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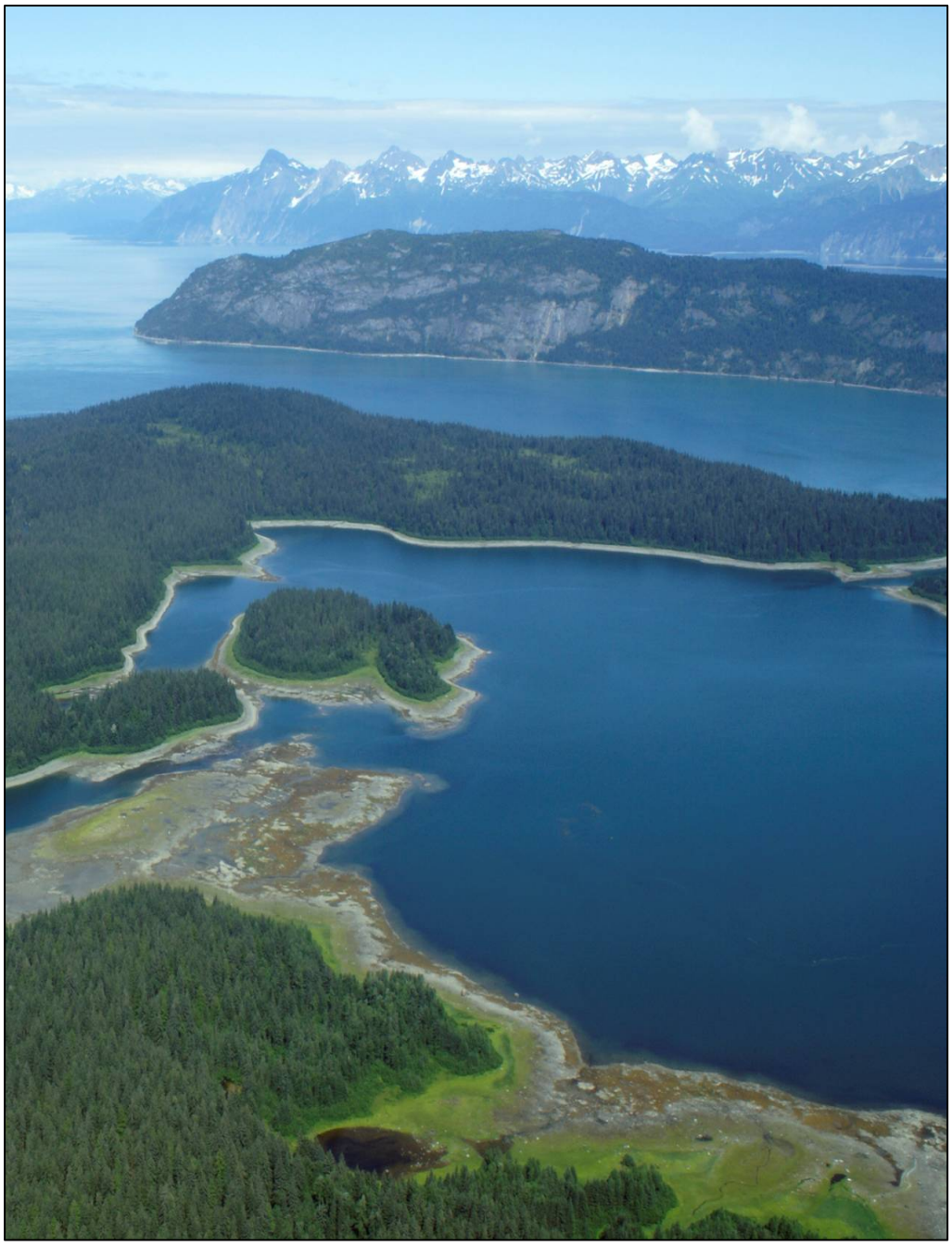
Vital Signs Monitoring Plan
Southeast Alaska Network

Natural Resource Report NPS/SEAN/NRR—2008/059



ON THE COVER
Glacier Bay National Park. Looking northeast across Berg Bay to Willoughby Island, with the East Arm and Mt. Wright in the background.
Photo by Bill Eichenlaub. NPS. July 2007.

Vital Signs Monitoring Plan
Southeast Alaska Network

Natural Resource Report NPS/SEAN/NRR—2008/059

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U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

Glacier Bay National Park and Preserve
Klondike Goldrush National Historical Park
Sitka National Historical Park

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Acronyms:

AK-EPMT	Alaska Exotic Plant Management Team
ARO	Alaska Regional Office, Anchorage, AK
BOD	Board of Directors
DMP	Data Management Plan
DOI	Department of the Interior
GLBA	Glacier Bay National Park and Preserve
PDS	Protocol Development Summary
I&M	Inventory and Monitoring Program
KLGO	Klondike Gold Rush National Historical Park
MDN	Mercury Deposition Network
NPS	National Park Service
SEAN	Southeast Alaska Network
SITK	Sitka National Historical Park
TC	Technical Committee
USDA	U.S. Department of Agriculture
USGS-BRD	U.S. Geological Survey – Biological Resources Division
WRCC	Western Regional Climate Center
WRD	Water Resources Division (NPS)

Table of Contents

LIST OF FIGURES vii

LIST OF TABLES vii

LIST OF APPENDICES viii

THE SOUTHEAST ALASKA NETWORK MISSION STATEMENT ix

ACKNOWLEDGEMENTS xi

EXECUTIVE SUMMARY xiii

CHAPTER 1: INTRODUCTION AND BACKGROUND 1

1.1 PURPOSES OF THE VITAL SIGNS PROGRAM 1
1.1.1 NPS Policies and Mandates that Link Monitoring and Management of Parks *2*
1.1.2 SEAN Parks Legislation *4*
1.1.2.1 GLBA Enabling Legislation *4*
1.2 GOALS OF VITAL SIGNS MONITORING 6
1.2.1 Integrating Water and Air Quality Monitoring *7*
1.3 MONITORING OBJECTIVES 8
1.4 SOUTHEAST ALASKA NETWORK: ENVIRONMENTAL SETTING 8
1.4.1 Klondike Goldrush National Historical Park *14*
1.4.2 Sitka National Historical Park *15*
1.4.3 Glacier Bay National Park and Preserve *15*
1.5 RESOURCE PRESERVATION CONCERNS 16
1.5.1 Broad-Scale Concerns of All SEAN Parks *17*
1.5.2 Park-Scale, Issues-Oriented Monitoring: What Are the Most Important Management and Scientific Issues to the Network? *19*
1.6 THE SEAN APPROACH TO PROGRAM DEVELOPMENT 20
1.7 DATA CAPTURE AND REVIEW OF MONITORING BY OTHERS 22

CHAPTER 2: CONCEPTUAL ECOLOGICAL MODELS 23

2.1 INTRODUCTION 23
2.2 ECOLOGICAL CONTEXT 24
2.2.1 Global Setting of Southeast Alaska Parks: Far-field Drivers of Change *24*
2.2.2 Local Resource Preservation Concerns: Near-field Drivers of Change *26*
2.3 DRIVERS OF ENVIRONMENTAL CHANGE 26
2.3.1 Holistic Model *26*
2.3.2 Physical Drivers in Southeast Alaska *28*
2.4 ECOSYSTEM INTERACTIONS 29
2.4.1 Succession in Freshwater *29*
2.4.2 Primary Succession on Land *30*
2.4.3 The Marine Environment *31*

CHAPTER 3: VITAL SIGNS 33

3.1 VITAL SIGN SELECTION 33
3.1.1 Terrestrial, Freshwater, and Marine Scoping Workshops *33*
3.1.2 Compile, Rate, and Prioritize Candidate Vital Signs *35*
3.1.3 The Core and Secondary Programs *36*
3.1.4 Relationship between Vital Signs and Conceptual Models *38*

CHAPTER 4: SAMPLING DESIGNS **41**

4.1 SAMPLING DESIGN BY VITAL SIGN 41
4.1.1 Area-based Sampling *41*
4.1.2 List-based Sampling *44*
4.1.3 Index Sites *45*
4.1.4 Census Designs *47*

CHAPTER 5: SAMPLING PROTOCOLS **49**

CHAPTER 6: DATA MANAGEMENT AND ARCHIVING **56**

6.1 INTRODUCTION 57
6.2 INFRASTRUCTURE AND SYSTEMS ARCHITECTURE 60
6.3 PROJECT MANAGEMENT AND DATA PROCESSING WORKFLOW 61
6.4 DATA MANAGEMENT ROLES AND RESPONSIBILITIES 64
6.5 DATABASES 64
6.6 DATA ACQUISITION, PROCESSING, AND REPORTING 67
6.7 QUALITY ASSURANCE AND QUALITY CONTROL 69
6.8 DATASET DOCUMENTATION 70
6.9 DATA OWNERSHIP AND SHARING 70
6.10 DATA DISSEMINATION 71
6.11 RECORDS MANAGEMENT, DATA MAINTENANCE, AND ARCHIVING 71
6.12 PROJECT TRACKING AND DOCUMENTATION 73
6.13 IMPLEMENTATION 73
6.14 WATER QUALITY DATA 73

CHAPTER 7: DATA ANALYSIS AND REPORTING **75**

7.1 DATA ANALYSIS 75
7.2 REPORTING 77

CHAPTER 8: ADMINISTRATION/IMPLEMENTATION OF THE MONITORING PROGRAM **81**

8.1 SEAN ORGANIZATIONAL STRUCTURE 81
8.2 STAFFING PLAN 83
8.2.1 Reliance on and Integration with Park Staff *84*
8.2.2 Reliance on Cooperators, Partners, and Contractors *86*
8.3 PROGRAM REVIEWS 88

CHAPTER 9: SCHEDULE **89**

CHAPTER 10: BUDGET **95**

CHAPTER 11: LITERATURE CITED **99**

GLOSSARY **113**

List of Figures

Figure 1.1 Relationships between park mandates, resource protection, and long-term monitoring 2
Figure 1.2 The Alexander Archipelago and the Southeast Alaska Network parks 10
Figure 1.3 Map of Sitka National Historical Park. 11
Figure 1.4 Map of Klondike Goldrush National Historical Park. 12
Figure 1.5 Map of Glacier Bay National Park and Preserve 13
Figure 2.1 Important ecological features within the three ecosystem components in Southeast Alaska 24
Figure 2.2. Resource preservation concerns in Southeast Alaska Parks 25
Figure 2.3 Holistic conceptual ecosystem model: Drivers of change 27
Figure 3.1 Thirteen of the 36 final Vital Signs mapped onto the SEAN conceptual model 39
Figure 3.2 Twenty-three of the 36 final Vital Signs mapped onto the SEAN conceptual model 40
Figure 6.1 The SEAN Functional Model of Data Management 58
Figure 6.2 The SEAN information architecture 61
Figure 6.3 SEAN project stages. 62
Figure 6.4 SEAN data management operations. 63
Figure 6.5 SEAN roles and responsibilities mapped to the 4 program Core Functions 65
Figure 6.6 Conceptual draft of a SEAN Vital Sign web page 72
Figure 8.1 Interaction between the Southeast Alaska Network organizational elements 83

List of Tables

Table 1 The Core and Secondary Vital Signs Programs xv
Table 1.1 Preliminary monitoring objectives 9
Table 1.2 Resources and issues of concern to the Southeast Alaska Network Parks. 21
Table 3.1 The Core and Secondary Vital Signs Programs 37
Table 4.1 Summary of overall design features for SEAN Core Program Vital Signs 42
Table 4.2 Number of weather stations within 60-km of SEAN's park units 47
Table 5.1 Justification and measureable objectives for monitoring protocols 51
Table 6.1 Repository content 64
Table 6.2 Positions mapped to the four program Core Functions 66
Table 6.3 Development tasks associated with capturing data 68
Table 6.4 Operational tasks associated with capturing data 69
Table 7.1 Summary of analyses and responsibilities for the SEAN Core Program 76
Table 7.2 Reports to be produced 79
Table 8.1 Composition of the SEAN Board of Directors, 2008 81
Table 8.2 Composition of the SEAN Technical Committee, 2008 82
Table 8.3 Anticipated cooperators and partners for the SEAN Core Program 87
Table 9.1 Schedule for developing, testing, and finalizing monitoring protocols 90
Table 9.2 Summary of tasks for protocol development or for acquiring existing data 92
Table 9.3 Frequency and timing of sampling 94
Table 10.1 Anticipated income and expenditures for the SEAN in FY2009 96
Table 10.2 Projected budget for the Southeast Alaska Network, FY2009-2013 97

List of Appendices

APPENDIX A – IDENTIFICATION OF ON-GOING AND HISTORIC MONITORING PROJECTS AND BASELINE STUDIES

APPENDIX B – SOUTHEAST ALASKA NETWORK VITAL SIGN SELECTION HISTORICAL DOCUMENTATION

APPENDIX C – PROTOCOL DEVELOPMENT SUMMARIES

APPENDIX D – CHARTER FOR THE SOUTHEAST ALASKA NETWORK BOARD OF DIRECTORS

APPENDIX F – JUSTIFICATIONS AND POLICIES SUPPORTING LONG-TERM ECOLOGICAL MONITORING

APPENDIX G – CONCEPTUAL FOUNDATIONS FOR MONITORING

APPENDIX H – SAMPLING DESIGN CONCEPTS AND DEFINITIONS

APPENDIX I – THE PARENT LIST OF 36 PRIORITY VITAL SIGNS FOR THE SOUTHEAST ALASKA NETWORK

Mission Statement of the Southeast Alaska Network

The SEAN collects, manages, analyzes, and reports long-term ecological data for the primary purpose of informing the network parks of the status, condition, and trends of key natural resources. The SEAN effectively delivers information so that customers – park staff, partners, and the public – can readily locate and use it with minimal reliance on network staff.

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Executive Summary

The Southeast Alaska Network (SEAN) includes Glacier Bay National Park and Preserve, Klondike Gold Rush National Historical Park, and Sitka National Historical Park (hereafter GLBA, KLGO, and SITK). The SEAN is one of 32 networks of national parks included in the Servicewide Inventory and Monitoring (I&M) program and one of four networks in Alaska. Park units within the SEAN contain approximately 3.3 million acres (8.2 million hectares) of parklands. GLBA includes 2.77 million acres (1.12 million hectares) of designated marine and terrestrial wilderness. KLGO and SITK contain designated cultural landscapes with significant natural resource components. Together, the SEAN parks encompass approximately 4 percent of the area managed by the National Park Service.

Knowing the condition of natural resources in national parks is fundamental to the ability of the National Park Service to manage park resources "unimpaired for the enjoyment of future generations." Funded by the Natural Resource Challenge, NPS has implemented a strategy to programmatically institutionalize natural resource inventory and monitoring. The effort was undertaken to ensure that the 270 park units with significant natural resources possess the information needed for effective, science-based resource management decision-making. The national strategy consists of a framework having three major components: 1) completion of basic resource inventories upon which monitoring efforts can be based; 2) creation of experimental prototype monitoring programs to evaluate alternative monitoring designs and strategies; and 3) implementation of ecological monitoring in all parks with significant natural resources. The NPS strategy focuses monitoring on a select group of ecological elements and processes, known as Vital Signs. Vital Signs are defined as a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

The complex task of developing ecological monitoring and attendant data management strategies requires a front-end investment in planning and design to ensure that monitoring will meet the most critical information needs, produce ecologically relevant and scientifically credible data that are accessible to managers in a timely manner. The result of a three-phase, multi-year scoping and planning effort, this Vital Signs Monitoring Plan: 1) outlines SEAN monitoring goals and the planning process used to develop the monitoring program; 2) summarizes existing information concerning park natural resources and resource management issues across the network; 3) provides a conceptual model framework for SEAN park ecosystems; 4) selects and prioritizes seventeen Vital Signs; 5) presents a sampling framework for marine, freshwater, and terrestrial ecosystems in parks; 6) summarizes planned monitoring protocols, 7) describes the network's approach to data management, and 8) provides information on program administration, funding, and operations.

The SEAN's monitoring architecture is structured to detect both natural and anthropogenic causes of change in ecosystem structure, function, and process. This architecture addresses the distinct spatial and temporal scales pertinent to each park and will incorporate a sampling design intended to both capture relatively local, park-specific trends and also to "function like a network," so that inference scope is maximized. Selected Vital Signs can be described as

response variables (discrete ecosystem elements that are influenced by various other ecosystem elements as well as ecological processes; e.g., wildlife populations) and covariates (ecosystem processes and elements that may not be of primary interest in and of themselves, but are particularly valuable in helping understand the context and factors of change in response variables; e.g., weather, oceanography, etc.).

This plan presents a Core Program and a Secondary Program (Table 1). The SEAN Core Program includes 12 Vital Signs on which the network will focus its time, staff, and funds. For these Vital Signs, SEAN will develop formal monitoring protocols and fund operation, data collection, analysis, and reporting. The 6 Vital Signs in the Secondary Program are park-led monitoring efforts towards which SEAN will contribute data management expertise as time and funds allow. In distinguishing these 2 programs, SEAN explicitly focuses its limited resources and this Monitoring Plan on implementing and sustaining the highest-priority Vital Signs while also working to ensure (as time and resources allow) that park-led efforts benefit from adherence to the same rigorous, long-term data management standards as the Core Program Vital Signs.

Over both the near-term and long-term, rigorous data management systems are the mechanisms by which SEAN will demonstrate its usefulness to parks and the public. Our data management procedures, beginning with system development and running through program operation, are built upon four "Core Functions": acquisition, certification, repository, and dissemination. SEAN data management philosophy – the perspective from which we will approach both program development and operations – is explicitly focused on information dissemination. SEAN fundamentally integrates data delivery goals and objectives with protocol development and data acquisition; SEAN data will not be collected without forethought to whether they will result in achievement of monitoring objectives. The SEAN Data Management Plan is a companion to this report; it identifies key data resources and processes to manage inventory and monitoring data.

We present our anticipated approach to sampling design for each of the 12 Core Program Vital Signs. Where possible and practical, we emphasize colocation of sampling sites (particularly for freshwater Vital Signs) and consistency across designs to facilitate integrative Vital Sign reporting and to support weight-of-evidence assessments.

Reporting is the process by which we deliver information, derived from monitoring data, which communicates the condition of Vital Signs. Vital Signs monitoring reports will include: 1) Resource Briefs that concisely summarize the justification, methods, key findings, and available data for each Vital Sign; 2) annual summaries written for park and network managers; 3) five-year trend reports for park superintendents and natural resource managers; 4) internet websites for NPS staff, external cooperators, and the general public; 5) biannual newsletters for NPS staff, also made publicly available on the SEAN website; and 6) e-mail bulletins for park superintendents, natural resource managers, and the general public on request. To promote efficient reporting, data management efforts during the summary and analysis phase focus on automation of routine reports. Summary analysis for annual reports of Vital Signs monitoring studies will include graphed results and descriptive statistics (mean, standard deviation, sample size) for all of the primary variables included in the project. Five to ten year trend reports will typically include correlation and trends analysis.

Table 1 The Core and Secondary Vital Signs Programs of the Southeast Alaska Network Vital Signs Monitoring Program. The 12 Core Vital Signs are the top priority Vital Signs that SEAN will address in the first five years of program implementation, and are the focus of this Monitoring Plan. A formal monitoring protocol will be developed for each of these 12 Vital Signs. Secondary Vital Signs will receive programmatic and data management support from SEAN as funding and staff schedules allow.

Ecological Monitoring Framework					
Level 1	**Level 2**	**SEAN VITAL SIGN**	**SEAN PARKS**		
			GLBA	**KLGO**	**SITK**
Air and Climate	Air Quality	**Airborne Contaminants**	●	●	●
	Weather and Climate	**Weather and Climate**	●	●	●
Geology and Soils	Geomorphology	**Glacial Dynamics (extent)**	●	●	
	Hydrology	**Streamflow**	●	●	●
		Oceanography	●		
Water	Water Quality	Freshwater Benthic Macroinvertebrates and Algae	++		○
		Freshwater Contaminants	●	●	●
		Freshwater Water Quality	●	●	●
		Marine Contaminants	●	●	●
Biological Integrity	Invasive Species	Invasive/Exotic Plants	○	○	○
	Focal Species or Communities	**Intertidal Communities**	+		●
		Marine Predators	●		
		Kittlitz's Murrelets	●		
		Western Toads	+	○	
	At-risk Biota	Humpback Whales	○		
Human Use	Visitor and Recreation Use	Human Uses and Mode of Access	○	○	○
	Soundscape	Underwater Sound	○		
Landscapes (Ecosystem Patterns & Processes)	Landscape Dynamics	**Landform and Landcover**	●	●	●

● Vital Signs for which the network will develop protocols and implement monitoring using funding from the Vital Signs or water quality monitoring programs.

○ Vital Signs that are currently being monitored by a network park, another NPS program, or by another federal or state agency using other funding. The network will collaborate with these other monitoring efforts. These Vital Signs represent the Secondary SEAN Program.

\+ Vital Sign applies to this park but will not be monitored at this time due to higher priorities and staff and funding limitations.

Administrative oversight for the program originates from the Board of Directors (BOD), the Chiefs of Resources, and Technical Committee (TC). The BOD, representing the superintendents of the three parks, the Regional I&M Coordinator, and the Network Coordinator (non-voting member), is charged with oversight of the network. The TC represents the natural resource technical staff of the 3 parks and serves as the scientific and operational body of the network that develops recommendations on how monitoring is implemented. The Network Coordinator will work closely with the Chiefs of Resources to plan park-specific implementation, time, and funding commitments. The Network Coordinator is supervised by the GLBA Superintendent with performance review input from the BOD. In turn, the Network Coordinator supervises the SEAN Data Manager. The SEAN staffing plan includes Project Leaders who oversee implementation of particular Vital Signs monitoring projects; Park Leads who support project implementation and assist with permitting and logistics; technical experts who provide support in GIS, data management, statistical analysis, and survey design. For many Vital Sign monitoring projects, the Park Lead is also the Project Leader.

Several sources of funding are combined to support operations of the SEAN. The two principle funding sources are allocated through the Natural Resources Challenge: Vital Signs monitoring funds ($441,000) and Water Quality funds ($42,000). All funds are managed by the Network Coordinator under the oversight of the BOD. An Annual Work Plan directs expenditure of funds to projects, parks, and offices; it is submitted for approval by the Washington Office after being developed with input from the TC and review by the BOD. All SEAN program funds must be strictly accounted for and disclosed in an Annual Administrative Report, which is jointly produced with the Annual Work Plan.

SEAN will be subject to periodic reviews to ensure high program quality and accountability. A full Program Review will occur in 2011, three years after this plan is implemented. This Program Review is intended to ensure that progress has been made toward protocol completion and that the SEAN organization is oriented toward meeting its goals and objectives. The Network Coordinator will ensure that all monitoring protocols have been sufficiently tested and developed, and are then submitted to the Regional Coordinator for formal peer review. Beginning in FY2011, the SEAN will host a triennial Science Symposium and Investigators' Report. This will be in the form of a two-day meeting at which all investigators conducting monitoring will deliver technical presentations and discuss the results of their work. The Network Coordinator will use this meeting to solicit both detailed, project-specific review of work on specific Vital Signs, progress toward monitoring objectives, and also to request a more general critique of program implementation.

Chapter 1: Introduction and Background

The Southeast Alaska Network (SEAN) includes Glacier Bay National Park and Preserve, Klondike Gold Rush National Historical Park, and Sitka National Historical Park (hereafter GLBA, KLGO, and SITK). The SEAN is one of 32 networks of national parks included in the Servicewide Inventory and Monitoring (I&M) program and one of four networks in Alaska. Park units within the SEAN contain approximately 3.3 million acres (8.2 million hectares) of parklands. GLBA includes 2.77 million acres (1.12 million hectares) of designated marine and terrestrial wilderness. KLGO and SITK contain designated cultural landscapes with significant natural resource components. Together, the SEAN parks encompass approximately 4 percent of the area managed by the National Park Service.

For the purposes of this document, we define monitoring as the collection and analysis of replicated observations or measurements to evaluate changes in condition and, for some Vital Signs, progress toward meeting a desired condition (Elzinga et al. 1998). Desired conditions are typically defined in the parks' General Management Plans or Resource Stewardship Strategy.

1.1 Purposes of the Vital Signs Program

The primary purpose of the Vital Signs Monitoring Program – to monitor the status and trend of key natural resource elements so that park managers can effectively preserve them – relates directly to the purposes of the National Park System. In this section, we review the justifications for integrating natural resource monitoring, set by enabling legislation for the NPS overall and for the SEAN parks specifically, that establish the importance of a program to track natural resource conditions.

Vital signs, defined by NPS[1], are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, acoustical, geological, plants and animals resources, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including regional, landscape, community, population, or genetic level. Vital signs may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

More specifically, the purpose of the SEAN program is to design and implement monitoring protocols for a core set of selected high-priority Vital Signs and, when possible, to provide data management support for a secondary set of park-led Vital Signs. These core and secondary programs are described in detail in the third and subsequent chapters.

[1] NPS I&M Glossary, available at: http://science.nature.nps.gov/im/monitor/glossary.cfm

1.1.1 NPS Policies and Mandates that Link Monitoring and Management of Parks

The enabling legislation establishing the NPS and its individual park units clearly mandates, as the primary objective, the protection, preservation, and conservation of park resources in perpetuity for the use and enjoyment of future generations (NPS 1980). NPS policy and pertinent legislation (National Parks Omnibus Management Act of 1998) require that park managers know the condition of natural resources under their stewardship and monitor long-term trends in those resources to fulfill the NPS mission of preserving parks unimpaired (Figure 1.1; see Summary of Laws, Policies, and Guidance). The laws and management policies that follow provide the mandate for inventories and monitoring in national parks.

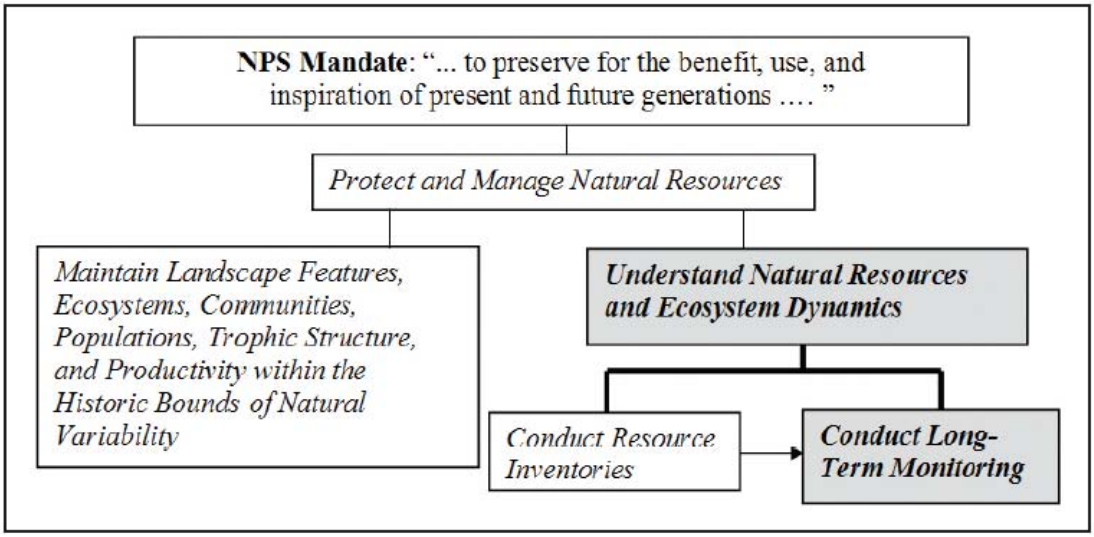

Figure 1.1 Relationships between park mandates, resource protection, and long-term monitoring.

The mission of the NPS (NPS Organic Act, 1916) is:

"*...to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purposes of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.*"

Congress strengthened the NPS's protective function and provided language important to recent decisions about resource impairment when it amended the Organic Act in 1978 to state that "*the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established….*"

More recently, the National Parks Omnibus Management Act of 1998 established the framework for fully integrating natural resource monitoring and other science activities into the management

processes of the National Park System. The act charges the Secretary of the Interior to "*continually improve the ability of the National Park Service to provide state-of-the-art management, protection, and interpretation of and research on the resources of the National Park System,*" and to *"assure the full and proper utilization of the results of scientific studies for park management decisions*." Section 5934 of the Act requires the Secretary of the Interior to develop a program of "*inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources*."

Congress reinforced the message of the National Parks Omnibus Management Act of 1998 in its text of the FY 2000 Appropriation Bill:

"The Committee applauds the Service for recognizing that the preservation of the diverse natural elements and the great scenic beauty of America's national parks and other units should be as high a priority in the Service as providing visitor services. A major part of protecting those resources is knowing what they are, where they are, how they interact with their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data."

The 2006 NPS Management Policies updated previous policy and specifically directed the Service to inventory and monitor natural systems:

"Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will evaluate possible causes and effects of changes that might cause impacts on park resources and values. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions."

Further, *"The Service will:*

- *Identify, acquire, and interpret needed inventory, monitoring, and research, including applicable traditional knowledge, to obtain information and data that will help park managers accomplish park management objectives provided for in law and planning documents;*
- *define, assemble, and synthesize comprehensive baseline inventory data describing the natural resources under NPS stewardship, and identify the processes that influence those resources;*
- *Use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals;*
- *Analyze the resulting information to detect or predict changes (including interrelationships with visitor carrying capacities) that may require management intervention and to provide reference points for comparison with other environments and time frames; and*
- *Use the resulting information to maintain--and, where necessary restore-- the integrity of natural systems (2006 NPS Management Policies).*

Additional statutes that provide legal direction for expending funds to determine the condition of natural resources in parks, and that specifically guide the natural resource management of Network parks include the following:

- Taylor Grazing Act 1934;
- Fish and Wildlife Coordination Acts, 1958 and 1980;
- Marine Mammal Protection Act 1972;
- Wilderness Act 1964;
- National Historic Preservation Act 1966;
- National Environmental Policy Act 1969
- Clean Water Act 1972, amended 1977, 1987;
- Endangered Species Act 1973, amended 1982;
- Migratory Bird Treaty Act 1974;
- Forest and Rangeland Renewable Resources Planning Acts, 1974 and 1976;
- Mining in the Parks Act 1976;
- American Indian Religious Freedom Act 1978;
- Archaeological Resources Protection Act 1979;
- Federal Cave Resources Protection Act 1988;
- Clean Air Act, amended 1990; and
- Wild and Scenic River Act 1990.

1.1.2 SEAN Parks Legislation

The SEAN has some distinct, though not unique, challenges associated with the pronounced variety of spatial scales and recognized resources of the networks parks. This section describes the within-network diversity represented by the SEAN parks, as communicated by the enabling legislation of each.

1.1.2.1 GLBA Enabling Legislation

Presidential Proclamation designated Glacier Bay National Monument (February 25, 1925), with the purpose of preserving and protecting the area's tidewater glaciers, vegetation, unique opportunities for scientific study of glaciers and related flora and fauna changes over time, and historic value associated with early explorers and scientists. GLBA was expanded (by approximately 523,000 acres) and designated as a National Park and Preserve by the Alaska National Interest Lands Claim Act in 1980 (ANILCA, [P.L. 96-487] December 2, 1980). ANILCA further specified GLBA's directive to include preserving lands and waters containing nationally significant natural, scenic, historic, archeological, geological, scientific, wilderness, cultural, recreational, and wildlife values; preserving the unrivaled scenic and geological values associated with natural landscapes; maintaining sound populations of, and habitat for, wildlife species of inestimable value to the citizens; preserving the natural, unaltered state of the coastal rainforest ecosystem; preserving wilderness resources and related recreational opportunities; maintaining opportunities for scientific research and undisturbed ecosystems; allowing the park to remain "[a] large sanctuary where fish and wildlife may roam free, developing their social structure and evolving over long periods of time as nearly as possible without the changes that extensive human activities would cause". The specific direction for GLBA to provide research opportunities is a feature that distinguishes the GLBA mandate from that of many other national parks.

Although ANILCA was passed before the inauguration of the NPS Inventory and Monitoring program, the act contains language that describes the need for an ecological monitoring program. The passage of ANILCA had, and will continue to have, large ramifications for national parks in Alaska. It is important to understand the intent of this law and its effect on the management of Alaska national parks.

Title I, Section 101(b) of ANILCA states that:

- it is the intent of Congress in this Act to preserve unrivaled scenic and geological values associated with natural landscapes;
- to provide for the maintenance of sound populations of, and habitat for, wildlife species of inestimable value to the citizens of Alaska and the Nation, including those species dependent on vast relatively undeveloped areas;
- to preserve in their natural state extensive unaltered arctic tundra, boreal forest, and coastal rainforest ecosystems;
- to protect the resources related to subsistence needs;
- to protect and preserve historic and archeological sites, rivers, and lands, and to preserve wilderness resource values and related recreational opportunities including but not limited to hiking, canoeing, fishing, and sport hunting, within large arctic and subarctic wildlands and on free-flowing rivers;
- and to maintain opportunities for scientific research and undisturbed ecosystems.

1.1.2.2 KLGO Enabling Legislation

Public Law 94-323, June 30, 1976 created KLGO "in order to preserve in public ownership for the benefit and inspiration of the people of the United States, historic structures and trails associated with the Klondike Gold Rush of 1898". Sec. 2(a) Pending such establishment and thereafter, the Secretary shall administer lands, waters, and interests therein acquired for the park in accordance with the provisions of the Act approved August 25, 1916 (39 Stat. 535), as amended and supplemented, and the Act approved August 21, 1935 (49 Stat. 666), as amended. (b) The Secretary is authorized to cooperate and enter into agreements….. in order to contribute to the development and management of such lands in a manner compatible with the purposes of the park. Such agreements, acquisitions, dispositions, development, or use and land-use plans shall provide for the preservation of historical sites and scenic areas, recreation, and visitor enjoyment to the fullest extent practicable.

1.1.2.3 SITK Enabling Legislation

The Presidential Proclamation (N.959, 36 Stat. 2601, Mar. 23, 1910) that created Sitka National Monument states: "Whereas, within the limits of public park created by proclamation June 21, 1890, near Sitka, Alaska, is located the decisive battle ground of the Russian conquest of Alaska in 1804, and also the site of the former village of Kik-Siti [Kiks.adi] tribe, the most warlike of the Alaskan Indians; and that here also are the graves of a Russian midshipman and six sailors, killed in the conflict, and numerous totem poles constructed by the Indians, which record the genealogical history of their several clans…"; Public Law 92-501, October 18, 1972, Sitka National Monument in the State of Alaska re-designated as Sitka National Historical Park, and it shall be administered, protected, and maintained in accordance with the provisions of the Act of August 25, 1916 (16 U.S.C. 1, 2-4), as amended and supplemented.

Clearly, the information gained from an ecological monitoring program is integral to the ability of SEAN park managers to steward the land in a manner consistent with enabling legislation, including ANILCA. Although each SEAN park preserves unique areas, these parks share the common purpose of protecting outstanding natural resources across a full complement of spatial scales. This common purpose, coupled with common larger context of the coastal temperate rainforest of Southeast Alaska, unifies the network.

1.2 Goals of Vital Signs Monitoring

The first section of this chapter addressed the broad goals of monitoring in the context set by the enabling legislation for national parks generally and for the SEAN parks specifically. In this section, we first discuss the importance of inventory, monitoring, and research in stewarding natural resources. We then discuss our goals and objectives for SEAN monitoring, summarize our progress to date, and describe the next steps toward program implementation.

The overall goals of natural resource monitoring in the national parks are to develop scientifically sound information on the current status and long-term trends in the composition, structure, and function of park ecosystems and to quantitatively determine how well current management practices are sustaining those ecosystems. Five Vital Sign monitoring goals guide all network monitoring programs:

1. Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other altered environments.
4. Provide data to meet certain legal and congressional mandates related to natural resource protection and visitor enjoyment.
5. Provide a means of measuring progress toward performance goals.

The SEAN long-term monitoring program will be designed around these five broad, Servicewide goals. We have specifically chosen to focus the SEAN monitoring program on general ecological function and several key species of management concern because our parks are primarily concerned with effects of anthropogenic and large-scale environmental influences on park-level resources and populations. Servicewide monitoring goals 1 and 3 establish the primary framework for the monitoring in the SEAN because they emphasize the establishment of baseline reference conditions representing the current status of park and preserve ecosystems, and an understanding of the range of natural variation in park ecosystems and detecting changes through time.

1.2.1 Integrating Water and Air Quality Monitoring

Issues affecting water quality, the role of water quality monitoring in an integrated ecosystem context, Water Resources Division (WRD) core parameters, and other water quality variables/metrics were discussed at coastal, freshwater, and marine scoping workshops. The network's strategy for water quality monitoring (funded by the NPS WRD) is to fully integrate the design and implementation of water quality monitoring with the network-based Vital Signs monitoring. Steps taken toward developing a water quality monitoring component include (i) identifying and evaluating existing monitoring efforts, historic data, and information needs; (ii) developing a list of biological, chemical, and physical parameters for monitoring; and (iii) determining watershed and water body features.

As part of these efforts, the network has determined that one waterway – Pullen Creek, partly within KLGO – is an impaired [303(d)-listed] waterway. The primary water quality concern for Pullen Creek is heavy metal contamination, in particular lead, zinc, cadmium, and mercury. These metals have been found in Skagway Harbor and are thought to originate from an ore transfer facility associated with the railroad in the town of Skagway. Other potential sources of metals in Pullen Creek are formerly used defense sites (FUDS) from World War II and urban runoff (Hood et al. 2006). Although Pullen Creek is within KLGO's administrative boundary, the NPS has no jurisdiction over any portion of the stream.

The State of Alaska does not designate Outstanding National Resource Waters. Water quality data collection within these parks has been sporadic, and trend analysis is not possible. In general, the SEAN waters show little evidence of human impact, but the network is concerned about potential impacts to water (and air) quality associated with cruise ship activity and delivery of airborne pollutants from industrial development in Asia. Of particular concern, however, is the portion of the Indian River that flows through SITK; specific water quality and quantity monitoring is being developed to address concerns with upstream residential development and diversion.

There are no designated Class I Air Quality (Clean Air Act with 1990 Amendments) areas in the SEAN. GLBA presently has both requisite national park and designated wilderness acreage but these were not established until the 1980 Alaska National Interest Lands Conservation Act (ANILCA) ten years after the passage of the original Clean Air Act in 1970. All parks are required to preserve the scenery unimpaired (NPS 1916), and all the SEAN parks are designated as Class II airsheds. Thus, measurable air quality parameters are of high value to natural area managers. In addition, the SEAN is a partner to the recently completed Western Airborne Contaminants Assessment Project (WACAP), a research effort to determine the risk to ecosystems and food webs in western national parks from the long-range transport of airborne contaminants. Beyond the importance of air quality monitoring for its own sake, wet and dry deposition of contaminants from far-field sources (e.g., pollutants delivered from Asian industrialization) is a growing concern because of their potential impacts to a wide array of other Vital Signs.

1.3 Monitoring Objectives

Network monitoring objectives, organized in the national I&M program's ecological framework, have been established to help focus the monitoring program and facilitate partnerships. Table 1.1 presents these general objectives for the 12 Vital Signs that form the SEAN Core Program (see Chapter 3). Network monitoring objectives established during Vital Sign development ensured that a full spectrum of ecological attributes and management issues were considered for possible monitoring. Detailed, quantifiable, Vital Sign monitoring objectives have been identified for individual Vital Signs as part of protocol development (Chapter 5 and Appendix C).

1.4 Southeast Alaska Network: Environmental Setting

The SEAN consists of three units of the NPS. GLBA (5,130 mi^2 [13,286 km^2]) is headquartered in Gustavus, KLGO (20.6 mi^2 [53.3 km^2]) is managed by staff in Skagway, and SITK (0.18 mi^2 [0.47 km^2] is managed in Sitka. Collectively, these units comprise 3.3 million acres (1.3 million hectares) – fully 4 percent of the land managed by the NPS, and include a diversity of geologic and hydrologic features, ecosystems, wildlife, and climate conditions that are equaled few places in North America.

The three SEAN parks are strongly influenced by their proximity to the Gulf of Alaska and the maritime passages of the Alexander Archipelago (Figure 1.3). Southeast Alaska includes over 1,100 islands, which are the tops of the partly submerged Coast Range. The region is bounded to the east by a mainland mountain range with peaks reaching 10,000 feet (3,048 m) elevation. These mountains and associated icefields are bisected by several large glacial rivers. The ocean coast to the west is lined with mountain ridges and peaks with heights ranging from 5,000 feet (1,524 m) to over 15,000 feet (4,572 m) above sea level.

Marine environments and influences are integral components of all the Southeast Alaska parks. Storm systems typically approach Southeast Alaska from the Gulf of Alaska to the west and drive abundant moisture ashore. The dramatic topography produces a strong orographic effect with high precipitation near the ocean coast, and distinct rain shadows on the leeward side of mountain masses. These extremes are exemplified by the SEAN parks. For example, SITK (Figure 1.4) is exposed to the Gulf of Alaska and receives two or three times more precipitation (96") than KLGO (Figure 1.5), which is about 100 miles (161 km) from the open ocean. GLBA (Figure 1.6) incorporates its own steep precipitation gradient from its outer coast on the open ocean to the drier eastern side of the Fairweather Range. Although strong gradients in precipitation characterize the region, generally high precipitation and cool temperatures support temperate rainforest ecosystems and myriad freshwater environments, including glaciers, glacial rivers, clearwater streams, lakes, and wetlands. Within the network parks, freshwater and terrestrial ecosystems are well represented. Although GLBA is the only park that includes an extensive marine component within its boundaries, both KLGO and SITK border productive estuaries, and all three parks are greatly influenced by marine processes.

Table 1.1 Preliminary SEAN monitoring objectives, organized in the Inventory and Monitoring Ecological Management Framework.

Level 1	Level 2	SEAN Vital Sign	Monitoring Objective
Air and Climate	Air Quality	Airborne Contaminants	Track decadal trends of selected contaminants by direct measures of total deposition, air concentration, and lichen tissue concentration.
	Weather and Climate	Weather and Climate	Track the weather conditions at selected locations in SEAN parks.
Geology and Soils	Geomorphology	Glacial Dynamics	Determine changes in glacial extent and configuration of selected glaciers in GLBA and KLGO.
	Hydrology	Streamflow	Determine status and trends of streamflow in select SEAN streams.
		Oceanography	Track spatial and temporal variation in water temperature, salinity, turbidity, pH, dissolved oxygen, light penetration, and primary productivity in marine waters of Glacier Bay proper.
Water	Water Quality	Freshwater Contaminants	Track selected contaminants through analysis of sediment and fish tissue samples.
		Freshwater Water Quality	Determine trends of core water quality parameters (temperature, dissolved oxygen, conductivity, pH) in select SEAN streams.
		Marine Contaminants	Track marine contaminants at selected locations in all SEAN parks through biannual collection and analysis of blue mussel tissue samples.
Biological Integrity	Focal Species or Communities	Intertidal Communities	Determine the status and trends of intertidal species composition and distribution for the SITK intertidal zone.
		Marine Predators	Determine long-term trends in the abundance and spatial distribution of marine birds and mammals within GLBA proper.
	At-risk Biota	Kittlitz's Murrelets	Determine annual and long-term trends in KIMU abundance and spatial and temporal distribution within Glacier Bay proper.
Landscapes (Ecosystem Patterns & Processes)	Landscape Dynamics	Landform and Landcover	Determine long-term status and decadal trends in the areal extent and configuration of key land-forms within, and on lands influencing, SEAN parks.

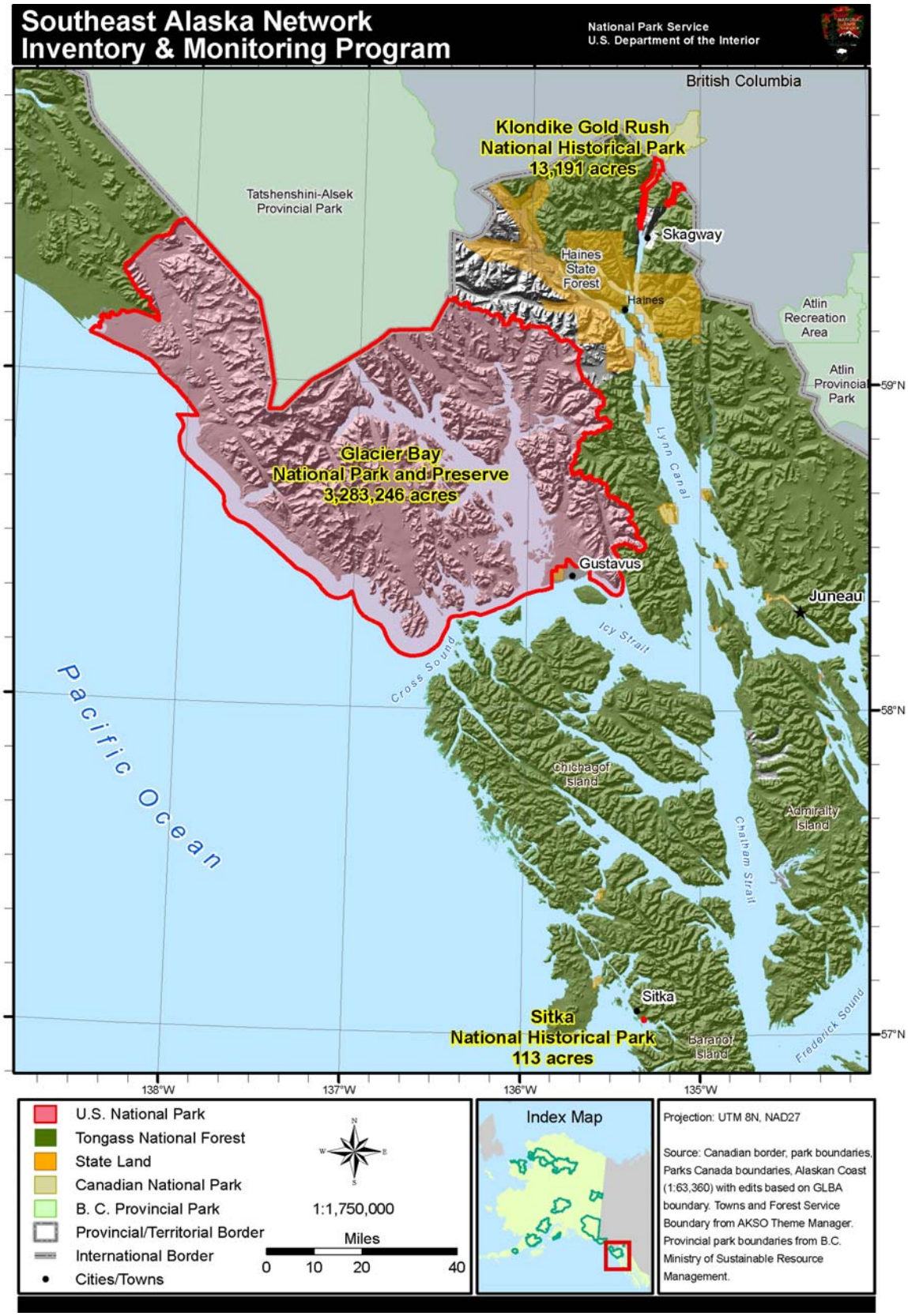

Figure 1.1 The Alexander Archipelago and the Southeast Alaska Network parks

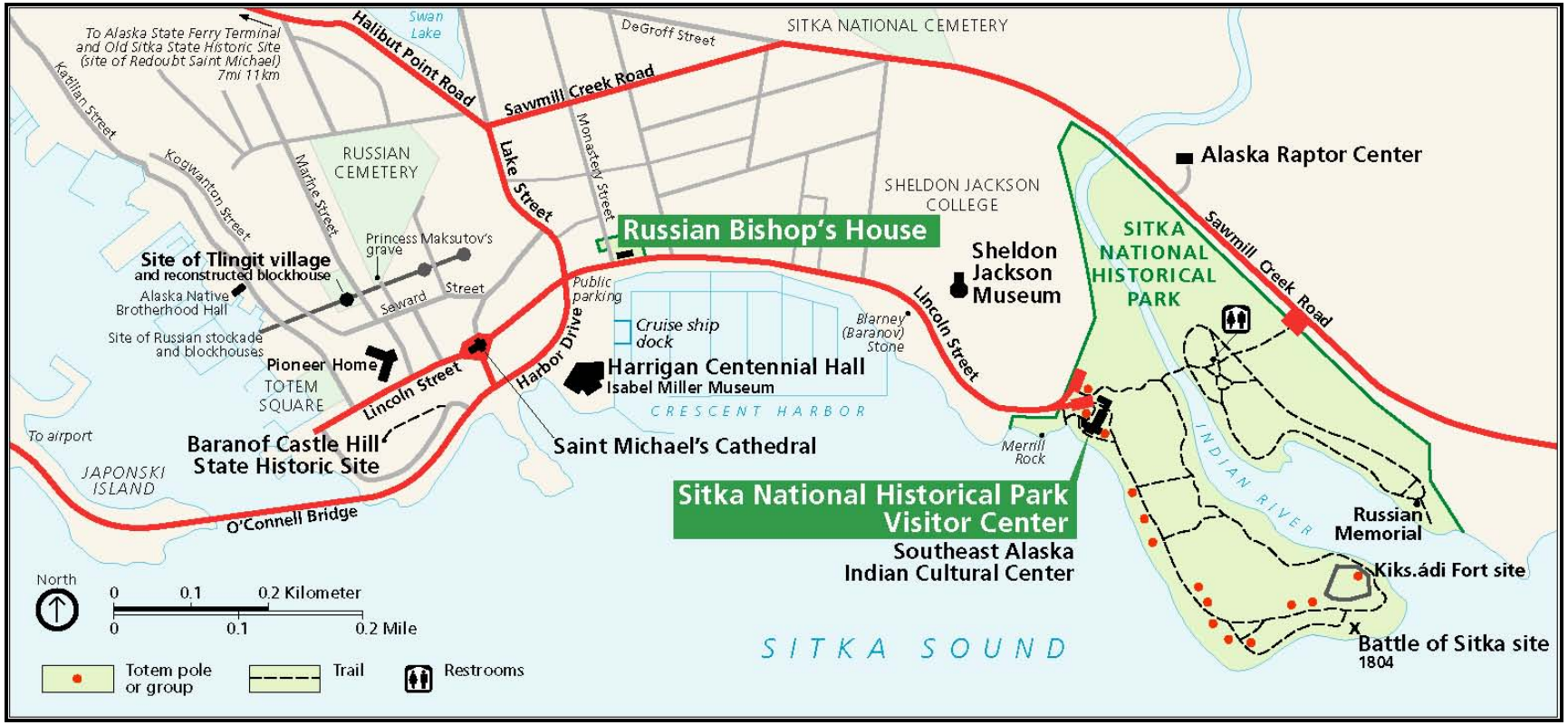

Figure 1.2 Map of Sitka National Historical Park.

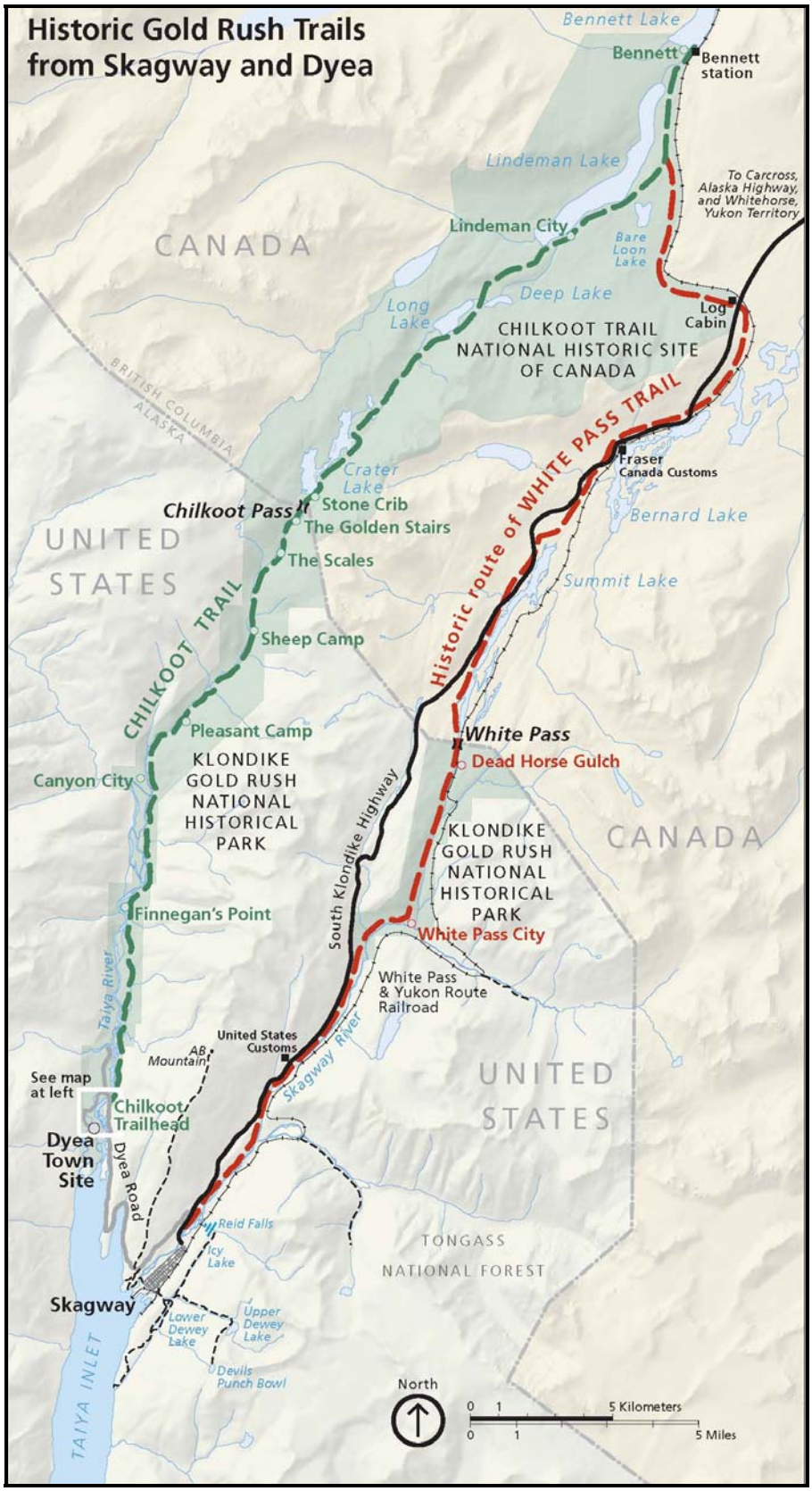

Figure 1.3 Map of Klondike Goldrush National Historical Park.

Figure 1.4 Map of Glacier Bay National Park and Preserve.

KLGO and SITK are mandated specifically to maintain their cultural landscapes, which are composed of important ecological features. A cultural landscape is defined by the NPS as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values." Nearly all cultural landscapes are dependent on park natural resources. It is these interconnected, dynamic systems of land, air and water, vegetation and wildlife which have dynamic qualities that differentiate cultural landscapes from other cultural resources, such as historic structures. Thus, their documentation, treatment, and ongoing management require a comprehensive, multidisciplinary approach, including ecological monitoring. The integrity of the parks' natural resources must be maintained in order to maintain the integrity of these cultural landscapes. For example, the SITK designated cultural landscape centers around a healthy Indian River and temperate rainforest associated with the Old Public Park (established in 1890) and the Totem Trail. KLGO administers the Chilkoot Trail which winds through several ecological zones before reaching White Pass. These cultural landscapes overlay significant ecological resources that maintain a link with a community's past and are vital to maintaining its integrity and sense of place, to the point that cultural and natural properties are indistinguishable. Although natural resources are not emphasized in their enabling legislation, they were identified as having "significant natural resources" by park managers and included in the I&M Program.

1.4.1 Klondike Goldrush National Historical Park

KLGO was established in 1976 and comprises three separate units totaling 13,191 acres (5,338 hectares). It rests at the northern end of the Lynn Canal surrounded by steep, glaciated mountains. The park includes parts of both the Taiya and Skagway valleys which provide short pathways to glacier-free mountain passes connecting to the Canadian interior. The Taiya and Skagway Rivers reach two of only three glacier-free passes through the Coast Ranges of Alaska. As a result, KLGO is where the cold interior eco-region meets the Northwest Coast. The diversity of plant and animal species in Upper Lynn Canal are the highest in Alaska. With subarctic, alpine, boreal forest, north coast forest, and marine systems converging at KLGO, the park hosts species assemblages found nowhere else in the world. Plant diversity is high, as plant communities transition from wet coastal rainforest to drier interior conditions (Carlson et al. 2007). Over 174 vascular plant species are present. The Chilkoot Trail unit of the park contains a variety of vegetation zones, including intertidal sand flats, coastal meadow, coastal western hemlock/Sitka spruce forest, subalpine montane zone of mountain hemlock/subalpine fir, and alpine tundra at the highest elevations. The Skagway and Taiya Rivers carry large amounts of glacial silt, causing the rivers to shift their course frequently as new bars and channels are formed. Chum, coho, and pink salmon spawn in the lower Taiya River and its tributaries. Resident fish include Dolly Varden char. Thousands of migratory and resident waterbirds and other predators, including bald eagles, seals, and sea lions, are attached to the spring eulachon run. The park contains mountain goats, black bear, and a small population of moose. Brown bears are regularly seen feeding on spawning salmon in the Taiya River system. Wolverine, marmot, porcupine, marten, and coyote are also present. Mink, bald eagles and many other birds, are found along the saltwater edge. One hundred fifty-eight species of birds have been recorded in the park. The western toad and Columbian spotted frog are the only amphibian species confirmed in the park. The unique geographic and ecological setting of KLGO underscores its importance as a rare linkage between interior and coastal Alaskan systems.

1.4.2 Sitka National Historical Park

SITK was first designated a federal public park in 1890 and received its current designation in 1972. It includes 113 acres (46 hectares) of coastal lowland and riparian forest, the Indian River, and tidelands in Sitka Sound. The park protects and preserves a battleground, the site of the Kiks.ádi fort Shiskinoow, and the Russian Memorial associated with the 1804 Battle of Sitka; a collection of Tlingit and Haida totem poles; the grounds and structures associated with the Russian Bishop's House ("Russian mission") and the natural resources that give context to the historical events that occurred here. The convergence of the Indian River, the coastal rainforest, and the Pacific Ocean provides a biologically rich environment for a variety of aquatic resources and the organisms that depend on them. Sitka spruce/western hemlock forest dominates. Red alder is the major tree species of floodplains and riparian zones. One hundred fifty bird species have been recorded in and around the park. Salmon runs sometimes pack the Indian River with over 1.5 million fish. Brown bears, river otters, mink, and black-tailed deer frequently use park resources and habitat. Over 165 vascular and 172 nonvascular plant species have been inventoried in the park. Fifty two benthic macroinvertebrate species typical of cold clearwater streams have been identified from the Indian River. The park's intertidal zone and estuarine areas, comprising fully 44% (50 acres) of the park's acreage, teem with marine invertebrates such as seastars, limpets, chitons, polychaete worms, barnacles, clams, crabs, shrimp, and snails. Over 219 invertebrate species have been recorded in initial surveys, along with 85 species of marine algae. Marine fishes abound, including several species of rockfish, gunnels, surf perch, sculpins, coxcombs, greenlings, and tubesnouts. Although the State of Alaska owns the intertidal zone within the park boundary, SITK has the authority to manage these intertidal lands from a state lease. This unique management situation underlies a pronounced interest of the park's natural resource staff in intertidal issues.

1.4.3 Glacier Bay National Park and Preserve

GLBA, first designated a National Monument in 1925, was expanded to 3,283,246 acres (1,328,700 hectares) by ANILCA in 1980. This Act also designed 2.77 million acres of marine and terrestrial wilderness within the park. GLBA is situated at the southern reaches of a coastal, mountainous, wilderness landscape that includes the fourth largest area of glacial ice on earth. GLBA protects and preserves extensive icefields, alpine glaciers, and tidewater glaciers that emanate from mountain ranges rising abruptly from the coast. A long history of glacial activity and of tectonic activity along an active plate boundary has produced a complicated and dynamic geography and geology. A great diversity of bedrock types, geomorphic features, surface ages, and local climates has allowed the development of myriad habitat types in terrestrial, freshwater, and marine environments. A coastal rainforest of western hemlock and Sitka spruce is the dominant lowland vegetation in the region. Vegetation types representing early successional stages dominate in recently deglaciated areas. Lakes, streams, wetlands, and marine ecosystems are also developing in areas recently exposed by retreating glaciers. Over 300 streams are present in the park, 100 of which are newly formed since glaciers have receded. Most streams with a connection to the ocean host Pacific salmon runs. About 30 species of land mammals occur in GLBA, including beaver, red fox, hoary marmot, porcupine, river otter, mink, marten, wolverine, and ermine. Black bears are widespread and common, while brown bears are less numerous and found primarily in open habitats and close to salmon streams. Moose occur widely throughout thickets, meadows and open forests of lower elevations; deer are found in the

mature plant communities fringing Icy Strait. Mountain goats occupy high elevations with suitable habitat.

Within GLBA's jurisdiction are over 600,000 acres of marine waters, including 53,000 acres of designated wilderness waters. As a result, GLBA is one of only a handful of large conservation areas in the world that includes extensive saltwater habitat. It is also the largest marine area managed by the NPS. GLBA's approximately 1,180 miles of coastline represent nearly 30% of total NPS marine coastline – nearly three times more than the next largest coastline park. Due to large tidal fluctuations, the marine photic zone continuously receives dissolved nutrients from depth, while large surface inputs of fresh water provide stability during periods of sufficient daylength to sustain phytoplankton growth. These conditions stimulate high primary and subsequent secondary production of phytoplankton and zooplankton – the foundations of the marine food web – which support an abundance of forage fishes and other marine vertebrate predators. Invertebrates such as Dungeness crab, Tanner crab, sea anemones, and shellfish are also abundant in park marine waters. These resources in turn support diverse and abundant marine mammals, including harbor seals, Steller sea lions, humpback and killer whales, Dall's and harbor porpoises, and a northern sea otter population that is approaching 2,000 individuals. About 240 species of birds have been recorded from the park, preserve, and nearby environs, including a diverse array of seabirds, passerines, shorebirds, raptors, and waterfowl. GLBA provides valuable opportunities to study and enjoy coastal flora and fauna in an unimpaired state, and to educate the public about the biological richness of marine systems and relationship to adjacent glacial and terrestrial systems. More information is available at the web pages for each park (http://www.nps.gov/glba/; http://www.nps.gov/klgo/; http://www.nps.gov/sitk/).

1.5 Resource Preservation Concerns

An implicit goal of the SEAN monitoring program is to achieve and sustain relevance to the parks that it is intended to serve; it must provide data useful to protection of park resources now and in the future. To ensure relevancy over time, the monitoring program must address broad concerns and not be limited to the issues of today, because these issues will undoubtedly change (MacCluskie and Oakley 2005).

Understanding concerns pertaining to park resources is a fundamental first step in informing development of a monitoring program. That is, in order to begin describing what we choose to monitor and why, we must first describe why we are concerned about particular resources. This process is necessary in order to devise a monitoring program that is responsive and relevant to those concerns.

Concern for park resources is essentially a perception of risk of harm to a valued resource. Risk is typically perceived because a valued resource is sensitive to an apparent and substantial stressor. Concerns about threats to the SEAN park resources can be generally characterized as those that are broad-scale and apply to all network parks, and those that are more local and park-specific. This section identifies and briefly describes the SEAN's key resource preservation concerns. Relationships among the concerns are discussed in conceptual models presented in Chapter 2.

1.5.1 Broad-Scale Concerns of All SEAN Parks

The resource protection concerns of the SEAN parks fall into two main categories:

1. Concerns stemming from global industrialization: these include climate change, long-distance air and marine pollution, species additions and losses (biodiversity) and effects on migratory species when they are not present in network parks
2. Concerns relating to human activities and development in the parks and in the regions of the parks

1.5.1.1 Global Industrialization

Vitousek et al. (1997) presented a concise, sobering picture of human domination of the Earth's ecosystems. Growth of human populations and resource consumption are maintained by agriculture, industry, fishing, and international commerce. These activities change the Earth's surface by way of two major effects: (1) changes in major biogeochemical cycles, and (2) adding or removing species. These alterations to the functioning of the Earth's ecosystems are driving global climatic change and the irretrievable loss of biological diversity. This conceptual model of humanity's role in Earth's ecosystems provides a broad context for considering the resource protection concerns of the SEAN parks. Although the SEAN parks are relatively distant from many of the actual or potential sources of influence, human activities are changing the surrounding world so quickly and dramatically that this broad perspective – regional and even global – is necessary.

Others (including the Central Alaska Network, MacCluskie and Oakley 2004) have noted that the most significant potential adverse effects on Alaska's national parks from industrialization may result from activities in areas far away from the parks themselves. Concerns stemming from global industrialization fell into three categories: climate change, air and ocean pollution, and effects on biodiversity and species assemblages.

Climate Change: Overall climate warming trends documented elsewhere are also being detected in much of Alaska. Dramatic melting of snow and ice in Alaska has been occurring over the last few decades due to warmer climate. Warming has caused thawing of many glaciers and permanent snowfields across Alaska, as well as reductions in seasonal snowfall and shorter seasons of river, lake, and sea ice.

Warmer temperatures will result in a longer growing season. Changes in precipitation, vegetation community types, and marine, freshwater, and terrestrial processes will result in changes in vertebrate distribution and habitat use. Surface and groundwater processes will be affected by changes in timing and amount of runoff and snow/ice melt. All these processes could influence local marine characteristics or processes, with potentially profound changes on complex marine food webs. The magnitude and manifestation of many effects of climate change cannot be known at this time; large-scale, long-term ecological monitoring will be of tremendous value in understanding and responding to change in park resources.

Long-distance Air Pollution: Low population densities, lack of large-scale industrial development, proximity to the Pacific Ocean, and vast stretches of wildlands lead many to believe that the air quality of Southeast Alaska is among the most pristine in the world.

However, a lichen-based air quality study completed in 1999 demonstrated that sulfur, nitrogen, and heavy metal concentrations in the KLGO-Skagway area exceeded nutrient enhancement and heavy metal concentration thresholds established by the USDA for the adjacent Tongass National Forest (Geiser et al. 1994, Furbish et al. 2000, Dillman pers. com.). All SEAN parks may also be impacted by near-field mobile sources including cruise ships and other marine traffic, near-field point sources such as diesel-fired generators, and far-field industrial sources in Eurasia. A record number of cruise ships visited Glacier Bay proper in 2007, on both an annual basis (225 ship visits) and through the peak summer months of June through August (153 ship visits) (source: GLBA administrative records). Of 1.7 million visitors travelling to Alaska in 2007, fully 60% (1,029,800 visitors) travelled by cruise ship; virtually all travel through Southeast Alaska and cruise ship visitation is increasing (McDowell Group 2007).

In addition to air contamination degrading visibility and impacting the parks' scenic beauty, deposition of airborne contaminants in sensitive park ecosystems has the potential to contribute to foliar damage (Fenn 2006), terrestrial and marine community compositions shifts (Geiser et al. 1994, Fenn 2006), and bioaccumulation of contaminants in marine and terrestrial organisms (Goodyear and McNeil 1998, Pedersen and Lierhagen 2006).

Because coastal Alaska is the first land that Asian air masses encounter after traversing the Pacific, abundant orographic precipitation may deliver significant amounts of contamination. Due to geographic proximity and prevailing weather patterns, direct delivery of mercury from rapid industrial development in Asia may be important in Southeast Alaska. Methylmercury, the organic, bioavailable form of mercury, is 100 times more toxic than elemental mercury. It can bioaccumulate in a variety of taxa and can reach concentrations one million times greater than environmental concentrations (Wolfe et al. 1998). The ecological effects of these air pollutants in Alaskan ecosystems are unknown.

Effects on Biodiversity: The potential for non-native invasive species of plants and animals to become established in the network parks is another concern stemming from global industrialization. Species additions and losses due to the expansion of human commerce around the globe is one of the biggest ecological problems worldwide, and even remote Alaska parks need to be aware of this potential problem.

1.5.1.2 Human Activities and Development In and Near Network Parks

Local human activities that occur inside and outside park boundaries – including visitation, transportation, recreation, and development – can generate varied direct and indirect impacts on park resources. All SEAN parks experience high levels of commercial cruise ship visitation. Though cruises can be a low-impact means of exposing thousands of visitors to a park in a concentrated and contained way, they also carry risks of fuel or waste spills and discharge, contribution to local air pollution, and impact or disturbance risk to sensitive or endangered animals (including humpback whales [endangered], Steller sea lions [eastern population, threatened], and Kittlitz's murrelets [Candidate-Priority 2]). More traditional visitor use, such as kayaking and camping in GLBA, may occur at relatively low levels but is often concentrated in a few particularly desirable or accessible locations. Local impacts to campsites or nesting seabird colonies, for example, are not a trivial issue. Acre-for-acre, SITK experiences far greater visitation rates than do GLBA or KLGO, and impacts there may include weed introduction and

soil compaction or erosion. KLGO supports a variety of visitation types, from the high-intensity visitation of the near-town parts of the park and the Chilkoot Trail to the more dispersed visitation of remote off-trail backcountry areas of the park.

In two cases, development and consumptive use are significant issues to the SEAN parks. Residential development upstream of SITK has considerable potential to affect water quality and quantity of the Indian River. In GLBA, "grandfathered" commercial fishing (for halibut, salmon, and crab) continues in designated areas of Glacier Bay proper and throughout the outer waters adjacent to the park. Personal use and sportfishing also occur in GLBA; guided charter fishing is a rapidly growing consumptive use.

Visitor access to the SEAN parks is relatively concentrated and lends itself to monitoring. Due to size (SITK), remoteness and ruggedness (GLBA), or both (KLGO), network parks generally have a small number of key access points that can be monitored and controlled. On the other hand, visitation (and related impacts) outside these key access points is extremely difficult to measure and predict.

Taken together, local and regional modes of human use and development present considerable concern for park resources including water quality, threatened and endangered species, species of concern, invasive species, and general resource condition.

1.5.2 Park-Scale, Issues-Oriented Monitoring: What Are the Most Important Management and Scientific Issues to the Network?

To achieve success and continued support, long-term monitoring must provide data that are both useful and widely used. The data must be relevant to topics of widespread interest (i.e., the broad-scale concerns discussed in Section 1.5.1, above), as well as those of specific management concern. Most importantly, the information generated from the monitoring program needs to assist park managers in clarifying and addressing resource protection issues and measuring progress towards achieving the desired conditions described in General Management Plans and Resource Stewardship Strategies.

As used in this plan, "issues-oriented monitoring" implies that, by virtue of legislative mandate, importance to stakeholders, or risk from a specific threat, some park resources may receive attention beyond that which would derive solely from their ecological position of importance in the landscape. It *does not* imply that monitoring will focus only on a narrow range of issues perceived to be relevant to today's management challenges. The network's monitoring program cannot address every resource management interest. Limitations exist because institutional resources devoted to monitoring practices are constrained by time, finances, and personnel.

In framing our monitoring approach in the context of this goal of relevance, the SEAN asked the question: What are the most important management and scientific issues to the Network? To begin to answer, past and current monitoring efforts within the parks were summarized (see Section 1.6, below). Network park resource protection issues were compiled from former and current management plans, review of published and unpublished literature, and interviews with current and former park staff. Park staff developed a list of natural resource management issues or natural resources of special concern (current and anticipated) and identified the basis for

concern, if known, by identifying human-caused or environmental threats with the potential to adversely affect park resources. Issues were compiled and summarized under the headings of Physical Change, Biological Resources, Pollution, and Human Use (Table 1.2). This matrix was presented and discussed at scoping workshops attended by Regional NPS staff and scientists from other state and federal agencies. A recurring theme among issues was a lack of information. This is not surprising, given the vast size and complexity of the park units, the brief history of their resource management programs, and their relatively small staffs and budgets.

Park units in the Network share many of the same resource protection issues because of similarity in landscape features, geographic proximity, type and magnitude of public use, and certain commonalities of enabling legislation. Most protection issues are linked to human population growth and the many ways that human activities are manifested in ecosystem response at the global, regional, network, and park scales. In Chapter 2, resource protection issues and concerns of Network parks are discussed under the headings of *far-field* (global/regional) and *near-field* (network/park). Conceptualizing far-field and near-field human effects is a challenging task because the scales are linked, and environmental changes are not evenly distributed across the earth. Far-field human-related issues manifest themselves in the forms of climate change, long-distance air and ocean pollution, and demand for fossil fuels and other minerals. Near-field human-related issues include use of plants and animals, recreational use, and private lands development.

1.6 The SEAN Approach to Program Development

For clear practical and budgetary reasons, it is not possible to monitor all attributes of interest at once. Therefore, our program will be implemented in a stepwise fashion, wherein protocol development is a priority in early years, followed by data collection and regular evaluation and adaptation. Chapter 9 details the SEAN's roll-out process for strategic, prioritized implementation given known constraints.

The SEAN has followed the basic three-phase, five-step approach to designing a monitoring program, described in detail in the "Recommended Approach for Developing a Network Monitoring Program" (http://science.nature.nps.gov/im/monitor/index.cfm):

Phase 1

1. Define the purpose and scope of the monitoring program.
2. Compile and summarize existing data and understanding of park ecosystems.
3. Develop conceptual models of relevant ecosystem components.

Phase 2

4. Select Vital Signs and specific monitoring objectives for each.

Phase 3

5. Determine the appropriate sampling design and sampling protocols.

In February 2005, the SEAN Technical Committee held a freshwater ecosystems scoping workshop; terrestrial and marine workshops were held in January and February 2006. The general purposes of the workshops were to review and discuss the current state of knowledge

Table 1.2 Resources and issues of concern identified by the Southeast Alaska Network Parks.

Resource Issue/Concern	***Glacier Bay NP&Pr***	***Klondike Gold Rush NHP***	***Sitka NHP***
Air & Climate			
Air quality	X	X	X
Geology & Soils			
Glacial lake outburst floods	X	X	
Taiya River erosion		X	
Water			
Water quality	X	X	X
Glacier Bay, Dry Bay, Salmon River	X		
Pullen Creek and Skagway River		X	
Indian River			X
Biological Integrity			
Exotic plants	X	X	X
Salmon	X	X	X
Marine invertebrates and nonvascular plants	X	X	X
Eulachon (candlefish) runs	X	X	
Moose populations	X	X	
Forage fish distribution and dynamics	X		
Vulnerability of rockfish populations	X		
Seals, sea lions, Kittlitz's murrelets, and black-legged kittiwake apparent declines	X		
Marine resource extraction (habitat impacts of weathervane scallop fishery; possibly some finfish and crab harvest)	X		
Mountain goat populations		X	
Declining eulachon runs		X	
Western toad populations		X	
River pollution (filamentous green algal and diatom mats)			X
Human Use			
Vessel effects on marine environments	X	X	X
Backcountry use	X	X	
Bear and camper interface	X	X	
Shoreline camping impacts	X		
Proposed deepwater dock			X
Landscapes (Ecosystem Pattern and Processes)			
Marine-derived nutrients budget and cycle	X	X	X
Underwater soundscape	X		
Toxic leachates from old asphalt plant			X
Airborne soundscape	X	X	X

concerning park ecosystems, resource protection issues, and potential options for monitoring. More specifically, the primary objectives of each workshop were (1) to review system-level conceptual models and (2) to generate a list of potential Vital Signs and monitoring questions. The workshops were attended by the SEAN Technical Committee, NPS staff from other networks and the Alaska Regional Office, and scientists from universities, State of Alaska agencies, and other federal agencies. The full texts of each workshop notebook are included on the electronic copies of this Monitoring Plan and are posted to the SEAN Website: http://science.nature.nps.gov/im/units/sean

Pre-workshop preparation involved assembling extensive background material on network parks and developing objectives and monitoring questions. This background material was mailed to participants before the workshop to familiarize them with the landscape and to stimulate discussion. Scoping workshop discussions were recorded and compiled into a workshop summary report that was sent to participants and are posted on the network website. Chapter 3 further discusses these workshops and subsequent steps in identifying, prioritizing, and selecting Vital Signs.

1.7 Data Capture and Review of Monitoring by Others

Recognizing that development of a network-based approach to monitoring would naturally springboard off existing efforts, the SEAN undertook a thorough evaluation of current and historic monitoring at each of the network parks – conducted by NPS or other partners. The SEAN contracted a thorough search for and review of past and ongoing investigations to identify work that could be classified as monitoring or become a basis for future monitoring. The SEAN Parks Project Tracking Database formed the backbone of the review, and was supplemented by many other databases (e.g., NatureBib, library searches, and project files). The products of this effort (delivered in the fall of 2006) were three park-specific tables that categorized several hundred projects by ecological subject (e.g., birds, intertidal communities, large mammals, weather, etc.), status (ongoing or historic), potential value as baseline data, and general characterization (i.e., the “who, what, when, where, and how”). These park-specific tables (in Appendix A) were used by the SEAN to learn from past experience and to identify candidate monitoring sites for our suite of Vital Signs.

Chapter 2: Conceptual Ecological Models

Most generally, ecology is the study of the distribution and abundance of plants and animals and their interaction with the environment on levels from cellular to ecosystem (Krebs 1985). Other variables – both biotic and abiotic elements of the ecosystems – may be useful in learning about a Vital Sign and explaining distribution and abundance. In this chapter, we discuss our use of conceptual models to represent our understanding of the basic structure and function of SEAN ecosystems.

2.1 Introduction

Ecological monitoring programs are designed and implemented based on an understanding of how the subject ecosystems function. Based on both knowledge and assumptions, this understanding should be explicitly presented in conceptual models, so that it is available for discussion, evaluation, and ultimately for refinement through incorporation of information gained through monitoring (Maddox et al. 1999). Indeed, development of conceptual models is a key requirement of the Vital Signs Monitoring Program for each network. Conceptual models play several useful roles in monitoring program design, including:

- Formalizing current understanding of the context and scope of the ecological processes important in the area of interest;
- Expanding our consideration across traditional discipline boundaries;
- Integrating biotic and abiotic information and processes; and
- Facilitating communication among scientists from different disciplines, between scientists and managers, and between managers and the public (Thomas 2001).

Within the SEAN monitoring program, the development of conceptual models had the specific purpose of iteratively guiding the process of Vital Signs selection. The models were used in scoping sessions and then revised based on the outcome of those sessions. A critical role of the models was to identify the principal drivers of change – both natural and anthropogenic – in network ecosystems. With the drivers of change identified, the types of ecological changes most important for park managers to detect can be determined, based on their inherent importance or their influence on receptors of particular significance. The process of deciding which changes (and of what magnitude) the network wants to be able to detect helped form the foundation for Vital Sign selection.

This chapter, then, represents our current understanding of the salient elements and processes of ecosystems of the SEAN parks. In this chapter, we present the three fundamental conceptual ecosystem models developed with several cooperating researchers. Appendix G presents a more detailed discussion of ecosystem interactions and all conceptual models generated during the three scoping workshops. Two pervasive themes of these models are (1) the linkages between the physical and biotic realms, and (2) the substantial interactions among terrestrial, freshwater, and marine ecosystem components in Southeast Alaska. The overlap of terrestrial, freshwater, and marine environments is represented by mapping the major habitat types in the SEAN parks in Figure 2.1. Most of the habitats shown depend on more than one environment. Although this is not unique to Southeast Alaska, deep marine incursions and abundant precipitation make

marine and freshwater influences equal to the terrestrial in coastal areas of this region. This relationship among environments represented by the three overlapping ovals of Figure 2.1 is carried forward in the conceptual models presented here and several models presented in Appendix G.

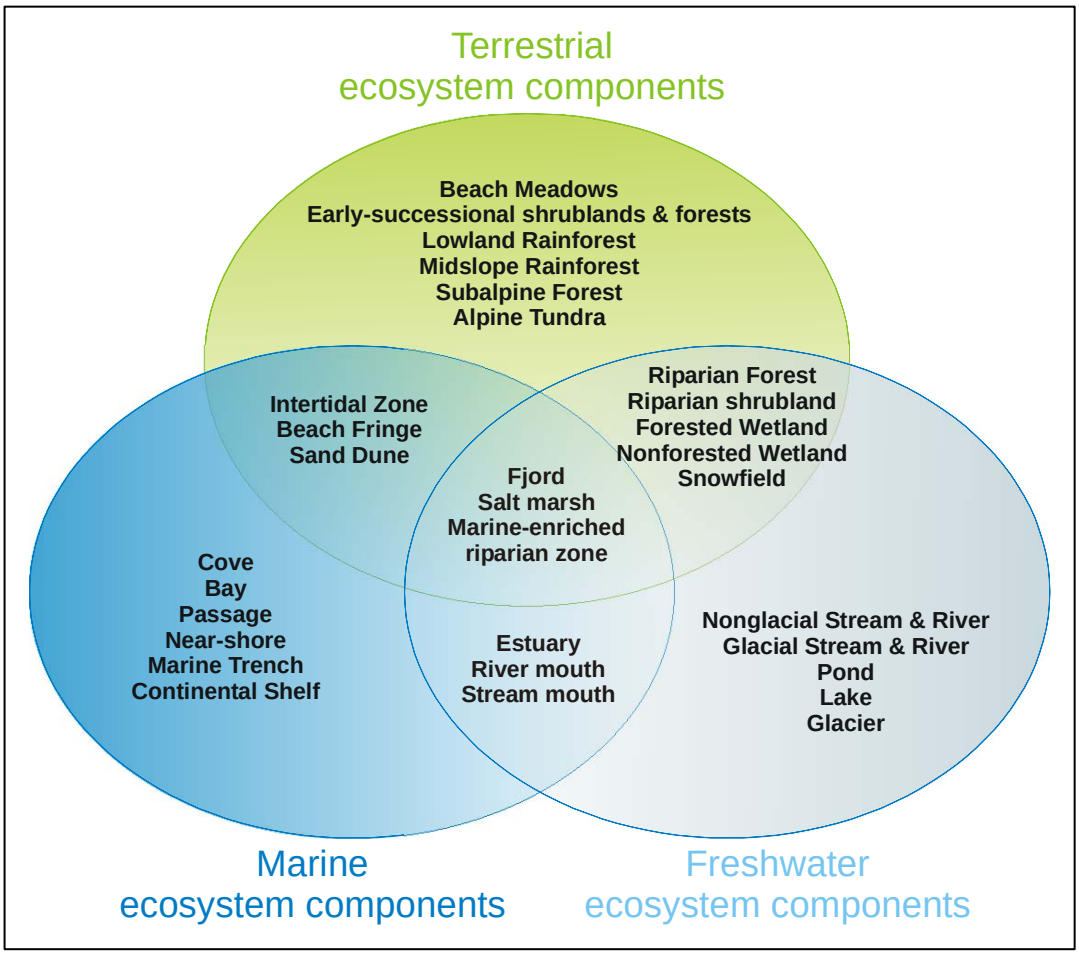

Figure 2.1 Important ecological features within the three ecosystem components in Southeast Alaska. Habitats can be associated with a single ecosystem component or with an overlap where two or three of the components come in contact. Most habitats exist in mature states and also in earlier stages of primary or secondary succession.

2.2 Ecological Context

2.2.1 Global Setting of Southeast Alaska Parks: Far-field Drivers of Change

Many habitats in Southeast Alaska are as wild and pristine as any in the world. However, human enterprise has caused changes that affect every place on earth (Vitousek et al. 1997). Thus, the relatively natural environments of Southeast Alaska operate within a regional and global system of physical and biological drivers that have been altered by human activity. Human enterprise has transformed much of the Earth's surface, altered its biogeochemical processes, and eliminated or redistributed species and populations (Vitousek et al. 1997). Three important

consequences of these changes are climate change, loss of ecosystem processes and habitats, and loss of species, populations and communities (Figure 2.2).

Land transformation around the world has altered global biogeochemical cycles by transferring large quantities of carbon from fossil fuels and biomass into the atmosphere, and by fixing nonreactive atmospheric nitrogen (N_2) into reactive compounds (e.g., nitrous oxide, nitric oxide, ammonia) that contribute to the greenhouse effect and can alter plant nutrient status. The effects of carbon- and nitrogen-based greenhouse gases have already contributed to global climate change (Houghton et al. 2001), and continued changes threaten to alter natural competitive balances in plant and animal communities and initiate new disturbance regimes.

