components. In addition to the investigating the linkages between the three sub-components, the project team will analyze linkages indicated by arrows.

Full implementation of vital signs synthesis for the climate-stream-salmon system includes six major categories of activities: compilation and standardization of data –both NPS and other sources; development of time series metrics for each of the nine components of the vital sign synthesis (figure 3); analysis of linkages between time series metrics of measures within a vital sign (represented by two sets of 3 boxes in Figures 2 and 3), analysis of linkages between vital signs (represented by arrows in Figures 2 and 3); conversion of linkages –in the form of statistical relationships– into structured equation models (SEM); and conceptual model development and refinement. The last category is an ongoing activity that occurs throughout the project and serves two important goals: 1) facilitate decisions about the appropriate metrics to incorporate into the analyses based on the end goal of providing usable results, and 2) ensure strong collaboration and communication through the use of a visual, continuously updated and expanded conceptual model framework.

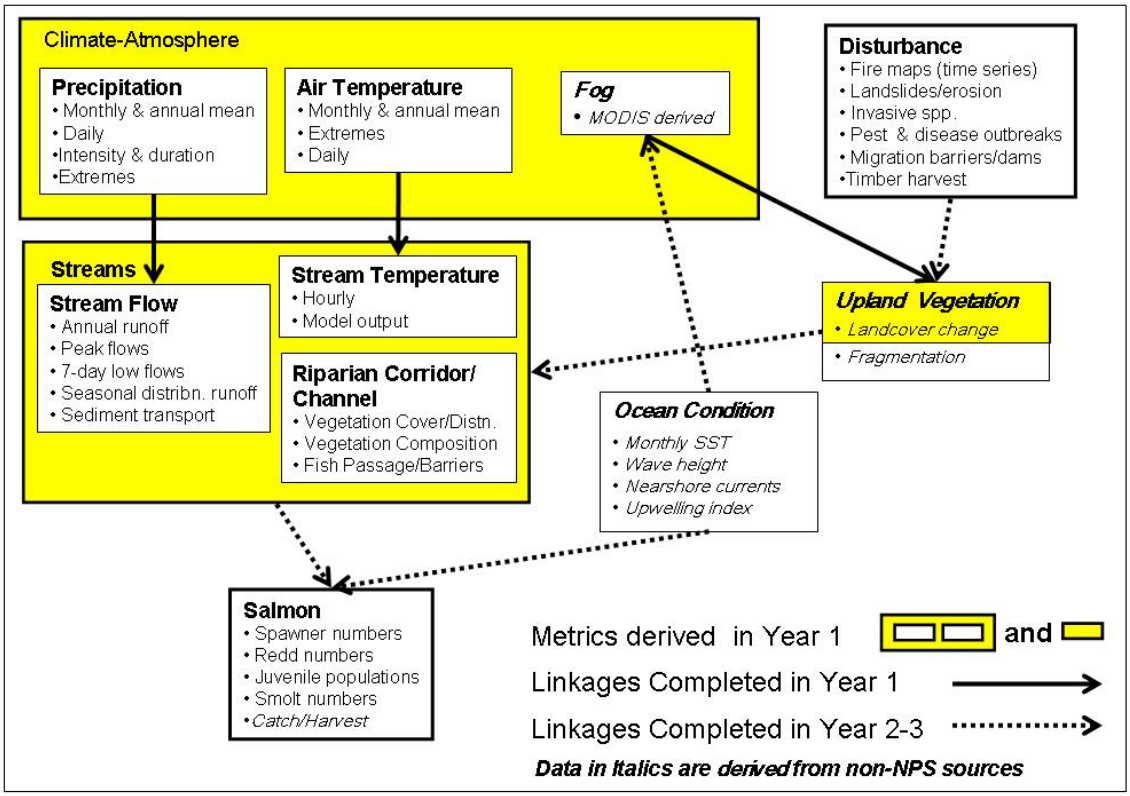

Figure 3. Vital sign indicator metrics and linkages for the climate-streams-salmon system. Boxes highlighted in yellow identify the vital sign indicators that will be derived during year 1. Linkage analysis will be applied to metrics within the same box such as precipitation, air temperature, and fog, all within the Climate-Atmosphere box. Analysis of relationships between measures in different indicator boxes such as between precipitation and stream flow or air temperature and stream temperature are identified by arrows. Solid arrows identify linkage analyses to be completed in year one. The metrics for ocean conditions are not identified as being derived in year 1 because they are already available and accessible from NOAA.