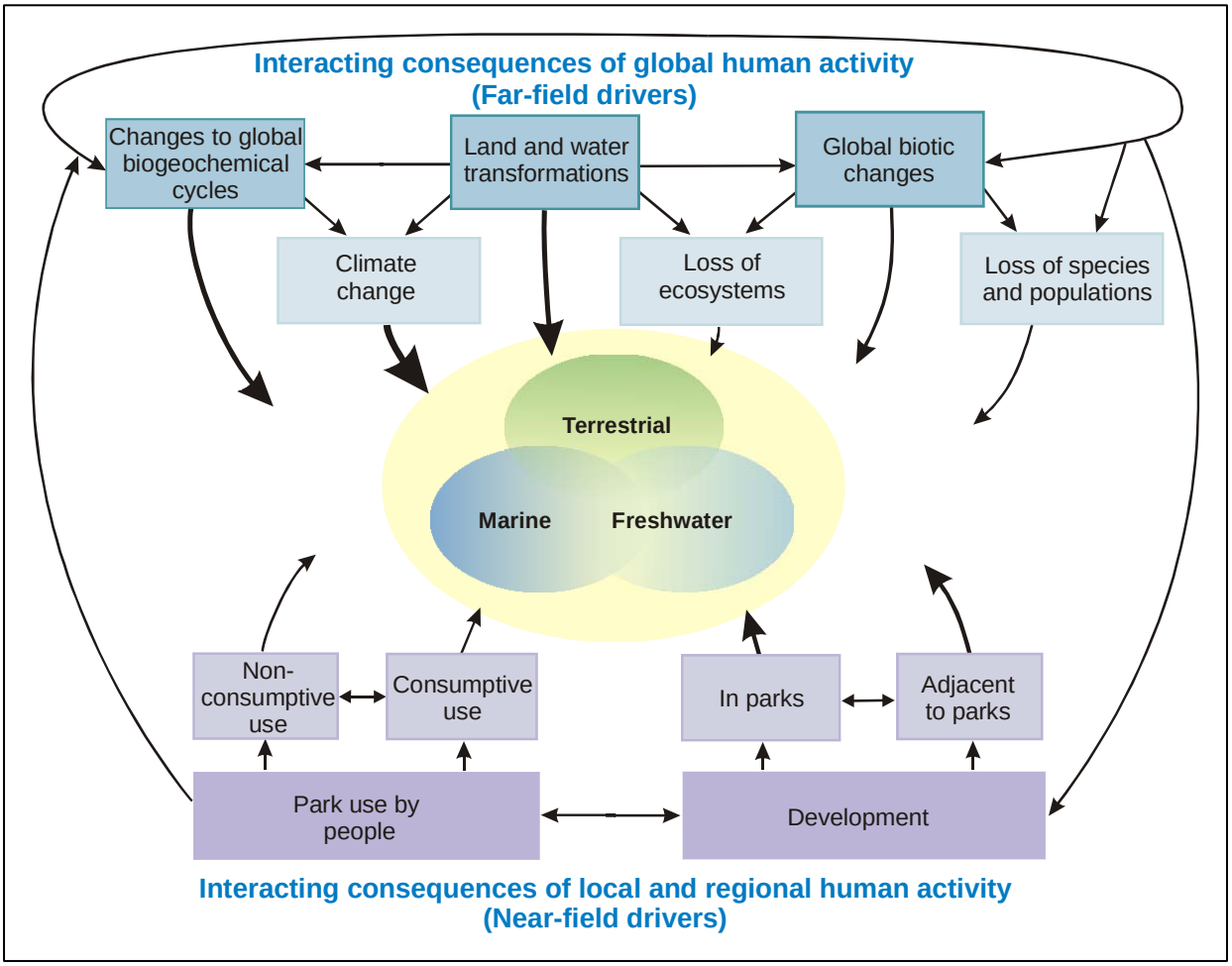

Figure 2.2. Resource preservation concerns in Southeast Alaska Parks. Far-field (top) and near-field (bottom) drivers of change that are likely to threaten resources in Southeast Alaska (thicker arrows indicate greater concern). The transformation of the earth's surface, oceans, and atmosphere has driven changes in global biogeochemical cycles and the biotic makeup of ecosystems. The interaction of these types of changes has resulted in global climate change, and the loss of ecosystems, communities, populations and species around the world. At the local and regional level, park use and development can result in stresses on natural systems.

Land transformation is also responsible for global biotic changes caused by the harvest of plants and animals, habitat conversions and fragmentation, and freshwater diversion. Although Southeast Alaska has been generally insulated from the loss of local species, populations, and ecosystems, it is not immune to this type of damage.

2.2.2 Local Resource Preservation Concerns: Near-field Drivers of Change

At the local and regional scale there are several activities that have the potential to negatively impact park resources. Human activity in and near the parks is a primary resource preservation concern. Local human activity is unlike other resource preservation concerns because there is greater potential for managing human activity to modify environmental effects. There are two categories of human activity that are most likely to affect natural and cultural resources in network parks: development in and near parks, and use by park visitors (Figure 2.2).

Consumption of natural resources by park visitors can be responsible for damage to and/or overharvest of plants or animals, leaving waste and refuse in parks, soil compaction, and introduction of invasive or exotic species to park habitats. In the SEAN parks, the most important potential environmental effect of these stressors is disturbance of wildlife and subsequent changes in plant and animal populations. Other important effects include the establishment and spread of invasive species and altered successional pathways. The noise, crowding, or refuse left by park visitors in formerly pristine areas can be an aesthetic concern for other visitors.

Although generally less threatening than other concerns, research activity or resource management activity can influence natural environments. Field-based research activity may result in changes in populations and communities, alterations in successional pathways, and degraded visitor experiences. Research and management can also lead to increased public awareness of ecological issues, ecological restoration projects, and protection of threatened resources.

2.3 Drivers of Environmental Change

2.3.1 Holistic Model

We have identified four broad categories of environmental factors that influence the current environmental conditions in Southeast Alaska and that are most likely to drive ecological changes in the future (Figure 2.3). These four drivers are climate, geologic processes, ocean processes, and human activity.

1) *Climate.* The regional climate has a controlling affect on the landscape of Southeast Alaska, supporting the highly productive coastal rainforest and its denizens, supplying snowfall to feed alpine glaciers, creating myriad wetland and freshwater ecosystems, and influencing marine processes.

2) *Geological processes and patterns.* The geology, geography, and landforms of the coastal region determine how the regional climate interacts with the land or water to shape a particular ecosystem. Dramatic coastal mountains and islands of the Alexander

Archipelago dominate the landscape and create a spatially complex system of marine and terrestrial environments.

3) *Ocean processes and patterns.* The processes and patterns of the ocean support productive and diverse marine ecosystems and strongly influence the weather, biochemistry, and biota of freshwater and terrestrial systems. All SEAN parks are adjacent to marine waters, and Glacier Bay includes an internationally significant marine reserve with strong connections to surrounding unprotected marine systems.

4) *Human activity.* Human activity (past and present, near and far) has affected all ecosystem components in Southeast Alaska and has great potential to drive changes in those components in the future. For example, human effects on global climate and the unpredictable risk of resulting climate changes may produce the most serious future concern.

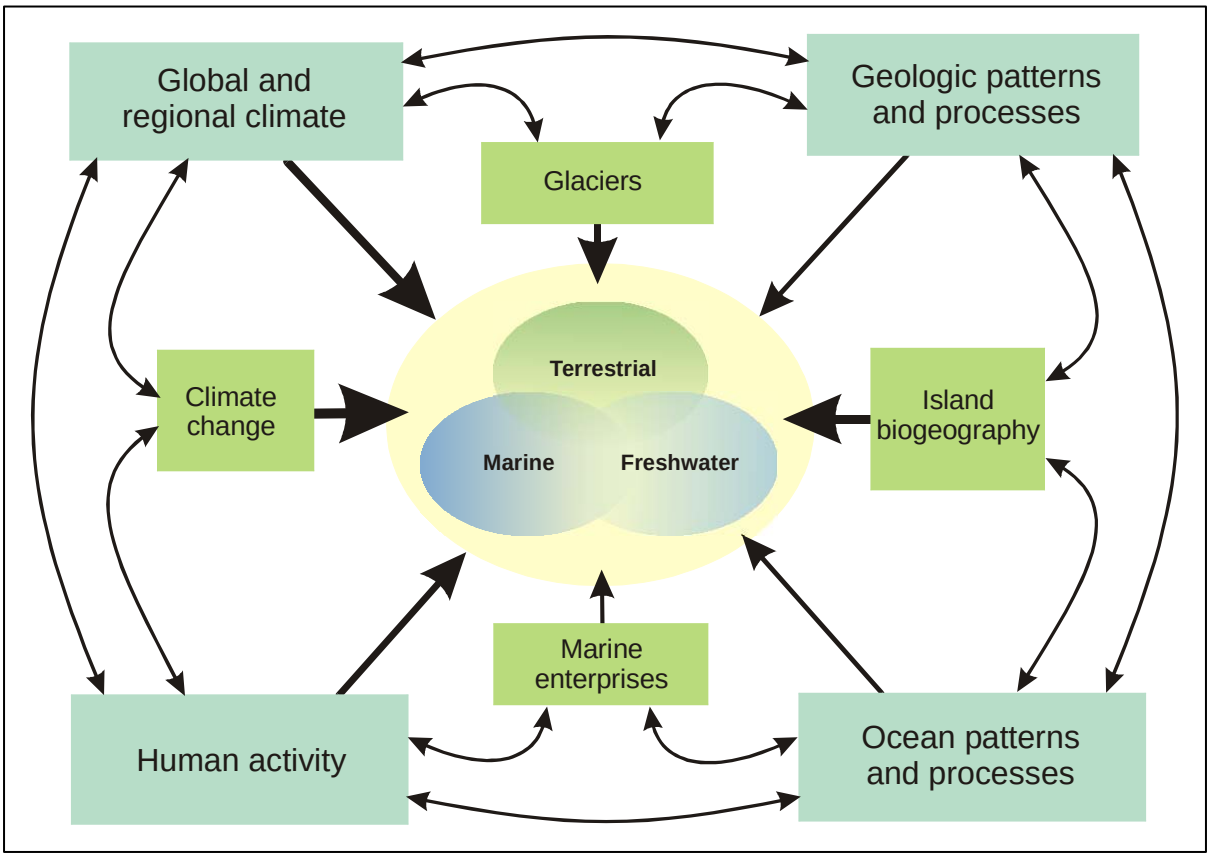

Figure 2.3 Holistic conceptual ecosystem model: Drivers of change. Climate, geologic processes, ocean processes, and human activity are the four major driving forces shaping landscapes and ecosystems in Southeast Alaska. Thicker radial arrows indicate greater influence.

Interactions among these four major drivers produce four more specific influences on ecosystem components in Southeast Alaska (Figure 2.3):

1) *Climate change*. The long-term influence of humans on global and regional climate (Houghton et al. 2001) is expected to cause substantial changes in the climate of Southeast Alaska during the current century. We consider the potential for climate change to be the most important anthropogenic driver of landscape change. The potential environmental stresses caused by the predicted course of global warming could cause unprecedented change in all of the ecosystems of Southeast Alaska.

2) *Island biogeography*. The geographic interaction between land and sea in the coastal landscape of Southeast Alaska creates a unique spatial matrix of islands, peninsulas, mainland landmasses, and the marine and freshwater ecosystem components that connect them. The natural fragmentation of the land and marine waters in Southeast Alaska makes the concept of island biogeography useful for prediction of undesirable change and identification of management strategies to mitigate that change.

3) *Glaciers*. The interaction of regional climate and geography produces the conditions responsible for Southeast Alaska's extensive glaciation. Glaciers, in turn, influence the local climate, modify terrain, produce unique wildlife habitats, and discharge water, ice, sediment, and organic material into freshwater and marine systems. Glaciers have strongly influenced the natural and cultural resources of all three SEAN parks.

4) *Marine enterprise*. Coastal habitats in direct contact with marine waters are vulnerable to the environmental impacts of human activity at sea. Oil spills and other impacts resulting from commercial fishing, maritime transport (including cruise ship traffic), and coastal development in support of this maritime activity are potential threats throughout Southeast Alaska.

2.3.2 Physical Drivers in Southeast Alaska

2.3.2.1 Key Environmental Drivers

Two dominant drivers – wetness and disturbance – influence the major ecological communities in Southeast Alaska. On land, near-constant wetness drives the development of plant communities and soils that are strongly influenced by autogenic (self-produced) processes. For example, leaching of rainwater through continuously accumulating organic soil horizons drives the development of an impervious soil horizon. This paludification leads to poorly drained soils and the plant communities that can tolerate them. Disturbance – whether by glaciers, downslope movement, windstorms, or insects – drives ecosystems in the opposite direction, creating younger, simpler systems. Compared to mature ecosystems, recently disturbed successional systems are able to sequester fewer resources, and nearby hydric systems receive the exported nutrients and energy. The results are lakes and streams that are more productive than their young successional setting would suggest. Adding to this temporal trend is the pronounced effect of large populations of anadromous fish which bring marine nutrients and energy into young and old streams, lakes, and adjacent terrestrial ecosystems.

2.3.2.2 Origins of Terrestrial and Freshwater Features

A combination of factors has given rise to the Southeast Alaska landscape of small, complex watersheds, and a great diversity of habitat types and community ages. Primary among these factors is a geographic location where moist, temperate air masses produce a maritime climate coupled with complex lithology and extreme topography associated with an active tectonic plate boundary. Glacial activity is an important consequence of these factors. Glaciers are a conspicuous element of today's environments and have been modifying the landscape for millennia. Long histories of intense glacial activity and sea level fluctuation have further increased the topographic and geomorphic diversity.

The result is a variety of terrestrial environments from lowland to alpine, and from well-drained to wetland. Steep terrain, active glaciers, lethal forest insect pests, and severe weather subject these diverse plant communities to repeated disturbances and produce a complex mosaic of community ages, further enhancing landscape and biotic diversity.

2.3.2.3 Regional Influences on Marine Systems of Southeast Alaska

A combination of factors has given rise to the high productivity and community diversity in marine environments of Southeast Alaska. Primary among these factors are a regional maritime climate with strong seasonality, and the deeply divided coastline which generates insularity, complex circulation, and diverse benthic habitats. At Glacier Bay, glacial activity has produced a fjord system with cold, sediment-rich freshwater input that contributes to complex water-mass structure and strong seasonal stratification. Diverse nektonic, benthic, and demersal communities are supported by high productivity of phytoplankton or macroalgal populations.

2.4 Ecosystem Interactions

In this section, we discuss the key ecological processes and settings that generate the patterns and processes that we observe today, and we describe the mechanisms by which processes occurring in one realm (i.e., freshwater, marine, or terrestrial) are interconnected with those in another. In Southeast Alaska, many of these processes are closely related to active primary succession in a post-glacial context.

2.4.1 Succession in Freshwater

New streams and lakes are created as retreating glaciers expose fresh terrain and a delay in biotic development in those waterways is mediated by high sediment load and variable flow rates associated with unvegetated watersheds. These processes are dampened by upstream lakes, which trap sediment and moderate flow, allowing stream communities to stabilize sooner (Milner 1997). The successional development of aquatic plant and animal communities is closely tied to the concurrent development of adjacent terrestrial plant communities (Milner et al. 2000). As vegetation colonizes stream banks, the addition of organic matter into streams promotes invading communities of stream invertebrates. The early input of leaves and catkins from shrubs is followed by the accumulation of coarse woody debris in stream channels. This debris provides cover for fishes and supports colonization by anadromous salmonids. The input of marine nutrients and energy from spawning salmonids to stream and riparian environments accelerates the development of stream invertebrate communities and creates a positive feedback to stream primary and secondary productivity.

Glacial activity in the upper reaches of a watershed can affect stream development for hundreds or thousands of years after streamside surfaces become ice-free. In Glacier Bay and Klondike Gold Rush, sediment-rich glacial streams traverse lowlands occupied by forest ecosystems that have been developing for more than 10,000 years. Productivity in these streams will remain low until sediment sources are reduced. Where lakes associated with active alpine glaciers are in the watershed of such streams, rapid ablation (the reduction in volume of a glacier due to melting and evaporation) of glaciers and snowfields in the last 30 years may have increased the potential for glacial-lake outburst flooding. Catastrophic downstream flooding and debris flows have resulted from increased meltwater and higher lake levels behind loosely consolidated and saturated alpine moraines. The Taiya River in Klondike Gold Rush has experienced at least three glacial lake outburst floods in the last 120 years, most recently in 2003.

Southeast Alaska watersheds that have been free of major glaciation for thousands of years, such as the Indian River in Sitka, tend to have mature riparian forests, and rivers tend to flow clear during most of the year. These mature rivers generally drain steep topography and are cold and swift. Their beds tend to be made up of gravel, cobbles, and boulders with a low amount of fine deposits such as silt. This provides multiple surfaces and habitat for a diverse benthic community. The silt-free interstitial spaces within gravel and cobble substrates allow surface water to flow through the hyporheic zone which delivers dissolved oxygen to invertebrates, salmonid eggs and newly emerged fry, removes waste products, and provides protection from strong current and predators (Edwards 2001). The Indian River and other rivers with old-growth and mature secondary growth forests in their riparian zones are significantly influenced by large trees that fall directly into and across the stream. This large woody debris (LWD) creates relatively immobile log barriers, log jams, and root wads that stabilize the river channel, provide cover, and form pools, all of which are critical for juvenile salmonid survival (Naiman et al. 2000, Montgomery and Buffington 2001)

A study of 33 lakes at Glacier Bay ranging in age from 10 to 13,000 years has indicated how their successional development is closely tied to the ecological development of the land in the surrounding watershed (Engstrom et al. 2000). Due to the compounding influences of lake chemistry and watershed geomorphology, lakes eventually (over several thousand years) become less fertile and less productive as they mature, even as carbon and nutrients accumulate in the surrounding landscape. These interactions emphasize the dependence of lake development on plant succession and soil development in the surrounding terrestrial environment (Engstrom et al. 2000). There are no true lakes in Sitka or Klondike Gold Rush, however, intermittent ponds are seasonally present in both parks.

2.4.2 Primary Succession on Land

Two centuries of glacial recession at Glacier Bay has produced a landscape with plant communities in various stages of primary succession. These communities allow inference about the processes that determine how plant communities are assembled through time, both at GLBA and at the relatively older communities of SITK and KLGO. The geographic location of a site recently exposed by retreating glaciers influences the site's climate, soil characteristics, and landscape position. Landscape position (a site's spatial relationship to physical and ecological features) affects the rate of substrate stabilization and the proximity of mature vegetation which could supply seeds for colonizing plant populations (Fastie 1995). At Glacier Bay, these factors

have varied from place to place, resulting in substantial variability in the composition of early plant communities. As succession proceeds, the ability of early plant populations to fix atmospheric nitrogen and the activity of herbivores influence interactions among plants (e.g., competition and facilitation) (Chapin et al. 1994). Differences among sites in early nitrogen fixation and in the consequent accumulation of soil nitrogen lead to long-term differences in ecosystem function. Therefore, predicting the pathways and endpoints of terrestrial ecological succession at any site requires knowledge of landscape-scale patterns.

2.4.3 The Marine Environment

2.4.3.1 The Glacier Bay Marine Ecosystem

At least six major ecosystem processes are recognized as important determinants of the structure and function of the Glacier Bay marine ecosystem. A model focusing on these processes was developed for Glacier Bay by Bodkin et al. (2004) (Appendix G). The generality of this model makes it useful for describing ecological interactions in any marine system in Southeast Alaska. The six processes included in the model are:

1. Human influences
2. Oceanography
3. Trophic interactions
4. Production dynamics
5. Transportation
6. Disturbance (e.g. glaciation)

The application of this model is based on current understanding of the relative importance of each of the ecosystem processes in regulating the abundance and structure of populations. The model is intended to be used to answer the question: *What is the relative magnitude of influence of each ecosystem process on the population abundance and structure of a species?* Through a process of repeatedly asking this question for individual species, it is possible to identify populations for which there is either a relatively good or a relatively poor understanding of structuring processes, and to identify processes that are important across populations. These processes are broadly defined (e.g., production dynamics can incorporate reproduction as well as survival), and other processes (e.g., competition, life history traits, sources of propagules) may be fundamental in structuring some populations. These processes often are not independent, and complex interactions can be expected.

2.4.3.2 The Transfer of Marine-derived Nutrients and Energy to Riparian Systems

Anadromous salmonid fishes return annually to streams in each of the network parks. Adult salmon return after multiple years as marine predators and die in the streams after spawning. These large runs of fish bring important nutrients (e.g., nitrogen and phosphorous) and energy (caloric food value) from the ocean to the freshwater ecosystem (Gende et al. 2004). Some of these nutrients and energy become part of the aquatic food web through scavenging by invertebrates (Lessard et al. 2003), predation on eggs, or uptake by plants. Terrestrial animals, including brown and black bears, river otters, gulls, and bald eagles, prey on live fish or scavenge dead fish. Animal waste and uneaten fish on and near the stream banks provide marine nutrients to riparian vegetation and the terrestrial food web (Ben-David et al. 1998). The water

current flushes uneaten carcasses back to marine waters, and (in combination with the eventual out-migration of young salmonids) much of the marine-derived nutrients and energy in the stream may be eventually returned to the ocean. Nevertheless, a portion becomes incorporated in the terrestrial ecosystem and gradually migrates even beyond riparian areas.

2.4.3.3 Productivity in the Intertidal Zone

The intertidal zone is a component of all three parks. Although the areal extent of the intertidal zone is small relative to the marine or terrestrial ecosystems it borders, its high species diversity and productivity make it ecologically important to a large number of terrestrial and marine animals. The particular combination of plants and animals present in the intertidal zone depends in part on a variety of physical factors, including latitude, exposure to the open sea, ocean currents and fronts, and proximity to tidewater glaciers and turbid outwash or clearwater streams. Biotic interactions within the communities and interactions with land and sea animals (e.g., predation, herbivory) further modify the biotic diversity. Communities of intertidal plants and animals are subject to environmental stresses associated with daily tidal fluctuations, physical disturbance by weather events, and predation or herbivory from marine or terrestrial animals. The influx of cold, sediment-laden freshwater and icebergs from nearby tidewater glaciers influences the composition, structure, and productivity of these communities (Sharman 1988). Although they are well adapted to natural disturbance, these communities are highly vulnerable to new types of disturbance caused by human activity on land or at sea. For example, trampling by foot or vehicle traffic, changes in nearshore currents caused by docks and other shore-fast structures, and marine oil spills are threats to intertidal communities.

Chapter 3: Vital Signs

This chapter describes the process used to identify, organize, and prioritize a final set of Vital Signs for the SEAN. We also discuss the manner in which the selection and prioritization of Vital Signs was linked to park management and protection issues, ecological principles, conceptual ecosystem models, and the Network's monitoring objectives. The historical documentation of Vital Sign list generation, justification, prioritization, and selection is included as Appendix B.

The SEAN Technical Committee used a four-step process to identify and prioritize Vital Signs, with each step building upon earlier work and discussion:

1. Conduct scoping workshops for the freshwater, terrestrial and marine ecosystems in SEAN parks.

2. Prepare draft Ecological Monitoring Framework tables that identify candidate Vital Signs.

3. Rate and rank management and ecological significance of candidate Vital Signs.

4. Discuss and analyze the ratings and rankings for candidate Vital Signs, identify those of greatest importance for long-term monitoring, and finalize those that are of highest priority and around which the SEAN ought to develop the monitoring program

The ultimate result of this process was the identification of a Core Program and a Secondary Program. The SEAN Core Program is the collection of Vital Signs on which the network will focus its time, staff, and funds. For these Vital Signs, SEAN will develop formal monitoring protocols and fund operation, data collection, analysis, and reporting. Vital Signs in the Secondary Program are park-led monitoring efforts towards which SEAN will contribute data management expertise as time and funds allow.

3.1 Vital Sign Selection

3.1.1 Terrestrial, Freshwater, and Marine Scoping Workshops

Three scoping workshops were held in Juneau, Alaska to bring together park managers and scientists familiar with the ecology of the SEAN parks. The goals of these workshops were to review and refine the SEAN's conceptual ecosystem models and to produce lists of potential monitoring objectives, monitoring questions, and Vital Signs related to each ecosystem. We focused one workshop on freshwater environments (April 2005), one on terrestrial (February 2006), and one on marine (February 2006). Each was professionally facilitated.

Scoping workshop notebooks were a key element of the scoping process; they provided background information, context, and guidelines for Vital Sign selection. Each workshop had an ecosystem focus, but the fields of discussion and opportunities for choosing Vital Signs were unbounded. Redundancy within and among workshops was encouraged and valued because it

would underscore the importance of specific ecosystem drivers or components across systems and would help generate an integrated set of Vital Signs.

At each workshop, the Network Coordinator and the facilitator described the NPS Inventory and Monitoring (I&M) Program and the progress of the three other Alaska I&M networks. Invited scientists familiar with the park resources gave presentations on the environmental setting of the three SEAN parks. After the introductory presentations and general discussion, we divided workshop participants into groups of fewer than ten people to nominate monitoring questions and potential Vital Signs. By way of guidance, each group was instructed to consider three key questions:

- What conditions or key elements should be documented as indicators of ecosystem integrity?
- What should be monitored to determine the range of variability in the ecosystem's response to natural and human drivers?
- What should be monitored to identify the thresholds that would trigger a need to implement focused research, corrective/adaptive management, and/or mitigation measures?

We then conducted plenary sessions where the full workshop group further refined and combined the products of all small groups. These discussions focused on individual potential Vital Signs and broad issues that the participants believed should influence Vital Sign selection. From these workshops, four broad concepts emerged that governed SEAN Vital Sign selection:

- *Make use of historical datasets.* The SEAN parks have long histories (by Alaska standards), and the landscapes of Sitka and Glacier Bay have a long association with NPS. Scientific research at Glacier Bay spans more than a century. Early datasets can add great value to monitoring programs by establishing credible baseline states and/or long-term ranges of variability. Shorter-term datasets spanning one or two decades (e.g., Glacier Bay studies on stream, lake, and vegetation succession, physical oceanography) also increase the predictive value of continued monitoring.

- *Drivers of change vs. changed ecosystems.* It is important to understand why ecological change is occurring, but monitoring drivers (e.g., climate, glaciers, human use) should not be conducted at the expense of learning about the mechanisms and manifestations of change. Ideally, matched pairs of driver and receptor would be monitored simultaneously.

- *Climate data and climate change.* Climate change will be measured by our program, and continuous weather and climate monitoring is seen as key to interpreting changes detected in other Vital Signs.

- *SEAN marine ecosystem and its connections.* The SEAN has one of the few national parks with a large marine component - GLBA. The phasing-out of commercial fishing and the designation of wilderness waters uniquely position the GLBA marine ecosystem for monitoring and research. Additionally, the GLBA marine ecosystem cannot be fully

understood separate from its context within the larger marine environment of Southeast Alaska, the Gulf of Alaska, and beyond. Regional monitoring programs of other agencies will be crucial to interpreting results of the SEAN monitoring of marine Vital Signs.

Detailed descriptions of these and other discussions, as well as full results of each workshop and lists of candidate Vital Signs, are included in summaries for each workshop which will be posted on the SEAN website (http://www.nature.nps.gov/im/units/SEAN).

3.1.2 Compile, Rate, and Prioritize Candidate Vital Signs

After the workshops, the SEAN staff summarized a candidate list of Vital Signs. Workshop brainstorming yielded a comprehensive, pooled list of more than 200 potential Vital Signs that were identified during the three scoping workshops. The SEAN staff, a consulting scientist and (later) the Technical Committee critically reviewed the pooled list. Together, they reduced the number of candidate Vital Signs to 80 and nested them within the NPS Ecological Monitoring Framework (NPS 2005). A nominated Vital Sign was removed from the list or nested within a primary Vital Sign based on three criteria:

- Was an individual metric or parameter, but was not itself a Vital Sign;
- Played a relatively minor role in the SEAN parks; or
- Could be considered a subset of another Vital Sign.

The SEAN staff entered the resulting master list of 80 candidate Vital Signs into a Microsoft Access database, which included potential monitoring questions and measures (generated at the scoping workshops) for each candidate Vital Sign. Information regarding which of the three scoping workshops had recommended each Vital Sign was also included.

The SEAN Technical Committee members from each park used the above-mentioned database to rate each Vital Sign relevant to their park according to four management significance criteria. The SEAN Technical Committee, three consulting scientists, the network Data Manager, and a facilitator met for three days (May 2-4, 2006) to rate and rank candidate Vital Signs. Each participant rated the ecological significance of each Vital Sign for each park based on three criteria. The Data Manager compiled the ratings from all nine workshop participants for both ecological and management significance. Ratings for each of the 80 Vital Signs were then merged and ranked, giving equal weight to management and ecological significance. Rankings were then distributed to the group. For a full description of the prioritization process and rating criteria, see the SEAN Phase III Report (Moynahan and Johnson 2008).

The group did not view the rankings as a definitive result, but rather as an important piece of information and a way to direct discussion about the relative importance of candidate Vital Signs. Through an iterative process of evaluating the numerical rankings alongside strategic and logistical considerations, the group identified 36 high-priority, unique Vital Signs. This list serves as the “parent list” from which the Network further focused the program based on staffing and funding resources.

For each Vital Sign, the group collectively identified whether monitoring would be dependent upon SEAN funding and whether monitoring would likely occur within the first five years of

implementation of the SEAN Monitoring Plan. Each participant was subsequently asked to suspend their role as advocate for their park's needs and to identify the five Vital Signs they felt were most important for the network as a whole to monitor. The result of these two inquiries was a list of 15 highest-priority Vital Signs. Each participant outlined the rationale for their choices, and collectively the group agreed that the list of 15 highest-priority Vital Signs was acceptable for the SEAN. The group cautioned that the SEAN should not drop the remaining Vital Signs, and that the list of 15 should not necessarily totally dictate where money and work should be entirely focused.

Much of this work in 2006 and the first six months of 2007 occurred with the SEAN Network Coordinator position being vacant. When the position was filled in July 2007, the new Network Coordinator called an August Technical Committee meeting to review the Vital Sign selection and prioritization process to date. In order to immediately confirm the direction and focus of the SEAN program development, the Coordinator cross-referenced the priority Vital Signs with additional information regarding their dependency on SEAN funding and the likelihood of implementation within the first five years. The 15 Vital Signs extracted from the "parent list" of 36 were thereby identified as the proper focus for the SEAN program development in the first five years.

In the winter of 2007-2008, based on emerging information and progress in program development, the SEAN elevated two Vital Signs (Kittlitz's murrelets and Freshwater Contaminants) from the list of 36 to the priority list. Similarly, in the summer of 2008, the Network elevated another Vital Sign – Marine Contaminants (which had been nested under the priority Oceanography Vital Sign) – to bring it on par with the Airborne Contaminants and Freshwater Contaminants Vital Signs. The final result of these two years of work is a list of 18 top-priority Vital Signs (Table 3.1).

3.1.3 The Core and Secondary Programs

To further focus the SEAN Program and assure its long-term sustainability, this Monitoring Plan advances the planning of the Phase III Report to distinguish the 18 top-priority Vital Signs by the role that the Network will play in their development, implementation, and execution. To that end, we identify a Core Program of 12 Vital Signs and Secondary Program of 6 Vital Signs (Table 3.1).

The SEAN Core Program includes 12 Vital Signs on which the network will focus its time, staff, and funds. For these Vital Signs, SEAN will develop formal monitoring protocols and fund operation, data collection, analysis, and reporting. Vital Signs in the Secondary Program are park-led monitoring efforts towards which SEAN will contribute data management expertise as time and funds allow. In distinguishing these 2 programs, SEAN focuses its limited resources on implementing and sustaining the highest-priority Vital Signs while also working to ensure (as time and resources allow) that park-led efforts benefit from adherence to the same rigorous, long-term data management standards as the Core Program Vital Signs.

While SEAN must first direct resources to the Core Program, it will actively seek and support opportunities to pursue execution of Secondary Program Vital Signs. These opportunities may be openings in the SEAN Data Manager's schedule, external partnering opportunities, or

Table 3.1 The Core and Secondary Vital Signs Programs of the Southeast Alaska Network Vital Signs Monitoring Program. The 12 Core Vital Signs (closed circles, bold text) are the top priority Vital Signs that SEAN will address in the first five years of program implementation, and are the focus of this Monitoring Plan. A formal monitoring protocol will be developed for each of these 12 Vital Signs. Secondary Vital Signs will receive programmatic and data management support from SEAN as funding and staff schedules allow.

Ecological Monitoring Framework					
Level 1	**Level 2**	**SEAN VITAL SIGN**	**SEAN PARKS**		
			GLBA	**KLGO**	**SITK**
Air and Climate	Air Quality	**Airborne Contaminants**	●	●	●
	Weather and Climate	**Weather and Climate**	●	●	●
Geology and Soils	Geomorphology	**Glacial Dynamics (extent)**	●	●	
	Hydrology	**Streamflow**	●	●	●
		Oceanography	●		
Water	Water Quality	Freshwater Benthic Macroinvertebrates and Algae	++		○
		Freshwater Contaminants	●	●	●
		Freshwater Water Quality	●	●	●
		Marine Contaminants	●	●	●
Biological Integrity	Invasive Species	Invasive/Exotic Plants	○	○	○
	Focal Species or Communities	**Intertidal Communities**	+		●
		Marine Predators	●		
		Kittlitz's Murrelets	●		
		Western Toads	+	○	
	At-risk Biota	Humpback Whales	○		
Human Use	Visitor and Recreation Use	Human Uses and Mode of Access	○	○	○
	Soundscape	Underwater Sound	○		
Landscapes (Ecosystem Patterns & Processes)	Landscape Dynamics	**Landform and Landcover**	●	●	●

● Vital Signs for which the network will develop protocols and implement monitoring using funding from the Vital Signs or water quality monitoring programs. These Vital Signs represent the Core SEAN Program.

○ Vital Signs that are currently being monitored by a network park, another NPS program, or by another federal or state agency using other funding. The network will collaborate with these other monitoring efforts. These Vital Signs represent the Secondary SEAN Program.

\+ Vital Sign occurs in this park but will not be monitored at this time due to higher priorities and staff and funding limitations.

Network collaboration with individual parks to identify and secure external funding sources. Similarly, the SEAN will also encourage rigorous monitoring of other Vital Signs identified during the scoping and prioritization process (i.e., the remainder of the "parent list" of 36 Vital Signs) that were not ultimately included in the Core or Secondary Programs. That "parent list" is presented in Appendix I.

This Monitoring Plan – as a 5-year implementation plan – focuses hereafter on the 12 Vital Signs comprising the SEAN Core Program.

3.1.4 Relationship between Vital Signs and Conceptual Models

About one-third (13) of the "parent list" of 36 final Vital Signs is directly related to the major drivers of ecosystem change identified in the SEAN's holistic ecosystem model (Figure 3.1). Five of these Vital Signs are drivers (weather and climate, landform and landcover, glacial dynamics, human use and modes of access, and consumptive use), and eight are phenomena directly influenced by those drivers (Figure 3.1). Nine of these 13 Vital Signs are directly related to human activity.

Of the 21 Vital Signs related to native organisms, nine are exclusively marine, terrestrial, or freshwater, and 12 are associated with two or more of the three environments (Figure 3.2). This emphasis on Vital Signs from multiple environments is both intentional and consistent with the acknowledged importance of interactions among terrestrial, freshwater, and marine ecosystems in the SEAN parks, and the goal of making broad, cross-ecosystem inferences from the results of monitoring individual Vital Signs.

Due to the coastal nature of all the SEAN parks and the unique inclusion of marine waters at GLBA, 16 of the 21 native organism Vital Signs have a strong association with the marine environment, or are intended to include marine communities (e.g., pests and diseases, landcover and landform, plant communities, phenology). This apparent marine bias is due in part to the inclusion of several conspicuous marine mammals, including two endangered/threatened species (humpback whales and Steller sea lions, respectively), but ten of these sixteen Vital Signs are also associated with terrestrial or freshwater systems, providing good representation for these environments as well.

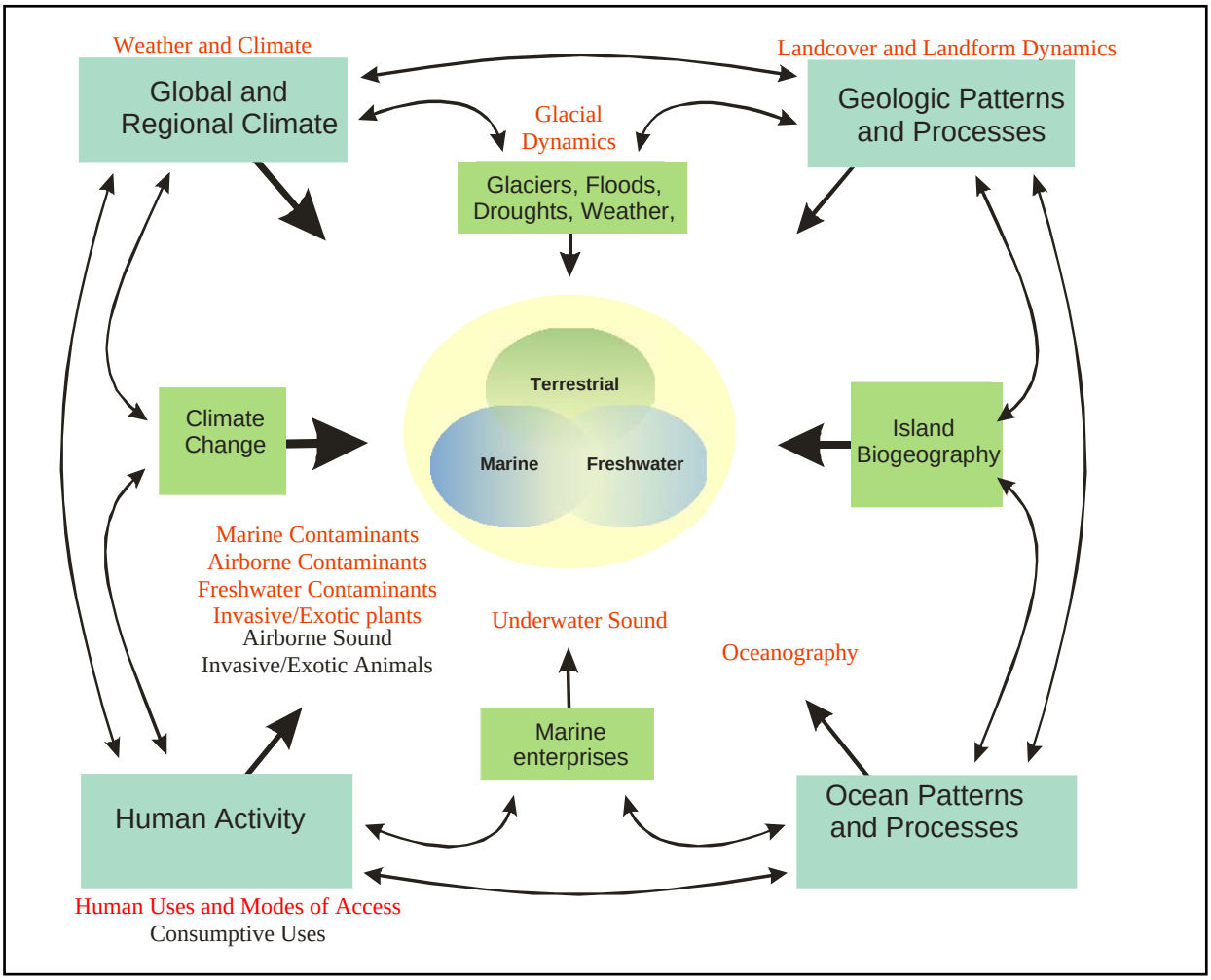

Figure 3.1 Thirteen of the 36 final Vital Signs mapped onto the SEAN conceptual model representing major drivers of ecological and landscape change. Vital signs shown outside of the boxes are drivers of change, and those inside the arrows are direct effects of drivers. Vital signs in red are among the SEAN's 18 high priority Vital Signs. In Figure 3.2, the remaining Vital Signs are mapped within the central ovals of this Figure 3.1.

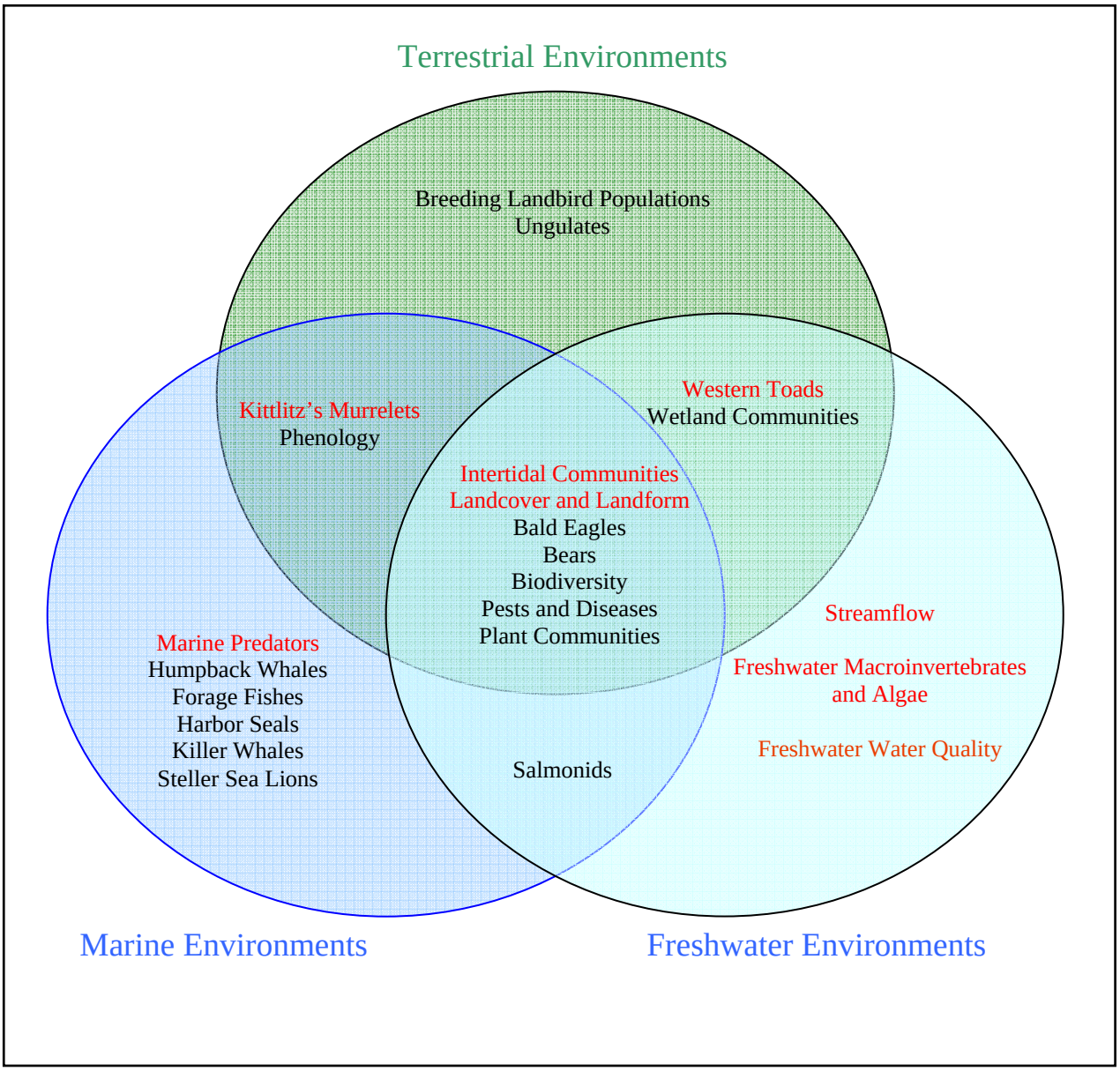

Figure 3.2 Twenty-three of the 36 final Vital Signs mapped onto the SEAN conceptual model representing the three interacting environments (terrestrial, freshwater, marine). Vital signs in red are among the SEAN's 18 high priority Vital Signs.

Chapter 4: Sampling Designs

Monitoring goals and objectives are linked to data collection through sampling designs. A quality sampling design is necessary to achieve intended monitoring goals and produce rigorous, robust, and defensible conclusions. To achieve the greatest precision, accuracy and resolution, the design must carefully consider the physical, chemical and biological characteristics of the vital sign and patterns of variability in space and time (Oakley et al. 2003). Sampling design planning is often an iterative process that results in adjusting monitoring/sampling objectives to accommodate the practical constraints of cost, time, logistics, safety, available information, and technology (Elzinga et al. 1998).

A sampling design explicitly considers the underlying basis of monitoring locations and the ability to make inference from sampled observations to a larger target population. The sampling design describes the process for determining how locations of monitoring measurements are selected, the number of locations, the target population of interest, and the extent of sample inference. The process for allocating sampling effort across space and time is also a key component of a sampling design. This chapter provides an overview of the major themes and concepts of sampling designs, and describes the designs the SEAN will use for the monitoring of each Vital Sign in its Core Program. All proposed designs represent our best approximations and optimal revisit schedules; we expect to refine designs during the protocol development process for each Vital Sign. A discussion of key concepts and definitions is included in Appendix H.

4.1 Sampling Design by Vital Sign

Sampling designs of the SEAN monitoring program can be organized by the underlying sample frame – area-based, listed-based, and index-sites. Additionally, certain Vital Signs can be monitored at the full spatial extent of a park, and thus, dividing the finite population into sample units is not required. For these Vital Signs, a census is employed to observe status and trends, and is a fourth organizing type. The remainder of this chapter contains one main section for each of the four frame types – area, list, index, and census – followed by a brief description of the sampling design for corresponding SEAN Vital Signs. A summary of the overall design features for each Vital Sign is presented in Table 4.1. We intend these descriptions as representations of our current thinking on how best to approach sampling for each Vital Sign; proposed sampling and revisit designs represent our best approximations of an optimal balance between rigor and practical limitations. We expect to refine sampling designs during the process of developing full, formal protocols.

4.1.1 Area-based Sampling

An area-based sampling frame uses geographic boundaries to delineate a given sample unit. An example of an area frame is a map of all intertidal areas in the SEAN park units. The map serves as the basis for drawing a probability sample.

Area sampling is the primary method for Intertidal Communities, Marine Predators, and Oceanography monitoring. The area frame is represented as polygons of the target population. For most, a specific number of locations within these polygons is selected, and constitute the location of sampling units.

Table 4.1 Summary of overall design features for SEAN Core Program Vital Signs.

Sample frame	Vital Sign	General description of frame	Spatial allocation	Re-visit plan	Response design
Area-based	Kittlitz's murrelets	GLBA proper marine environment	Systematic line transects	[1-0]	Boat-based surveys
	Marine Predators	GLBA proper marine environment	Systematic line transects	[1-0]	Boat-based surveys
	Intertidal Communities	Map of all intertidal areas in SITK	Systematic (15 transects)	[1-0]	Point, belt transects, and quadrat counts along transects
	Oceanography	GLBA marine environment for water samples	Random (24 locations)	[1-0]	Water column samples
List-based	Glacial Dynamics	All glaciers in GLBA and KLGO, monitored for extent	NA (census)	[1-9]	Aerial photography
	Marine Contaminants	GLBA, SITK intertidal environment	NA (index sites selected from the 2007 baseline study)	[1-1]	Assay of field-collected mussels
Index sites	Airborne Contaminants	1) For lichen and air samples in each park unit, selected locations to capture the known variation in cruise ship visitation	NA	[2-9] for lichen and air samplers	Samples of lichens within 2-ha areas, passive air samplers
		2) Hg measures at a wet-deposition monitoring station in Bartlett Cove (GLBA)		Hg: weekly from 2009-2012	Wet-deposition measures
	Freshwater Contaminants	Co-located with Freshwater Water Quality and Streamflow	NA	[1-9]	Assays of fish tissue an (in GLBA) lake core sediments
	Freshwater Water Quality	Co-located with Freshwater Contaminants and Streamflow	NA	Continuous; spring - fall	Field measures of NPS core parameters
	Streamflow	Co-located with Freshwater Contaminants and Water Quality	NA	Continuous; spring - fall	Automated stream gages
	Weather and Climate	Locations picked to suite needs of external weather-climate monitoring networks	NA	Continuous	Ground-based weather stations
Census	Landform and Landcover	For all park units, the full extent of the park and a TBD area around each park	NA	[1-9]	Ikonos imagery

4.1.1.1 Intertidal Communities

Observations of flora and fauna of intertidal areas in SITK will be recorded to track changes in these communities sensitive to marine-related development and marine pollution. Maps of intertidal units in SITK will be used to randomly select 15 permanent transects. Along each transect, observations of sessile species, macroinvertebrates, and small mobile species will be acquired through permanent point samples, belt transects, and quadrats. Inference scope will be limited to the sampled intertidal zone.

4.1.1.2 Kittlitz's Murrelets

Monitoring for Kittlitz's murrelets (KIMU) will involve a series of at-sea surveys conducted on several occasions during the summer months in GLBA. Multiple surveys throughout the summer will help estimate the seasonal peak in numbers of KIMU for timing of future surveys and ensure that surveys capture temporal variability of KIMU within the park. Surveys will consist of two types of transects to capture known spatial variability (i.e., patchiness) in distribution, following Kissling et al. (2007).

The data from the initial surveys will be compared with historical surveys conducted within Glacier Bay proper and from surveys in Icy Bay, Wrangell-St. Elias National Park (Kissling et al. 2007) and utilized in a power analysis to estimate sampling design power under different conditions of sampling (detectability, transect length, magnitude of population change, etc.).

4.1.1.3 Marine Predators

USGS conducted annual boat-based surveys in and around Glacier Bay proper for marine birds and mammals from 1999 through 2003. The surveys were designed to assess important areas of marine predator concentration in Glacier Bay. However, they also served as a means of surveying multiple species of marine birds and mammals for understanding long-term trends. These systematic surveys were conducted in June of each year covering nearly 30% of total marine habitat in Glacier Bay proper, with coverage of the entire shoreline and extensive sampling of offshore habitats with a fine-scale grid. A subset of June transects was surveyed in November of 1999 and repeated in March for four years (2000-2003).

These data will be used to develop the SEAN's monitoring protocol. Preliminary results indicated that adoption of the existing protocol, but with a reduction of up to 70% in effort, would yield data with precision acceptable for the SEAN's long-term monitoring purposes. Transects will be stratified by coastal and pelagic areas (relative the shoreline of Glacier Bay proper); stratification is particularly important for generating accurate population estimates for several key species. Because populations of many marine birds and mammals are inherently variable in space and time, the true value of using this transect methodology will be in the accumulation of long-term datasets (i.e., trend detection for some species will require 15-25 years of data).

4.1.1.4 Oceanography

Measures of standard oceanographic parameters (water temperature, salinity, turbidity, pH, dissolved oxygen, light penetration, and primary productivity) throughout the water column will

be acquired at 24 permanent stations across the distance-from-tidewater-glaciers/turbid-outwash-streams gradient within Glacier Bay proper. Stations were established by USGS (Hooge et al. 2003, Etherington et al. 2007) to capture known variation in Glacier Bay proper, including mid-bay sills and deep basins. A protocol describing Conductivity-Temperature-Depth (CTD) casts to measure water temperature, salinity, photosynthetically active radiation (PAR), optical backscatterance (OBS – turbidity), and chlorophyll-*a* fluorescence (proxy for phytoplankton concentration) was developed by USGS (Hooge et al. 2003, Etherington et al. 2007), and will be adopted by the SEAN. Oceanographic data for the outer coast will be harvested from external programs (NOAA, Univ. of Alaska, Alaska Dept. of Fish & Game), and will include elements of physical and chemical oceanography (e.g., salinity, pH) as well as biological oceanography (e.g., primary productivity).

4.1.2 List-based Sampling

A list-based frame is a list of possible sample units, derived from inventories or intimate knowledge of the extent of a resource. An example would be a list of all glaciers in the SEAN park units. The list-based frame is used to draw probability samples, or all units of the list are selected for monitoring (i.e., census). A list-based scheme will be used for monitoring two of the Core Program Vital Signs: Glacial Dynamics and Marine Contaminants.

4.1.2.1 Glacial Dynamics

All glaciers will be identified in GLBA and KLGO. High-altitude aerial photography (and/or satellite imagery, potentially) will be used once every ten years to delineate spatial extent (terminus position), surface area, and elevation of each glacier. Photography will occur at the end of the summer ablation season to allow accurate determination of the equilibrium line and to take advantage of the maximum yearly exposure of lowland features. We expect that a decadal time step will be sufficient to capture significant changes. Location of measures will generally correspond to historical stations that were selected for their representativeness of glacier systems in GLBA and KLGO.

SEAN does not expect to undertake mass-balance monitoring at this time, but has retained these monitoring elements in the Glacial Dynamics PDS to facilitation potential future expansion of glacier monitoring if additional funding is identified.

4.1.2.2 Marine Contaminants

Marine Contaminants, In 2007, SEAN funded a baseline marine contaminants project (Tallmon 2007) that sampled intertidal blue mussels (*Mytilus trossulus*) from several sites in GLBA (both within Glacier Bay proper and in outside waters) and at SITK and KLGO. Mussels provide an excellent time-integrating bio-proxy for a broad spectrum of marine water pollutants (persistent organic pollutants, polycyclic aromatic hydrocarbons, and metals). The protocol followed was similar to that of NOAA's nationwide Mussel Watch Program. SEAN will follow the recommendations of the forthcoming (expected fall 2008) report of the baseline study to select one or two representative sites from the Glacier Bay locations and one site in SITK. These sites will be monitored in alternate years (mid-summer), starting in 2009. Every attempt will be made to encourage NOAA to add these sites to its larger Mussel Watch Program.

4.1.3 Index Sites

Index sites are a special case of the list-based frame, used to collect information on points or locations that are hand-picked by lead investigators and monitored to yield adequate data on a particular Vital Sign. These samples are usually selected as "representative" sites, and – given the lack of probability sampling – statistical inference is limited to the monitored areas.

Selection of index sites is justified due to the high costs of the surveys or equipment involved in the measurements (e.g., airborne contaminants, weather & climate). The use of index sites is appropriate in cases where selected sites represent the majority of the population of monitored subjects, or where the spatial fluctuation in measures across a larger area is inconsequential for long-term monitoring purposes. Given limited monitoring resources and large, inaccessible land areas, the SEAN employs this type of frame in monitoring five of the 12 Core Program Vital Signs: Airborne Contaminants, Weather & Climate, and three freshwater Vital Signs.

4.1.3.1 Freshwater Vital Signs – Common Considerations and Colocation

Three of the Core Program Vital Signs are related to freshwater water quality: Freshwater Contaminants, Freshwater Water Quality, and Streamflow. At least one stream in each park unit is selected for monitoring these three Vital Signs (Table 4.1). Up to two additional young, recently deglaciated streams in GLBA may be included. Streams were selected on the basis of being the only stream in a park unit (i.e., the Indian River at SITK), on the importance of the stream for anadromous fish spawning and rearing, and on the importance of the stream as a source of sediment and pollution discharge to the ocean. Within each stream, a 100-m section will be selected on the basis of accessibility and used in monitoring all three freshwater Vital Signs. The ability to include other streams and lakes will be determined as costs and effort are better defined in pilot implementation.

The colocation of freshwater Vital Signs monitoring provides efficiency in terms of data collection effort and provides integrative information useful in evaluating reasons for observed trends in one or more Vital Signs. Dependent upon site access and characteristics, streamflow measures may not be precisely spatially coincident with other Vital Signs on all streams; however, near-upstream measures will provide a useful proxy of streamflow through the selected index site.

4.1.3.2 Freshwater Contaminants

The SEAN will monitor freshwater contaminants fish, macroinvertebrate, and sediment sampling on a rotating basis. Field staff will collect sediment samples from the streambed and benthic macroinvertebrates from long-lived species with a ≥2 year life cycle. Fish tissue samples will be collected from resident fish and juvenile salmonids (primarily coho), that stay in freshwater systems long enough to bioaccumulate toxins. Collection of Hg, other heavy metals, and a "legacy" suite (e.g., PCBs, toxaphene, PAHs, DDT, chlordane, HCH, dioxins, furans, and chlordane) will alternate with collection of other persistent organic pollutants (e.g., PBDEs, PFAs, SCCPs, PCNs, endosulfan, trifluralin, and methoxychlor).

4.1.3.3 Freshwater Water Quality

Core parameters currently identified (NPS 2002) are temperature, pH, conductivity, dissolved oxygen, flow/stage/level (see Streamflow Vital Sign below), and turbidity. In-situ water quality

core parameters will be sampled using recording instrumentation known as data sondes. These instruments incorporate multiple sensors integrated into a single instrument. Sondes with integrated dataloggers will be placed in streams for continuous data recording and subsequent downloading. In addition to core measures, parameters to track biological productivity, nutrient enrichment, and organic pollution will be considered; these may include chlorophyll-*a*, total dissolved solids (TDS), alkalinity, total and dissolved iron, total phosphorous, total nitrogen, ammonia as N, major cations (silicon, magnesium, calcium, sodium, potassium), major anions (chloride, fluoride, ortho-phosphate as P, nitrate as N, nitrite as N, sulfate), dissolved organic carbon (DOC), biological oxygen demand (BOD, 5-day), and fecal coliform bacteria. Other parameters for consideration in more developed areas may include hexane-extractable material and pharmaceuticals. Collection of water samples will follow a rigorous quality assurance/quality control protocol that includes chain-of-custody records for samples. Laboratory analyses and reporting will also follow a QA/QC plan. Samples will be processed by a certified lab (e.g., Analytica Alaska in Juneau).

4.1.3.4 Streamflow

Data from existing USGS stream gages will be harvested each year. Streamflow measures of the Indian River will be collected via two gages recently and cooperatively established by SITK, the City and Borough of Sitka, and the Alaska Department of Fish and Game. In GLBA, traditional USGS stream discharge measurement techniques will be established by the SEAN. In KLGO, a gage will be established on the Taiya River. Data from all existing gages on selected streams will be used, regardless of their location relative to the index site used for other freshwater measures. These data provide an overall condition assessment of the stream, and upstream gages provide some indication of condition of the actual index site. The primary recorded measures will be stage height and discharge, reported on seasonal, annual, and peak bases.

4.1.3.5 Airborne Contaminants

Air quality of all SEAN parks may be impacted by near-field mobile sources including railway operations, busses, cruise ships and other marine traffic; near-field point sources such as diesel-fired generators; and far-field industrial sources in Eurasia. In addition to air contamination degrading visibility, deposition of air contaminants has the potential to contribute to foliar damage (Fenn 2006), terrestrial and marine community compositions shifts (Geiser et al. 1994, Fenn 2006), and bioaccumulation of contaminants in marine and terrestrial organisms (Goodyear and McNeil 1998, Pedersen and Lierhagen 2006). Monitoring of air contaminants both directly and in lichen species affords efficient and cost-effective methods for tracking airborne contaminants. Two-hectare monitoring sites will be selected to capture variation in cruise ship routes and other physical site criteria, with two sites in KLGO, two in GLBA, and one in SITK. These sites will complement the 73 plots already established throughout SE Alaska as part of the regional lichen monitoring program operated by the USDA Forest Service, some of which may serve as additional controls to high-visitation sites selected in SEAN parks. Lichen samples will be collected at each site, and assayed for 24 elements, total nitrogen, total sulfur, and total nitrate concentration. Passive throughfall samplers at each site will measure wet and dry deposition, providing data on sulfates, nitrates, and ammonium and hydrogen ions. Passive air samplers will be operated at sites from approximately mid-April to mid-October to provide concentration measures of SO_2, NHO_3, NH_3, NO_2, and NO_x in ambient air. Lichen community samples also will be collected on adjacent sites, following methods used by the Tongass National Forest

(Geiser et al. 1994, Geiser 2004). We will construct predictive models of elemental concentration in lichens from pollutant concentrations in ambient air. Lichen sampling and air samplers will be activated for two consecutive years per decade.

Hg monitoring will be part of a regionwide network run by the Mercury Deposition Network (MDN, http://nadp.sws.uiuc.edu/mdn/), which is housed within the National Atmospheric Deposition Program (http://nadp.sws.uiuc.edu/). A historic wet-deposition station in GLBA will be brought back on-line to provide weekly samples for at least the next three years. After three years of data collection, results will be evaluated relative to other extant stations in coastal Alaska to determine whether the GLBA data are distinct and valuable for monitoring regional mercury deposition, or whether variation in GLBA data is adequately captured by another NADP station in the region.

4.1.3.6 Weather and Climate

Programs external to the SEAN currently are monitoring weather and climate. Davey et al. (2007) identified existing stations within 60 km of each of the SEAN's park units (Table 4.2). Only GLBA contains weather stations. The SEAN monitoring efforts will consist of establishing three or four weather stations within the parks, acquiring and archiving data from existing stations, and analyzing data specific to park units. Basic parameters (e.g., precipitation and temperature) and other available measures (e.g., snowfall and depth) will be included in analyses. Many of the climate stations have a long period of record, with some dating back to the 1890's. This temporal sample provides a useful context for delineating future, broad-scale climatic extremes and change. For efficiency, initial monitoring efforts will determine a short-list of stations most useful to SEAN park units, and only work with data from these stations. Moreover, climate products already available from WRCC (Western Regional Climate Center – Reno) and from other climate centers (e.g., PRISM – Oregon State Climate Center, Corvallis) will be used to provide broad-based assessments of historical and current climatic conditions.

Table 4.2 Number of weather stations within 60 km of SEAN's park units. Number of stations within a park unit is noted inside the parentheses. (Table from Davey et al. 2007).

Network	GLBA	KLGO	SITK
COOP (NWS-Cooperative Observer Program).	36 (3)	13 (0)	6 (0)
CWOP (Citizen Weather Observer Program)	2 (0)	1 (0)	0 (0)
NADP (National Atmospheric Deposition Program)	1 (0)	0 (0)	0 (0)
NRCS-SC (USDA/NRCS snowcourse network)	4 (0)	2 (0)	0 (0)
NWS-AK (NWS Alaska Region network)	6 (1)	1 (0)	0 (0)
RAWS (Remote Automated Weather Station network)	2 (0)	0 (0)	1 (0)
SAO (Surface Airways Observation Network)	14 (1)	3 (0)	3 (0)
SNOTEL (USDA/NRCS Snowfall Telemetry network)	2 (0)	2 (0)	0 (0)
Other	3 (0)	2 (0)	2 (0)
Total	70 (5)	24 (0)	12 (0)

4.1.4 Census Designs

Census designs are used where all the individuals of a sampling frame may be monitored, as is the case with mapping efforts and with some known small wildlife or plant populations. SEAN will use a census design for monitoring Landform and Landcover.

4.1.4.1 Landform and Landcover

Landform and landcover will be monitored via satellite. IKONOS or other high resolution space borne imagery will be acquired for the full extent of each park unit and relevant adjacent areas outside the park unit to monitor near-park disturbances and boundary contrasts. The extent of extra-park area to include will be determined by processes with the potential to influence park lands, such as drainage, extra-urban threats (SITK), etc. The expense of imagery acquisition and processing requires a minimum 10-year revisit design. Change detection will be concentrated on specific landforms (e.g., moraine deposits, glacier extent, firn lines, terraces, fluvial deposits, proglacial lakes, alluvial deposits, accretion zones on river systems, shoreline features, erosion zones on river systems, river channels). Broad class types will be required for vegetation, but types will be sufficient for condition monitoring of the SEAN's vegetative areas. Classified maps from the most recent and previous monitoring events determine status and trends in landcover composition and structure. We will consider options to use medium-resolution imagery (e.g., ASTER) every five years to enhance temporal resolution for detecting broad-scale changes.

Chapter 5: Sampling Protocols

Sampling protocols for monitoring Vital Signs are study plans detailing how "data are to be collected, managed, analyzed, and reported, and are a key component of quality assurance for natural resource monitoring programs" (Oakley et al. 2003). Protocols consist of three main sections: 1) narrative; 2) standard operating procedures; and 3) supplementary materials (Oakley et al. 2003). The protocol narrative describes why a particular Vital Sign and metric(s) were selected; specifies objectives and details of the proposed sampling design to meet those objectives; identifies field methods that will be used to gather data; explains how these data will be managed, analyzed, and reported; discusses personnel requirements and training and safety procedures; and describes operational requirements such as scheduling, equipment, and budget. Standard operating procedures provide detailed instructions on how to accomplish every topic mentioned in the narrative. Supplementary information includes relevant sources of data such as sample databases and digital images (Oakley et al. 2003).

The SEAN staff met with cooperators from the SEAN parks (Technical Committee membership) and the NPS Alaska Regional Office (NPS-ARO), during November 2007 to discuss a schedule for developing and implementing sampling protocols. Additional discussions were held with USGS-BRD, a key potential cooperator. Our Core Program of 12 Vital Signs were selected primarily based on their ecological and management significance, and secondarily with regard to the SEAN's workload and funding capacity in the first years of implementation. We must balance our desire for holistic monitoring program with the realities of staffing and budget limitations. To achieve that balance, we have opted to prioritize development and implementation of the Core Program over opportunistic contributions to Vital Signs listed under the Secondary Program (refer to Chapter 3).

In Chapter 9 we describe the importance of building a reasonable schedule that emphasizes quality over quantity. That is, the SEAN has decided to focus on completing fewer, but high-quality Vital Signs monitoring protocols within a given year, rather than aspiring to complete the maximum number in the shortest timeframe. To meet this implementation goal of doing a few things well while still maintaining our longer-term vision for a fully implemented, holistic monitoring program, we have decided to focus initial implementation (begun in 2008) on five Vital Signs: Airborne Contaminants, Marine Predators, Weather and Climate, Oceanography, and Freshwater Water Quality[2]. These first 5 Vital Signs were selected for three key reasons: (1) they were consistently identified by the SEAN Technical Committee as being of high priority and direct relevance to SEAN parks, (2) all have considerable extant raw and analyzed data that will contribute directly to protocol development, and (3) there are immediate and substantial partnering opportunities to leverage SEAN contributions and capitalize on expert assistance in tailoring protocols to the SEAN parks. Table 5.1 displays the five-year (2009-2013) schedule of development and testing of Core Program protocols monitored only by the SEAN or monitored in partnership with SEAN parks or other agencies. See Section 8.4 for further details on partnerships with other agencies, and see Chapter 9 and Table 9.1 for recognized issues to be

[2] Development of the Freshwater Water Quality protocol will be closely coordinated with the other three freshwater Vital Signs (Contaminants, Macroinvertebrates and Algae, and Streamflow) to coordinate collocation and sampling design considerations.

addressed during protocol development and testing. A protocol development summary (PDS) briefly describes key elements of sampling protocols that will be implemented within five years of the initial draft release of the Monitoring Plan, and how the SEAN expects to go about developing each protocol (see http://science.nature.nps.gov/im/monitor/ for the basic guidelines). A summary of the justifications and measurable objectives for all PDSs is provided in Table 5.1; the PDSs themselves are in Appendix C.

Table 5.1 Justification and measureable objectives for monitoring protocols used to monitor Core Program Vital Signs within the SEAN parks.

SEAN Vital Sign and Protocol	SEAN PARKS			Scheduled Year of Protocol Completion	Justification	Measurable Objective
	GLBA	KLGO	SITK			
Oceanography	●			2009	Oceanographic conditions and processes are critical to marine flora and fauna and are likely to be an important determinant of both short- and long-term variation in the marine biotic community, from primary production to top predators.	1. Measure spatial and temporal oceanographic trends in water temperature, salinity, turbidity, pH, dissolved oxygen, light penetration, and primary productivity in marine waters of Glacier Bay proper.
Airborne Contaminants	●	●	●	2010	Airborne contaminants and increased particulate loads have potential to affect climatic conditions, alter marine and terrestrial ecological processes, and degrade visibility impacting the parks' scenic beauty. All SEAN parks may be impacted by near-field mobile sources including cruise ships and other marine traffic, near-field point source such as diesel fired generators, and far-field industrial sources in Eurasia. Mercury (Hg) may be an important contaminant in Southeast Alaska due to its proximity to Eurasian sources and the prevailing weather patterns. Once Hg becomes bioavailabile in an organic form, methyl mercury (MeHg) it is 100 times more toxic and can bioaccumulate in a variety of taxa, reaching concentrations one-million times greater than environmental concentrations.	1. Determine long-term trends in the concentrations of selected chemical elements in lichen tissue. Join a regional network of lichen collection sites allowing SE Alaska wide inferences. 2. Track actual concentration (ppm or ppb) of SO2, NHO3, NH3, NO2 and NOx in ambient air, 3. Track total deposition (total wet and dry in kg/ha/yr) for N & S compounds. 4. Determine long-term trends in lichen community composition through measurement of permanent lichen plots. 5. Determine deposition of mercury as part of the National MDN program by establishing and maintaining an MDN monitor in GLBA.

Table 5.1, continued

SEAN Vital Sign and Protocol	SEAN PARKS			Scheduled Year of Protocol Completion	Justification	Measurable Objective
	GLBA	KLGO	SITK			
Kittlitz's Murrelets	●			2010	The National Park Service is a steward to the global population of KIMU. Best estimates indicate that over 20% of the world's population resides seasonally or year-round within Glacier Bay and Wrangell-St. Elias National Parks alone. KIMU are a species of management concern as a result of substantial declines across their range, including some areas where declines have exceeded 70%. In 2007, the USFWS upgraded KIMU to a Priority 2 for listing under the Endangered Species Act due to widespread and dramatic declines across their range. The population in Glacier Bay National Park is estimated to have declined 80% since the early 1970's.	1. Generate population abundance estimates that, at a minimum, achieve 90% power (at α=0.05) to detect a 50% change in population within the next 10 years. 2. Determine annual and long-term trends in KIMU within Glacier Bay proper by generating population estimates every summer using at-sea surveys and a line transect methodology. 3. Quantify annual variation in spatial distribution of KIMU occurrence within Glacier Bay proper. 4. Adapt and implement the existing KIMU monitoring design developed in Icy Bay, WRST, (Kissling et al. 2007) for Glacier Bay proper to achieve the monitoring and sampling objectives identified above and to maximize inference scope.
Marine Contaminants	●	●	●	2010	Marine waters in SEAN parks are believed to be pristine, but are subject to 2 risks of contamination: chronic delivery and accumulation of far-field contaminants associated with global industrialization, and acute, localized contamination associated with local human activity and marine enterprise. Biennial monitoring of a broad array of contaminants will allow SEAN to track long-term trends in the former while maintaining a high-quality, updated baseline inventory that would be indispensible in the event of the latter.	1. Determine long-term trends in marine contaminants at selected locations in all SEAN parks through biennial collection and analysis of blue mussel tissue samples.

Table 5.1, continued

SEAN Vital Sign and Protocol	SEAN PARKS			Scheduled Year of Protocol Completion	Justification	Measurable Objective
	GLBA	KLGO	SITK			
Marine Predators	●			2010	Marine mammals and seabirds in GLBA are among the most emblematic and readily observable wildlife in the park. A large proportion of these species is also of particular management concern, due either to conservation status iconic or charismatic characteristics. Many visitors to GLBA both aspire and expect to observe a variety of seabirds, cetaceans, and pinnipeds. Top trophic-level predators (including marine mammals and seabirds) can serve as an index of ecosystem health because they assimilate and reflect the dynamics of populations at lower trophic-levels.	1. Determine long-term trends in the abundance and spatial distribution of marine birds and mammals within GLBA proper using grid-based sampling of at-sea surveys twice each summer stratified by along-shore (shoreline) and pelagic line transects that covers approximately 10% of the marine habitat.
Weather and Climate	●	●	●	2010	Climate is a basic driver of all ecological systems. Global climate models predict climate change and variability will be most severe at high latitudes. There are many indications that environmental conditions are already changing in Alaska.	1. Determine variability and long-term trends in climate for all SEAN parks through monthly and annual summaries of descriptive statistics for selected weather parameters, including air temperature, precipitation, snow depth, wind speed, and wind direction.
Freshwater Water Quality	●	●	●	2011	Freshwater quality is critical to the functioning of aquatic, terrestrial, and nearshore marine ecosystems across SEAN. Threats to SEAN stream water quality include climate change, visitor impacts, urban development, invasive species, and long-range atmospheric contaminants.	1. Track core water quality parameters (temperature, dissolved oxygen, conductivity, pH) in select SEAN streams.

Table 5.1, continued

SEAN Vital Sign and Protocol	SEAN PARKS			Scheduled Year of Protocol Completion	Justification	Measurable Objective
	GLBA	KLGO	SITK			
Streamflow	●	●	●	2011	Streamflow is a critical monitoring component of aquatic ecosystems and habitats because many chemical and physical variables are influenced directly or indirectly by it. Climate change, urban development, water diversions, and other factors may alter streamflow and cause increase in erosion and siltation, increase of high-volume flash discharges in fall and winter and extreme low water in summer, threatening habitat for aquatic life such as spawning salmon and macroinvertebrates.	1. Determine status and trends of streamflow in select SEAN streams.
Freshwater Contaminants	●	●	●	2012	Contaminants such as mercury, POPs, fire retardants, PCBs, and PAHs, are known biological toxins and can bioaccumulate in SEAN aquatic environments. They can enter aquatic ecosystems from local sources, long-range atmospheric transport or by marine-derived nutrients (spawning salmon).	1. Track levels of selected contaminants in selected lotic and lentic waterbodies through analysis of sediment and fish tissue samples, with an emphasis on paired lakes that do and do not support anadromous fish populations (i.e., sockeye salmon) that may deliver marine-derived contaminants.
Intertidal Communities			●	2012	Intertidal invertebrates provide a critical prey resource for myriad vertebrate and invertebrate marine predators, as well as spawning and nursery habitats for forage fish and juvenile crustaceans. SEAN intertidal areas are biologically rich and are sensitive habitats vulnerable to disturbance. Threats include visitor trampling, adjacent development, oil spills, sewage, and boat groundings.	1. Determine the status and trends of intertidal species composition and distribution for the SITK intertidal zone. 2. Determine trends in the occurrence and distribution of invasive/non-native intertidal invertebrates and macroalgae
Glacial Dynamics	●	●		2013	In both parks, glaciers have been and continue to be principal direct and indirect determinants of landform, oceanography, ecological pattern/process, and scenery. Changes in	1. Determine (by direct measurement or modeling/proxy) changes in glacial extent and configuration of selected glaciers in GLBA and KLGO.

Table 5.1, continued

SEAN Vital Sign and Protocol	SEAN PARKS			Scheduled Year of Protocol Completion	Justification	Measurable Objective
	GLBA	KLGO	SITK			
					glacial extent and mass balance serve as proxies for climate change.	
Landform and Landcover	●	●	●	2013	Landscape structure is the base upon which physical and ecosystem processes function. The composition, quantity, patch configuration, and juxtaposition of terrestrial landscape components (landcover and landform types) control energy and material flow, inputs to marine systems, habitat availability, and wildlife movement patterns. Changes in landform and landcover types occur rapidly in SEAN parks in response to climate-mediated glacial retreat and primary succession, isostatic rebound, tectonic activity, wild-land fire, and insect outbreaks. Landcover and land use change could have profound impacts with cascading effects across terrestrial and aquatic systems.	1. Determine long-term status and decadal trends in the areal extent and configuration of key landforms within, and on lands influencing, SEAN parks. 2. Complete the extent mapping component of the Glacial Dynamics monitoring protocol. 3. Determine status and long-term trends in the areal extent and configuration of plant community types at broad botanical levels within, and on lands influencing, SEAN parks. 4. Determine status and long-term trends of selected key landscape metrics (e.g., proportion of area in different cover types, number and density of patches, mean patch size) of NPS lands within and on adjacent lands influencing SEAN parks.

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Chapter 6: Data Management and Archiving

"Documents prepared without carefully considering how people access or read information inevitably end up as digital landfill: either inaccessible or, if inadequately networked, forgotten."
Martin and Coleman 2002.

The long-term success of the SEAN's monitoring efforts is fundamentally dependent on thoughtful and efficient data management. We have focused the network's approach to data management on four functional areas that are described in this chapter and throughout this Monitoring Plan: data acquisition, verification, storage, and dissemination. All are integrated with and flow from protocol development (Chapter 5).

Nested under the SEAN's mission statement and goals, we explicitly emphasize delivery of useful products to customers (NPS employees, external partners, the general public) by leveraging modern, web-based technologies. The SEAN has the advantage of being among the later networks to be developed, making us well-positioned to design our data management operations around the most recent mainstream information technology (IT) capabilities.

Just entering development, the SEAN's IT facilities are described in detail in its Data Management Plan (DMP) (Johnson et al. 2008), which is built in conformance with the national I&M Program Data Management Plan, formally known as "Data Management Guidelines for Inventory and Monitoring Networks" (NPS 2008). Whereas the national plan provides an overarching strategy and direction, the SEAN plan provides detailed specifications for developing and fulfilling its information management role. This chapter represents a distillation of the SEAN's DMP; headings used here directly correspond to the DMP chapters.

In the Introduction section we give a broad overview of the perspective and principles that guide our approach to data management. Subsequent sections discuss processes and architecture in greater detail. The full SEAN DMP is available at the SEAN website.

6.1 Introduction

The SEAN will provide direct support to the three network parks and make information available to the NPS and the outside world. Its data management design is based on the foundational functional model depicted in Figure 6.1. This model is explicitly customer-centric; it is based on deciding and describing exactly what needs to be delivered and then developing processes to properly provide those products.

The SEAN's data management is based in the four Core Functions shown in Figure 6.1: 1) Information Dissemination, 2) Information Repository, 3) Information Certification, and 4)

Information Acquisition. Each of these Core Functions must be addressed during the two phases of establishing a data management program that is fully integrated within the Vital Signs monitoring program: the Development Phase and the Operations Phase. Given the context of our customer-centric philosophy, we have structured the Development Phase to flow in a clockwise order illustrated in Figure 6.1 (e.g., 1-2-3-4). That is, the SEAN will work to clearly articulate the desired end-products before initiating data collection in the field. We recognize that this presentation is likely opposite the direction in which a monitoring program *operates*. Indeed, the Operation Phase (once the program is fully developed) does flow in the chronological and counter-clockwise order of 4-3-2-1 (beginning with data collection and ending in dissemination).

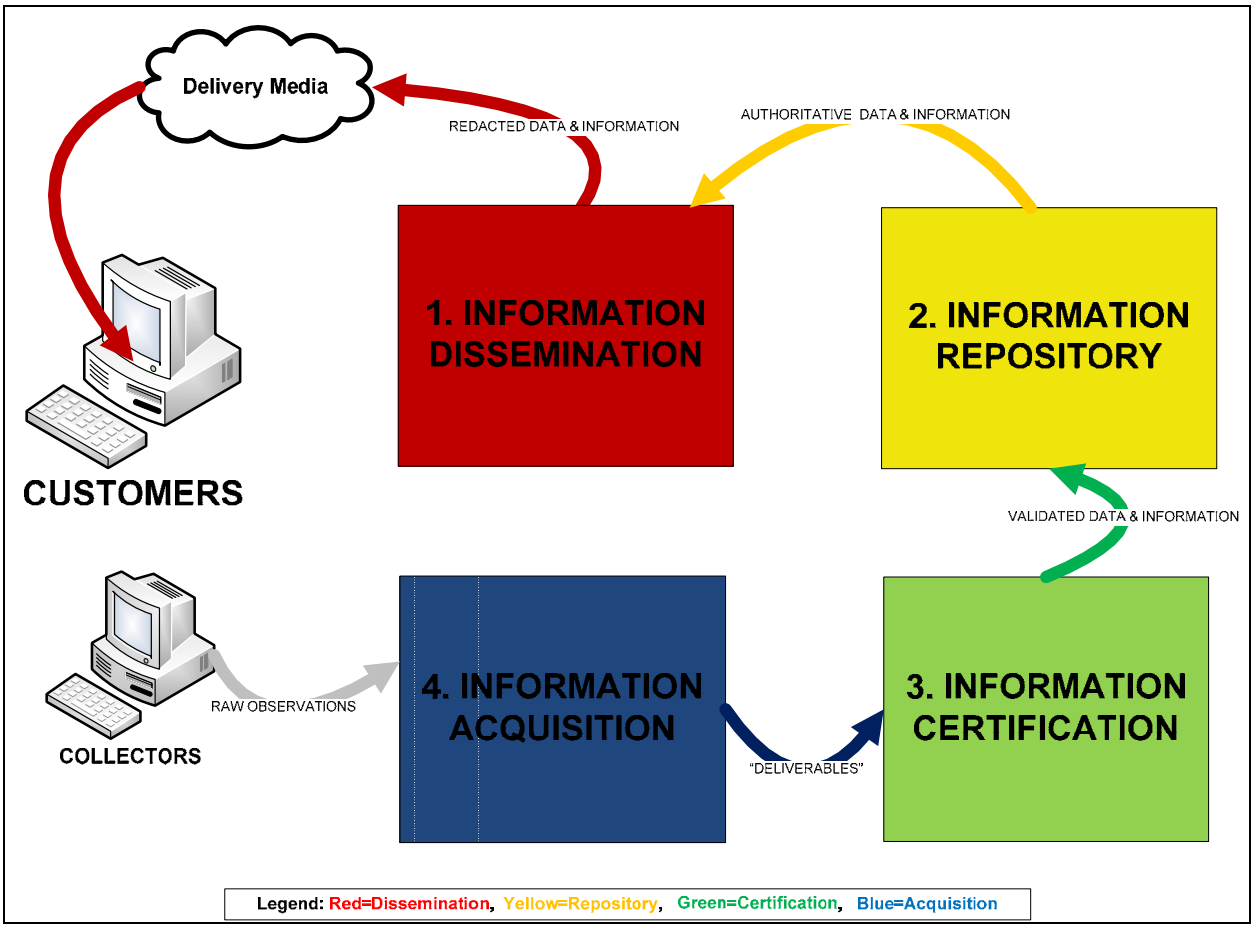

Figure 6.1 The SEAN Functional model of data management. Dissemination services (red) provide all data products to all customers using Internet web servers. Repositories (yellow) store the certified inventory and monitoring products called for in the protocols. Certification processes (green) assure repositories have the highest quality data and that sensitive items are restricted to authorized users. Data acquisition processes (blue) led by park staff and cooperators include a wide array of tasks, ranging from designing field forms to producing talks on long-term trends.

The purpose of our emphasis on dissemination is to underscore the critical importance of specifying the desired data and products before constructing observation, certification, and repository processes. A useful analogy: to achieve a desired objective, it is more effective to pick a destination and then drive to it, rather than to drive around and see if the place you at which you arrive in is useful. The SEAN DMP addresses both network *development* and network *operations*, which have significantly different characteristics that require some different skills. Please note that the color-coding for these Core Functions in Figure 6.1 is carried throughout other figures in this Chapter. The figure illustrates the linear process by which information is made available:

- Valid information is acquired from collectors
- Certification is granted to valid information
- Repositories are populated with certified information
- Information is disseminated from repositories
- Customers make use of disseminated information

Long-term monitoring projects have fundamentally different data management requirements than one-time, stand-alone projects (e.g., research investigations or baseline inventories). The usefulness of time-series (i.e., monitoring) data over time is dependent upon their consistency over time. Modification of data collection between collection periods produces discontinuities which result in opportunities for interpretation errors and may constrain retrospective analyses. Therefore, rigorous planning is needed to select (for each Vital Sign) the stable data elements that are useful over the long run, and to establish broader priorities that identify the types of data management services to which the SEAN will direct its attention. To this end, we identify three priorities for the network in pursuing its mission.

1. First and foremost, the SEAN will establish and execute projects that directly perform long-term monitoring related to the Core Program Vital Signs described in Chapter 3.
2. We may assist the SEAN parks with technical data management support on park-specific projects that relate to a Vital Sign that is not in the Core Program, but is on the "parent list" of 36 (see Chapter 3).
3. Lowest priority is assigned to one-time measurements that may inform a Vital Sign monitoring process but that are not Vital Signs themselves. Development of data management processes for these efforts may cost as much as full operation of some long-term programs. We include this item in our plan because we recognize that a particularly important future data need could be identified that would require considerable effort or expense to obtain.

For Vital Sign data to be accessible across time and people, it must be readily locatable and accompanied with sufficient documentation (i.e., metadata) to enable accurate interpretation and reliable use by a customer. Data use should not be conditional on collaborating with specific network or park staff, because data must be longer-lived than any individual's tenure. Metadata – the documentation necessary to make time-series data useful – will vary by Vital Sign.

The World Wide Web ("web") offers easy access to information, and linking of data with its essential documentation. Computer networks at all SEAN parks have adequate bandwidth,

latency, and reliability for staff to rely on the web for daily work. Also, customers generally do not have to purchase or install special software products to work with data. Browsers are free, and plug-ins are readily available. Technologically, we can now leave behind the "push model", where key persons need to provide customers with assistance. The "pull model" lets current and future customers make good use of Vital Signs data on their own.

The SEAN is committed to making all of its data products and supporting information available through the web. The SEAN internet home page will deliver program information and have a link for each Vital Sign. Once a Vital Sign monitoring protocol is fully designed and implemented, the SEAN Data Manager will create a main page for it. As deliverables and documentation become certified, links on the Vital Sign home page will provide access to them. The SEAN will require that all project data deliverables assume a form that may be directly disseminated over the web.

NPS emphasizes that data quality is extremely important to maintain long-term integrity, and the SEAN will enforce an "authoritative source" concept, whereby one and only one copy of each data deliverable will be stored in one and only one repository. After Vital Sign datasets are acquired, they will be validated by the Data Manager. The project leader will then certify completeness. The certified data deliverable will then be installed in one and only one designated repository, fully replacing any earlier version of that deliverable. Adherence to this approach is essential because if multiple copies of data exist, those copies will eventually diverge. Given the long-term horizon for I&M Vital Signs data, the probability of two copies of any dataset remaining identical over time approaches zero. When multiple divergent datasets are known to exist, the accuracy of none can be assured. For this reason, SEAN data management will maintain only one authoritative copy of any product, and only that one copy will be disseminated.

Finally, the SEAN recognizes that the field of archiving is actively developing and faces extraordinary challenges regarding digital objects. Standard archiving processes described in the national DMP will be followed.

6.2 Infrastructure and Systems Architecture

Application software standards required by DOI and NPS will be observed; data product specifications in protocols will never call for software that violates agency standards. The SEAN will further limit the formats of acceptable products in order to keep the number of formats manageable. Internet access is required to cooperate with the SEAN. Park offices have good network connectivity; we will rely on park, regional, and I&M technical staff to assure its continuation.

Data storage will be provided by several repositories that maintain their own production facilities. One staging area for initial validation will exist as directories on the SEAN file server. To facilitate automated file backup and for reliability and security reasons, no data deliverables will be stored on SEAN workstations. Draft data objects will be stored, whenever possible, on IT-maintained park file servers. Because field computers are not as robust as park file servers, project leaders should back up field data to servers as often as is practical.

From the basic functional diagram in Figure 6.1, the SEAN has developed a service architecture (Figure 6.2). The dissemination services (red boxes in Figure 6.2) are provided to all customers by internet web servers maintained by WASO and our partners (e.g., the Western Regional Climate Center). Repositories (yellow) are located at WASO I&M, outside agency partners, collection curators, and the SEAN itself. The I&M repositories include the stores for enterprise applications like NPS DataStore and NPStoret. Local collections of physical specimens also serve the repository Core Function. The certification processes (green) restrict repository content to the highest quality products. Sensitive items will be appropriately redacted before leaving the certification block. Led by park staff and cooperators, data acquisition processes (blue) generate all the deliverables, including nontabular items.

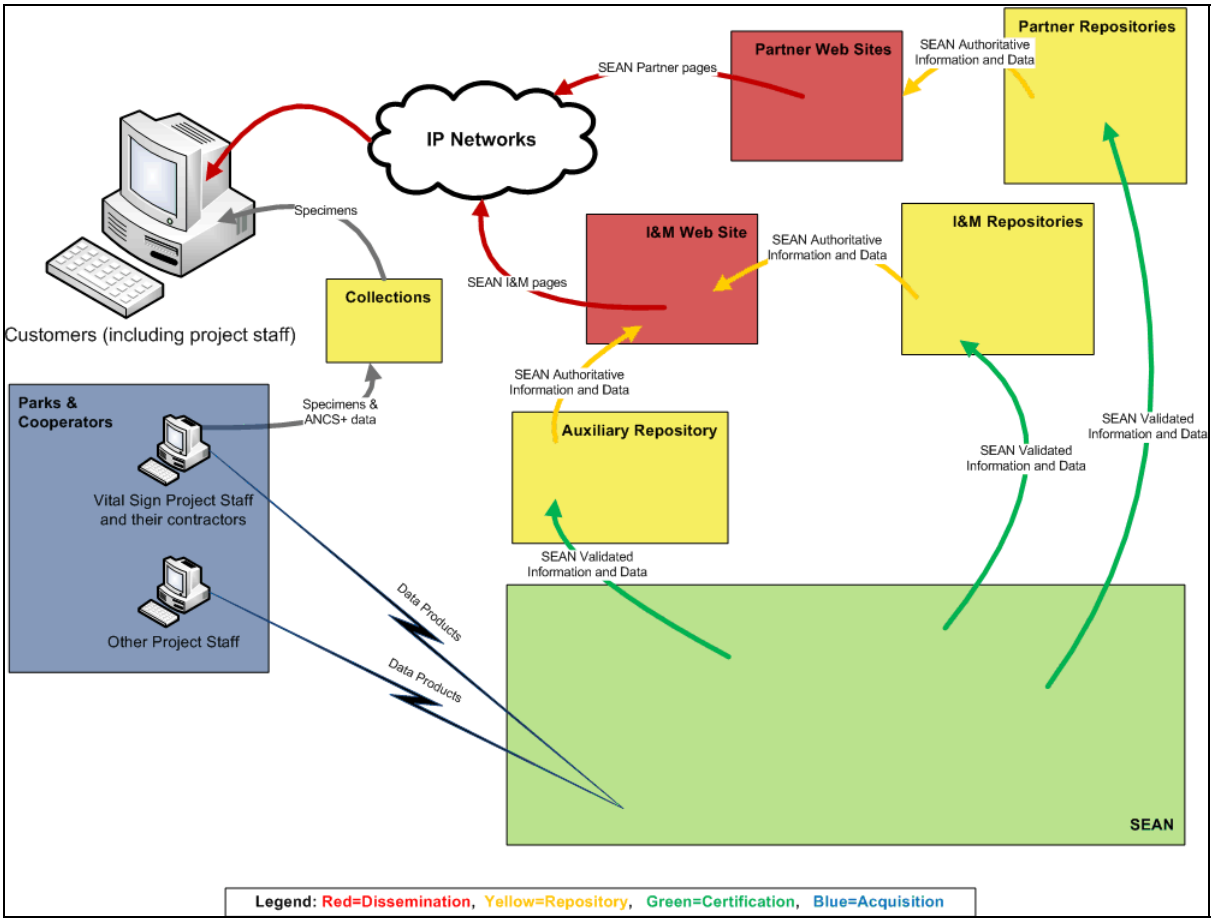

Figure 6.2 The SEAN information architecture.

6.3 Project Management and Data Processing Workflow

The SEAN will follow the four-stage project management model illustrated in Figure 6.3. The model comprises two phases: Development and Operations. Development follows the 1-2-3-4 path, beginning at end-product definition and working back to datapoint observation. Through that effort, the SEAN will specify a variety of items, including: funding; staff; the frozen detailed protocol; contents of the vitals sign's web main page; which, if any, partners will be employed

for dissemination and repository Core Functions; programs to deliver specific content when called by web links; which repositories will be used for each deliverable; the data objects and containers needed in the repository to house products; processes for loading certified data into repositories; how the validity of data is measured; the programs that enforce validity; which specific items are sensitive; processes that enforce privacy of sensitive data; which, if any, cooperators will be used for segments of data acquisition; which, if any, dataloggers or field entry computers will be employed; data collection form layouts; programs to enter, edit, and query collected data; interfaces to external data sources. The Operations Phase, following the 4-3-2-1 functional order, is illustrated in Figure 6.4.

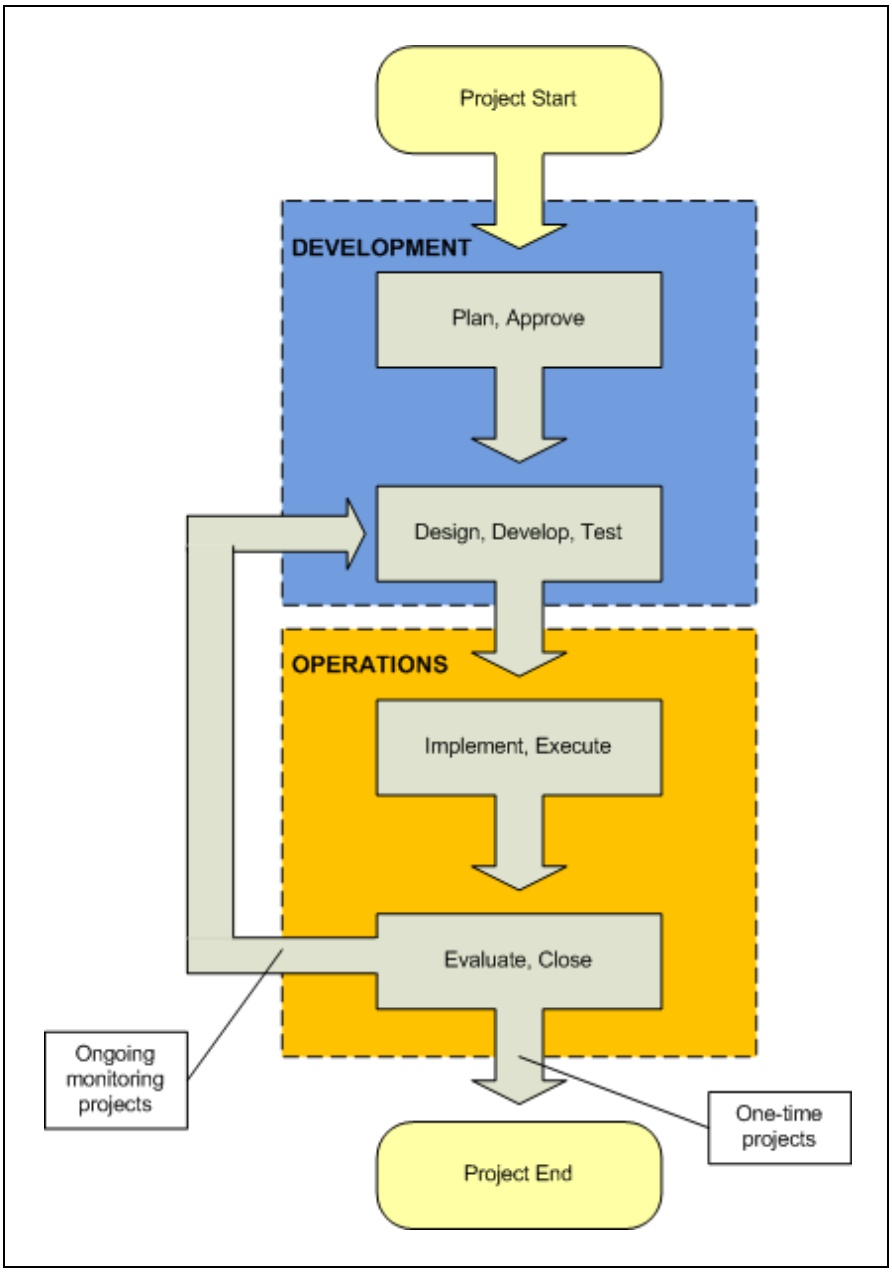

Figure 6.3 SEAN project stages.

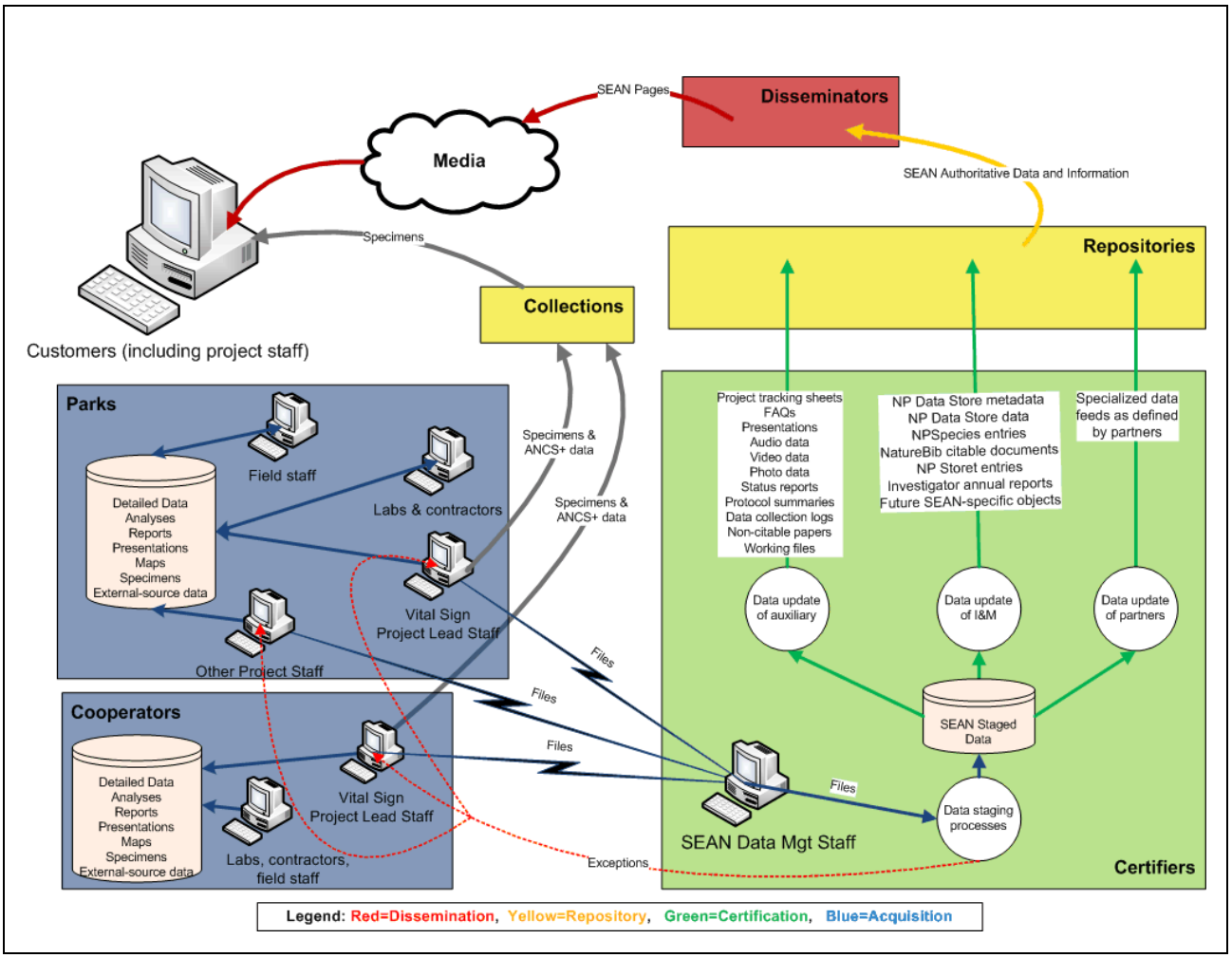

Figure 6.4 SEAN data management operations.

Data acquisition includes gathering raw data, external data, specimens, media, and GIS objects. From these items, project leaders (working on park file servers) create tables, analyses, reports, and presentations. Complete deliverables will be transmitted to SEAN data management for validation. Once at the SEAN, data will be staged on a file server and analyzed for complete conformance to detailed specifications and constraints, as detailed in the Vital Signs protocol. Imperfect submissions will be returned to project leaders for correction. Valid submissions will then be redacted to restrict sensitive items and will be installed in the appropriate repository. The three repository types (described in Figure 6.4, with the exception of Collections) is designed for particular content (Table 6.1).

Table 6.1 Repository content.

Auxiliary (SEAN) Repository	I&M Repository	Partner Repository
• Project tracking sheets • Protocol summaries • Project abstracts • Status reports • Data collection logs • FAQs • Presentations • Audio data • Video data • Photo data • Noncitable papers • Working files	• NPS Data Store metadata • NPS Data Store data • NPSpecies entries • NatureBib citable documents • NPS Storet entries • Investigator annual reports • Future SEAN-specific objects	• Specialized data feeds as defined by partners

6.4 Data Management Roles and Responsibilities

Operations of the four Core Functions are completed by parties with overlapping responsibilities (Figure 6.5). While not explicitly defined in the four operating functions, two additional responsibility classes are required to build and run the network: program management and system development. These two critical responsibilities are directed by the Network Coordinator and Data Manager, respectively.

Information management is a joint responsibility among network participants. Table 6.2 identifies specific positions needed to accomplish the four program Core Functions[3]. Program management will be a constant need. Development is necessarily front-loaded. Initially, more resources will be required for development and fewer for operations, but development needs will drop substantially once the initial Vital Sign programs have been established.

6.5 Databases

The SEAN defines databases very broadly as containers holding deliverable data products. Repositories house databases, and databases store objects that include tabular data, photos, and reports.

Four repository types are used by the SEAN. First, "partner" stores support specialized information for which dissemination is already well developed by a third party. NOAA's Western Regional Climate Center, for example, is a partner repository that will be used for tabular weather and climate data. Second, "I&M" repositories house data products maintained by enterprise applications like NPSpecies, NPS Data Store and NatureBib. Third, an "auxiliary" repository will be maintained by the SEAN to hold products that the other repositories are not designed to accept, such as project tracking reports and audio files. Fourth, "collection" repositories curate project-generated specimens. Though physically dispersed, all repositories

[3]See the full SEAN Data Management Plan (available at the SEAN website) for full details on operations, including descriptions of key roles and responsibilities for each position.

share the capability of being centrally accessed using web links organized in the SEAN's Internet pages.

As the I&M "Integration of Resource Management Applications" (IRMA) initiative develops, more types of data products may be accepted by the I&M repository. The SEAN expects that, eventually, many auxiliary repository elements may be seamlessly migrated to I&M.

Database creation follows the 1-2-3-4 functional workflow:

- Define end products
- Locate dissemination points
- Identify repositories that support the deliverables
- Model data and relations required to build those deliverables
- Create repository containers to hold the required data (if they don't already exist)
- Outline methods for validating, securing, and submitting data to repositories
- Build data acquisition tools to support both the raw data and the information generated by the project

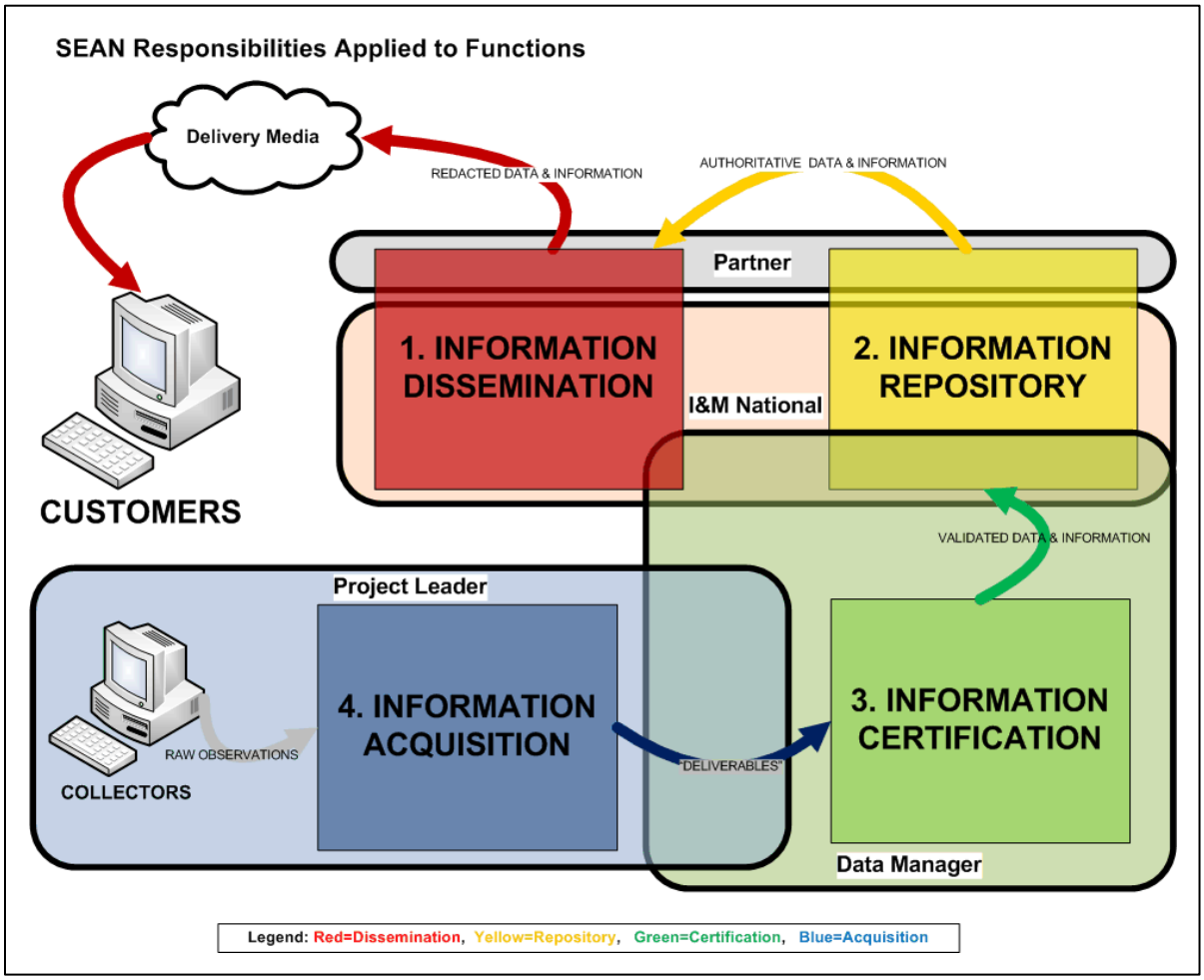

Figure 6.5 SEAN roles and responsibilities mapped to the four program Core Functions.

Table 6.2 SEAN monitoring program positions mapped to the four program Core Functions, plus overall program management and system development.

Staff or Position	**Program Management**	**Information Dissemination**	**Information Repository**	**Information Certification**	**Information Acquisition**	**System Development**
Network Coordinator	●				●	●
Technical Committee	●				●	
National I&M Data Manager	●					
Network Data Manager		●	●	●		●
I&M IT Staff and Management		●	●			●
Partner Staff	●	●	●			
Park Superintendent				●		
Project Leader				●	●	●
Park and AKRO IT Technical Staff					●	●
Curator			●			
Subject Matter Experts				●		●
Park and Regional GIS Specialists					●	●
Subcontractors, labs, etc.					●	●
Park Staff					●	
Cooperators					●	
Web Developers						●
Database Developers						●

Duplicated effort may be avoided by deliberately defining final network products that fit existing I&M repository enterprise application databases. For example, formal reports can be specified in a manner that assures they are citable and may therefore be loaded into NatureBib. Similarly, Microsoft Access database tables used for data acquisition may be laid out so they are assured of fitting within NPS Data Store.

For some Vital Signs, the repository Core Function will be provided by partners. Because the network is ultimately responsible for the Vital Signs data, it will permanently maintain safekeeping copies of submissions made to partners. In adherence with the "authoritative source" policy, these copies will not be available for dissemination; they are solely for internal business continuity processes.

Nontabular data will typically be stored as files in the auxiliary repository, within directory structures defined by the SEAN. However, customers will not have direct access to the directories; they will access files via guided web pages. The I&M NPS Data Store repository

will be used for all SEAN metadata, regardless of where the authoritative source data are actually housed.

Repository of physical specimens will be managed by the park curator or, in certain cases, an outside collection curator. The project leader will be responsible for delivering properly prepared specimens to the curator with proper identification and Automated National Catalog System (ANCS+) data in a form acceptable to the curator.

The certification process validates all Vital Sign data. Custom programs will analyze all tables in the databases to validate them against the mandatory criteria defined in the protocol. Database validation programs also report to the project leader optional criteria exceptions and outlier analyses. Nontabular data (e.g., reports or audio files) are difficult to validate. In those cases, validation will include confirming that the file can be correctly opened by current versions of associated software. For all file types, validation will be withheld until the deliverables are compared against specifications in the protocols, and until the metadata are seen to be complete. Once the data are stamped as valid, the project leader will certify the data and attest that they may be disseminated. The deliverables will then be installed in their appropriate repository.

Data acquisition processes store all project data locally in a standard folder structure defined in the protocol, greatly facilitating review by all involved in the project. Tabular data are collected in local databases that are compliant with the NPS Natural Resource Database Template (NRDT) and designed specifically to support the products of the project.

6.6 Data Acquisition, Processing, and Reporting

In this section, Data Acquisition refers to Core Function 4 depicted in Figure 6.1. We use the term “data acquisition” to mean the collection and organization of field data and the creation of deliverable data products from them. “Processing” refers to the Core Function 3 tasks that formalize, validate, redact, and certify the proposed products. “Reporting” relates to the Core Function 2 installation of certified products into repositories. The “Dissemination” Core Function is summarized in section 6.10.

It is important to note that each of these staged Core Functions have two phases: Development and Operations. It is essential that time-series data are consistently collected and managed over time. Because changing the collection rules invites error at a fundamental level, development should be completed, and the data rigorously defined, before any operations begin. As an example, consider that auto manufacturers finish building pickup trucks before selling them; they do not need technicians bolting on overlooked parts as the trucks speed down freeways. This concept holds true with building a comprehensive data management system: if the original development is done well, operations may continue full speed for many years with only an occasional reopening of development.

Certain tasks are inherent to robust data collection, processing, and reporting. Table 6.3 presents those tasks that must be undertaken during the Development phase, and Table 6.4 lists those that occur during Operations.

Table 6.3 Development tasks associated with capturing data, listed in order of execution.

Function	Tasks
Prerequisites	• Specify the desired final deliverable data products • Draft data model that supports creating deliverables • Identify NPS application interfaces • Identify partner repository interfaces • Identify outside raw data sources • Identify needed GIS functionality • Develop detailed database design diagrams • Identify business rule constraints • Define validation criteria for all data, including nontabular objects • Specify the formats and versions of deliverables • Draft project deliverable tracking spreadsheet • Freeze the data products in the protocols
Reporting to Repositories	• Verify appropriate backup, restore, security, and accessibility are available • Create auxiliary repository containers • Create and test extract-transform-load processes used to accurately install project data in particular repositories
Validation/Certification Processing	• SEAN Board of Directors, Executive Committee, and Technical Committee identify which elements of the proposed datasets are sensitive • Create and test validation processes • Create and test processes that limit sensitive data access to NPS staff • Data Manager and project leader clarify reporting requirements and schedules
Data Acquisition	• Create/test NRDT-compliant database tables and objects • Build any required GIS components and interfaces • Import any required external data • Design/print any sampling forms • Obtain any dataloggers, tablets, and handhelds • Create/test entry/edit programs using “front-end builder” platform • Build reports for predefined analyses • Distribute software to field computers • Review field computer backup procedures • Initiate a “project log” for recording collection events and exceptions

Table 6.4 Operational tasks associated with capturing data, in order of execution.

Function	Tasks
Data Acquisition	• Project leader originates certain metadata • Oversee entry/verification of raw data • Backup as necessary to prevent catastrophic loss • Update the project log • Submit raw data products for validation • Revise products until validation is passed • Certify products for installation in repositories • Build any deliverables requiring valid detailed data • Submit deliverables for validation, correction, and certification • Send specimens to curators • Archive any original collection forms • Update deliverable tracking system
Validation/Certification Processing	• Accept submissions and attempt to validate them • Report errors and outlier analyses to project leader for resolution • Originate certain metadata • Accept project leader certifications • Review metadata for completeness • Update deliverable tracking system
Reporting to Repositories	• Apply security tags to sensitive data products • Once certified, transmit products to repositories of partners, national I&M program, SEAN • Verify repository has correctly and completely accepted data • Update deliverable tracking system

6.7 Quality Assurance and Quality Control

Quality assurance comprises steps that encourage accurate and complete data acquisition, including frozen monitoring protocols, thorough staff training, and carefully designed data entry processes. Data verification will be observed in accord with the data management plan.

Quality control is accomplished by formally validating every data product submitted. All validation criteria are enumerated in detail in advance in the protocol, both for tabular and non-tabular deliverables. A standard unit of data submission, such as oceanographic data stream by calendar year, must be observed for each project.

Once data are validated, the project leader states the submission is certified and the Data Manager sends it to the repository. No repository updates will be attempted until an entire submission unit has passed all mandatory validation and been certified. Where applications permit, each repository update will be stamped with its data, user ID, and protocol version.

6.8 Dataset Documentation

Metadata documentation is essential to ensure data usefulness over time. Metadata for all data capable of being documented using the 8-level Federal Geographic Data Committee (FGDC)/NPS metadata standard will be stored in NPS Data Store. Metadata will also be documented for external data obtained from non-NPS sources that are used in support of analyses.

Some nontabular data lack recognized detailed metadata standards. For example, photographs may exhibit a wide variety of attributes, but no single definition of what should be recorded as metadata is available from a single authoritative body. Where practical, files that accept attributes will have them embedded in the files. JPEG photos and MP3 audio are examples of file types that can carry their metadata inside them. The exact content included, in the absence of recognized standards, will be defined by the Data Manager in SOPs.

The network's Internet website will be intended to provide access to considerable documentation for each Vital Sign, including tracked deliverables, exception logs, and abstracts. One goal of the dissemination Core Function is to provide sufficient documentation tied to the delivered data so it can effectively "stand on its own." The SEAN Vital Sign monitoring protocols – which will also be web-accessible – will thoroughly document data as well.

6.9 Data Ownership and Sharing

NPS will retain ownership of network data, both certified products and all levels of draft data. Furthermore, data ownership will include data directly originated by NPS and data collected by cooperators. The SEAN will work to structure cooperative agreements so that data ownership is explicit and clear. Network data that employ a partner for repository and dissemination services will remain property of NPS. A partner that requires transfer of data ownership to them is not acceptable and will not be employed.

NPS data are in the public domain. Sensitive data, however, will be restricted according to law and policy. The park superintendents and network staff will collaborate on assigning sensitive designations to specific items on a deliverable-by-deliverable basis. Before submission to a repository, the Data Manager will mark every row or file that is sensitive. Applications that access repositories will not display sensitive items unless proper authorization credentials have been established. The SEAN will not submit sensitive data to partner repositories whose access is not entirely under control of NPS.

Draft work copies of data in various stages of completeness are the responsibility of the Project Leader. These may includes tabular data as well as reports, analyses, presentations, and other nontabular data. When properly validated, a deliverable becomes the responsibility of the network Data Manager. The Data Manager will distribute products to repositories as soon as they are certified. However, if a Project Leader fails to certify validated data in a timely fashion, the Data Manager may submit data to repositories unilaterally when it is in the best interest of the NPS.

The Project Leader stewards all data products up to the point they meet all mandatory validation criteria. The network Data Manager stewards validated data. Freedom of Information Act (FOIA) requests for validated data will be serviced by the network Data Manager. FOIA requests for draft and incomplete data will be serviced by the responsible Project Leader.

6.10 Data Dissemination

Dissemination, being the first Core Function considered in the SEAN's design, drives all else in the network. All deliverables are to be digital and available through Internet web browsing.

For data to be valuable, they must be accompanied by adequate documentation to clearly explain how to use and interpret them. Each Vital Sign or project will have its own main page that offers the deliverables specified in the protocol, including (among others) progress reports, deliverable tracking, permit details, and contact information.

The SEAN has acquired and installed a network search appliance that indexes and delivers selected background documents, correspondence, and ancillary files. Customers may use the search appliance to browse the program's full offerings. Vital sign web pages will be made available by links on the primary SEAN Internet homepage. Figure 6.6 illustrates a draft of a Vital Sign main page.

Only the single authoritative copy of validated and certified data will be disseminated from designated repositories. To ensure that data meet the measureable standards defined in the protocol, repositories will never be loaded with project data until a candidate items passes all validations. Repositories will be populated in blocks of defined submission units, so partial update problems will not arise. Formal user authentication processes will be used to protect sensitive data.

6.11 Records Management, Data Maintenance, and Archiving

All SEAN repositories will have the capability to archive digital items. All SEAN deliverables must be provided as computer files of an acceptable protocol-specified format. For example, physical photographic prints may be scanned and submitted as JPEGs; posters submitted as original PPTs or PDFs; analog video as AVI. While this is a change from older practices, it is not burdensome for new material: most deliverables are now "born digital."

The SEAN will assist project leaders in finding park or other agency archives capable of cataloging and storing any physical items requiring permanent archiving. Physical collections are essential for items like biological or mineral specimens. Their usefulness is realized through physical examination. But items should be stored digitally whenever possible, because it makes them vastly more available.

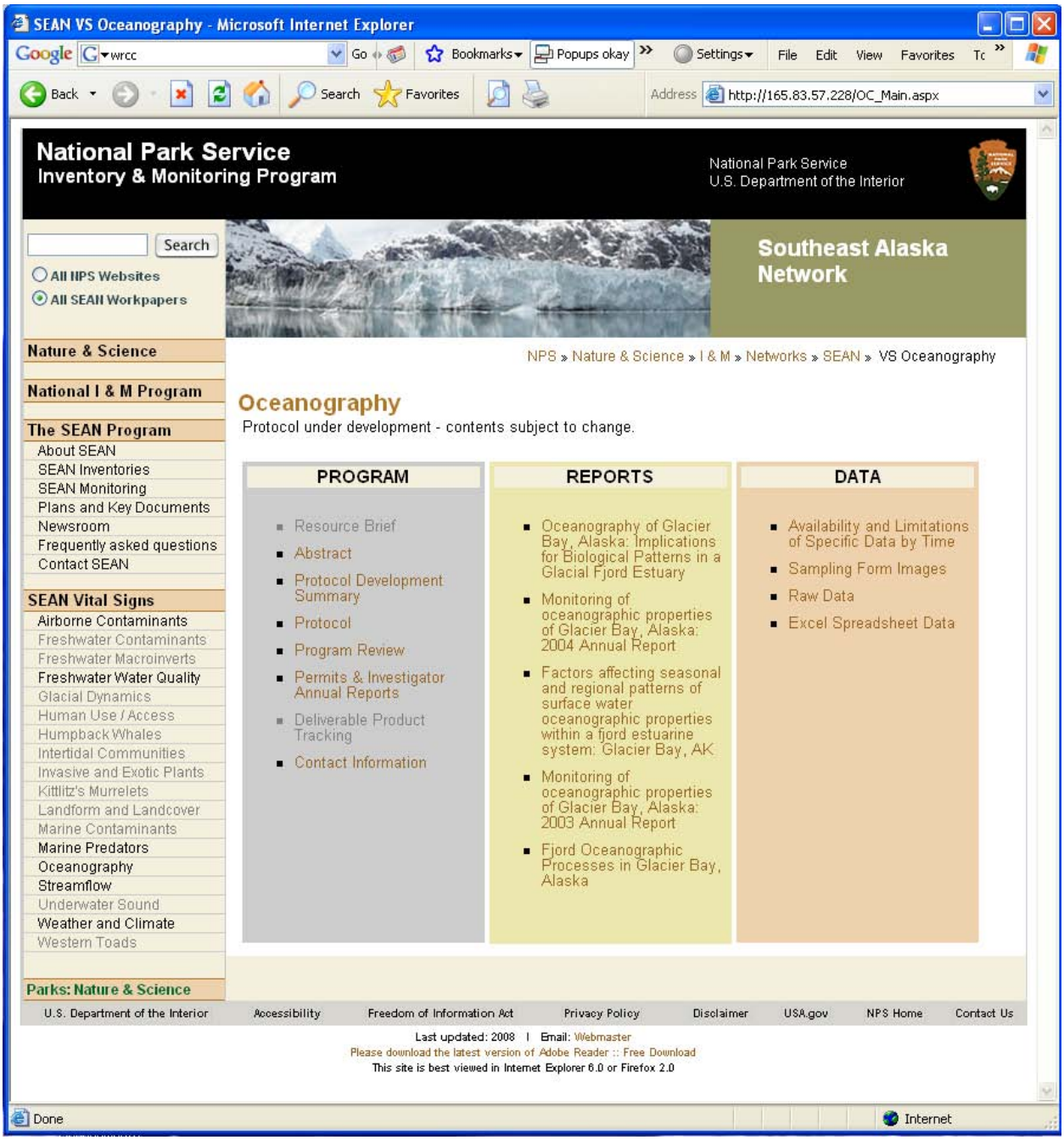

Figure 6.6 Conceptual draft of a SEAN Vital Sign web page, to be nested below the primary, standard Network webpage. The completed and functional webpage will conform to all NPS webpage standards.

I&M enterprise application repositories are particularly attractive because their data are professionally and reliably archived. Partner repository archiving practices, on the other hand, may be unknown. Therefore, a copy of each partner submission will be kept at the SEAN for NPS archiving, to prevent loss due to partner error.

SEAN-held products will be backed up using best practices detailed in the DMP. Because digital media have finite physical and logical life spans, we will implement processes that periodically renew "permanent" media when needed. To guard against version obsolescence of digital data, resources must be periodically expended to upgrade repository files to current formats.

6.12 Project Tracking and Documentation

The SEAN DMP outlines a method for using spreadsheets to track progress in building the specified products. Each project will have a tracking sheet with a separate tab for each submission unit – typically each collection year. A matrix of deliverables and milestones will be filled with task completion dates. The deliverable tracking will be updated only by SEAN staff. It will always be available for public viewing as a link on the corresponding project web page. This type of tracking will cover operations only; development is tracked internally. In the future a database approach may enhance project tracking.

6.13 Implementation

The data management plan proposes a phased implementation that provides essential functionality first. Subsequent enhancements will add in other phases, without impacting existing service. The first phase will include development of substantial new processes and will be the most time-consuming. After development processes are well underway, operations will begin overlapping with development. Eventually, operations will require far greater resources than development. The data management support infrastructure that is designed and built for the first-to-be-implemented Vital Signs will be substantially reused for later Vital Signs, thereby gaining efficiency and ensuring compatibility over time.

6.14 Water Quality Data

Several water quality Vital Signs will be among the first that SEAN will undertake. Monitoring protocols will be established in the Development Phase, and then the web page content will be drafted. The monitoring protocols for these Vital Signs will identify an EPA-compatible Storet repository to which these data will be submitted. The protocol will identify business rule constraints for the partner repository, including Storet formatting rules. We will define a validation process, develop and install an acquisition database (likely the MS Access tool already in wide use for this purpose), and develop a tracking sheet that lists deliverables and milestones.

In the Operations Phase, data will be collected and entered into the MS Access database. When the project leader judges the dataset to be complete, it will be submitted as a whole for validation. Errors will be reported to the project leader by the Data Manager. The project leader will correct the errors in the MS Access database and resubmit. When the data pass validation, the project leader will issue certification to the Data Manager. Metadata will be submitted to

NPS Data Store by the Data Manager, who will then submit the properly-formatted data to the NPS Water Resources Division (WRD). WRD will, in turn, ensure delivery of the data to the EPA partner repository for storage and dissemination. The Data Manager will provide ongoing project tracking in the publicly-viewable sheet created for that purpose.

Chapter 7: Data Analysis and Reporting

In this chapter, we describe how data collected as part of the SEAN monitoring program will be analyzed and how information will be disseminated. We anticipate that our primary audience will be park managers interested in reporting on the condition of park resources and meeting park goals and legal mandates. Still, we have structured our data management approach (Chapter 6) and our analysis and reporting strategy to serve both that audience and also a wide variety of non-park audiences.

7.1 Data Analysis

For the purposes of this program, we define data analysis as the process by which observations of natural resources are converted into meaningful information (MacCluskie et al. 2005). This is a broad definition of data analysis that includes a range of activities that occur post-collection, such as applying and interpreting statistical tests and models, interpreting remotely sensed imagery, and comparing historical and contemporary photos. We also include in this definition of data analysis the processes of data exploration, quality control, and mining existing data for relevant information.

Efficient and effective data analysis results from careful planning. That planning – including details on proposed data analyses – will be embodied by finalized monitoring protocols. All protocols will be focused on the fundamental goal of analysis of monitoring data: to detect change over time. In this way, SEAN data analysis is primarily concerned with temporal variation in observations.

Generally, we anticipate three primary steps of data analysis for which the SEAN will be responsible: data management, data summarization, and in-depth analysis. Additional steps or further in-depth analyses by others outside the network will be encouraged to the fullest extent possible; indeed, the SEAN approach to data management (summarized in Chapter 6) is designed to facilitate the access and use of SEAN data by any interested party.

A comprehensive and efficient approach to data management serves as the first step and underpinnings for all SEAN products. As such, the SEAN Data Manager will be actively engaged in all Vital Sign monitoring, from protocol development through analysis and reporting. Chapter 6 describes the four nodes of data management as acquisition, certification, repository, and dissemination. Field operations flow in this order, but the development of the data management program proceeds in the opposite order. In this way, the SEAN positions itself to ensure that data acquired, analyses conducted, and reports delivered are all directly in-line with the goals, objectives, needs, and expectations identified by technical specialists and managers at the start of the development process.

The second step is timely data summarization, which includes preparation of descriptive statistics (e.g., mean, measures of variance), plots, charts, and graphs that provide information on the status of a Vital Sign. The SEAN will prepare these items with a specified frequency (Table 7.1), and use them to identify problems with sample design or data collection. Data summaries may provide the first indication of change in status of a Vital Sign. Full, completed protocols for

Table 7.1 Summary of analyses and responsibilities for SEAN Core Program Vital Signs.

SEAN Vital Sign and Protocol	Analysis	Lead
Airborne Contaminants	Report following each decadal revisit to field sites; integrative report with Marine Contaminants and Freshwater Contaminants every 10 years.	Project PI
Freshwater Contaminants	Summarize contaminant data as available; trend analysis every 5 years; integrative report with Air Contaminants and Marine Contaminants every 10 years.	Cooperator - PI
Freshwater Water Quality	Summarize core parameter data as available; trend analysis every 5 years	Cooperator - PI
Streamflow	Annual summary of streamflow values, max/min, dates.	Park Lead
Glacial Dynamics (extent)	10-year report on observed changes in extent.	Cooperator - PI
Intertidal Communities	Post-observation summary statistics of diversity indices and species richness; 5-10 year return on trend analyses	Park Lead
Kittlitz's Murrelets	Annual summary of population estimates, raw counts, density maps	Park Lead
Landform and Landcover	10-year report on cover class representation	Cooperator - PI
Marine Predators	Annual summary of population estimates, raw counts, density maps by species.	SEAN Coordinator with Cooperator for detailed analyses
Marine Contaminants	Bi-annual summary of assay results; integrative report with Air Contaminants and Freshwater Contaminants every 10 years.	Park Lead with Cooperator - PI
Oceanography	Annual summary of quarterly oceanographic data, trend analysis every 5 years	Park Lead with Cooperator - PI
Weather and Climate	Annual summary of descriptive stats, trend analysis every 5 years	Park Lead

each Vital Sign will include Standard Operating Procedures for each Vital Sign. Adherence to these SOPs and summarization schedule will aid the SEAN in its reporting on Vital Signs.

The third step includes trend analysis and other sophisticated analyses that aim to detail the magnitude and direction of Vital Sign change and factors contributing to change. The analysis and synthesis reports will interpret the findings, incorporate appropriate literature, and seek other data sets/reports from SEAN monitoring or elsewhere to help in interpreting and understanding observed trends. With a staff of two, the SEAN must take care to not over-commit on the role it will play in conducting detailed data analysis in-house. The SEAN balances its staff and budget limitations with the approaches outlined in Chapter 8 (Staffing) and Chapter 10 (Budget); the salient point is that the SEAN will rely heavily on partnerships and cooperative agreements to deliver detailed analyses and interpretation. Contributions from external collaborators will be balanced and strengthened by direct input from the many subject-matter experts at GLBA, KLGO, and SITK who will serve as Park Leads or Principle Investigators. Data analysis responsibilities will fall primarily upon the Park Lead, particularly for those Vital Signs for which the SEAN will primarily provide programmatic support (as opposed to comprehensive support, see also Table 4.1). This integrated approach is reflected in our staffing plan (described in Chapter 8).

7.2 Reporting

Reporting is the primary means by which the SEAN will deliver information – derived from analyzed data – to decision-makers and other customers. The primary audience for the results of Vital Signs monitoring is park management: superintendents, park resource chiefs, and other managers who require natural resource data to make and defend management decisions. However, other key audiences for monitoring results include park planners, interpreters, researchers and other scientific collaborators, the general public, Congress, and the Office of Management and Budget. To be most effective, monitoring data must be analyzed, interpreted, and provided at regular intervals to each of these audiences in a format they can use, which means that the same information needs to be packaged and distributed in several different formats.

The list of reports to be produced by the SEAN follows national guidelines and meets network reporting goals (Table 7.2). The content and amount of detail included in the various products of the monitoring program will differ depending on the intended audience for each report. At the network level, park managers and natural resource staff and collaborators need to have available the detailed, complex scientific data relevant to the park's issues and resources. At the national level, however, a different scale of analysis and reporting is needed to be most effective.

Although the form of reporting to different audiences will vary, the SEAN will strive for two characteristics in all reports and communications: timeliness and accessibility. Park managers cannot always anticipate their information needs, and often the timescale for providing critical information is short. Management action to protect natural resources is most effective if implemented early. Similarly, park visitors would prefer to know about changes in status of natural resources as soon as possible.

As described in Chapter 6, dissemination of both data and reports will be primarily web-based. Reporting will not be exclusively through the web; other modes of reporting SEAN progress and findings may include:

- Informal verbal communication with superintendents and NPS staff
- Informal verbal communication with staff from other natural resource agencies
- Staff meetings
- Public presentations (talks and posters)
- Newsletters
- Reports (annual reports, project-specific reports, analysis and synthesis reports, State of the Park reports, etc.)
- Journal articles

Written project reports will generally take two forms. Informational reports (including annual data summaries) will be short, frequent, easily-digestible reports that provide updates on operations, observations, and apparent trends. The SEAN will emphasize these reports in the first years of implementation, with the objective of keeping park staff, cooperators, and partners informed of, interested in, and committed to the SEAN's implementation. Documentary reports will contain greater detail on methods, results, and interpretation, and will also evaluate the efficiency and effectiveness of Vital Sign specific monitoring. These less frequent reports will serve a more technical purpose; they will formally document data analyses, will make program details available for scrutiny and peer review, and will serve as the formal historical record of Vital Signs monitoring. For any report format, we anticipate that reporting procedures will evolve with the monitoring program and adapt to changing communication technology.

A fundamental report will be the Resource Briefs – one- to three-page summaries for each Vital Sign on the monitoring approach and key findings. Intended for wide distribution as the first source for an overview on the approach and status of a given Vital Sign, these Resource Briefs will be least common denominator among Vital Signs. They will be updated annually and served over the SEAN web page. The Annual Administrative Report and Workplan provides a means to track the accountability of the program. Results that may aid in the day-to-day management decisions of the parks and that maintain interest in the monitoring program will be presented in annual technical reports. Concise information that may be of interest to a larger audience will be presented in a newsletter and on the SEAN website. Findings from the program will also be presented verbally at public talks, professional meetings, and through public media. The network will also conduct periodic program and protocol reviews.

Together, all SEAN analyses and reports will be useful to the Network parks in understanding and reporting on condition of park resources. Additional, integrative reports will be specified as protocol development progresses; once monitoring protocols are finalized and frozen, the Network Coordinator will identify natural opportunities for integrative reporting. Several particularly likely integrative reports include:

1. SEAN-wide contaminants assessment, based on data collected under the Airborne, Marine, and Freshwater Contaminants Vital Signs,
2. SEAN-wide freshwater ecosystem assessment, based on data collected under the four freshwater Vital Signs: Physicochemical Water Quality, Contaminants, Streamflow, and Macroinvertebrates and Algae,

3. SEAN-wide landform dynamics, based on data from Landform and Landcover, Glacial Dynamics, and Weather and Climate, and
4. GLBA-based, targeted biological assessment of data collected under Oceanography, Weather and Climate, Marine Predators, Humpback Whales, Kittlitz's Murrelets.

Table 7.2 Reports to be produced by the Southeast Alaska Vital Signs Monitoring Program

Type of Report	Purpose	Target Audience	Frequency	Peer Review Process
Resource Briefs	Succinctly summarize and distribute key findings and monitoring updates for each Vital Sign	Network staff, Park management and staff; Servicewide program managers, external scientists, general public	Updated Annually	Network Level; Coordinator and Technical Committee
Annual Administrative Report and Workplan	Account for expenditures and work accomplishments during the preceding fiscal year; outline planned work and expenditures for the coming fiscal year	Network staff, Technical Committee, Board of Directors, Regional Coordinator, Servicewide program managers; used for annual report to Congress	Annual	Regional office; Servicewide program manager
Annual report for each protocol	Inform Technical Committee and park staff of findings; document and archive data from previous year; early identification of apparent trends or need for adjustments	Park resource managers, network staff	Annual	Network level
Analysis and synthesis reports - trends	Identify trends of concern; evaluate program direction; actively disseminate information to park managers	Superintendents, park resource managers, external scientists	3-10 years	Technical Committee; external peer review
Program and protocol review reports	Formal review of operations and results; review administration of the network	Superintendents, park resource managers, monitoring program managers, external scientists	5 years	Regional or national
Integrative Reports	Detailed, coordinated analyses that simultaneously consider data generated by multiple Vital Signs.	Superintendents, park resource managers, external scientists	10 years	Technical Committee; external peer review
Scientific posters and peer-reviewed literature	Peer review of program and projects; feedback on study design, results, and interpretation; collaboration	Park resource managers, network staff; external scientists	Varies	Professional peers/editors
Professional symposia, conferences, and workshops	Peer review of program and projects; feedback on study design, results, and interpretation; collaboration	Park resource managers, network staff; external scientists	Varies	Professional peers/editors
SEAN contributions to State of the Parks Report	Report condition of park resources at a national level; highlight activities and interesting findings	Congress, budget office, monitoring program managers, public	Annual	National level

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Chapter 8: Administration/Implementation of the Monitoring Program

In this chapter we describe the Network's organizational structure, the decision-making process of the network, the staffing plan, integration of network monitoring operations with other park operations, anticipated state and federal partnerships, and the periodic review process for the program.

8.1 SEAN Organizational Structure

Membership and operation of the SEAN Board of Directors (BOD) is guided by a charter (Appendix E). The BOD for the SEAN includes the superintendent of each park, the Alaska Region I&M coordinator, and the network coordinator (Table 8.1). One of the superintendents serves as the chair for the BOD, and this position rotates among the superintendents every two to three years. The three superintendents and regional I&M coordinator are the voting members of the BOD, and the other members serve as advisors to the voting members.

Table 8.1 Composition of the SEAN Board of Directors, 2008.

Title	Current Member	Voting	Advisor
Superintendent, GLBA	Cherry Payne	X	
Superintendent, KLGO	Susan Boudreau	X	
Superintendent, SITK	Mary Miller	X	
Regional I&M Coordinator	Sara Wesser	X	
Network Coordinator	Brendan Moynahan		X

The BOD ensures that the monitoring program is built upon a collaborative vision for the network and considers the mandates, needs, interests, and goals of all park units. The BOD works to maintain the integrity of Vital Signs Monitoring and Water Resources funds and staff and assures that monitoring resources are not diverted or reassigned to other programs. Additionally, the BOD ensures that park staff selected to participate in the SEAN are fully committed to Vital Signs monitoring and establishes personnel appraisal systems that reward network cooperation. Finally, the BOD responds to information gained through long-term monitoring and acts on recommendations from the Technical Committee (TC) to institute new management actions or modify existing management actions where necessary to protect or restore park ecosystems. An important feature of the charter governing decision-making by the SEAN BOD is that all decisions are made by consensus.

The SEAN Technical Committee (TC, Table 8.3) consists of the Network Coordinator (chair), lead ecologist or biologist from each of the SEAN parks, the Coastal Cluster Ecologist (for GLBA, SITK, KLGO, and WRST), and the Regional I&M Coordinator. Though not formally identified as a regular member of the TC, the SEAN Data Manager is requested by the Network Coordinator to attend TC meetings and serve as an active advisor on topics related to data collection, data management, and information delivery.

The TC is a working group that provides technical oversight and advice for decision-making. Key roles are to provide guidance and support needed to sustain on-the-ground monitoring efforts and to assist the Network Coordinator in the preparation of the Annual Administrative Report and Work Plan. The TC may make frequent use of work groups to evaluate options and provide alternatives and may often rely on work group reports as a basis for action. All work groups will be chaired by a member of the TC, and work group members will be approved by the TC.

Table 8.2 Composition of the SEAN Technical Committee, 2008.

Title Current	**Member**	**Unit**
SEAN Coordinator, Chair	Brendan Moynahan	SEAN
SEAN Data Manager	Bill Johnson	SEAN
Ecologist	Lewis Sharman	GLBA
Biologist	Geoffrey Smith	SITK
Biologist	Dave Schirokauer	KLGO
Ecologist, Coastal Cluster Program	Scott Gende	GLBA, SITK, KLGO, WRST
Regional I&M Coordinator	Sara Wesser	AKRO

The Network Coordinator will work closely with the Chiefs of Resources at GLBA, KLGO, and SITK to facilitate implementation of the monitoring program at the park level. The Chiefs assist with resolving operational, implementation, and planning issues that are beyond the authority of the TC but are not substantial enough to be elevated to the BOD. The Chiefs can commit and direct park staff and funds toward execution of the monitoring plan.

The Board of Directors, Technical Committee, Chiefs of Resources, and Network Coordinator work in concert to accomplish the goals and objectives of the monitoring program (Figure 8.1). The Board of Directors is the final decision-making body and is accountable for the operation and productivity of the network. The Technical Committee works with the Network Coordinator to formulate recommendations for all aspects of the program. The Network Coordinator then presents these recommendations to the Board of Directors for review, input, and approval. The Network Coordinator works with the Chiefs of Resources to identify and resolve operational issues related to implementation of approved projects and tasks. The Technical Committee also serves as the means by which park staff (not on the Technical Committee) may raise various issues for discussion or clarification.

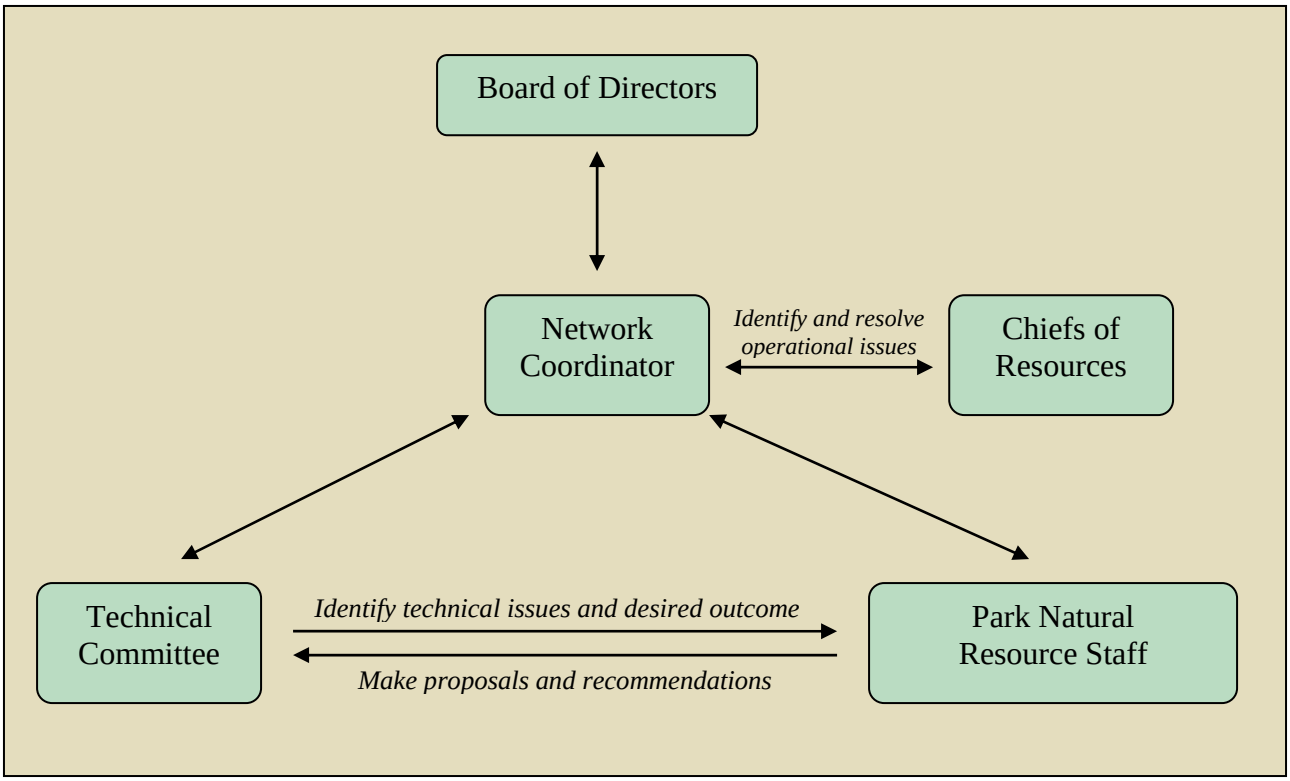

Figure 8.1 Interaction between the Southeast Alaska Network organizational components.

The Network Coordinator position serves several functions. Foremost among these is to ensure the communication of information within and among the many people and groups involved in the program, including the BOD, TC, Chiefs of Resources, regional and national program staff, staff of the network parks, partners, and cooperators in the program. This communication is accomplished in part by regular meetings of the TC (approximately four per year), the Chiefs of Resources (as needed, typically by telephone or during park visits), the BOD (four per year), and regular updates for the Chair of the Board of Directors. The Network Coordinator has a crucial role of being a translator; i.e., a senior scientist who serves as a link between the technical issues related to designing and conducting a monitoring program and the managers and resource management issues that monitoring data are intended to inform. The Network Coordinator is also responsible for managing the network budget and providing annual accountability of the funds. The Coordinator works with the TC to establish objectives for the program and to direct annual and long-range implementation. A final important role of the Network Coordinator is to ensure regular and thorough review of the program and to correct program components that are not meeting rigorous standards.

8.2 Staffing Plan

The SEAN staffing plan is based on a small core network staff (the Network Coordinator and Data Manager), heavy reliance on park staff, and strategic development of cooperative relationships and partnerships to assist with implementing the monitoring plan prescribed by the network. The SEAN core staff is centrally based in Juneau at the Glacier Bay Field Station at Indian Point. Network staff are administratively supported by GLBA. The SEAN Data Manager provides local IT support to the SEAN and two Coastal Cluster Program employees. Using

Juneau as the central base for the SEAN facilitates travel to and from parks for both the SEAN and park staff, and also aids in partnership development with other agencies and groups that are based in Juneau.

Keys to the SEAN staffing plan are that (1) the core network employees assume considerable flexibility in roles and responsibilities, and (2) the park-based staff makes a substantial commitment to active involvement in organizing and conducting field monitoring. This approach is based upon the need to:

- Minimize staff costs and conserve funding needed for field operations;
- Capitalize on efficiency and safety associated with local knowledge of park staff;
- Ensure programmatic integration of monitoring with other park operations such as resource protection and interpretation; and
- Fully utilize the breadth of both network and park staff expertise.

Given the small network staff, a fundamental challenge for the SEAN is to secure the range of technical specialists needed to implement the monitoring program without over-committing the network budget to staff salaries. As noted by other networks (e.g., CAKN, SWAN, and ARCN), the SEAN must strike a balance between hiring staff to conduct the monitoring program and having the operational funds to do the work (i.e., collect the data). Due to limitations imposed by the current budget, the SEAN does not anticipate hiring additional permanent network staff beyond the current Network Coordinator and the Data Manager. It follows that the SEAN will rely not only on park staff, but also on partnerships and contract assistance.

8.2.1 Reliance on and Integration with Park Staff

The "network concept" is based on the principle of park and network staff joining together to plan, coordinate activities, share and leverage resources, and implement operational monitoring. Programmatic integration of monitoring with park operations such as protection, interpretation, maintenance, and stewardship is crucial. Due to inherent staffing limitations, the SEAN faces the challenge of being substantially reliant on park staff without becoming burdensome. Both KLGO and SITK have single-person natural resource staffs (plus their Chiefs of Resources); GLBA has a more sizeable natural resources staff – approximately 13 – which includes seasonal hires and the two members of the Coastal Cluster Program[4]. To work effectively and efficiently with parks, the SEAN will incorporate the following elements into the monitoring program:

- *Lead.* Network Vital Signs monitoring staff must professionally lead the program in order to inspire confidence and build strong internal support and credibility. This is extremely important during initial years of the program and will be achieved by the Network Coordinator (i) developing and communicating the vision of the network and the value of long-term monitoring to all organizational levels of SEAN parks; (ii) encouraging the active involvement and ownership of the TC membership and park staff; and (iii) earning the support and backing of the BOD and the Chiefs of Resources by demonstrating the value of the network approach.

[4] Although much of the attention of Coastal Cluster staff happens to be focused on GLBA at the moment, this program is designed to serve all 4 of its cluster parks (GLBA, SITK, KLGO, and WRST) equally.

- *Be a support program, not a separate program.* The SEAN staff will be active and visible members of the network parks. The Network Coordinator will travel regularly to each of the parks to assist with design, planning, data collection, and reporting results. The Data Manager will visit parks as needed in order to work directly with project leaders to design, construct, test, and coordinate data collection and management activities. By having a visible presence on the ground and at planning sessions at each park, the network staff will have their work seen and valued as a fully integrated program at each park.

- *Demonstrate, inform, and assist*. In addition to its primary role of conducting long-term monitoring to inform park management, the SEAN staff will work to demonstrate relevance and benefits to park staff. To the extent that it fits with monitoring operations and objectives, the SEAN will work to customize products and data management directly to the needs of park staff. This may be done through network cooperation with extant staff work processes and assistance with data management operations.

- *No surprises*. The SEAN will work to always propose and schedule park support and to clear requests with supervisors and/or the Chiefs of Resources with the support of the Technical Committee.

- *Foster ownership and involvement.* Involve park biologists, interpreters, rangers, pilots, maintenance, and other staff in the collection of monitoring data, as educators, or in a support capacity for carrying out most monitoring operations. Involvement will also be achieved through frequent park visits to build personal and working relationships between network and park staff. This involvement and personal familiarity of the park staff with SEAN work, and of the network staff with park operations and realities, will facilitate park-based field monitoring.

Park staff will serve two primary roles in conducting the monitoring and delivering information: Project Lead and Park Lead. The Project Lead is the individual designated to take overall responsibility within the network context for the design, measurement, and reporting on a Vital Sign. He or she works with the Network Coordinator and the Technical Committee to determine the long-range direction for data collection. The Project Lead oversees collation and summarization of the monitoring data and interacts regularly with the Data Manager. The Park Lead is the staff member from a SEAN park who ensures that park-level interests are considered in the execution of the monitoring Vital Sign. The Park Lead works with the Network Coordinator and the Project Lead to communicate relevant park operations and assist with compliance, permitting, and other park requirements. These two roles will often be served by the same individual.

As the program moves from design and protocol development into field implementation and data collection, the SEAN will evaluate whether to fund term or seasonal biological technicians or data management assistants. This approach will ensure that annual field work is completed, that park staff are not overburdened with support to the SEAN, and will avoid the addition of permanent staff that the SEAN budget cannot sustain.

Field sampling will be conducted by teams consisting of Project Leads, Park Leads, park staff, and SEAN biological technicians. Creating monitoring teams from network and park-based staff is crucial to integrating science and management and institutionalizing the monitoring program within park operations.

8.2.2 Reliance on Cooperators, Partners, and Contractors

Cooperators are parties external to the SEAN who will be actively involved as project (or field-effort) leaders for defined monitoring tasks. Partners are entities external to NPS who will contribute, manage, or serve data directly related to a SEAN Vital Sign. Due to its minimal network staff size, the SEAN will rely heavily on cooperators for implementation of the monitoring program. Most of that reliance will fall on the relationship between the SEAN and the parks, but there will also be considerable reliance on cooperators that are supported entirely or in part by network funds. Examples of likely external cooperators include faculty or students at the University of Alaska Southeast (a current cooperator working on the design of the water quality monitoring program) or the U.S. Geological Survey (a cooperator that will assist with collection and analysis of oceanographic data). The SEAN will strategically work with external partners who offer an established service. Excellent examples of partners with whom the SEAN will cooperate include the Western Regional Climate Center (WRCC, serving weather and climate data that will be collected and delivered by the SEAN) and possibly the Alaska Ocean Observing System (AOOS, which serves standard oceanographic data collected throughout Alaska waters). Current and expected cooperators and partners are listed by Vital Sign in Table 8.3.

The appeal of working with partners to store and disseminate data is apparent – selected partners have already established themselves as long-term, single-stop sites for rich, standardized datasets. They are known quantities to which the SEAN can directly link from the network web page. We acknowledge that there is both strength and risk in building a monitoring program that is dependent upon cooperators. Strength is added because cost-sharing projects and coordinating activities that yield the desired monitoring data are often efficient ways to use funds, reduce mobilization costs, and collaborate with experts in other organizations. Risk results from the fact that cooperators' capacity for cost-sharing, cooperation, and in-kind contributions can vary over time; this may inject a certain amount of unpredictability into a program that is dependent upon repeatability and predictably in data collection and over the long term. The SEAN's approach to working with cooperators will be to pursue, wherever possible, the establishment of multiyear (3- to 5-year) cooperative funding agreements.

To the extent that the SEAN will rely on contract work with private professionals, we anticipate that it will figure most prominently during the first five to seven years, when expert technical input is needed for protocol development. Our overall staffing objective is to build a monitoring program that can be sustained and operated primarily by network and park staff, with strategic assistance of key partners. To that end, we will likely engage external technical experts in order to build monitoring protocols that will not only yield the desired data, but also have a high likelihood of being sustained over many decades.

Table 8.3 Anticipated cooperators and partners for the SEAN Core Program Vital Signs.

SEAN Vital Sign	Monitoring Conducted and Managed Solely by SEAN and SEAN Parks	Monitoring Conducted and Managed by SEAN and Cooperator(s)
Airborne Contaminants		SEAN Mercury Deposition Network U.S. Forest Service
Freshwater Contaminants		SEAN Univ. Alaska Southeast
Freshwater Water Quality		SEAN Univ. Alaska Southeast
Streamflow	SEAN	
Glacial Dynamics		SEAN TBD
Intertidal Communities	SEAN	
Kittlitz's Murrelets		SEAN NPS Coastal Cluster Program U.S. Fish and Wildlife Service Alaska Dept. Fish and Game
Landform and Landcover		SEAN TBD
Marine Predators	SEAN	
Marine Contaminants		SEAN NOAA MusselWatch Program
Oceanography		SEAN Alaska Ocean Observing System
Weather and Climate		SEAN Western Regional Climate Center

In general, the SEAN will favor cooperative agreements with agencies and universities over contracts because they (1) are relatively flexible, (2) lend themselves to long-term relationships, (3) allow direct access to and collaboration with subject matter experts and research professionals, and (4) in some cases – particularly with Cooperative Ecosystem Studies Unit (CESU) agreements – will result in lower overhead costs to the SEAN.

8.3 Program Reviews

Scheduled, periodic reviews of the network's monitoring program and protocols will ensure that network and park personnel critically evaluate progress toward meeting the objectives of the Vital Signs Monitoring Program. Reviews will also provide the opportunity to evaluate whether SEAN needs to adjust direction or effort as it develops a fully-implemented and functional program. Three levels of review are planned.

First, the Annual Administrative Report and Work Plan (AARWP) will provide the Technical Committee, Chiefs of Resources, and Board of Directors with an opportunity to evaluate accomplishments of the past year and to explicitly articulate the focus and funding allocation for the coming year. Each year's finalized AARWP will be posted to the SEAN website.

Second, beginning in FY2011, the SEAN will host a triennial Science Symposium and Investigators' Report. This will be in the form of a two-day meeting at which all investigators conducting monitoring will deliver technical presentations and discuss the results of their work. During the second day of the meeting the Technical Committee will discuss the presentations and evaluate progress and results. The Network Coordinator will use this meeting to solicit both detailed, project-specific review of work on specific Vital Signs, progress toward monitoring objectives, and also to request a more general critique of program implementation. The symposium format will encourage a broader and longer-term review than is afforded by the AARWP, and the SEAN will benefit from the focused group review by those experts personally invested in the program.

Finally, the national I&M staff will formally review the program three years after implementation. A formal report will be generated from this periodic review, with specific suggestions for improvements and course corrections to the monitoring program. Among other things, this review will evaluate whether the SEAN has established an organization, staff, and resources to ensure long-term success. Subsequent program reviews will occur every 5 years thereafter.

Chapter 9: Schedule

This chapter identifies the target dates for protocol completion, identifies tasks that need to be completed in support of those protocols, and summarizes the frequency of sampling for protocols that will be implemented in the next five years. Our approach to the implementation of monitoring in the SEAN is to start slowly, focus on a small number of projects, and be prepared to make adjustments. During the early years of the program it is important not to overburden network and park staff with overzealous plans to take on too much too quickly and, thereby, overshoot its capabilities. Nevertheless, we aim to balance that prudence with an eagerness to establish the functionality of the program and quickly demonstrate the benefits and relevance to SEAN parks.

Other Alaska networks (e.g., SWAN) have described holistic monitoring programs that can be viewed as hierarchical and occurring at multiple levels (tiers) based on scale of resolution and rates of change (see SWAN Phase III Report, Bennett et al. 2005). Spatially continuous monitoring (Tier 1) is usually conducted by satellite remote sensing or aerial photography and is directed at broad landscape-scale patterns of change (e.g., climate or glacial extent). Frequent multipoint ground-based monitoring using probabilistic sampling designs (Tier 2) are used to document status or change in a resource (e.g., resident lake fish or water quality) or to provide ground verification of remotely-sensed parameters in Tier 1. Finally, the most frequent monitoring and intensive sampling (Tier 3) occurs at a limited number of smaller, intensively monitored resources (e.g., specific wildlife populations) for the purpose of determining cause-and-effect relationships, the status of a harvested resource, or to understand how processes interrelate.

While we find this model to be a helpful conceptual tool for organizing an approach to the complexity of ecological monitoring at multiple scales, we can also see that the implementation of the SEAN monitoring program will be more immediately shaped by the logistical limitations of staff and budget. The SEAN must operate strategically at a certain scale of economy, such that high-quality information on the most important Vital Signs is captured, archived, and served. In this way, the SEAN is charged with doing a few things well, making maximum use of existing data and monitoring efforts, and forging and maintaining long-term partnerships with entities outside the NPS.

To that end, the schedule for the first few years of the program (Table 9.1) is directed toward some Vital Signs (e.g., Weather and Climate) that are fundamentally important to understanding other resources, and toward some that are more locally important and for which excellent opportunities exist for either initiating or continuing monitoring (e.g., Marine Predators and Airborne Contaminants). Some focal Vital Signs, such as Oceanography, fit both criteria. Table 9.1 is useful in understanding that, though SEAN is undertaking development of a considerable number of Vital Signs, not all Vital Signs will require large investments in time and money.

Table 9.1 Schedule for developing, testing, and finalizing monitoring protocols for Vital Signs of the Southeast Alaska Network.

SEAN Vital Sign and Protocol	PARKS			Protocol Development Status					Relative Cost and Effort for Protocol Completion	Relative Cost and Effort to SEAN for Data Collection
	GLBA	KLGO	SITK	FY2009	FY2010	FY2011	FY2012	FY2013		
Oceanography	•			**Implement, Peer Review & Finalize**					**Low**	**Low**
Airborne Contaminants	•	•	•	*Develop Draft*; Test and Revise	**Peer Review & Finalize**				**Medium**	**Medium**
Marine Predators	•			*Develop Draft*; Test and Revise	**Peer Review & Finalize**				**Medium**	**Low**
Kittlitz's Murrelets	•			*Develop Draft*; Test and Revise	**Peer Review & Finalize**				**Low**	**Medium**
Marine Contaminants	•	•	•	*Develop Draft*; Test and Revise	**Peer Review & Finalize**				**Low**	**Medium**
Weather and Climate	•	•	•	*Develop Draft*; Test and Revise	**Peer Review & Finalize**				**Low**	**Low**
Streamflow	•	•	•	*Develop Draft*	Test and Revise	**Peer Review & Finalize**			**Medium**	**Medium**
Freshwater Water Quality	•	•	•	*Develop Draft*	Test and Revise	**Peer Review & Finalize**			**Medium**	**Medium**
Freshwater Contaminants	•	•	•		*Develop Draft*	Test and Revise	**Peer Review & Finalize**		**Medium**	**Medium**
Intertidal Communities			•			*Develop Draft*; Test and Revise	**Peer Review & Finalize**		**Low**	**Low**
Glacial Dynamics (Extent)	•	•					*Develop Draft*; Test and Revise	**Peer Review & Finalize**	**Medium**	**Medium**
Landform and Landcover	•	•	•				*Develop Draft*; Test and Revise	**Peer Review & Finalize**	**High**	**High**

In strong agreement with the processes followed by other networks, the SEAN will focus in the initial years on developing protocols, Vital Sign-specific monitoring plans, and the infrastructure for managing and serving data. The SEAN can certainly benefit from the work that other networks have already accomplished. In particular, the SEAN's protocol development and implementation will make maximal use of existing draft or approved protocols from other networks. The result should be a greatly shortened and more cost-effective protocol development effort. Of course, protocols for some Vital Signs must be developed originally, as they do not occur within other networks or for which monitoring within the SEAN has substantially unique field challenges (e.g., Marine Predators, Western Toads, or Kittlitz's Murrelets).

Throughout the five-year implementation phase, draft protocols will be written, field-tested for one to two years, submitted for peer review, and finalized. The typical protocol development process – from draft to finalization – will be three years. Some key questions that need to be answered during protocol testing include: Are there problems with methods or equipment? Do procedures require too much time or staff? Are standard operating procedures (SOPs) for data collection and management too complex? How can the protocols be made more efficient? How well do the resulting products meet the needs of the parks and other users? We anticipate that in many cases pilot monitoring, including tests of data management SOPs, will reveal the need for changes in protocol design. Table 9.2 encapsulates the key known issues that must be addressed during protocol development for each Vital Sign.

The timing and frequency of monitoring is guided by the spatial and temporal patterns of variance in the parameters being measured and by the information desired (Table 9.3). The limited resources of the SEAN and logistical challenges prohibit routine measurements at high frequency or close spatial intervals. Measurements will be made at intervals of time and space that allow for detection of large-scale changes in physical processes and smaller scale biotic responses.

Table 9.2 Summary of tasks to be completed for protocol development or for acquiring existing data, SEAN Vital Signs Monitoring Program.

Target Year for Protocol Completion	Vital Sign	Parks	Key Issues to be Addressed During Protocol Development and Testing
2009 Ocea	**nography**	GLBA	Techniques for sampling core parameters are well established. Work will focus on database development and writing the protocol to NPS specifications; existing protocol underwent a thorough interagency review by an expert panel in 2006. Network will investigate adding a measure of ocean acidification to the current protocol.
2010	**Airborne Contaminants**	All	A monitoring protocol is one specified product of a study that will occur across all network parks in 2008-2010. Field work and contaminant sampling (using multiple designs) will occur in 2008 and 2009; a protocol is a specified deliverable for 2010. Using this product as the basis, SEAN will submit a final protocol for peer review and approval. Concurrent monitoring for wet-deposition mercury at GLBA will begin in Spring 2008, following the national protocol from the Mercury Deposition Network, which SEAN has joined.
2010	**Kittlitz's Murrelets**	GLBA	The NPS Southeast Alaska Coastal Cluster, the Fish and Wildlife Service, and the USGS have conducted intensive KIMU surveys and are working on formalizing a monitoring protocol which would be directly applicable to GLBA populations. SEAN work will focus on adapting this forthcoming protocol to meet NPS specifications and will implement it in GLBA. SEAN will work to coordinate annual monitoring with the Marine Predators and Oceanography vital signs.
2010	**Weather and Climate**	All	Techniques for monitoring weather and climate are well-developed; protocol development will focus on identification of candidate weather station sites, site selection, adoption of existing NPS protocols for SEAN use, and integration of SEAN data management with external partners.
2010	**Marine Predators**	GLBA	SEAN has established a CESU Agreement with a quantitative population ecologist at UAF to assess and modify an existing survey protocol for long-term monitoring. Protocol development will focus first on identifying which species the protocol should target and selecting the desired precision, and then will use existing data from 1999-2003 to conduct power analyses to determine the sampling effort required to achieve the desired degree of precision.
2010	**Marine Contaminants**	GLBA, SITK	Protocol will be developed from the approach used in the on-going (and SEAN-funded) 2007 Baseline Contaminants Study (Tallmon). SEAN will investigate the possibility of developing the GLBA and SITK mussel sampling as formal NOAA MusselWatch sites.

Table 9.2, continued

Target Year for Protocol Completion	Vital Sign	Parks	Key Issues to be Addressed During Protocol Development and Testing
2011	**Freshwater Water Quality**	All	In 2009, SEAN will assess the product of an on-going agreement with UAS to recommend specific approaches to protocols for comprehensive water quality monitoring in SEAN parks. This agreement has already delivered the PDSs for these freshwater-related vital signs, and is currently developing protocol recommendations, with attention toward co-locating sampling of all freshwater vital signs. The full protocols will be written and reviewed, in order of priority of implementation: Freshwater Water Quality, Streamflow, and Contaminants. SEAN will ensure that the Contaminants protocol dovetails with contaminants monitoring that will occur under the Airborne Contaminants and Marine Contaminants sampling approaches. In this way, contaminants-related monitoring occurring under different vital signs can best inform mode of delivery and pathways to bioavailability across air, freshwater, marine, and terrestrial sources.
2011 Stre	**amflow**	All	
2012	**Freshwater Contaminants**	All	
2012	**Intertidal Communities**	SITK	NPS is awaiting the final report of a USGS study that will recommend a monitoring protocol in SITK. This report will serve as the basis for the network protocol, which will be written to NPS specifications and peer-reviewed.
2013	**Glacial Dynamics**	GLBA, KLGO	SEAN will conduct a cost and methods comparison, and will modify and adopt approved protocols of other networks (e.g., NCCN). Because glacial extent is essentially a mapping task for one type of land cover, it will be included within the Landform and Landcover Vital Sign.
2013	**Landform and Landcover**	All	The PDS proposes a 4-year protocol development process. Investigate whether to include an initial retrospective analysis to evaluate historic changes of landscape patterns and conditions. Although this is not an essential part of developing this protocol, it would inform the development of the protocol by refining and helping to prioritize the list of landscape components for future mapping efforts. Full mapping using high-resolution satellite imagery is expected every 10 years. SEAN will also evaluate whether to use LandSat, ASTER or other coarse resolution imagery during the mid-point of each decadal cycle to map a subset of features that may be changing at high rates, and the effects of any unpredictable or catastrophic events (e.g., outburst floods) that may have occurred since the last mapping cycle.

Table 9.3 Frequency and timing of sampling for Vital Signs to be monitored by the SEAN.

SEAN Vital Sign	Sample Interval	January	February	March	April	May	June	July	August	September	October	November	December
Airborne Contaminants													
Lichen sampling	Annually												
Passive samplers (concentration)	Weekly												
Throughfall samplers (deposition)	Weekly												
Freshwater Contaminants	Decadal												
Freshwater Water Quality	Continuously												
Streamflow	Continuously												
Glacial Dynamics	Decadal												
Intertidal Communities	Triennially												
Kittlitz's Murrelets	Annually												
Landform and Landcover	Decadal												
Marine Contaminants	Biannually												
Marine Predators	Annually												
Oceanography	Quarterly												
Weather and Climate	Continuously												

Chapter 10: Budget

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Chapter 11: Literature Cited

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Glossary

Ablation refers to the reduction in volume of a glacier due to melting and sublimation.

Adaptive Management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form-"active" adaptive management-employs management programs that are designed to experimentally compare selected policies or practices, by implementing management actions explicitly designed to generate information useful for evaluating alternative hypotheses about the system being managed.

Allochthonous refers to all organic matter that a stream receives from production that occurred outside the stream channel.

Anastomosis refers to a form of lotic waterbody in which streams branch out and reconnect; commonly referred to as "braiding."

Attributes are any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem.

Availability bias results when individuals or species are present but unavailable for detection (i.e., detection probability is zero). For example, an availability bias would result from the failure to record plant species because they were dormant and underground during a sampling occasion. Conducting surveys from the same platform when multiple platforms are more appropriate may induce availability bias

Benthic refers to aquatic organisms that live near and are adapted to the bottom or substrate of a waterbody.

Biodiversity is short for "biological diversity" and is typically used to refer to the variety of life forms found on earth. Biodiversity may be used to describe the number of taxa found in a specific geographic area by levels of the taxonomic hierarchy (e.g., # of phyla represented, # of bird species, # of chironomid genera, etc.) Various metrics have been developed to describe biodiversity including species richness, Shannon-Wiener diversity index, etc.

Colocation refers to monitoring multiple Vital Signs at the same physical locations.

Conceptual Models are purposeful representations of reality that provide a mental picture of how something works to communicate that explanation to others.

Covisitation refers to recording observations on multiple Vital Signs during a sampling occasion.

Data refers to a collection of organized observations. Data may consist of numbers, words, or images, particularly as measurements or observations of a set of variables. SEAN data

will exist in a variety of forms, including tabular observations, spatial data, documentation, reports, images, sound and video files, and administrative records.

Database refers to the comprehensive collection of containers holding the Network's data products (see Chapter 6).

Data Analyses, as defined for this program, are the processes by which observations of the environment are turned into meaningful information. These include all evaluations after data are collected and entered into an electronic file. Data analysis includes quality control checks that occur during summarization and exploratory data analysis and extends through to analytical procedures leading to conclusions and interpretations of the data (see Chapter 7).

Data Management refers to the development of a modern information management infrastructure and procedures to ensure that relevant natural resource data collected by NPS staff, cooperators, researchers, and others, are entered, quality-checked, analyzed, reported, archived, documented, cataloged, and made available to others for management decision-making, research and education (see Chapter 6).

Demersal refers to organisms that live in the water column of the ocean and freshwater lakes, near and just above the seabed or benthos.

Ecological integrity is a concept that expresses the degree to which the physical, chemical, and biological components (including composition, structure, and process) of an ecosystem and their relationships are present, functioning, and capable of self-renewal. Ecological integrity implies the presence of appropriate species, populations and communities and the occurrence of ecological processes at appropriate rates and scales as well as the environmental conditions that support these taxa and processes.

Ecosystem is defined as "a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries" (Likens 1992).

Ecosystem drivers are major external driving forces such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., earthquakes, droughts, floods) that have large scale influences on natural systems.

Ecosystem management is the process of land-use decision making and land-management practice that takes into account the full suite of organisms and processes that characterize and comprise the ecosystem. It is based on the best understanding currently available as to how the ecosystem works. Ecosystem management includes a primary goal to sustain ecosystem structure and function, recognition that ecosystems are spatially and temporally dynamic, and acceptance of the dictum that ecosystem function depends on ecosystem structure and diversity. The whole-system focus of ecosystem management implies coordinated land-use decisions.

Firn line is the highest level to which the fresh snow on a glacier's surface retreats during the melting season, or the boundary of the area of snow on a glacier surviving one year's

ablation. In the absence of superimposed ice, this limit is equivalent to the equilibrium line.

Focal resources are park resources that, by virtue of their special protection, public appeal, or other management significance, have paramount importance for monitoring regardless of current threats or whether they would be monitored as an indication of ecosystem integrity. Focal resources might include ecological processes such as deposition rates of nitrates and sulfates in certain parks, or they may be a species that is harvested, endemic, alien, or has protected status.

Hyporheic refers to the saturated area beneath and along side a streambed where water percolates through interstitial space in the subsurface gravel.

Indicators are a subset of monitoring attributes that are particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system.

Isostatic rebound, also called post-glacial rebound is the rise of land masses that were depressed by the huge weight of ice sheets or glaciers.

Lentic refers to ecosystems composed of non-moving freshwaters, e.g., lakes, ponds and wetlands.

List-based Sampling refers to how sampling locations for selected protocols were selected by construction of a list of sample units and choosing a random sample of units from the list.

Lotic refers to ecosystems composed of moving freshwaters, e.g., rivers and streams.

Mass balance, related to glacial dynamics, the difference between accumulation and ablation (melting and sublimation).

Measures are the specific feature(s) used to quantify an indicator, as specified in a sampling protocol.

Metadata are the documentation items that describe the content, context, quality, structure, and accessibility of a data set.

Necktonic refers to organisms that live in the water column of the ocean and freshwater lakes and are capable of propelling themselves independent of the water currents.

Paludification refers the development of an impervious soil horizon through the long-term process leaching of rainwater through continuously accumulating organic soil horizons.

Park Lead refers to staff members from a specific park who ensure that park-level interests are considered in the execution of monitoring for a Vital Sign (see Chapter 8).

Perception bias arises when there is a failure to detect an individual or species that is available for detection (i.e., detection probability is nonzero). For instance, individuals left unrecorded due to their lack of identification features at the time of recording observations and measures results in perception bias.

Project Leader refers to the individual designated to take overall responsibility within the network context for the design, conduct and reporting on a Vital Sign. He or she works with the Network Coordinator and Technical Committee to determine long-range directions for data collections. They oversee collection and summarization of the data.

Protocols, as defined for this program, are detailed study plans that provide rationale for monitoring a Vital Sign, and provide instructions for carrying out the monitoring. Protocols consist of a narrative, standard operating procedures, and supplementary materials (Oakley et al. 2003).

Response design directs how to record the response (Vital Sign metric) within each sampling unit, which includes choosing a method of measurement and an optimum shape and size of units (Stevens and Urquhart 2000).

Revisit Design refers to how visits to all panels in a sampling design will be scheduled over time (see Chapter 4 and McDonald 2003).

Sample Units are the smallest entities upon which measurements are taken (see Chapter 4 and McDonald 2003).

Standard Operating Procedures are detailed instructions for carrying out monitoring operations and form one part of Monitoring Protocol (Oakley et al. 2003).

Status, as used in this program, refers to the condition of a resource or Vital Sign at a given point in time.

Stressors are physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level (Barrett et al. 1976:192). Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, land-use change, and air pollution.

Trend, as used in this program, refers generally to directional change measured in a resource by monitoring its condition over time. Trends can be measured by examining individual change (change experienced by individual sample units) or by examining net change (change in mean response of all sample units) (see McDonald 2003).