Compilation and Standardization of Data

Data for the climate-stream-salmon system synthesis from NPS are in the form of vital sign measures and other data sets that are not specifically incorporated into the vital sign database (for example, archival timber harvest data). Also, data developed for the parks through CESU agreements or Pacific Coast Science and Learning Center research efforts will be obtained from NPS archives. Datasets from other sources include the USGS Landsat archive, NOAA International Comprehensive Ocean-Atmosphere Data Set (I-COADS), and NOAA Southwest Fisheries Science Center, Environmental Research Data Server. Fog data are essential to a better understanding of water balance in coastal systems and are being provided by Park Williams (UCSB; pers.comm.). His methodology, which forms the basis for his doctoral dissertation, fuses MODIS sensor data on cloud cover and airport records of cloud height to derive a gridded daily dataset for coastal California during the summer months of June – September 2000 to present. Although the process is computationally intensive he has developed an automated algorithm and

has offered to provide fog data at time-aggregated intervals that would be required for our analyses.

Standardizing the available data will take two forms, 1) working with data formats, and 2) data transformations. Manipulations of data format are commonly necessary when data are being compiled from different data warehouses for eventual ingestion into a particular analysis application program. Geospatial data often require additional formatting manipulations related to ensuring congruent georeferencing. Based on the structure of the datasets, data transformations maybe necessary to meet assumptions of statistical analyses or have the same spatial scale for comparable analysis. These transformations can take many forms: spatial and temporal aggregations or disaggregation; normalizing statistical distributions of sample data; log transformations and scale transfers (Bierkens and others 2000).

Trend Detection

Several time scales are relevant to the climate-stream-salmon system. In this region of California, extreme storms are studied on a scale of hours to days, floods on a scale of days, droughts on a scale of seasons to years, and climate change on a scale of decades to centuries. We will identify trends in precipitation, temperature and stream flow using standard time series analyses (Helsel and Hirsch 1997). The trend detection process will identify sustained trends at various scales, and cycles of differing duration, which will provide the context for management actions. For example, if managers know the current condition is a dry phase of the PDO, restoration efforts can reflect that knowledge

Climate-Atmosphere

Several climate data metrics will be derived for precipitation and air temperature including, daily, monthly, and annual means, analysis to identify extremes events, and intensity and duration of precipitation and temperature events. NPS vital signs monitoring will provide park-specific data for precipitation and temperature. A regional analysis of trends will be possible in Year 2 when additional data are provided to KLMN through an existing contract with Oregon State University. Fog metrics will include at minimum daily, weekly, monthly means for June – September, and if data become available, estimated daily, weekly, monthly, and annual mean water content.

Streams

StreamStats*, a USGS program, will be used to calculate stream flow and stream temperature statistics as well as basin characteristics. Stream flow metrics to be compiled include annual runoff, daily mean flow, peak flows, 7-day low flows, timing of channel-scouring flows, and seasonal distribution of runoff. Annual and monthly mean precipitation and annual and monthly mean air temperature will be examined for temporal trends. Plots of cumulative departures from the mean will identify relatively wet and dry periods, and hot and cold periods. Standard nonparametric analysis (Gilbert 1987) will be used to test significance of trends. Temporal Analyst* (a time series data management program for ArcGIS; www.temporal-analyst.com) will be used to process and display precipitation, temperature, and stream flow data within a spatial context on a regional scale.

* Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Riparian Corridor and Channel metrics such as canopy cover (from existing NPS vegetation maps) will be compiled into an ArcGIS linear referencing schema to more easily analyze attributes such as percent drainage area associated with particular segments along the stream.

Salmon

Data collected by NPS for coho salmon in Redwood Creek (KLMN) and Redwood Creek (SFAN) includes life cycle measures for each year class (juveniles, smolts, and spawners), numbers of nest sites (redds), mortality index, and a measure of observer efficiency. This last measure will be particularly important in autocorrelation analyses between age classes (Shea and Mangel 2000). To develop methodologies that will be useful for coho salmon time series analysis for NPS staff, additional data from the NMFS Southwest Fisheries Science Center database covering brood years of 1986 – 2007 (which includes CDFG data) will be used in the analyses described below in the vital sign linkage methodology section.