Vital Signs, as used by the National Park Service, are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are

directed to preserve “unimpaired for future generations,” including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

Appendix A

Identification of monitoring projects and potential baselines among ongoing and former research in the parks of the Southeast Alaska Network

Contents

TRANSMITTAL LETTER **A-4**

PROCEDURE FOR CONSTRUCTING THE PROJECT EVALUATION TABLES **A-5**

EXPLANATORY COMPANION TO THE PROJECT EVALUATION TABLES **A-6**

IDENTIFYING BASELINE CANDIDATES & MONITORING FOR SEAN: DEFINITIONS AND RANKINGS **A-7**

GLBA PROJECT EVALUATION TABLE **A-8**

ATMOSPHERE A-8
FRESHWATER A-11
Streams –physical/general *A-11*
Hydrology/water quality *A-11*
Fish (incl. salmon) *A-12*
General ecology/succession *A-16*
Lakes *A-19*
Impacts (including fishing) *A-21*
TERRESTRIAL A-23
Bedrock geology *A-23*
Landform dynamics *A-23*
Isostatics/Tectonics *A-24*
Glaciers *A-26*
Soils *A-28*
Plants *A-29*
Birds *A-34*
Mammals *A-39*
Amphibians *A-45*
Invertebrates *A-46*
General (Incl ecology/succession) *A-48*
Impacts *A-49*
MARINE A-51
Oceanography/water quality *A-51*
Bathymetry/sediments *A-54*
Fish *A-57*
Birds *A-60*
Whales *A-64*
Pinnipeds/sea otters *A-68*
Invertebrates *A-75*
General marine (incl acoustics) *A-82*
Impacts *A-88*
INTERTIDAL A-92
Landforms/sediments *A-92*
Invertebrates/algae *A-93*
Fish *A-95*
Birds *A-96*
General/impacts *A-97*
GENERAL, OTHER A-98

KLGO PROJECT EVALUATION TABLE **A-102**

ATMOSPHERE A-102
BIRDS A-103
MAMMALS A-105
FISH A-105
PLANTS A-105

AMPHIBIANS A-106
VISITOR USE/ IMPACTS A-107
GEOMORPHOLOGY A-107
WATER QUALITY A-108
GENERAL ECOLOGY A-108
PHOTOGRAPHY A-109

SITK PROJECT EVALUATION TABLE A-110

ATMOSPHERE A-110
BIRDS A-110
MAMMALS A-111
LAND PLANTS A-111
MARINE/INTERTIDAL A-112
INDIAN RIVER A-113
GENERAL ECOLOGY A-114
LANDSCAPE A-115
HISTORY A-115
ASPHALT PLANT A-115
WATER QUALITY A-116

Transmittal Letter 10/17/06

MEMORANDUM
TO: Susan Boudreau, GLBA
FROM: Greg Streveler, ISES
SUBJECT: Transmittal of final products

Susan, per our agreement, here on this CD (and on the park web) are copies of the final drafts of all work I have done related to identification of monitoring projects and potential baselines among ongoing and former research in the park. On this CD, you should find:

- Procedure for construction project evaluation tables, final
- Identifying baselines and monitoring candidates, final
- Explanatory companion to tables
- GLBA Project evaluation table, final
- GLBA monitoring project summaries, final
- SITK Project evaluation table, final
- KLGO project evaluation table, final

If all these documents meet with your satisfaction, my work on this project is hereby terminated. Thank you for the opportunity to work on this worthwhile project.

Procedure for Constructing the Project Evaluation Tables

Greg Streveler

10/17/06

I began this project by first developing the task concept through a series of discussions with Chiska Derr. In a nutshell, the agreed objective was to review all past and ongoing research to identify work that can be classified as monitoring, or that could become the basis of monitoring in the future.

The next step was to put a draft procedure for identifying ongoing monitoring and baseline candidates through several drafts in consultation with Chiska and staff from SEAN parks. With the task and procedure clarified, webmaster Bill Eichenlaub acquainted me with the NPS intranet and pointed me toward the most productive sources for my purposes. We decided that the SEAN park's Project Tracking database (/Science/Resource Management/SEAN-data-management/project-tracking/project_tracking_database) would form the backbone of my review, but many supplementary databases (notably k/eco_data, naturebib, library/products/reports, and research/research projects/investigator files) were invaluable.

For SITK and KLGO, I asked the Resource Management Specialists to supplement the Project Tracking lists, after which I filled in as much detail as possible from sources available to me electronically on the park intranets. This work was followed by onsite visits with Geoff & Meg, reviewing all pertinent literature at their command and further gleaning their personal knowledge. The lists were finished after a further round of review with Meg (later, Theresa) & Geoff, in which the final details were emplaced and their views on monitoring/baseline determinations were fully integrated.

For GLBA, I first supplemented the Project Tracking list with notes on monitoring subjects from a RM workshop, then began to iteratively query and a number of sources, beginning with the electronic ones available on the park intranet. These were extensively supplemented from my personal library and that of the park, and the USGS hard copy files. All Project Tracking headings were examined, whether relevant or not; other work was cited if I went to some trouble to evaluate it. The vast GLBA literature was weeded down by eliminating out-of-hand:

- a variety of topics such as most of archaeology, sociology, and bedrock geology (except where a monitoring component suggested itself);
- most projects that on their face were very cursory or crudely done.

An attempt was then made to examine some form of report or data on all the rest. Many sources from the staff and elsewhere were then iteratively queried until there existed a credible first draft.

I then farmed the draft out to the park RM staff, the USGS staff, and a few key independent researchers for their formal input on details and references, which added very considerably to the breadth and accuracy of the document. The semi-final package was then farmed out one last time to the staff, and final details were elicited from key non-staff. Results were compiled into the final.

Explanatory Companion to the Project Evaluation Tables
for
GLBA, KLGO and SITK
Greg Streveler 10/17/06

The purpose of these tables is to present in outline form the basic information on all past and present research for SEAN parks that is of potential interest from a standpoint of ecosystem monitoring. The master list of all such projects was constructed by me with periodic review by Park RM, USGS and selected independent research personnel during April – September, 2006.

Column 1 of each Table gives each project's name. If in regular print, this name is as it appears in the park's Project Tracking database; if in italics, it is a name invented to encapsulate material not in that database.

Column 2 gives an assessment of that project's status as ongoing monitoring. The code in that column refers to the companion document "Identifying Baseline Candidates & Ongoing Monitoring". There are only two possible answers here: "Yes" and "No", in most cases accompanied by an explanatory code. The lack of a coded explanation means that the reason is considered to be self-evident.

Column 3 gives an assessment of the project's status as potential baseline material. There are three possible answers here: "No", "Yes" and "PRIME". The "PRIME" category is reserved for projects that struck me as the most important baseline candidates. Again the codes accompanying these determinations are explained in "Identifying Baseline Candidates & Ongoing Monitoring". I have tended to be inclusive here when in doubt, so that potentially useful items do not fall off the radar screen prematurely.

Column 4 gives a telegraphic summary of the project, with key references.

Explanatory Companion
to the
GLBA Monitoring Project Summaries Table

This table is a distillate of the GLBA Project Evaluation Table. Its intent is to display two sorts of projects: 1) those which are ranked as "Ongoing Monitoring", and 2) those which are judged to present significant opportunities for additional monitoring, but for some reason have not risen to that status. Low ranking projects are removed as an aid to focus on the more important ones in a SEAN context.

Material in all columns is taken verbatim from the Project Evaluation Table in all cases except for Column 4. In that column, "Ongoing Monitoring" projects are re-crafted into prose statements as an aid to their inclusion into the upcoming SEAN Phase II report.

Identifying Baseline Candidates & Monitoring for SEAN: Definitions and Rankings

Reviewers: Chiska, Scott, Lewis, Rusty, Meg, Geof

Greg Streveler 10/17/06

The SEAN definition of Monitoring: "The collection and analysis of replicated observations or measurements to evaluate changes in condition and progress toward meeting a management objective."

Monitoring can have a great variety of sophistication levels, ranging from qualitative or casual observations that only grossly describe the status quo, to carefully structured and data rich programs that allow precise statistical evaluation &/or identification of small deviations from the status quo. It has been agreed that I am to focus on the upper levels of this spectrum. The following is a second attempt to define projects that rise to the level of "Baseline Candidate" or "Ongoing Monitoring". Projects that fail to fulfill these criteria will fall off the list, and will not receive further attention from me.

I. A project is a Baseline Candidate if all the following criteria are met:

A1 - It has sample sizes and data quality sufficient to permit some evaluation of confidence limits or level of detectable change,

or

A2 - It is sufficiently exhaustive, either alone or in concert with other data sets, to permit firm statements about a key phenomenon (for example, presence/absence of river otters in the Indian River estuary);

And

B - It has protocols sufficiently described to locate study localities and to replicate the mode of sampling/observation.

II. If a project that is ranked as a Candidate, will get a ranking of "Prime Candidate" if:

A - It clearly meets the SEAN Ecological Significance Criteria:
(a) important as a controller or integrator; (b) useful as an integrator; (c) linked to other vital signs

or

B - It meets SEAM Management Significance criteria:
(a) needed to make or implement a management decision or evaluate an outcome of a management action: (b) required by a legal mandate; (c) there is a formal mandate for monitoring; (d) resource is "listed" or otherwise of concern to an agency.

III. A project is "Ongoing Monitoring" if it:

A1 - Meets the above criteria for a Baseline Candidate,

or

A2 – Has been intended as monitoring

And

B1 - Has been repetitively sampled at least once in the last few years

or

B2 - There are firm plans for follow-up.

GLBA Project Evaluation Table 10/17/06 Final

Greg Streveler, in consultation with GLBA & USGS Staff

(for explanation of codes, see a companion document,"Identifying Baseline Candidates and Ongoing Monitoring")
Project names in *italics* are not in the *GLBA* Project Tracking *database.*

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Atmosphere			
Air Quality Camera System	No	No	Never happened, according to Eichenlaub
Airborne Contaminants Assessment	Yes ? (A1,B2?)	Yes (A2, B)	What: Assessment of semi-volatile organics, persistent organic pollutants. How: Passive air filtration and vegetation sampling, using protocol developed for Western parks When: 2005 (sampler will be collected , 2006) Where: On face of Beartrack Mountain, below timberline Who: Dixon Landers (WACAP) Comments: We don't have the exact details of the analysis, but it is a likely candidate for replication.
Atmospheric Mercury *qnd Lead* Assessment	Yes (A1,B1)	Yes (A2, B)	What: Monitoring of atmospheric Hg (and Pb210), as a "pristine" benchmark against which to compare readings from more trammeled parts of the world. How: Passive monitoring of precipitation When: July 2003 – July 2005 Where: Bartlett Cove Who: Dan Engstrom Comments: Samples are being processed. Assume it is according to a national protocol.
Cruise ship stack Emission Opacity	Yes (A2,B1)	PRIME (Ba,b,c)	What: Measurement of cruise ship (and tour vessel) stack emissions for their compliance with opacity regs How: Opacity readings a minimum of twice per operating season for each cruise ship, and on an opportunistic basis for tour vessels. Where: Glacier Bay When 1991-present Who: NPS rangers Ref: GLBA Marine Vessel Emissions Program (2006 edition)

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Comments: given length of baseline and volume of data, and interest to management, this is a key monitoring program
Weather Data, NCDC	Yes (A2,B1)	PRIME (Aa,c)	What: Weather data from 8 stations in region averaged How: Data obtained from National Climatic Data Center on daily avg air temp, daily precip, daily average wind speed. When: Jan 1993-July 2002 Where: Yakutat, Elfin Cove, Hoonah, Bartlett Cove, Gustavus, Auke Bay, Juneau and Haines Ref: Etherington, L., et al. 2004. Factors affecting Seasonal and Regional Patterns of Surface Water Oceanographic Properties within a Fjord Estuarine system: Glacier Bay, Alaska. USGS/BRD report to NPS, Gustavus. Comments: Very important data set. Could be extended backward for further elucidation of historical weather patterns. Up-to-date data also collected on continuous basis, and could be purchased at any time.
Bartlett Cove & Gustavus Weather Stations	Yes (A2,B1)	PRIME (Aa,c)	What: weather records How: NWS official stations Where: Bartlett Cove and Gustavus, the former in the same spot the latter moved a couple of times, now automated from airport. When: operated nearly continuously since the 1950's Refs: recent records synopsized in the NCDC weather summary per Etherington, but much more time depth available.
Lawson's Weather Stations	Yes (A2,B1)	PRIME (Aa,c)	What: Lowland weather patterns How: 24 automated stations that must be downloaded and serviced at least annually, measuring standard parameters as well as isotopic composition of oxygen in precipitation. When: For about a decade, and ongoing Where: Along Glacier Bay, numerous localities Who: Dan Lawson Comments: Lawson has the data; no synoptic report yet.
Other weather data	No (B1)	PRIME (Aa,c)	What: various short-term records from summer field stations; a major synthesis of regional weather records up to 1989 Where: Muir Inlet, Falls Creek; Dry Bay Who: up-Bay rangers, IPS, Gustavus Electric, Lewis Hunter; Chad Soiseth Refs: info in various NPS field logs and IPS reports

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Hunter, L. 1994. Grounding-line Systems and Glacier Mass Balance of Modern Temperate Glaciers and their Effect on Glacier Stability. Ph.D. Thesis, Northern Illinois U. Lowe, F. 1966. Climate *in* Goldthwait, et. Soil Development and Ecological Succession In a Deglaciated Area of Muir Inlet, Alaska. IPS Rept #20. Comments: Hunter's work is of the first importance for the park, giving a regional synopsis very complementary to that of Etherington, above. Lowe gives a good summary of data for Muir Inlet as of the mid 60's. Soiseth advises that a station is now established at Dry Bay, and has bee functioning since May '05. I have not attempted to survey the info scattered in various logs and reports, but there are really quite a few data from the summer months, especially in Muir Inlet. An important record for Dixon Harbor was obtained during winters of 1973-4, & 1974-5 by Home (1977).
Glacier Bay Climate Model	No	No	What: First coherent, data-driven climate model for GLBA. Ref: Hunter, L & R. Powell. 1993. *in* Proceedings of the Third Glacier Bay Science Symposium , Engstrom, ed. NPS, Anchorage Comments: Of the first importance; based on data given in Hunter's thesis (see above), but not useful for monitoring.
Air pollution Potential, upper Fjords	No	No	What: Meteorological measurements to determine air pollution potential in upper fjords. How: Measured cloud cover, temp, humidity, radiation, wind speed. Where: Main measurements made at Goose Cove, stations at o and 127m ASL. When: Summer 1976 Who: Carl Benson, Gerd Wendler Ref: Benson, C. et al. 1978. On the Climate and Air Pollution Potential in GLBA, Alaska. Geophysical Inst. UAF rept to NPS Comments: A one-year sample of weather variables is not sufficient for use as a baseline in itself, but could be useful if patched together with other short records from Muir Inlet research camps and ranger stations.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Freshwater			**The Freshwater section is somewhat duplicative of the work of Eran Hood, Sonia Nagorski & Ginny Eckert. The reader is referred to their reports for further details on water quality issues.**
Streams – physical/general			
Streams GIS Layer			Not sufficient precision to document change on all but largest scale
Hydrology/water quality			**This subsection is only flagged, since it is the primary focus of the Eckert/Nagorski/Hood report, except for the geomorphological component.**
Abyss Lake Jökulhlaups, 1997-2001	No (B1)	Yes (A2,B)	What/where: Analysis of Outburst history of Abyss Lake area. Who: Chad Soiseth, Scott Grover. When: 1997, 2001 Refs: Grover, S. (1997). An investigation of the 1997 Abyss Lake Jokulhlaup in Glacier Bay National Park. Gustavus, Alaska, U.S. National Park Service, Glacier Bay National Park and Preserve**:** 11 pp. Grover, S. (2003). An investigation of glacial outburst floods from Abyss Lake, Glacier Bay National Park, Alaska. Fort Collins, Colorado, U.S. National Park Service, Water Resources Division**:** 14 pp. Comments: Added more detail here because of the geomorphological aspect of the work. The summary of drainage shifts and lake level changes is based on field obs and air photo analysis. I have called this monitoring on the basis of my understanding that the system is under surveillance for future changes.
Outburst lake mapping & Monitoring	Yes (A1,B1)	Yes (A2,B)	What: Mapping and monitoring of outburst lakes with objective of creating a predictive model of their behavior How: Mapping from photos and visits; measurement of depths and strandline changes, mapping of downstream effects Where: Throughout park and elsewhere When: 2005-2006 Who: Denny Capps Comments: PhD work in progress, U British Columbia
Abyss Lake Water-level	Yes (A2,B1)	Yes (A2,B)	What: Collection of 20 photos, 1997-present.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Who: Bill Eichenlaub Comments: Intended as a continuing collection for purpose of monitoring
Alsek River Gauging Station	Yes (A2,B1)		Dan Neal, USGS. Perennial gauging station. Important record.
East Alsek Water Quantity & Quality			Chad Soiseth. Summer of 2005 draft report available. Second year of data to be finalized in 2007.
Baseline Water Quality Data Inventory and Analysis			Chris Cofeen, Cathy Connor. According to project tracking, was supposed to happen in 2002-03. Some data from USGS Ed Neal exist with Chad Soiseth but project was not completed.
Kahtaheena River Gaging Station	Yes (A2,B1)		Station run for a couple of years around 2002-02 on Falls Creek by USGS, Juneau, for Gustavus Electric Co. Reestablished in 2006.
Air Temp and Water Temp Flux			Dan Lawson, Jim Taggart. Comparison of marine and atmospheric temperature records, Glacier Bay.
Dixon Harbor Area Hydrology			Dan Bishop, 1975-76. Has some potentially important data on pH & heavy metal concentrations from a number of water bodies. That latter are shown to approach toxicity levels for fish in some instances. Ref: . Bishop, D. M. (1977). Hydrology of coastal streams near Lituya Bay, Environaid**:** 30 pp. Dixon Hbr Biological Survey.
Burroughs Glacier Margin Geochemistry			Dave Mickleson. Good water chemistry data from sites, some of which are relocatable. Ref: Mickelson, D. M. and N. R. Ham (1995). Thirty years of glacier process studies at Burroughs Glacier, Wachusetts Inlet, Glacier Bay, Alaska. Proc. 3rd Glacier Bay Science Symp, 1993, Gustavus, Alaska, USNPS.
Fish (incl. salmon)			
Coastal Chinook Salmon Data Storage Tag Project	No	No	What :Exploration of utility of a tagging tool Who: James Murphy
East Alsek Sockeye Salmon Decline (*includes* East Alsek Monitoring)	Yes (A1,B1)	PRIME (Ab,Ba)	What/how: 1) map and quantify sockeye salmon spawning habitat and macrophyte beds to determine whether spawning habitat is limiting and how macrophytes are affecting habitat, 2) use archived adult scales and contemporary juvenile scales and otoliths to evaluate habitat change effects on growth, 3) quantify juvenile sockeye distribution, relative abundance, and growth to establish basic life history information and collect scale and otolith samples, and

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			4) Determine growth rate of aquatic vegetation and rate of sediment deposition in relation to activity of spawning sockeye. Project results will resolve questions regarding feasibility of large-scale habitat manipulation to improve fish returns and inform fisheries management. Where: East Alsek River When: 2005-06 Who: Derrek Faber, Chad Soiseth Ref: Faber, D, et al. 2006. Evaluation of Habitat and growth Trends for East Alsek Sockeye Salmon in Glacier Bay National Preserve, Alaska. UA Southeast, Juneau. Comments: Currentlly in progress with '06 as final of 2 y field season. This is UAF Master's student Derrek Faber's thesis work. Anticipated completion by end of 2007. Comments: Comprehensive study; most germane part to inventory/monitoring is objective 1, which is providing detailed map and quantitative description of habitat distribution & parameters.
Freshwater Fish Species	No	No	Empty category
Freshwater fish distribution database inventory: 1952-1994	No	No	What: This is an Access database table companion to the physical characteristics of streams database table. The data table indicates species and life stage presence among park streams as reported over recent history from a wide variety of sources. Data exist for perhaps half of the more than 300 streams in the park. Data quality are highly variable ranging from a single stream visit by a nonscientist to multiple and repeated visits to streams over several years (i.e. Milner at Berg Bay and Wolf Point Creek). Comments: Larger studies on individual creeks are reported under other headings
Post-Glacial Salmon Recolonization	No	Yes? (A1?,B)	What: Genetic variation among sockeys and pinks How: analysis of allozymes and mitochondrial DNA Who: Chris Kondzela, Tony Gharrett Where: four Glacier Bay systems, including Gull lake, Seclusion River, North Berg When: 1993-94? Refs. Kondzela, C & A. Gharrett. 2004. Post-Glacial Colonization of Pink and Sockeye Salmon in glacier Bay. Abstract, 4th GB Science Symposium, Juneau. Kondzela, C. & A. Gharrett. Draft. Sockey Salmon Colonization in Glacier Bay. Comments: Draft reviewed by Chad, but paper not available. Based on poster at science symposium, study designed to elucidate between-stream relationships at a point in time, and presumably could be replicated in the future to note genetic changes (say, due to infusion of hatchery fish or somesuch). I presume the work could be replicated in the future if done well enough to distinguish between-stream differences.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Salmon - Chinook - Dundas/Seclusion Study	No	No	What: Survey in search of Chinook salmon How: Visual surveys of adults; minnow trapping for juvs Where: main channels of Dundas/Seclusion complex When: Sept, 2002. Ref: Waltmeyer, D. & C. Soiseth. 2004. An Evaluationn of Chinook Salmon Freshwater Habitat Use in GLBA, Alaska. Tech Rept NPS?NRWRD/NTR-2004/321 Comments: Cursory; samples of fish small. Results for Chinook negative (but found lots of Dollies in Seclusion). Not useful for baseline
Salmon - Coho Fry	No	No	Dan Van Leeuwen Proposal for study that was aborted
Diet of Coho Juveniles as function of stream age	No	No	What: Diet of juvenile coho as function of stream age / ecosystem development. How: Stomach analysis of fish compared to invertebrate availability as demonstrated by sampling of aquatic and terrestrial streambank fauna. Where: Wolf Point Creek, Ice Valley Creek and Berg Bay South Creek. When: July/August, 2005 Who: Emily Greenall, under the supervision of Milner Ref: Greenall, E. 2005. A Study Comparing the Changes in Aquatic and Terrestrial Invertebrate Composition, and Juvenile Coho Salmon Diet Preferences Between Three Streams of Different Ages. M.S. Thesis, King's College, London. Comments: Based on relatively small samples [ex: stomachs (N=16-21/stream), pitfall traps (N=10-17/stream)]; sample sites not precisely located. Her hypothesis that there would be a correlation between stream age (therefore food choices) and fish diets was not borne out.
Salmon - Coho Genetics and Colonization	No (B1)	Yes (A1,B)	What: Documentation of metapopulation genetics in streams of various post-glacial ages. How: Genetic analysis of coho stocks, focusing on nine nuclear loci, using age, watershed size and inter-stream distance as variables Where: Known-age streams along the Glacier Bay chronosequence. When: 1997 Who: Kim Scribner, Chad Soiseth, George Sage, Lyman Thorsteinson, Eric Knudsen, Jennifer Neilsen. Ref: Scribner, K., et al. In prep. Coho Salmon Colonization in Recently Deglaciated Streams in Glacier Bay, Alaska: Implications for Pacific Salmon Restoration. To be submitted to J. Fisheries. Comment: Relatively large total sample (N=615) from a total of 17 streams, or an average of 36 fish/stream. This level of sampling allowed distinction among streams with a large degree of confidence; hence each stream can be considered well characterized genetically.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			These data would allow comparison at some later date A resampling of streams could potentially indicate changes in gene freq. for specific loci sampled. However, one criticism of earlier drafts of this paper was that samples from juvenile fish could have been biased toward related individuals.
Falls Creek Resident Dolly Varden Genetics	No (B1)	Yes (A1,B)	What: Genetic characteristics of resident population How: Microsatellite analysis, using 5 loci; 27 fish sampled. Where: Falls creek above proposed hydro development When: 2000 Who: Erika Leder Ref: Leder, E. 2001. Genetic Affinities and Population Differentiation among Dolly Varden of the Falls Creek Area; a preliminary Investigation. Draft report to NPS and Gustavus Electric. U Wisconsin, Madison. Comments: Not an extensive study, but sample size and homogeneity of genetics at these loci make the results quite solid and replicable.
Salmon - Stream Surveys	No	No?	Repository for lots of stream surveys and related data gleaned from various sources by Chad Soiseth. See *Freshwater fish distribution database inventory*: 1952-1994, above.
Salmon-stream Surveys - Historical	No	No	What: Various notes and surveys on salmon escapements and stream characteristics How: Visual observation Where: Various streams in park When: 1901-1990 Refs: Soiseth, C. Undated. Summary of Stream Surveys in Glacier Bay National Park and Preserve: 1952-1994. NPS/RM report in Library/Products/Publications. Schroeder, M. 1990. The Salmon Resources of Seven Spawning Streams Within GLBA, Alaska. Also see these reports in Archives: Moser, 1901;Prather & Mow, 1989, Mattson et al,, 1959; Huneke & Owens, 1966; Johnston, 1965; Cebula, 1963; Blackie 1989; Baade, 1954-55. See also Murrell (1975, 1977) in the second & third Dixon Harbor Biological Survey reports, and Marriott (1980) in the Lituya Bay Environmental Survey report. Comments: Of various quality. Some, notably Murrell & Marriott (see elsewhere) are replicable but cursory. Not generally useful as baseline material. This describes Freshwater fish distribution database and inventory above.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Salmonid Presence and Relative Abundance Survey	No	No	Seems to overlap with the above project. Has small amt. of data from Indian river and Wolf Point Creek minnow trapping in park database.
Boussole Lake & Valley Salmon – 1970-s	No (B1)	Yes (A1, B)	What: Salmonid populations and food habits How: systematic minnow trapping, stomach analysis; stream surveys; short-term use of weir Where: Boussole Valley & Lake, Dixon Harbor vicinity When: 1975 Who: Ed Murrell Refs: Murrell, E. 1977. Growth and August Foods of Juvenile Anadromous Dolly Varden and Coho Salmon in the Boussole Valley of GLBA. M.S. Thesis, University of Alaska, Fairbanks. Murrell, E. Freshwater and Anadromous Fishes. *In* Dixon harbor Biological Survey: final report on the summer phase of 1975 research. Streveler & Worley, eds. NPS, Juneau. Comments: Minnow trapping in Boussole Lake and Boussole Valley streams was done in a systematic fashion. In streams, each of 39 station were occupied twice in August about 20 days apart. In the Lake, 56 stations were trapped in August and a subset in September. Trap stations mapped with fair accuracy. Given the number and coverage of samples, this work would provide a reasonably good baseline. The escapement counts are not replicable.
Sockeye Salmon Mark & Recapture	No	No	What/where: Estimate escapement population estimates and sex ratios for East and Doame River sockeyes; construct correction factor for peak survey counts. How: Mark-recapture of adults to estimate escapement on East; visually assess sex ratio; on Doame, evaluate feasibility of providing similar program here. Ref: Tracy, M. 2004. East Alsek River Mark-recapture Experiment and Doame River Mark-recapture Feasibility Effort. Permit Appl'n to NPS Comments: Three years of data were collected to calibrate aerial survey estimates of sockeye escapement. Data exist in report form from ADFG. Results do not constitute a baseline.
General ecology/succession			
Stream Colonization	Yes (A1,B1)	Yes (A1,B)	What: Documentation of a number of biological & physical characteristics of at least 16 streams & their biotic communities Where: spread through the chronosequence

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			When: 1978-present. Who: Sandy Milner and a succession of students & collaborators Ref: Milner, A. 1983. The Ecology of Post-glacial Streams in GLBA, SE Alaska. Ph. D. Thesis. University of London. Sidle, R & A. Milner. 1989. Factors Influencing Stream Development in GLBA, AK. Arctic & Alpine Res. 21(4): 350-363. (nearly identical paper in 2nd Science Symposium). Milner, A. & R. Bailey. 1989. Salmonid Colonization of New Streams in GLBA, AK. Aquaculture & Fisheries Mgt 20:179-192. Adamson (Flory), L. 1996. Invertebrate Community Development in a New Stream in GLBA, Alaska. Phillips, I. 1999. The Influence of Wood on the Ecology of Stream Invertebrates. Ph. D Thesis, U Birmingham. Milner, A. & I. Phillips. 2000? The Role of Riparian Vegetation and Woody Debris in the Development of Macroinvertebrate Assemblages in Streams. Unpublished manuscript. Robertson, A. & A. Milner. 1999. Meiobenthic Arthropod Communities in New Streams in GLBA, Alaska. Hydrobiologia 397: 197-209. Milner, A. et al. 2000. Colonization and Development of Stream Communities Across A 200 Year Gradient In GLBA, Alaska. Can. J. Fish. Aquatic Sct. 57:2319-35. Milner, A.M. and I.T. Gloyne-Phillips (2005) The role of riparian vegetation and woody debris in the development of macroinvertebrate assemblages in streams. *Rivers: Research and Application* 21:403-420 Robertson, A. & A. Milner. 2006. The influence of Stream Age and Environmental Variables in Structuring Meiofaunal Assemblages in Recently Deglaciated Streams. Limnology, Oceanography 5(3): 1454-1465. Veal, A.J. (2004) The ecology of Stonefly Creek in Glacier Bay National Park. PhD thesis, University of Alaska. McDermott, M. (2006) The Lotic Meiofaunal Community of a Recently Deglaciated Stream. Ph. D. Thesis, Roehampton University. Comments: Some of these streams, notably Berg Bay North & South (numerous visits), Ice Valley (numerous visits) , several in Wachusett Inlet (Stonefly Creek,1997-present), and Vivid Lake Creek, have long-term data that can be repeated. Milner cites the existence of such sites on 5 streams in his 1987 paper. Sampling sites initially set up by Milner are located in his thesis; GPS coordinates now available. Other sites are described in several of

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			the above works.
Wolf Creek Watershed Monitoring;	Yes (A1, B1)	PRIME (Ab)	What: Long term monitoring of environmental and biotic variables within one watershed in connection with a study of stream development How: Various qualitative & quantitative measures Where: Wolf Point Creek along the W shore of Muir Inlet When: annually, 1977-present Refs: Milner, A. 1993. Community Development in Wolf Point Creek, GLBA, Alaska. *in* Proceedings of the Third Glacier Bay Science Symposium , Engstrom, ed. NPS, Anchorage. Milner, A.M. (1987) Colonization and ecological development of new streams in Glacier Bay National Park, Alaska. *Freshwater Biology*. 18:53-70. Milner, A.M. (1994) Colonization and succession of invertebrates in a new stream in Glacier Bay, Alaska. *Freshwater Biology*. 32:387-400 Adamson (Flory), E. 1996. Invertebrate Community Development in a New Stream in GLBA, Alaska. PhD Thesis, U of Sterling, UK. Milner, A et al. 1999. Invertebrate Community Development in a New Stream in GLBA, Alaska: a Long Term Record *in* Friberg & Carl (eds) Biodiversity in Benthic Ecology, Denmark. NERI Tech Rept No. 266.. [*includes discussion of fish colonization*] Flory, E. and A. Milner. 1999. Influence of Riparian Vegetation on Invertebrate Assemblages in a Recently formed Stream In GLBA, Alaska. J. N. Am. Benthol. Soc. 18(2):261-273. Flory, E. & A. Milner. 2000. Macroinvertebrate Community Succession in Wolf Point Creek, GLBA, Alaska. Freshwater Biol. 44:465-580. Flory, E.A. and A.M. Milner (1999) The role of competition in invertebrate community development in a recently formed stream in Glacier Bay National Park, Alaska. *Aquatic Ecology* 33:175-184 Monaghan, K. 2000. The Effects of Fish Colonization on the Invertebrate Community Succession in a New Stream, Alaska. Ph.D Thesis, U Birmingham. McDermott, J. The Lotic Meiofaunal Community of a Recently Deglaciated Stream. Ph. D. Thesis, Roehampton University. Milner, A. , et al. 2004. Ecological Development of the Wolf Creek Watershed from 1971 to 2001: a 25 year record. Abstract, 4th GB Science Symposium, Juneau. Comments: Milner's 2005 fish collecting permit refers to a long-term sampling site on Wolf Point Creek, at which most of the data from the cited reports were taken. Nearly annual

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			records exist of numerous stream characteristics from this stream, many of which have been quantitatively sampled. Changes over time have been sufficiently large to be portrayed with considerable confidence, providing perhaps the most data-rich & protracted baseline for any system in the park.
Falls Creek Aquatic Biota	Yes (A2,B))	PRIME (Ba)	What: Inventory of stream habitat types, fish populations and benthic invertebrate divedrsity/biomass index How: Stream surveys for adult salmonids, trapping; snorkeling and mark/recapture for juveniles and upland Dolly Varden population; systematic Surber sampling of aquatic invertebrates in lower Falls Creek as Where: Falls Creek and associated drainages When: 1999-2001 Who: Liz Flory Refs: Flory, E. 1999. Fish and Fish Habitats of the Falls Creek Area. Icy Strait Env. Svcs. Rept to Gustavus Electric, Gustavus. Flory, E. 2001. Resident Dolly Varden, Anadromous Fish Species and Benthic Invertebrates of the Falls Creek Area, 2000. Icy Strait Env. Svcs. Rept to Gustavus Electric, Gustavus. Comments: Extremely important study in area of future hydro site. Upland Dolly Varden population estimation, stream habitat map, and invertebrate index especially replicable.
Lakes			**Parts of this section are also directly related to work by Eckert, Nagorski & Hood water quality synopsis**
Lake Evolution	No (B1)	Yes (A1,B)	What: Compared modern chronosequence with a temporal record based on lake sediments, to define the sorts of trajectories lakes go through during watershed maturation How: Sampled ~ 30 lakes 3+ times over 3 years for water chemistry and diatoms; once each for a sediment core. : Measuring hydrologic, chemical and biotic parameters of lakes in chronosequence; sampling of diatoms, etc. in stratigraphy of lake bottoms. When: 1988-90 Where: Lakes throughout the park and on Pleasant Island. Refs: Engstrom, D, et al. 2000. Chemical and Biological trends during lake evolution in Recently Deglaciated Terrain. Nature 408:161-166. Fritz, S. et al. 2004. Patterns of Early Lake Evolution in Boreal landscapes: a Comparison of Stratigraphic Inference with a Modern Chronosequence at Glacier Bay, Ak. Engstrom, D., S.Fritz and S Juggins. 2004. Patterns of Early Lake Evolution in

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			GLBA: a comparison of sediment records with a classic chronoseqence. Abatract, 4th GB Science Symposium, Juneau. Comments: Lakes not precisely located in published materials but almost certainly available from investigators. Again, study not designed as baseline, but can be used as such over a larger scale, especially for differences in water chemistry that might occur on a regional scale, since these data can be controlled for succession.
Lake Extents GIS Layer	No(B1)	Yes (A2,B) (A2, B)	What: Layer of GLBA Lakes based on 1996 digital orthophoto quads (which cover ~80% of park) Who: Bill Eichenlaub Comments: This work by Bill is an example of the sort of precise mapping now possible electronically from georeferenced photography. It provides a precise baseline of lake extent as of the time of photography.
Lake algae, diatoms & Invertebrate successional history	No (B1)	Yes (A2,B)	What: documented algal, diatom (benthic, planktonic) and zooplanktonic populations in space and time, using the same set of lakes used by Engstrom et al. to study general lake chemical evolution. How: direct measurement of existing biota; inference from remains in lake sediments. When: 1988-90 (& possibly later) Where: Lakes throughout the park and on Pleasant Island. Who: Olaf Olson, Craig Williamson, the Engstrom team Refs: Olson, O. 1998. Mechanisms of Long-term Change in Periphytic Diatom Community Structure. PhD thesis, Lehigh U. (I haven't seen this ref.) Olson, O. G., D. R. Engstrom, et al. (1995). Long-term changes in zooplankton community structure inferred from chronosequence of lakes in Glacier Bay National Park, Alaska. Third Glacier Bay Science Symposium, Glacier Bay National Park & Preserve, AK, U.S. National Park Service. Williamson, C. et al. 2001. Ultraviolet radiation and Zooplankton Community Structure Following Deglaciation in Glacier Bay, Alaska. Ecology 82(6):1748-1760. Comments: Uses same lakes as does Engstrom. Lakes shown on map in sufficient detail to relocate. Careful work that is in large part replicable; could become critical if UV rates go up due to ozone depletion.
Lake Hydrology/Chemistry Relationships, Lester Island	No(B1)	Yes? (A1?,B?)	What: Details of water input type and pattern as determinant of water chemistry. How: Piezometers, and weirs on inlet streams Where: Three small lakes on Lester Island When: not specified, but probably 1988

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Who: Jim Almendinger Ref: Almendinger, J. E. (1990). Hydrologic control of lake chemistry on Lester Island. Second Glacier Bay Science Symposium, Glacier Bay National Park & Preserve, AK, U.S. National Park Service. Comments: Lakes are specified, but details of design not specified, and only data summary presented. Water quality data given in Engstrom study (see above). If investigator can provide more details on hydrology & monitoring scheme, probably is a valuable baseline, especially in concert with other Engstrom stuff.
Lake Productivity with Relation to Sockeye production	No (B1)	Yes (A1,B)	What: Measurement of nutrient levels, light penetration, chlorophyll production and zooplankton populations How: Standard methodology for each parameter. When: 1990 (May & Aug) – 1991(4 times, June-Aug) Where: Berg bay north upper and lower lakes; Vivid lake. Who: Sandy Milner Ref: Milner, A. 1992. Lake Productivity with Relation to Sockeye Salmon Production in GLBA. UAA, Anchorage. Comments: Methods well spelled out. Sufficient samplings to allow use as baseline for summer conditions in the lakes.
Impacts (including fishing)			
Bartlett River Coho Creel Survey	No (B2)	Yes (A1,B)	What: Survey of coho catch How: Creel survey Where: Bartlett River When: 1996-98, 20 days/yr over ~45 day season. Who: Chad Soiseth, Kathy Smikrud Ref: Soiseth, C. and L. Adamson (1998). Glacier Bay National Park and Preserve Bartlett River Recreational Fishing survey and bear education campaign, 1996-1997 seasons, U.S. National Park Service, Glacier Bay National Park and Preserve. Comments: Draft in progress by Soiseth, currently incorporating NPS reviewer comment. Will likely be published as NPS WRD technical publication. Chad has calculated confidence limits for the catch data; major changes in total catch would have to occur to be noted by a re-survey. CPUE, however, is more tightly constrained, and may be a better

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			measure against which to contrast change.
Charter Sportfishing Logbook Program	Yes (A2,B2)	Yes? (A1?,B)	What: Survey of marine and freshwater charter and guided client effort, catch, and harvest. How: creel survey When: 1995-Present Where: Park-wide including Preserve Who: Chad Soiseth Ref: Access data table exists. Data queries exist but data has not yet been summarized and no final/annual summary exists Comments: If treated in aggregate, may give a reasonable sample of harvest and CPUE trends for period of record. Should allow some level of comparison to a future survey. Effort, catch and harvest are self-reported by charter captains with little independent assessment of accuracy. Data accuracy and reliability are suspect and information for some individuals is known to be inconsistent and probably not very reliable. Moreover, a significant recall bias likely exists.
Dundas/ Seclusion River Charter Harvest	Yes (B2)	Yes? (A1?,B)	What: Survey of coho and Dolly Varden catch How: creel survey When: 1997-2000, 7-26 visits/yr Where: Dundas/Seclusion River Who: Chad Soiseth Ref: Data in project tracking, summarized but not statistically treated Comments: 50-140 anglers contacted. If treated in aggregate, may well give a reasonable sample of harvest and CPUE for that general period. Should allow some level of comparison to a future survey. . This is part of a longer term (since 1995) and ongoing catch and harvest monitoring program of permitted charter operators. Catch and harvest reporting were self-reported by charter anglers and data accuracy and reliability is considered suspect by Chad.
Fisheries - Dry Bay	No	No	No data found. Seems to be a general category of Chad's for keeping track of literature and BOF activities relative to the fishery
Dry Bay Subsistence and Personal Use	No	No	Not a subject appropriate to present purposes

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Terrestrial			
Bedrock geology			
Bedrock Geology	No	No	Purpose is to classify and map geologic formations
Tectonic Elements and Plutonic Belts	No	No	General description of regional tectonic history
Landform dynamics			
Collapsing Kame Terrace, Adams	No (B1)	Yes (A2, B)	What: Detailed measurement of a landform undergoing rapid change How: careful field mapping and fixing of elevations Where: SW Adams, White River watershed When,: Summer 1968. Who: Gary McKenzie Ref: McKenzie, G. 1969. Observations on a Collapsing Kame Terrace in GLBA, SE AK. J. Glaciology 8(54):413-425. Comments: Very well described and measured. Replicable. If the park were ever to get into monitoring the evolution of postglacial landforms, this would be a prime candidate
Casement& Burroughs Forelands Landforms	No (B1)	Yes (A2,B)	What: Detailed mapping of landforms How: aerial and foot recon; photos Where: Casement and Burroughs Glacier Forelands When: 1962-63; 1969-70 Who: Roy Welch, Robert Price, Dave Mickelson Refs: Welch, R. 1964. The Form and Origin of Landforms Produced During the Wastage of Casement Glacier, Alaska. M.S. Thesis, University of Oklahoma. Price, R. 1964. Land Forms Produced By Wastage of the Casement Glacier, Southeast Alaska. IPS Rept #9. Mickelson, D. 1971. Glacial Geology of the Burroughs Glacier Area, Southeastern Alaska. IPS Rept #40. Mickelson, D. M. and N. R. Ham (1995). Thirty years of glacier process studies at Burroughs Glacier, Wachusetts Inlet, Glacier Bay, Alaska. Proc. 3rd Glacier Bay Science Symp, 1993, Gustavus, Alaska, USNPS. Comments: Each of these studies produced detailed maps and photos of landforms which

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			could be monitored for changes over time. Mickleson (1993) pesents an important chronology of studies
Cave Inventory	No	No	What, where: Survey to locate caves/karst on "Little White Cap" mtn east of Dundas Who: Kevin Allred & Wayne Howell. mountain, Dundas. Ref: Report in: K:\Resource Mgmt\Cultural\Caves\Caves Report.doc
Interstadial Wood - Tree Ring Analyses	No	No	What, where: Purpose to reconstruct paleoclimate of glacier Bay How: analysis of tree rings Who: Dan Lawson. Ref: Lawson, D., G. Wiles, et al. (2005). A dendroclimatic record of paleoclimate of the last 10,000 years, Glacier Bay National Park and Preserve: 2005 Progress report. Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory**:** 6 pp. Comments: baseline only in the most general sense.
Tidal Inlet Landslide	Yes (A2,B2)	PRIME (Aa, Ba)	What: history and present status of a rock mass poised to slip catastrophically and generate a giant wave, along with modeling of the likely wave. How: precise measurement and description of rock mass, with special reference to its size and exact position. Permanent GPS stations installed, allowing exact (to the cm) detection of incremental change in position. Where: Tidal Inlet, N shore When: First measurements made 2002; revisited at least once since then. Who: Gerald Weiszorek, Roman Motyka Ref: Weiczorek, G. et al. 2003. Preliminary Assessment of a Landslide-induced Wave Hazard: Tidal Inlet, GLBA, AK. USGS Open File Rept 03-100. Comments: The purpose of this work is to allow precise replication of measurements of the rock mass's behavior. And of course this is a critical management concern.
Isostatics/Tectonics			
Rapid Uplift of Southeast Alaska (*also includes* Tide Gauge Records of Uplift, Uplift and Seismicity)	Yes (A1,B2)	PRIME (Aa)	What: Ice unloading in Glacier Bay during Little Ice Age and subsequent landscape changes How: Precise GPS measurements of uplift rates; estimation of past rates by geomorph interpretation Where: Throughout park lowlands When: 1999-2004 Who: Chris Larsen, Roman Motyka

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Ref: Larsen, C et al. 2004. Glacial isostatic Rebound Models for Rapid Uplift in Southeast Alaska. Geophys Inst, U Alaska. Powerpoint program and Abstract, 4th GB Science Symposium, Juneau. Also, Larsen's thesis is on his website. Comments: Most of this study is historical; however, the precise uplift measurements are highly replicable, even on a short timescale.
Gravity Measurements	No (B1)	Yes (A2,B)	What: Gravity measurements How: Portable gravimeter Where: Gustavus airport When: 1968-1988 Who: Dave Barnes Ref: Barnes, D. 1990. Gravity, gravity-change and other geophysical measurements in Glacier Bay National Park and Preserve. Second Glacier Bay Science Symposium, Glacier Bay National Park & Preserve, AK, U.S. National Park Service. Comments: Barnes says that the Gustavus measurements are the only ones in the park vicinity precise enough to detect decadal gravity changes, if any (none have been detected yet). (Gravity measurements are critical in sorting out isostacy from tectonics when interpreting uplift)
Plate Boundary Observatory at Cape Spencer	Yes (A2,B2)	Yes (A1,B)	What: Earthscope observatory installation to monitor plate boundary as part of global network How: Install precision GPS and strainmeter When: to be installed in 2006 and operated indefinitely Where: Cape Spencer Who: Michael Jackson, Kyle Bohnenstiehl, Ben Pauk Ref: Permit application in park electronic files Comments: An excellent monitoring subject
Fairweather Fault Monitoring – 1960's	No (1)	Yes? (A2?,B?)	What: Survey of landform changes and microearthquatke activity along fault trace How: site visit and seismograph recording When: June 1968. Where: East of Crillon Lake Who: Robert Page Refs: Page, R. The Fairweather Fault Ten Years After the Southeast Alaska EarthQuake of 1958. Unpublished report in Barco library Archives. Page, R. 1969. "The Fairweather fault ten years after the southeast Alaska earthquake of 1958." Seismological Society of America Bulletin 59(5): 1927-1936.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Comments: Observation site probably cannot be precisely relocated from printed descriptions & photos, and since scarp was cut into soil, traces of the fault would probably be very obscure. However, probably replicable record of microearthquake activity.
Fairweather Fault Monitoring – modern	Yes? (B2?)	Yes (A1,B)	What: lateral crustal motions relative to the Fairweather (and Chatham Strait) faults How: Precise GPS monitoring Where: Throughout park lowlands When: 1999-2004 Who: Chris Larsen, Roman Motyka, David Freymueller Ref: Larsen, C et al. 1994. Tectonics of Southeast Alaska. Geophys Inst, U of Alaska, Fairbanks. Powerpoint presentation at 4th GB Sci Symposium Comments: Precision work; definitely replicable. Note relationship to Jackson project, above
Glaciers			
Glacial Thinning	Yes (A1,B2)	PRIME (Ab)	What: precise documentation of the surface elevations of selected glaciers in the park to detect changes in their rates of ablation & accumulation. How: remote sensing from satellites and aircraft When: last several years & ongoing, with retrospective based on usgs topomaps Where: A series of glaciers around the park, including Muir, Casement, Margerie , Hopkins, Brady [and others]. Who: Keith Echelmeyer. Refs: Arendt, A., K. et al. 2002. Rapid wastage of Alaska glaciers and their contribution to rising sea level. Science 297:382-386. Comments: Data specific to Glacier Bay are "soon to be published" according to Etherington. This work is of the first importance as background to many sorts of drivers and changes in park ecosystems.
Glacier Change Photography	Yes (A1,B1)	PRIME (Aa,b)	What: Monitoring the position of glacier termini in the park] How: Establishment and reoccupation of ground-based photo stations; aerial photography When: 1926 – present Where: Many glaciers throughout park Who: W.O. Field & son, Austin Post, Bruce Molnia, David Harris, others. Refs: Field, W.O. Glacier Bay Ice Termini Photos & observations, 4 volumes many small reports in NPS Library Archives

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Post, A. photo collection in his private library and USGS archives, Tacoma(?) Streveler, G & S. Brown. 1997. Recommendations for Continued Occupation of the W.O. Field Photostations. Icy Str. Env. Svcs. Rept to NPS Clague, J. & S. Evans. 1993. Historic Retreat of Grand pacific And Melbern Glaciers, St. Elias Mountains., Canada. J. Glaciology 39(133):619-624. Comments: Bruce Molnia has taken this project over; to my knowledge has not produced a report, but results are on a website.
Glacier Dynamics	No	No	What,where: History of glacial advance retreat in Glacier Bay during late Holocene Who: Dan Lawson; Cathy Connor, Greg Streveler Comments: not relevant to the present purposes
Glacier Mass Balance in relation to Climate and conditions at the terminus	No (B1)	PRIME (Aa,b,c)	What: Multivariate study of bathymetry, topography, climate and glacier mass balance. How: bringing together much existing data and collecting original data in Tarr and Muir Inlets on details of sediment flux and micro bathymetry. Where: Glaciated parts of park, with particular emphasis on Tarr & Muir Inlets When: 1990-1992 Who: Lewis Hunter, Ross Powell Ref: Hunter, L. 1994. Grounding-line Systems and Glacier Mass Balance of Modern Temperate Glaciers and their Effect on Glacier Stability. Ph.D. Thesis, Northern Illinois U. Hunter, L. E. and R. D. Powell (1995). Climatic controls on glacier mass balance in Glacier Bay National Park and Preserve, Alaska. Proceedings of theThird Glacier Bay Science Symposium, Glacier Bay National Park & Preserve, AK, U.S. National Park Service. Comments: synopsis of AAR positions over time is a very useful baseline complementary with the Echelmeyer work (see also comments in climate section).
Crillon Glacier Studies	No (B1)	Yes (A2, B)	What: Measurements of ice flow, air temperature, lake depths, frontal position How: flow rates by theodolite on fixed markers and ice frontal features; depths by direct soundings; temps by thermograph. Where: Crillon Lake vicinity When: 1933-34, 36; 1961. Who: Dick Goldthwait, Ian McKellar, Caspar Kronk, Brad Washburn Refs: Goldthwait, R. 1936 Crillon glacier Glacial motion sheets, graphs of motion and temperature thermograph sheets. Data in Barco Library archives. Goldthwait, R. et al. 1963. Fluctuations of Crillon Glacier System, Southeast Alaska. Int'l Assoc. Sci. Hydrol Bull. 8(1):62-74. (Manuscript in Barco library archives).

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Comments: Methods well spelled out. The flow rates measured should, if summed, be comparable to measurements made today.
Relict Neoglacial Ice - Lituya	No	No	What: Investigated of a drunken forest How: Foot & aerial photo recon Where: near Fish Lake, Lituya When: 1973. Who: Austin Post & Greg Streveler Ref: Post, A. & G. Streveler. 1976. Tilted Forest: Glaicological-geologic Implications of Vegetated Neoglacial Ice at Lituya Bay, Alaska. Quaternary Research (6): 111-117. Comments: The itinerary and excavation site for ice is located reasonably precisely, as is the outer limit of drunken forest at that time. Replicable
Soils			
Soil Development & Chemistry	No (B1)	Yes (A2,B)	What: Soil development along the Glacier Bay (and outer coast) Chronosequence How: Soil description on surfaces of various ages When: over many years Where: Mostly along east side of Glacier Bay, but also on outer coast (Ugolini) Who: cast of thousands Refs: Crocker, R. & J. major. 1955. Soil Development in Relation to Vegetation and Surface Age at Glacier Bay, Alaska. J. Ecology 43:427-448. Ugolini, F. 1966. Soils. *in* Goldthwait, et. Soil Development and Ecological Succession In a Deglaciated Area of Muir Inlet, Alaska. IPS Rept #20. Ugolini, F & D. Mann. 1979. Biopedological Origin of Peatlands in Southeast Alaska. University of Washington. Ugolini, F. 1980. Soils. *In* Lituya Bay Environmental Survey, Streveler, Worley & Molnia, eds. NPS, Gustavus. Bormann, B. & R. Sidle. 1986. Changes in Productivity and Distribution of Nutrients in a Chronosequence at GLBA, Alaska. J. Ecol (78):561-78. Stottlemeyer, R. 1988. Effects of Ecosystem Succession on Soil and Streamwater Chemistry in Glacier Bay. *in* Proceedings of the Second Glacier Bay Science Symposium, Milner & Wood, eds. NPS, Anchorage. Hobbie, E. et al. 1993. A Stable Isotopic Investigation of Nitrogen Dynamics at Glacier Bay, Alaska. *in* Proceedings of the Third Glacier Bay Science Symposium ,

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Engstrom, ed. NPS, Anchorage Fastie, C. 1994. Two Centuries of Primary Succession at Glacier Bay, Alaska: a Test of a Classic Glacial Retreat Chronosequence. Ph.D. Thesis. University of Alaska Chapin, F., et al. 1994. Mechanisms of Primary Plant Succession Following Deglaciation at Glacier Bay Alaska. Ecological Monographs 64 (2): 149-175. Comments: as a group, these works give a good picture of soil development, but the only ones whose work is located precisely enough (in the material available to me) to be approximately replicable are Ugolini (1966), Chapin, & Fastie. Ugolini (1980) may be, if the Weisbrod transects he used are relocatable.
Microbial Utilization of Salmon-derived Nutrients	No	No	What: Change in riparian microbial communities along chronosequence as a consequence of nutrient dynamics related in part to presence/absence of salmon How: Sample soils at one site each near mouths of 3 streams for biogeochemical and molecular analysis. When: 2006 Where: Wolf Point, Ice Valley and Berg Bay South creeks Who: Eran Hood, Scott Gende, Cory Cleveland Ref: project proposal in park electronic files Comments: intended as pilot study to inform a larger proposal to NSF
Plants			
Actinorhizal Rosaceae	No	No	What: Exploration of symbiosis between Dryas and commensal cyanobacteria Who: Van den Heuvel. Comments: not relevant in present context
Botrychium Collection	No	No	What: collections of the genus for park and elsewhere to work out systematics Who: Mary Stensvold, USFS Comments: not relevant in present context
Dry Bay Vegetation	Yes (B1)	Yes (A2, B)	What: Part of the GB landcover map effort (see below), with the addition of retrospective mapping. How: See landcover map, below; in addition, mapped from 1948 & 1966 photos using same protocols to make comparisons over that time period. When: 2004 Where: Preserve Who: Susan Klein did the mapping

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Ref: The 1996 data is incorporated into the Park Landcover Map; earlier maps produced separately Comments: The coarse-grained, somewhat arbitrary (and mapper-specific) nature of community boundaries preclude use as baseline to detect minor change. Large change over time or space will be detected. Photos from ground-truthing are a valuable adjunct.
GLBA Plant Inventory	No	No	What: Vascular plant field inventory How: Directed site surveys Where: whole park When: 2001-03 Who: Rob Lipkin & crew Ref: Carlson, M & R. Lipkin. 2004. GLBA Vascular Plant Inventory; final technical report. ANHP, Anchorage. Comments: This is a key inventory reference, but does not lend itself to monitoring
Landcover Map	No (B1)	Yes (A2, B)	What: Map of plant communities How: Mapped from 1996 airphotos with ground-truthing to document species presence/abundance. Accurately located photos from ground-truthing. Where: In vegetated regions of park When: Field work, 2004 Who: Jess Grunblatt, Keith Boggs, several others (notably Susan Klein, the mapper from photos) and Koren Bosworth (taxonomy) Ref: Draft map produced as of 5/06. Comments: The coarse-grained, somewhat arbitrary (and mapper-specific) nature of community boundaries preclude use as baseline to detect minor change. Large change over time or space will be detected. Photos and notes from ground-truthing are a valuable adjunct.
Moss Colonization of the Walker Glacier	No	No	What: Survey level data in course of working on provenance of the Tat River "Iceman" Who: James Dickson. Comments: not relevant in present context
Permanent Quadrats at GB - Cooper	Yes (A2,B2)	Yes (A1,B)	What/where: total of nine $1m^2$ quadrats placed in Teacup Hbr vicinity (6) and on Island in Hugh Miller mouth (3). Hugh Miller quadrats expanded by Juday in 1991 to include a larger area for statistically valid monitoring of large woody plants. How: photography and mapping of plants in quadrat When: All monitored by Cooper through his 4th expedition in the late '30's. All but the two

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			at Hugh Miller subsequently lost (but possibly relocatable). Refs: Cooper, W. 1923. The Recent Ecological History of Glacier Bay, Alaska. (section III has plot locations Ecology 4: 93-128;223-246;355-365. Cooper, W. 1931. A Third Expedition to Glacier Bay, Alaska. Ecology 12: 61-95. Cooper, W. 1939. A fourth Expedition to Glacier Bay, Alaska. Ecol 20(2):130-155. Juday, G. et al. 1991. Ten Years of Successional Change on the Hugh Miller Inlet Plots. U Alaska Ag & Forest Expt Stn rept to NPS. Comments: These 9 plots are the longest monitored permanent quadrats of any sort in the region. Of great historical interest, being established by the "father" of the park, now all lost but two on an island in Hugh Miller Inlet (Is it possible that the others could be re-found?). Ian Worley most likely has the data from the interval 1941- 1975 (Lawrence's & Worley's data). Noble I believe did another occupation in the 1980's. Juday, Worley, Noble may have the post-Cooper data. Sue Hazlett may be working on this. On these, the Initially a small sample size (one square meter), has been greatly augmented by Juday's expansion. Given a prime ranking because I just had to based on the plots' longevity.
Permanent Vegetation Study Plots	Yes (A2,B2)	Yes (A2,B)	What: Variations in forest structure and history along the E shore of Glacier Bay and their historical/ecosystemic implications. How: 10ea 10ha areas used as study areas. 10ea 150m^2 plots sampled in each & permanently marked. Silvicultural measures made in each; cores from living and dead trees, among other, measures, used to reconstruct past stands and history of nutrient availability. Soil chemistry/structure documented Where: Ten localities from Bartlett Cove to Muir Inlet When: 1987-91; revisited in 1995-6; partially in 2004 - 2005 Refs:Fastie, C. 1994. Two Centuries of Primary Succession at Glacier Bay, Alaska: a Test of a Classic Glacial Retreat Chronosequence. Ph.D. Thesis. University of Alaska Fastie, C. 1995. Causes and Ecosystem Consequences of Multilpe Pathways of Primary Succession at Glacier Bay, Alaska. Ecology 76(6):1899-1916. Comments: Fastie's plots are marked with metal stakes. Great opportunity for add'l permanent plot establishment. Need to think how to compare with Carstensen/Noble and Eglitis/Schultz plot data.
Primula Biogeography	No	No	What: study looks at genetics of the genus over a broad geographic range, using small samples from GLBA Who :Guggisberg Comments: too cursory

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Spruce Seedlings Survival	No	No	Seedlings from the Chapin/Fastie study, now all removed
Nitrogen Fixers in early Succession	No	Yes (A1,B)	What: mapping of nitrogen fixers on surfaces of two ages in comparison to soil parameters How: Plant mapping in circular plots along a transect along with soil description and chemistry. Where: N end of Wachusett Inelt When: Summer, 1991 Who: Steve Kohls, Don Lawrence Ref: Kohls, S. J. and D. B. Lawrence (1995). Nitrogen fixers in early primary succession on surfaces of two ages at Wachusett Inlet, Glacier Bay National Park and Preserve, Alaska. Third Glacier Bay Science Symposium, Glacier Bay National Park & Preserve, AK, U.S. National Park Service. Comments: Not a large study, but well described and executed. Site relocatable
Vegetation Mapping, Falls Creek	No (B1)	Yes (A2, B)	What: Plant community maps, inventory of notable species How: mapping from air photos with abundant ground truthing and plant identification Where: Lower Falls Creek watershed and vicinity, including parts of Gustavus and the park after the land trade. When: 1999-2000 Who: Koren Bosworth, Greg Streveler Refs: Bosworth, K & G.Streveler. 1999, 2001. Plant Communities, Rare or Sensitive Plant Species, and Wetlands of the Falls Creek Area. Icy Strait Env. Svcs. Repts to Gustavus Electric, Gustavus. Comments: Somewhat arbitrary (and mapper-specific) nature of mapped community boundaries preclude use as baseline to detect minor change. Large change over time or space will be detected; especially valuable given the changes wrought by hydro development.. Species list from the various communities gives baseline against which to compare arrivals of invasives and possible loss of rare/sensitives.
Plan Community Analysis – Dixon Harbor Area	No	No	What: classification and structure of plant communities How: Describe community types from visual impression; test types by ordination of species presence/abundance sampling of community types, using a protocol developed for this study. Where: Dixon habor – Torch Bay vicinity When: 1973-75 Who: Ian Worley, Greg Streveler Refs: Worley, I & G. Streveler. 1973. Plant Communities. *in* Dixon Harbor Biological

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Survey: final report on the summer phase of 2003 research. Streveler, Worley, Terry, Gordon. NPS, Juneau. Worley, I & G. Streveler. 1975. Plant Community Analysis. . *in* Dixon Harbor Biological Survey: final report on the summer phase of 2004 research. Streveler & Worley, eds. NPS, Juneau. Worley, I. 1977. Plan Community Analysis. *in* Dixon Harbor Biological Survey: final report on the summer phase of 2005 research. Streveler & Worley, eds. NPS, Juneau. Comments: Thorough characterization, but not sufficiently tied to sites to replicate
Dryas studies	No(B1)	No? (A1?,B?)	What: nitrifiying effect of Dryas on surrounding vegetation How: series of obs & experiments on Dryas effects on growth rates of other plants, especially cottonwood. When: 1940's-1950's Where: bench between Goose and Nunatak Coves Who: Don Lawrence Ref: Lawrence, D. et al. 1967. The Role of *Dryas Drummondii* in Vegetational Development Following Ice Recession at Glacier Bay, with Special Reference to Nitrogen Fixation by Root Nodules. J. Ecol. 55:793-813 Comments: If plots relocatable, would allow revisitation of a number of cottonwood trees known since seedlings. Lewis Sharman has large packet of info about location of Lawrence "farm". behind Goose Cove.
Forest Community Responses to Bark Beetles	Yes (B1)	PRIME (Ac)	What: Documenting vegetational response to mortality of spruce dominants How: Established 100ea 1m^2 plots (for small scale features) & 9 ea 18m x 18m (for larger scale ones) When: Established in 1984; partially remapped & re-photographed in 1992 and 1997. Where: Lester, Young, Bartlett Cove, Bartlett River trail Who: Richard Carstensen, Mark Noble, Cathy Pohl Ref: Carstensen, R, et al. 1993. Forest Community Responses to the Bark Beetle Infestation at Glacier Bay, Alaska, 1984-1993. Unpublished ms in Streveler files. Comments: The 1997 data are unpublished. This work is meticulous and detailed; a very important adjunct to the USFS beetle effects work.
Mechanisms of Plant Succession	No (B1)	Yes (A1,B)	What: Sophisticated, multifaceted investigation of the relationships among seral dominants Where: along the classic east shore transect from Muir Inlet to Bartlett Cove. How: 4ea 2km^2 study areas, within each of which 10 intensive sites. Measured soil paramaters, radiation, life history & growth stage traits of dominants. Spruces & alders

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			planted in some experiments and later harvested. When: 1983-87; plantings harvest finished 2004 Who: Terry Chapin, Lars Walker, Chris Fastie, Lewis Sharman Ref: Chapin, F., et al. 1994. Mechanisms of Primary Plant Succession Following Deglaciation at Glacier Bay Alaska. Ecological Monographs 64 (2): 149-175. Comments: VERY IMPORTANT STUDY. Study areas relocatable. Soil measures, max plant height, max stem diameter replicable. Didn't give it a PRIME only because the replicable measures may not be of great interest.
Primary vs. Secondary Succession	No (B2)	No? (A2, B?)	What: Contains some data on nature of wave scar succession at Lituya. How: Verbal description and some quantitative data from a lowland site Where: Lituya Bay. When: 1977 Who: Don Lawrence Ref: Lawrence, D. 1979. Primary versus Secondary Succession at GLBA, SE Alaska. *In* proc. Of 1st Conf on Sci Res in the National Parks. New Orleans, LA. NPS, Washington, D.C. Comments: Based on one day's work. Study sites may have been permanently marked. This may be evident in Lawrence's field notes, which I think are at U Minn.
Eider Island Vegetation transect	No (B1)	Yes? (A2, B?)	What: Vegetation transect How: belt transect from top of island to lower limit of plants; transect marked by iron stakes Where: Eider Island, Beardslee Entrance When: about 1970 Who: Cliff Estabrook, seasonal ranger/nat Ref: Should be report and data in Estabrook's notes; haven't found Comments: If this work is still around, and if the stakes are still there, this would be a valuable though limited baseline against which to measure, for instance, the progress of invasive species. My recollection is that Estabrook had study sites also in the upper Beardslee islets N of Forxfarm Island and maybe also on what is now called Boulder Island (formerly Ascention Island).
Birds			
Bald Eagle Movement	No (B1)	No (A1)	What: Monitored eagle movements How: Tracked movements of 20 Adult and fledgeling eagles by satellite and conventional

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			telemetry. When: 1991-1993. Where: Eagles tagged in Glacier Bay; tracked within park and as far away as Haines and Prince Rupert. Who: Mary Kralovek Ref: Kralovek, M. 1994? Bald Eagle Movements In and From GLBA, Alaska. Virgina Poly, Blacksburg, VA. Comments: Reasonably good sample size and range of ages. If replicated by capture from the same general areas, should be fair inedicators of changes in eagle movement patterns.
Bald Eagle Nest Monitoring	Yes (A1,B1)	PRIME (Ab,Ba)	What: Eagle Nest location & productivity surveys How: Systematic vessel surveys from offshore, mostly from vessels, though Robards also used helicopter. All surveys enumerated active and inactive nests; most also recorded presence of eaglets and other immatures as indices of productivity. Where: Glacier Bay When: 1966 – 2002. Who: Mary Kralovek & other NPS (Bren Harrington, Jeff Mow, Steve Prather, Hank Lentfer, Annie Farrris); Fred Robards, Stanley Cain & other FWS Refs: Robards, F & J. King. 1966. Nesting and Productivity of Bald Eagles, Southeast Alaska – 1966. Bureau of Sport Fisheries & Wildlife, Juneau. Wik, O. 1971 field notes, containing survey of eagle nests in Glacier Bay. NPS, Gustavus. (I haven't found these). Cain, S. 1982. Eagle Population an dNest Survey of glacier Bay – Trip Report. USFWS, Juneau. Jones-Toscano, E et al. 1983. Eagle Nest Survey, GLBA. NPS, Gustavus. Harrington, b. 1975. Eagle Count. NPS, Gustavus. (Nest mlocation map apparently lost, but productivity data in report). Lentfer, H. & A. Meier. 1989. Survey of the 1989 Breeding Bald Eagle Population in the Beardslee Islands in GLBA, Alaska. NPS/RM, Gustavus. Mow, J. 1989. Bald Eagle Report – 1989. NPS, Gustavus (Also made annotations to Cain survey made as result of ranger obs.) Farris, A. 1990. 1990. Survey of the 1990 Breeding Bald Eagle population in the Beardslee Islands in Glacier Bay, Alaska. NPS, SCA Volunteer. Kralovek, M. 1989. Bald Eagle Nest Tree Survey and Database. NPS K/eco-data. Kralovek, M. 2002. Bald Eagle Productivity and Nest Distribution and

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Characteristics in GLBA, 1994-2002. Abstract, 4th GB Science Symposium, Juneau. (Couldn't find other survey that has been done by NPS, (by Bren Harrington) Comments: The Robards survey was reasonably thorough. The Cain survey was very thorough and made moreso by ranger work in '89. Mow & Jones surveyed subset of nests. The Beardslees, especially, have been repetitively and thoroughly surveyed; these data especially are quite replicable.
Diversity and Relative Abundance of Songbirds	No	No? (A1?,B?)	What: breeding landbird surveys; in 1997, also include woody vegetation sampling. How: Standard breeding bird survey protocols (listening/viewing stations along transects); all woody stems enumerated in 20 5m circular plots along each census transect. Whan: 1997-98 Where: Upland vegetation of Wachusett, Adams, Mid-Lower Muir & Bartlett Cove, to illustrate a successional sequence (1997); Riparian vegetation to test for bird differences along salmon vs. non-salmon streams, Geikie, Fingers, Spokane (1998). Who: Mary Willson, Scott Gende, Jeff Nichols Ref: Willson, M. F. and S. M. Gende (1998). Breeding landbird survey, midbay region, GBNPP, U.S. National Park Service, Glacier Bay National Park and Preserve**:** 12 pp. Willson, M. F. and J. V. Nichols (1997). Breeding landbird survey, East Arm, Glacier Bay, U.S. National Park Service, Glacier Bay National Park and Preserve**:** 25 pp. Comments: Methods reasonably clear, location of study transects and sample sites are rather approximate in literature available, but may be better in investigator files. Brief but rigorous. Possibly reliable for baselines; in concert with Trautman, Spackman, and especially Saracco they provide a reasonable picture that could be duplicated in a larger sense.
Goshawk Habitat	No	No	Who: Mary Kralovek. Comments : study never happened
Landbird Abundance, Community Composition	No? (A1)	No? (A1?,B)	What: Bird abundance and community composition related to variables in lowland coastal forest habitats. How:57 variable circular plot point bird counts conducted along 10 transects selected by stratified random sampling; vegetative community composition and physiognomy measured along perpendicular transects centered on each point. Where: Transects scattered through bay and Excursion Ridge When: June 2004 Who: Jim Saracco, Scott Gende Comments: Methods rigorous and repeatable, but data rather thin. Was the inception of a

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			proposed larger study.
Landbirds in Riparian Vegetation	No (B1)	Yes (A1,B)	What: Bird species richness and abundance in relation to riparian plant communities along the American portions of trans-mountain rivers in SE Alaska How: Stratified random sampling of vegetation; point counts of birds using USFWS protocols Where: Major rivers, including the Alsek in GLBA When: Summer 2005? Who: Jim Johnson, Bob Christensen Ref: Johnson, J. 2005. Relationship between Breeding Bird Communities and Riparian Vegetation of Southeast Alaska. Powerpoint program supplied by Bob Christensen Comments: Data for plant community structure and bird distribution/abundance highly replicable. Sample sites are GPS'd
Burroughs Songbird survey	No	No	What: Brief survey of passerines How: 4 hr foot survey in 3 sample areas Where: Burroughs Glacier Forelands When, July 1991 Who: Susan Spackman Ref: Spackman, S. 1991. Distribution of Passerines along a 50 year Chronosequence in Glacier Bay, Alaska. (*Streveler files*) Comments: brief but rigorous. Transect approximately relocatable. One of our only bird studies from this critically shrinking habitat (But see Willson & Gende, above)
Outer Coast Upland Bird Surveys	No (B1)	Yes? (A1,B?)	What: Survey of avifauna How: General observation; occupation of 5ea. 500m transects 9 times, during which birds recorded according to a standard protocol at 50 m intervals & vegetation described Where: Dixon Harbor vicinity. Justice Creek to Topsy Creek; Lituya Bay. When: summer, 1974; early summer, 1976-77. Who: Sam Patten, Dick Weisbrod Ref: Patten, S. 1974. Birds. *In* Dixon Harbor Biological Survey, Streveler & Worley, eds. NPS, Gustavus. Weisbrod, A. 1980. Birds. *In* Lituya Bay Environmental Survey, Streveler, Worley & Molnia, eds. NPS, Gustavus. Comments: These are the most comprehensive and rigorous of several bird studies associated with the Dixon harbor & Lituya work. Nothing related to terrestrial birds is replicable at Dixon Harbor. The Lituya transects <u>may</u> be precisely relocatable, as their bases

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			were marked with permanent metal tags and related to mining claim boundaries. Methodology is well described and quite similar to modern FWS nation-wide survey protocols.
Marbled Murrelet Dawn Watches	No	No	What, Where: Surveys of murrelet nesting behavior at Bartlett Cove How: standard protocols Who: Rusty Yerxa, Judy Rice Refs: Rice, J. 1996. Marbled Murrelet Assessment for the Bartlett Cove Visitor Experience Enhancement and Opportunity Expansion. NPS, Denver. Yerxa, R. 1999. Report on Marbled Murrelet Dawn Watches Conducted July 18-20, 1999, at Bartlett Cove, GLBA, Alaska. NPS/RM, Gustavus Comments: Yerxa utilized some of the same sites, and the same established protocol used by Rice; the results are comparable, but based on scanty overlapping data (4 stations, 1-2 occupations). Purposes of work were to provide opportunity for a visitor activity and to assess potential road improvement impacts, not to provide a monitoring baseline. Also, most sites monitored have been subsequently altered by development.
Birds of the Falls Creek Area	No	No	What: Generally qualitative survey of upland birds; assessment of Murrelet nesting habitat and use How: keeping of general notes; directed survey of habitat potential and use along road route, using standard protocols. Where: Falls creek development area When: 1999-2000 Who: Hank Lentfer, Greg Streveler Refs: Lentfer, H. & G. Streveler. 1999. Birds of the Falls Creek Area. Icy Strait Env. Svcs. Rept to Gustavus Electric, Gustavus. Comments: Murrelet work replicable in theory, but most of area now disturbed or erased by construction.
Molting goose surveys	No	No	What, how: Counting & banding of molting geese Where: Adams, predominantly, but also elsewhere, such as in Weird Bay Who: USFWS banding effort in Adams in early '60's by FWS and proceeding with counts by NPS over the years; also see Calambokidis. Refs: Robards, F. 1960. Construction of a Portable Goose trap. J. Wildl. Mgt. 24(3):329-331. (Some GB data, but I can't find the main FWS report) Calambokidis, J. 1983. Biology and Behavior of Molting Canada geese in Glacier Bay, Alaska. Cascade Research collective, Olympia.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Taylor, M. 1984. Survey of Molting Canada Geese in Adams Inlet. NPS, Gustavus. Comments: This work has seriously lapsed, despite the possibility that Glacier Bay may remain one of the major molting grounds in SE. There are numerous counts from Adams, especially, in staff field notes (if these still exist).
Muir Inlet Upland Birds – 1960's	No (A1,B1)	No? (A1?,B?)	What: Bird distribution and abundance How: Numerous observations by 3 good observers. In case of Trautman, semi-rigorous reoccupation of a series of upland stations in various lowland habitats Where: eastern Muir Inlet When: summer, 1962-1967 Refs: Wik, O. 1967. Birds of Glacier Bay National Monument. NPS, Gustavus. Trautman, M. 1966. Birds *in* Goldthwait, et. Soil Development and Ecological Succession In a Deglaciated Area of Muir Inlet, Alaska. IPS Rept #20. Welch, R. 1965. Ecological Observations in the Muir Inlet Area, GLBA, Alaska. IPS Rept #15. Comments: The volume of observations, antiquity, and number of years involved make this record of considerable interest if not directly replicable. Trautman's major transect from Casement to Muir Point is grossly reoccupiable and is the closest thing to rigor on upland birds from that period.
Mammals			
Bear Activity and Habitat Assessment	Yes (A1,B1)	Yes (A2,B)	What: Assessment of bear habitrat and activity levels in areas of management concern; constructing a history of bear-human interactions How: Activity assessed by reading of sign, video camera installation, and hair traps. Habitat quality assessed by veg plots, scat analysis, plant nutrient analysis and isotopic analysis of hair. Spacio-temporal history constructed from park database Where: Eight areas of management concern along central and upper Glacier Bay, chosen due to suspected high human and bear use, long term camping closure areas, and/or high numbers of historical bear-human conflicts. Who: Tania Lewis, Steve Partridge, Tom Smith. When 2000-2005, repeated visits June-August Refs: Lewis, T. Bear Activity and Habitat Assessment Project; 2004 Progress Report. NPS/RM, Gustavus. Lewis, T. 2006. Bear Activity and Habitat Assessment Project 2005 Progress

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Report. NPS/RM, Gustavus. (Final report in prep by Steve Partridge). Comments: Purpose is to inform park management decisions by quantifying habitat and activity levels in areas of concern, including Sandy Cove and Tarr Inlet camping closures. Some aspects, such as habitat mapping and sign distribution, are sufficiently precise that they could provide a general baseline if applied to larger areas rather than individual sites. Having said that, the site photos and vegetation plots are relocatable; the latter should be considered along with other relocatable veg plots (e.g., Cooper, Fastie, Gurnblatt) as a fabric of potential monitoring opportunities.
Bear Sightings and Incidents	No	No	What: RM database on bear sightings and incidents How: opportunistic (some, such as obs from tourboat are somewhat systematic) When: Going back to before the 1960's Where: Throughout park Who: anyone, but mainly park staff. Comments: Give very general insight into changes over time. Some of the synopses based on these data (see bear impact study for examples) sharpen the patterns. Can be considered monitoring in the context of such studies, but not stand-alone.
Moose Population Assessment	Yes (A1, B2)	PRIME (Aa, Ba)	What: Management background research on population dynamics, body condition, browse condition, and movements of moose How: coordinated fabric of aerial surveys checked by mark/recapture, direct measurement of body fat, analysis of reproductive tracts of hunted animals, monitoring of browse consumption on willow transects and plots, direct observation of food preferences, exclosures, tracking of GPS-tagged cows Where: on the Gustavus forelands and vicinity When: Surveys since the late "80's; intensive science since about 2000. Who: Kevin White, Neil Barten Refs: Barten, N. et al. 2002. Strategic Plan for Management of Moose on Gustavus Forelands, Unit 1(c), 2001-2005. AFG, Juneau. White, K et al. 2004. Effects of food-limitation on an Irruptive, High-density Moose Population in the Gustavus Forelands, Alaska. Abstract, 4th GB Science Symposium, Juneau. White, K. 2006. Powerpoint presentation provided by investigator Comments: Disciplined work. Willow mensuration data from permanent plots and transects highly repeatable, as are body condition indices; population censuses (within loose confidence limits, requiring mark/"recapture" of tagged animals) repeatable, especially as

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			index for total herd size (herd composition less so).
Patterns of Nest Predation by Red Squirrels	No	No	Who: Willson, Gende Comments: Study didn't happen here, though one in Juneau area is similar
Water Shrew Taxonomic Status	No	No	Who: Olson. Comments: Didn't catch any water shrews
Bear surveys, Falls Creek shore	Yes (B1)	Yes (A2,B)	What: Spring Black Bear (and other mammal) use of the shore zone How: Direct observation and track analysis Where: Super habitat NW of Falls Creek mouth, When: 1997-1999 Who: Greg Streveler Refs: Streveler, G. 1997,1998. Bear and Other Wildlife Usage of the Falls Creek Vicinity, spring 1997-98. Icy Strait Env. Svcs. Repts to Gustavus Electric, Gustavus. Lentfer, H. & G. Streveler. 1999. Mammals of the Falls Creek Area, may-september 1999. Icy Strait Env. Svcs. Rept to Gustavus Electric, Gustavus. Comments: Track analysis and # individuals seen provides a good 3-year index to bear use along that shore.
Endicott Gap Large Mammal Survey	No	No	What: General survey of large mammal distribution & abundance, with particular reference to trans-boundary movements How: sign analysis, sightings Where: Endicott Gap area When: late 1970's Who: Greg Streveler, Leigh Smith. Ref: Streveler, G. P. and L. Smith (1987). Endicott Gap large mammal survey, U.S. National Park Service, Glacier Bay National Park and Preserve**:** 13 pp. Comments:. Ballpark estimate of population sizes and movement patterns based on reading sign. Not intended to be replicable, and it ain't
Brown Bears of the upper West Arm	No(B1)	Yes (A1,B)	What: Habitat descriptions, estimate of the abundance of brownies Where: The Tarr/Hopkins area How: Scat collection and analysis, sign interpretation; track size analysis; direct obs When: summer, 1988 1989, 1991 Who: Janet Warburton, David Wolfe Refs: Warburton, J. 1988. A background Survey of the Distribution, Abundance & Habitats of Brown Bears in the West Arm of Glacier Bay. NPS/RM

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Wolfe, D. 1989. Brown Bears of the Upper West Arm of Glacier Bay: Shoreline numbers, Movement patterns and Habitat Usage. NPS/RM Duncan, T. & L. Climo. 1991. Brown Bear Use of Beacher in the West Arm Closure Area, GLBA, in 1991. NPS/RM Comments: Warburton methods not sufficiently constrained to be replicable. Did as good a job as is possible with track analysis. Result treated statistically. Protocols described well. Replicable, and would be a useful extension of baseline of later studies. Duncan's work more cursory, but track analysis directly comparable to first two studies. Overall, this work provides a reasonably repeatable view of bear populations in this area.
Dixon Harbor Large Mammal Survey	No	Yes (A2,B)	What: Survey of mammals weasel sized & up How: Observation, track & scat analysis Where: Dixon Harbor – Torch Bay vicinity When: 1973-75; 1991 Who: Greg Streveler, Lewis Sharman, Hank Lentfer Refs: Streveler, G. 1973. Larger Mammals. *in* Dixon Harbor Biological Survey: final report on the summer phase of 2003 research. Streveler, Worley, Terry, Gordon. NPS, Juneau. Streveler. 1975. Larger Mammals. *in* Dixon Harbor Biological Survey: final report on the summer phase of 2004 research. Streveler & Worley, eds. NPS, Juneau. Streveler, G. 1977. Larger Mammals. *in* Dixon Harbor Biological Survey: final report on the summer phase of 2005 research. Streveler & Worley, eds. NPS, Juneau. Sharman, L & H. Lentfer. 1991. 1991Dixon Harbor Biological Survey. NPS, Gustavus. Comments: Most material too qualitative to repeat. However, for Brown bears, wolves and goats, the population estimates, derived over three years for a small number of individuals (and in the case of wolves, corroborated by Home's winter work) are pretty reliable. Sharman's & Lentfer's work provides good comparisons for wolves and brown bears, but not goats. They make many comparisons of behavior, distribution and diet of these and other species that allow at least general conclusions about decadal changes in cases where such changes have been substantial.
Wolf Pack Ecology/Sensitivity	No (A1)	Yes? (A2?, B)	What: Detailed snapshot of one wolf pack's use of Adams Inlet How: Extensive foot travel along wolf use routes, observation of wolves, field analysis of scats. Where: South half of Adams Inlet watershed

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			When, July 1993 Who: Brad Meiklejohn Ref: Meiklejohn, B. 1993. Ecology and Sensitivity to Human Disturbance of a Wolf Pack at GLBA< Alaska. U. Vermont Field Naturalist Program Report. Comments: Our only coherent data on wolves in the Glacier Bay watershed. Parts of the work are replicable if a pack should set up again in the same area: these include the sketch of the diet and the general use patterns.
Mountain Goat Surveys	No(B1)	PRIME (Bd)	What: Survey of most vegetated alpine, from timberline to 4000 ft How: 1983, snowshoe survey; 1985, systematic survey via helicopter per ADF&G protocol Where: 1983, Adams; 1985, Glacier Bay watershed & adjacent parts of Excursion area When: March, 1983; July 8-14, 1985 Who: Gary Vequist, Layne Adams Refs: Vequist, G. 1983. Population Changes of Mountain Goats in Adams Inlet. Report in BarCo library. Adams, L. & G. Vequist. 1986. Mountain Goat Survey, GLBA, 1985. NPS Nat Resource & Inventory Report. AR 86-03. Comments: 1985 work highly replicable. All data given in detail; each sighting mapped. Used protocols that allow direct comparison with ADF&G data from adjacent areas. 1983 report gives figures for Adams going back to 1968, for valleys that today have few or no goats in them.
Wolf predation on Mountain Goats	No(A1)	No? (A2?,B)	What: Analysis of several hundred wolf scats Where: from park (mostly outer coast) and elsewhere How: analysis done by eyeball in field for most part When: late '70's & early '80's Who: Joe Fox, Greg Streveler Ref: Fox, J. & G. Streveler. 1986. Wolf Predation on Mountain Goats in SE Alaska. J. Mamm. 67(1):192-195. Comments: paints a picture of wolf food habits that is replicable only in a gross sense; minor dietary items could have been missed.
Moose Survey, Adams Inlet	No(B1)	Yes (A2, B)	What: History of Moose in Adams, notably including description of surveys How: Aerial surveys, Protocol described reasonably well. Gives data from Adams Island, which was totally censused. Where: Adams Inlet watershed. When: Late winter 1984,85,86.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Who: Gary Vequist Ref: Vequist, G. 1986. Colonization of Post-glacial Plant Communities by Moose in Adams Inlet, GLBA. Paper given at Interagency Moose Conference, Anchorage, March 1986. NPS/RM Comments: I once saw a copy of Gary's flight-lines in the files. If that still exists, the entire survey would be replicable; if not, then at least the survey of Adams Island remains so.
Space/habitat use by moose in relation to OHV's	No	No	What: How do OHV trails and use affect moose distribution & habitat use How: compared 9,752 collared moose locations with trail distribution with and without heavy OHV use. Where: Forelands <u>outside preserve</u> to the northwest When: data from 2003-04 Who: Sanjay Pyare & Winston Smith Refs: Pyare, S & W. Smith. 2005. Space use and habitat Use by Moose in Relation to OHV routes on the Yakutat Forelands: preliminary results of a GIS-Based analysis conducted for th US Forest Service. Comments: Not directly relevant to park, except that some collared moose also had locations the preserve.
Moose Effects on Soil Nutrient Dynamics	No	No	What: Soil differences in browsed and unbrowsed willow thickets How: Soil assays in ADF&G browse monitoring sites and exclosures (two sets of paired plots) Where: Gustavus When: 2004 Who: Eran Hood, Amy Miller, Kevin White Ref: Hood, E. et al. 2004. Effects of Moose Foraging on Soil Nutrients in the Gustavus Forelands, Alaska. Abstract, 4th GB Science Symposium, Juneau. Comments: Reconniassance level study with not enough replicates to be considered a baseline.
Small mammal studies (mice, voles, shrews)	No	Yes? (A1,B?)	What: Survey of mammals on East side of Muir Inlet, the lower outer coast, the Beardslee and Sandy Cove Islands & associated mainland. How: generally based on trapping, with varying degrees of rigor Where, when: various park localities & times Who: Gene Good, Carol Terry, Cliff Estabrook, Bea VanHorne, Steve Antell Refs: Good, E. 1966. Mammals. *in* Goldthwait, et. Soil Development and Ecological