Upland Vegetation

The free access to the 30+ year USGS Landsat archive (complete availability projected for Jan 2009) will provide an opportunity for parks across the nation to duplicate change detections methods developed for this project. Several different methods for change detection (image differencing, image ratioing, vegetation index differencing, image regression, post-classification differencing) will be considered during close consultation with NPS staff. The most labor intensive method, post-classification, although most traditionally practiced, may not be required for this project. This is true if the linkages relate more to functional attributes (such as productivity) that can be derived with non-land cover classes through a tasseled-cap analysis. Using an image difference detection (Pat Chavez pers. comm.) that first identifies potential changes of interest followed by a prioritization of importance (either due to location, potential type of change, or ancillary knowledge from NPS staff) may arrive at a usable product much more quickly. The metrics to be derived from this compilation include a rate of change based on the 30 year record in 5 year intervals and a frequency of disturbance events. Only disturbance events that are discernable at the coarse scale of 30-90 m Landsat pixels, such as fires, larger landslides, or logging will be targeted.

Ocean Condition

The subset of time series data of ocean conditions that would improve the analyses of this project will be identified through a close collaboration with the Environmental Research Division of the NOAA Southwest Fisheries Science Center. The national CoastWatch program coordinator for the west coast, David Foley, has agreed to be the main liaison between this project and the NOAA ERD to ensure that the data provided are used to maximum advantage and to facilitate a coordinated research effort between this USGS/NPS project and their Integrated Ecosystem Assessment Program.

Disturbance

The category “disturbance” includes a wide variety of potential datasets: fish passage barriers, their placement and removal; timber harvests; fires; pest outbreaks; and road construction, their construction, removal, or mitigation, location of barriers. The frequency measures to be derived from these data will depend in large part on the need for greater explanatory power beyond the initial univariate and multivariate analysis, as described in the section below. Determining the

form (time interval or frequency measure) for the disturbance data will be accomplished in close consultation with NPS staff.

Vital Sign Linkage

Several relationships among and between resource elements will be investigated. To date, many vital signs have been analyzed as individual elements, but in many cases linkages among the elements have not been investigated. It will be useful for park managers to understand these linkages for several reasons. First, if metrics are correlated (e.g., daily precipitation and mean daily stream flow), data gaps can be filled using those statistical relationships, and the length of record of one element can be extended by using the data record of the second element. In addition, specific hypotheses regarding the linkages can be tested. Examples are listed below.

Precipitation and air temperature

Wentz *et al.* (2007) and Lambert *et al.* (2008) suggest that annual mean precipitation is related to annual mean air temperature. To see if this concept is valid for coastal California National Park units, annual mean precipitation will be regressed directly onto annual mean temperature, based on meteorological stations within or adjacent to parks.

Air temperature and stream temperature

Coho salmon are very sensitive to elevated stream temperatures. The relationship between air temperature (as a surrogate for solar radiation, which directly affects water temperature) and stream temperature will be tested to examine maximum and minimum temperatures and duration of elevated temperatures above thresholds of concern.

Stream temperature and streamflow

Stream temperature, an important factor in summer survival of salmon, tends to increase to a peak in late July to early August. Increases in stream temperature can be accelerated by the diversion of stream flow for agriculture or other uses, or may be delayed if summer rains increase stream flow. The relationship between stream temperature and stream flow will be tested through regression analysis.

Precipitation and streamflow

In the KLMN and SFAN many more data sets are available for precipitation than for stream flow. It would be useful for fish biologists to be able to extend the record of stream flow, especially during time periods critical to salmon spawning, rearing and migration. To assess this possibility, annual and monthly mean stream flow will be regressed directly onto annual and monthly mean precipitation, respectively.

Regime shifts

There is growing evidence that population trends in species such as salmon are affected by climatically induced shifts in potential productivity that result from cyclical trends in oceanic conditions such as the pacific decadal oscillation or ENSO events (Mueter and others 2006). A method for accounting for this variability is to truncate the population time series into segments before and after the regime shift. Regressions will be run with truncated data to investigate if that improves an ability to discern correlations among age class trends.