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Succession In a Deglaciated Area of Muir Inlet, Alaska. IPS Rept #20. Estabrook. C. 1968. Summary of Small mmmals Collected during 1968 Summer Season, GLBA. Seasonal Ranger Report Terry, C. 1977. Small Mammals *in* Dixon Harbor Biological Survey; final report on the summer phase of 1975 research. Streveler & Worley, eds, NPS, Juneau (she also produced a Ph.D thesis from the U Kansas) Van Horne, B. 1977. Small Mammal Populations in Glacier Bay, Alaska; summary of results for summer, 1976. Draft report, Oregon State U. Terry, C. 1980. Small Mammals *in* Lituya Bay Environmental Survey. Streveler, Worley, & Molnia, eds. NPS, Juneau Terry, C. 1981. Population Fluctuation in the Arvicolidae (Rodentia) and their relationships to "microtine cycles". Ph.D. Thesis, U. Kansas. Antell, S 1987. Systematics and Zoogeography of Mammals in S. E. Alaska. Ph.D. Dissertation, Washington State U. Comments: Study by Terry in the Dixon harbor area is particularly thorough, being based on 3 years' data and related to approximately relocatable sites; it is replicable in a general sense. The other studies cannot be considered replicable, though they give very interesting insights into the small mammals of their respective areas. Antell's work is based mostly on reviewing specimens of Terry's.
Amphibians			
Western Toad Inventory	No (B1)	Yes? (A2?,B)	What: Toad survey of four areas in park. How: Foot survey, filling out forms on potential habitat for 19 ponds Where: Taylor-Dundas lowland, Ripple cove moraine, lower Bartlett River, When: June, 2004 Who: Richard Carstensen, Bob Christensen, Cheryl Van Dyke,Pyare Refs: Carstensen, R. 2004. Summary Thoughts on Glacier Bay Toad Survey, 6/04. Notes to NPS Christensen, B. 2004. Monitoring Western Toad Populations in GLBA. Abstract, 4th GB Science Symposium, Juneau. Comments: Small sample of the park, but searched systematically for presence/absence and gross abundance.
Opportunistic amphibian survey	No	No	What/how: Collection of amphibian distribution/abundance records from GLBA &

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			environs. When: principally 2001-03, but also looking at historical records Who: Blain Anderson. Refs: Anderson, B. 2004. an Opportunistic Survey of Amphibians in Alaska's National Parks. NPS, Anchorage Anderson, B. 2004. An Opportunistic Amphibian Inventory of Alaska's National Parks, 20001-03. Abstract, 4th GB Science Symposium, Juneau. Comments: Compilation of records; not intended to be replicable, but a valuable compendium of records as adjunct to the Carstensen study (see above).
Boareal Toad as a Successional Animal	No	No	What: Ecological characterization, with particular reference to habitat selection and dispersal capability. How: general observation and some experimentation on tolerance to salt water. Where: Glacier Bay watershed When: 1981-82. Ref: Taylor, M. 1983. The Boreal Toad as a Successional Animal in Glacier Bay, Alaska. M.S. Thesis, U Cal Hayward. Comments: Many interesting qualitative observations, useful for presence/absence and rough abundance in a number of generally described localities, but not useful for quantification.
Invertebrates			
Spruce Beetle Effects	Yes (B1)	PRIME (Aa)	What: Monitoring progress of beetle infestation in terms of tree mortality and changes in stand structure & understory composition. How: fourty five 1/5 acre permanent plots in lower GB, within which many silvicultural and beetle density measures made. When: Work begun 1982; revisits yearly until 1988, then 1992 & 1998. Revisited in 04, 05; GPS'd then. Refs: Eglitis, A. 1982. Biological Evaluation R10-82-1, Spruce Beetle, GLBA. USFS, Anchorage. Eglitis, A. 1988. Spruce Beetle in GLBA: 1987 update. USFS Forest Pest Mgt. Rept. R10-89-1. Schultz, M. 2001. Changing Forest Structure & Composition in GLBA long-term Spruce Beetle Mortality Plots. USFA Biological Eval. R10-TP-93.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Schultz, M. 2004. Spruce Beetle and Forest Structure in GLBA: Results from long term plots. Abstract. 4th GB Science Symposium, Juneau. Comments: Especially in conjunction with Carstensen/Noble's work (see above, in "plants" section") this forms an extremely important baseline. As in many cases, need to get plot location data from investigators.
Insects along Muir Inlet Chronosequence	No	No	What: Insect survey How: general collecting When: 1965 Where: along Muir Inlet Who: David DeLong Ref: DeLong, D. 1966. *in* Goldthwait, et. Soil Development and Ecological Succession In a Deglaciated Area of Muir Inlet, Alaska. IPS Rept #20. Comments: Our earliest and still broadest & most detailed study of terrestrial insects (but also see Mann, below, from the outer coast), but unfortunately not keyed to relocatable sites
Ice worm ecology/physiology	No	No	What: Iceworm distribution, behavior, physiology, food habits. How: Disciplined observation and measurement of rel. densities on well-located spots on & near glacier. Densities on one quadrat observed quantitatively over time of day Where: Casement Glacier When: Summer 1967 Who: Dan Goodman Ref: Goodman, D. 1971. Ecological Investigation of Ice Worms on Casement Glacier, SE Alaska. Inst. Polar Studies Rept #39. Comment: If the glacier weren't changing so rapidly, some of the density measurements would be replicable. Perhaps the most useful thing is his delimitation of places on the glacier where iceworms were noted; these could be checked to see if the worms are still there, but the answer is probably trivial, as they will eventually be below the firn line.
Outer Coast Insects& Spiders	No	No	What: surveys of Carabid beetles and spiders. How: general collecting; pit traps When: 1977-1981 Where: Lituya Forelands Who: Dan Mann Refs: Mann, D. 1980. Terrestrial Arthropods. *In* Lituya Bay Environmental Survey, Streveler, Worley & Molnia eds. NPS, Gustavus Mann, D. 1983. The Quaternary History of the Lituya Glacial Refugium, Alaska.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Ph.D. Thesis, University of Washington. Comments: Our only information on terrestrial inverts for the outer coast, but not designed to be replicable.
General (Incl ecology/succession)			
Johns Hopkins Inlet Landslide	No	No	Documentation of a single mass wasting event by a park visitor
Park and Wilderness Boundaries	No	No	A map exercise
Vegetation & Wildlife of Gustavus	No	Yes (A2, B)	What: surveys of birds and mammals along Gustavus shores; general assessment of wildlife/habitat relationships; observations of crane numbers & habitat use during fall migration; detailed vegetation mapping; mapping of human trails, streams and ditches. How: Repeated foot surveys along shore at low and high tide, using standard routes relative to the tide. Fall counts of cranes and their habitat selection. Where: All of Gustavus, with special attention to the Critical Habitat Area When: fall/winter 1981-81; fall 1982; summer/fall 2002-03 Who: Greg Streveler, Craig matkin, Judy Brakel Ref: Streveler, G. & C. Matkin. 1983. A preliminary Eavaluation of Wildlife Populations & Habitats on Gustavus Beaches and Dude Creek Uplands. Gulf Coast Oceanic Society, Gustavus, Rept to ADF&G. Streveler et al. 2003. Gustavus Plant Communities: their Composition, History and Use by Fish, Wildlife and People. Icy Strait Env. Svcs. rept to The Nature Conservancy, Gustavus. Streveler et al. Sandhill Crane Use of the Dude Creek CHA During Fall Migration. Icy Strait Env Svcs rept to ADF&G, Gustavus. Comments: Protocols generally well described. Crane counts and beach surveys systematic but not structured to allow calculation of confidence limits. Veg, stream/ditch and trail mapping is constrained by reference to many natural landmarks; these are the most replicable parts of this work.
Biological Inventory of Selected NPS & Adjacent Lands	No	No	What, how: General Biological inventory Where: non-marine portions of the Bartlett Cove, Gustavus and Indian Point vicinities When: 1995 Who: Greg Streveler, Bruce Paige, Koren Bosworth.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Ref: Streveler, G et al. 1995. Biological Inventory of Selected Portions of the Bartlett Cove, Gustavus and Indian Point Areas, Southeast Alaska. Icy Strait Env. Svcs rept to NPS, Denver. Comments: General synopsis of vegetation & vertebrates of these areas.
Winter Birds & Mammals, Dixon Harbor	No	No	What: Presence, general abundance and habits of Birds and Mammals How: Daily observation Where: Dixon harbor vicinity When: Nov 1993 – March 1994, November 1994 – May 1995 Who: Scott (Sappington) Home Ref: Home, W. 1977. Ecology of Overwintering Mammals and Birds on the Pacific Coast of GLBA, Alaska. University of Alaska, Fairbanks rept to NPS Comments: Observations, though protracted and careful, are not carried out in ways that allow replication. However, they do provide good estimates for the numbers and activity patterns of certain species, notably canids and birds generally in Thistle Cove vicinity.
Impacts			
Camper Impacts	No (B1)	Yes (A2,B)	What: Survey of campsite areas to determine relative degree of degradation from a social point of view How: Chose areas most frequented by campers; developed a protocol for measuring detractions from wilderness character. (Attempted but largely abandoned quantification of ecological impacts) When: 2001-2002 Where: Throughout Glacier Bay Who: Tania Lewis & Nat Drumheller Ref: Smith, et al. 2002? Bear-Human Interactions at GLBA: Conflict Risk Assessment. USGS/NPS, Anchorage. Lewis, T & N. Drumheller. 2003. Wilderness Camp Impacts: Assessing Human Impacts On the Shoreline of Glacier Bay. Draft Final Rept, NPS/RM. Lewis, T, et al. 2004. Wilderness Camping in Glacier Bay: assessing human Impacts to Shoreline habitat. Abstract, 4th GB Science Symposium, Juneau. Comments: Sample sites located precisely in park database; protocols spelled out well and avoid observer-specific judgements to a large degree. Should be replicable; site photos are especially useful. In many sites, vegetative conditions will rapidly alter the site

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			configuration & desirability; thus site-specific comparisons will have to be made in the short term. However, overall campsite conditions could be compared over time.
Dry Bay ATV Impacted Wetlands Inventory	No (B1)	Yes (A2,B)	What: Inventory of ATV effects on wetlands How: 40 GPS's point locations where trails cross wetlands photographed, veg sampled in 30 m plots, soil examined Where: Dry Bay When: 2006 Who: Bud Rice Comments: No report yet, but based on conversation with Bill E, sounds like replicable work; point photos especially useful.
Off Highway Vehicle Tracks Inventory	Yes (A1,B1)	Yes (A2,B)	What: GIS layer mapping ATV tracks How: plotting them to ~3m accuracy from air photos with ground truthing When: 2001-03-06 Where: Dry Bay Who: Bill Eichenlaub Comments: Precise work that is highly replicable
Exotic Plant Inventory & Control-GLBA	Yes (A2,B2)	Yes (A2,B)	What: Invasive plant surveys and limited eradication How: Systematically and opportunistically searched for invasives; eradicated where practicable; described and delimited all exotic patches by GPS with sufficient accuracy to detect annual changes. When: 2003 - ongoing Where: Focused on the Bartlett Cove area with secondary emphasis on Dry Bay & the Beardselee Islands; and visits to other sites included Dundas Bay, Berg-Fingers, the West Arm, and mid-bay islands. Who: Jeff Heys, Whitney Rapp Refs: Heys, J. & C. McKee. 2004. Exotic Plant Survey of GLBA: Summer 20004 Field Season Report. NPS/RO & USGS/BRD Rapp, W. 2005. Invasive Plant Management in GLBA, Gustavus AK: Summer 2005 Field Season Report. NPS/RM.
Man-made disturbances inventory	No (B1)	Yes (A2,B)	What/how: Brief report and 30 or so photos of various vegetative disturbances, structures and refuse. Where: scattered along shore of the bay When: 1970-71

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Who: Ole Wik, seasonal ranger Ref: Wik, O. Undated. Man-made Distrubances in Glacier Bay and their Regeneration; a photographic report. NPS, Gustavus Comments: At least a dozen of the photos are of relocatable sites. Several are of old structures of historic interest. Wik is a superb observer. There is another report in the library by Kim Heacox of some interest in this context.
Bear Campsite Assessment	No (B1)	Yes (A1,B)	What: Habitat & encounter risk assessment for bears & people at well-used campsites How: Mine park records for distribution of incidents, camper distribution; rank 162 campsites in terms of quality of bear habitat, encounter potential and potential for bear displacement Where: Glacier Bay When: 2001-02. Who: Tom Smith, Terry DeBruyn, Tania Lewis, Allison Banks, Rusty Yerxa, Steve Partridge, Nat Drumheller. Ref: Smith, T & T. Lewis. 2002. Risk Assessment of Bear-Human Interactions at Campsites within GLBA, Alaska: 2001 year end report. . USGS, Anchorage, Smith, T. et al. 2004. Bear-Human Interaction at GLBA: Conflict Risk assessment Abstract. 4th GB Science Symposium, Juneau. Comments: No final report prepared yet. Based on the abstract and attendance at the talk, I'd judge that at a minimum the site photos, habitat evaluations and mapping of "permanent" wildlife trails are useful in the present context. Statistical analysis has not been reported yet, but in Tania's view, the work is replicable.
Marine			
Oceanography/water quality			**This sub-section is somewhat duplicative of the work of Eran Hood, Sonia Nagorski and Ginny Eckert.**
Bartlett Cove Water Temperatures	--	--	Refers to water temperature loggers that were deployed as part of the sea otter effects study (Donnellan, Fisher, Barber). See comments under that study
Bartlett cove Oceanography	No	No	What: Water quality and current velocity in vicinity of proposed sewage outfall site. How: CTD measurements, current velocity readings. Where: Bartlett Cove When: Two days, Aug-Sept 1998

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Who: Dan lawson Ref: Lawson, D et al. 1998. Oceanographic Investigation of the Proposed Outfall Location in Bartlett Cove, GLBA, Alaska. Contract report to NPS by CRRREL, Hanover, NJ. Comments: Gives basic idea of patterns in these parameters, but too cursory for baseline.
Fjord Oceanography	Yes (A1,B1,B2)	PRIME (Aa,c)	What: USGS program of oceanographic work, emphasizing water mass characteristics, currents, waves & fronts. How: Principal focus is on results of CTD & chlorophyll-a measured at repeatedly occupied stations. Also temperature loggers moored at various locations throughout the Bay. Where: midchannel throughout the bay and off the bay mouth When: 1992-present. Who: Hooge, Etherington (Arimitsu since Lisa left) Refs: Hooge, P & E. Hooge. 2002. Fjord Oceanographic Processes in Glacier Bay, Alaska. USGS/BRD, Juneau. Etherington, L. 2003. Monitoring of Oceanographic Properties of Glacier Bay, Alaska. USGS/BRD, Gustavus. Etherington, L., et al. 2004. Factors affecting Seasonal and Regional Patterns of Surface Water Oceanographic Properties within a Fjord Estuarine system: Glacier Bay, Alaska. USGS/BRD report to NPS, Gustavus. Etherington, L. et al. In Review. Oceanography of Glacier Bay, Alaska: Implications for biological patterns and productivity in a glacial fjord estuary. Esutaries and Coasts. Comments: Three of the most important papers ever generated for the park. Methods carefully specified; highly replicable (and in fact, the stations have been systematically reoccupied by Etherington up through 2005, and Arimitsu on a reduced schedule since then.
Frontal Zones in Glacier Bay	No (B1)	Yes (A1,B)	What: Investigate structure, distribution, timing of frontal zone structures How: Surface temperature mapping via satellite; oceanographic measurements of various sorts; surface drifters Where: lower and mid bay north of Sitakaday When: 2004 Who: Lisa Etherington, Erika Madison, Dave Douglas Ref: Etherington, E. 2004. Research on Oceanographic Currents: physical-biological coupling at frontal zones in GLBA. USGS/BRD Research Permit application Comments: Data have not been written up yet. This study relates closely to “ocean current measurements” below. Dave Douglas has produced surface temp maps that by proxy indicate frontal structures. Metadata has been turned over to the park. A poster was

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			generated.
Ocean Current Measurements	No (B1)	Yes (A1, B1)	What: Examine oceanographic current patterns with specific reference to location & characteristics of frontal boundaries How: ADCP, CTD and surface drifter data Where: Lower & Mid Glacier Bay, adjacent Icy strait (+ 2 ADCP/salinity lines up the bay & Icy Strait by Cokelet) When: ADCP & CTD transects/stations: April-Oct 2001; July 2002, July-August 2004. . (Drifters deployed: twice during summer 2002. Who: Lisa Etherington, Phillip Hooge, Mondragon, Jennifer Fisher, Erika Madison Refs: Etherington, L. 2005. Research on Ocean Currents: Physical-biological coupling at frontal zones in GLBA. Project summary for NPS Comments: Data synopsis in K/eco-data. Fisher sampled set locations in Sitakaday April-October 2001: samples were collected weekly during both flood and ebbing conditions, with a total of 22 days samples. This effort could be considered a baseline.
Oceanography/ Currents - GNOME Model	No	No	What: NOAA model that predicts oil spill spread in surface waters Where: Glacier Bay Ref: Cheng, R. R., S. J. Taggart, and J. K. Nielsen. 2006. Preliminary hydrodynamic modeling of tidal circulation in Glacier Bay, Alaska. *in* The 7th Intternational Conference on Hydroscience and Engineering. Comments: First generation model has been developed. This is not based on unique data, and so is not a baseline candidate
Oceanography of Muir Inlet-1960's	No (B1)	Yes? (A1?,B1)	What: General oceanography with particular ref to summer/winter characteristics. How: Standard measurements Where: Muir Inlet When: ~13 times, from Aug 1965-July 1967. Who: Matthews & Quinlan Refs: Matthews, J. and A. Quinlan. 1975. Seasonal Characteristics of Water Masses in Muir Inlet, a Fjord with Tidewater Glaciers. J. Fish. Res. Bd. Canada 32(10):1693-1703. Quinlan, A. 1970. Seasonal and Spatial Variations in the Water Mass Characteristics of Muir Inlet, Glacier Bay, Alaska. M.S. Thesis, University of Alaska. Comments: Data presented as means for sketchily located stations at 5km intervals from glacier. Figures averaged for whole inlet probably replicable. If so, valuable baseline for comparison with Hooge & Hooge and later work by Etherington..

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Oceanography of Muir Inlet- 1990's	Yes (A1,B1)	Yes (A1,B)	What: Oceanographic parameters in the vicinity of Muir Glacier to assess proglacial environment. How: CTD, Oxygen, Turbidity; one sample run/yr at a grid along three transects, July; single visits at other times of year. Where: uppermost Muir Inlet When: 1994-2000 Who: Susan Bigl, Dan Lawson Ref: Bigl, S et al. .Fjord Oceanographic Processes, Muir Inlet, Glacier Bay, Alaska, 1994-2000. Comments: Adds data to the Hooge oceanographic stations 19 & 20 and could be integrated with same. As such, important baseline, critical to Cheng's current model.
Tide Station Data	Yes (A1,B1)	Yes (A1,B)	What: continuous records of tidal height How: fixed tidal stations. When: Early Record by Reid, 1890's, Tidal Inlet; 3 year record at Bartlett Cove, mid 1960's; shorter records at Johnson Cove, Muir Inlet, Geikie Inlet 1950's – 1960'; partial year record at Point Gustavus, 1999. Who:Harry Reid, NOAA Comments: Only existing tidal records for Glacier Bay.
Bathymetry/sediments			
Multibeam Sonar	No (B1)	Yes? (A2?, B)	What/how: 3-D projections of the submarine topography Where/when: much of the main trunk of Glacier Bay done by USGS 200-2003. Ross Powell has done some multibeam sampling within Muir Inlet in 2004. Who: Paul Carlson and several local USGS personnel, notably Phillip Hooge; Ross Powell. Ref: Carlson, P. et al. 2003. Multibeam Bathymetry and Selected Perspectives & Views of Glacier Bay, Alaska. USGS Water Resources Investigation. Rept 03-4141. Comments: Purpose is mapping surface topography. Highly replicable. Gives picture of the ocean floor in sufficient detail that, if replicated, would detect major changes in surface topography. Will not detect small changes.
Seafloor Mapping and Classification	No	No	What: Map of benthic habitats How: Ground truthed existing bathymetric and reflectance data by reference to submarine digital video footage of substrate character, biota and geomorphic complexity, and stratified these against depth to make a classification of habitat types.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			When: 1996-2005 Where: In the offshore portions of the middle and lower bay Who: Phillip Hooge, Lisa Etherington, Jodi Harney Refs: Hooge, P., et al. 2004. Sea Floor Habitat Mapping and Classification in Glacier Bay, Alaska, Phase 1&2, 1996-2004. Harney, J, et al. 2005. Geologic Characteristics of Benthic Habitats in glacier Bay, Southeast Alaska. USGS Open File Rept. 2006-1081. Comments: Product is a habitat map, extremely important basic information, but neither the classification nor the type boundaries are sufficiently exact to permit use as a baseline. Similar in scale and scope to terrestrial plant communities map.
Sidescan Sonar	No (B1)	Yes (A2,B)	What: high resolution sea floor mapping. How: This is a high resolution sonar technique for mapping benthic substrate. Where: Glacier Bay Who: same as above Comments: The side-scan sonar data is included in the Hooge et al. 2004 report above, but was not used in producing the habitat map (Harney et al. 2006). Side-scan sonar was used in mapping smaller coves in Glacier Bay, whereas the multibeam was used for the main Bay. This technique produces fine-grained benthic maps that will illustrate moderate-scale sea floor changes.
Queen Inlet Channels and Sediments	No (B1)	Yes (A2, B)	What: Delimitation and description of features that relate to sediment transport from the delta front to a fan in the bay proper. Where: on the Floor of Queen inlet and adjacent parts of Bay How: Sidescan and multibeam sensing. When: 1988-99. Who: Paul Carlson in conjunction with Ross Powell, Ellen Cowan, A. Phillips & D. Rearic. Early work by Chuck Hoskin & Dave Burrell. Refs: Burrell, D. 1971. Suspended Sediment Distribution Patterns within an Active Turbid -Outwash Fjord. Proc. Is Int'l.Conf. on Port and Ocean Engineering under Arctic Conditions, Vol 1:227-245. Hoskin, C. & D. Burrell. 1972. Sediment Transport and Accumulation in a Fjord Basin, Glacier Bay Alaska. J. Glaciol. 80(5):539-550. Carlson, P. et al. 1989. Turbidity Current Channels in Queen Inlet, Glacier Bay Alaska. Can. Jour. Earth Sci. 26:807-820. Carlson, P. et al. 1988. *in* Proceedings of the Second Glacier Bay Science

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Symposium. NPS, Anchorage. Carlson, P et al. 1992. Submarine Sedimentary Features on a Fjord Delta Front, queen Inlet, Glacier Bay Alaska. Can. Jour. Earth Sci. 29.:565-573. Carlson, P, et al. 1999. Growth of a Post-Little Ice Age Submarine Fan, Glacier Bay Alaska. Geo-marine Letters (1999):227-236. Comments: Detailed descriptive work designed to describe sedimentation character & rates; map the topography; and elucidate processes generating it. Much of the work, especially the most recent, is quite detailed and exact, allowing detection of topographic changes on the order of 10m. Measures of sedimentation rates and character are also roughly replicable. Queen Inlet has the best studied combo of subsurface topography and generative processes in the park, along with McBride Inlet, below.
Tarr SedimentTtransport/ Deposition	No (B1)	Yes (A2,B)	What: Measurement and characterization of sediment flux How: Sediment traps, seismic reflection profiles. Where: Tarr Inlet When: Summers 1989-1991 Who Jinqui Kai (Ross Powell's advisee) Kai, J. 1994. Sediment Yields, Lithofacies Architecture and Mudrock Characteristics in Glacimarine Environments. Ph.D Thesis, Northern Illinois U. Comments: Methods of sediment trapping described quite well; locations of traps shown with fair accuracy on map of Tarr. Replication of all or a subset of sampling stations seems doable for indicating moderate-great change
McBride SedimentTtransport/ Deposition	No (B1)	Yes (A2,B)	What: Measurement of sedimentation rates How: Sediment traps; bathymetry; water column characteristics Where: McBride Inlet When: 1984-1987 Who: Ellen Cowan, Ross Powell Refs: Cowan, E. 1988. Sediment Transport and Deposition in a Temperate Glacial Fjord, Glacier Bay, Alaska. Ph.D. Thesis, Northern Illinois U. Cowan, E. & R. Powell. Circulation and Suspended Sediment Dynamics in McBride Inlet, a Tidewater Glacial Fjord. *in* Proceedings of the Second Glacier Bay Science Symposium. NPS, Anchorage. Cowan, E. & R. Powell. 1990. Suspended Sediment Transport and Deposition of Cyclicly Interlaminated Sediments in a Temperate Glacial Fjord, Alaska USA. In: Dowdeswell, J & J.Scoukse (Eds). Glacimarine Environments. Geol. Soc. London.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Cowan, E & R. Powell. 1991. Ice-proximal Sediment Accumulation Rates in a Temperate Glacial Fjord, Southeastern Alaska. GSA Spec. paper 261. Cowan, E & R. Powell. 1994. High Frequency Climate Signals in Fjord Sediments of GLBA, Alaska. Abstract, 4th GB Science Symposium, Juneau Comments: Positions of sam pling stati ons m apped reason ably p recisely. In all, oceanography & sedimentology of this small inlet documented exhaustively. Good baseline candidate (but change in geometry of inlet due to ice recession is a confounding factor).
Johns Hopkins Sediment Deposition	No (B1)	Yes (A2,B)	What: Rates of sediment accumulation in basins How: inference from seismic-reflection data. When: 1979 Where: Johns Hopkins Inlet Who: Jinqui Cai & Ross Powell Ref: 1993. Glacier Fluctuations and Sediment Yields Interpreted from Seismic-reflection Profiles in Johns Hopkins Inlet, Alaska *in* Proceedings of the Third Glacier Bay Science Symposium , Engstrom, ed. NPS, Anchorage Comments: Careful estimation of volumes and accretion rates on decadal scale; replicable on that basis.
Fish			
Halibut Diet	No (B1)	Yes? (A1,B?)	What: Document halibut diet (+ size distribution & sex ratio) of sport- & commercial-caught halibut How: Stomach analysis of over 700 fish; length measurement, sex determination (on the same number?). Preliminary stomach analysis finished. When: Aug 1991, June-Aug 1992 & 1993. Where: in Glacier Bay Who: Liz Chilton, Gretchen Bishop Ref: Bishop, G.. 1993. Pacific Halibut Diet. Fisheries Program Annual Accomplishment Report. NBS, Glacier Bay. Chilton, L , et al. 1993. *in* Proceedings of the Third Glacier Bay Science Symposium , Engstrom, ed. NPS, Anchorage Comments: The sample size looks promising for approximate replication if done on a large scale, approximately duplicating the sites from which the fish were procurred.
Halibut Movement	No (B1)	Yes	What: Home ranges and movement patterns

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
		(A1, B)	How: deploying 110 sonic and 1598 IPHC harvest tags; plotting tag recoveries Where: Glacier Bay When: 1991-1996, with tagging starting in 1992. Ref: Hooge, P., et al. Draft. Home Range and Movement Patterns of Pacific Halibut: Site Fidelity Within and Between Years. USGS/BRD, Juneau. Comments: Though not designed as baseline, precision of tagging and recovery sites for sonic tags could allow use as such if the monitoring question were related to home range. IPHC harvest tags were attached to a large number of halibut. Although the recovery locations were imprecise these types of data could be extremely valuable if replicated during fisheries closures to estimate whether more halibut more out of the Bay when the size and/or density of halibut increases in closed areas.
Halibut (*and other demersal fishes*) distribution, abundance population structure	No (B1)	Yes? (A1?, B)	What: Distribution and relative abundance of halibut (and other demersal fishes) in Glacier Bay. Part of the above study How: Systematic, precisely located grid of skates. All halibut were measured. All fish caught were recorded. Where: throughout the bay. When: 1992-93 Who: Phillip Hooge, Jim Taggart, Jennifer Mondragon, Gretchen Bishop Ref: Mondragon, J et al. 2004. The Distribution and Relative Abundance of Pacific Halibut in a Recently Deglaciated Fjord: the role of glacial inputs and ecosystem age. Abstract, 4th GB Science Symposium, Juneau. Bishop, G. & SG Taggart. 1993. Habitat Correlates of Pacific Halibut and other Groundfish Species in GLBA. *in* Proceedings of the Third Glacier Bay Science Symposium, Engstrom, ed. NPS, Anchorage Comments: Methods and locations clear & replicable. Important pre-closure data on size structure of the population. This is may be a valuable baseline if viewed on a Glacier Bay sub-regional scale; for smaller scales the data are too sparse, especially for some of the nine incidentally caught species. The papers available do not provide details on distribution of fish, but these data exist in USGS databases.
Halibut Synthesis	No	No	What: A general, non-technical summary of several projects Who: Phillip Hooge. Comments: too general and qualitative to be useful in the present context
Small Schooling Fish	No (B2)	Yes? (A1?,B)	What: documents presence and relative abundance of ~90% of expected demersal marine fishes

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			How/when: Beach seine (1999-2000), midwater & bottom trawl (2001-02); hoop & line. Where: in GB proper Who: John Piatt, Mayumi Arimitsu, Martin Robards, Gary Drew Refs: Robards, M., et al. 2002. Glacier Bay Small Schooling Fish Project. USGS/BRD Rept, Anchorage. Arimitsu, M, et al. 2003. Inventory of Marine and Estuarine Fishes in Southeast and Central Alaskan National Parks. USG S/BRD Final Report, Anchorage. Robards, M., et al., 2003. Ecology of Selected Marine Communities in Glacier Bay: Zooplankton, Forage Fish, Seabirds and Marine Mammals. USGS/BRD, Anchorage. Comments: sampling systematic and relocatable; a rigorous study that is not intensive enough locality-by-locality to be replicable on that scale, but valuable on a larger scale if the whole study or major parts of it were replicated.
Spatial Patterns of Outer Coast Rockfish	Yes? (A1?,B1)	Yes? (A1?,B)	What: Preliminary assessment of the nearshore black rockfish community and associated habitats within the outer coast region of Glacier Bay National Park How: SCUBA visual and video surveys. Etherington: Stratified random sampling of transects within 3 exposure strata: exposed, outer Bay, inner Bay. Fish abundance and size by species. Benthic habitat data also collected. Bodkin: capture/measure/release. Where: Lower outer coast; Bodkin mentions three sites, but not sure whether these are the same as Etherington's. He also sampled three fished sites along Yakobi outside the park. Who: Lisa Etherington, Jim Bodkin. When: Etherington, Summer, 2003; Bodkin, May 2006 Comments: Data not written up yet. Etherington thinks the methods are good and repeatable, but her work was planned as a pilot study, so sample size is not large enough for a baseline. Bodkin has picked up this work beginning in 2006; his total sample of 800 fish should begin to provide a rigorous comparison . It is likely that this will become an important baseline.
Sleeper Shark Distribution & Movements	No	No	What: Sleeper shark distribution, residence times & home ranges, and food habits How: implanted sonic tags in three individuals (Muir); examined 3 sharks caught in pot survey for crabs (Hopkins). Where: Upper Muir, Mouth of Hopkins When: 1990's; checked for tag relocations over three years (sharks not relocated after one year) Who: Hooge, Taggart & shop Ref: Hooge, P & S.J. Taggart. Review draft. Movements of Sonic-tagged Sleeper Sharks in

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Glacier Bay, Ak. USGS/BRD, Juneau. Taggart, S. J., A. G. Andrews, J. Mondragon, and E. A. Mathews. 2005. Co-occurrence of sleeper sharks, *Somniosus pacificus*, and harbor seals, *Phoca vitulina*, in Glacier Bay. Alaska Fishery Research Bulletin **11**:113-117. Taggart, SJ et al. 2004. Co-occurrence of Pacific Sleeper Sharks & Harbor Seals: are sleeper sharks predators, competitors or scavengers of harbor seals? In Taggart, SJ et al. 2004. Testing the Effectiveness of a high latitude Marine Reserve Network. USGS/BRD, Juneau. Progress Report. Comments: sample sizes too small for baseline, but is our only info on a key predator. Taggart reports that some fishermen have reported a large increase (in Glacier Bay) in sleeper sharks in recent years, which adds to the relevance of this information.
Ichthyoplankton study	No (B1)	Yes (A1,B)	What: Ichthyoplankton distribution & abundance How: vertical tows in 4 segments, 0-100 m. When: May-June, 2000 Where: 11 of Hooge's stations (even numbered ones) Who: Martin Robards Ref: Robards, M. et al. 2003. Ecology of Selected Marine Communities in Glacier Bay: Zooplankton, Forage Fish, Seabirds & Marine Mammals. USGS/BRD, Anchorage Comments: Cumulative total of 76 precisely located samples makes this study replicable at a reasonable level for early summer conditions.
Birds			
Foraging Ecology and Monitoring of Kittiwakes	No (B2)	PRIME (Ab)	What: Surveys of kittiwake numbers and productivity at various nesting sites, most notably the Margery colony. When: numerous years going back to the late 1960's Where: The upper and mid bay; outer coast Refs: Gordon, R. 1973. *in* Dixon Harbor Biological Survey: Final Report on Summer Phase of 1973 Research, Streveler & Worley, eds. . NPS, Gustavus. Patten, S. 1995. Birds. *in* Dixon Harbor Biological Survey: Final Report on Summer Phase of 1974 Research, Streveler & Worley, eds. . NPS, Gustavus. Weisbrod, A. 1978. Lituya Bay Mining Impact: Avifaunal Survey. NPS, U Washington CPSU, Seattle. Acuna, C & L. Selig. 1983. Population Observations at Lituya Bay: Kittiwake, Sea

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Lion, harbor Seal. NPS/RM, Gustavus. Heacox, K. 1983. The Margerie Glacier Kittiwake Colony, GLBA, Alaska. NPS/RM, Gustavus. Jettmar, K. The Lituya Bay Kittiwake Colony, GLBA: a Census. NPS/RM, Gustavus. Climo, L. & T. Duncan. 1991. The Status of Black Legged Kittiwakes in GLBA, 1991. NPS/RM, Gustavus Sharman, L. & H. Lentfer. 1991. 1991 Dixon Harbor Biological Survey. NPS/Rm, Gustavus. Lentfer, H. 1992. Census of Breeding and Productivity of Selected Black Legged Kittiwake Colonies in GLBA, Alaska in 1992. NPS/RM, Gustavus Hooge, E. 1993. Census Methodologies of Black-legged Kittiwakes in GLBA. *in* Proceedings of the Third Glacier Bay Science Symposium , Engstrom, ed. NPS, Anchorage Yerxa, R & E. Hooge. 1994. Status of Selected Black-legged Kittiwake Colonies in Glacier Bay, Alaska: census and productivity report, 1994. NPS/NBS, Gustavus Yerxa, R, M. Kralovek & E. Hooge. 1995. Status of Selected Black-legged Kittiwake Colonies in Glacier Bay, Alaska: census and productivity report, 1995. NPS/NBS, Gustavus. Hooge, E et al. 1998. Black Legged Kittiwake Monitoring Handbook. USGS, Gustavus. Comments: In aggregate, this is one of the most thoroughly surveyed species in the park; the Margerie & Lituya colonies particularly have excellent and repeated data on bird numbers and productivity. The methodology since the early 1990's is on a very rigorous basis.
Gull Egg Environmental Assessment, S Marble island	No (B2)	PRIME (Aa,Bd)	What: Population sizes and fecundity of seabirds with particular reference to glaucous-winged gulls How: Protocols per Byrd (1989), well spelled out for each species. When/where: Summer 1999 on S Marble Island Who Stephanie Zador, John Piatt Ref: Zador, S & J.Piatt. 1999. Populations and Productivity of Seabirds at South Marble island, Glacier Bay, During May-July, 1999. USGS/BRD Comments: This is a highly disciplined study with clear protocols and good stats. Purpose was to construct exploitation model, but highly replicable
Gull Egg Predation Simulation Model	No	No	Ref: Zador, S. & J. Piatt. 2006. Balancing Predation and Egg harvest in a Colonial Seabirds: a Simulation Colony. Ecological Modeling 195: 318-326.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Comments: This is a model, based in part of information from S Marble Island; see above study for ecological specifics relative to S Marble Island.
Gulls of N Marble Island	No (B1)	Yes (A1,B)	What: Breeding ecology of gulls (and other bird species) on N marble island How: Extended onsite observation, mapping of colonies, measurement of productivity, timing. When: May-August, 1972; April-August, 1973. Who: Sam & Renee Patten Ref: Patten, S. 1974. The Breeding Ecology of the Glaucous-winged Gull in Glacier Bay, Alaska. M.S Thesis, U Washington. Comments: A thorough and careful study; important background to Zador's work, from the neighboring island.
Kittlitz's *and Marbled* Murrelets - Distribution, Abundance	Yes (A1, B1)	PRIME (Ba,b)	What: determine the seasonal, at-sea habitat use of murrelets within Glacier Bay National Park, including both East and West Arms of Glacier Bay Proper. How: Systematic vessel-based counts on strip transects using standard protocols; radio telemetry data from birds captured and tagged in 2004. Where: Glacier Bay Who: Marc Romano, John Piatt, Yumi Arimitsu, Alison Agness, Gary Drew When: June-August surveys, 2003; two 10-day cruises during the summer of 2004 Ref: Romano, M., et al. 2004. At-sea Density and Distribution of Kittlitz's and marbled Murrelets in Glacier Bay, Alaska, Summer, 2003. Romano, M & John Piatt. 2004. Temporal and Spatial Variability in Distribution of Kittlitz's Murrelets in Glacier Bay. Abstract, 4th GB Science symposium, Juneau. Comments: Careful, repeatable work of the utmost importance, given the species declining status. 2004 paper cites data from 1991 & 1999/2000, which allow decadal comparisons.
Kittlitz's Murrelet Population	--	--	Included in *FWS Birds & Mammal surveys – 2000's*
Behavioral Ecology of Kittlitz's Murrelets	No	No	What: Murrelet movements, foraging behaviors How: Telemetry on 15 tagged birds Where: Glacier Bay When: 2004 Who: Marc Romano, John Piatt Ref: Romano, M & J. Piatt. 2004. Behavioral Ecology of Kittlitz's Murrelets as Determined by Radio Telemetry. Abatract, 4th GB Science Symposium, Juneau. Comments: This study is not designed to provide a replicable baseline, but to elucidate

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			aspects of life history.
Scoter surveys	No (B1)	No? (A1?,B)	What: Counts of scoter flocks How: Usually just by eyeballing When: late 60's to 80's Where: Generally on the middle west side of GB, where most big scoter flocks used to be concentrated Who: Susanne Carter, Barb Blackie, Lewis Sharman, Ole Wik, Jerry Hok and other rangers/biotechs. When: Various times, going back at least to 1967 Refs: Carter, S. 1985. Census and Behavior of Surf and Whitewinged Scoters in the Hugh Miller Inlet Area of Glacier Bay, Alaska. Cascadia Research Collective, Olympia Wa. Comments: I did not make a concerted search for the various inhouse reposts and field notes that previously existed. One can only hope that they are still around somewhere.
FWS Outer Coast aerial surveys	No (B1)	PRIME (Ab,Bd)	What: survey of nearshore marine birds How: low aerial flights over nearly entire outer coast shoreline Where: Spencer-Dry Bay When: 8 surveys, June-October, 2001, 2002. Who: Bruce Conant, Jack Hodges, Russ Oates, Mike Jacobson, Jim King. Ref: Conant, B & D. Groves. 2002. Gulf of Alaska Shoreline Waterbird Surveys. USFWS, Juneau. Comments: Repeated surveys done by very seasoned observers. Gives reliable index to bird numbers & distribution. Valuable work.
FWS SE-Wide Aerial Waterbird Survey	No (A1,B1)	No (A1)	What: Aerial survey of all SE Alaskan coastal waters for waterbirds How: Via aircraft @ 150ft, 2 observers, covering ¼ mi strip of water starting at shore. Where: all park coastline except outside coast N of Spencer When: late 1990's (1997 for parts of park) once in winter, once in summer Who: Jack Hodges, Debbie Groves Ref: data in FWS files, according to Debbie Groves. Hodges is preparing a report Comments: This one-time survey is a useful baseline on a regional scale, but for a locality there is too much variation for a one-time survey to be useful in that context. May however, take on more significance in concert with the above project, and with the marine predator survey of Piatt et al. Also useful in placing park fauna in a regional context.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Whales			
Humpback Whale Entanglement	No (B1)	PRIME (Ab, Ba,d)	What: Documents rates of whale entanglement in gear How: Analysis of scarring on peduncle evident on photos Where: Northern SE Alaska, including Glacier Bay When: Photographs taken 2003-04 Who: Janet Neilson Ref: Neilson, J. 2006. Humpback Whale Entanglement in Fishing Gear in Northern Southeastern Alaska. M.S. Thesis, UAF Comments: The large sample size (n >160) allows high degree of confidence in results, and therefore in its use as monitoring rates of entanglement.
Killer Whale Acoustics	No	No	What: Document occurrence of transient killer whales & acoustic communications associated with predatory behavior How: photo I.D; follow whales to record communications in assn with predation events When: 2004-present Where: Glacier Bay Who: Volker Deecke, Jan Straley Ref: Deecke, V. 2006. Predatory Behaviour and Acoustic Communication of Mammal-eating Killer Whales in GLBA. Permit appln to NPS in park electronic files Comments: elegant study, but designed to elucidate relationship between certain behaviors and related acoustics rather than provide a baseline. However, it will add to Matkin's long-term efforts to document the number, behaviour and timing of use by these whales (see below)
Killer Whale Population Assessment	Yes (A1, B2)	PRIME (Aa,b, Bd)	What: Population & feeding ecology, and relationships with other marine mammals How: Repeated photographic identification and observation Where: Glacier Bay and Icy Strait, with comparisons elsewhere in the range of local pods When: Summer, with occasional checks other seasons. Summer effort 1989-2001 ~ two days/week; 2002-present, 40-45 days/season. Who: Dena matkin Refs: Matkin, D., et al. in press. Killer Whale Feeding Ecology and Non-predatory Interactions with Other Marine Mammals in the Glacier Bay Region, Alaska. Fourth Glacier Bay Science Symposium. Matkin, D. 1992. Summary of Killer Whale Research in Glacier Bay and Icy Strait,

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Alasks, 1983-1990. Rept to NMFS, Seattle. Comments: Seminal work on a charismatic top predator. Methods simple and well spelled-out. Degree of confidence in population figures analyzed. Demographics highly repeatable.
Whale Foraging & Prey Concentrations *(1)*	Yes (A1,B1)	Yes (A1,2)	What: Relationship between foraging whales and concentrations of prey How: Sonic and net sampling of prey in vicinities of feeding whales. Krieger's work based on obs of 44 whales; Piatt/Gabriele study based on obs of 20 whales for 3-6 hrs each. Who: Ken Krieger, John Piatt, Chris Gabriele When: 1984 (Krieger); 2001-02 (Piatt & Gabriele) Where: Glacier Bay & adjacent Icy Strait Refs: Krieger, K. 1988. *in* Proceedings of the Second Glacier Bay Science Symposium. NPS, Anchorage. Comments: Piatt/Gabriele data partially analyzed but not reported yet. Both works have sufficient sample size to give good picture of whale foraging habits during the study periods, and therefore should be replicable, at least in a general sense
Whale Foraging & Prey Concentrations (2)	Yes (A1,B1)	Yes? (A2?,B)	What: Take Hydroacoustic signature of vicinity of feeding whales each time they are encountered during whale census activities How: Each time feeding whale encountered, take & archive reading of echo-sounding of prey mass in the vicinity When: 1996 – present Where: Glacier Bay – Icy Strait Who: Chris Gabriele, Janet Neilson Refs: Gabriele, C et al. 1996, 1997, 1999. Population Characteristics of Humpback Whales in Glacier Bay and Adjacent Waters - annual reports. NPS/RM, Gustavus. Comments: Data are summarized in the abovementioned reports; have been collected annually since then but not reported. These date are not truthed by net sampling. The hope is that one day it will be possible to retroactively identify the types of feed documented on these records.
Humpback Whale Monitoring - *1990's to present*	Yes (B2)	PRIME Ab, Ba,b,d)	What: Humpback distribution, abundance, population ecology How: Vessel-based observation Where: Glacier Bay and adjacent parts of Icy Strait When: 1991 – Present Who: Chris Gabriele, Janet Doherty (Neilson) Refs: Gabriele, C et al. 1993. Variability in Counts of Individually Identified Humpback Whales in glacier Bay and Icy Strait. *in* Proceedings of the Third Glacier Bay Science

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Symposium , Engstrom, ed. NPS, Anchorage Gabriele, C. 2004. Age At First Calving of Female Humpback Whales in Southeastern Alaska. Abstract, 4th GB Science Symposium, Juneau. Neilson. J & C. Gabriele. 2005. Results of Humpback Whale Population Monitoring in Glacier Bay and Adjacent Waters:2005. NPS/RM, Gustavus Comments: This long-term study, especially when combined with similar (though not always as rigorous) ones going back to the mid '70's, provide one of the most valuable baselines related to the park biota. The 2004 ref illustrates the detail and quality of life history information now provided by this long term data set. The 1993 analysis sets parameters for replicability of survey data – one of the few GLBA data sets that are this rigorously constrained.
Whale Population & Behavior - 1980's	No (B1)	PRIME (Ab,Bab,d)	What: Series of natural history studies prior to Gabriele's, covering the gamut of demographics, distribution, behavior, and relationship to vessels How: Methods & coverages of surveys described in each of these papers Where: Glacier Bay & environs When: 1980's Who: Scott Baker, Anjenette Perry, Gary Vequist, Jan Straley Refs: Perry, A., et al. 1985. The Natural History of Humpback Whales in Glacier Bay, Alaska. NPS/RM Baker, et al. 1986. Population Characteristics of Humpback Whales in Glacier Bay and Adjacent Waters: 1986. NPS, Gustavus Vequist, G. & C. Baker. 1987. Humpback Whales in Glacier Bay, Alaska: a long-term history of habitat use. NPS/RM, Gustavus Straley, J. 1989,90. Population Characteristics of Humpback Whales in Glacier Bay and Adjacent Waters. Rept to NPS, Gustavus. Straley, J. 1994. Seasonal Characteristics of Humpback Whales in Southeastern Alaska. M.S. Thesis. University of Alaska. (also see 3rd symposium paper of same title) Comments: The basic demographic info is quite repeatable, and in fact forms the foundation for Gabriele's subsequent work. The Vequist paper is the best summary of all work done in Glacier Bay during the decade 1976-86.
Whale Populations and Behavior-1970's	No (B1)	Yes (A1,B)	What/how: Whale population behavior, distribution, abundance, age structure, based on extended observation & photography; followed up by Dean's statistical analysis, especially of blow interval data as index of stress. When: 1970's

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Who: Chuck Jurasz, Ginny Palmer, Fred Dean Refs: Dean, F et al. 1985. Analysis of Humpback Whale Blow Interval Data, 1976-1979. Final Rept on Contract to NPS, Au Alaska, Fairbanks. Jurasz, C & V. Palmer. 1981. Censusing and Establishing Age Composition of Humpback Whales, Employing Photodocumentation in GLBA, Alaska. Rept to NPS, Anchorage. Comments: Exhaustive statistical analysis of blow intervals as indicator of stimuli responses, notably to vessels. Important baseline, especially given its antiquity. Many other data in the cited Jurasz report and several others by these authors give a less rigorous view of whale populations and behaviors during the 1970's.
Humpback Whale Genetics	Yes (A1,B1)	Yes (A1, B)	What: Determining whale sex and genetic population structure How/where: Molecular markers for paternity; analysis of mitochondrial haplotypes at elevenmicrosatelite loci for population differentiation. 139 whales sampled from SE Alaska, California and Gulf of Maine. When: Samples procured in SE, 2000-present Who: Denny Vant, Chris Gabriele, Janet Neilson Ref: Vant, MD. 2002. Population Structure and Genetic Diversity of Humpgack Whales in the North Bacific: a multi loci Approach. MS Thesis, U Aukland, NZ. Comments: Careful and thorough study that identifies population structure with statistically reliable clarity. Good baseline. Much data in recent years remains unreported.
Humpback Whale distribution vs. vessels & oceanography	No (B1)	Yes (A1,B)	What: Whale distribution and behavior in relation to boats, tides and time of day How: Documentation of whale and vessel distribution in time and space, from land and kayak-based platforms. Comparison of distributional data with synopses of oceanography (notably tidal stage and satellite measurements of sea surface temperatures as proxy for frontal locations). Where: the Point Adolphus area When: 1999-2001 Who: Nikki Koehler, Chris Gabriele, Mia Grifalcone Ref: Koehler, N. 2004. Humpback Whale and Vessel Use Patterns and Interactions at Point Adolphus. Abstract, 4th GB Science Symposium, Juneau. Comments: Distributional data for whales and boats highly replicable. Not given a PRIME only because the data are entirely outside the park., but of course many "Glacier Bay" whales are involved.
Harbor Porpoise Censuses	Yes	Yes	What: Censusing harbor porpoise numbers

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
	(A1, B1)	(A1,B)	How: Calambokidis and Taylor – obs from shore. Prather and Dahlheim – boat transects. In the case of Prather, too cursory to be useful. Dahlheim – line transect protocols well described in 1994 paper. When: 1979 – present; Dahlheim's censuses spring/summer/fall 1991-93, and 2006. Refs: Taylor, B & P. Dawson. 1984. Seasonal Changes in Density and Behavior of Harbor Porpoise Affecting Census Methodology in GLBA, Alaska. Rep. Int. Whal. Commission. 34. Calambokidis, J. 1983. The Behavior of Harbor Porpoises in Glacier Bay, with emphasis on marked Individuals. Cascadia Research Collective. Prather, S. et al. 1989. Harbor Porpoise Baseline Survey, 1989. NPS/RM Dahlheim, M. 1994. Abundance and Distribution of Harbor Porpoises in Southeast Alaska, Cook Inlet and Bristol Bay, Alaska. NMFS Marine Mammal Lab, Seattle Dahlheim, M. in prep. *Porpoise survey just completed at this writing; results not reported yet.* Comments: All work prior to Dahlheim's not sufficiently extensive &/or rigorous to provide a credible baseline. Taylor's work in Sitakaday Narrows is repeatable but confined to a small area. Dahlheim's surveys are statistically and methodologically rigorous; they cover enough territory to give a rough index to porpoise abundance, but can hardly be said to census the park.
Pinnipeds/sea otters			
Harbor Seal Diet and Foraging Areas	Yes (A1, B1)	Yes (A1,B)	What: What and where are seals eating in Glacier Bay? Multi-agency study of possible factors in seal decline How: Scat analysis; stable isotope analysis of shed hair; tracking seals via VHF transmitters and TDR recorders; fine-scale hydroacoustics surveys in areas where seals show foraging behavior Where: Throughout bay, but mostly Spider Is & Hopkins vicinities When: 1996-2002 by Matthews' crew; 2004-06 by Blundell/Gende/Womble's crew Who: Beth Matthews; Gail Blundell, Jamie Womble, Scott Gende, Mike Sigler Refs: Matthews, E. 2002. Diet of Harbor Seals at a Glacial Fjord and a Terrestrial Haulout in Glacier Bay, 1996-2001. Progress Report. UAS Matthews, E. 2004. Trophic Differences in Harbor Seals from a glacial Fjord and a Terrestrial Haulout in Glacier Bay Inferred from Stable Carbon and Nitrogen Isotopes from

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Molted Hair. Abstract, 4th GB Science Symposium, Juneau. Womble, J. et al. 2006. Harbor Seal Foraging Ecology Investigations in GLBA. 2005 Annual Report To NPS Comments: This is a large and complicated set of studies with several facets. Sample sizes for hair were large, especially from Hopkins (N=101), less so for Spider (N=30); Matthews' scat sample size was smaller (N=86) and spread widely in space & time. The isotope data can be considered a reasonably good baseline. Matthews considered scat analysis provisional pending more samples, but that is being amplified by Womble as of 2006, when 44 samples were collected from Spider, Flapjack & Adams. TDR's retrieved (n~30) over three years, 04-06, will provide considerable data on dive location & interval when analyzed, and the sample size is approaching adequate for a baseline. Large scale acoustic surveys were carried out monthly in 2005 at transects in Beardslee Entrance & Hopkins (3 replicates/ site); small scale surveys were done opportunistically (n=40).
Harbor Seal Genetics	Yes (A1,B1)	Yes (A1,B)	What: Characterizing genetics of Glacier Bay harbor seals in comparison with others in region to clarify metapopulation structure. Where: a number of Glacier Bay sites. How: Blood, hair, serum, tissue analysis When/who: 1996-2002 (Beth Matthews); 2004-2006 (Gail Blundell, Jason Herreman). Comments: Not sure of Matthews' sample sizes; Blundell: over 400. No results have been published yet, but sample sizes should allow high confidence in results. Womble advises that early results suggest that stocks are structured on a much finer scale than the three currently recognized for Alaska.
Harbor Seal Monitoring - Locations and Counts	Yes (A1, B1)	PRIME (Ab, Ba,d)	What: Censusing seals in Glacier Bay How: Mostly land-based counts of hauled-out seals, using various protocols; Streveler tried and discarded aerial counting; Matthews used it as adjunct to land counts. Streveler used vessel counts in winter. Womble has continued aerial counts of terrestrial haulouts as part of region-wide trend surveys. When: Streveler, 1973-78; Calambokidis, 1982-84; Matthews, 1996-2002**?** Womble et al, 2004-present. Where: Particular emphasis on the major natal areas, but some counts during molting and winter.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Who: Greg Streveler, John Calambokidis, Beth Matthews, Jamie Womble Ref: Streveler, G. 1979. Distribution, population ecology and Impact Susceptibility of the Harbor Seal in Glacier Bay, Alaska. NPS, Juneau. Calambokidis, J., et al. 1987. Distribution and Haul-out Behavior of Harbor Seals in Glacier Bay, Alaska. Matthews, E. 1992. Harbor Seal Censuses in GLBA: a comparison of land-based and aerial censusing. UAS rept to NPS/NMFS, Juneau Matthews, E. 1993. Long-term Trends in Abundance of Harbor Seals and Development of Monitoring Methods in GLBA, Southeast Alaska. *in* Proceedings of the Third Glacier Bay Science Symposium , Engstrom, ed. NPS, Anchorage Matthews, E. & G. Pendleton. 2000. Declining Trends in harbor Seal Numbers at Glacial Ice and Terrestrial Haulouts in GLBA, 1992-1998. UAS/ADF&G Rept to NPS. Matthews, E et al. 2004. Declines in Harbor Seal Numbers in GLBA, 1992-2002. Abstract, 4th GB Science Symposium, Juneau. Womble, J, et al. 2005. Glacier Bay Harbor Seal Foraging Ecology Research, Final Report, 2005 field season. ADF&G report to NPS. Mathews, E. and G. Pendleton. 2006. Declines in harbor seal (Phoca vitulina) numbers in Glacier Bay National Park, Alaska, 1992-2002. Marine Mammal Science 22:167-189. Comments: Matthews has stitched together data from all these sources and has set a high standard for replicability and statistical treatment. Her work is highly repeatable, and provides one of the few data sets that is rigorously examined for replicability. Womble's work is also based on regional protocols, and provides a repeatable index, but (as she point out) such data are quite variable and must be looked at in aggregate to give a valid trend picture. The Hopkins work of Matthews has been discontinued, but is planned to resume in 2007 in some form.
Harbor Seal Pup Call Frequency	No	No	What: Documentation of frequency and temporal patterning of pup calling. How: keeping track of pup vocalizations in course of other seal work Where: Hopkins When: 1990's Who: Laura Dzinich, Beth Matthews Ref: Dzinich, L & E. Matthews. Unpublished ?(abstract 1999). A Diurnal Pattern to Variation in Rates of Harbor Seal Pup Calls in Johns Hopkins Inlet, GLBA, Alaska. NPS/UAS.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Comments: Postulated to be correlated with the timing of mothers' feeding periods, and if so might be an index to a time of mother/pup separation & thus impact susceptibility. But that correlation has not been demonstrated.
Harbor Seals 1998 - McBride	No (B2)	Yes (A1,B)	What: Evaluation of human/vessel disturbance of seals How: Systematic observation, using defined protocols Where: McBride Inlet When: 37 days during pupping season, 1998. Who: Tania Lewis Refs: Lewis, T. 1999. Distribution, Pupping Phenology, and haul-=out Patterns of Harbor Seals at McBride Glacier Fjord, GLBA. NPS/RM, Gustavus. Lewis, T. and E. Matthews. 2000. Effects of Human Visitors on the Behavior of harbor Seals at McBride Glacier Fjord, GLBA. UAS & NPS/RM Comments: Purpose is as title states. Gives general idea of # of seals using fjord, but not enough data to provide a baseline. Comments: Nice study, applicable so long as McBride remains an iceberg source.
Sea LionNumber, Movements and Metapopulation Structure (Includes "Sea Lion Brand Resighting" and "Sea Lion Pup Branding" from the project tracking database)	Yes (A2,B1)	PRIME (Ab,Bb)	What: Numbers; movements of individuals between rookery/haulouts, and interchange between regions; metapopulation structure of the species. How: Rookery counts; Branding and resightings of branded animals; genetic assays of individuals for comparison with selected loci in stocks from other regions Where: Various haulouts/rookeries in GLBA, with particular attention to S Marble and graves When: 1994 – present (with notes from 1975-77, 199697) Who: Beth Matthews, Ken Pitcher, Lori Jemison, Tom Gelatt, Andrew Trites, Kelley Hastings, Park staff Refs: Acuna, C & L. Selig. 1983. Population Observations at Lituya Bay: Kittiwake, Sea Lion , Harbor Seal. NPS/RM, Gustavus. Patten, R. 1975. Marine Mammals . *in* Dixon Harbor Biological Survey: final report on the summer phase of 2004 research. Streveler & Worley, eds. NPS, Juneau. Streveler, G. 1980. Larger Mammals. *In* Lituya Bay Environmental Survey, Sterveler, Worley & Molnia, eds. NPS, Gustavus [*Page on marine mammals is missing from archives copy!*] Calkins, D. et al. 1999. Steller Sea Lion Status and Trends in SE Alaska: 1979-1997. Mar. Mamm. Sci. 15(2):462-477. Matthews, E. 2003. Observations of Steller Sea Lions from the Western Population

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			at South Marble Island, GLBA. Jemison, L. 2005. Trip Report: Sightings of Branded Steller Sea Lions in Southeast Alaska, 1-25 July, 2005. ADF&G, Juneau Gelatt, T et al. 2004. Steller Sea Lion Population Trends, Diet, and Brand-resighting Observations in GLBA. Abstract, 4th GB Science Symposium, Juneau. Pitcher, K ,et al. in prep. Status and Trends in Abundance and Distribution of the Eastern Steller Sea Lion Population. Comments: The brand/resighting work, especially if the 03-05 work is lumped, provides an excellent index to occurrence of branded animals in the park, and thus to the provenance of our animals. The ADF&G reports also have data on the frequency and types of entanglement gear found on sea lions. Womble also has 4 years+ of data from aerial surveys. Survey data give good long-term trend indices. Pitcher advises that Greg O'Corry-Crowe has a paper in progress on sea lion genetics that covers the Graves Rocks rookery, which will show that ~70% of founding females came from the western North Pacific stock, even though it is nominally within eastern stock boundaries.
Sea Lion Scat Analysis	Yes? (A1?,B1)	Yes? (A1?,B)	What: Dietary analysis Where: Graves rocks, South Marble How: scat collection and analysis When: "a number of years" up to present, back at least to 1994 for Graves and 2001 for S Marble. Who: Laurie Jemison, Ken Pitcher, Andrew Trites, Dom Tollit (UBC) Comments: No data are published yet, but analyses were obtained from Pitcher for 1994 (Graves) and 2001 (S Marble & Graves). For those years, n~50 per site. Trites has the raw data. Analysis is backed up at the time of this writing.
Sea Lion Aerial Surveys in relation to Spring Fish Spawning Areas	No (B2)	Yes? (A1?,B)	What: Surveys of haulouts to determine seasonal distribution in relation to prey availability How: Systematic monthly aerial counts Where: 25 sites in SE AK, incl. Marble is, Graves Rocks, Pt. Carolus, Tarr Inlet in park When: March 2001-May 2004, for all but Tarr which was only surveyed in 2004. Adams Inlet, Dixon River, Alsek River, Excursion River included during April & early May Who: Jamie Womble, Mike Sigler, Mary Willson Refs: Womble, J. 2003. Seasonal Distribution of Steller Sea Lions in relation to High-quality Ephemeral Prey Species in SE Alaska. M.S. Thesis, UAF. Womble, J, et al. 2005. Distribution of Steller Sea Lions in Relation to Spring Spawning Fish in SE Alaska. Marine Ecology Prog. Series 294:271-282.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Womble, J. et al. in review. Season Specific foraging strategies of a marine predator: linking seasonal distribution patterns and prey availability. NOAA, Auke Bay. Comments: Studies well designed, but purpose was to demonstrate relationship between sea lion densities & fish resources, not provide population baseline. Aerial surveys of haulouts accompanied by photos are reliable means for spot checks, but do not always capture the variability at a site. Sampling density & duration appears sufficient to provide an order of magnitude baseline if aggregated over several haulouts and times.
Sea Otters and Benthic Marine Communities	Yes? (A1,B2?)	PRIME (Ab,Bd)	What: Document ecosystemic conditions in the shallow benthic of prior to sea otter invasion. How: 30 permanent study sites at which the biota (macroalgae, benthic diatoms, sea urchins, predatory snails, sea stars, crabs) resurveyed annually. At each site, did 1990ea. $1m^2$ and 1040ea. $10m^2$ quadrats. Assessed population structure for sea stars, snails and urchins. Where: Shallow subtidal, lower and mid Glacier Bay When: (1999 pilot) 2000-2003 Who: Mike Donellen, Jennifer Fisher, Julie Barber Ref: Donellen, M., et al. 2004. The Ecological Effects of Sea Otters on Shallow Marine Benthic Communities in GLBA, and Inventory and Monitoring of Shallow Subtidal Communities in Lower/Mid Glacier Bay, annual report 2004. NPS/RM Comments: This was envisioned as a pre-sea otter study, and is admirably configured for that, with lots of data and (Bill tells me) good statistical rigor. It would be critical to follow up on it as an adjunct to Bodkin's intertidal work.
Sea Otters and the Nearshore Communities	Yes (A1,B2)	PRIME (Ab, Bd)	What: Sea otter distribution and abundance, food habits, effects on intertidal clams and crabs How/where: aerial surveys in Glacier Bay and adjoining waters of two types: abundance and distribution. Direct foraging observations to document dietary preferences. Estimated species composition, density, biomass, and sizes of intertidal clams at 59 sites in Glacier Bay, 14 sites in Idaho Inlet, 12 sites in Port Althorp and 2 sites in Dundas Bay. Related MADS work on Dungeness crabs also cited here. Scheding's work based on MADS crab sampling data. When: boat-based surveys began soon after release of recolonists, in the early 1970's. Aerial surveys begun in 1994 and continued to present. Some clam beds sampled in 99-03,before otters. Done yearly up to present. MADS work (see elsewhere in this doc.) Who: Bodkin, Esslinger, Kloecker; Neilson (aerial surveys); Scheding (Crab work); park

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			staff Refs: Acuna C. & L. Selig. 1983. Sea Otter Observation on the Outer Coast, 1983. NPS, Gustavus. (in Sharman files) Perrelli, R. 1985. Sea Otter Outer Coast [& *Pt. Gustavus*] Observations, Summer, 1985. NPS, Gustavus (in Sharman files) Klinger, N. 1987. Sea Otter Outer Coast Observations, 1987. NPS, Gustavus. (in Sharman files) Vequist, G. 1987. Sea Otter Recolonization of Ancestral Range in GLBA. NPS, Gustavus. (in Sharman files) Shirley, T. C., G. Bishop, C. E. O'Clair, S. J. Taggart, and J. L. Bodkin. 1996. Sea otter predation on Dungeness crabs in Glacier Bay, Alaska. Pages 563-576 *in* High Latitude Crabs: Biology, Management, and Economics. Alaska Sea Grant College Program, AK-SG-96-02. Bodkin, J., et al. 2000. Sea Otter Studies in GLBA: aerial surveys, foraging observations and Intertidal Clam Sampling. USGS/BRD, Anchorage Scheding, K. 2004. The bathymetric distribution of Dungeness crabs, *Cancer magister,* in bays with and without sea otters. Masters of Science. University of Alaska, Fairbanks, Fairbanks. Bodkin, J. 2005. Sea Otter Movements and Life History in GLBA. 2004 Ann Report on Project 9353AOC Bodkin, J et al. 2004. Perspectives from an Invading Predator: sea otters in Glacier Bay. Abstract, 4th GB Science Symposium, Juneau. Comments: Based on the reports seen, Bodkin's and Scheding's work is procedurally and statistically tight, excellent for a baseline. Most of the earlier observations are less constrained, but provide a valuable historical background.
KelpBeds and Sea Otters	Yes (A1, B1)	PRIME (Ab, Bd)	What: Manipulated sea urchin and kelp densities to observe proxy effects of otter predation on urchins. How/when: Set up unspecified # of plots over 2 years, 1973-4; did various removals of urchins and kelp. Revisited and resampled more or less same sites in 1987 and 2003. Where: Torch Bay subtidal Refs: Duggins, D. 1979. Kelp Beds and Sea Otters: an experimental approach. Ecology 61(3):447-453. Duggins, D. 1980. Kelp Dominated Communities: Experimental Studies on the Relationship Between Sea Urchins, Their Predators and their Algal Resources. Ph.D.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Thesis, Universtiy of Washington Estes, J & D. Duggins. 1995. Sea Otters & Kelp Forests in Alaska: Generality and variation in a Community Ecological paradigm. Ecol. Monographs 65: 75-100. Duggins, D. 2003. Trip Report, Southeast Alaska, 2003. Report to NPS Comments: Very important baseline given its duration and rigor, especially now that the sample sites are GPS'd. (Duggins has this info) The 1970's-80's-90's comparisons are only approximate but still very valuable given the magnitude of changes over this period. Important adjunct to Bodkin's work.
Invertebrates			
Brachyuran Larvae Distribution & Abundance, Dungeness Crab Larval Dispersal	No(B1)	Yes? (A1,B?)	What: Is Glacier Bay a net sink or producer of crab larvae? E.g., what is the spatial and temporal distribution of crab larvae relative to tidal stage and oceanographic conditions? How/where: Year 1: sampled larvae at 5 stations in lower bay, 3 depths. Year 2: weekly in Sitakaday. Documented vertical distribution changes, day & night. Deployed drifters twice during summer, 2002. When: 2001-02 Who: Jennifer Fisher Refs: Fisher, J. 2004. Distribution, Abundance and Timing of Brachyuran Larvae in a High-latitude Fjord. Abstract, 4th GB Science Symposium, Juneau. Fisher, J. 2005. Larval Dynamics of Brachyuran Crabs in a High Latitude Fjord, Southeast Alaska. M.S. Thesis, San Jose State University. Comments: Jen's thesis covers the questions of larval temporal dynamics, but not the spatial aspects. Etherington's note in k/eco-data says that the drifter data is not in files available to her. Sampling was intended to elucidate timing and behavior, and appears not to have been sufficiently spread in space or time to provide a replicable picture suitable for a baseline. Might be a useful baseline on phenological changes, in concert with Eckert's work.
Dungeness Aggregation	No	No	What/where: Description of crab aggregations in pothole features in Bartlett Cove Diving on the potholes Who: Phillip Hooge Ref: Hooge, P., et al. 2004. Sea Floor Habitat Mapping and Classification in Glacier Bay, Alaska, Phase 1&2, 1996-2004. Comments: Reconiassance study. Not meant for replication.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Dungeness Crab Larval Abundance	Yes (A2, B1)	Yes? (A1?, B)	What: Settlement and recruitment of Dungeness crab. How: monitoring settlement bags and plankton collectors When: 2000-present Where: Bartlett Cove, Beardslee Islands. Who: Ginny Eckert, Heidi Herter. Refs: Permit appln in Project Tracking , 2005 Investigator's Annual Report Most recent meeting presentation: How Big is Big Enough? America's Largest Temperate Marine Reserve May Not Be Self Sustaining for Some Species: Recruitment of Dungeness Crabs in Glacier Bay, presented by G. Eckert at Ocean Sciences 2006, Honolulu, HI. Herter, H. defense in Fall 2006. Spatial variation in Dungeness crab larvae in Beardslee Islands and Bartlett Cove, GLBA. M.S. Thesis *Approximate title; work not seen.* Papers in progress. Comments: Study designed to document timing of life history phases and their spatial distribution in lower Glacier Bay. Based on IAR, could be used for monitoring if timing of such events was to be used as an index of phenological changes.
Dungeness Crab Larvae Spacio-temporal Distribution	Yes? (A1?,B1)	Yes? (A1?, B)	What: Patterns of larval abundance How/where: Light traps repetitively occupied at Bartlett Cove; 114 locations throughout Bay light trapped once each at two depths. When: Bartlett Cove 2000-2003; elsewhere, summer 2002 Who: Ginny Eckert, Jeff Douglas, Jim Taggart, Jennifer Fisher Ref: Eckert, G. et al. 2004. Temporal and spatial Patterns in Dungeness Crab Larval Abundance within Glacier Bay. Abstract, 4th GB Science Symposium, Juneau. Comments: The Bartlett Cove data have enough replicates to function as a baseline; the one-time samples elsewhere provide a general snapshot that, if replicated, could illustrate only a gross change in pattern.
Dungeness Crab Larval Movement *(better title: relationship between adult and larval crab abundance)*	Yes (A1,B1)	Yes (A1,B)	What: Relationship between adult and larval crab abundance How: Extensive pot survey of adult populations in concert with plankton tows Where: Lower Glacier Bay and Icy Strait When: 1996-2002 Who: Wongyu Park, Tom Shirley, Jim Taggart Ref: Relationship Between Abundance of Dungeness Crab Adults and Larvae: regional population increase or larval export from an MPA? Abstract, 4th GB Science Symposium,

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Juneau. Comments: Large sample size, rigorous design. Highly replicable.
Dungeness Crab-pot Dive Experiment	No (B1)	Yes (A1,B)	What: Assess the effectiveness of pot surveys in population assessment. How: Sample crabs in with commercial crab pots, and a dive study that assesses populations in the same areas. Where: Lower Glacier Bay, Dundas Bay and Gustavus Flats When: April & September, 1993-2000 Who: Jim Taggart, Chuck O'Clair, Tom Shirley, Jennifer Mondragon Ref: Taggart, S. J., et al. 2004. Estimating Dungeness crab (*Cancer magister)* abundance: crab pots and dive transects compared. Fishery Bulletin **102**:488-497. Comments: This systematic and extensive work provides much data on crab abundance and population structure. Though the sampling density was not sufficient to document population parameters in a locality , it does so on a sub-regional scale. Highly replicable.
Dungeness Crab Distribution/Movements/Abundance in shallow water	No (B1)	Yes (A1,B)	What: Survey of crab density in shallow waters How: Census by divers on 2m x 100m transects, 0 to 18m depth, 15 randomly placed transects in each of 5 sites. Tracked 16 adult male, 8 non ovigerous adult female and 11 ovigerous female sonic-tagged crabs for a week. Where: Lower Glacier Bay & Icy Passage. When: 1992-93 Who: Chuck O'Clair, Tom Shirley, (the MADS group) Ref: O'Clair, C et al. 1993. Nearshore Distribution and Abundance of Dungeness Crabs in GLBA, Alaska. *in* Proceedings of the Third Glacier Bay Science Symposium , Engstrom, ed. NPS, Anchorage Comments: Carefully designed and described study. Highly replicable, except for the sonic tag component, which is based on a small sample for a short time.
Dungeness Fjord Oceanographic Gradient (FOG)	No(B1)	Yes (A1,B)	What: Survey of crab distribution throughout Glacier Bay in comparison to oceanographic parameters and distance from bay mouth How: 468 pots at 52 sites at -10m; CTD measurements made at each pot site; Hooge oceanographic transects also referred to. When: Aug-Sept, 1999. Who: Jim Taggart, Phillip Hooge, Jennifer Mondragon, Alex Andrews Ref: Taggart, SJ et al. 2003. Living on the Edge: the distribution of Dungeness Crab in a Recently Deglaciated Fjord. Marine Ecology Progress Series 246:241-252. Comments: Carefully planned study designed to exhibit general patterns and very replicable

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			on that scale. Taggart adds that monitoring animals such as this, that have disjunct distributions to see if their distributions change, would be a good indicator of ecosystem change.
Abundance of Male and Female Dungeness Crabs	No (B1)	Yes (A1,B)	What: Spatial variability in distribution of adult crabs by sex How: Systematic pot fishing Where: Lower Bay and Icy Passage When: 1992-93 Who:Erica Leder Ref: Leder, E.et al. 1993. Male Size and Female Reproduction in Dungeness Crab in Glacier Bay, alaska *.in* Proceedings of the Third Glacier Bay Science Symposium , Engstrom, ed. NPS, Anchorage Comments: As with the above study (to which it is related) the methods are careful and well described, and sample sizes are sufficient to allow confident replication.
Tanner & Red King Crab Pot Survey (*includes* "Tanner Crab Nurseries" *listed in project tracking database; also has an important multi-species component*)	No (B1)	PRIME (Ba)	What: Distribution, abundance, condition and population parameters of Red King & Tanner crabs; special attn. given to apparent nursery areas in Scidmore and Wachusett. How: Systematic pot survey, using commercial crab and shrimp gear. Substrate was grab-sampled during fall survey. Temperature measured at each pot. Where/when: Most of glacier Bay (excluding Hopkins, Adams, McBride and some side bays sampled (and in some cases re-sampled) during summer, 2002. Wachusett and Hugh Miller sampled again on finer scale, Fall, 2003. Who: Jim Taggart, Jennifer Mondragon, Alex Andrews, Julie Nielsen Refs: Taggart, SJ et al. 2003. Testing the Effectiveness of a high latitude Marine Reserve Network. Phase 1: Distribution of King and Tanner Crabs in Glacier Bay, Alaska. USGS/BRD, Juneau. Progress Report. Taggart, SJ et al. 2004. Testing the Effectiveness of a high latitude Marine Reserve Network. USGS/BRD, Juneau. Progress Report. Neilsen, J et al. 2004. Glacial Fjords in GLBA: Nursery areas for Tanner Crabs? Abstract, 4th GB Science Symposium, Juneau. Mondragon, J. et al. 2004. Spatial Distribution and Relative Abundance of Tanner and Red King Crab Inside and Outside Marine Reserves in Glacier Bay, Alaska. Abstract, 4th GB Science Symposium, Juneau. Nielsen, J. K. 2005. Distribution and movement of juvenile Tanner crabs *Chionoecetes bairdi* in Glacier Bay National Park. M. Sc. thesis. University of Alaska Fairbanks, Fairbanks.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Nielsen, J., et al. Submitted. Distribution of juvenile and adult Tanner crabs *Chionoecetes bairdi* in a glacial fjord ecosystem: implications for understanding recruitment processes. Canadian Journal of Fisheries and Aquatic Sciences **XX**:xx-xx. Comments: All species caught in pots were recorded as well as the target crabs. This survey should be viewed as a comprehensive of mobile benthic macroafauna. Will be very valuable for monitoring changes in relative abundance and distribution of shrimp, predatory gastropods, smaller crab species. The shrimp and crabs are indicators of regime shift. The commercially fished species are very important for monitoring the effects of the NPS decision to close commercial fishing (e.g. will blue king crabs recover now that the fishery is closed? Incidence of rizocephalan parasites was also carefully measured in 2002.
Movements of Red King & Tanner Crabs	Yes (A1, B1)	Yes (A1,B)	What: Estimate the movement of crab populations How: sonic tags attached to ~60 crabs, monitored 6 times by vessel; crossings of Muir sill monitored by fixed dataloggers. Where: near the boundary of the Muir Inlet reserve. When: Tagged Sept 02, Oct 03; tracked Nov 02-Feb 04 and 05 Who: Jim Taggart, Jennifer Mondragon, Alex Andrews, Julie Nielsen Ref: Taggart, SJ et al. 2004. Testing the Effectiveness of a High-latitude Marine Reserve Network in GLBA, Alaska. USGS/BRD/ Juneau Mondragon, J et al. 2004. Spatial Disrtribution and Relative Abundance of Tanner and Red King Crabs inside and Outside of Marine Reserves in Glacier Bay, Alaska. Mondragon, J. et al. 2004. Spatial Distribution and Relative Abundance of Tanner and Red King Crab Inside and Outside Marine Reserves in Glacier Bay, Alaska. Abstract, 4th GB Science Symposium, Juneau. Comments: data loggers have been only partially successful, but many relocations have been made by vessel. Large sample size makes it possible to estimate movement of populations and allows replication.
Bitter Crab Disease in Tanner Crabs	No	PRIME Aa?,Ba)	What: distribution & prevalence of bitter crab disease in Glacier Bay crabs How: testing blood of crabs caught during systematic pot survey for disease vectors Where: Glacier Bay When: 2002 Who: Kyle Moselle, Sherry Tamone, Jim Taggart, Jennifer Mondragon Ref: Moselle, K et al. 2004. The Distribution of Bitter Crab Disease in Tanner Crabs from Glacier Bay, Alaska.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Comments: large, systematic sample size, simple technique. Highly replicable and related to an important subject economically and (perhaps) ecologically.
Zooplankton studies	No (B1)	Yes? (A1,B?)	What: Zooplankton survey How: 50m vertical hauls at even numbered oceanongrapic station (per Hooge & Hooge 2002), and immediately offshore of beach seine sites (per Arimitsu, 2003) Where: Glacier Bay When: 1999-2002 Who: Martin Robards Ref: Robards, M. et al. 2003. Ecology of Selected Marine Communities in Glacier Bay: Zooplankton, Forage Fish, Seabirds & Marine Mammals. UDGD/BRD, Anchorage Comments: Sampling frequency and timing available in Glacier Bay database. Makes comparisons between authors' data and those of Wing 1963 (presumably unpublished), and Krieger & Wing, 1984. Given the point-in-time nature of sampling and lability of system, not likely to be an adequate baseline on a fine scale, but very useful on a regional scale and for average biomass determinations of the various surveyed species.
Ice-proximal Marine Invertebrate Concentrations	No (B1)	Yes? (A1?,B)	What: Distribution & abundance of benthic, epibenthic and planktonic invertebrates near tidewater glaciers How: Grabs, sediment traps; plankton tows When: 1984, 1986 Where: Near Riggs and McBride glaciers Ref: Simenstad, C. & R. Powell. 1988. *in* Proceedings of the Second Glacier Bay Science Symposium, Milner & Wood, eds. NPS, Anchorage. Comments: Zooplankton work potentially important adjunct to that reported in above ref., but paper at hand does not give sample size of tows. Benthic work also need clarification of sample sizes, but is clearly extensive and therefore valuable. Comparison with the Mueller work in the Dixon Harbor area should be possible. In both cases, station localities are approximately located.
Gustavus School Plankton Study	No	No	What: A school project to identify plankton Who: Chohla Dick. Comments: not designed to produce data
Invertebrate Predator Population Ecology	No	No	What: The distribution & ecology of Nucella Where: Glacier Bay Who: Gail Irvine.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Comments: According to Eichenlaub, Irvine did some preliminary work on *Nucella*, but her large proposal didn't get funded.
Multi-Agency Dungeness Study (MADS)	--	--	This is a general heading for a number of studies, reported in this table under several separate headings. Taken altogether, work done under this rubric is among the most extensive and replicable work done in the park. Despite the closure of the fishery in the park, it is of great relevance to the question of marine reserve design.
Red Tree Coral Exploration	No	No	What: Qualitative description of coral at a couple of localities Who: Tamone, Andrews, the other MADS crew Ref: Stone, R. P., J. Mondragon, and A. G. Andrews. 2005. Deepwater emergence of red tree coral, *Primnoa pacifica* in Glacier Bay, Alaska *in* 3rd International Symposium on deep-sea corals, Science and management. Poster Presentation, Miami, Florida. Comments: Not a monitoring subject per se, but the presence of coral provide the potential for reconstructing temperature, and gross trophics using isotope analysis of growth rings.
Tanner Crab Molt	No(B1)	PRIME (Ab,Ba)	What: Molt hormone analysis to document the presence of a terminal molt in crabs of various size. How: physiological analysis Where: Glacier Bay When: 2004 Who: Sherry Tamone, Jim Taggart, etc. Refs: Tamone, S., et al. In press. Ecdysteroid levels in Glacier bay Tanner crab: evidence for a terminal molt. Pages xx-xx *in* J. F. Piatt and S. M. Gende, editors. Fourth Glacier Bay Science Symposium. U. S. Geological Survey, Juneau. Tamone, S. T.,et al. 2006 Submitted. Ecdysteroid levels in Glacier Bay Tanner crab: evidence for a terminal molt. Canadian Journal of Fisheries and Aquatic Sciences **XX**. Comments: Found that a lot of terminally molted crabs are below legal size, which makes them immune from harvest mortality and likely sets them up for high reproductive success compared to their conspecifics that terminally molt above legal. This sets up a very strong selection favoring terminal molting below legal size. This study sets a baseline for determining whether the proportion of crabs terminally molting below legal size decreases after closure of commercial fishing. VERY IMPORTANT FISHERY IMPLICATIONS
Leather Chiton (Gumboot) studies	No (B1)	No? (A1?,B?)	What: Compared effects of *Katherina* removal on community structure How: removed gumboots from 2ea 25 sq m. plots and measured the result on kelps and selected macroinvertebrates in comparison to adjacent untreated plots.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Where: Torch Bay intertidal When: 1979-1983. Who: Megan Dethier, Dave Duggins Ref: Dethier, M. & D. Duggins. 1988. Variations in Strong Interactions in the Intertidal Zone along a Geographic Gradient: A Washington- Alaska Experiment. Comments: plots were permanently marked; if authors can relocate plots and provide more details on experiment protocols, may be a potential baseline. However, sample size is small.
Ecology of urchin/kelp/starfish community	No (B1)	Yes? (A1,B?)	How: Urchin experiments: urchins & algae rigorously censused on 200-400 sq m plots; then various manipulations were performed on 50 sq m plots within these areas. Starfish plots: starfish removed in some; urchins caged in others, + controls. Where: 4 shallow subtidal sites in central Torch Bay When: over 3 years, 1975-78. Who: Dave Duggins Ref: Duggins, D. 1980. Kelp Dominated Communities: Sea urchins, their Predators and their Algal Resources. Ph.D. Thesis, University of Washington.136p. (plus several related papers.) Comments: Rigorous study; could be important baseline if exact study areas can be located by author.
General marine (incl acoustics)			
Marine Ecosystem Conceptual Model(*s*)	No	No	Hale & Wright's, Bodkin's lovely models. Comments: conceptual; not intended to present specific data
Beardslee Islands Bird and Mammal Surveys	No	No	What: bird and mammal surveys How: skiff-based observation along standard transects. When: Summer, 1988 (Matkin); Summer, 1991 (Duncan & Climo); December, many years, 1975-2005 (Streveler) Where: Beardslees Ref: Duncan, T & L. Climo. 1991. Beardslee Island Bird & Mammal Survey, 1991. NPS, Gustavus. Comments: Matkin (probably should be discounted; report not found); Climo & Duncan (text of report found but not data appendix, which is a shame because did repeated surveys and were good observers); Streveler (Many years of Audubon bird counts; Paige has the data)

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			In all, not good baseline material except in a general sense, as observers, routes and conditions were too variable.
Marine Mammal and Seabird Distribution Surveys *(marine predator surveys)USGS*	No (B1)	PRIME (Ab,c;Ba,d)	What: Systematic surveys of Marine Birds and Mammals How: Repeated boat surveys along a standard set of transects, using standard protocols Where: Glacier Bay, Dundas Bay('99) and eastern Icy Strait When: June, 1999-2001; subset of Glacier Bay in Nov 1999 and March 2000. Who: Jim Bodkin, John Piatt, Gary Drew, Martin Robards, others Refs: Bodkin, J. et al. 2000. Marine Predator Surveys in GLBA. USGS/BRD, Anchorage Robards, M. et al. 2003. Ecology of Selected Marine Communities in Glacier Bay: Zooplankton, Forage Fish, Seabirds & Marine Mammals. USGS/BRD, Anchorage Piatt, J et al. 2004. Hotspots in a Glacial Landscape: Patchiness of Marine Fish, Birds and mammals in Glacier Bay. Abstract, 4th GB Science Symposium, Juneau. Drew, G & J. Piatt. 2004. Marine Habitats and their Effects on Marine Bird and Mammal Distributions in GLBA. Abstract, 4th GB Science Symposium, Juneau. Drew, G & J. Piatt. 2004. Monitoring of Marine Predator Communities in GLBA, 1991-2003. Abstract, 4th GB Science Symposium, Juneau. Comments: Systematic, replicable and extensive in space and time. Probably enough data to portray moderate changes in the more abundant species. Authors compared their 99-00 data with unpublished 1991 data, and were able to place confidence limits on some species trends over that time period.
FWS Marine Bird and Mammal Surveys -1980's	No (B1)	Yes (A2,B)	What: Bird and mammal censuses Where: Cross Sound and lower outer coast (1981); Cross Sound and Glacier Bay (1982) How: vessel surveys, focusing on colonies and (in 1982) vessel transects When: 1981,82 Who: Art Sowls, Dave Nyswander, John Trapp, Jay Nelson, Bill Lenhausen Refs: Sowls, A. etal. 1982. Marine Bird and Mammal Surveys of the Outer Coast of SE Alaska, Summer 1981. USFWS, Anchorage Nelson, J. & W. Lenhausen. 1983. Marine Bird and Mammal Survey of the Outer Coast of SE Alaska, Summer 1982 Comments: Counts not done to modern, statistically treatable protocols, but made by very seasoned observers. Detailed field notes given for each colony in 1981; 1982 report refers to a data appendix not sent to park, that resides in FWS Anchorage office (PARK NEEDS COPY OF THIS!).
FWS Marine Bird and Mammal	Yes (A1,B1)	PRIME	What: census of marine bird and mammal populations, with particular emphasis on

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Surveys -2000's		(Ab,Bd)	murrelets. How: Variety of vessel-based transects, including linear transects 1 km offshore and a zigzag transect of variable offshore distance, standard transects in the bays and Icy Strait. Add'l visits to hotspots in 2004. The two years' data coalesced into one set of population estimates. Also censuses of colonies. Where: Western Icy Strait and outer coast, from Carolus – Dry Bay, including Dundas, Taylor, lower outer coast fjords and Lituya. When: July 2003-04 Who: Michelle Kissling, Kathy Kuletz, Steve Brockman Ref: Kissling, M. et al. submitted. Distribution and Abundance of Kittlitz's Murrelets Along the Outer Coast of GLBA. 4th GB Sci Symposium Comments: Rigorous study intended to be repeated every 3-5 years.
Hydroacoustic Survey for Euphausiids & Fish (1)	No (B1)	Yes? (A1,B?)	What: Characterization of potential prey resources, in proximity to whale feeding activity How: hydroacoustics with truthing by netting Where: Glacier Bay and elsewhere outside park When: summers, 1981-84 Who: Ken Krieger, Bruce Wing Ref: Krieger, K. & B. Wing. 1986. Hydroacoustic Monitoring of Prey to Determine Humpback Whale Movements. NMFS, Juneau Comments: Pretty extensive work. Gives broad picture of whale feed, useful on regional scale. Utility as baseline greatly increased if survey tracks can be relocated. Transects used are approximately located in report: Wing says that's all the detail there is.
Hydroacoustic Survey for Euphausiids & Fish (2)	No (B1)	Yes (A1,B)	What: Survey for Plankton & fish biomass distribution How: systematic, vessel-based hydroacoustic scanning; 48 trawl tows at 38 stations to truth the fish related to acoustic readings; CTD data taken with each tow; relative measures of chlorophyll at some stations Where: Stations throughout Glacier Bay and Icy Strait in water column <100 m. When: June 1999 Who: Abookire, Piatt, Speckman Ref: Robards, M. et al. 2003. Ecology of Selected Marine Communities in Glacier Bay: Zooplankton, Forage Fish, Seabirds & Marine Mammals. UDGD/BRD, Anchorage Comments: Systematic and extensive, using predator survey tracks and trawl sites per fish inventory database. Given the point-in-time nature of sampling and lability of system, not likely to be an adequate baseline on a fine scale, but very useful on a regional scale and for

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			average biomass determinations of the various surveyed species. Unfortunately, these authors do not attempt to draw comparisons with Krieger & Wing's work. I presume that station data are in the USGS database.
Marine Mammal Sightings	Yes? (A1?, B2)	Yes? (A2?, B)	What: Kept track of non-humpback marine mammals in course of whale survey work. How: Rigorous protocol for sample area and obs/time. When: 1994-present Who: Chris Gabriele, Janet Neilson, Tania Lewis Ref: Gabriele, C. & T. Lewis. 2000. Summary of Opportunistic Marine Mammal Sightings, Glacier Bay and Icy Strait, 1994-1999. NPS/RM. Comments: Data have been gathered up to present, but not reported since 2000. The authors' intend work "to be primarily descriptive [and to] … complement or inform work of other researchers". I consider it replicable and valuable so long as it continues to be carried out in strict adherence to present protocols, and especially if by the same observers; there is some disagreement among the GLBA staff in this regard, however. These data are especially important for scarce species like Minke whales & Dall porpoises, and add importantly to the data for harbor porpoises & killer whales.
Marine Reserves Effectiveness	--	--	A general topic with Goals: "Measure transfer rate of halibut, Tanner crab and red King crab between the newly created [Glacier Bay] reserves and the adjancent area … A second long-term goal is to measure detailed movement patterns of crab and halibut to identify essential fish habitat, seasonal changes in distribution, migration patterns and changes in movement and habitat requirements with ontogeny." The halibut and crab studies are reported under more specific headings elsewhere in this table.
Underwater Acoustic Monitoring	Yes (A2,B1)	PRIME (Ab,Ba)	What: Attempt to model impact of ship underwater sound on humpback whales' hearing and behavior. How: Constructed model using GB specific data (measurement of 35 vessel signatures) and a number of assumptions, notably on whale responses to and uses of the acoustic environment; from the model, made predictions on the distances humpback whale social functions and hearing acuity would be affected by two specific vessels going a specific speed. Where/When: M/V Capelin sound output measured at Glacier Bay,October 2002; Cruise ship outputs measured at Ketchikan Naval range, 1999-2001 & 2004. Bartlett Cove baseline, 2000-2002.. The Bartlett Cove station has been recording more or less continuously up to present. Who: Erbe, Kipple, Gabriele

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Refs: Kipple, B. & C. Gabriele. 2003. Glacier Bay Watercraft Noise: Underwater Acoustic Noise Levels of Watercraft Operated by GLBA as Measured in 2000 & 2002. Naval Surface Warfare Ctr., Carderock Div. Rept to NPS. Tech. Rept. NSWCCD-71-TR-2003/522. Erbe, C. 2003. Assessment of the Bioacoustic Impact of Ships on Humpback Whales in Glacier Bay, Alaska. (Incl Exec. Summary by C. Gabriele) Rept to NPS by Erbe. Kipple, B. 2002. Glacier Bay Underwater Noise – Interim Report. Naval Surface Warfare Ctr., Detachment Bermerton. Technical Report to NPS. Gabriele, C. 2002. Underwater Acoustic Monitoring Project. Abstract in Projects/Investigator files Kipple, B. 2004. Coral Princess Underwater Acoustic Levels. Naval Surface Warfare Ctr., Detachment Bermerton. Technical Report October 2004 to Princess and NPS. Kipple, B & C. Gabriele. 2004. How Loud are those Cruise Ships Anyway?: Underwater Noise – Skiffs to Ships. Abstract, 4th GB Science Symposium, Juneau. Comments: Purpose of study is to make a first generation model, not to provide replicable data. Erbe says that there are too many assumptions in model to be used for management at this time. From baseline standpoint, boat signatures replicable. The baseline for naturally occurring sound is based on 5200 noise samples from Bartlett Cove over nearly 2 years, and should be an excellent baseline for that spot.
Underwater Noise Research - 1980's	No (B1)	Yes (A2, B)	What: Characterized acoustic environment of the bay by a variety of direct measures. Correlated acoustic measures with individual whale behavior as documented by Baker, Herman. How/when: Summer, 1981: emphasized acoustic environment by measurements of sound at 38 stations around the bay. Summer, 1982: emphasized correlations with whale behavior. Where: Glacier Bay, emphasizing areas where whales frequent. Who: Miles, Malme Ref: Malme, C et al. 1982. The Acoustic Environment of Humpback Whales in Glacier Bay and Frederick Sound/Stephens Passage, Alaska. Bold, Baranek & Newman, Inc. Tech. Report 4848. Miles, P. & C. Malme. 1983. The Acoustic Environment and Noise Exposure of Humpback Whales in Glacier Bay, Alaska. Bold, Baranek & Newman, Inc. Tech. Memo #734. Comments: Stations are located in 1982 report to within 1 to .1mi. The methods are very

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			well described. Should be generally replicable.
Ecology of Selected Marine Communities	--	--	What: Synthesis of oceanography, plankton, forage fish, and marine predator studies. Does not include any benthic/demersal stuff. When: Various, but mostly in the last decade; refers to some earlier work Where: Glacier Bay Who: Robards, Drew, Piatt, Anson, Abookire, Bodkin, Hooge, Speckman Ref: Robards, M., et al., 2003. Ecology of Selected Marine Communities in Glacier Bay: Zooplankton, Forage Fish, Seabirds and Marine Mammals. USGS/BRD, Anchorage Comments: THIS IS A MAJOR SYNTHESIS of several important studies (all of which except the zooplankton study are reported elsewhere on this outline). Detailed studies summarized there will be reported under other headings.
Torch Bay-Dixon Harbor Benthic Fauna & sediment chemistry	No	Yes (A1,B)	What: survey of subtidal benthic fauna and sediment chemistry How: document species presence and estimate rel. abundance for 3 grabs each at 22 stations; one sample from each station analyzed for clast size and a number of chemical constituents, notably heavy metals. Where: Dixon Harbor and Torch Bay When: 1975-76 Who: George Mueller, A.S. Naidu and Doug Schamel. Mueller, G. et al. 1977. Benthic Marine Studies. *in* Dixon Harbor Biological Survey: final report on the summer phase of 2005 research. Streveler & Worley, eds. NPS, Juneau. Comments: detailed but only roughly quantitative analysis of fauna. Geochemical analysis extensive and quite repeatable, given the number of stations, even though the stations are not precisely located.
Juvenile fish/oceanography surveys	Yes (A1,B1)	PRIME (Aa,c)	What: Growth, distribution and abundance of juvenile salmon and associated fauna, with associated CTD parameters along standard transects in Icy Strait & near Icy Point (SECM program) When: Six times, May – October, 1997 to present Where: 4 Transects in Icy Strait & at Icy Point, respectively Who: Joe Orsi, Emily Fergusson, Molly Sturdevant, Burce Wing. Ref: Orsi, J. et al. 2005. Survey of Juvenile Salmon and Associated Epipelagic Ichthyofauna in the Marine Waters of Southeastern Alaska, May-August 2004. Report to the North Pacific Anadromous Fish Commission, 2005, Auke Bay Biological Lab Comments: A valuable long-term study with major tie-ins to other biologic and oceanographic work in the area. Methods apparently rigorous and well described.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Sedimentation & Composition of Fjord Wall Communities	No (B1)	No? (A1?,B?)	What: Correlation of rock wall shallow subtidal invertebrate communities with glacial influence (principally sediment in the water column) How: Suspended sediment amts and CTD measurements and evaluation of biota from photography of adjacent rock wall Where: 9 stations from Willoughby N to upper Tarr an Muir Inlets (as well as elsewhere in SE) When: 1990 Who: Diane Carney, John Oliver, Cynthia Armstrong Ref: Carney, D. et al. 1999. Sedimentation and Composition of Wall Communities in Alaskan Fjords. Polar Biol. 22:38-49 Comments: Sites may be precisely identifiable due to photography (and I presume GPS locations). Work is based on single occupations for oceanographic data. Emphasis on biotic sampling was extensive geographically and does not provide a very large data suite per site; therefore, the utility as a baseline is limited to change on a regional scale.
Impacts			
Vessel Effects on Marine and Nearshore Zone	No	No	What: Overview of vessel impact potentials When 2000 Who: James Wuebben, Lewis Hunter, Dan Lawson, Susan Bigl Ref: Wuebben, J. et al. 2000. Impact Study of Vessel Effects on the Marine and Nearshore zone, Glacier Bay, Alaska. CRREL report to NPS Comments: A broad but cursory overview of a large range of impact potentials. Presents little or no original data
Commercial Fisheries, *including* Commercial Tanner Crab Harvest	Yes (A2,B1)	Yes (A2,B)	What: Various data sets and talks assembled by Soiseth in "Project Tracking" on fisheries and catches. Includes IPHC Halibut catch in Glacier Bay and nearby areas, ADF&G harvest data for many species. ADF&G Tanner crab stock assessment surveys, Glacier Bay, Icy Strait and other areas in SE AK. Comments: these programs are certainly intended as monitoring of catch levels, and as crude indices to stock sizes & composition.
Commercial Fishing Compensation Project	No	No	Comment: Financial, political; not relevant in this context
Dungeness Crab Gear Distribution Survey	No	No	That fishery is now closed

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Dungeness Injury	No	No	What: Frequency, causes and implications of injury to crabs in a pot fishery How: Experimental pot fishery backed up by lab study of injured crabs' competitive abilities Where: Bartlett Cove When: June-October 2002 Who: Julie Barber Ref: Barber, J. 2004. Factors Influencing Injury of Trapped Dungeness Crabs and Survival Consequences for Released Males. M.S. Thesis, U of Rhode island. (According to Taggart, there is another manuscript that was never finished.) Comments: Field portion designed to elucidate the effect of soak time on injury rate, of a fishery that no longer exists in the park. (But could be very important for fisheries in region. There is a very large data set on injury rates in Dungeness crabs both before and after commercial fishing closure.)
Kittlitz's Murrelets & Vessels	No (B1)	PRIME (Ba,d)	What: Effects of vessels on murrelet distribution, use patterns. How: Observation of murrelets in presence/absence, before/after, during vessel encounter, Where: 7 murrelet concentration sites in Glacier Bay When: 41 days during may-July, 2004. Who: Alison Agness, John Piatt Ref: Agness, A. 2006. Effects and Impacts of Vessel Activity on the Kittlitz's Murrelet in Glacier Bay, Alaska. M.S. Thesis, U Washington. Comments: Very careful and replicable work with much attention to statistical treatment.
Cross Sound and Icy Strait sport fishery harvest (includes Sport Fishing Interaction Survey*)*	Yes (A2,B1)	Yes? (A1?,B)	What: Survey of charter fishery effort and harvest How: Creel surveys; questioning of individual fishers When: 2002 and 2003, continued by ADF&G since then Who: Jason Gasper, Vince Gallucci, marc Miller; Bruce Kruger. Refs: Gaspar, J, et al. 2005. Sportfish Information for managing GLBA, vol 1, Catch, Harvest, and Effort for the Gustavus and Elfin Cove Sportfishery in the Cross Sound and Icy Strait Region of northern SE Alaska during 2003. NPS Tech. Rept, Seattle. Kruger annual data reports to ADF&G Comments: NPS study compares and contrasts effort and harvest among Gustavus and Elfin Cove based charter fleets. Documents seasonal local depletion of Pacific halibut. Calculates CPUE, HPUE. ADF&G work monitors catch characteristice of fish landed at Gustavus dock . Work generally sufficient to document major changes in catch characteristics, to some unknown level of accuracy (but at least the self-reporting bias is eliminated). This

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Galluci/Gaspar work also has a sociological component.
Sea Lion Reaction to Vessels - Marble island	No (B1)	Yes? (A1?,B)	What: Observations of vessel approach distance and sea lion reaction How: Visual observation and gauging of vessel appprach distances; defined & measured disturbance rigorously Where: South Marble Island When: 23 days in summer, 1994,95,97. Refs: Matthews, E. 1997. Effects of Vessel Traffic on the Behabior of Steller Sea Lions at a Haulout in GLBA. UAS rept to NPS. Matthews, E. 2000. Reaction of Steller Sea Lions to Vessels at a Haulout in Glacier Bay. UAS rept to NPS Comments: This sample of 23 days and 88 vessel approaches is a reasonable sample of activity during those years; if replicated during approximately the same time of year, may be a fairly good baseline for disturbance as a function of approach distance then
Researcher Disturbance to Sea Lions	No (B1)	No?(A1?,B?)	What: Part of a regional study to determine the effects of research on sea lion haulouts & rookeries. How: Observers placed on selected sites for 2 weeks to document effects of research activities. Where: S Marble, Graves When: Summer, 2003 Who: Laura Kucey Ref: Kucey, L. 2005. Human disturbance and the hauling out behaviour of Steller sea lions. MS thesis, University of British Columbia, Vancouver. Comments: I've not reviewed this thesis, nor has the RM staff, but based on project description the work may be replicable.
Harbor Seal reaction to vessels	Yes? (A1?,B1)	PRIME (Ba)	What: documenting frequency, severity and timing of disturbance related to human (vessel) and other causes relative to aerial census overflights (Spider) and seismic surveys (Hopkins) How: Direct observation using defined protocols Where: Spider Island, Johns Hopkins Inlet, North Marble Island When: 1996- 1999, comparing back to 1991 data at Spider island; 1994 in Hopkins; 1998 at North Marble Who: Beth Matthews, Janene Driscoll Refs: Matthews, E. 1996. The Effects of Seismic Reflection Surveys and Vessel Traffic on Harbor Seals In Johns Hopkins Inlet, GLBA, Alaska. NPS, Gustavus. Matthews, E. 1997. Preliminary Assessment of Harbor Seal haulout Behavior and

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Sources of Disturbance ath the Spider Island Reefs in GLBA. UAS rept to NPS. Matthews, E. 2000. Progeress Report: Measuring the Effects of Vessels on Harbor Seals at North Marble Island, a terrestrial Haulout in GLBA. UAS rept to NPS. Matthews, E. and J. Driscoll. 2000 Draft. Disturbance of Harbor Seals and Potential Effects on Counts from Aerial Surveys, GLBA, 1991-1999. Comments: Principal purpose of Spider Is work was to evaluate effects of disturbance on counts, but also quite useful as index of disturbance over that decade and a baseline for the future. Hopkins and Marble work was more cursory, but very systematic and replicable. Crucial info given the plight of seals lately.
Marine Mammal tissue analysis	No	No	What: analysis of one stranded whale's tissues for organochlorides When: 2002 Where: Pt. Gustavus stranded whale Ref: Letter from Gina Ylitalo to Chris Gabriele, 6/4/02. Comments: Another set of samples are "on the shelf" for the stranded 2004 calf, which are planned to be submitted for pathology analysis. Too few samples for baseline.
Cruise Ship Impact on Water Quality	No	No	What: Study is part of an ongoing program being conducted by the Alaska Department of Environmental Conservation to evaluate the impacts of the commercial cruise ship industry on Alaskan coastal waters. The study will collect bateriological and oceanographic samples at one sampline station in Bartlett Cove. When: 2003 Where: one station at Bartlett Cove Who: Gendron, ADEC Comment: Park has rec'd no data from this according to Rusty Yerxa. Judging from permit appln, was to be a small, cursory study.
Increase in male Dungeness after fishery closure	Yes (A1,B1)	Yes (A1,B)	What: Change in average size of male crabs How: Systematic pot fishery before and after closure, with outlier as control Where: Lower Glacier Bay; outlier in Icy Strait When: 1997-2001 Who: Jim Taggart , Tom Shirley, Chuck O'Clair, Jennifer Mondragon Refs: Taggart, SJ et al. 2004. Increase in the Relative Abundance of Large Male Dungeness Crabs Following Closure of Commercial Fishing in Glacier Bay, Alaska. Abstract, 4th GB Science Symposium, Juneau. Taggart, S. J., T. C. Shirley, C. E. O'Clair, and J. Mondragon. 2004b. Dramatic increase in the relative abundance of large male Dungeness crabs, *Cancer magister*,

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			following closure of commercial fishing in Glacier Bay, Alaska. Pages 243-253 *in* J. B. Shipley, editor. Aquatic protected areas as fisheries management tools. American Fisheries Society, Bethesda, MD. Comments: Carefully designed study. Highly replicable.
Survey of private vessel fishing license permit holders in Glacier Bay proper	No (B1)	Yes? A1?,B)	What: Survey of private angler fishery effort and harvest Where: in Glacier Bay How: Phone and mail, asking general info for # & species of fish caught. When: 2002 and 2003 Who: Sarah Osterhoudt, Jane Swanson, Darrell Johnson Ref: Osterhaudt, S. et al. 2005. Sportfishery Information for Managing GPBA, vol 2, A survey of Fishing License Holders Entering Glacier Bay on Private Vessel Permits. NPS Tech. Rept, Seattle Comments: Companion to Gasper et al report. Authors caution that data not field checked and "may not be representative of the intended population". Soiseth feels that the data are the best available on this subject..
Intertidal			
Landforms/sediments			
Dry Bay Shoreline Change	No	No	What: History of shoreline change at Dry Bay How: Compiling historic maps Who: Chad Soiseth Comments: Not enough detail on these various sketch maps to replicate.
Beach Characteristics, Icy Point-Sea Otter Creek	No (B1)	Yes? (A2,B?)	What: Character of shorelines How: 55 beach transects, documenting beach profile, ht of storm beach activity, and vegetation zones; 90 sediment samples along these transects. Where: Cape Fairweather-Icy Point (with aerial obs N of Cape Fairweather) When: 1975-1977 Who: Bruce Molnia & crew Refs: Molnia, B. 1978. Beach Dynamics, Geology and Oil spill Susceptibility of the Gulf of Alaska Coastline in GLBA – Sea Otter Creek to Icy Point. USGS Open File Report 78-284. (This report is in archives on microfiche – can't access). Molnia, B. 1980. Beach Characteristics and Physical Aspects of Oil Spill

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Susceptibility. *in* Lituya Bay Environmental Survey, Streveler, Worley & Molnia, eds. NPS, Gustavus. Comments: Transects probably could be relocated within 100m or so. Profiles are sketches whose accuracy is based on survey data related to an estimate of MSL. The 1978 report may offer more detail, but I did not review it. I observed the field work, and feel that changes in elevation of >1m could be detected. Replicable on that level.
Invertebrates/algae			
Intertidal Bivalve Study	No (B1)	PRIME (Ab, Bd)	What: Survey of clam density and species composition How: Ten .25m quadrats sampled at 0 tide level, ~86 sites When: 1999-2000 Where: Many places along Glacier Bay, Idaho Inlet and Port Althorp. Who: Jim Bodkin, Kim Kloecker, Esslinger, DeGroot,, Monson Refs: Bodkin, J & K. Kloecker. 1999. Intertidal Clam Diversity, Size, Abundance in GLBA: 1999 Ann rept. USGS, Anchorage Bodkin, J et al. 2000. Sea Otter Studies in GLBA: Aerial surveys, foraging observations, and Intertidal Clam Sampling. USGS, Anchorage. Comments: A very important, rigorous study that provides a splendid baseline on a resource undergoing drastic change.
Intertidal Community Change	No	No	What: Assess biodiversity and temporal changes in rocky intertidal communities along the western coast of the United States, Where: This study will resample a site within Glacier Bay National Park which was initially studied in July of 2002. Who: Peter Raimondi Comments: Only thing found is a permit appln in project tracking. That appln suggests that sampling of the site will be done in a way to allow long-term monitoring. This needs to be corroborated. Project appears not to have occurred, so far as is known to Rusty Yerxa
Torch Bay Intertidal Community Studies – 1970's	No	No	What: Biotic characterization of intertidal biota; investigations of species interactions and response to disturbance. How: Careful mensuration, disturbance experiments, removal/addition experiments Where: Torch Bay When: 1993-94 Who: Dave Duggins, Jim Quinn

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Refs: Duggins, D & J.Quinn. 1975. Rocky Intertidal Communities. *in* Dixon Harbor Biological Survey: final report on the summer phase of 1994 research. Streveler & Worley, eds. NPS, Juneau. Quinn, J & D. Duggins. 1977. Rocky Intertidal Communities. *in* Dixon Harbor Biological Survey: final report on the summer phase of 1995 research. Streveler & Worley, eds. NPS, Juneau. Comments: Much of descriptions, though detailed, are not pinned to precise sites. Several removal/addition experiments were initiated and monitored, but these are also not exactly located, and besides, since responses to disturbance are usually rapid, the value of monitoring them at this late date are nil.
Wachusett Intertidal Transects	No (B1)	Yes? (A2?,B?)	What: Intertidal Transects How: General desription AND PHOTOS of four intertidal transects Where: upper and central Wachusett Inlet When: summer 1971 & 1982 Who: Bill Garry, Lewis Sharman, Cathy Coghill Refs Garry, W. 1971. Intertidal Transects in Wachusett Inlet. Report & Photos in Barco library archives. Sharman, L. & C. Coghill. 1982. Wachusett Inlet Intertidal Sruveys, August 1982. Barco Library archives Comments: The transects are marked by cairns and are as well Field's photostations; this plus photos may well make them relocatable. The photos also will illustrate gross changes in cover by major organisms. Sharman & Coghill did reoccupy them in 1982. Work not done in great detail, but given the changes expected between now & then, it forms a useful if hazy "before" picture.
Intertidal Monitoring	No (B1)	Yes? (A1?,B)	What: Purposes are to develop monitoring protocols and to elucidate "dynamics of processes that contribute to variation" in rocky intertidal communities. How: Develop and use protocols for monitoring; sampled 25 rocky sites 4 times each When: 1997-2001 Where: Various sites along Glacier Bay Who: Gail Irvine Ref: Irvine, G. 2005. Development of Coastal Monitoring Protocols and Process-Based Studies for Intertidal Assemblages of Glacier Bay National Park and Preserve; Addendum to BRD-NRPP Project. Comments: The purpose was to develop rather than apply a protocol. Efficacy of that

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			protocol is under analysis; if the result is positive, then some or all of the 1997-2001 data can be used as a baseline for future monitoring
Marine Intertidal Community Development	No (B1)	Yes (A1,B)	What: Factors influencing biotic differences on bedrock-boulder shores How: Measured water chemistry & turbidity, distance from glacier; measured species presence & abundance in quadrats along vertical transects; did site-to-site boulder transplants. Where: along the east Glacier Bay chronosequence. When: summer, 1984. Who: Lewis Sharman Ref: Sharman, L. 1988. Marine Intertidal Community Development following Glacial Recession in Glacier Bay, Alaska. *in* Proceedings of the Second Glacier Bay Science Symposium. NPS, Anchorage. Comments: Not in paper, but Lewis has photos and notes that will allow reoccupation of his 6 study sites and re-measurement of the biotic & physical parameters. Significant adjunct to Gary/Sharman and Irvine work.
Fish			
Spawning Beaches	No	No	What: Opportunistic observations on beaches used by spawning forage fishes Who: several staff members. Comments: Related to next study
Capelin Spawning Ecology	No	No	What: Spawning ecology of capelin Where: Glacier Bay When: 1999-2004 How: based on midwater trawling/ beach seining/ oceanography. also did analysis of coastal inventory for potential spawning sites Who: Yumi Arimitsu, others Ref: Arimitsu et al. in review. Glacial influence on distribution, abundance and spawning dynamics of Pacific capelin. Comments: Have not seen draft paper, but assume it is based on a synthesis of data from other studies cited at various places above; therefore not listed separately here for its baseline potential.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Birds			
Black Oystercatcher Ecological Assessment	Yes (A1, B21)	Yes (A1,B)	What: Breeding biology, overwintering survival and abundance/distribution of breeding territories How: Capture, banding/resighting, morphometric measurement, observation, with objectives of assessing population distribution, abundance, productivity. Where: Beardslee Islands When: 2004-ongoing Who: David Tessler, Lewis Garding, Yumi Arimitsu Ref: Tessler, D. 2005. Black Oystercatcher Distribution and Productivity in the Beardslee islands, GLBA, Alaska. ADF&G, Juneau. Comments: Part of an interagency study to document aspects of oystercatcher biology on a regional basis. Thorough, disciplined study, a valuable update and extension of Lentfer's baseline.
Breeding Ecology of Black Oystercatchers	Yes (A2, B1)	Yes (A2,B)	What: Survey of Oystercatcher nesting activity How: repeated visits of all shorelines by kayak Where: Beardslee Islands and adjacent mainland When: May 30 – July 10, 1989 Who: hank Lentfer & Anya Meier Ref: Lentfer, H. & A. Maier. 1989. Distribution & Biology of Black Oystercatchers in the Beardslee Islands, Glacier Bay, Alaska. NPS/RM Comments: Thorough survey which very likely noted all nesting pairs in the area. Important baseline against which to compare Tessler's recent work.
Shorebird GIS Data from the Bear Campsite Assessments Project	No	No? (A1?,B)	What: Noted shore-nesting bird occurrences as part of protocol for measuring visual impacts to campsites. How: visual observation Where: Many campsites along Glacier Bay When: 2001-02 Who: Tania Lewis, Nat Drumheller. Comments: data not worked up but possibly a useful adjunct to Arimitsu study.
Shorebird Surveys - NPS			Who: Mary Kralovek. Comments: Never happened

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
General/impacts			
Beach Surveys for Nesting Birds (*same as* "Human Disturbance of Coastal Marine Birds")	No (B1)	Yes (A2,B1)	What: Determine the near-shore distribution of the arctic tern, black oystercatcher, mew gull and glauous-winged gull, herring gull, parasitic jaeger, semipalmated plover and spotted sandpiper, with emphasis on coastal areas receiving high visitor use. Assessed oystercatcher breeding productivity in Beardslee Islands. How: Determined high use areas from NPS data. Did foot surveys of most heavily used sites: other shores were observed at close range from a boat, and followed up by foot if signs of nesting beharvior noted; some closed areas not surveyed. Areas with highest concentrations surveyed twice on successive years. Where: Glacier Bay When: 2003-05; oystercatcher breeding in Beardslees, May-July, 2004. Who: David Tessler, Yumi Arimitsu, Marc Romano, John Piatt Refs: Arimitsu, M., et al., 2004. Ground-Nesting Marine Bird Distribution and the Potential for Human disturbance in GLBA, Alaska: 2003 Annual Report. USGS/BRD, Anchorage Arimitsu, M. et al. 2004. Ground-neting Marine Bird Distribution and Potential for Human Impacts in GLBA. Abstract, 4th GB Science Symposium, Juneau. Arimitsu, M. et al. 2005. Ground-Nesting Marine Bird Distribution and Potential for Human Impacts in Glacier Bay. USGS (BRD), Anchorage. (Final report currently in review) Comments: Survey methods spelled out well in reports, but somewhat vague on exact boundaries of areas defined as "high use" and on the number & exact itineraries of observers (This may be remedied in the final report). The work did not include controls (since most concentrations were found to be in closed areas) and was based on one-time visits, so it provides more of an index than a population estimate. But as such, should be replicable for general patterns.
Beach Debris Surveys	No (B1)	Yes (A2,B)	What: Foot surveys of beaches to note amounts and types of beach debris How: Most or all using NOAA standard protocols. Where: Bartlett Cove, Lester & Young Islands, Taylor Bay, Outer coast When: 1988-1992 Who: Numerous investigators Refs: Streveler, G. 1989. Accumulation of Debris and Bird/Mammal Carcasses on GLBA

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Beaches: a summary of existing data. Sharman, L. & H. Lentfer. 1991. 1991 Dixon Harbor Biological Survey. NPS, Gustavus. Rettew, J. Persistent Marine Beach Debris Survey, Lester & Young Islands, GLBA, Gustavus, Alaska. NPS/RN, Gustavus. Polasky, C. 1992. Bartlett Cove Beach Debris Survey, GLBA, Gustavus, Alaska. NPS, Gustavus Greer, Antaya, Schroeder 1991-1992. Raw Data in Sharman's files. Johnson, S. 1988. Surveys from Taylor Bay to Justice Creek (with NPS's Hager & Perry) NOAA Raw data in Sharman's files. (1992 data in same file presumably Rettew's) Comments: Generally done to NOAA protocols, and in all cases well enough described to replicate. Very useful baseline
Coastal Resources Inventory and Mapping Program; Coastal Inventory - Dynamic Segmentation	No (B1)	Yes (A2,B)	What: Systematic characterization of biota, substrate, morphology and exposure of shore How: Using standard coastwalker protocol developed at GLBA Where: Entire park intertidal zone with exception of outer coast N of Lituya When: 1997-2003 Who: Lewis Sharman et al. Ref: Data archived at GLBA/RM Comment: The coastwalker data are not sufficiently quantitative for baseline use, but the relocatable photos accompanying each shore segment can be used to document gross changes in plant and encrusting invertebrate cover, as well as in shore morphology.
Outer Waters Vessel Activity Surveys	Yes (B1)	Yes (A2,B)	What: vessel survey How: Aerial surveys, with a stratified sampling design; photos of individual vessels Where: Waters in GLBA outside Glacier Bay proper When: 2002-03 Who: Chad Soiseth Ref: Soiseth, C. 2004. Vessel Use and Activity in GLBA's Outer Waters. Abstract. 4th GB Science Symposium, Juneau. Comments: Multiple replicates of day of week and weekend strata over two summer (June-Sept) seasons. The design is replicable and established a baseline of use and activity in GLBA's outer waters from Excursion Inlet to Icy Point
General, Other			
Birds of Glacier Bay Nat'l Monument	No	No	What: Richly annotated checklists with much historical information.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			How: Compiled by rangers based on a theirs' and others' observations Where: Glacier Bay mostly When: 1962, 1967 Refs: Jacot, F. 1962. Checklist of Birds for Glacier Bay National Monument. NPS, Gustavus. Wik, O. 1967. Birds of Glacier Bay National Monument. NPS, ranger division, Gustavus Comments: Wik is an excellent observer, and pulls together much relevant information. Should be considered important inventory material, and certainly allows conclusions to be drawn about changes in cases where these are major. Jacot's contribution is mostly subsumed into Wik's.
Climate-Glacial-Ocean Linkages	No	No	What: Ice-proximal sediment records as proxies for short-term climate change (as mediated through water column events and glacial discharge) How: Reading sedimentary record of such things as summer organic deposition, frequency of dropstones, proportions of seasonal rythmites. Where: upper Glacier Bay When: ongoing, dating back to Cowan/Powell's early work see elsewhere in this document) Ref: Cowan, E & R. Powell. 2004. High Frequency Climate Signals in Fjord Sediments of GLBA, Alaska. Abstract *In* 4th Glacier Bay Science Symposium, Juneau. Comments: This paper is a general treatise on the utility of such records, not a presentation of records themselves.
Falls Creek EIS	No	No	Specific parts thereof considered under other headings.
Gustavus *and lower Glacier Bay* Bird Data	No (A1)	No	What: Observations of local birders, including the Audubon Christmas counts (Paige) and owl surveys (Drumheller) When: for last 30 years or so Comments: don't follow replicable protocols & therefore are not good baseline material except in a general sense
Ranger Daily Logs	No	No?	Scattered observations generally; may contain elements that are replicable, especially from notes of Ole Wik & Jerry Hok in late '60's.
Digital Orthophotos	No (B1)	PRIME (Ba)	What: 1996 georeferenced black/white digital ortophoto coverage for park and Tongass. In case of GLBA, ~80% coverage. Comments: According to Bill E, these are the state-of-the-art photo collection now available for accurate GIS layer bases. Extremely important as the basis for future mapping

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			of all sorts
Visitor - Backcountry Surveys	No (B1)	PRIME (Ab,Ba)	What: Five survey projects done prior to 1990: - backcountry users, 1978 & 1984 - cruiseship passengers in 1979 & 1989 - Alsek River recreationists in 1984 Refs: Johnson, D et al. 1990. Social Science Perspectives On Visitor Use in GLBA. U Washingoton CPSU Littlejohn, M. GLBA Bartlett Cove Visitor Survey. Visitor Services Project Rept 114. U Idaho CPSU Comments: This work is included despite being sociological in nature, since it is virtually the only body of such literature for the park. The Johnson ref (Chap 6) gives an overview of 4 of the 5 sociological studies done in the park prior to 1990 (the 5th, a survey of cruiseship passengers, was being analyzed at the time of writing). Each was done by polling professionals and is therefore (likely) replicable; and in fact Johnson does make direct comparisons between studies in his report. The 1999 visitor survey is reputed to have design flaws according to Allison Banks.
Backcountry Visitor Use Data	Yes (A2,B)	PRIME (Ac,Ba)	What: use volumes, distribution & trends How: Data from park records When: 1996-2003 Where: Glacier Bay Who: Mary Kralovek, Allison Banks Ref: Kralovek, M et al. 2004. Distribution and Number of Backcountry Visitors in GLBA, 1996-2003. Abstract, 4th GB Science Symposium, Juneau. Comments: an exceedingly important baseline
Wildlife Sightings Database	No	No	What: park sighting records How: Opportunistic, unsystematic When: Going back to before the '60's Where: park Who: whomever Comments: useful to provide very general impressions over the long term, but not valuable as a baseline per se.
Map for New Park Brochure- 2006	No	PRIME (Ab,Ba)	What: Map for new park brochure, which is based on latest /best topographic & bathymetric information.

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Who: Tom Patterson Comments: Bill Eichenlaub says GIS data accumulated by Patterson is state of the art, and potential basis for any major GLBA mapping project.
Dry Bay Photo Mosaics	No (B1)	PRIME (Ba)	What: stitched-together collage of aerial photos from 1948, 1966, 1978, 1980 & 1996 Who: Bill Eichenlaub Comments: These photos provide superb baseline for following and documenting changes in vegetation, landforms, human works.
Historical photos	No (B1)	PRIME (Ab,Ba)	What: various aerial photography series for park, beginning with 1929 and 1948 sets. Many other sources, including: - Bill Field's collection, I think now archived at UAF, plus a large selection of prints at GLBA. - Harris's (1969) occupation of many Field photostations - Many Institute of Polar Studies geology reports have poor copies of repeatable historic photos in them; in a number of cases, the authors are still around and probably have the originals, from which good copies could be made. Key works with photos include: Taylor (IPS 3); Price (IPS 9); Welch (15); Mckenzie (25); Mickelson (40) and Larson (65,66). - Original photos in Cooper & Lawrence reports Mark Noble, U Minn and Richard Carstensen are all likely repositories for Cooper/Lawrence photos. Yerxa is accumulating historic photos for NPS archives. - Austin Post has large set of aerials he has taken personally; also has historical file. - Many early park employees have photos in their personal files - A series of photos from Icy Strait and Dundas from the '30's by a trap guard named Edberg, in GLBA archives. - Morgan DeBoer's and Jim Mackovjak's historical photo collections from Gustavus area. - Molnia's recent reoccupation of Field's stations SEE ESPECIALLY: Lawrence, et al. 1993. Repeat Photograohy and landscape Change at Glacier Bay, 1979-1993. *in* Proceedings of the Third Glacier Bay Science Symposium , Engstrom, ed. NPS, Anchorage

KLGO Project Evaluation Table Final, 10/17/06

Greg Streveler, in consultation with Meg Hahr & Theresa Thebault, KLGO

(Codes follow numerics in a companion document,"Identifying Baseline Candidates and Ongoing Monitoring for the SEAN parks")

Project	Ongoing Monitoring?	Potential Baseline?	Comments
Atmosphere			
Lichen-air quality pilot	Yes (A1, B2)	Yes (A2,B)	What? Survey lichens for indications of reduced air quality How? Tissue evaluation for heavy metals, Where? Two sites in Skagway Valley, 2 in Taiya Valley When? 1998-1999 Who? Linda Geiser, Elaine Furbish Refs: Furbish, E, L. Geiser and C. Rector. 2000. Lichen - Air Quality Pilot Study for KLGO and the City of Skagway, AK. NPS, RM. 48p. Hahr, M. 2004. Assess current status of lichens and develop air quality biomonitoring protocol. Proposal to NPS Air Resources Division. Comments: Canadian government installed passive air samplers (to measure mercury and other contaminants) in SKG for one year starting in 2006. Park will resample pilot study plots and install passive air samplers (PASDs) during two-year follow-up study (fy 07).
Dyea weather station	No (B1)	Yes?(A1?,B?)	3 summers' data from Dyea campground FTS weather station beginning in 2003. Monitoring may be continued.
NOAA weather, SKG	Yes (A1,B1)	Yes (A1,B)	What? Weather station Where? Skagway Airport (mouth of Skagway River) When? ongoing Who? National Weather Service
NRCS Snow Survey Site (Moore Creek snow course & automated weather station)	Yes(A1,B1)	Yes? (A1, B), (Snow yes; station after more time)	What? Snow depth and precip gage read manually; automated weather station (solar radiation, wind speed, air temp, snow depth). Where? Adjacent to the Klondike Highway at the Moore Creek Bridge, near treeline below White pass. When? Snow monitored since the '80's; weather station since 2004. Who? USDA-Nat Resource Cons Svs , NPS Ref? Data online at http://www.ak.nrcs.usda.gov/snow/
ADEC Cruise Ship emissions (opacity)	Yes?(A2,B2?)	No (A1)	What? Readings of visible emisions (opacity) from vessel smoke stacks How? Certified observers read the visible emissions from cruise ships to determine whether ships are in

Project	Ongoing Monitoring?	Potential Baseline?	Comments
monitoring			compliance with the State Marine Vessel Emission standard (18 AAC 50.070) Where? Skagway Harbor When? Once per year (random) Who? ADEC Comments: A pretty cursory program park collected this data in the past (via maintenance staff), but not clear where the info is kept. If we could locate the data, we'd need to evaluate quality. We are hoping to partner with tribe or other entity to continue this work
ADEC Fine Particulate Matter Pollution (PM2.5) Monitoring	No(B2) Yes	? (A1?,B?)	What? Monitoring of particulates How? PM2.5 Continuous Monitoring Station Where? 2 sample stations at Skagway When? Jan 2004-March 2005 Who? ADEC (vanVliet) Ref: No report; data at ADEC Comment: park has had hard time getting summary of results from ADEC, but in phone conversation with Hahr, vanVliet said that state standards were not exceeded
Birds			
Bald Eagle productivity	Yes(A1,B1)	Yes (A2,B)	What? monitored 3 nests annually How: repeated obs to note whether active Where? along the Taiya River When? 2002-06 Who? NPS; Ref: Data maintained by USFWS, JNU (Jacobson). Comment: Known nests have not been active in these years; nest to S outside of park active lately. One nest was destroyed due to erosion of riverbank (undercutting the tree). Two new nests were constructed and were recordedin 2006 as active nest structures.
Off-road Breeding Bird Surveys (ORBBS) - ALMS	Yes(A1,B1)	Yes (A2,B)	What? Offroad Breeding Bird Survey, expanded and subsumed into the Alaska Landbird Monitoring System How? ORBBS and ALMS protocols Where? 2 routes in Taiya Valley When? Since 1995 Who? NPS/FWS(Rudis) conducts survey Ref? data managed by USGS - Handel Handel, C. & M. Cady. 2004. Alaska Landbird Monitoring Survey: potentials for setting up and conducting point count surveys. USGS AK Sci Ltr. 50p.

Project	Ongoing Monitoring?	Potential Baseline?	Comments
			Comment: data probably adequate for regional comparisons; needs to be reviewed for utility as park monitoring tool.
Christmas bird count	Yes (A2)	No (A1)	Counts not systematic nor strictly comparable from year to year
Breeding Landbird Inventory	Yes (A1,B1)	Yes (A1,B)	What: Includes the more quantitative surveys and other qualitative efforts; purpose is to refine park bird list How:. Twenty-eight new survey points were established throughout the park (across the elevational and ecological gradient) and sampled (following the ALMS protocol) for this inventory. When: 2003 Who: Colleen Handel (USGS) Comments: The protocol developed for this effort was peer-reviewed. These survey points were permanently marked, GPS'ed, and detailed habitat parameters were measured at each location. These 28 survey points can be relocated and resampled. This sampling network was designed to be used for long-term monitoring.
Nocturnal Owl Inventory	No	No	One winter's data. Followed BBS and USFWS protocol, but few owls encountered. Would take revised methodology to get enough data for reproducible results.
BBS bird survey	Yes (A,B1)	Yes(A2,B)	What? Breeding Bird Survey How? Per national BBS protocol (50 stops along a standard route, 3-minute obs/listen.) Where? 25 miles along Chilkoot Trail & Dyea; When? Since 1993 with a break from 1999-2004 Who? FWS (Andres, Rudis) Ref? USGS (Handel) manages data Comment: data probably adequate for regional comparisons; needs to be reviewed for utility as park monitoring tool.
Coastal Waterbird surveys	Yes (A2, B1)	Yes? (A1?,B)	What? Spring waterbird counts, as companion to the Breeding Landbird Inventory How? Spring, ~ weekly counts at specific points along road Numbers as well as species noted. Where? Offshore of road from SKG - Dyea Who? NPS When? Begun 2003, continued thru 06. Ref: Hahr, M. & T.Trapp. 2004. Waterbird and Breeding Landbird Inventories in KLGO. NPS, SEAN. 44p. Comment: Ranger reports from the 1980s and early 1990s indicated large numbers and diversity of waterbirds along the KLGO coast during spring migration. Those reports justified inclusion of coastal waterbirds in what was intended to simply be a Landbird Inventory for KLGO. Initiated as part of bird inventory, but have been continued. Sampling design exists, but not peer-reviewed. Would have to look at data to judge its suitability for baseline and trend detection.

Project	Ongoing Monitoring?	Potential Baseline?	Comments
Mammals			
Goat surveys	No (NPS part) ? on rest	No?	What? Surveying mountain goats How? Mostly aerial surveys, but Joly's: two ground-based surveys from standard overlooks, 1996 Where? in Taiya Watershed When? Various times and investigators Who? NPS (Joly& Canadian cooperator); BLM (Denton); USFS (Millstein); ADFG (Barten); Temsco Ref? Joly, K. 1996. Mountain Goat Survey of Upper Taiya River Drainage. NPS, RM. 10p Comment: NPS - Joly's work repeatable but too cursory; for others, word is that there are competing data sets and ideas about goats vs. helicopters. I have not seen the data or reports, and so cannot really evaluate this work personally
Bear scat survey	No	No	Small sample size. Scat surveys are inexact indices of bear population sizes. At most, they tell you centers of bear activity and could be useful from a management perspective, but not for population-level monitoring.
Fish			
Eulachon genetics study	No (B2)	Yes? (A2,B)	What? Comparison of Eulachon genetics among "populations" to gauge the relationships among them. How? Measure frequency of alleles at selected microsatellite loci of 100 fish from numerous river systems across their Alaska range. Where? Samples obtained from Taiya and Skagway rivers. When? Samples collected 2003 (Taiya and Skagway) and again in 2005 (Taiya) (not yet analyzed) Who? USFS (Rob Spangler) Ref? No report yet Comment: May allow changes in genetic structure of populations over long run.
SEAN marine/estuarine fish inventory	No	No	Litzow, M., J. Piatt, and M. Arimitsu. 2002. Inventory of Marine and Estuarine Fishes in Southeast Alaskan National Parks during summer, 2001. NPS, ANC. Structured to extend species list; not rigorously quantitative.
Plants			
Exotic plant surveys	Yes (A2,B1)	PRIME (A2, Ba)	What? Surveys of introduced plants in Dyea and along Chilkoot trail How? Systematically recorded identities & extents of exotics. First survey: divided trail/Dyea area into polygons and recorded species presence/abundance in each. Last two: GPS'd extent of individual patches along trail/Dyea and the White pass unit, following NPS Exotic Plan Management Team protocols. When? 2000, 2004, 2005 2006 Who? NPS (Furbish, Delost, Schultz) Refs? Furbish, E. 2001. Exotic Plant Survey of the Chilkoot Trail, KLGO. NPS/RM, 49p. Delost, J. 2004. Exotic Plant Survey of KLGO. NPS/RM. 17p.

Project	Ongoing Monitoring?	Potential Baseline?	Comments
			Schultz, D. 2005. Exotic Plant Survey of KLGO. NPS/RM. 14p. Comments: 2006 report will be completed September 2006
Vascular plant inventory (ANHP)	No	No	Purpose is for constructing an annotated checklist and evaluating presence of species of interest/concern
Subalpine fir mortality	Yes (A1,B1)	Yes? (A2?, B)	What? Monitoring balsam bark beetle infestation of fir How? 02: Set up 6 ea. 9 ha relocatable plots on which beetle density indexed (pheromone traps) and tree mortality recorded. More plots since then near Skagway (outside park). Where? The upper Skagway valley (White Pass City area). When? Started 2001 Who? USFS (Schultz) Ref: Mark Schultz memo to Meg Hahr 3/8/06 Comment: Memo gives general idea on progress of infestation; haven't seen data to judge its quality
Sitka Spruce, tomentosus and bark beetle infestation	No (B1)	Yes? (A1?,B)	What? Monitoring Sitka Spruce tomentosus and relationship to subsequent bark beetle infestation How? Installation of plots in Dyea (details forthcoming), taged 142 for continued monitoring/sampling Where? Dyea When? August 2006 Who? Mark Schultz, Lori Trummer (USFS) Ref: Mark Schultz, Lori Trummer personal communication August 2006 to Theresa Thibault Comment: Preliminary report due September 2006 describing monitoring purpose/implementation.
Amphibians			
SEAN amphibian opportunistic inventory	No	No	Qualitative and opportunistic; intended for inventory level summary of existing observations
Western toad monitoring pilot study	Yes? (A1?,B)	Yes? (too soon to tell but USGS is optimistic)	What? Mark-recapture study of western toads – ARMI Apex-level Monitoring Site How? Systematic marking of adult western toads at breeding ponds using PIT tags (microchips) to estimate population size, determine population trends, and describe metapopulation dynamics. Where? Western toad breeding ponds in Dyea area When? Initiated in 2004 Who? NPS/USGS ARMI (Adams, Payne) Ref: Hahr, M. 2005. Southeast Alaska Cluster Program Request for funding for Establishment of an ARMI Apex Monitoring Site. Proposal to SE AK Coastal Cluster Program Comment: USGS arrived in KLGO to train NPS staff in toad tagging techniques at the tail end of the breeding season so an estimate of the breeding population could not be obtained in 2005. The 2006 tagging efforts will span the entire breeding season allowing for a complete dataset with which to determine

Project	Ongoing Monitoring?	Potential Baseline?	Comments
			whether the breeding population is sufficiently large to satisfy the requirements of the Apex-level ARMI monitoring program.
Amphibian habitat surveys	Yes (A1, B2)	PRIME (Ab)	What? Systematic survey of toad presence/absence – ARMI mid-level monitoring pilot study. Purpose is to provide landscape level index of changes in toad occupancy of suitable habitat. In order to determine whether KLGO is an appropriate area for an ARMI mid-level monitoring site. Characterized habitat quality and toad presence/absence, life stage and general abundance in 129 surveys of 39 wetlands. How? According to USGS Amphibian Research & Monitoring Initiative Mid-level monitoring protocol. Where? Throughout Taiya and Skagway watersheds. When? 2004-2006. Potential amphibian breeding sites were surveyed in 2004 & 2005 to document amphibian species occurrence and reproduction. Who? NPS, USGS ARMI (Adams, Payne) Ref: Payne, K. 2005. Amphibian Productivity Monitoring and Habitat Assessment in KLGO. NPS/ RM.46p. Comment: will be continued in 2006 by Kevin Payne with direction from Mike Adams (USGS ARMI)
Visitor Use/ Impacts			
Chilkoot trail visitor use	Yes (A2, B)	PRIME (Ba)	Overnight users of the Chilkoot trail are closely monitored by the NPS through the permit system
Dyea Social Science Survey.	No (B1)	PRIME (Ba)	What? Survey of volumes of various types and volumes of visitor use How? Physical counts of day use of Chilkoot Trail and Dyea Townsite Trail (by infrared beam); Surveys of Dyea users and polling a sample thereof to determine their experience and reactions thereto. Vehicle traffic counters at 3 locations in Dyea Townsite. Monitoring protocol also developed. Where? at Dyea and the base of the chilkoot trail Who? Van de Kamp, Sekamp Ref: (Van de Kamp and Seekamp. 2005. Visitation and Visitor Use Experience at Dyea (and the Chilkoot Trail). Visitor use of the Dyea area and day use of the lower Chilkoot Trail were quantified and described for the first time in the history of the park, for the 2004 season.
Geomorphology			
Taiya erosion – Dyea Townsite	Yes (A2, B1)	Yes (A2,B)	Measurement of Taiya River bank erosion in the Dyea townsite, 1967-present; long baseline Ref Inglis, R. 2002. Assessment of Bank Retreat Monitoring Data from 1979-2002 for the Taiya River at KLGO (*but only deals with Dyea area*). USGS,WRD. 16p. Comment: Designed to inform townsite protection questions; probably too small a sample of river behavior

Project	Ongoing Monitoring?	Potential Baseline?	Comments
			to be of interest for SEAN.
Taiya Watershed Reconnaissance Geohazards Survey	No	No	Capps 2003 study; descriptive
Nourse Lake Moraine-dam assessment	No	No	BLM 2004-05 study (Denton et al). Purpose to sound morainal dam for buried ice. Comment: Problems with equipment developed during the study. Current status: study in review, already determined a need for followup visit to site for additional information.
Water Quality			**Items in this section only flagged. For more information, see Nagorski & Hood's & Eckert's reports on Water Quality**
Water quality investigation/analysis			USGS/WRD took baseline WQ measurements at stream gage sites on Taiya and West Creek, 2004
Streamflow Gages			USGS & NPS- historic gages on Taiya and West Creek. New gage on Taiya since 2003.
General Ecology			
Ecological recon inventory	No	No	This extensive USFS inventory of park resources has a great deal of reconaissance-level data, but the sample sites are pinned down only to the quarter-section.
Coastwalker project	No (B1)	Yes (A2,B) (A2,B)	What? Systematic characterization of biota, Substrate, morphology and exposure of shore How? Using standard coastwalker protocol developed at GLBA Where? Entire park intertidal zone When? 1999 Ref? Data archived at GLBA/RM with copy at KLGO Comment: The coastwalker data are not intended for baseline use, but the relocatable photos accompanying each shore segment can be used to document gross changes in plant and encrusting invertebrate cover, as well as in shore morphology.
Ecological surveys	No	No	Comment: Reports and notes by Streveler provide background on geology, fire history, river history, etc., but do not contain repeatable data
Dyea Wetland inventory	No (B1)	Yes? (A2?,B)	What? Characterized and mapped wetlands in the Dyea area of KLGO How? Using FWS wetland inventory protocol Where? in the lower Taiya valley When? 1999 Who? Koren Bosworth Ref: Bosworth, K. 2000. Wetlands of the Dyea area of the lower Taiya River Valley. By Bosworth for

Project	Ongoing Monitoring?	Potential Baseline?	Comments
			NPS. 37p. Comment: Careful list of dominant plants and special delineations should allow documentation of gross changes in these parameters
Natural history observation database	No	No	Comment: Opportunistic observations
Photography			
Repeat photography	No (B2)	PRIME (A2, B)	What? Reoccupation and re-photography of sites from which historical photos have been taken. Where? Retakes of 7 1895 - early 1900's photos from vantages in the Taiya and Skagway valleys When? 2005, 2 days Who? Richard Carstensen & Cathy Pohl Ref: Carstensen's illustrated field notes and report provided to KLGO Comments: would be very valuable to expand this program
Lidar, historical and aerial photos	No (B2)	PRIME (Ba)	What? Most of the park photographed by LIDAR technology in 2003. Several generations of black/white color and infrared photography exists at various scales for various parts of the park and environs A large and systematically curated collection of historical phots is housed at KLGO. Comment: Data have not been extracted from the LIDAR, but this set has immense monitoring potential for many aspects of vegetation and geomorphology. This is true to a lesser degree for the other aerial photography. Historical photos have great potential for monitoring change on various scales (see Repeat photography for one example).
Chilkoot trail campsite monitoring	No (B1)	Yes? (A2?,B)	What? Large amount of undigested but systematic data on campsite condition How? Mapped, described vegetation and visual conditions, using standard form Where? Campgrounds at Dyea and along trail When? 1994-95 Who? NPS (Rangers) Refs: Large binder of data in RM office Comment: hard to judge whether data are sufficiently relocatable after the decade elapsed time.

SITK project Evaluation Table FINAL 10/17/06

Greg Streveler, in consultation with Geof Smith, SITK

(Codes follow outline in a companion document, "Identifying Baseline Candidates and Ongoing Monitoring for the SEAN parks")

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Atmosphere			
Weather stations, Sitka	Yes (A1,B2)	PRIME (A2,B)	What? 1) Magnetic Observatory Site near SITK has kept weather records intermittently, 1898-1989 , with the longest continuous records being from 1908-1926 and 1949-1982. Site has moved at least once during this period. 2) Japonski Airport, 1930-present 3) Three other stations in area with data beginning from 1996 to 2005. Comment: together, these stations provide the longest weather record in the state.
Birds			
Eagle nest survey	Yes (A1,B1)	Yes (A2,B)	What? The one eagle nest in the park is monitored for activity and fledgling productivity; area checked for other active nests Where? Throughout park How? Visual check from ground When? 2002-2005 Who? NPS (Smith) Ref: Data kept at park Comments: This one nest is an important indicator of park ecosystemic health; maybe deserves a PRIME.
Bird Observation & Inventory	No	No	What? Bird observation records for park Where? Throughout park How? Opportunistic observation When? From 1980 Who? NPS (Smith), Ward, Tedin Comments: Ward & Tedin have additional data that the park needs to get hold of. Purpose of project is construction and updating of qualitative checklist
Breeding bird survey	Yes (A2,B1)	No (A1)	What? A standard breeding bird survey route annually that includes 12 points Where? Only 6 points in the park How? Per national BBS protocol, using 3 minute and longer obs intervals When? 2000-2005 (except 2001)

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Who? NPS (Smith) Ref: Data archived by NPS Comments: not enough data to be considered a baseline, but it is part of a larger data set that is probably useful for the general area.
Migratory bird reconnaissance	No	No	Comment: These periodic patrols of the park and intertidal zone during peak migration periods are not sufficiently rigorous for monitoring purposes.
Christmas bird count	Yes (A2, B1)	No (A1)	Comments: Counts not systematic or strictly comparable from year to year; nonetheless is considered monitoring on a national scale
Mammals			
Small mammal inventory	No	No	Ref: Muldoon, C. 1987. Small Mammal Inventory, SITK, May-Aug, 1987. Comment: 749 trap nights, but no exact location data. Intended to document species presence.
Land Plants			
Vascular plant inventory (ANHP)	No	No	What? Inventory of vascular species presence in park, with notes on species of particular floristic interest (including exotics) How? Standard Ak Natural Heritage Program inventory When? 2002 Who? ANHP (Lipkin, Carlson) Ref: Lipkin, R & M. Carlson. 2004. SITK Vascular Plant Inventory. Ann. Technical Rept. AHNP, Anchorage. 10p. Comments: Park has not received the final species list not herbarium specimens. This work is intended to extend the SITK species list, and is not quantitative.
Vegetation inventory and forest health	No (B2)	Yes? (A1?,B)	What? 11 permanent plots on which detailed tree mensuration and semi-quantitative shrub & forb descriptions are given. Forest pathogens present are described and in some cases roughly mapped. When? 1994. Who? USFS (Russell, Dougan) Ref: Russell, J. & B.Dougan. 1994. Vegetative Inventory and Forest Health Assessment, SITK. USFS, Chatham Area. 15p. Comments: There will be an effort this year to relocate the plots, and if successful should provide repeatable data.
Nonvascular plant survey	No	No	Ref: LaBounty, K. 2005. Non-vascular plants to SITK: bryophyte inventory, 2004-05. NPS. 11p. Comment: designed for construction of a species list
Exotic plant surveys	Yes (A1,B1)	PRIME (A2,B)	What? Densmore, et al.: General work that includes cursory surveys in a number of parks, including SITK Spencer: did some work but never provided a report McKee: Records and precisely delimits extent of 9 species in an "extensive" survey

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			Rapp: Records and precisely delimits extent of 27 spp; probably the most thorough inventory to date. How? McKee: Says thoroughly covered the park; accurately delimits extent of infestation by species identified via GPS with "sufficient accuracy to monitor yearly change". Rapp: Redescribed areas found in 2004; identified and precisely located additional areas via GPS; follows NPS (Heys) EPMT protocol. When? 2004 was the fourth year of exotic plant surveys, but this is the first one that is precisely relocatable Who? NPS (Rapp, McKee, Roland, Densmore) Refs: Densmore, R., P. McKee & C. Roland. 2001. Exotic Plants in AK National Park Units. USGS/NPS 127p. McKee, C. 2004. Exotic Plant Surveys at SITK, Alaska: Summer 2004 Field Season Report. USGS/BRD. 10p. Rapp, W. 2005. Invasive Plant Management in SITK, Sitka, Alaska: summer 2005 Field Season Report. NPS/GLBA. 40p. Rapp data archived electronically at GLBA and SITK Comments: The last two years of this survey effort has provided important and replicable data
Marine/Intertidal			
SEAN Marine/estuarine fish inventory	No	No? (A2?, B)	What? Inventory of nearshore fishes along SITK forefront How? By beach seine. Two precisely located sample sites; 4 sets at each in June, 1 set at each in September. When? 2001 Who? Brewer, Arimitsu, Litzow Ref: Litzow, M., J. Piatt, and M. Arimitsu. 2002. Inventory of Marine and Estuarine Fishes in Southeast Alaskan National Parks during summer, 2001. NPS, ANC. Intended to extend species list; replicable albeit very small sample size
Intertidal monitoring	Yes? (A2,B2?)	PRIME (Bd)	What? Monitor distribution and abundance of intertidal zone macrobiota Where? On park shore, exclusive of estuary How? Using protocol developed by Gail Irvine. Includes 15 transects along which point intercept and quadrat data are obtained; visual count of mobile predators make in band along transects as well When? 1999, 2002, 2003 Who? USGS (Irvine), NPS (Smith) Ref: Terastat Consulting. 2006. Draft Statistical Review of Sampling and Analysis Methods for Intertidal Monitoring at SITK. Comment: report gives general ok; recommends setting permanent transects and # quadrats proportional to

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			transect length. This is one of the park's best baselines, and I give it a PRIME on that basis, even though some question remains on methodology.
Coastwalker project	No (B2)	Yes (A2,B)	What? Systematic characterization of biota, Substrate, morphology and exposure of shore How? Using standard coastwalker protocol developed at GLBA Where? Entire park intertidal zone When? ~2000 Who? NPS (Sharman & Eichenlaub) Ref: Data archived at GLBA/RM Comment: The coastwalker data are not intended for baseline use, but the relocatable photos accompanying each shore segment can be used to document gross changes in plant and encrusting invertebrate cover, as well as in shore morphology.
Eelgrass community ecology	No (B2)	Yes? (A1?, B)	What? Characterizing structure of eelgrass community, with special reference to shrimp (*Hippolyte)*as an indicator of community intactness, and to presence of pollutants in tissues of selected species How? Systematic sampling of invertebrates and algae, and bioassay at selected sites Where? Sitka Sound (one station in park) When? 2004-2005 (on pilot basis) Who? Baldwin Ref: Shirley, T & A. Baldwin. 2003. Eelgrass habitat and associated fauna at SITK. 6p. Proposal from UAF to SITK as part of Ph.D dissertation study Comment: this work should be a reasonable basis for monitoring on the scale of Sitka Sound, but it is unclear whether it will be for SITK specifically.
Chemistry/physics of a tidepool	No (B2)	Yes? (A1?, B)	What? Describes chemical/physical conditions in a small tidepool How? Sampled water temp, salinity, d.o. in water column, two places within tidepool, 1-2x/mo. Where? Indian River estuary When? Fall/winter, 1997-1998 Who? Logue (Sheldon Jackson student) Ref: Logue, J. 1998. Chemical and Physical Characteristics of a small Tidal Pond in the Indian River Estuary System. Sheldon Jackson College. 8p. Comments: This is a long-lived pool and could be reoccupied rather precisely given the map of the sample sites. But the data set is quite small, and there are no plans for reoccupation.
Indian River			
Stream ecology Water Quality and Streamflow of the	No (B1)	Yes (A1,B) but	What? Contains systematic information on macroinvertebrates and algae as well as water quality data How? Random Surber plots and algal measurement stations, allowing estimates of species abundance Where? On reaches OUTSIDE OFTHE PARK

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
Indian River, Sitka, Alaska, 2001-2002.		outside park	When? 2001-2002 Ref: Neal, E, T. Brabets & S. Frezel. 2004. Water Quality and Streamflow of the Indian River, Sitka, Alaska,. USGS Comment: (*I AM ONLY FLAGGING WATER QUALITY STUFF*)
Freshwater macroinvertebrates	No	No	Comment: This work by NPS (Smith) for over 4 years provides a database representing 53 species, and an extensive bibliography of relevant literature. It is intended to refine the park's species list and provide a first-order idea of species abundance. Doesn't fit the criteria used here, but is a valuable precursor.
Salmon escapement database	No	No	ADF&G does opportunistic and semi-quantitative escapement surveys every year, approximately timed to the peaks of species runs. They give only a first order estimate of abundance
Chinook salmon study	No	No	What & How?: Summary of history of adult escapement data and minnow trapping results, with historical accounts of observations When? 1985-2001 minnow trapping; historical accounts going back to time of Russians Where? Indian River Who? NPS (Brewer) Ref: Brewer, B. 2001. Origin and History of Chinook Salmon in the Indian River, Sitka, Alaska. NPS/SITK. 22p. Comment: doesn't rise to level of monitoring, but valuable background in evaluation of native/exotic status, and any attempts at eradication.
Aquatic Resource Survey: Indian River, SITK	No (B1)	Yes? (A2?, B?) stream profile data only	What? Lots of hydrology information (deferred to Eckert), but also contains macroinvertebrate sampling data and 5 channel profiles. Includes analysis of the macroinvertebrate data by Major and Milner, as an index to water quality. How? Surber sampling, 3-5 samples per station Where? Several sample stations, in park and upstream. Sample profiles in park. When? Spring/fall,1994 Refs: Paustian, S. and T.Hardy. 1995. Aquatic Resource Survey, Indian River, SITK, Alaska. USFS, Chatham area. 60p. Major,E. and A. Milner III. 1994. Macroinvertebrate Analysis Summary of data from the Indian River, SITK. Environmental and Natural Resource Institute, For the USFS. 10p. Comments: Invert sample sites not relocatable, but stream profile sites appear to be mapped with sufficient precision to allow reoccupation. The Major/Milner analysis gives a pronouncement on water quality based on invert presence/absence.
General Ecology			
Ecological inventory	No	No?	What? Thorough characterization of upland communities in park How? Using standard USFS survey and mensuration techniques for plant communities, soils and physical site

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
			characteristics. When? 1993 Who? FS team led by Trull. Ref: Krieckhaus, B., R. Foster & S. Trull. 1993. Ecological Inventory of SITK. USFS, Chatham Area, 17p. Comment: much data here, including some quantitative measurement of silvic characteristics, and semi-quantitative estimation of shrubs and forbs on standard plots. Original plot cards not at park and maybe lost. The forms are presumably similar to those used at KLGO, and if so will not allow precise relocation. There will be an effort this year by NPS to relocate the the permanent forest inventory plots, and if successful, to consider resampling them.
Natural history observation database	No	No	Comment: Opportunistic observations.
Ecosystem observations	No	No	Streveler. General, cursory
Landscape History			
Physical & cultural landscapes and landscape history	No	No	What & where?: Data-driven description of present physical/biological landscape and, especially, a detailed hypothesis on the evolution of park landscapes. When? Field work in 1994 Who? Vanguard Research Ref: Cheney, G., R.Betts & D. Longenbaugh. 1995. Physical and Cultural Landscapes of SITK. Vanguard Research, Douglas, Ak. 160p. Comment: Major work. Marvelous background work with much information and maps, but not tailored for monitoring
Landscape history	No	Yes (A2, B) (the photos)	What& where? Landscape history from a landscape architect's point of view, How? Synthesis based on the Cheney work, some original observation, and a lot of historical photos for the more modern period. When? Field work in 1997. Who? NPS? (Smith-Middleton, Alanaen) Ref: Smith-Middleton, H. & A. Alanen. 1998. Impressions of Indian River: A Landscape History of SITK. NPS/RO. 326p. Comment: Some of the historical photos could be re-taken; would be a good way to document several sorts of change.
Asphalt Plant			
Asphalt plant site	Yes (in		What? Original assessment of site and adjacent bank of river for hydrocarbon pollution

Project	Ongoing Monitoring?	Potential Baseline?	Characterization
environmental assessment	concert with the next project)	(see next project)	How? Took series of samples from pits dug onsite, and from along riverbank; assayed for asphaltic and aromatic hydrocarbons. When? Fall, 1994 Who? Contractors Ref: Shannon& Wilson, Inc. 1995. Environmental Site Assessment, Indian River Asphalt Site, SITK, Sitka, Ak. Shannon & Wilson, Fairbanks. 95p. Comments: Sample sites relocatable. Cites report by Molnia, 1980, on erosion by the Indian River. Report not found.
Asphalt plant site monitoring	Yes? (A2,B2)	Yes (A1?, B)	What? Water quality monitoring protocol set up; portions of it followed by NPS. How? Deschu set up 3 monitoring sites; NPS has reoccupied 2 of these sites for 5+ years. General water quality parameters monitored, with specific reference to hydrocarbons. When? Monitoring from 1996-1999 and 2001-2005. Probably will not be done this year. Ref: Deschu report not seen. Data entered into a database. I review data for any unusual readings. Comments: no money to continue this monitoring. Nothing alarming has resulted from this sampling. However, debris such as asphalt chunks and metal pieces continue to erode from the site. Given a "yes?" on monitoring, as is planned to be discontinued. Some question whether the small number of monitoring sites gives a sufficient sample of the situation.
Water Quality			
Assessment of Coastal Water Resources and Watershed Conditions of SITK	--	--	(Eckert et al. 2006) Hot off the presses. Comprehensive assessment of the Indian River watershed conditions and threats, including marine, estuarine, and freshwaters. (I HAVE DEFERRED WATER QUALITY MATTERS TO THESE AUTHORS, who are preparing a report similar to mine on water resources (EXCEPT FOR THE ASPHALT PLANT MONITORING) I will just flag these reports: Nadeau, R. & S. Lyons. 1987. Instream Flow Investigations, Indian River, SITK. USFWS, Anchorage. USGS/WRD (Williams) 2000. Progress Report for Indian River Water Resource Data, SITK, Ak. (park has not rec'd final) USGS/WRD. 1998. Baseline Water Quality Data, Inventory and Analysis, SITK. See also Paustian and Hardy, 1995, and Neal, et al.,2004, both discussed above

Appendix B

Historical Documentation of Vital Signs Selection for The Southeast Alaska Network

Introduction

This document was compiled by Barbara Sheinberg (Sheinberg Associates, Juneau, AK) who served an active role as a facilitator for SEAN from 2005 through 2007. In many ways, Barb performed some aspects of the role of Network Coordinator during the period from 2006-2007 when the Network Coordinator position was vacant. This document is her historical record of the reasoning and intentions behind each vital sign discussed by the SEAN Technical Committee. This March 2007 document does not include some information, such as updated monitoring objectives from the Protocol Development Summaries. It represents the state of the SEAN at the time when the Network Coordinator position was filled by Brendan Moynahan in July 2007.

Vital-Sign Specific Information Presented in this Document	Source
EMF Level 1	Table 3.3 draft chapter 3/Phase 2 Report-Fastie
EMF Level 2	Table 3.3 draft chapter 3/Phase 2 Report-Fastie
EMF Level 3	Table 3.3 draft chapter 3/Phase 2 Report-Fastie
Vital Sign Number	
SEAN VITAL SIGN	SEAN Technical Committee
Justification	April & May 2006 SEAN Technical Committee meeting reports Access database
Threats	Access database
Comments on Threats	Access database
Management Concerns	Access database
Comments on Management Concerns	Access database
Monitoring Objectives	May 2005 Freshwater Scoping Workshop report March 2006 Marine Scoping Workshop report March 2006 Terrestrial Scoping Workshop report.
Monitoring Questions	April & May 2006 SEAN Technical Committee meeting reports Access database May 2005 Freshwater Scoping Workshop report March 2006 Marine Scoping Workshop report March 2006 Terrestrial Scoping Workshop report
Example of Measures	April & May 2006 SEAN Technical Committee meeting reports Access database
Possible Partners	April & May 2006 SEAN Technical Committee meeting reports
Relevant Monitoring or Study	April & May 2006 SEAN Technical Committee meeting reports
Comments	April & May 2006 SEAN Technical Committee meeting reports Access database
GLBA/KLGO/SITK	April & May 2006 SEAN Technical Committee meeting reports
Comments, Possible Partners or Threats	March 2006 Scoping Meeting Reports

Southeast Alaska Network
Vital Signs Selection Documentation

(Organized by Ecological Monitoring Framework [EMF] Level 1, 2 and 3)

Table of Contents

Visibility and Particulate Matter B-4
Air Contaminants B-6
Weather and Climate B-11
Glacial Dynamics B-16
Landform Dynamics B-21
Surface Water Dynamics B-25
Marine Physiochemical and Biological Water Mass Characteristics B-30
Freshwater Physiochemical Water Quality B-39
Freshwater Contaminants B-42
Freshwater Benthic Macroinvertebrates and Algae B-45
Invasive Exotic Plants B-48
Invasive Exotic Animals B-52
Pests and Diseases B-55
Marine Mammals and Seabirds B-59
Intertidal Communities B-62
Wetland Communities B-65
Salmonids B-68
Forage Fishes B-71
Western Toads B-74
Murrelets B-76
Breeding Landbird Populations B-78
Bald Eagles B-82
Bears B-84
Harbor Seals B-86
Ungulates B-88
Killer Whales B-90
Biodiversity of Select Groups or Assemblages B-92
Steller Sea Lions B-95
Humpback Whales B-97
Consumptive Use B-100
Human Uses and Mode of Access B-104
Plant Communities B-111
Landcover and Land Use B-118
Phenology B-124
Airborne Sound B-126
Underwater Sound B-129

EMF Level 1 - Air and Climate
EMF Level 2 - Air Quality
EMF Level 3 - Visibility and particulate matter

SEAN VITAL SIGN
VISIBILITY AND PARTICULATE MATTER

Justification

Threats

From visibility and particulate

GLBA -- Within Glacier Bay air emission sources include exhaust from fuel combustion during vessel operations, fuel combustion for heating of buildings at Bartlett Cove, fuel use by vehicles in the park, occasional campfires, exhaust from electric power generators, and vessel traffic emissions. Emissions from motorized vessels contain respirable PM10 (particulate matter that can be taken into the lungs) and particulate matter smaller than 2.5 microns in diameter, carbon monoxide, sulfur dioxide, nitrogen dioxide, lead, and ozone. Visibility reductions occasionally occur in the park during certain unique weather conditions that trap air pollution within a layer of cold air near the surface.

KLGO -- Cruiseships docked in the Skagway harbor generate power by running their engines in port all day. On days with little wind, a brownish haze (cruiseship emissions) is visible over the town of Skagway and upper Taiya Inlet.

SITK -- Local sources such as cruise ships and motor vehicles produce emissions that effect visibility such as sulfur dioxide and produce particulate matter.

Comments on Threats

Management Concerns

From visibility and particulate

GLBA -- There is no historical data regarding visibility within the park, other than personal observations. Daily emission totals, visible plumes of smoke from vessel stacks, and weather conditions contribute to reductions in visibility. During temperature inversions or days with low winds, stack emissions do not dissipate quickly and can result in long plumes from vessel stacks that block views. Visible vessel emissions can produce haze within the park. Increases in vessel quotas could increase the particulate and pollutant load entering the air column and have a detrimental effect on air quality and visibility.

KLGO -- Impacts to the viewshed can be expected with reduced visibility. Reduced visibility would impact both the Skagway/White Pass and Dyea/Chilkoot Trail National Historic Landmarks and visitors to KLGO.

SITK -- Reduced visibility in and around the park could impact scenic vistas and visitor experience.

Comments on Management Concerns

Monitoring Objectives

Understand the natural range of variability in air quality across SEAN parks and determine if there are any air quality concerns.

Monitoring Questions

- Is the particulate matter content of air or the composition of aerosols changing in or near SEAN parks?
- Are anthropogenic sources of aerosols or particulate matter reducing visibility below historic levels?

Example of Measures

- Opacity of cruise ship plumes.
- Opacity of air over harbors of towns.
- Composition of aerosols.

Possible Partners

CAKN has a large air monitoring program run out of Denali.

Relevant Monitoring or Study

Comments

Dan -- Baseline data lacking; may be difficult to acquire cheaply; difficult to monitor efficiently in GLBA

Dan -- Baseline data lacking; may be difficult to acquire cheaply in KLGO and SITK

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Air and Climate
EMF Level 2 - Air Quality
EMF Level 3 - Air contaminants

SEAN VITAL SIGN
AIR CONTAMINANTS

Justification

A set of air quality data is needed over the long term as a baseline for park conditions both to enable change detection and as a backdrop against which other change detection may be considered.

Threats

From air contaminants

GLBA -- Fallout of air contaminants may cause foliar damage in plants (look at lichen tissue for elemental content) and bioaccumulate in terrestrial and marine apex predators. Persistent organic pollutants and mercury are the contaminants of concern. The contaminants may originate from cruise ships, smaller diesel and 2-stroke engines, or urban/industrial pollution from Asia.

KLGO -- Far-field and near-field sources of air contaminants may be impacting park resources and pose threats to human health and safety in the park/Skagway.

SITK -- Air contaminants from cruise ship emissions, local emissions, and long-range transport across the Gulf of Alaska may be reaching the park and impacting park ecosystems.

From wet and dry deposition

GLBA -- If air quality is not pristine (less-than-Class-I-quality), and wet/dry deposition of contaminants is significant or increasing, multiple biological resources dependent upon a contaminant-free environment are at risk. Mercury and POPs are especially important to know about because of their effects on biota. For example, some lichen species are highly sensitive (directly) to contaminants in precipitation, and surface/soil/water substrates can be contaminated to the detriment of other taxa. Direct foliar damage (vascular plants) was also identified as a potential impact. Many aquatic species are sensitive to certain contaminants in very low concentrations, some of which can accumulate in sediments and/or biooaccumulate up the trophic web. Natural processes of plant primary succession (terrestrially and in lakes) following deglaciation are sensitive to soil and water pH which can be perturbed by wet/dry deposition (which typically result in increased acidification). Natural phytoplankton community composition similarly is sensitive to ocean surface water pH; relatively small changes (decreases) in

pH can cause substantial changes that can cascade through the marine system. The vector would be low-pH precipitation ("acid rain"). The Level 3 category of "wet and dry deposition" was explicitly identified only in the Marine Scoping Workshop, but could be considered a potential threat in both freshwater (lakes) and terrestrial (re. lichens and soil dynamics/biota) ecosystems as well.

KLGO -- A pilot lichen-air quality study conducted in 1998/9 (Furbish et al. 2000) found elevated levels of sulfur and heavy metals in lichen tissues from the Skagway/Klondike area. The presence of sulfur in lichen tissues indicates on-going pollution, while the timing of heavy metal accumulation in lichens is less certain since metals can bioaccumulate in lichens. Historic exposure may have occurred during the time when lead/zinc ore was transported via the WP&YR trains from mines in Canada to the port in Skagway then barged south. Ore transport ceased in the 1980s, but contaminants may still be present in the environment and recirculated due to winds and construction activity. Other sources of air contaminants include cruiseship and other vessel emissions, incinerator, diesel powered trains, tour buses, vehicles, wood smoke, and transpacific sources of air pollutants such as mercury and POPs.

SITK -- Contaminants from multiple sources may be born on the wind and deposited in and around the park and enter park ecosystems. These include emissions from cruise ships and other water craft, motor vehicle traffic emissions, and long-distance transport of industrial or agricultural pollution.

Comments on Threats

<u>From air contaminants</u>

GLBA -- Statement regarding air contaminant threats (left) taken from marine and terrestrial workshop notes. Ozone was removed as potential vital sign because it is believed to be an urban pollutant, not expected to be an issue in SEAN parks. Measures noted: mercury content in mussels, carcasses of apex predators, seabird eggs, Engstrom's precipitation station already at Bartlett Cove, and microlayer measurements using SPMDs.

Management Concerns

<u>From air contaminants</u>

GLBA -- Air quality in the parks is presumed to be pristine, but this is not really documented. Vessel management schemes may influence air quality with potential effects on vascular and non-vascular plants, animals, and visitor experience. Visible emissions / opacity are already monitored and regulated. However, the amount of emissions is not accounted for, as vessel traffic of all kinds increases and as cruise ships

become increasingly large, and air contamination could increase and would not be detected by current measures.

KLGO -- Air contaminants may be impacting park biota, aquatic systems and cultural resources.

SITK -- Airborne compounds that produce acid rain, heavy metals, persistent organic compounds, other pollutants may be damaging SITK ecosystems.

From wet and dry deposition

GLBA -- Lack of data, especially re: mercury, POPs, and pH. There is a lack of information (except for Hg at Barlett Cove in the early '00s) re: past/present composition or rates of contaminant deposition. We lack a baseline against which to judge future changes/trends. GLBA should have pristine air quality ("natural" levels of wet/dry deposition), and we intend to manage and maintain our air quality as if we were a Class I airshed. In order to accomplish this we need to confirm that the park indeed possesses Class I-level air quality (i.e., "natural" levels of deposition). Cruise ship emissions may be a significant local source (internal to the park) of wet/dry deposition. GLBA reports to GPRA Air Quality Goal I(a)(3).

KLGO -- Lichen-air quality pilot study showed that air pollutants are present in the Skagway/Klondike area. ADEC monitored PM2.5 (particulate matter) in Skagway in 2004 and found no exceedences but data have not been formally reported to the public. KLGO is receiving funding from WASO-ARD in 2008 for follow up air quality work. In May 2006, the Canadian Government installed a passive air sampler (PASD) in KLGO (Dyea) to monitor transpacific mercury deposition.

SITK -- Acid rain, heavy metals, persistent organic compounds, other pollutants may be damaging SITK ecosystems.

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- What is being emitted from cruise ship air stacks?
- What is the normal range of variation in the concentration of atmospheric contaminants?
- Are there long term trends in these concentrations?

From wet and dry deposition

- What airborne contaminants are being deposited in SEAN parks?

- Where are they being deposited?
- Is there a trend in the amount or spatial cover or concentration of these deposits?
- Is there a trend in the amount or spatial cover or concentration of these deposits?

From scoping workshops

- Are contaminants brought by airborne vectors affecting marine organisms?

Example of Measures

From wet and dry deposition

- Concentrations (in foliage, lichens, or sampler surfaces) of sulfur, nitrogen, mercury, signature pollutants from cruiseship fuel, indices of Asian pollution, persistent organic compounds.

Possible Partners

Is the one regional air quality monitoring station in Petersburg, the Interagency Monitoring of Protected Visual Environment (IMPROVE), adequate for SEAN parks needs, or are local monitoring stations needed? The worst air contaminants are coming from across the Pacific Ocean, so this may be adequate. It is suspected that local cruise ship point sources are not causing air pollution, but do not know for certain. SEAN needs expert advice on air contaminants to establish a monitoring program.

CAKN has a large air monitoring program run out of Denali.

Relevant Monitoring or Study

Regional air quality monitoring station in Petersburg, IMPROVE.

Comments

Concentrations in the air of sulfates, nitrates, mercury, persistent organic compounds, suites of elements specific to different passive samplers, signature pollutants from cruise ship fuel, indices of Asian pollution. What does Denali do for its AQ monitoring program? Lichen tissue assays as a proxy for air contamination.

Dan -- Baseline data are non-existent; for determining future changes which may have deleterious effects on ecosystems, acquire for long term monitoring?

Scott -- Note the problems with relating estimates in lichen with biologically relevant (NOTE: rest of comment missing)

Greg -- Ranked Sitka higher because of its proximity to the Gulf of Alaska and Asian pollution sources

Air contaminants

Dan -- Baseline data are non-existent; for determining future changes which may have deleterious effects on ecosystems, this increases my ranking med high to high.

<u>From wet and dry deposition</u>

Dan -- KLGO and SITK local impact potentially more severe than GLBA that may reflect global sources; creative monitoring or sampling (e.g. snow chemistry) may be required to accomplish baseline data acquisition.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Air and Climate
EMF Level 2 - Weather & Climate
EMF Level 3 - Weather and Climate

SEAN VITAL SIGN
WEATHER AND CLIMATE

Justification

This is a primary driver in SEAN park ecosystems. This is the most important baseline dataset to obtain. Reliable consistent baseline weather data is very important for park management.

Threats

From weather and climate

GLBA -- Relatively small changes in weather patterns/parameters can have very large effects environmentally, potentially fundamentally altering very basic processes such as marine circulation, phytoplankton bloom dynamics (and thereby the entire marine production cycle), as well as (for example) terrestrial vegetative phenology which could have cascading effects throughout the terrestrial ecosystem.

KLGO -- Local climate in Skagway/KLGO varies significantly from the other SEAN parks and the rest of SE AK. Skagway receives approx. 26 inches of precip each year, making it one of the driest places in SE AK. Fire is a natural part of the park's ecology and is directly influenced by climate/weather patterns.

SITK -- Weather drives the function of park ecosystems. Disruptions in weather patterns such as those caused by global climate change may be negatively impacting park ecosystems.

From extreme disturbance

GLBA -- Extreme weather and accelerated glacial melting associated with climate change could cause an increase in extreme disturbance events.

SITK -- Extreme weather events are a major element that shapes the SITK terrestrial environment. The small terrestrial area of the park magnifies their effect.

Comments on Threats

Management Concerns

From weather and climate

GLBA -- Lack of data. GLBA has a thin long-term dataset of weather/climate that is mostly restricted (until the last decade) to records from Gustavus, Yakutat, Cape Spencer(?), and Bartlett Cove. Data from elsewhere in the park is notably sketchy or nonexistent. Data from within the park generally is limited to temperature and precipitation only. In order to more clearly detect local trends and place them within the context of regional and global trends, we require additional weather/climate data of more types from more locations. These types of data provide essential context for understanding trends in other VSs. Weather/climate is likely the factor(s) that will most confound efforts to distinguish natural variability from anthropogenic effects. Without a good understanding of weather/climate, this distinction will likely be impossible.