Multiple regression analyses using combinations of factors influencing stream temperature (air temperature, stream flow, riparian condition, distance from coast, etc.) will be run, and the best fit models will be chosen using Akaike's Information Criterion (AIC) or Bayesian Information Criterion (BIC) (Clark and Gelfand 2006). These analyses will help inform the nature of the models used in the next step, structural equation modeling.

Structural Equation Modeling

Structural equation modeling (SEM) is a statistical technique that takes a hypothesis-testing approach to multivariate data analysis (Byrne 1998, Grace 2006). The first step is to create a pictorial representation (conceptual model) of the hypothesized relationships among system components. These hypotheses can be developed for the climate-stream-salmon system based on the results of analyses described above and on ecological theory and understanding from other sources. The conceptual model is then expressed as a series of regression (structural) equations. Finally, the hypothesized model can be tested statistically for consistency with observed data. The plausibility of the model is assessed by the goodness of fit between the data and the model.

SEM has several benefits over earlier approaches to multivariate analysis (e.g., principle components analysis, discriminant analysis, factor analysis, multiple regression). First, it is confirmatory rather than exploratory or descriptive (Byrne 1998), and therefore easier to interpret ecologically. Also, SEM provides estimates for measurement error for measured variables and the ability to incorporate unobserved (latent and composite) variables (Bollen 1989, Byrne 1998, Grace and Bollen 2007). The possibility of including unmeasured variables is an important advantage when trying to understand complex ecological systems where only some aspects can be feasibly measured.

The requirement for constructing a pictorial conceptual model is a productive tool for obtaining input and insight from all staff members of NPS irrespective of their background in statistics and data analysis. The conceptual modeling process can be repeated for other sets of monitoring data by NPS staff and the analysis is becoming increasingly accessible as capable software packages proliferate (e.g., LISREL, PRELIS, SIMPLIS; Byrne 1998).

7.3 Expected Results or Products

Year 1

The following products will expand and build the capacity of the I&M networks by increasing the number of current databases, highlight relationships among vital signs, and illustrate temporal trends in NPS data. The data compilation and initial statistical analyses can be used by park managers or other researchers as a base to investigate linkages among other vital signs as well. It will also put current environmental conditions in the context of long-term trends and cycles to support effective planning for management actions.

1) Compiled and standardized datasets for precipitation, air temperature, stream flow and stream temperature (Vital Signs and non-NPS data)
2) Summary report including stream flow statistics and interpretation of temporal trends in precipitation, air temperature and stream flow.
4) Summary report with interpretation of regression analyses involving linkages among abiotic vital signs (precipitation, air and stream temperature and stream flow).

5) Report including maps and interpretation of: a) rate of change over 30 years in 5 year intervals, and b) episodic disturbance.
6) Meeting with SFAN and KLMN staff to present results and interpretation, answer questions, and discuss future needs.

Year 2
1) Trend detection of ocean indices – univariate analysis
2) Multivariate analyses of abiotic variables & land cover
3) Use Temporal Analyst to portray regional trends in precipitation, air temperature and stream flow. Create maps that can be used by NPS interpreters as well as by resource managers.
4) Workshop w/NPS to review analyses & develop conceptual model for structural equation model analysis.

Year 3
Hypotheses regarding linkages among factors influencing salmon populations, including measured and unmeasured variables, will be tested to create a comprehensive understanding of the most important drivers and interactions. This understanding can be used to inform management actions, predict future changes, and inform the public.

1) SEM analysis report
2) Peer-reviewed publication.

7.4 Technology/Information Transfer

This project will meet the national need of the NPS monitoring program for tools for integrated reporting of groups of related vital signs, inventories, and data available from other agencies. The broader synthesis across multiple abiotic and biotic data sets across the geographic range of SFAN and KLMN will place NPS vital signs in the context of the surrounding region regarding an important ecologic and economic resource, salmon. The conceptual model presented in Figure 1 can be adapted and applied to other I&M networks and the statistical methodology developed to examine temporal trends and linkages among vital signs can be used to synthesize other data sets in collected by SFAN and KLMN as well as other networks.

Users of this data synthesis include NPS resource managers, interpretation staff and visitors. It is expected that adjacent land managers, agencies and citizen groups will be interested in the regional context of this data synthesis. SFAN, for example, already has a memo of understanding to share data with a variety of public and private land managers in the San Francisco Bay Area. NPS also has a strong commitment to work with other public land managers. MUIR (administered by GOGA), for example, is completely surrounded by Mount Tamalpais State Park. PORE and GOGA are also adjacent to several stat parks including Samuel P. Taylor State Park and Angel Island State Park as well as land managed by the Marin Municipal Water District.