KLGO -- Changes in the park's weather/climate will affect the frequency and intensity of wildfire and other natural disturbance processes including flooding. Current climatic conditions and geographic factors are responsible for the park's diverse flora/fauna.

SITK -- Weather events such as floods and wind events often determine the direction of terrestrial succession and alter river course and hydrology.

From extreme disturbance

GLBA -- Human safety could be at risk if slope failures or outburst floods happen in areas where Park visitors are when they occur. An increase in the occurrence of extreme disturbance events could have ecological impacts.

KLGO -- Human health and safety, cultural resources and park infrastructure are all at risk from extreme disturbance events.

SITK -- Although extreme disturbance events such as floods and damaging wind storms are part of the natural ecosystem process in the temperate rainforests of Southeast Alaska, the damage of such events can be magnified in the park because its area is small and it is surrounded by development that can exacerbate the problem.

From coastal/oceanographic

GLBA -- Ecological changes that could result from oceanographic changes (due to climate change) are largely unknown, but likely would have far-reaching impacts on the marine, terrestrial and freshwater ecosystems.

Comments on Management Concerns

From extreme disturbance

SITK -- A major wind storm occurred in December 2004. Over 30 large trees were uprooted or snapped off. The Manager of a bordering trailer park decided to cut and drop an additional number of large trees into the park, causing additional severe damage. One of those trees hung up in a tree in the park and it also had to be cut down.

Monitoring Objectives

Understand the natural range of variability in climate patterns across SEAN parks to provide context for research.

Monitoring Questions

- What are the long term trends in weather at SEAN parks?
- What are the long term trends in weather offshore (upstream) from SEAN parks?
- Is the spatial variability in weather within parks constant?
- Are regional climatic patterns changing?

Example of Measures

- Snow depth.
- Hourly means of temperature, precipitation, wind speed and direction, barometric pressure, relative humidity, light (PAR) at stations at and above sea level on land, and also at sea (moorings.)
- Trends of PDO and sea surface temperature in the Gulf of Alaska.

Possible Partners

KLGO has a weather station near the mouth of the Skagway River, but obtaining data from National Weather Service is not easy. It would be helpful to institutionalize NPS obtaining of this data. This one weather station may be adequate, would be nice to have one in Taiya valley. A weather station in Bartlett Cove may be being established.

Relevant Monitoring or Study

KLGO has been measuring snow depth for 10 years at treeline.

Snow depth also measured at hundreds of sites around state, generally to predict spring flooding.

Comments

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- There is extremely deficient weather and climate data in GLBA; only available for the southern periphery.
- Paleodata can be obtained from lake, ice and marine cores.
- There is no weather climate station in KLGO's Taiya Inlet.
- Climate Data Sources: Use existing climate sampling stations: National Weather Service (NWS) at Skagway; Natural Resource Conservation Service (NRCS) snow course and weather station at Skagway, NOAA station near Sitka, State Climate Centers. There are weather stations in Yakutat, Juneau, Gustavus, Bartlett Cove and Sitka. Fill-in gaps with new stations; be careful about picking sites - scale and site-specific variability should be considerations.
- Alaback and McClellan predict increased blowdown with global warming.
- Possible to use climate monitoring sites established in GLBA by Dan Lawson for glacial studies? Uncertain as to longevity, elevation coverage?
- Sitka has 200 years of historic weather records, Skagway may too.
- Need more weather monitoring stations in GLBA to capture the microclimatic range.
- Noted that weather and climate high service-wide in selection of vital signs. Very important to have paleoclimatic data, to provide a baseline from which to evaluate current climatic trends. Paleoecology and historical geology are ways of extending the baseline back in time, increasing the power of current monitoring.
- Climate data are important to all monitoring/research efforts. If I&M does nothing else, monitor local weather data because there is so much spatial variability. BUT, if we do nothing but monitor climate, we'll KNOW only climate!
- Use remote sensing tools.
- For the "Big Picture," look as far out as the Gulf of Alaska - the location of the bifurcation of the west wind drift, where it hits Southeast Alaska.
- Weather patterns are complicated by topography when they get near shore; that is why weather needs to be measured offshore.
- Continuous recording of data are valuable. Add moorings with continuous recording capability. Solar radiation (not just daylength, but the amount of light, PAR) is a data gap. Important because it influences the phytoplankton bloom and ecosystem productivity.
- Air/Sea Interactions is key - Effect on current, Mesoscale features, and Island effect.
- Sources of offshore climate data -- Need to look at what other agencies can provide to see whether it answers the questions of the SEAN network. If not, supplement, as possible. - Satellite data – look at Gulf data sources (UAF GOA [Gulf of Alaska]), - AK Ocean Observing System, - Pacific Marine Environmental Lab (PMEL), Seattle,

-NODBC (National Oceanographic Data Buoy Center) Fairweather Grounds buoy, Sitka buoy, need one in the Park.

- Source for nearshore climate data: - Cape Spencer weather station.
- Again, historic climate data and paleoclimatic data are important. Need to look retrospectively at climate so that current climate changes can be put in context of the magnitude of changes that have occurred over geologic timescales.
- The 3 vital signs: PDO, where Alaska Coastal current bifurcates, timing of the spring bloom, are also directly connected to hydrology.T3

EMF Level 1 - Geology and Soils
EMF Level 2 - Geomorphology
EMF Level 3 - Glacial features and processes

SEAN VITAL SIGN
GLACIAL DYNAMICS

Justification

Whales, bears and glaciers are the popular signatures of GLBA, there will always be a need for knowledge and understanding of glaciers.

Threats

From glacial features

GLBA -- The local population(s) of harbor seals heavily utilizes/is dependent (for pupping habitat) upon icebergs calved from active tidewater glaciers. Their population dynamics certainly relate to the availability of preferred pupping habitat. Glacial lake outburst floods could threaten human lives/property within the park. Some species (e.g., Kittlitz' murrelets, red-throated loons) are highly adapted to periglacial environments which may be decreasing in character and/or extent. Conversely, glaciers could re-advance!

KLGO -- Both the Skagway and Taiya Rivers are glacial river systems strongly affected by glacial patterns and processes. Glacial lake outburst floods have historically shaped the Taiya River valley and may change in frequency and magnitude as the glaciers retreat up valley.

SITK – NA

From coastal/oceanographic

GLBA -- Eventual grounding of tidewater glaciers will have large but unknown effects on oceanography and other coastal processes.

From marine features

GLBA -- Glaciers in Glacier Bay continuously shape the seafloor and many oceanographic characteristics, but accelerated changes due to climate change may take things in an entirely different direction.

Comments on Threats

Management Concerns

From glacial features

GLBA -- At GLBA, glaciers (particularly tidewater ones) - and opportunities for the scientific study thereof - are values explicitly referenced in the park's enabling legislation. Visitors come to Glacier Bay in large part to view tidewater glaciers. The public expects us to have a deep and relatively complete knowledge of glacial dynamics. Recently this has become manifest in visitors' questions about the park's glaciers re. the larger global phenomena of warming and climate change and its effects. Knowledge of glaciers, although relatively robust compared to some other resources, is by no means comprehensive and is insufficient to provide managers with a sense that they can explain or predict glacial behavior and its effects on other park resources/values. Like weather/climate, glaciers are a driver of many other potential VSs (all 3 systems, perhaps most broadly in the marine), and an understanding of their influences is important to our ability to distinguish between natural variation and human-caused change. The park possesses a valuable and possibly unique opportunity to contribute knowledge to science in general re. glaciology, catastrophic glacial retreats, highly dynamic tidewater glacial systems, etc. Knowledge about local glacial history (and associated landscape evolution) is essential to the understanding/appreciation of the history of the Huna Tlingit people and their ties to the park. Glaciers rule!

KLGO -- Glacial processes are significant drivers of aquatic and floodplain ecosystems in the park. Likewise, the affects of glaciers on park fluvial systems have direct effects on cultural resources (archeological sites, artifacts) and infrastructure (trails, campgrounds).

SITK – NA

From coastal/oceanographic

GLBA -- Grounding of formerly tidewater glaciers will reduce visitor opportunities to view tidewater glaciers.

From marine features

GLBA -- Changes in seafloor shape and turbidity may create hazards for marine operations and human safety.

Comments on Management Concerns

Monitoring Objectives

- Understand effects of Pleistocene, Little Ice Age and active glaciations on SEAN ecosystems.

- Understand short- and long-term changes in the physical, biological and chemical features of glaciers.
- Understand how glaciers influence short- and long-term changes in the physical, biological and chemical features of freshwater ecosystems.
- Understand the short- and long-term changes in the physical, biological and chemical features of permanent snow packs.
- Understand how permanent snow packs affect short- and long-term changes in the physical, biological and chemical features of freshwater ecosystems.

Monitoring Questions

- Are glaciers in and near SEAN parks growing or shrinking?
- Are the flow rates of glaciers changing?
- Are calving rates of tidewater glaciers changing?
- What is the rate of volume change in park glaciers?
- How is the glaciers' mass balance changing?

<u>From scoping meetings</u>

- How have past and ongoing glacial cycles affected marine environments?
- How do tidewater glaciers affect marine ecosystems?

Example of Measures

- Annually measure the terminal position and firn line position.
- Measure how glaciers influence and interact with rivers, streams and at the marine margin.
- Measure nutrient value of glacially-derived sediment and water.
- Locations of glacier termini.
- Locations of lateral boundaries of glaciers.
- Elevation profiles of glaciers.
- Glacier mass balance (firnline is a measure of this, capture in late September before snow falls).
- Glacier flow rates.
- Glacial retreat.

Possible Partners

Relevant Monitoring or Study

Burroughs Glacier has been studied for decades.

Comments

Do we want retrospective data sets from ice and sediment cores. Remember how much we talked about that during the workshops?

Glacial dynamics includes process, hydraulics, hydrology, the physical interaction, three dimensional nature and processes. Glacial dynamics is a connector between ecosystems. Just because a glacier is slowly receding doesn't tell you anything about how it influences the environment or the ecosystem. People think about mapping when you say glacial extent, and that's really not what's important.

Some glaciers mass balance changes are due to micro-climatic influences, for example the configuration of the ice shed makes a huge difference. If you monitor a suite of glaciers you would see more long term effect, not micro-climatic induced effects. Is the annual variation in mass balance likely more dynamic for those glaciers that are more responsive to micro climatic changes? Topography might cause snow to drift over ice, even in bad snow years you'd get a high snow content, therefore, it would have a higher ratio of accumulation compared to times where it was a bad snow year and you didn't have that factor. So I'm not sure how the sensitivity would respond. But if you want to know what is going on with glaciers in any park, you would pick something like a Brady Icefield where there are less of these influences. One thing you can do now that is simple and very inexpensive is to use aerial photography to measure the terminal position and the firnline position yearly. And there are photography records going back 100 years. Use this baseline data, it may be critical in terms of the long term records of (whatever the parameter is).

Dan -- Glaciers are sensitive indicators of changes in climate and affect each of the three ecosystems; strong influence on biological and physical systems and processes. SEAN technical committee notes that as a group this is true, but it may not be true for individual glaciers; in Kenai they are not finding this to be true (Hahr), not true for Harding Icefield.

Greg -- Not pervasive in park, but very important "lateral" contributors; easy to monitor.

Dan -- Alpine and small valley glaciers are sensitive indicators of climate change; less extensive here than GLBA, still very important in affecting freshwater and (NOTE: rest of comment is missing).

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**

Comments, Possible Partners or Threats from Scoping Workshops

- Tidewater glacial face hydrodynamics (especially carbon, dissolved nutrients, sediment) are really important.
- Use remote sensing, mapping for current glacial extent.

Glacial dynamics

- Geomorphology is a significant driver in the ecosystem, it is linked to climate.
- Some suggest that glacial activity is not geomorphology.
- Is the goal to understand dynamics and changes in the parks or to address impacts in the parks? Answer: both.

EMF Level 1 - Geology and Soils
EMF Level 2 - Geomorphology
EMF Level 3 - Hillslope features and processes

SEAN VITAL SIGN
LANDFORM DYNAMICS

Justification

The landcover and land use vital sign focuses on documenting the extent of vegetation and features; the landform dynamics vital sign focuses on geomorphology and their processes. This will document landforms and how they change through time. Much in GLB.

Threats

<u>From extreme disturbance</u>

KLGO -- Glacial lake outburst floods, forest fires, tsunamis have shaped KLGO's landscapes up until the present.

<u>From coastal/oceanographic</u>

GLBA -- Eventual grounding of tidewater glaciers will have large but unknown effects on oceanography and other coastal processes.

Comments on Threats

<u>From extreme disturbance</u>

GLBA -- According to vital sign list notes: This vital sign includes slope failures, glacial outburst flooding and other extreme disturbances. This potential vital sign is meant to imply documenting the specifics of these events after they occur. Measures of the ecological impacts of extreme disturbance events may or may not be measurable in a systematic fashion, since each one will be unique.

Management Concerns

Comments on Management Concerns

Monitoring Objectives

- Understand the non-glacial physical processes effecting terrestrial ecosystem stability and change. Understand how geomorphic processes affect the terrestrial ecoystem.

- Understand landscape processes well enough to reconstruct the paleo-landscape and project landscapes into the future.
- Understand how extreme disturbance events affect terrestrial communities and processes.
- Understand how changes in marine and terrestrial topography affect park terrains.

Monitoring Questions

- How are selected landforms changing over time?

<u>From floodplain dynamics</u>

- How are river channels migrating across their floodplains?

<u>From scoping meetings</u>

- How much (and which) change is attributable to natural successional processes? ("Succession" - community development through time, distance from influence of tidewater glaciers/turbid outwash streams).
- What other processes affect landscape dynamic components in a marine system?
- How do changes in terrestrial ecosystems and landscapes affect the marine landscape and ecosystems?
- Are coastal shorelines changing by erosion, uplift, earthquakes or other processes?
- How do extreme disturbance events such as marine storms, tsunamis and earthquakes affect park lands, especially coastal areas?

Example of Measures

- Rate of isostatic rebound.
- Geomorphologic map with location and extent of various (or select areas of) landforms: floodplains, river channels and course, fault lines, shoreline, estuaries, periglacial features, avalanche shoots, break-out lakes, rock slides etc.
- Location, extent, geometry, surface shape.
- Rate of change for select erosional and depositional processes.
- Results of extreme events.
- Maps of stream channel courses.
- Rates of bank erosion and channel migration.
- In SITK and KLGO take vital signs in the watershed, not just the park.
- Tools: Lidar, repeat mapping, aerial and satellite imagery.
- Sampling design may be to focus on subset of park. Need DEM elevation data on map. Use USGS protocol.
- Estimate changes in outer coast beaches, in periglacial environment, lakes that are going extinct (Nunatak Cove, Birdbay North).
- Need to design a SOP/protocol to set up a database to document anecdotal information (e.g. pilot observations w/ reports of landslides and other extreme

disturbances). Need to define what goes in database (e.g. do we want to document avalanches, which happen all the time?).

From scoping meetings

- What are the changes in the landscape that are having measurable effects on vegetative distribution?
- How do extreme disturbance events, such as storms, tsunamis, floods, and earthquakes, affect park lands (especially coastal areas?)

Possible Partners

Relevant Monitoring or Study

There is a long database on glacial extent available. Need to reoccupy some past monitoring stations and take measurements.

Comments

This vital sign crosses over with landcover in that both care about and document extreme disturbance events. Also crosses over with surface water dynamics, relative to floodplain dynamics.

KLGO wants to determine erosion rates to assist with management.

Greg: Flood plain dynamics is a 'biggie,' especially in KLGO.

Lakes are disappearing at Dry Bay and dramatically changing the ecology of the valley. Different scales are relevant and different dynamics are at play in each park. For changes in beach geomorphology you need one scale and frequency of data, for landcover changes due to fire you need a different one.

250 years ago Dundas Valley was one big floodplain; it is on its way to becoming like Excursion Valley now. The whole ecology of the valley will change.

KLGO -- Coastal processes affect the nature and productivity of the Taiya River estuary thereby influencing the use of the area by fish and wildlife including eulachon, bald eagles, migrating waterbirds, river otters, salmon, and harbor seals.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- KLGO is interested in the sediment load in park glacial streams; this effects channel movements, flood plain dynamics, and management of infrastructure in the floodplain. The more sediment, the more braided the rivers. The floodplains are where the salmon spawning habitat is and the deciduous riparian forest.
- Way to monitor episodic/drastic events is to document after they occur.
- Document small events on a yearly basis to feed into future models.
- Document when extreme disturbance events occur and results; these events are difficult to "monitor." Use post-event mapping/satellite imagery.
- Can use seismic stations (one is located in Deception Hills on the fault just southeast of Dry Bay) for detecting extreme disturbance events.

EMF Level 1 -
EMF Level 2 -
EMF Level 3 -

SEAN VITAL SIGN
SURFACE WATER DYNAMICS

Justification

Threats

From surface water dynamics

GLBA -- Without a reasonable understanding of surface currents, our ability to protect marine and intertidal resources from spill impacts will continue to be limited.

KLGO -- Changes in the characteristics of surface waters through the year directly affect the distribution and abundance of associated biota including salmon, eulechon, beaver, river otters, harlequin ducks, bald eagles, bears, macroinvertebrates and mink.

SITK -- Only the lower 0.6 miles of the Indian River is within the park boundary, yet the surface water the park receives represents the entire Indian River Basin and all the impacts to the entire system as the result of human activity.

From stream/river channel

GLBA -- Abundance and distribution of spawning salmon and their predators (seasonally) is strongly influenced by stream channel characteristics. As channels evolve, salmon/predators will appropriately respond. It is important to understand the degree to which changes in these biotic resources are primarily attributable to natural channel evolution, vs. human-caused impacts.

KLGO -- The Taiya River is a highly dynamic glacial river that dominates the Dyea and Chilkoot Trail Units of KLGO. Channel morphology and dynamics are of great interest to the park. Past development has altered lower portions of the river and future planned developments may also result in direct impacts to the river and its tributaries.

SITK -- Human activities in and outside the Indian River channel outside the park boundary can alter the hydrological process of the river, causing changes in erosion rates and locations that could impact park resources and its tributaries.

Comments on Threats

Management Concerns

From surface water dynamics

GLBA -- Spilled contaminants (e.g., petroleum) are transported largely by surface currents. Surface water physical dynamics (freshwater and marine), including flow and general character, can be an essential driver of surface water biota (e.g., marine hytoplankton blooms) which in turn powers the entire marine ecosystem and ultimately has some important effects on some portions of the terrestrial and FW systems. For Glacier Bay proper we currently possess a decent dataset for surface and near-surface oceanographic parameters (except currents), and this trend monitoring must continue. Although crude qualitative models of marine surface current dynamics have been developed, our empirical knowledge is extremely scant. GLBA reports to 3 GPRA Goals that might have relevance to this Vital Sign: Surface Water Quality (Ia4A), Water Quality (Ia4B), and Water Quantity (Ia4C). There is also the Goal for Land Health - Marine and Coastal (Ia1F) that might pertain.GLBA -- Spilled contaminants (e.g., petroleum) are transported largely by surface currents.

KLGO -- Management of the White Pass & Yukon Route railroad/tracks and plans for future development of a trail to White Pass City may affect surface water dynamics within the White Pass Unit. Proposed development within the Taiya River Watershed will have significant effects on surface waters within the watershed.

SITK -- Human subdivision and other developments that have the potential for adding contaminants and increasing siltation to the river, water extraction (instream flow reduction), recreation activity, and other upstream impacts threaten the integrity of the Indian River surface water which the park receives.

From stream/river channel

GLBA -- GLBA park enabling legislation references opportunities for scientific study of environmental changes (like primary stream development) associated with dynamic glaciation. GLBA has become fertile ground for research on stream physical (and community) development following glacial recession (Milner et al.). Long-term monitoring provides the fundament for this important and valuable (to science) work; this research can also provide information to managers regarding stream response to human disturbance. Understanding of channel trajectories can provide information for predicting quality of critical spawning habitat quality of economically valuable salmon resources. Importantly, this category includes discharge characteristics of streams and tidewater glaciers (including sedimentation) - which strongly influence an abundance of park resources and VSs. Management must recognize and understand trends in order to respond appropriately to change. GLBA reports to 3 related GPRA Goals that might have relevance to this VS: Surface Water Quality (Ia4A), Water Quality (Ia4B), and Water Quantity (Ia4C).

KLGO -- Bank stabilization, bridge construction, roads, gravel extraction and recreational activities affect river dynamics, erosional process and floodplains within the park.

SITK -- River bed gravel extract and the fill that extended the trailer park adjacent to the boundary have altered the river channel in the park, resulting in increased erosion that threatens park resources. These activities continue periodically to the present day.

Comments on Management Concerns

Monitoring Objectives

- Understand how hydrologic processes affect the terrestrial ecosystem.
- Understand short and long term changes in physical, chemical and biological features of rivers, streams and other moving water (lotic) systems (watersheds, stream channel characteristics, groundwater dynamics, surface water dynamics, water quality, water chemistry, aquatic macroinvertebrates, exotic plants and animals, fish, benthic algae, benthic invertebrates).
- How is the connectivity among different freshwater bodies and ecosystems changing over time?

Monitoring Questions

- Are there long terms trends in annual rate or seasonality of streamflow?
- Is in-stream flow adequate to support aquatic life? (particularly important to SITK)
- Is the amount of discharge of freshwater into seawater changing?
- Is the sediment load of discharge changing?
- Is the nutrient or carbon load of discharge changing?

<u>From floodplain dynamics</u>

- Are changing discharge characteristics making rivers more erosive?
- Is flood frequency or severity changing?

<u>From scoping meetings</u>

- How do groundwater processes affect intertidal communities?
- How do changing water sources influence freshwater bodies, e.g., influence of glacial melt, snow melt, rainfall, and ground water?
- How are water sources changing temporally and spatially, i.e., what are the relative contributions of various water sources to freshwater systems (same vital signs as in previous question)?
- How do freshwater inputs influence near-shore marine productivity?
- What is the influence of marine-derived nutrients on freshwater systems over time?

Example of Measures

- Stream discharge (rate [volume/time]) of stream flow.
- Stage height of flood events.
- Modeled flow from tidewater glaciers (e.g., based on mass balance.)
- Periodic analysis of sediment concentration in streamwater.
- Need to know what is in the discharge too; sediment load is important. Continue (Chris Larson) work that is determining how many cubic kilometers of ice we've lost in GLBA. All that exited the marine system and had a huge estuarine-marine effect, which is continuing. That freshwater exit is a huge physical and chemical driver. It is noted that the best opportunity to detect oxides in nitrogen and sulfur is when snow melts and you measure it in freshwater streams (rather than measuring soils.)

Possible Partners

Relevant Monitoring or Study

Comments

Chris G - For all parks: Not sure of the distinction between floodplain and surface water dynamics. Combine?

Greg - Freshwater dominates much of park.

Greg - Discharge integrates many things from physical world.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- Tidewater glacial face hydrodynamics (especially carbon, dissolved nutrients, sediment) are really important.
- How does freshwater input change in space and time? What is it transporting? How does the pattern change over time?
- Use stream gauges - instrument a few streams and model from there.
- On a watershed basis, you would want to know what is coming off the hillsides and what is being generated by the ice itself. Once you have a benchmark for how much the watershed is inputting, then glacial mass balance will provide an indication of change. See Lawson, Arendt's work. If you have a system that is not glacially influenced, you may want information on temperature, nutrients and volume.
- There has been a lot of stream mapping in Southeast Alaska. Obtain stream gauge data. Other sources of basic hydrologic data: monitoring wells, piezometers (Bishop, Streveler).

Surface water dynamics

Types of water body

- Wetlands (bogs, fens, marshes, forested wetlands; occupied by macroscopic plants)
- Glaciers and ice fields (glacier-associated water bodies: ponds, trap, supra-, en- and sub-glacial, stagnant and buried ice, proglacial lakes)
- Seasonal snow pack
- Liquid water bodies
- Ground water (minus hyporheic flow, karst hydrology)
- Permafrost (ground ice)
- Ponds (ephemeral, high-elevation bedrock, inter-morainal, kettle, dredge {amphibian habitat}, ponds on glaciers, trap lakes and ponds, supraglacial {see glaciers list})
- Permanent snow pack

EMF Level 1 - Water
EMF Level 2 - Hydrology
EMF Level 3 - Marine hydrology

SEAN VITAL SIGN
MARINE PHYSIOCHEMICAL AND BIOLOGICAL WATER MASS CHARACTERISTICS

Justification

A set of marine water data is needed over the long term as a baseline for the condition of this park ecosystem, to enable change detection, and as a backdrop against which other change detection may be considered. This vital sign is important to GLBA and SITK.

Threats

From water chemistry

GLBA -- Legal and illegal discharges from marine vessels have the potential to negatively affect Park resources.

From toxics

GLBA -- Marine water quality threats include potential impacts caused by wastewater discharges (treated wastewater, bilge and ballast water), antifouling paints, air emissions that may precipitate into marine water and accidental oil discharges.

From marine hydrology

GLBA -- An inadequate understanding of GLBA oceanography (how upwelling, large, medium and small scale ocean currents affect marine processes) leaves us unable to distinguish change, not to mention determine the causes of change, at the ecosystem level. Climate change and management actions may result in oceanographic changes that are difficult to detect but have far-reaching effects on the marine ecosystem. Need to determine whether the turbidity caused by cruise ship prop wash affects the distribution of small schooling fishes. Information on the correlation between oceanography and the relative abundance and distribution of zooplankton and forage fish is needed to account for natural change.

KLGO – NA

SITK -- NA

From point-source human

GLBA -- Pollution from shipboard wastewater (blackwater and graywater) effluent from small and large vessels may affect marine life. Non-regulated endocrine disrupters and toxic flame retardants are found even in the highly treated wastewater from cruise ships, which may have biological effects on a variety of marine species. Petroleum leakage from outboard engines and exhaust at low levels may affect marine life.

From non-point source human

GLBA -- Pollution a threat from non-point source human impacts, including vessel wastewater discharges.

From coastal/oceanographic

GLBA -- Changes in water column stratification that could result from climate change and glacial retreat would likely change plankton species composition and biomass, timing of spring bloom, timing and volume of freshwater input and ocean temperature with cascading effects on marine vertebrates and other taxa. The Pacific Decadel Oscillation (PDO) and where the Alaska Coastal Current bifurcates will have an effect on this vital sign.

Comments on Threats

From water chemistry

GLBA -- Marine workshop report says: tidewater glacial face hydrodynamics are really important, especially carbon, dissolved nutrients, sediment. Not sure how to interpret this into a management concern or threat

Management Concerns

From water chemistry

GLBA -- Monitoring of water quality in Glacier Bay is needed to determine whether legal or illegal discharges from marine vessels are occurring and have the potential to negatively affect Park resources.

From toxics

GLBA -- Potential impacts of toxics both in the marine and freshwater systems are a management concern. The park needs to determine whether legal or illegal discharges from marine vessels are occurring.

From marine hydrology

GLBA -- Managers currently lack the data necessary to detect oceanographic change or determine causal factors. Changes in marine hydrology will affect T&E species, at-risk biota, anadromous fish and terrestrial and freshwater taxa in profound but unknown ways. Management actions may be having direct but unmeasured effects on marine hydrology. For example, de-stratification of the water column by cruise ship turbulence in transit and as they sit at the glaciers, may have effects on habitat suitability for marine species ranging from plankton to fish, with effects throughout the ecosystem, from larval fish to harbor seals. Oceanographic system is foundation for all other marine processes in Glacier Bay. Present studies need to continue in order to maintain contemporary oceanographic data, attempt to account for observed variability in biological resources, and additional studies are needed to identify effects vessels might have on certain oceanographic parameters.

KLGO -- NA

SITK -- NA

From point-source human

GLBA -- Human health and safety is a concern related to chemical contaminants, heavy metals, and sewage contamination of surface waters. The impacts of chemical contaminants (e.g. reproductive failure, change in endocrine function, tissue damage) are of most concern in relation to marine species.

From marine features

GLBA -- Ecological changes that occur in response to changes in marine processes and features could impact habitats for biota at risk, T&E species, anadromous fish and coastal vegetation.

Comments on Management Concerns

Monitoring Objectives

- Understand oceanographic processes influencing the marine ecosystem.
- Understand the natural range in variability of marine water quality parameters.
- Determine the concentration of contaminants in marine ecosystems.

Monitoring Questions

- How do currents change in speed, direction and timing?
- How do the physical characteristics of the water mass change in space and time (and how does that affect dependent biology)?

- Why do marine hotspots, where large numbers of marine mammals and seabirds aggregate and feed, shift in time and space?
- What will the impact be to the marine ecosystem when the terminus of retreating tidewater glaciers is no longer in marine waters?

From scoping meetings

- How do the three levels of ocean currents (large-Alaska Coastal Current, medium-e.g. the bifurcation near Sitka, small-those within or in front of parks) affect marine processes?

Questions about circulation and upwelling

- Are the temporal and spatial patterns of marine upwelling changing?
- Are the temporal and spatial patterns of marine circulation changing?
- Is the nutrient and energy content of upwelling water masses changing?

From bioaccumulated toxics

- Has there been a change in the level of target contaminants in top level predators?

From marine and freshwater primary productivity

- Has there been a change in the location or amount of marine primary productivity in park waters?
- Is there a long term trend associated with the annual spatial variability of the spring phytoplankton bloom in GLBA?
- Has there been a change in the species composition of the phytoplankton blooms in Glacier Bay?

From marine contaminants

- Are there long term trends in the concentration of contaminants in marine waters?
- Are there long term trends in the concentration of contaminants in marine sediments? from marine derived nutrients
- Has there been a change in the amount of marine-derived nutrients introduced to focal streams in SEAN parks?
- Has there been a change in the amount of marine-derived nutrients introduced into the riparian zone of focal streams?
- Has there been a change in the response of stream or riparian communities to introduced marine-derived nutrients?

From scoping meetings:

- What are the concentrations of contaminants being released into the marine environment from known pollution sources?

- What are the biological indicators of the health of marine water quality (marine ecosystem)?
- What are the biological indicators of toxicity and pathology in marine water quality (marine ecosystem)?

From water column core parameters

- How do depth profiles of physical and chemical characteristics of seawater change?
- How do biotic, chemical, and physical characteristics of seawater vary spatially?

From scoping meetings:

- How are marine biological processes affected by the water column's physical properties and dynamics?
- What are the changes in the nearshore geomorphic features?
- How do longshore currents affect shoreline processes?

From hydrocarbons

- Is there a change in the contamination of marine water by engine fuels or lubricants?

From sewage

- Is there a change in the incidence or degree of contamination of marine waters by sewage?
- Is there a change in the effects of nitrogen and phosphorus fertilization of plants or animals in marine waters near wastewater outflows?
- How do currents change in speed, direction and timing?

Example of Measures

You can monitor some of this suite of parameters at once:

- CTDs (temp, salinity, DO, turbidity, nutrients, others).
- Contaminants (toxics, hydrocarbons, sewage); gather from water, sediments, tissues (mussels, etc.)
- Primary production (chlorophyll A); could be with CTDs.
- Water mass characteristics -- location and timing of upwelling; vessel transects of temp, salinity, nitrate, ammonia, phosphate, silicate, pH, DO, chlorophyll-A, turbidity, sediment load; seasonal maps of estuarine currents; nutrient and carbon concentrations in upwelling water masses; simultaneous measures of discharge flow rates and circulation patterns.

From bioaccumulated toxics

- Concentration of target contaminants in predator tissue.

From marine and freshwater primary productivity

- Distribution and concentration of chlorophyll-a.
- Time course of chlorophyll-a (or other productivity indicator) at moorings.
- Phytoplankton species composition.

From marine contaminants

- Concentrations of target inorganic and organic compounds in seawater.
- Concentrations of target inorganic and organic compounds in marine sediments.

From marine derived nutrients

- Isotopic ratios of carbon and nitrogen in stream organisms and riparian zone organisms and soil.
- Nitrogen content, biomass, and growth rates of stream and riparian zone organisms.

From water column core parameters

- Depth profiles of temperature, salinity, nitrate, ammonia, phosphate, silicate, pH, dissolved oxygen, chlorophyll-a, turbidity, sediment load.
- Stationary measures of above parameters from moorings.
- Transects of above parameters from vessels.

From hydrocarbons

- Reports of fuel or lubricant spills.
- Observations of hydrocarbon slicks on soil or water.
- Concentration of hydrocarbon in water samples.

From sewage

- Presence of coliform bacteria in marine waters.
- Difference in biomass, growth rate, or element content of marine organisms near versus far from wastewater outflows.
- Need a mixed sampling protocol. Target both problem areas and baseline stations.
- Whenever a marine mammal and seabird hotspot is observed, collect distribution and relative abundance data and marine physiochemical and biological water mass data.

Possible Partners

Relevant Monitoring or Study

Robars 2003: near-glacier productivity should be monitored.

Comments

Sampling design; Collect data in select areas to include hotspots, at face of tidewater glaciers where enter marine ecosystem.

Protocol/sampling design for first three measures (CTDs, contaminants, primary production) and parts of the fourth (water mass characteristics) is the same; monitor whole suite of measures at once. But, protocol for measuring water mass characteristics would be to obtain data from remotely sensed map. Therefore, some scientists suggest that fourth set of measures belong with vital sign 33, land (and ocean) cover and land use. From remotely sensed map and/or satellite data, can get sea surface water temp, surface salinity, chlorophyll distribution, surface discharge patterns, vertical fronts, sea level altimetry, seasonal sediment plumes, etc. Oceanographers can learn interesting things from remotely sensed maps of the nearshore environment. This could be a very inexpensive way to get outer coast data. Not sure how often one would repeat this - every season, annually, every 10 years? How would one ground-truth remotely sensed marine data (ask NOAA/use NOAA's data, ask Dave Douglas)?

Have we sufficiently covered marine primary productivity? It seems like we always skip over zooplankton and calcareous things. One of the global threats that may be coming is ocean acidification. Should we have a vital sign that includes measuring this?

<u>From bioaccumulated toxics</u>

Greg -- One of the best!

Dan -- Baseline data are virtually non-existent; should such baseline data be acquired now and re-sampling not done for 10-20 years?

<u>From marine and freshwater primary productivity</u>

Scott -- Productivity is driven by other lower order things (nutrients, light) and zooplankton grazing dynamics; good linkages but not sure how sensitive as an indicator.

<u>From marine contaminants</u>

Dan -- Important to know but limited help in detecting ecosystem change - baseline lacking; cost of sampling to acquire baseline?

Greg -- Ranked higher because of proximity of sources; why is KLGO not in the mix? from marine derived nutrients

Scott -- Difference here is the potential to serve as an indicator vs. what we know about dynamics of delN or delC values and their reflection of SDN in freshwater or riparian ecosystems…

If anyone reads this comment, they deserve a badge for commitment…

Greg -- impoverished

Greg -- ranks a little lower than GB because marine source offsite mostly

<u>From water column core parameters</u>

Greg -- a 'biggie'

Dan -- Change detection will be limited to regional scale; major changes may be detected; locations of water masses more dependent on local conditions and processes (e.g. glacier margin or stream mouths)

<u>From hydrocarbons</u>

Dan - Baseline data needed but monitoring hydrocarbons as an ecosystem indicator of change does not seem justified; could be included in comprehensive water quality sampling scheme with 10 or more year frequency repetition?

Greg - Indicator high because of SKG harbor proximity

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- Refer to results of December 2005 workshop on GLBA oceanography. Information regarding ocean currents is essential. GLBA has a long-term dataset on physical oceanography (24 sampling stations). However, dataset is not related to known sites and does not include current data. Use existing dataset to model currents and identify information gaps. There should be data at the park specific to Muir Glacier, where oceanographic data was collected for 10 years. Should be a report in park library.
- Use data from Icy Strait (outside GLBA). Source: NOAA Auke Bay Lab, SE Coastal Monitoring program.
- Park equipment is being used to some extent. CTD (conductivity-temperature-depth) data could be used to model currents.

- Install moorings.
- May be able to use Water Quality program funding for current data.
- A recurring theme is that a challenge for the marine ecosystem is that it's a highly protected area in a non-protected region. This is particularly true for the marine ecosystem, and the connectivity is so high between what is happening in the marine ecosystem within the parks and outside of the parks and in the region. The vital signs picked may well be outside the park; very few marine species spend their entire lives within the parks.
- Partners for current monitoring: NOAA-Southeast Coastal Monitoring program (SECM); NOAA's old drift card data; Alaska Ocean Observing System (AOOS, little money for Southeast); Dr. John Whitney-NOAA, has computer trajectory models; University researchers; National Pacific Research Board (work with oceanographic priorities for Gulf of Alaska and Southeast Alaska).
- Install thermosalinographs on ships of opportunity (with flourometer nutrient sensor). Add moorings for temporal component.
- Nutrients drive phytoplankton bloom dynamics and marine productivity dynamics generally.
- Look at NOAA Auke Bay SE Coastal Monitoring program data.
- EMAP (EPA) program sampled Southeast Alaska in 2004 - all water chemistry and nutrients measured, 40 stations.
- Talk to Deb Rudis & Jeff Short about means to monitor (think in terms of Oilspill Protection Act 1990).
- Mussel Watch (NOAA) is an existing bioassay program. Establish sites in SEAN parks. Nice time integrator. May be very cheap, or even at no cost to parks.
- Sitka notes that there are a lot more barnacles than mussels in the park. Wonder about utility of Mussel Watch there?
- There are well-established protocols for sediment contamination.

<u>regarding productivity hotspots:</u>

- Limited nutrient data collected in GLBA (summer 2002 - Taggart; summer 2004 - Piatt not yet analyzed)
- Sonar fish school tracking/mapping (USGS/Piatt/Dragoo surveys)

EMF Level 1 - Water
EMF Level 2 - Water Quality
EMF Level 3 - Water chemistry

SEAN VITAL SIGN
FRESHWATER PHYSIOCHEMICAL WATER QUALITY

Justification

A set of freshwater data is needed over the long term as a baseline for park conditions, to enable change detection, and as a backdrop against which other change detection may be considered.

Threats

GLBA -- Groundwater quality can indicate soil contamination from petroleum products and other toxics; contaminant sources and high concentrations can be located via groundwater.

KLGO -- groundwater dynamics determine the location, distribution and types of wetlands and surface waters in the park. Groundwater quality may be affected by human waste management (pit toilets, septic systems) and fuel storage within the watershed.

SITK -- Little is know about the groundwater processes that effect park resources. Human development around the park and in the Indian River Basin has the potential to radically alter ground water dynamics in the park.

Comments on Threats

Management Concerns

GLBA -- Lack of data. The only knowledge of GLBA hyporheic character come from a handful of currently unmonitored (except at Dry Bay) wells in Bartlett Cove associated with groundwater contamination studies at the solid waste depot and the fuel farm/VIS area. Also an additional small handful at Dry Bay, and a triple handful in Gustavus. Knowledge of groundwater character/dynamics is key to understanding certain processes of stream and lake development (nutrients and C flow within and between ecosystem types, especially from the terrestrial system). GLBA reports to 2 GPRA Goals that might have relevance to this VS: Water Quality (Ia4B), and Water Quantity (Ia4C).

KLGO -- The park knows very little about the characteristics of groundwater within the Taiya and Skagway watersheds. Groundwater dynamics appear to be closely linked to wetland dynamics and western toad breeding phenology. Isostatic rebound is altering groundwater dynamics within KLGO with an average uplift rate of 3/4" per year.

SITK -- Human activities outside the park could have drastic impacts to the groundwater dynamics within the park.

Comments on Management Concerns

Monitoring Objectives

- Understand short and long term changes in physical, chemical and biological features of rivers, streams and other moving water (lotic) systems (watersheds, stream channel characteristics, groundwater dynamics, surface water dynamics, water quality, water chemistry, aquatic macroinvertebrates, exotic plants and animals, fish, benthic algae, benthic invertebrates).
- Understand short and long term changes in physical, chemical and biological features of lakes, ponds and other still water (lentic) systems.

Monitoring Questions

- What are the long term trends in water quality of streams and lakes?
- What is the status of the "health" of large rivers (water quality, macroinvertebrates)?
- What are the (present) conditions of freshwater bodies (water quality)?
- How do marine derived nutrients affect freshwater systems?

Example of Measures

<u>Repeated measures of:</u>

- dissolved oxygen
- temperature
- pH
- oxygen
- siltation
- nutrients (phosphorous, nitrogen, etc.)
- alkalinity
- hardness
- silica
- dissolved organic carbon
- conductivity
- turbidity
- sediment load

Possible Partners

Relevant Monitoring or Study

Dan - Limited data exist on freshwater parameters; baseline acquisition needed.

Comments

Greg - A 'biggie' in all parks.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- How does freshwater input change in space and time? What is it transporting? How does the pattern change over time?
- Have we lost the concept of freshwater productivity, with the vital sign lumping and nesting? If so, does this matter?

EMF Level 1 - Water
EMF Level 2 - Water Quality
EMF Level 3 - Toxics

SEAN VITAL SIGN
FRESHWATER CONTAMINANTS

Justification

Freshwater contaminant data integrates information about the entire watershed and impact of humans.

Threats

From water chemistry

KLGO -- Due to the linear nature of both the Chilkoot Trail and White Pass units of KLGO, these park units are dominated by valley bottom and floodplain ecosystems. Water chemistry is a major driver of aquatic systems and the biota present within these systems.

SITK -- Only the lower 0.6 miles of the Indian River is within the park boundary, yet the surface water the park receives represents the entire Indian River Basin and all the impacts to the entire system as the result of human activity.

From toxics

KLGO -- Toxins may be released into park aquatic systems from a number of sources: WPYR, fuels spills, stormwater runoff, and intentional dumping.

SITK -- Upstream development in the Indian River Basin has been rapid and continues to accelerate. This development increases the risk that toxic chemicals will be released into the Indian River.

From point-source human

KLGO -- Point sources such as pit toilets, septic systems, grey water disposal WP&YR, and stormwater runoff could negatively impact surface water quality in KLGO.

From non-point source human

GLBA -- Pollution a threat from non-point source human impacts.

Comments on Threats

Management Concerns

From water chemistry

KLGO -- WP&YR railroad, Chilkoot Trail recreational use, inholdings, surrounding development (subdivisions with septic systems), and stormwater runoff from homes/roads are management concerns.

SITK -- Human subdivision and other developments that have the potential for adding contaminants and increasing siltation to the river, gravel extraction, and dam maintenance threaten the integrity of the Indian River water chemistry, the accumulative impacts of which are received in the park in the lower 0.6 miles of the river.

From toxics

KLGO -- Discharges of toxins into park aquatic systems are a management concern. Potential sources should be identified and monitored.

SITK -- Upstream development in the Indian River Basin may result in the release of toxic chemicals into the Indian River which may impact the stream ecosystem included the portion of the river within the park.

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Are there trends in the concentration of contaminants in the water of streams and lakes (water, sediments or biological tissues)?
- Is there a change in the incidence or degree of contamination of surface waters or groundwater by sewage?
- Is there a change in the effects of nitrogen and phosphorus fertilization of plants or animals near wastewater outflows?
- Is there a change in the contamination of soil or water by engine fuels or lubricants?
- What is the level of contaminants in freshwater systems?

Example of Measures

- fecal coliform (in groundwater or surface water)
- heavy metals
- concentrations of target inorganic and organic compounds
- persistent organic pollutants
- difference in biomass, growth rate, or element content of organisms near versus far from wastewater outflows
- concentrations of hydrocarbons (polycyclic aromatic hydrocarbons)

- reports of fuel or lubricant spills
- observations of hydrocarbon slicks on soil or water

Possible Partners

Relevant Monitoring or Study

Comments

Monitor freshwater contaminants because we know they are not supposed to be there. But a problem is, what levels are unhealthy? It is hard to get a dose response effect as a measure of an impact from contaminants. But you could say that monitoring this is reflective of something you might want to tackle.

Greg - Freshwater contaminants a 'biggie,' especially for Sitka.

Dan - Baseline data limited on freshwater contaminants; may be useful to acquire data now for future.

The Hydrocarbon issue is quite important in SITK and KLGO as they are adjacent to urban areas.

Greg - Hydrocarbon indicator high because of SKG harbor proximity.

Dan - Baseline data on hydrocarbons needed, but monitoring as an ecosystem indicator of change does not seem justified; could be included in comprehensive water quality sampling scheme with ten or more year frequency repetition?

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Water
EMF Level 2 - Water Quality
EMF Level 3 - Aquatic macro-invertebrates and algae

SEAN VITAL SIGN
FRESHWATER BENTHIC MACROINVERTEBRATES AND ALGAE

Justification

Threats

From aquatic macroinvertebrates

GLBA -- The vital sign here is freshwater benthic macroinvertebrates and algae. These comprise an essential element of the freshwater ecosystem. No known immediate (or likely potential) threats.

KLGO -- Good indicators of water quality and aquatic health in clearwater systems. No indices have yet been developed for glacial systems, which the Taiya and Skagway rivers are.

SITK -- Aquatic macroinvertebrates and benthic algae (diatoms, etc.) are good indicators of water quality and the health of stream ecosystems. Human development that has the potential for adding contaminants and increasing siltation to the river, gravel extraction, and water diversion (instream flow reduction) in the Indian River Basin threaten to shift macroinvertebrates and benthic algae species composition to that representing a degraded stream. Species diversity may also be reduced.

Comments on Threats

Management Concerns

From aquatic macroinvertebrates

GLBA -- Benthic macroinvertebrate/algal dynamics comprise an important driver of freshwater (especially stream) systems. Fishes, including rearing salmon, rely heavily upon benthic macroinvertebrates (some of which graze upon algae) for food and are sensitive to their composition, abundance, and distribution.

KLGO -- Much work would need to be done within park glacial river systems in order to use macroinverts and algae as indicators of WQ and stream health.

SITK -- Human development that has the potential for adding contaminants and increasing siltation to the river, gravel extraction, and water diversion (instream flow

reduction) in the Indian River Basin could degrade the Indian River, the accumulated effects of which would be seem in the final 0.6 miles of the river within the park. Aquatic macroinvertebrates and benthic algae would be some of the first organism to be effected and the most sensitive species to these changes would be lost or reduced.

Comments on Management Concerns

Monitoring Objectives

Understand short and long term changes in physical, chemical and biological features of rivers, streams and other moving water (lotic) systems (watersheds, stream channel characteristics, groundwater dynamics, surface water dynamics, water quality, water chemistry, aquatic macroinvertebrates, exotic plants and animals, fish, benthic algae, benthic invertebrates).

Monitoring Questions

<u>From freshwater algae</u>

- Are there long term changes in the community of freshwater algae in streams or lakes?
- Are there long term changes in the abundance of indicator taxa of freshwater algae in streams and lakes?

<u>From freshwater macroinvertebrates</u>

- Are there long term changes in the community of stream invertebrates?
- Are there long term changes in the abundance of indicator taxa of stream invertebrates?

- What is the status of the “health” of large rivers (water quality, macroinvertebrates)?

Example of Measures

<u>From freshwater algae</u>

- Area of stream bottom occupied by each species of freshwater algae.
- Concentration (individuals/volume) of diatoms and phytoplankton in lake water.
- Diversity, community composition, and biomass of freshwater algae in streams or lakes.

<u>From freshwater macroinvertebrates</u>

- Counts per area of stream bottom of aquatic insect and other invertebrate taxa.
- Diversity, community composition, and biomass of invertebrate taxa.

Possible Partners

Relevant Monitoring or Study

Comments

Freshwater macroinvertebrates are a biological index that is very sensitive to change. Measure caddis fly, may fly, stone fly etc. If change is detected, then increase water quality parameters being measured to determine cause. If sole reason to measure is to determine water chemistry, why not just do water quality measures? Measuring macroinvertebrate levels is complementary with water quality monitoring, nor redundant. Only monitor macroinvertebrates in clear water streams.

<u>From freshwater algae</u>

Greg -- benthic algae small part of GLBA freshwater ecosystems; same at KLGO

<u>From freshwater macroinvertebrates</u>

Greg -- Generally a good index to water quality

Greg -- Great index to water quality on Indian river at SITK

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Biological Integrity
EMF Level 2 - Invasive Species
EMF Level 3 - Invasive/Exotic plants

SEAN VITAL SIGN
INVASIVE EXOTIC PLANTS

Justification

If not controlled immediately, invasive and exotic plant entry to the park ecosystem will cause huge change to the vegetation community and all that depend upon it. This could be an ecosystem controller. This is an immediate concern in SITK, and a management concern for all SEAN parks.

Threats

From invasive plants

GLBA -- Replace native flora, cascading disturbance throughout the natural system. Invasive plants appear to be on the cusp of a rapid expansion in the GLBA terrestrial ecosystem. They could also invade FW systems. Invasive scan threaten the integrity of entire ecosystems and are viewed as a good indicator of overall ecosystem health. They can out compete native plants and perturb an entire flora (and thereby the fauna), fundamentally altering the ecosystem.

KLGO -- Big problem. Number of new species is increasing and distribution throughout park may be increasing as well. Exotic/invasives are second to habitat loss worldwide and the top threats to biodiversity and causes of species imperilment worldwide. As AK climate warms, the threat from exotic species will likely increase as well.

SITK -- Exotic plants are threatening to disrupt the terrestrial ecosystems of the park. Over 14 species are now present in the park of which at least four are or have the potential to spread rapidly. Others such as spotted knapweed and garlic mustard may arrive on Baranof Island any time and get transported into the park from the over 300,000 visitors that come to the park each year.

From terrestrial complex
KLGO -- Invasive species are a threat to the terrestrial complex.

From point-source human
GLBA -- Exotic species from bilges may invade marine ecosystems or transmit disease. Invasive plants may travel in with people via various means.

Comments on Threats

Management Concerns

From invasive plants

GLBA -- GLBA has only a token inventory of invasive plants. We understand the composition, distribution, and relative abundance of exotics from only a few select sites, and have only two years of data. Our concentration of effort has been focused on low-elevation sites near tidewater; we have no information from higher-elevation communities. It is likely that human activity is the primary cause of the spread of invasive plants, so invasive plant status can be a good indicator of human influence on otherwise pristine ecosystems. GLBA reports to GPRA Goal Ia1B, Invasive (non-native) Vegetation.

KLGO -- Numerous species have been detected within the park and several especially noxious species have shown up in Skagway - bird vetch and white sweetclover. Lots of vectors for introductions and difficult to manage potential sources due to mixed ownership within park boundary and multitude of uses.

SITK -- Highly aggressive exotic plants present in the park included Japanese knotweed, creeping buttercup, dandelion, and European mountain ash. The buttercup is moving into forested areas rapidly and needs to be immediately controlled. Other highly aggressive species, like reed canary grass, have been found just outside the park boundary in the 2005 survey.

Comments on Management Concerns

Monitoring Objectives

- Determine if any invasive species are present in the parks.

Monitoring Questions

- Are there any near- or offshore marine invasive plant species present, and are they increasing in area or abundance?
- Which terrestrial invasive plant species are present in SEAN parks?
- What is the abundance and distribution of invasive plant species in SEAN parks?
- What is the rate of increase of abundance and distribution of invasive species?
- What is introducing invasive/exotic plants and what measures can be taken to limit or control invasion?
- To what extent are exotic species affecting freshwater systems?

Example of Measures

- Distribution and extent of invasive and exotic plants.

Marine

- Population sizes and locations of marine exotic eelgrasses and exotic algae.

Terrestrial/aquatic

- Population sizes and locations of dandelions, European mountain ash, creeping buttercup.

- National protocol being developed.

Possible Partners

Hope to rely on Environmental Management Plan (EMP) for eradication efforts; NPS needs to coordinate with them. NPS role may be to take EMP data and summarize it every five years, and keep an early eye out for invasion in SEAN parks.

Relevant Monitoring or Study

Comments

Monitor invasive plants and animals because we know that they can cause huge destruction in many ways and that they're not supposed to be there. We don't know the mechanism, but we do know if they start showing up with greater frequency we better identify it right away because we could potentially have a disaster. We may not have an invasives problem at SEAN parks now, but 100 years from now we probably will.

Dan -- Seems this falls under another NPS program and can be considered there, given limited resources for I&M?

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- Presence of invasive species can be indicative of overall park health.
- Invasive species change with time. One can't predict which plant will become the aggressive invasive. A patch can sit there for six months, then suddenly explode.
- Build on NPS Exotic Plant Management Team (EPMT) work. Note that EPMT may not be sufficient -- it will implement treatment, but parks would be expected to monitor the results of that treatment.
- USFS just completed a white paper on invasive species for the Alaska region -- both current and potential invasive species. Will send that report to the NPS.

- USFS has funding, has done a lot of surveys. They will be a good partner, coordinate with them.
- There is a central databank with USFS S&PF, Alaska Natural heritage Center, and NPS to a smaller degree.
- The definition between exotic and invasive is not straight-forward. It is suggested that exotic is non-native, and invasive is a particularly aggressive non-native. Spatial scale and time are factors in the definition. One groups states that for NPS purposes, "invasives" are species exotic to an ecosystem.
- Distribution is critical.
- Invasives are coming down the Alsek/Tat Rivers.
- Do paired studies-an invasive species and vectors of distribution (boats, boat drop off sites, wind, trucks/cars, ferries/vehicles, rafters, kayakers).
- KLGO is most at risk for plant invasions.
- Can we identify techniques to reduce invasive species transmission (e.g. wash boots in water before coming ashore)?
- What would protocol and sample design be if parkwide inferences were desired on the degree of invasiveness, or the level of exotic species and invasive species that are in the Park, and monitor that over time? This would be a good indicator of how intact the park's native plant community was, whether it was being impacted by a number of different species. There would be interruptions to natural processes, included successional dynamics, if invasive species were having a large impact.
- GLBA is a rapidly changing environment. How do we distinguish an invasive species from something that would normally colonize the area?
- Exotic versus invasive.

EMF Level 1 - Biological Integrity
EMF Level 2 - Invasive Species
EMF Level 3 - Invasive/Exotic animals

SEAN VITAL SIGN
INVASIVE EXOTIC ANIMALS

Justification

Concerns include Atlantic salmon, introduction of exotics by bilge water, exotic slugs and their impact on vegetation, starlings in SITK and GLBA.

Threats

From invasive animals

GLBA -- GLBA invasive animals include a slug (terrestrial) that may be outcompeting native slugs and overgrazing native plants. Another known exotic is Atlantic salmon that may be outcompeting native salmon both at sea and for spawning habitat, may interbreed with and genetically alter native salmon, and may introduce disease into native salmon populations. Invasives can threaten the integrity of entire ecosystems and are viewed as a good indicator of overall ecosystem health.

KLGO -- domestic cats, dogs, rabbits have all been documented within KLGO. Bobwhite quail, eastern grey squirrel, starling, pigeons, turkeys, turtles, a lizard have been seen.

SITK -- SITK has several exotic animals that could be negatively affecting the park's ecosystems.

From terrestrial complex

KLGO -- Invasive species are a threat to the terrestrial complex.

From point-source human

GLBA -- Exotic species from bilges may invade marine ecosystems or transmit disease.

Comments on Threats

Management Concerns

From invasive animals

GLBA -- There has been no directed focus on the status/trends of invasive animals in GLBA. We do not understand the magnitude of the potential threat of invasive animals to native biota. We suspect that other exotics so far unknown within the park may in fact occur there or be poised to invade. GLBA reports to GPRA Goal Ia2C, Invasive Animal Species.

KLGO -- Doesn't appear to be a significant concern at the moment, but things could change.

SITK -- Little is know of the effects that exotic animal infestations are having on park ecosystems. Species know to be present include European starlings, pigeons, exotic slugs, domestic dogs, cats, and possibly rats. Starling populations appear to be increasing rapidly. Large flocks are using the park for feeding and some starlings may even be breeding in the park.

Comments on Management Concerns

Monitoring Objectives

- Determine if any marine invasive species are present.

Monitoring Questions

- Are there any near- or offshore marine invasive animal species present, and are they increasing in abundance?
- Which terrestrial invasive animal species are present in SEAN parks?
- What is their abundance and distribution?
- What is the rate of increase of invasive animal species abundance and distribution?
- What is the ecological relationship between exotic and natural animals?
- Are invasive/exotic animals causing a detrimental effect on natural animals?
- Are there places that are particularly prone to invasion by invasive/exotic animals?

Example of Measures

- Distribution and extent of invasive and exotic animals.
- Population sizes and locations of Atlantic salmon, green crab, European starlings, pigeons, domestic (and feral?) dogs and cats, rats, rabbits, northern bobwhite, exotic slugs, wild turkeys.
- Marine invertebrates in ballast water

  Protocol could be to set up a database to document anecdotal reports of invasive/exotic animals.

Possible Partners

Relevant Monitoring or Study

Comments

Greg -- not much in the way of animals.

Dan -- Does this fall under another NPS program and can be considered there, given limited resources for I&M? Are new species to GLBA invasive or due to ecosystem changes?

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- Invasives are important. Track colonization events or processes.
- Ballast water not discharged in SEAN parks (per MARPOL).
- Hull fouling organisms are mostly an issue for sedentary ships, rather than moving vessel traffic.
- It would be very difficult to monitor anything disengaging from a hull and entering marine waters in the parks.
- Be aware of potential invasives (e.g., those affecting Gulf of Alaska).
- ADFG program is monitoring for Atlantic salmon.

Also see comments for 11 Invasive/exotic

EMF Level 1 - Biological Integrity
EMF Level 2 - Infestations and Diseases
EMF Level 3 - Insect pests

SEAN VITAL SIGN
PESTS AND DISEASES

Justification

When pests and diseases attack it can reorganize the ecosystem. They drive change. Pest or disease outbreaks will typically be park management concerns. Pests and diseases can be from native and non native species.

Threats

From insect pests

GLBA -- The "threats" here are those posed to natural terrestrial vegetation assemblages by epidemic outbreaks of spruce bark beetles, aphids, hemlock looper. The potential vital sign is one of these insect "pests" or a suite of them. These are not threats if they occur naturally under natural conditions, but they ARE threats if they occur anthropogenically. A Sitka spruce weevil (Pissodes strobei) is currently moving northward through B.C. (not in Southeast AK yet); this beetle infests young spruce leaders, with major impacts to spruce regeneration.

KLGO -- Western balsam bark beetle (White Pass subalpine fir), lodgepole pine needle miner (Dyea). Native species that have had localized outbreaks.

SITK -- Insect pest like aphids have the potential to kill large numbers of mature trees in the area. Infestations seem particularly bad after warm winters. Warm winters are more common then in the past, possibly because of global climate change.

From animal diseases

GLBA -- Toxic algal blooms have the potential to kill marine organisms. Algal blooms may be naturally-occurring or caused by pollution. Avian flu and West Nile virus have the potential to decimate wild bird populations in Alaska. Parasites originating from farmed Atlantic salmon may affect wild salmon stocks. Genetic changes in populations may occur as a result of animal diseases. Climate change is expected to change animals' susceptibility to disease.

KLGO -- Avian Influenza, West Nile Virus, Chytrid Fungus (detected in western toads in KLGO), huntavirus.

SITK -- Diseases that are carried by birds and have the potential to spread rapidly around the world through migratory bird flyways or visitor use could reach SITK and cause ecosystem distributions and present a health hazard for visitors and staff.

From point-source human

GLBA -- Exotic species from bilges may invade marine ecosystems or transmit disease.

Comments on Threats

Management Concerns

From insect pests

GLBA -- In light of the "Threats" from insect pests, it is essential to distinguish between natural outbreaks and those triggered anthropogenically. Currently we have little ability to accomplish this, and no knowledge upon which to base a determination of cause and effect. These events are of considerable concern because of their ability to fundamentally alter the character of large portions of terrestrial habitat (witness lower G.B. following the spruce bark beetle outbreak of the early 1980s). If such an event could be linked to human activity, management would doubtless consider some reaction (and/or some preventative actions). GLBA reports to GPRA Goal Ia1E (Land Health - Upland) that might have relevance to this VS.

KLGO -- Non-native species may become a concern or unnatural behaviors of natives. Work with Mark Schultz of the Tongass N.F. to monitor.

SITK -- Aphids have killed many large spruce and hemlock trees in the park in recent years.

From animal diseases

GLBA -- Human safety is at risk when animal diseases affect humans, including poisoning from the consumption of tainted meat, fish or shellfish, or through direct disease transmission to people. Animal diseases may decimate populations of T&E species, at-risk biota and other taxa, bringing about profound ecological change in some cases. Visitor access and experience could be constrained by concerns about animal diseases, depending on the situation. Pollutants resulting from management actions are sometimes a factor in animal disease.

KLGO -- Could have significant impacts on park wildlife and implications for human health and safety.

SITK -- Diseases such as the Avian Influenza could reach the park when infected birds arrive after breeding in Asia or travel on overlapping migratory flyways with Asian routes. West Nile Virus could reach the park from migratory birds that come from the south.

Comments on Management Concerns

Monitoring Objectives

- Understand effects of marine infestations and diseases.
- Determine if there are any native insect or disease outbreaks adversely affecting the terrestrial ecosystem.

Monitoring Questions

From insect pests

- Has there been a change in the population size of spruce bark beetles, or an increase in the areal extent of infestation?
- Has there been a change in the population size of spruce aphid, or an increase in the areal extent of infestation?

From scoping meetings:

- Are there any infestations or diseases or changes in genetic structure of organisms prevalent in the marine ecosystem from either human-caused pollution or ecosystem-related changes?
- Are harmful algae blooms (HABs) affecting marine ecosystems?
- Are there any insect or disease outbreaks affecting the terrestrial ecosystem?

Example of Measures

- Map extent of outbreak areas
- Map distribution of outbreak areas
- Document early warning signs for avian flu

From insect pests

- Number of bark beetles captured in traps.
- Areal extent of dying or dead spruce trees in outbreak areas.
- Distribution of trees affected by spruce aphid.

Protocol should include monitoring where outbreaks could be expected.

Key pests/diseases to monitor: aphids, red tide, spruce bark beetle, spruce root fungus, avian flu, chytrid fungus

Possible Partners

Relevant Monitoring or Study

Comments

<u>From insect pests</u>

What to do with Spruce bark beetles and other insect pests in the park? USFS will be all over it if there's an eruption in one of the parks. Maybe we should put them on the list? It is not worth monitoring them to see if the population is ready to erupt - it's not going to happen that way. You just wait for it to erupt.

Greg -- ranked lowest because of generally youthful forests

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- ADFG program is monitoring for Atlantic salmon/disease. There are more parasites showing up in farmed salmon than in wild fish.
- ADFG Palmer (or Homer?) Lab has new monitoring capabilities for paralytic shellfish poisoning.
- Larval surveys with PCR analyses or bio-chemical analyses.
- Taggart commented on diseases and infections. He said there are changes in genetics with the structure of populations. He passed out reference material about *Traits Acquired from Results of Commercial Fishing*.
- In GLBA, spruce bark beetle is currently the only insect pathogen in the park.
- There are native species that go through episodic outbreaks. How to distinguish whether it is a natural infestation or occurrence or part of succession or habitat evolution?
- Hennon et al (FSL) can predict what insects will increase with a warming climate.
- Hennon has noted Sitka spruce weevil, Pissodes strobei, are moving north through British Columbia. The weevils infest young spruce leaders, with major impacts to spruce regeneration.
- Sitka and Excursion Inlet (near GLBA) both have aphids.
- It may be harder for invasives to colonize islands so they may be less at risk, but once colonization has occurred, extinctions are more common on islands.
- The MOST important things to do are education and establish a warning system.
- USFS S&PF will be a good partner, has a program. Encourage them to continue their work.

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Marine communities

SEAN VITAL SIGN
MARINE MAMMALS AND SEABIRDS

Justification

Marine mammals are long lived, some species are resident, and all are good integrators of ecological information. We need information on a guild of marine mammals and seabirds, not just single species. There is a single protocol, predator surveys, for monitoring this suite of marine mammals and seabirds. It is important to monitor a suite of species in our most trampled environment, within their habitat. This is important baseline monitoring information to acquire and maintain. This dataset is important for cruise ship management. The relative abundance of species to each other provides another set of information.

Changes in relative abundance of seabirds that are divers versus those that feed at higher levels in the water column informs us about conditions at those differing trophic levels and can serve as a proxy for forage fishes. It has been said that "the best plankton nets are seabirds."

Threats

<u>From mammals</u>

GLBA -- Apparent decline in harbor porpoise numbers is unconfirmed.
"Determine if vessel wakes change the behavior of whales ..., rafting sea otters and other marine mammals to determine the biological significance of these effects" (from VQOR-EIS).

<u>From birds</u>

GLBA -- Seabird populations will be affected by oceanographic changes caused by global climate change. Pressure to open Bartlett Cove to all traffic, not subject to vessel permit limits would negatively affect the many seabirds that use Bartlett Cove.

Comments on Threats

<u>From birds</u>

GLBA -- Harlequin ducks, Black oystercatchers, Kittlitz's murrelets and marbled murrelets mentioned specifically in Marine Report.

Management Concerns

From mammals

GLBA -- Sea otter re-colonization of GLBA will have far reaching effects on other marine species (kelp, urchins, clams, crabs).
We need to determine if the observed decline in harbor porpoise sightings indicates a true population decline and whether aspects of NPS and regional vessel management policies can reverse any negative trends.

From birds

GLBA -- Visitor experience will be negatively affected if we lose charismatic seabird species, such as puffins. Traditional Tlingit gull egg collection at South Marble Island may not be sustainable if climate change reduces the viability of the gull population.

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Why do marine hotspots, where large numbers of marine mammals and seabirds aggregate and feed, shift in time and space?
- How are the relative abundance and distribution of different species changing?

Example of Measures

- Relative abundance of species and guilds.
- Distribution of species and guilds.
- Whenever a marine mammal and seabird hotspot is observed, collect distribution and relative abundance data and marine physiochemical and biological water mass data.

From seabirds

Choose K-selected species to monitor that spend most of their life in the parks.

Possible Partners

NRPP proposal and funding.

Relevant Monitoring or Study

Continue predator surveys; have about 10 years of data.

Comments

From seabirds

Is this a gap if we don't include? Choose K-selected seabird species to monitor that spend most of their life in the parks.

K-Selected marine mammals

Monitor K-selected marine mammals. Look at numbers of marine mammals in the park, think about the measures that would give information about park specific versus non park specific matters. There is no mechanistic link there unless you couple it with something else on the cause and effect of marine mammal decline, because it could be so many things.

Parks Where Vital Sign will be Monitored
✓ **GLBA**

Comments, Possible Partners or Threats from Scoping Workshops

- Harbor seals and sea otters best to monitor (park-specific processes).

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Intertidal communities

SEAN VITAL SIGN
INTERTIDAL COMMUNITIES

Justification

Threats

From intertidal communities

GLBA -- Spills and trampling. Marine intertidal communities' habitats comprise the boundary between the marine and terrestrial ecosystems, and are the concentration/accumulation areas for "floating" pollutants such as petroleum and marine debris - both of which are damaging not only to intertidal communities but also to other biota. Marine vessel spills are a constant threat. Intertidal communities are vulnerable to human trampling, and the intertidal zone is an area of focused human activity because of easy human access/travel and because they attract human investigation. Much human activity in the park (that doesn't occur on marine waters) happens in the intertidal zone.

KLGO -- Threats to intertidal communities include visitor use, oil spills, and toxins.

SITK -- Intertidal communities in the park are at risk from human activity, including ship and boat traffic, oil spills, boat groundings, visitor use, and proposed developments such as a deepwater cruise ship dock to be built adjacent to the park boundary.

From point-source human
SITK -- Point-source pollution, such as the waste water treatment plant and the fish processing plant outfall, may be negatively affecting the park's intertidal zone.

From non-point source human

SITK -- No point pollution sources such as the discharges from ships and boats and oil emissions from outboard engines may be effecting the park's intertidal zone. Contaminants could be entering and bioaccumulating in the intertidal ecosystem.

From coastal/oceanographic

SITK -- Human alterations and activity can alter the shoreline processes that would have direct and indirect effects on the SITK's intertidal zone.

From Threats in Access, when we were considering "estuarine communities" as a vital sign:

KLGO -- The Taiya River estuary appears to be quite productive as is evidenced by the year.

Comments on Threats

Management Concerns

From intertidal communities

GLBA -- Negative impacts of spills/trampling cannot be accurately recognized, assessed, and effectively rehabilitated/restored without good information on the natural condition. The known range of natural variability is very broad, so long-term monitoring is essential if we hope to distinguish between that kind of variability and anthropogenic impacts. GLBA reports to GPRA Goal Ia1F (Land Health - Marine and Coastal) that might have relevance to this VS.

KLGO -- There's little info on KLGO's intertidal communities. Most are outside of the park's management jurisdiction although they are within the park boundary.

SITK -- Little is known about the intertidal community of the park. This zone comprises almost half of the park acreage. Monitoring the health of the intertidal zone is crucial in detecting impacts that might be occurring to theses critical park resources.

From point-source human

SITK -- The outfall from the fish processing plants in Sitka may be adding nutrient loading to the intertidal ecosystem.

From non-point-source human

SITK -- The park intertidal zone may be experiencing negative impacts from nonpoint pollution sources unknown to park managers.

From coastal/oceanographic

SITK -- Proposed developments such as a deep water dock for cruise ships to be built adjacent to the SITK boundary could alter shoreline processes including longshore drift and the deposition/erosional process. This could severely impact the park's intertidal zone.

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Have there been changes in the species composition of marine intertidal communities?
- Has there been a change in the biomass or productivity of marine intertidal communities?

Example of Measures

- Species composition of intertidal communities.
- Biomass of intertidal community components.
- Productivity of intertidal community components.

When picking what to monitor, consider cause and effect. Intertidal communities are resilient; they are subject to high disturbance. What is not changeable in the marine communities? What comes back quicker? What is the natural range of oscillation? What is the natural response and variability? If you know this, then if there is a natural or anthropogenic change that causes a disturbance outside the normal range, this would be important to detect and understand.

Possible Partners

Relevant Monitoring or Study

Comments

Greg - Ranked highest because of relative prevalence in park.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- Because of global recognition of oil spills as a major impact to marine communities, should have a specific question related to this potential cause of change in the marine environment. Need to have data on the status and trends of the communities before a spill event, to be able to assess effect of a spill on the environment. In response to the question: "Isn't this just doing inventory?" the response was: "Inventory becomes your first data point in a monitoring program." Need a physical model of what would happen in event of an oil spill. Use this modeling to select areas that are most susceptible to spill impact, and gather baseline data in those locations. Recent information shows that offshore weather in the Gulf of Alaska heads southward, then east through Icy Strait and north into GLBA. Organisms most likely to be impacted are those in contact with the sea surface (e.g., sea ducks) and those in contact with the intertidal zone.

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Wetland communities

SEAN VITAL SIGN
WETLAND COMMUNITIES

Justification

Threats

From wetland communities

GLBA -- Wetlands in the park provide important resting habitat for migratory waterfowl, notably cranes; and ground-nesting birds. Wetlands also support unique plant species. For example, the "poor fen" type wetland or open shrub and herb wetlands contain some rare plant species and also supports plant diversity that may be important. The relative scarcity of this habitat type in southeast Alaska, its low level of disturbance, and its easy access enhance these wetlands value for education and scientific study.

The preserve supports extremely concentrated ORV use during the commercial and subsistence fishing seasons. ORV access is through wetlands and adjacent shorelines that support a high density of nesting shore and seabirds and serves as a major migratory stopover for waterfowl and shorebirds. The preserve is also the sole take-out point for rafters floating the Tatshenshini-Alsek River corridor and receives international attention as part of a World Heritage Site.

Access road to Bartlett Cove passes through a variety of wetlands. Threats to both wetlands and fish habitat because of the poor road design and inadequate erosion control has been a concern to the park. There have been threats to the wetlands and salmonid spawning and rearing habitat from erosion and sedimentation problems in ditches and waterways adjacent to the entrance road.

KLGO -- Unlike most of SE AK, KLGO has a limited number of wetlands. Wetlands in the Dyea area may be drying and diminishing in area as a result of isostatic rebound.

SITK -- Most of the terrestrial area of the park is a form of wetland. Threats include change in climate (warming and drying), negative groundwater interactions from outside the park as the result of development, and building structures and increasing the breath of the trail system in the park as the result of park management decisions.

Comments on Threats

GLBA -- Clean Water Act, Executive Order 11990 ("Protection of Wetlands") and 11988 ("Floodplain Management").
GPRA Ia1C Land Health-Wetlands

Management Concerns

<u>From wetland communities</u>

GLBA -- Motorized use in support of commercial and subsistence fishing is authorized and occurs extensively in the park preserve. Routes and areas for ORV use have not been formally designated. The park needs accurate information regarding existing routes, sensitive wetlands, natural hydrological processes, and long-term monitoring. Management has concerns to wetlands adjacent to the park road. Best management practices to stabilize exposed soil, minimize erosion and sedimentation has continued and the park has made considerable progress.

KLGO -- Chytrid fungus has been detected in western toads in KLGO. This non-native aquatic fungus has been implicated in amphibian die-offs around the world. Need to collect info on the distribution of the pathogen in park wetlands. Wetlands contribute to the heterogeneity of habitats within the park and susceptible to human disturbances.

SITK -- Protecting wetlands in the park is a GPRA goal (Ia01C) and the NPS is directed to protect wetlands from Executive Order 11990.

Comments on Management Concerns

Monitoring Objectives

Understand short- and long-term changes in the physical, biological and chemical features of wetlands.

Monitoring Questions

- Are individual wetlands changing in size, hydrology, or species composition?
- Is the total area of wetlands in a park changing?

Example of Measures

- Land cover of wetland vegetation types.
- Hydrology of selected wetlands.
- Plant community composition of wetlands.

Possible Partners

Relevant Monitoring or Study

Comments

There is a GRPA goal addressing wetlands.

There is wetland damage from ORV use in Dry Bay.

Greg - but change is kind of slow to monitor

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- Hydrology drives vegetation if landscape doesn't interfere.
- Flow regime is a driver of riparian vegetation. Riparian vegetation is at the intersection of hydrology and the terrestrial environment.

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Fishes

SEAN VITAL SIGN
SALMONIDS

Justification

Threats

From fishes

GLBA -- Marine pollution may affect populations of marine fishes. Parasites and diseases from escaped farmed fish may affect wild populations. Exotic parasites and diseases originating from ship bilge/ballast water may spread to wild fish populations. Underwater sound from vessels may affect the distribution and behavior of marine fishes, with effects on marine mammals and seabirds. Sport harvest in small systems such as the Bartlett River may be occurring at too high a level for steelhead cutthroat trout and other small populations. Invasion of farm-escaped Atlantic salmon (one has already been caught in East Alsek river system). Natural ecosystem processes driven by uplift like in East Alsek River may have profound effects on local populations of salmonids and other fish. Sport harvest of largest individual marine fish may lead to decreasing fish size over time through natural selection and other forces. Remnant population of Dolly Varden trout upstream of the Falls Creek hydroelectric dam will be affected by the hydro plant.

KLGO -- Native Coho, pink and chum salmon occur in the Taiya River. Salmon runs are important for the park's black and brown bears. There are no hatcheries or human-made barriers to fish passage along the Taiya River.

SITK -- New regulations proposed by Alaska Department of Fish and Game would open the Indian River to salmon fishing, including subsistence and person take fishing. This means a daily harvest of as many as 50 pinks and 20 kings per person per day would be allowed depending on the type of fishery. Equipment that will be allowed for taking fish will include hook and line, gaff, purse seine, and dip net.

Comments on Threats

Management Concerns

From fishes

GLBA -- Threats to some fishes will affect T&E species and other at-risk biota with ecosystem wide effects. Sport fishery harvest levels are set by State ADFG so Park may not be able to control over harvest of small or vulnerable populations. GLBA

Commercial fishing closures in 1990s created rifts between the Park and many local residents. Increasing marketing of Icy Strait waters as a sport fishing haven may increase fishing effort in and near Park waters. Actual sport fishing effort in Park waters is difficult to document because ADFG statistical areas don't match up with Park administrative boundaries.

KLGO -- As glacial inputs to the Taiya River decrease through time, salmon population and nearshore fishes (herring spawn [Sitka], gunnels): relative abundance, distribution dynamics would be expected to alter. Proposals to build a very large fish hatchery in Skagway could negatively impact native fish populations in the Taiya River.

SITK -- Salmon populations may be considerably altered by the new proposed ADF&G fishing regulations on the Indian River.

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Has there been long term changes in the presence of salmon species in park streams?
- Has there been a long term change in the timing, reproduction, or numbers of returning salmon of each species in park streams?
- Has there been a change in the diet of salmon in park waters?
- How are juvenile salmon densities changing over time in the Indian River?

Example of Measures

- Presence/absence of salmon in park streams.
- Number of returning fish at selected park streams.
- Number of recruits per spawner, freshwater residence time, and body condition.
- Diet from stomach contents.
- Spring spawner numbers.
- If relevant, this can include monitoring of cutthroat or steelhead.
- Density, absolute and relative abundance, growth rates, and species compositions.

Possible Partners

Relevant Monitoring or Study

Comments

Some life history stages of salmon occur exclusively within a park.

For salmon, which life history stage are we talking about? Fry, smolt, adult, etc.? Are we separating the marine derived nutrients, which are primarily from salmon, versus any

other ecological effect from adult salmon in freshwater? Are salmon important for ecological or management reasons? Adult salmon are not that important for their ecological role in marine communities. Adult salmon may have a prominent role in freshwater, but that's mostly covered through marine derived nutrients (unless concern is behavioral response of predators moving in).

Landcover dynamics are not going to be that sensitive for adult salmon but would be for fry; the fry: smolt ratios, or fry weights or in-stream processes, for example, that may be influenced by overland or land cover management issues. So there are a number of management issues, depending on which life history stage of salmon are of concern.

GLBA may be more concerned about population dynamics. SITK may be concerned about water quality parameters, which may influence scour, which would influence egg production. Salmon rated highly for different reasons for each rater and each park.

The adult spawning numbers and behavior dramatically influence algae and the distribution and density of benthic macro invertebrates in the stream. Just from the amount of redds that they dig up and the amount of gravel that they move plays an important role.

Should we measure some of those effects, or should we measure marine-derived nutrients through isotopic signatures? There are differing issues based on which life history stage is being considered.

Hatchery is biggest issue for SITK; is the population in Indian River an induced run? ADFG does not do juvenile salmon counts, which we need as this is life stage when salmon is in the SITK park.

Scott -- I think population dynamics of adult salmon are a function of things outside the park and thus are not a useful indicator of park change. Juvenile salmon (fry:smolt ratios; survival or body mass) may be a better indicator

Parks Where Vital Sign will be Monitored

✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Fishes

SEAN VITAL SIGN
FORAGE FISHES

Justification

Threats

From fishes

GLBA -- Marine pollution may affect populations of marine fishes. Parasites and diseases from escaped farmed fish may affect wild populations. Exotic parasites and diseases originating from ship bilge/ballast water may spread to wild fish populations. Underwater sound from vessels may affect the distribution and behavior of marine fishes, with effects on marine mammals and seabirds. Weathervane scallop dredge fishery on GLBA outer coast may have negative effects on benthic and demersal fish. Over harvest of commercial and sport lingcod and rockfish may be occurring. Natural ecosystem processes driven by uplift like in East Alsek River may have profound effects on local populations of salmonids and other fish. Sport harvest of largest individual marine fish may lead to decreasing fish size over time through natural selection and other forces. Killing and mutilation of spiny dogfish by sport and commercial fishermen may have population level effects.

KLGO -- NA

SITK -- NA

Comments on Threats

GLBA -- From marine report: Are the composition, distribution or abundance of organisms within the apex trophic level of the pelagic (forage fishes) marine food web changing and, if so, how?

Management Concerns

From fishes

GLBA -- Threats to some fishes will affect T&E species and other at-risk biota with ecosystemwide effects. Sport fishery harvest levels are set by State ADFG so Park may not be able to control overharvest of small or vulnerable populations. Weathervane scallop harvest is managed by ADFG so park has limited control on its effects on fishes or other benthic inhabitants. GLBA Commercial fishing closures in 1990s created rifts

between the Park and many local residents. Increasing marketing of Icy Strait waters as a sportfishing haven may increase fishing effort in and near Park waters. Actual sportfishing effort in Park waters is difficult to document because ADFG statistical areas don't match up with Park administrative boundaries.

KLGO -- As glacial inputs to the Taiya River decrease through time, nearshore fishes (herring spawn [Sitka], gunnels): relative abundance, distribution dynamics would be expected to alter.

SITK -- NA

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Have there been changes in the distribution of forage fishes in park waters?
- Have there been changes in the species composition of forage fishes in park waters?
- Have there been changes in the population structure of forage fishes in park waters?

Example of Measures

- Distribution and abundance of forage fish species in park waters.
- Size or age structure of forage fish species in park waters.
- Changes in relative abundance of seabirds can serve as a proxy for forage fishes.

Possible Partners

Relevant Monitoring or Study

Comments

Lots of K-selected species feed on forage fishes. Marine mammal success may depend upon their health and abundance. It is hard to conceive of a protocol for measuring forage fishes; there are different groups with differing and unknown life histories. Presumably rated highly in some parks because euchalon run in rivers there. There are so many things that rely on the forage fish, they would provide some insight into what some of the top level predators are doing.

Greg -- A big deal at GLBA; only drawback is it is hard to monitor.

Scott -- would focus on anadromous species (eulachon etc. in KLGO) which are quite ephemeral in space and time.

Parks Where Vital Sign will be Monitored

✓ **GLBA**
✓ **KLGO**

Comments, Possible Partners or Threats from Scoping Workshops

Forage fish diet (stomach contents) could be an indirect measure of zooplankton.

- It was noted that forage fish and krill need to be a vital sign somewhere in this series of questions on productivity in order to capture nearshore information because most vital signs we listed focus on offshore.

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Amphibians and Reptiles

SEAN VITAL SIGN
WESTERN TOADS

Justification

Threats

From amphibians and reptiles

GLBA -- The vital sign of interest here is the western toad. Just as many amphibians are in deep trouble globally, toads are declining rather precipitously throughout their Alaskan range, and this decline appears to hold for the GLBA population. The causes are completely unknown (although chytrid fungus was just recently isolated from a toad in SE Alaska).

KLGO -- Western Toads have apparently declined in the park over the last 15-20 years based on anecdotal observations by park staff and local residents. Western toads are the only species of amphibian in the park.

SITK -- It is reported that the Sitka area once had a large boreal toad population. The species is now scarce in the region. The loss of this population could be an indication of habitat alteration, climate change, or some other anthropogenic agent.

Comments on Threats

Management Concerns

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Has there been a change in the local population size or distribution of the western toad?
- Has there been a change in the local reproductive rate of the western toad?
- How is amphibian distribution and abundance changing?

Example of Measures

- Number of documented breeding sites of western toads.
- Counts of adults, tadpoles, or egg masses.

Possible Partners

Relevant Monitoring or Study

Comments

This may be important. Toads are very sensitive to change, good indicators of change. But they're not controllers, toads could disappear and the ecosystem probably wouldn't change much.

Greg - great indicator, that's all.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**

Comments, Possible Partners or Threats from Scoping Workshops

- It is noted that there is anecdotal evidence to suggest a decline in the western toad, but there is no research or long-term monitoring data set to substantiate this.

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Birds

SEAN VITAL SIGN
MURRELETS

Justification

Kittlitz's murrelets are a candidate threatened and endangered (T&E) species and will be listed soon. They are a park management concern. They are the only rare species on the SEAN vital sign list. The protocol for monitoring them is different from other marine mammals or seabirds. Their population is dramatically declining and no one knows why; it may be a decline in their food, habitat or other. Half the global population is in GLBA. They are closely associated with tidewater glaciers, but no one knows why.

Threats

Comments on Threats

<u>From birds</u>

GLBA -- Kittlitz's murrelets mentioned specifically in Marine Workshop Report.

Management Concerns

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Has there been a long term change in the local population size of Kittlitz's murrelet?
- If so, why is kittlitz's murrelet population declining?
- Has there been a long term change in the nesting area or reproductive success of Kittlitz's murrelet?
- Has there been a long term change in the local distribution of Kittlitz's murrelet?
- Has there been a long term change in the diet of local Kittlitz's murrelet?
- Where do Kittlitz's murrelets nest, where are they foraging, what are they eating?
- Are Kittlitz's murrelets a 'mine canary'?

Example of Measures

- Distribution.
- Relative abundance.

- Nesting habitat.
- Breeding surveys.
- Diet, from stomach contents.

Possible Partners

Relevant Monitoring or Study

Piatt has population data.

Comments

The possibility of expanding this vital sign to include Marbled murrelets was discussed. Some researchers find it hard to distinguish between the two species when monitoring.

Parks Where Vital Sign will be Monitored
✓ **GLBA 1**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Birds

SEAN VITAL SIGN
BREEDING LANDBIRD POPULATIONS

Justification

Landbirds per se are not a good indicator of park health because they spend much time outside park, but reproductive success for those breeding in SEAN parks is a good indicator of park health. This is a '1st order' indicator – if a change is documented it alerts us that other types of investigations or monitoring is needed (e.g. decline in sparrows now attributed to decline in caterpillars).

Threats

From birds

GLBA -- Camper disturbance of nesting shorebirds in popular camping areas like the Beardslees may eventually have population level effects. Receding glaciers may reduce the abundance of periglacial species, such as the red-throated loon and Kittlitz's murrelet. Increasing landscape fragmentation may affect populations of terrestrial breeding birds. Poor understanding of how species composition and population of breeding birds are changing in parks, in response to local and global pressures.