An important product to help park management, visitors, and other stakeholders understand the results of this study is a collection of maps integrating temporal and spatial information. Figure 4 is an example of such a map that shows the time-weighted average of annual precipitation across a region. Similar maps showing exceedance frequencies or durations of rainfall or stream flow,

for example, can also be created with the use of Temporal Analyst. Maps can then be joined in an animation to easily relay concepts of trends to the lay person.

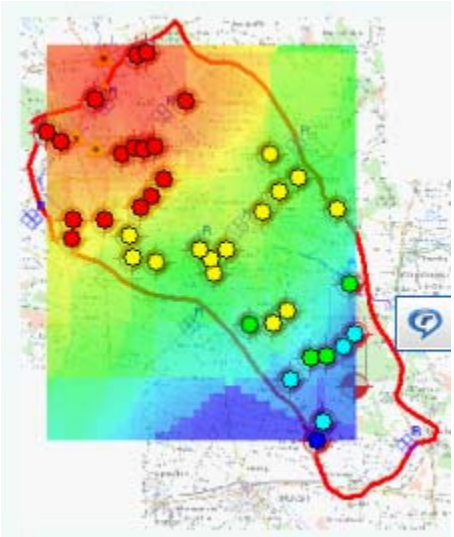

Figure 4. Example map of time-weighted average of annual precipitation across a region.

The results from the proposed project will have high transferability to other land management agencies and regulatory agencies dealing with the management and restoration of salmon-bearing streams in California and the Pacific Northwest. It will provide the framework for coupling a predictive model with terrain-based information. This project will provide a framework of assessing linkages among vital signs that can be applied to other NPS I&M networks. Project results have direct implications for several parks (REDW, WHIS, YOSE, GOGA, and PORE) which have recently embarked on stream restoration programs. Although many stream restoration projects have been proposed throughout the western United States, most land management agencies do not have access to the level of detailed information and long-term monitoring data that are available for the drainage basins in KLMN and SFAN parks.

Results from this study can be used by the National Park Service and other agencies to: 1) develop, test and evaluate monitoring protocols for the NPS "Vital Signs Monitoring Program," 2) prepare environmental documents needed in planning restoration activities, 3) include stream protection recommendations during timber harvest plan reviews on private lands, 4) establish index reaches in park streams for long-term monitoring as required in the EPA Water Quality Attainment Strategy.

7.5 Work Schedule

FY09

Process	Who	Time Period
Coordinate for NPS	PGSC, WERC, FRESC	Throughout
Data compilation & standardization	NPS Data managers, PGSC, WERC	Nov 008 – Feb 2009
Time Trend Metrics – climate & streams	WERC	Feb 2009 – May 2009
Vegetation metrics analysis	PGSC	Jan 2009 – Jun 2009
Meet with NPS staff to discuss results and interpretation	NPS, PGSC, WERC, FRESC	Jul 2009
Write draft summary reports – time trend metrics	PGSC, WERC, FRESC	Aug 2009 – Sept 2009

FY10

Finalize summary reports – time trend metrics	PGSC, WERC, FRESC	Oct 2009 – Nov 2009
Time trend metrics – salmon, ocean, fog	PGSC, WERC	Oct 2009 – Dec 2009
Analysis of vital sign linkages	PGSC, WERC	Jan 2010 – Apr 2010
Present & discuss results and interpretation with NPS	NPS, PGSC, WERC, FRESC	May 2010
Write draft summary reports – vital sign linkages	PGSC, WERC, FRESC	Jun 2010 – Jul 2010
Workshop with NPS staff to begin conceptual model for SEM	NPS, PGSC, WERC, FRESC	Sept 2010
Finalize summary reports – vital sign linkages		Aug 2010 – Sept 2010

FY11 – details to be determined; will complete SEM analysis

Note: David Foley of the NOAA CoastWatch program has volunteered to work with us as an in-kind contribution.

FY 2011 Work plans

Finalize summary reports of temporal and spatial trends in climate, streamflow, and salmon. Present and discuss results and interpretation with NPS. Complete SEM model.

8. Out Year Plans (see sections 7.1 – 7.5 above)

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