KLGO -- KLGO has been monitoring breeding landbirds since 1995. Large numbers of migrating waterbirds pass through the park each spring and fall, stopping over in the Taiya River estuary. Harlequin ducks breed in the park.

SITK -- Neotropical, shore birds, and other migratory birds face many threats on their migratory routes, including habitat destruction, exposure to pollution and pesticides, storm events, and habitat fragmentation.

Comments on Threats

From birds

GLBA -- Terr Wksp Report: The breeding birds listed as "species of concern" are listed due to limited population size, or because their migratory route or breeding grounds brings them to places where they are at risk (e.g., the wandering tattler breeding habitat is in a zone that could be influenced by oil spills, putting breeding population at risk.)

Management Concerns

From birds

GLBA -- Five species of terrestrial birds in SE Alaska (Bald Eagle, Queen Charlotte Goshawk, Western Screech-Owl, Northern Saw-whet Owl, and Black Merlin) have been identified as being of high conservation concern at the continental level by Partners in Flight. All of these have been identified as high priority birds within Alaska and the nation (Boreal Partners in Flight 1999, U.S. Fish and Wildlife Service 2005). Concerns related to the availability of nesting habitat and suspected prey species have elevated Western Screech-Owl and Northern Saw-whet Owl as management issues at the state and national level. Blue grouse, red-breasted sapsucker, varied thrush, and Pacific slope flycatcher were also listed as being of concern at the continental level because large proportions of the global population of each breeds in SE Alaska. Birds on the parks' existing "species of concern" list: peregrine falcon (GLBA), blackpoll warbler (KLGO), golden eagle (KLGO), olive-sided flycatcher (KLGO), Queen Charlotte goshawk (GLBA), wandering tattler (KLGO) also continue to be of concern. Falls Creek hydroelectric project roads and recreational trails will increase access to "yellowlegs savannah" and other previously inaccessible bird habitats.

KLGO -- Habitat loss and the introduction of non-native species (e.g., starlings, pigeons) due to increasing human development may impact bird populations. Increasing numbers of corvids (crows, jays, ravens) have also been noted in association with expanding human developments. Corvid abundance is negatively correlated with song-bird reproductive success due to increased predation. There is a great deal of local interest in birds from the Skagway Bird Club members.

SITK -- SITK has a rich complement of neotropical migrants and resident passerines that breed and/or overwinter in the park. Monitoring records can be used to compare and be incorporated in regional and larger scale studies that evaluate the health of neotropical and other bird populations.

Comments on Management Concerns

From birds

GLBA -- Terrestrial birds info from BPIF letter to Tongass managers in winter 2006 (circulated by Meg Hahr).

Monitoring Objectives

Monitoring Questions

- Has there been a long term change in the number of local breeding land birds?
- Has there been a long term change in the local population sizes of breeding land birds?

- Has there been a long term change in the local reproductive success of land birds?

From scoping meetings:

- How are species composition and population of breeding birds changing in our parks, in response to local and global pressures?
- How is increasing landscape fragmentation affecting populations of breeding birds?

Example of Measures

- Relative abundance of encounters from breeding bird surveys.
- Capture-recapture results from banding program.
- Association of habitats.

When selecting species to monitor, consider species for which there is past data that are at edges of their range (e.g. Caspian terns at edge just moving in).

When selecting species to monitor, use guilds that represent different niches (seed eaters, insect eaters) to learn about the health of different communities for which they are dependent. They are proxies for the health of these different habitat types, and species for which they are prey depend upon them.

Data on plant communities (vital sign 32) is needed for protocol to monitor breeding land birds. This vital sign must be linked with the plant community's vital sign.

Possible Partners

Relevant Monitoring or Study

Kessel has habitat classification and protocol to use for breeding bird studies; use this.

Comments

This is of low importance for GLBA; high importance for SITK and KLGO.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- To select birds for vital signs, consider species with smaller habitats, nesting success, population status.
- There are well-established protocols for breeding songbirds in a statewide monitoring effort. KLGO participates in this program. The reason that breeding birds tend to be

monitored in parks is because they are impacted in the rest of their range, and their numbers can be measured in parks as an indicator of how they are faring globally.

- Note: Some species are at risk due to changes in the SEAN park(s) that affect their habitat. Others are at risk due to impacts outside of the park (or even outside of Alaska) that are not within park control.
- The breeding birds listed as "species of concern" are listed due to limited population size, or because their migratory route or breeding grounds brings them to places where they are at risk (e.g., the wandering tattler breeding habitat is in a zone that could be influenced by oil spills, putting breeding population at risk.)
- For breeding birds, use data from statewide breeding bird surveys. There are well-established protocols for breeding songbirds in a statewide monitoring effort. KLGO participated in this program.

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Birds

SEAN VITAL SIGN
BALD EAGLES

Justification

The public is quite interested in bald eagles. They are a charismatic watchable wildlife species. Until very recently they were a T&E species. There is decades of baseline data available. They are an abundant top predator. They may affect bird diversity. Monitoring distribution, relative abundance and breeding success is relatively easy to accomplish. Jacobson hypothesizes that Southeast Alaska is now at carrying capacity; things impacting their food and habitat would show up quickly in changed numbers or breeding success.

Threats

Comments on Threats

Management Concerns

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Has there been a long term change in the local population size of bald eagles?
- Has there been a long term change in the local reproductive success of bald eagles?
- Has there been a long term change in the local distribution of bald eagle breeding sites?

Example of Measures

- Distribution.
- Relative abundance.
- Successfully breeding pairs.
- Shoreline counts of active bald eagle nests.
- Occupancy of nesting territories.
- Census of bald eagle nesting success.
- Brood sizes, population productivity, eggshell thickness, contaminant concentrations.

Use USFWS protocols; boat or aerial surveys.

Bald eagles

Possible Partners

Relevant Monitoring or Study

Comments

Greg -- Major top predator; great integrator since preys broadly

Meg - Do have 3 nests in KLGO, one is active in 2006

Greg - Nests in SITK park; is good indicator and integrator; ranked lower than GLBA because park eagles at SITK are so influenced by circumstances outside of park.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Mammals

SEAN VITAL SIGN
BEARS

Justification

Bears are one of two signature animals for GLBA.

Threats

From mammals

GLBA -- Climate change may affect bear denning behavior and food supply.

KLGO -- Brown and black bears are present in the Park.

Comments on Threats

Management Concerns

From mammals

GLBA -- Bear distribution and abundance and behavior can be a human safety concern. Conversely, campers and boaters may disturb bears on shorelines.

KLGO -- Defense of life and property (DLP) killings of bears negatively impact population in the Park.

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Has the range of brown or black bears within a park changed?
- Has the size of brown or black bear populations within a park changed?
- Has the incidence or nature of human encounters with brown or black bears changed?

Example of Measures

- Distribution and density of brown and black bears.
- Records of human-bear encounters.

- Measure changes in density.

Possible Partners

Relevant Monitoring or Study

Comments

Bears are a K-selected species; they are a top level predator.
Are bears indicative of the health of the ecosystem? They are very important from a management perspective; they are a charismatic animal and 'watchable wildlife.' Bears hibernation habits may change as snow level and duration changes.

Greg -- common throughout; great integrator and well linked.

Scott -- population dynamics could be function of park specific processes; important ecologically in terrestrial community.

Greg -- bears common some places in park; see GB

Greg -- no bears

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Mammals

SEAN VITAL SIGN
HARBOR SEALS

Justification

There has been a major decline in SEAN harbor seal populations (we've lost 3000 since ___), they are a charismatic species, they are an important part of the upper trophic level food chain. We want to know different things about them than the data that will be gathered for the marine mammal and seabird vital sign, for harbor seals we want to know about haul-outs (location, use).

Threats

<u>From mammals</u>

GLBA -- The causes of the substantial decline in harbor seal numbers in Glacier Bay are unknown. "Determine if vessel wakes change the behavior of ... hauled-out pinnipeds, ... to determine the biological significance of these effects" (from VQOR-EIS).

KLGO -- Harbor seals are present in the park.

Comments on Threats

Management Concerns

<u>From mammals</u>

GLBA -- Harbor seal decline is of concern to Hoonah Tlingit tribe. Vessel traffic in harbor seal pupping and breeding habitat may disturb the seals at sensitive times in their life history. Native hunting of harbor seals outside the Park will have an effect on seal population inside the Park.

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- What is the distribution and relative abundance of harbor seals?
- Has the distribution of harbor seal feeding areas changed?
- Has the distribution or number of pupping sites changed?

- Have there been changes in the number of pups produced each year?
- Has there been a change in forage area selection?
- Has there been a change in mortality patterns?
- Has pup survival changed?
- What do harbor seal population trends tell us about the availability of forage food?

Example of Measures

- Distribution and relative abundance of harbor seals.
- Distribution and number of pupping sites.
- Counts of pupping success.
- Pup survival.
- Count how many pups are born on land and how many are born on ice.

Possible Partners

Relevant Monitoring or Study

Comments

Greg -- Seals: what are they trying to tell us?

Dan -- Monitoring harbor seal population may reveal change, but cause may be changes to physical environment; monitoring of glacier extent, marine water quality, iceberg discharge, etc., may prove useful to understand.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Mammals

SEAN VITAL SIGN
UNGULATES

Justification

Moose and goats are the two primary species of interest. They affect the structure of the food base, they are landscape transformers. Moose are a large, charismatic species in GLBA. Most of their range is in the park, a small part is out of the part which is where they are heavily harvested. Park managers will continue to need to know about moose hunting and the impact on the population and ranges even if that activity occurs outside the park. Vegetative communities are linked to moose.

Threats

<u>From mammals</u>

GLBA -- Moose hunting outside the park, managed by ADFG, will affect populations inside the Park.

KLGO -- Mountain goats and, more recently, moose are present in the Park.

Comments on Threats

Management Concerns

<u>From mammals</u>

GLBA -- Moose hunting outside the park, managed by ADFG, will affect populations inside the Park.

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

• What is the effect of hunting during the rutting season on moose populations and disbursement?

Example of Measures

- Distribution
- Relative abundance
- Use and extend ADFG mensuration techniques.
- Use BLM baseline data and techniques for goats at KLGO.
- Don't want to collar moose.

Possible Partners

Relevant Monitoring or Study

Comments

GLBA added this for consideration, but on May 3-4 we eliminated moose. Did we decide to eliminate herbivores as a VS?

Without moose willows would dominate; moose make a difference in plant community successional trajectories.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Mammals

SEAN VITAL SIGN
KILLER WHALES

Justification

Killer whales are a top predator. They feed on other marine life (seals, salmon), and are an indicator about the marine species they feed on. Killer whales are a K-selected species.

Threats

From mammals

GLBA -- Bioaccumulation of marine contaminants may affect health of apex predators like the killer whale. Killer whales are at risk of lethal or serious injury from entanglement with sport or commercial fishing gear. "Determine if vessel wakes change the behavior or whales ... to determine the biological significance of these effects" (from VQOR-EIS).

Comments on Threats

Management Concerns

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Has the distribution and number of transient and resident killer whales using park waters changed?
- Has the diet of transient and resident killer whales using park waters changed?

Example of Measures

• Relative abundance.
• Distribution.
• Reproductive rate.
• Type and level of contaminants.
• Location of killer whale sightings.
• Diet from feeding observations.

Possible Partners

Relevant Monitoring or Study

Comments

Parks Where Vital Sign will be Monitored
✓ **GLBA**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Biological Integrity
EMF Level 2 - Focal Species or Communities
EMF Level 3 - Terrestrial complex

SEAN VITAL SIGN
BIODIVERSITY OF SELECT GROUPS OR ASSEMBLAGES

Justification

Indices of species richness can be a good indicator of ecosystem health. One of the National Park Service's duties is to protect biodiversity.

Threats

From terrestrial complex

GLBA -- Vital sign of interest here is biological diversity. Connectivity. Species dispersal.

Comments on Threats

Management Concerns

From terrestrial complex

GLBA -- Management's major concern is maintaining biological diversity in the Park. The key is to concentrate on protecting the most sensitive components of the terrestrial complex. In addition, connectivity between ecosystems is also essential. Despite uncertainty (global warming; major ecological disturbance; species decline.)

Comments on Management Concerns

Monitoring Objectives

Understand trends in biodiversity.

We want to know what certain cohorts are doing; for example, what is happening with the GLBA shallow subtidal community (Bodkin's crew's work)?

Monitoring Questions

- Is species richness or diversity of major plant or animal groups changing?
- Is the genetic variability of key populations or species changing?
- Is the genetic structure of key metapopulations changing?

From scoping meetings:

- What are the trends in biodiversity at a variety of organizational levels (e.g., species diversity, genetic diversity)?

Example of Measures

- Species Richness, indices of select communities (monitoring the 'middle' of the range)
- Indices of biodiversity.
- Indices of genetic variation of key groups.
- Metapopulation dynamics.
- When selecting assemblages to monitor, consider including some that are: 1) 'mine canaries' throughout the ecosystem and monitor them for relative abundance at both ends of the range (e.g., in KLGO this could be pica, arctic ground squirrels and other animals at the edge of their range); 2) at the southern and northern end of their range that are moving in or out (e.g. red cedar).

Set up an index of species richness; need a standardized effort, every 'x' number of years. (Can do this by keeping a good species list.)

Possible Partners

Relevant Monitoring or Study

Comments

From May 18-19 meeting summary:

Are 'select' and 'diversity' oxymoronic?
We have 3 or 4 assemblages on our vital sign list; consider measuring species richness for those. This focuses on the 'obvious' ones. One scientist raises a question about whether we should also be measuring some of the 'non-obvious' ones? Southeast's island biogeography may confound things, or, conversely may help determine what we monitor. It is noted that the marine ecosystem is not bound to island biographic parameters, it is an open system.

From May 2-4 Attachment A:

This is so broad, what do we measure? Depending on the scale, you measure a carefully selected list or area(s) for number of species, species density, species richness, species evenness. Classically you measure immigration and extinction rates. Can look at metapopulations and genetic diversity.
Biological inventories have value.
The diversity of organisms is indicative of change.
Biodiversity at its simplest is species richness over time.

Biodiversity may fail at times to capture/indicate change and ecosystem health (e.g., Robinson work in Midwest on migratory birds – no change to species richness and diversity over 15 years but reproductive success plummeted due to edge predators moving in). Are we capturing the right process? If this remains a selected vital sign we must be convinced that there is a good way to measure it. Ecosystem-wide biodiversity is a good 'umbrella' vital signs, many other vital signs can fit 'under' it, such as subtidal communities. Is how biodiversity changes something that is useful to know?
Should biodiversity of animals be included, or only plants?
Scale is a factor in what to measure, for example may be able to assess species richness in Sitka because area is small.
Pick an area carefully then identify a suite of species (plants, animals or birds) to monitor; determine which community if monitored will help us to understand change.

Greg - biodiversity is a key index of insularity

Scott - just not sure how to monitor this in a useful way.

Sara - I can see getting at this for plant biodiversity, but would we actually measure faunal biodiversity? Of all animal species? Seems beyond our reach.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

EMF Level 1 - Biological Integrity
EMF Level 2 - At-risk Biota
EMF Level 3 - T&E species and communities

SEAN VITAL SIGN
STELLER SEA LIONS

Justification

They are top level carnivores, long-lived, easy to observe, and easy to enumerate. They're relative abundance and distribution is indicative of underwater conditions and informs about vessel disturbance.

Threats

From T&E species

GLBA -- Steller sea lions are at risk of mortality and serious injury from entanglement in sport and commercial fishing gear. Steller sea lions are at risk of behavioral disturbance from close approaches by tour vessels to South Marble Island haulout sites. Climate change and its effects on the marine ecosystem will have unknown effects on Steller sea lions. Steller sea lions travel outside Park boundaries where they are subject to a variety of other threats.

KLGO – NA

SITK -- NA

Comments on Threats

Management Concerns

From T&E species

GLBA -- The number of Steller sea lions from the endangered Western stock that uses Glacier Bay waters needs to be tracked in order to determine the extent that GBNP management policies have on that population.

KLGO -- NA

SITK -- NA

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Is the number of steller sea lions using park waters changing?
- Is the seasonality of steller sea lions use of park waters changing?
- Has there been a change in the location of areas used by stellar sea lions for feeding, breeding or haulouts?
- Is the age structure of stellar sea lions in park waters changing?

Example of Measures

- Relative abundance.
- Distribution.
- Reproductive rate.
- Type and level of contaminants.
- Location of areas used by stellar sea lions for feeding, breeding or haulouts.
- Counts of adults and young at haul-outs.

Possible Partners

Relevant Monitoring or Study

Comments

Parks Where Vital Sign will be Monitored
✓ **GLBA**

Comments, Possible Partners or Threats from Scoping Workshops

At risk biota- Sea lion in GLBA?

EMF Level 1 - Biological Integrity
EMF Level 2 - At-risk Biota
EMF Level 3 - T&E species and communities

SEAN VITAL SIGN
HUMPBACK WHALES

Justification

Humpback whales are an endangered species, a charismatic 'watchable wildlife' species, popular with the public, and of concern to park management. Humpback whales are one of two signature animals for GLBA. The number of Humpback whales in GLBA has tripled in the last five years and because they are huge mammals that eat large quantities of food their impact on the ecosystem has also increased. More needs top be know about their distribution and ecological impact.

Threats

<u>From mammals</u>

GLBA -- "Determine if vessel wakes change the behavior or whales ... to determine the biological significance of these effects" (from VQOR-EIS).

<u>From T&E species</u>

GLBA -- Humpback whales are at risk of fatal or injurious vessel collisions within the Park and outside of it. Humpback whales are at risk of behavioral disturbance and temporary or permanent hearing loss due to acute or chronic exposure to vessel noise. Humpback whales are at risk of mortality and serious injury from entanglement in sport and commercial fishing gear. Climate change and its effects on the marine ecosystem will have unknown effects on humpback whales. Humpback whales travel outside Park boundaries where they are subject to a variety of other threats.

KLGO – NA

SITK -- NA

Comments on Threats

Management Concerns

<u>From T&E species</u>

GLBA -- Vessel management actions including cruise ship numbers, whale waters areas, and baywide cruise ship speed limits are made routinely and need to be based on sound,

objective criteria. Pressure to increase cruise ship traffic can result in increases regardless of scientific justifications. Pressure to open Bartlett Cove to all traffic, not subject to vessel permit limits would negatively affect the many whales that use Bartlett Cove. Vessel and fishery management outside the park (or the lack thereof) affects whales that also use Park waters. Humpback whales are one of the prime charismatic species that visitors come to see in GLBA, so negative effects on humpbacks will diminish visitor experience.

KLGO -- NA

SITK -- NA

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Is the number of humpback whales using park waters changing?
- Is the seasonality of humpback whale use of park waters changing?
- Has there been a change in the location of feeding areas used by humpback whales?
- Is the age structure of humpback whales in park waters changing?
- Is the diet of humpback whales in park waters changing?
- What is the duration of residency of whales in GLBA?

Example of Measures

- Locations and dates of individual whale sightings.
- Ages of individual whales.
- Diet from feeding observations and deciduous epidermis.
- Duration of residency
- Reproductive success
- Mortality (from direct observation)

Possible Partners

Relevant Monitoring or Study

Comments

Greg -- Not a controller, not a great linker

Scott -- Population dynamics and feeding drives sightings of humpback whales; how much do park specific processes influence population dynamics? Distribution mostly management concern…

Parks Where Vital Sign will be Monitored
✓ **GLBA**

Comments, Possible Partners or Threats from Scoping Workshops

- Humpback whales are increasing in abundance.

EMF Level 1 - Human Use
EMF Level 2 - Consumptive Use
EMF Level 3 - Consumptive Use

SEAN VITAL SIGN
CONSUMPTIVE USE

Justification

A huge but currently unquantified amount of biomass is being removed annually from park ecosystems through commercial and sport harvest of all types of fish and marine life, birds, animals and plants.

Threats

From consumptive use

GLBA -- GLBA Preserve - sport and subsistence hunting, fishing, and trapping is allowed. Commercial Fishing (outer coast, Dry Bay). Sport Fishing.

KLGO -- Hunting, fishing and trapping are all allowed within the park.

SITK -- NA

Comments on Threats

Management Concerns

From consumptive use

GLBA -- Lack of info on populations of species of traditional/cultural concerns: Bear, Mountain goats, and glaucous-winged gull.

KLGO -- Black and brown bear, beaver, marten, wolf, wolverine, mountain goat, moose, salmon?, dolly varden char. Hunting appears to be limiting ability of some species to colonize the park - especially moose and deer. May significantly lower population levels of fur-bearers as well. Limited info.

SITK – NA

Comments on Management Concerns

Monitoring Objectives

Consumptive use

Understand if human consumption of natural resources is adversely affecting SEAN ecosystem components.

Monitoring Questions

From migratory bird and egg harvest

- Have there been changes in the number of eggs and birds harvested in SEAN parks.

From commercial harvest of fish and invertebrates

- How are the numbers of commercially harvested marine organisms changing?
- How are the sizes of commercially harvested organisms changing?
- How is the bycatch of commercial harvest changing?

From moose, marten, bear harvest

- How are the numbers and sizes of harvested moose, marten and bear changing in and near SEAN parks?

From scoping meetings

- Are the current levels of resource harvest sustainable?
- What are the levels of consumptive use, both within and adjacent to the parks?
- Are the levels and patterns of consumptive use changing, both within and adjacent to the park?
- How do populations change in the absence of harvest?
- What is the movement of harvested species in and out of the parks?

Example of Measures

- Type and amount (numbers, weight) of what is being caught, hunted, harvested or gathered.
- Date that it was taken.

From migratory bird and egg harvest

- Counts of harvested eggs and birds.

From commercial harvest of fish and invertebrates

- Estimates of numbers, sizes, and bycatch from harvest reports and sample inspections

From moose, marten and bear harvest

- Counts and size of harvested animals.
- Do not need a region-wide sampling effort; do a directed sampling effort in focused areas.

Possible Partners

Relevant Monitoring or Study

Comments

Crab pot lines are thought to be a major source of whale entanglement.

From commercial harvest of fish and invertebrates

Greg - Not a useful indicator of ecological conditions

Scott - Mostly for intrusive or degrading practices such as dredge fishery or weathervane scallop fishery

Sara - I think commercial and sport harvest of fish should be a single vital sign

From moose, marten and bear harvest

Greg - Not a good indicator; driven by politics and harvest philosophy as much as ecology

Greg - Not enough harvest

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**

Comments, Possible Partners or Threats from Scoping Workshops

- Need to consider what consumption of marine resources is occurring outside of the SEAN parks and how that consumption is affecting marine resources in the parks.
- ADFG data source for commercial and sport harvest data.
- Want quantity of sport and commercial harvest, population trends, age and size structure and numbers.
- How do we obtain bycatch data? May not be able to get that data from ADFG. This is very important, and for some species is more important than data on the harvested species. Don't discount sport (charter) fish harvest. Data so far shows that non-charter sport fishing in marine waters is pretty minimal in GLBA, with the exception

of Dungeness crab in Bartlett Cove. Note, however, that the recreation use could continue to grow and become more important.

- Marine mammal data sources: USFWS otter; NOAA harbor seals.
- Regional numbers and scale are important.
- Dry Bay - leave to ADF&G
- ADF&G good partner, source for harvest data.
- Use ADFG harvest data; ADFG and NPS data re: defense of life & property kills (bear); State fish and wildlife population data

EMF Level 1 - Human Use
EMF Level 2 - Visitor and Recreation Use
EMF Level 3 - Visitor usage

SEAN VITAL SIGN
HUMAN USES AND MODE OF ACCESS

Justification

One of the purposes of the monitoring program is to detect change in the health of park resources, and to determine whether that change is caused by anthropogenic or natural processes. Human use and mode of access is a primary and fundamental dataset against which change detection will be evaluated to determine whether it is induced by anthropogenic means.

The demand for a variety of human uses and access to SEAN parks is expected to increase over time.

Need data on all human users - all types of visitors; researchers; fishers, harvesters, and gatherers; and others.

Threats

<u>From visitor usage</u>

GLBA -- Threats from visitor usage are the increasing numbers of visitors on private and commercial vessel trips, backcountry visitors, kayak drop-offs, camp sites, pollutants, vessel wastewater discharges, and vegetation impacts. Increasing visitation is not under the direct control of Park managers despite planning processes (e.g. VQOR-EIS) due to political pressure from outside sources, as well as legal mandates arising from conveyance of Native allotments inside Park boundaries.

KLGO -- 3,000 people a year hike the entire Chilkoot Trail. Thousands more day hike along the lower portion of the trail each summer. 400,000 travel through the White Pass unit via the WP&YR. Several commercial operators (horse, bike, raft, hike) bring thousands into the Dyea area each summer. Visitation is high in the Dyea/Chilkoot Trail unit. 950,000 visitors to the Skagway Unit.

SITK -- SITK averages about 300,000 visitors a year that utilize just 50 acres of terrestrial habitat and 50 acres of intertidal zone. This concentrated use has the potential to degrade park habitats over time.

Human uses and mode of access

From terrestrial complex

KLGO -- Habitat fragmentation is a threat to the terrestrial complex.

From point-source human

GLBA -- Light pollution from NPS structures affects the night sky and may attract birds and moths. Campers may be a source of pollution. Marine debris from vessels is a source of pollution that can be ingested by marine animals or litter the beaches.

From non-point source human

GLBA -- Non-point source human impacts can include increasing numbers of backcountry visitors, kayak drop-offs, and camp sites.

KLGO -- Impacts from visitors in backcountry areas of the park. Surrounding land uses and development.

From coastal/oceanographic

SITK -- Human alterations and activity can alter the shoreline processes that would have direct and indirect effects on the SITK's intertidal zone.

From Threats in Access, when we were considering "estuarine communities" as a vital sign:

SITK -- Human-altered stream bed dynamics, floods, and a degraded stream ecosystem could negatively influence the estuary of the park where freshwater interacts with the ocean tidal cycle.

Comments on Threats

Management Concerns

From visitor usage

GLBA -- Development and use of native allotments adds to this threat because of legal mandates for providing access to inholdings and these are wild cards so it is difficult to predict what will happen. Along with air and water pollution, vessel based visitation has the potential to disturb marine and terrestrial wildlife, as well as threaten them with collision. Vegetation impacts and disturbance of shore-nesting birds will occur from camping.

Human uses and mode of access

KLGO -- KLGO is preparing a VERP for Dyea. Plans to increase visitation to backcountry, undisturbed areas of White Pass Unit. Visitation along Chilkoot Trail is controlled by Parks Canada limit of 50 hikers/day but increases are possible in shoulder season. Helicopter overflights also an issue.

SITK -- Little is known about the impacts SITK's concentrated visitation (300,000/yr) is having on park habitats.

From terrestrial complex

KLGO -- Development outside of the park could alter habitat connectivity, metapopulation dynamics, edge effects, migration/travel corridors, and mortality factors.

From point-source human

GLBA -- Concern related to point source light (see also noise concerns under soundscape) relates to primarily to degradation of visitor experience and preservation of wilderness values. There are also potential impacts to other wildlife. Marine debris on beaches as well as carcasses of animals that died from marine debris encounters will diminish visitor experience.

From non-point source human

GLBA -- Major management concerns with walk-in campground at Barlett Cove that provides land-based overnight accommodations.

From coastal/oceanographic

KLGO -- Increased development within the Taiya River watershed and recreational activities on the Dyea Flats could affect coastal processes and associated biota.

SITK -- Proposed developments such as a deep water dock for cruise ships to be built adjacent to the SITK boundary could alter shoreline processes including longshore drift and the deposition/erosional process. This could severely impact the park's intertidal zone.

From groundwater dynamics

SITK -- Human activities outside the park could have drastic impacts on the groundwater dynamics within the park.

From Management Concerns in Access, when we were considering “estuarine communities” as a vital sign:

KLGO -- The Taiya River estuary is one of a limited number of estuaries where eulachon breed in SE AK. Anything that impacts the estuary or its marine and riverine influences is a management concern for KLGO.

SITK -- A healthy estuary depends on a healthy and unaltered river system and its interaction with the ocean. Alterations in the stream channel and the banks outside and inside the park have caused drastic chances in erosion, flow, and other dynamics of the Indian River estuarine area.

Comments on Management Concerns

Monitoring Objectives

- Understand how park and preserve ecosystems are affected by local and regional human use (visitor, recreation and park research/ administrative activities).
- Understand how park and preserve ecosystems are affected by both point and non-point source activities.

Monitoring Questions

- How is the number of visitors changing in SEAN parks?
- How is the type of visitor use, timing of visits, and areas of use changing in SEAN parks?
- How are visitors accessing SEAN parks and where are modes of access changing?

<u>From scoping meetings</u>:

- How are human use numbers and activities changing and which resources are at risk?
- What are the frequency, distribution and intensity of fires? (KLGO)
- How is the type and volume of marine debris changing on park beaches?
- How frequently do seabird and marine mammal mortalities relate to ingestion of or entanglement in marine debris?

<u>From camp sites and drop-off points</u>

- Has there been a change in the frequency or intensity of use of camp sites and drop-off points?
- Has there been a change in the soil, vegetation, water quality or debris near frequently used camp sites and drop-off points?

Example of Measures

Need to do a comprehensive analysis on all uses and means of access.
Use data is already being collected. Measures include:

- Counts or estimates of different types of visitors.
- Counts of visitors at different entry points.
- Logs of park activities by park personnel, contractors, or researchers.
- Group size
- Area user is going
- Number, size, and type of transportation device (e.g. one 32' fishing vessel, four single kayaks, one 1000 foot cruise ship, one ATV, one 24' research vessel, one 4-seat floatplane, two Bell helicopters, etc.)
- Route to destination(s)
- Condition of route, if applicable
- Length of stay at each destination
- Miles of trails
- Need data on admin. & research vessels (data gap)

<u>From camp sites and drop-off points</u>

- Need number using camp sites and drop-off points
- Need surveys of soil compaction (% bare soil) and debris near camp sites and drop-off points

Possible Partners

Relevant Monitoring or Study

NPS job is to collect and analyze existing data.

Comments

ANILCA opened up floatplane landings in the parks; floatplanes require an entry permit in GLBA.

<u>From camp sites and drop-off points</u>

Greg - Camping pervasive enough that sites begin to become ecologically consequential; not so for KLGO

Scott -- may be more important for trampling etc on trail; unknown impacts on wildlife.

<u>From boating impacts</u>

GLBA is always going to be accessed by boats (cruise ships, private vessels, tour boats, kayaks). We don't know exactly what and where the impacts will be, especially since they are getting cleaner - could be hydrocarbons will become less a concern. Could be related sport fishing, or where they moor and what is disturbed, or lack of treated sewage? We should monitor the level of boating impact relative to the type of boats and what the potential impacts would be.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

Should permanent vessel moorings in GLBA be considered a point source? Park gets considerable pressure to install them. Other point sources could include discharge outfalls (e.g., wastewater treatment, fish processing plant).

- Could use a simple, relatively inexpensive protocol for monitoring beach debris, search for one in use at another location. Directly describes a Park management value.
- Annual survey, beach debris collection at natural collection areas, visitor survey cards, opportunistic observer opportunities.
- NMFS (and NPS GLBA for lower GB proper) old marine debris study on the outer coast.

- These are essential questions. Link to the results of ecological monitoring.
- Need to monitor disturbance levels and indicators, with links to demographic information.
- Sitka impact -- intertidal trampling.
- Issue: disturbance and displacement of marine mammals and birds (impacts nesting, rearing, molting).

- It was noted that the CAKN vital signs for this objective (how park resources are affected by non-point source human effects) are related to tracking the population of gateway and adjacent communities (e.g., Gustavus, Yakutat, Haines, Skagway, Sitka).
- Non-point source human effects are more important than point-source human effects.
- Use park data characterizing users; special use permits; administrative permits, concessionaire data.
- Monitor the human use that's causing the change AND monitor the monitoring resources potentially affected - conduct a paired study.
- One group talked a lot about whether wilderness was or was not included. A scientist shared that he attended a kayak symposium in Juneau about 10 years ago where, due to human impact on animals, Donald Lawrence proposed a system of anchored barges be used for overnights instead of camping onshore. This would lesson impacts to vegetation and wildlife including bear problems. He ventured that he had never spent a night onshore as a researcher on GLBA. When asked to show hands for those that would be willing to spend the night on an anchored barge during trips to GLBA, 5 out of 50 said yes. This suggested it is all about wilderness, not animals.

Human uses and mode of access

- This is an issue for KLGO: historically, fire is a major organizing feature of the KLGO ecosystem. Over the last 200 years, the entire KLGO system has burned, except for a few gulches and above 2,000 feet elevation. Also a factor in SITK.
- Discussion of whether fire suppression has had an impact on plant succession. This is a research question (KLGO is looking into this via repeat aerial photography), not a monitoring question for vital signs.

EMF Level 1 - Landscapes (Ecosystem Pattern and Processes)
EMF Level 2 - Landscape dynamics
EMF Level 3 - Land cover and use

SEAN VITAL SIGN
PLANT COMMUNITIES

Justification

Threats

From vegetation complex

GLBA -- The vital signs of interest here are rare vascular and non-vascular plants (per the ANHP list), along with general ecosystem-wide plant biodiversity. We are presently unaware of declines/changes in any of these (but we haven't really looked, either).

KLGO -- Due to its geographic position and unique climate, KLGO has a very diverse vascular and non-vascular flora. Lichen inventory will be conducted in 2007.

SITK – NA

From "sparsely vegetated"

GLBA -- The VS of interest here (for GLBA) is periglacial barrens (and the species that depend on them). This community type will almost certainly decline as low-elevation glaciers "ground out" and cease or slow their retreats. These young communities will cease to be exposed/produced as rapidly as natural plant succession proceeds, such that the communities will succeed to older communities having different habitat conditions that are less suitable to specialized species such as Kittlitz's murrelets and red-throated loons.

KLGO -- NA

SITK -- NA

From grassland/herbaceous

GLBA -- Loss of grasslands and herbaceous communities. Invasive species, recreation activities (camping); global warming; disease
SITK -- NA

KLGO -- Beach meadows and uplifted tidelands on the Dyea Flats are a unique habitat and limited type within KLGO. Several species of passerines breed in these meadows. Small mammals likely occur here in some abundance, attracting coyotes and raptors.

SITK -- NA

From forest/woodland

GLBA -- No response given.

KLGO -- Deciduous riparian forest is a habitat type that is considered limited in Southeast Alaska. Due to an active floodplain and frequent flooding (as well as periodic catastrophic glacial lake outburst floods), the Taiya Valley has extensive deciduous riparian forests (black cottonwood - Sitka spruce). This habitat is important for several species of breeding landbirds.

SITK -- NA

From non-point source human

GLBA -- Vegetation impacts could result from non-point source human activities.

From Threats in Access, when we were considering "estuarine communities" as a vital sign:

GLBA -- The potential VS of interest here is eelgrass beds. Eelgrass is rare in G.B. proper, and the most likely threat here is petroleum spills.

Comments on Threats

Management Concerns

From vegetation complex

GLBA -- Rare plants, because they may be already "living on the edge" (that's why they're rare), may be sensitive indicators of environmental change. Therefore, it is important to understand the status of their populations, and to monitor trends in their distribution/relative abundance. Currently we have virtually no information on status or trends. We do have a good baseline for basic vascular plant biodiversity (species richness) courtesy of the Vascular Plants Biological Inventory, but no plans to monitor it. GLBA's enabling legislation strongly suggests that long-term monitoring may be appropriate because it recognizes the value of studying changing vegetation associated with glacial retreat and landscape development. GLBA reports to the following GPRA Goals that might have relevance to this VS: Ia01C (Land Health - Wetlands), Ia1D (Land Health - Riparian), Ia1E (Land Health - Upland), and Ia02B (Other Species of Concern, without park mgmt. objectives).

KLGO -- Changing climate, invasive species, herbivore immigrations, and air pollutants may have significant effects on park flora. Species richness and rare species may be altered by these changing drivers.

SITK -- NA

From "sparsely vegetated"

GLBA -- This process of landscape evolution is in this case natural, predictable, and inevitable. The big issues for management are 1) ensuring that the drivers are indeed natural ones (not anthropogenic), and 2) accepting the potential loss of some obligate species (or at least substantial declines in local abundance) or, alternatively, taking management action to preserve diversity/relative abundance potentially through active habitat manipulation. GLBA reports to GPRA Goal Ia1E (Land Health - Upland) that might have relevance to this VS.

KLGO – NA

SITK -- NA

From grassland/herbaceous

GLBA -- Increasing abundance and distribution of invasive species. Lack of baseline information addressing "current condition" and predicting "future condition". Lack of inventory data (species of management concern Where are they? Populations? Natural versus anthropogenic causes. Lack of info to detect external and internal threats. Identifying minimum and maximum ranges of variability. Can we do this? Modeling efforts. What steps do we need to take to more effectively protect the grassland/herbaceous communities from external and internal threats.

KLGO -- Impacts to beach meadows from OHV use. Removal of driftwood for firewood. Invasive species.

SITK -- NA

From forest/woodland
GLBA -- No response for forest woodland.

KLGO -- As glaciers retreat and floodplain dynamics change through time, large-scale disturbance patterns in the Taiya River floodplain may be altered. The cottonwood forest is gradually succeeding to Sitka spruce and over time, habitat suitability for deciduous riparian forest associated species may decrease.

SITK -- NA

From Management Concerns in Access, when we were considering “estuarine communities” as a vital sign:

GLBA -- Eelgrass is known to be important to certain invertebrates and fishes as preferred nursery/rearing habitat. This community type is relatively rare in GLBA.

Plant communities

Distribution and eelgrass patch dynamics are poorly known within the park. GLBA reports to GPRA Goal Ia1F (Land Health - Marine and Coastal) that might have relevance to this VS.

Comments on Management Concerns

Monitoring Objectives

To understand the range and variation of select plant communities in response to natural disturbance, so we can distinguish anthropogenic induced disturbance.

Monitoring Questions

- How is vegetation type, stand structure and composition changing across the landscape over time, in response to changes in landscape/terrain?

Example of Measures

- Plant composition and structure for select areas or assemblages. (What is there, how much is there, where is it)
- Measure biodiversity - specifically species types and densities, evenness of diversity and how this changes
- Age and size structure of woody plants in selected vegetation types
- Species composition of selected vegetation types (e.g., riparian vegetation, yellow cedar, or similar old growth community)
- Rare vascular and non-vascular plants

<u>From deciduous riparian forests</u>

- Species composition in permanent plots or along transects.
- Tree sizes or ages from permanent plots or along transects.

<u>From pro-glacial barrens at risk</u>

- Plant species composition of pro-glacial barrens communities
- Animal species using pro-glacial barren communities

<u>From rare vascular/non-vascular plants</u>

- Census results for target species
- Measures of encroachment on known populations of target species.

<u>From floodplain dynamics</u>

- Floodplain (including riparian) vegetation maps.

From eelgrass beds

- Location of eelgrass beds.
- Spatial extent of eelgrass beds.
- Density and biomass of eelgrass beds.

From yellow cedar

- Land cover of yellow cedar forest types.
- Tree density in yellow cedar stands.
- Growth rate of yellow cedar trees.
- Rates of mortality and recruitment.

Consider mapping at Dry Bay, Bartlett Cove, Falls Creek.
Focal types may include pro-glacial barrens, eelgrass.

When designing protocol and working on sampling design, think about selecting plots that: 1) could capture exotic plant data, 2) are communities prone to invasion, 3) include "training plots," 4) are areas that need to be ground-truthed to improve land cover maps, 5) are where change is expected, and 6) include some permanent and some temporary plots.

Plant succession is occurring at the same time that other change is occurring, which confounds our understanding. Change we observe may or may not be induced by natural causes. To help sort this out, pick some plots that are likely to change and some that are not likely to change to sample.

The landcover map tells you where to go, and then plant community investigations and mapping are needed to ground truth and provide detail.

There are linkages among this vital sign (plant communities) and biodiversity, invasive plants, phenology, herbivores. Keep this in mind during protocol development; this may be a case where we can do many things with one protocol.

Possible Partners

Relevant Monitoring or Study

KLGO has 24 plots where they measure breeding birds every year; their protocol may include some of the measures listed here.

Comments

This vital sign is like a tool to get information about other vital signs.

Plant community and structure is a more detailed, dynamic, smaller scale analysis than

land cover and land use. It includes community changes over time, mortality, recruitment, and other things that are lost in a land cover map. Plant community and structure analysis in select plots or areas might be done to ground truth land cover maps, to focus on areas where we suspect we will detect change, or to lengthen the baseline by redoing areas done 10-20 years ago. Identify community types or areas where we would focus this work. What are the specific environments where plant composition is critical as an indicator of change (alpine? pro-glacial barrens? wetlands? forest fuels in areas w/ fires?) All three of the other park networks rated this highly. Setting up permanent plots that you monitor long term is a hugely important dataset to detect change and as an indictor of forest health.

To check effects of global warming, make a list of all the species in the park and look at their ranges, say which communities have the largest share at the southern margins of their range. Then figure out protocol for watching maybe one or two of those communities. But, unless you define what changing phenomenon you are trying to catch, it's a 'pig in a poke,' extremely general question.

It is noted that lichens are a food source for many animals.
Non-vascular plants are important in SITK, their diversity could be a vital sign.
Nutrients are released when soils are disturbed.

<u>From plant communities</u>

Scott -- Natural vegetation changes in Sitka may be much lower than changes in GLBA, so differences in sensitivity as such, IF we aren't including invasive plants.

<u>From rare vascular/non-vascular plants</u>

Greg -- Rare vascular/non-vascular plants are a great indicator, but ecologically minor.

<u>From eelgrass beds</u>

May be a good indicator of change for SITK

<u>From yellow cedar</u>

Yellow cedar is typical of late successional communities, systems that are more at risk. It may be a 'mine canary' for older systems. Or, is there something else to monitor that gives information about late successional communities?
Potentially declining only in GLBA.

Yellow cedar is now assumed to be an early indicator of a particular kind of climate change. Apparently when there is less snow and the snow cover has a shorter season, the roots get cold and the trees die. It might be interesting to monitor yellow cedar but not sure how important it is really. Treeline is an excellent indicator of past regional climate

change, but so are thermometers.

Greg - may be more important than I'm indicating.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- Ground truth plots, long-term plot establishment.
- Hydrology drives vegetation if landscape doesn't interfere.
- Flow regime is a driver of riparian vegetation. Riparian vegetation is at the intersection of hydrology and the terrestrial environment.
- Note that AKNHP is producing a classification of all plant communities in the park, and in association with Landfire doing the same for the Tongass. These lists will be ranked for species at risk based on sensitivity to disturbance and rarity. A scientist notes that one must worry about plants that can be easily changed by human activities, whether they are rare or not.
- Monitor bounds of deciduous riparian forest (low elevation, low slope). This is a forest type that is particularly productive. Many more insects, which attract birds for breeding. Relatively uncommon throughout Southeast Alaska. Common for GLBA, but that is changing with vegetative succession.
- Yellow cedar is added to mid-elevation list: It is declining in southern and mid-Southeast Alaska, but not declining in northern SE Alaska (not present in KLGO). It is a long-lived, slow reproducing species in the mid-elevation, and could be a good indicator of change. USFS is currently doing a lot of research into yellow cedar decline.
- Shrub-line, and possibly treeline, is moving up in elevation, although this has not been measured. Evidence that this is true for alder, also reasonable evidence for spruce and hemlock. Could be in relation to localized climate change (e.g., general retreat of glaciers affects microclimates), or changes in hydrology, dewatering, less snow, drying out. (Connects to suggestion, under weather & climate section, to monitor snow pack longevity and distribution of snow beds.)

EMF Level 1 - Landscapes (Ecosystem Pattern and Processes)
EMF Level 2 - Landscape dynamics
EMF Level 3 - Land cover and use

SEAN VITAL SIGN
LANDCOVER AND LAND USE (includes freshwater bodies)

Justification

Vegetation and community types are both responding variables and controllers of other variables. Land use immediately adjacent to and in park inholdings is important in all three parks. In SITK and KLGO it will drive some change in park ecosystems; in KLGO adjacent and land use will cause habitat fragmentation in the park.

Land cover includes (but not limited to) landcover and land use such as beach meadows, deciduous riparian forest, shrub and treeline, pro-glacial barrens, freshwater bodies. Also includes physical and geomorphic processes such as (but not limited to) snow cover and depth, isostatic rebound, periglacial landforms, coastal and riparian geomorphology.

Threats

<u>From landcover and use</u>

GLBA -- Intensively managed areas that exist outside the boundaries of the park (fragmentation from logging and road building). Pollution. Climate change. Changes in critical habitat, connectivity, and pathways of migration. Insect outbreaks. Loss of keystone species.

KLGO -- Land use changes at the watershed scale could have significant impacts on park natural resources.

SITK -- Indian River basin developments have a potential to impact park aquatic and terrestrial ecosystems. Landcover and use changes rapidly in the area do to the high demand for suitable land for development.

Comments on Threats

Management Concerns

<u>From landcover and use</u>

GLBA -- Defining the current condition of the landscape. What should the landscape of the future look like? The role GLBA landscape as a core protected area (affects of climate change). How to maintain biological diversity including the health and integrity of entire ecosystem. Understanding how the structure of ecosystems and landscapes

influence key processes. Understanding the rate at which threats such as wind, insects, and disease may have on the landscape. Understanding the most threatening disturbances. Which landscapes are most fragile/susceptible to change? Which landscapes are not?

KLGO -- Development within park watersheds could result in increased fragmentation, habitat loss, invasive species, disturbance, noise, air/water pollution, human-triggered fires, etc.

SITK -- The park needs to continually update landcover and use maps and aerial photos of the Indian River Basin to assess the potential impacts that may occur to the Indian River water quality and hydrology.

From terrestrial complex

KLGO -- Distribution of terrestrial landcover types and vegetation associations directly relates to the distribution and abundance of wildlife populations.

Comments on Management Concerns

Monitoring Objectives

Understand how the pattern and distribution of freshwater features is changing across the landscape (land cover).

Monitoring Questions

From land cover

- How has the proportion of land cover types changed in SEAN parks?
- How has the distribution of major land cover types changed in SEAN parks?
- How has the number of units (patches) of land cover types changed in SEAN parks?
- Has the vegetation composition and structure within major landcover types changed in SEAN parks?

From extreme disturbance events

- Is the frequency of extreme disturbance events in or near SEAN parks changing?
- Is the severity of extreme disturbance events in or near SEAN parks changing?

From deciduous riparian forests

- Have there been changes within the parks in the aerial extent of deciduous riparian forest?
- Have there been changes within the parks in the species composition of deciduous riparian forest?

- Have there been changes within the parks in the age- or size-structure of deciduous riparian forest?

From pro-glacial barrens at risk

- What is the distribution and area of pro-glacial barrens communities?
- What is the species composition or pro-glacial barrens communities?
- Is the rate of loss of pro-glacial barrens communities a threat to their existence or to the existence of key community members?

From shrub/treeline communities

- Have there been changes in the elevation of alpine treeline or shrubline?
- Is the mosaic of alpine and subalpine vegetation patches changing?

From freshwater bodies

- Are there long-term trends in means or seasonal patterns of lake level or lake extent?

From glacier extent and dynamics

- What percent of each park is covered by ice and snow?

Example of Measures

From landcover

- Area of selected landcover type
- Distribution and number of individual units of each land cover type
- Glacial extent
- Change in extent and distribution of vegetative community types

From extreme disturbance events

- Date, intensity and size of individual disturbance events
- Frequency of events from long term record

From deciduous riparian forests

- Land cover of deciduous riparian forest types

From pro-glacial barrens at risk

- Distribution of pro-glacial barrens communities

From shrub/treeline communities

- Land cover delineating the treeline or shrubline
- Land cover of alpine and subalpine vegetation types

From freshwater bodies

- Annual time course of lake level and lake extent

From glacier extent

- Aerial mapping documentation of glacial extent (need to see whole profile)
- Extent of ice accumulation
- Number and size of icebergs

Want park-wide and watershed-wide coarse-scale landcover map, with finer-scale maps for selected areas.

This vital sign crosses over with landform dynamics in that both care about and document extreme disturbance effects.

Data will be gathered with remotely sensed maps; a landcover map will be created, and it is a tool. This gives information on everything from glacial extent to various vegetation communities to size of lakes to documenting extreme disturbance events, etc. These are all coarser data/categories - plant communities and structure mapping will give you a finer level of data. A landcover map captures what you can see from the air. Note that beach meadows and tree and shrub line and riparian forests are all dynamic and landcover will show the dynamism. Also, they are all either rare or the treeline is an indicator.

For landcover, 1:250,000 scale mapping doesn't tell anything; at KLGO and Sitka, use 1:12,000 mapping. Land use is important KLGO and SITK, because there's going to be tremendous development in Dyea and Skagway over the next 20 years that will cause habitat fragmentation issues in the park. In SITK park fragmentation is NOT a concern; it is outside of the park though.

Possible Partners

Relevant Monitoring or Study

Each SEAN park has some type of land cover map, as a starting point:

- GLBA has a photo-interpretation map (not a satellite map) at a 1:63,360 scale for its 300,000 acres, based on a 1996 photograph. Smallest unit is 20 acres. They also have more recent imagery available.
- KLGO has a plant association map from 1990(?) USFS aerial photos for its 13,000 acres. It identifies 7 plant associations. This may be okay for a basic landcover map,

but for long term monitoring something much more accurate with more than 7 plant associations is needed. NPS did random stratification and found its accuracy on the ground to be limited. KLGO also has very high resolution DOQs 2003 digital imagery for the park, and LIDAR with elevation data too.

- SITK has an ecological units map, produced by USFS using infrared (IR) imagery at 1:12,000 scale. The imagery is from the late 1990's. It identifies 10-11 plant associations and identifies landforms.

Comments

This is a biologic map, the landform dynamics map (vital sign #5) is a physical map.

Landcover mapping and landscape dynamics are identified as the top priority vital sign in KLGO; can't do anything without a good land cover map.

If land cover map scale is too coarse, it simply does not have the accuracy needed for a monitoring program. Too refine it for a monitoring program, need to identify the places for which you need more detailed data, then do plan community mapping (a different vital sign) for these areas.

There is a spectrum: from land cover maps, to flying areas with a digital camera, to on-the-ground plant community (structure and composition) mapping. BLM and USFS use digital photography now; don't know about USGS.

This is data from a point in time; it is what a satellite can see.

<u>From landcover</u>

Greg -- a 'biggie;' however, as indicator of some things, changes may be too slow or small to detected

<u>From extreme disturbance events</u>

Greg -- would be a 'biggie' if not essentially unmonitorable due to infrequency and unpredictability

Dan -- Although large area of wilderness, but magnitude and frequency of events(landslides, floods, earthquakes, storms) may have significant consequence

Dan -- Glacier outburst floods may have severe impact on flood plain ecosystems

<u>From deciduous riparian forests</u>

Greg -- not good indicators, as are impinged upon by many things

Dan -- Land cover mapping can be useful to assess deciduous forest distribution and done over longer time periods (15 - 25 years?)

Scott -- just seems that the dynamic nature of riparian *(Note, appears to be incomplete comment)*

<u>From pro-glacial barrens at risk</u>

Greg -- excellent indicator of change, but ecologically minor

Scott -- The 'at risk' implies management emphasis

Sara -- I couldn't see these as controllers, indicators, or linkages to network ecosystems. However, they are of interest in and of t *(NOTE incomplete comment)*

Data will be gathered with remotely sensed maps, a landcover map will be created, and it is a tool. This gives information on everything from glacial extent to various vegetation communities to size of lakes to documenting extreme disturbance events, etc. These are all coarser data/categories - plant communities and structure mapping will give you a finer level of data. A landcover map captures what you can see from the air. Note that beach meadows and tree and shrub line and riparian forests are all dynamic and landcover will show the dynamism. Also, they are all either rare or the treeline is an indicator.
For landcover, 1:250,000 scale mapping doesn't tell anything at KLGO and Sitka, use 1:24,000 1:12,000 mapping. Land use is important KLGO and SITK because there's going to be tremendous development in Dyea and Skagway over the next 20 years that will cause habitat fragmentation issues in the park. In SITK fragmentation is NOT a concern, it is all outside of the park though.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

Need to finish the benthic map for GLBA. Fill data gap in benthic mapping (between greater depth and shallow benthic map, there is an unmapped “gap”).

- Aerial photos best source to track landscape changes.
- Most effects on animal species from landscape changes would be indirect, through changes in plant communities/habitats. However, some might be direct, such as uplift draining areas that were breeding ponds for western toads. Or, mass wasting changing a route of a game trail.
- We know that we’re losing some periglacial habitat and vegetation communities. Will lose some guilds and species that live there.
- Use remote sensing as primary tool for monitoring. +T31

EMF Level 1 - Landscapes (Ecosystem Pattern and Processes)
EMF Level 2 - Landscape dynamics
EMF Level 3 - Land cover and use

SEAN VITAL SIGN
PHENOLOGY

Justification

Phenology is both a driver and a recipient. It is a result of global weather and climate, tectonics and human activity, and it drives productivity and the timing thereof in the marine and terrestrial ecosystems.

Threats

Comments on Threats

Management Concerns

Comments on Management Concerns

Monitoring Objectives

Monitoring Questions

- Has there been a shift in the timing of critical seasonal events in SEAN parks?
- Has there been a change in the length of the growing season in SEAN parks?
- Has there been a change in the time of migrational arrivals or departures for focal species in SEAN parks?

Example of Measures

- Times of vegetation green-up, blooming, ripening, and leaf fall.
- Times of migrational arrivals and departures.
- Times of reproductive behavior.

Possible Partners

Relevant Monitoring or Study

Comments

Phenology and its direct effect to the ecosystem is manifest in riparian areas where it is a big driver of biomass. In the terrestrial system, phenology doesn't seem as important?

Greg -- a 'biggie' as it integrates general climate

Dan -- Perhaps can be monitored through climate and weather data acquisition?

Scott -- phenology likely linked to climate changes or snow cover, etc., which should thus be more important than phenology

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- Changes in productivity and phenology will effect changes in flora and fauna species and in biological communities. If you're going to model or monitor the potential for certain species that haven't occurred in the parks to date, which species will depend on the length of the growing season? hat information may also be relevant to invasive species of concern, as well as species that are native.
- Source of remote sensing data is NDVI – infer productivity or phenology from greenness (looking at different spectral bands).
- USGS data (contact Dave Douglas).
- NPS developing national methodologies for monitoring phenology (per Meg).
- Leverage SEAN network funding to enlist universities to do work on this issue. Get the experts in this to give SEAN a good picture of what is going to happen with park productivity and seasonality, and what to monitor. There are places in GLBA that are going to green up, that were never green before.

EMF Level 1 - Landscapes (Ecosystem Pattern and Processes)
EMF Level 2 - Soundscape
EMF Level 3 - Soundscape

SEAN VITAL SIGN
AIRBORNE SOUND

Justification

The soundscape is an extremely important attribute in SEAN parks. Impact of airborne sounds on goats, nesting birds and other animals is at issue, in addition to impact on social and human enjoyment. Soundscape is a park management issue - if there were no remote areas with only natural sound in 20 years in SEAN and KLGO parks, park management have failed.

Threats

<u>From soundscape</u>

GLBA -- Airborne noise from unrestricted numbers of aircraft overflights over wilderness areas diminishes the experience of campers seeking wilderness experience. Airborne noise from aircraft and vessels masks the natural sounds in backcountry areas. Airborne noise from Bartlett Cove facilities and activities masks the natural sounds in front-country and nearby backcountry in the Beardslee Islands. Increasing vessel traffic generates airborne vessel noise that can disturb terrestrial wildlife and wilderness users.

KLGO -- Helicopters, fixed wing aircraft, trains, vehicle traffic, visitors, and boats impact KLGO's soundscape.

SITK -- Noise from ships and boats, vehicle highway traffic, float planes, jets, shooting ranges, etc. make SITK a very noisy place.

Comments on Threats

Management Concerns

<u>From soundscape</u>

GLBA -- Wilderness experiences of visitors are diminished by noise pollution in backcountry (and
front country) settings. GLBA lacks any real information on airborne soundscapes with which to judge the severity of threats. Changes in wildlife distribution and behavior resulting from diminished airborne soundscapes are nearly impossible to measure.

KLGO -- Human generated noise impacts the visitor's experience and disturbs park wildlife.

SITK -- Technical assistance was requested to abate human noise in SITK. It is difficult to find a place in the park that is free from human-generated noise.

Comments on Management Concerns

Monitoring Objectives

Understand how the terrestrial ecosystem responds to human generated sound.

Monitoring Questions

- Is the level, duration, frequency, location, or type of airborne sound changing in SEAN parks?
- Has there been a change in the response of park visitors or wildlife to airborne sound?
- Do creatures that gather food by streams depend on the soundscape to ensure food gathering success?

Example of Measures

- Level, frequency, location, type of sound, and duration of human-caused airborne sounds at focal locations.
- Reports of visitor response to sound.
- Observations of wildlife response to sound.

Possible Partners

Relevant Monitoring or Study

Comments

Greg -- sound probably doesn't control much, and is not a sensitive indicator, nor is it linked to a lot of important phenomena. Land critters acclimate well to sound, generally. Same for all parks

Greg -- will assume: KLGO & SITK are more trammeled than GLBA and therefore not as sensitive to noise pollution

Dan -- KLGO may be impacted in future as road from Juneau is constructed; may be useful as evidence of human impacts

Dan -- Given the setting of Sitka, this may be important sign of human impacts or potential for human impacts

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**
✓ **SITK**

Comments, Possible Partners or Threats from Scoping Workshops

- Above-water sound could play into bear management plan. How does human sound from drop-off sites and camping areas affect bears. Animal behavior can't be a vital sign for this though, it is too difficult to make the connection to above-water sound.
- If dose-response (re: goats for example) is issue, then jet noise does not matter; if wilderness is issue, then all sound matters.
- If studying goats, adopt- don't invent protocols; they are available.
- This is a research question, not a monitoring question applicable on a landscape scale. Or, perhaps targeted monitoring program in specific areas where noise is occurring next to sensitive terrestrial populations (e.g., helicopter overflight paths in mountain goat habitat).
- Monitoring above-water sound could be very expensive because areas are so large, must be selective.

EMF Level 1 - Landscapes (Ecosystem Pattern and Processes)
EMF Level 2 - Soundscape
EMF Level 3 - Soundscape

SEAN VITAL SIGN
UNDERWATER SOUND

Justification

GLBA has been and will always be accessed and traversed by a variety of vessels generating underwater sound. Vessel noise dominates underwater sound where it is being monitored. Underwater sound is a measure being used for cruise ship management. GLBA has a six year baseline dataset on ambient underwater sound taken from a hydrophone in Bartlett Cove, using an already established protocol. Comparable baseline datasets are rare. A National Academy of Sciences panel and NOAA are developing a national centralized effort on underwater sound. GLBA needs to expand its program, have some sites farther up bay. The effect of underwater sound on anything other than marine mammals is unknown.

Threats

<u>From soundscape</u>

GLBA -- Underwater noise from vessels (increasing in size and in number) generates noise that masks natural underwater sounds. Underwater vessel noise has the potential to result in behavioral change, masking of communication signals, temporary or permanent hearing loss in a variety of marine species including endangered whales and other biota at risk such as harbor seals.

KLGO -- Helicopters, fixed wing aircraft, trains, vehicle traffic, visitors, and boats impact KLGO's soundscape.

SITK -- Noise from ships and boats, vehicle highway traffic, float planes, jets, shooting ranges, etc. make SITK a very noisy place.

Comments on Threats

<u>From soundscape</u>

GLBA -- From Marine workshop: Underwater: What does the bay sound signature look like during the presence of vessels of different types (cruise ships versus small vessels)? What does the sound signature look like without vessels? What percentage of time will the bay's signature be altered by vessel noise, and is this percentage greater when ships travel at different speeds? Are whale vocalizations different during this noisy period and if so, what type of vocalizations are they (stress, contact attempts with others,

navigational attempts)? Are the percentages of different vocalizations altered in the presence of large ships? From VQOR: Information on the presence and extent of 'acoustic shadows' in front of cruise ships, and the possible role of these shadows in whale vessel collisions is needed to determine the optimal operating requirements for cruise ships in Glacier Bay. A better estimate of acoustic output of private and commercial vessels smaller than cruise ships is needed to estimate the distances at which they influence the underwater environment. A better estimate of acoustic output of cruise ships using new propulsion technology is needed to estimate the distances at which they influence the underwater environment.

Management Concerns

From soundscape

GLBA -- Background noise in the underwater soundscape may play a role in whale confusion that leads to ship strikes. Changes in wildlife distribution and behavior resulting from diminished underwater soundscapes are nearly impossible to measure. GLBA lacks underwater soundscape information in all areas except lower Glacier Bay. Diversity of private, vessel characteristics makes it difficult to choose a representative sound signature necessary to modeling their effects. New propulsion technologies in cruise ships necessitate continuous updating of sound signature information, needed for modeling their acoustic effects on soundscape and whales. It is unknown whether there are side-effects of decreasing ship speed (which would decrease ship loudness), such as decreased fuel efficiency, increased stack emissions, increased duration, that would make speed limits a bad idea.

KLGO -- Human generated noise impacts the visitor's experience and disturbs park wildlife.

SITK -- Technical assistance was requested to abate human noise in SITK. It is difficult to find a place in the park that is free from human-generated noise.

Comments on Management Concerns

Monitoring Objectives

Understand how the marine ecosystem responds to human generated sound.

Monitoring Questions

- Is the magnitude, durations, frequencies, locations or types of underwater sound changing in SEAN park waters?
- Is underwater sound masking the ability of underwater animals to find each other, breed, forage?
- Are there detrimental health effects?

- Does underwater sound effect fish disbursement to such an extent that it would make it hard for prey species to get food?

Example of Measures

- Magnitude, durations, frequencies, locations and types of sound

Possible Partners

Relevant Monitoring or Study

Comments

To date, there are no acoustic standards for unhealthy underwater sound for marine mammals.

Scott - A better indicator is the number and type of boats and their sound output rather than monitoring sound per se…

Chris G -- SITK has threats and management concerns entered, but SITK is not "checked" for this resource.

Parks Where Vital Sign will be Monitored
✓ **GLBA**
✓ **KLGO**

Comments, Possible Partners or Threats from Scoping Workshops

- GLBA - permanent (seasonal) underwater monitoring stations.
- SITK- community noise factor, monitoring around Indian River mouth?
- Important research question. Need to research cause and effect.
- Install an upbay GLBA station to complement the Bartlett Cove station?
- GLBA - USGS survey data.

Appendix C

Protocol Development Summaries

Contents

Airborne Contaminants 3
Freshwater Contaminants 6
Freshwater Water Quality 9
Streamflow 12
Glacial Dynamics 14
Intertidal Communities 16
Kittlitz's Murrelets 19
Landform and Landcover Dynamics 21
Marine Contaminants 25
Marine Predators 26
Oceanography 28
Weather and Climate 30

Airborne Contaminants

Justification/Issues Being Addressed

The low population densities, lack of large-scale industrial development, proximity to Pacific Ocean, and vast stretches of wild-lands lead many people believe the air quality of Southeast Alaska is among the most pristine in the world. However, a lichen-based air quality study completed in 1999 demonstrated that sulfur, nitrogen, and heavy metal concentrations in the KLGO-Skagway area exceeded nutrient enhancement and heavy metal concentration thresholds established by the USDA for the adjacent Tongass National Forest (Geiser et al. 1994, Furbish et al. 2000, Dillman pers. com.). All SEAN parks may be impacted by near-field mobile sources including cruise ships and other marine traffic, near-field point source such as diesel fired generators, and far-field industrial sources in Eurasia.

In addition to air contamination degrading visibility and impacting the parks' scenic beauty, deposition of air contaminants in sensitive park ecosystems has the potential to contribute to foliar damage (Fenn 2006), terrestrial and marine community compositions shifts (Geiser 1994, Fenn 2006) and bioaccumulation of contaminants in marine and terrestrial organisms (Goodyear and McNeil 1998, Pedersen and Lierhagen 2006). While all parks are required to preserve the scenery unimpaired (NPS 1916), Glacier Bay has the additional requirement of maintaining a Class 1 airshed, which requires the highest level of protection under the federal Clean Air Act passed in 1963 (PL 91-604) as amended in 1977 (PL 95-9) and reaffirmed in 1990 amendments. Thus, measurable air quality parameters are of high value to natural area managers.

Mercury (Hg) may be an important contaminant in Southeast Alaska due to its proximity to Eurasian sources and the prevailing weather patterns. Once Hg becomes bioavailability in an organic form, methyl mercury (MeHg) it is 100 time more toxic and can bioaccumulate in a variety of taxa and reaching concentrations one-million times greater than environmental concentrations (Wolfe et al. 1998). Because the use of lichen to monitor Hg deposition is not fully developed, and a well established network of wet-deposition Hg monitoring stations already exists across the country, we intend to join the national Mercury Deposition Network (MDN) for an initial period of 3-years.

Specific Monitoring Objectives Addressed by the Protocol

1. Determine long-term trends in the concentrations of selected chemical elements in lichen tissue. Join a regional network of lichen collection sites allowing SE Alaska wide inferences.
2. Track actual concentration (ppm or ppb) of SO2, NHO3, NH3, NO2 and NOx in ambient air.
3. Track total deposition (total wet and dry in kg/ha/yr) for N & S compounds.
4. Determine long-term trends in lichen community composition through measurement of permanent lichen plots.
5. Determine deposition of mercury as part of the National MDN program by establishing and maintaining an MDN monitor in GLBA.

Basic Approach

Because most sources of airborne pollution in the region are currently unregulated mobile sources (marine traffic) or are transported from far-field sources, and funding is limited, this protocol focuses on easily obtainable measures of air quality and ecological effects rather than the much more costly air quality parameters that are currently used in the regulatory arena. However, elemental concentrations in lichens and their ecological effect on lichen communities may enter the regulatory arena in the near future in determining critical loads (Porter et al. 2004, Leith et al. 2006). A long-term, 10 year revisit cycle is warranted due to slowly increasing levels of tourism, low levels of industrial development and slow population grown in the region. One data point per decade will provide managers and researchers with a broad picture of trends in air quality and how park conditions compare to other sites conducting comparable monitoring across the region (Tongass National Forest) and in the Pacific Northwest.

SEAN will determine the concentrations of selected chemical elements in tissue of three lichen species (*Hypogymnia heteromorphy, H. inactive, Platismatia glauca*) from 5 sites / collection plots across the network (two that were previously used in KLGO (Furbish 2000), two in GLBA and one in SITK). These data will be the site specific reference conditions against which future samples will be compared. These lichen collection plots will be part of a region wide monitoring program run by the USDA Forest Service. By leveraging the 73 plot already in place on Forest Service Land, course spatial resolution inferences can be made throughout Southeast Alaska. Fine-scale, park-wide inferences would require additional intra-park sample sites.SEAN elemental concentration results will be compared with reference data from the greater Southeast Alaska area and the Pacific Northwest.

SEAN will measure actual concentration (ppm or ppb) of SO_2, NHO_3, NH_3, NO_2 and NO_x in ambient air with Ogawa passive air samplers, and will measure deposition (total wet and dry in kg/ha/yr) by deploying passive through-fall samplers. Passive throughfall samplers following the methods of Fenn and Poth (2004) will be deployed at each lichen plot. Passive air chemistry and throughfall measurement data will be used to create model(s) tying pollutant concentrations in ambient air with elemental concentration in lichens. This will expand on active work in this area (Blum and Tjutjunnik 1992, Geiser pers. com.). Note: Most of this component is already funded by WASO-AQD at KLGO for FY08-09.

To track lichen community structure over time, SEAN will establish lichen community plots following methods used in the Tongass National Forest and Forests in the Pacific Northwest (Geiser et al 1994, Geiser 2004) as reference data for inter site comparisons and future intra site trend analysis and comparisons. Two lichen community plots per collection macro-plot will be read once per decadal sampling cycle. Metrics include standard site information (percent cover of dominant species by strata, abiotic data, etc.), abundance categories per lichen species, species richness, and other diversity metrics for lichens.

To track mercury wet deposition, SEAN will re-establish the wet-deposition monitoring station in GLBA and run it continuously for at least 3 years following MDN protocols (http://nadp.sws.uiuc.edu/mdn/). Precipitation samples are collected weekly, year-round. Mercury will be reported in ng/l. This Hg monitoring site will be part of a region wide

monitoring network run by the NADP MDN program and funded by the NPS and the State of Alaska Department of Environmental Quality. The NPS will have a site in Gates of the Arctic National Park and the State of Alaska has sites on Kodiak Island and Dutch Harbor. Spatial inference may be possible at the State wide level depending on the intra-site variation and correlation in Hg concentrations. These data will be analyzed after 3 years specifically to look at Alaska wide spatial and temporal patterns in Hg wet deposition. Fine-scale, parkwide inferences are not an expect outcome.

Principal Investigators and NPS Lead

NPS: Dave Schirokauer, Klondike Gold Rush National Historical Park, Brendan Moynahan, SEAN
Other Agency: US Forest Service Dr. Linda Geiser, National Deposition Monitoring Network

Development Schedule, Budget, and Expected Interim Products

Schedule and Budget:

	FY08		FY09		FY10	FY18	FY19
Item	Protocol dev pilot sampling SEAN	Protocol dev WASO-AQD & KLGO	Protocol dev & pilot sampling SEAN	Protocol dev WASO AQD & KLGO	Protocol writing SEAN & KLGO	Future Sample year 1	Future Sample year 2
GS-7 Bio Tech 4.5pp @ $1,625 pp		$7,312		$7,500		10,000	10,000
USFS Linda Geiser Travel 7 day		$1,000		$3,000		0	0
USFS L. Geiser Salary (0.5 pp)	1,600	$4,500	1,600	$2,700	$4,500	0	0
UFSU Lichenologist Karen Dillman: Set up and read 4 lichen community bio-monitoring plots	$3,200	$2,200	0	0	0	6,000	0
Lichen elemental analysis for 5 sites (45 samples @ $150) setup	$6,750	$6,750	$6,750	$6,750	0	$14,100	$14,100
Ogawa sampler analysis for **5 sites** - SO_2, NO_2, NO_X, HNO_3, NH_3 26 weeks @ 10 samples per week for 6 sites (1300) and an additional 20 samples for 18 days from two sites (360). USFS cost of $7 per sample.	$11,620	$11,620	$12,620	$12,620	0	0	0
Throughfall sampling resins filters and analysis for 5 sites (15 collectors per site)	$4,500	$4,500	$5,250	$1,000	$1,500	0	0
MDN Station	$13,000		$13,000		$13,000	$13,000	$13,000
MDN Equipment	$ 6,000		0		0	0	0
Supplies: Sample bags, shipping	$ 2,500	$1,500	$ 1,500	$500	0	$500	$500
Total	$49,170	$39,382	$40,720	$34,070	$19,000	$43,600	$37,600

Interim products include annual reports and field and lab data. Data on weekly ambient concentrations of nitrogen and sulfur oxides, seasonal deposition rates, annual elemental concentration data from lichen tissue and decadal data lichen community composition – plot data.

Freshwater Contaminants

Justification/Issues Being Addressed

Contaminants can enter Alaskan freshwater ecosystems from local or global sources via long-range atmospheric transport and marine-derived contaminants delivered to freshwaters during anadromous fish spawning runs (Blais et al. 2007). Mercury (Hg) and a suite of persistent organic pollutants (POPs) are not produced in SE Alaska, but these long-range global contaminants are probably entering the ecosystems of all SEAN parks.

Mercury is emitted primarily by fossil fuel burning, from which global emissions continue to increase, particularly in Asia (Pacyna and Pacyna 2002). Specifically, China is dramatically increasing its coal consumption (+14% annually in 2006 and 2007), and mercury released in the process is carried to Alaska along trans-Pacific atmospheric flow currents (Bradsher and Barboza 2006; Dastoor and Larocque 2004; Pacyna and Pacyna 2005). Sediment cores collected from lakes in GLBA and in neighboring Chichagof Island show that modern Hg accumulation rates in sediments are 2-3 times preindustrial accumulation rates and continue to rise (Engstrom and Swain 1997; Fitzgerald et al. 2006). Furthermore, bacteria common in wetland environments are known to convert even low levels of inorganic Hg to highly toxic methylmercury (MeHg). Wetland-generated methylmercury can readily be transported to near-shore marine systems by organic-rich outflowing streams, thereby making it bioavailable to freshwater and marine organisms. A 2007 NPS survey provided the first baseline dataset on Hg in SEAN streams from a one-time sampling event of streamwater, benthic macroinvertebrates, sediments, and juvenile fish of 17 streams with variable landscape characteristics (Nagorski et al. results pending). The establishment of a Mercury Deposition Network site in Bartlett Cove in 2008 will provide valuable information on atmospheric mercury inputs to the region, and marine contaminants (including Hg and POPs) will be conducted under the Oceanography vital sign. Therefore, the monitoring activities under this vital sign provide a critical link between airborne and marine contaminant monitoring

POPs comprise a long list of toxic and stable organic compounds derived from pesticides (both historic and current use), industrial/urban-use compounds, and combustion byproducts. POPs have been identified in arctic- and subarctic seawater, lake sediments, zooplankton, various fishes, whales, seals, bears, eagles, and indigenous peoples who rely on subsistence harvests (AMAP, 2004). Like mercury, POPs are carried via long-range atmospheric transport pathways and, upon deposition, can bioaccumulate as they pass across trophic levels. POPs of particular concern in high latitudes include dieldrin, Dichloro-Diphenyl-Trichloroethane (DDT), polychlorinated biphenyls (PCBs), chlordane, and Polycyclic Aromatic Hydrocarbons (PAHs) (NPS 2007). A new generation of POPs (or more broadly, semi-volatile organic compounds or SOCs) has been measured in high latitude air, seawater, and freshwater sediments as well (Van Oostdam et al., 2003). These include brominated flame retardents (in particular polybrominated diphenyl ethers (PBDEs), perfluorinated alkane compounds (PFAs), short chain chlorinated paraffins (SCCPs), and polychlorinated naphthalenes (PCNs). Studies in Southeast Alaska and adjacent areas include an evaluation of POPs imported to lakes in the Copper River basin (just north of GLBA) by migrating sockeye salmon (Ewald et al., 1998); an evaluation of POPs in seabird eggs (Vander Pol et al., 2004); a study of POPs levels in vegetation and air in GLBA and

the Stikine-LeConte Wilderness, Tongass National Forest, as part of the Western Airborne Contaminants Assessment Project (WACAP) (results pending), and a survey of POPs in juvenile coho salmon in 19 SEAN streams during 2007 (Nagorski et al. results pending).

Specific Monitoring Objective to be Addressed by the Protocol

Track levels of selected contaminants in selected lotic and lentic waterbodies through analysis of sediment and fish tissue samples, with an emphasis on paired lakes that do and do not support anadromous fish populations (i.e., sockeye salmon) that may deliver marine-derived contaminants.

Basic Approach

Freshwater, marine/intertidal, and precipitation/air contaminant monitoring in SEAN parks will be closely integrated, particularly for Hg monitoring in the Bartlett Cove area of GLBA. Testing for freshwater contaminants will be most effective (in terms of both cost and interpretation) by sampling parameters that integrate contaminant exposure over relatively long periods of time (e.g. lakebed sediments and resident fish) rather than relying on water samples that represent narrow temporal conditions. Sediments accumulate contaminants, especially in lakes, where cores may be sampled and dated to examine changes over the course of decades or centuries (e.g. work by Engstrom and Swain [1997] and Fitzgerald et al. [2006]). Streambed sediments represent a much more recent signature of contaminants in the watershed but may be complicated by grainsize variations and the inability to date them. Resident fish (e.g., threespined stickleback, cutthroat trout, rainbow trout and Dolly Varden) and juvenile salmon that have not yet migrated out of their natal streams (coho, sockeye, and chinook) would stay in freshwater systems long enough to bioaccumulate toxins specific to their watersheds and may prove to be excellent indicators of contaminant loads in SEAN parks. Benthic macroinvertebrates (BMI) may also have the potential to accumulate contaminants.

The three watersheds (Bartlett River in GLBA, Taiya River in KLGO, and Indian River in SITK) that will be monitored for other freshwater vital signs (Freshwater physicochemical characteristics, Streamflow, and Benthic Macroinertebrates and Algae) will be sampled for Hg (total and methyl) and POPs every 5-10 years (frequency depending on budget availability) using resident or juvenile anadromous fish, macroinvertebrates, streambed sediments, and water; we expect that POPs would be detectable only in fish tissues. In addition, resident fish and sediments will be sampled from several GLBA lakes. Priority lakes in GLBA should be in the Bartlett River watershed, including a lake in the mid-watershed reach accessible to anadromous salmonids, and Bartlett Lake (or other isolated aquatic system components devoid of anadromous salmonids, e.g. DV in the Falls Creek watershed), in order to compare the effects of atmospheric deposition (as collected under the Airborne Contaminants vital sign) with atmospheric deposition plus anadromous fish contaminant contributions. At least five individual fish will be taken from each lake/isolated system, with the addition of several water samples and soil samples from the contributing watershed. Contaminants will be measured at a glacially dominated lake as well. In this case, end-of-season snowpack samples will also be included in order to measure the contaminants in precipitation over the course of the winter, as the Bartlett Cove Hg deposition site may not be representative of colder, drier areas of the bay. An auxiliary component to the monitoring of this vital sign may include coring of the lake sediments for historical contaminant deposition profiles (ideally once every ~10 years),

continuing the efforts in the region by Daniel Engstrom's research group to track Hg deposition trends in the Glacier Bay region since global industrialization.

Sampling sites in all parks will be selected with an emphasis on collocation of sites monitored under the other freshwater vital signs (Physicochemical Water Quality, Macroinvertebrates and Algae, and Streamflow).

Principal Investigators and NPS Lead

GLBA: Chad Soiseth, Fisheries Biologist; SITK: Geoffrey Smith, Biologist; KLGO: Dave Schirokauer, Natural Resources Program Manager
Sonia Nagorski, Ph.D., Environmental Science Program, University of Alaska Southeast

Development Schedule, Budget, and Expected Interim Products

Detailed protocol development, including various cost scenarios, will take place in 2010-2012. Results of the studies by the WACAP group and Nagorski et al.'s 2007 contaminants survey (results pending for both) in the SEAN will help evaluate protocols, identify baseline concentrations, and location of potential focus study areas. Because of the high expense associated with contaminants analyses, this protocol will be implemented not annually but on a 5-10 year rotating interval, depending on funding. The estimated costs are:

Item	Estimated Cost
Monitoring in 3 study streams (Bartlett, Taiya, Indian Rivers) Each watershed: (1) Triplicate Hg samples ($300/ea) of fish, BMI, sediments, and water (2) Triplicate POPs samples ($750/ea) in fish)	$17,600 every 5-10 years
Monitoring in 3 GLBA lakes: Each lake system: (1) 5 Hg samples ($300/ea) of fish, soils, and duplicates of water (2) 5 fish samples for POPs ($750/ea) (3) 2 water samples for full chemistry ($350/ea) (4) 2 snowpack samples for Hg ($300/ea) for the glacial lake watershed)	$28,000 every 5-10 years
Lake coring for chronological deposition profiles. Each of 2 lakes: (1) 6 cores sectioned into 10 sections, analyzed for Hg and ^{210}Pb; air and boat access to and on lake).	$30,000-50,000 every 10 years

Costs associated with travel and ancillary water quality parameters for the 3 study streams are additional and can be combined with the Freshwater Physicochemical Water Quality vital sign monitoring efforts. The above estimates also do not account for expenses associated with travel, salary (in-house or contractor), overhead, and other potential costs outside of chemical analyses.

Freshwater Water Quality

Justification/Issues Being Addressed

The quality of freshwaters is critical to the functioning of aquatic, terrestrial, and nearshore marine ecosystems across SEAN. Water body types in SEAN are diverse and abundant, comprising upland and subalpine lakes, wetlands and ponds, groundwater resources, glacial streams, and nonglacial (clear water) streams. Each is influenced by a local and regional complex of geology, climate, glacial history, and other factors. All SEAN units are concerned about the potential effects on water quality due to climate change, visitor impacts, and long-range atmospheric contaminants. Other potential threats to water quality on at least some SEAN water resources include urban development of watershed areas outside park boundaries and potentially invasive/nuisance freshwater species. Current and historical water quality information for SEAN is very limited in terms of both spatial and temporal scope (Nagorski and Hood 2007). While a variety of water quality studies have been conducted in each park, only a small subset has specifically aimed to provide baseline water quality monitoring data, and none included long-term and/or continuous monitoring efforts. Therefore, monitoring of this vital sign will largely require a novel effort in each SEAN unit. The only SEAN stream designated as 303(d) impaired is Pullen Creek, a portion of which flows through the Skagway Historic Unit (in KLGO) but is not under the jurisdiction of the NPS.

Detection of long-term trends and short-term fluctuations will be most meaningful by employing a high-frequency (continuous, ideally) sampling design, because changes in water quality typically occur rapidly and can be short-lived. The four core parameters chosen for monitoring by the NPS Water Resources Division (WRD) are temperature, pH, specific conductance, and dissolved oxygen (Irwin 2004b; NPS, 2002; Roman et al. 2003). Additional parameters that will be monitored in SEAN include turbidity, nutrients (TN, TP, nitrates, ammonia, orthophosphate), dissolved and total organic carbon (DOC/TOC), major anions and cations, alkalinity, and trace elements.

Specific Monitoring Objective to be Addressed by the Protocol

Track core water quality parameters (temperature, dissolved oxygen, conductivity, pH) in select SEAN streams.

Basic Approach

Streams monitored for physicochemical water quality characteristics will be those that are also the subject of related vitals signs (Streamflow, Benthic Macroinvertebrates and Algae, and Freshwater Contaminants): (1) the Bartlett River in GLBA; (2) the Taiya River in KLGO; and (3) the Indian River in SITK. In addition, the NPS will work with the USGS to obtain samples from the Alsek River (GLBA) during regularly scheduled USGS site visits to the Alsek River stream gage when water quality samples would otherwise not be collected.

Water quality sampling is a well developed scientific field, although technological improvements in both field instruments and laboratory analytical capabilities are rapidly driving changes in sampling designs and methods. Many water quality monitoring protocols have been developed

and extensively tested by federal agencies; therefore, development of this protocol will not require the development of novel methods, but will focus on tailoring established protocols to meet the needs of the specific waterbody and the individual park unit. The NPS WRD provides guidance on monitoring protocol development, including quality assurance/quality control and on collection of core water quality parameters (Irwin, 2004a, b; NPS, 2002, 2003). Several other national monitoring programs also provide detailed methodologies, statistical sampling protocols, and quality control protocols that will provide useful information to the SEAN.

At the monitoring sites (to be selected on each stream based on access, location above tidal influence, current/historical use as a monitoring site, and suitability for a stream gage), water quality measurements will be two-tiered: (1) those composed of continuous, in-situ monitoring, and (2) those that require visits by personnel to collect grab samples for laboratory analysis. The continuously measureable (e.g. every 15 minutes, from May-October) parameters include the required core parameters (pH, specific conductance, temperature, and dissolved oxygen) plus to turbidity. The remaining parameters, which cannot be monitored continuously with in-situ meters, will require site visits by NPS and/or contracted personnel who will follow established protocols (e.g. USGS) for collecting, handling, and storing water samples that will be sent off for analysis to certified labs. Sampling frequency for grab samples should be at a range of discharges and seasonal climatic conditions. Collection of water samples will follow a rigorous QA/QC protocol that includes chain of custody records for samples, and samples will be analyzed by a laboratory that follows standard, federally-approved methods for water quality analyses and QA/QC procedures.

Data Analysis. Continuously monitored data will be downloaded at each site visit and compiled in a database that is compatible with statistical analytical programs and STORET. The Time Series Standard Aquarius program (by Aquaticinformatics Inc.) is an appropriate software package that can manage and analyze high volume water quality time-series data and is recommended for purchase by the network, as data management demands will be considerable. Data will be analyzed for diel, weekly, seasonal, annual, and longer term patterns and trends. Data will be evaluated for trend detection, for conformity with water quality aquatic life and human health criteria, and will be related to discharge measurements (for calculating chemical fluxes), to benthic macroinvertebrate and algae monitoring, freshwater contaminants, and other relevant vital signs monitoring that may be co-located at the sample sites.

Principal Investigators and NPS Lead

GLBA: Chad Soiseth, Fisheries Biologist
SITK: Geoffrey Smith, Biologist
KLGO: Dave Schirokauer, Natural Resources Program Manager
Sonia Nagorski, PhD. Environmental Science Program, University of Alaska Southeast.

Development Schedule, Budget, and Expected Interim Products

This monitoring protocol is one of the first planned for full development. The full protocol will be developed in the next year with field testing of instruments to commence as soon as funds become available. After two years, the protocol should be reviewed and evaluated. The estimated costs for monitoring of this vital sign are as follows:

Item	**Estimated Cost**
In-situ continuous meters (core parameters + turbidity)	$14,000 x 3= $42,000
Installation and maintenance of continuous meter	$ 500/yr
Aquatic informatics software	$4000
Analysis of grab samples for nutrients, DOC/TOC, other chemistry.	$ 150-350/sample; 10 samples/site/yr x 3 sites = $4,500-10,500/yr
Temperature loggers for sites without continuous meters	$350 x 2 = $700

Not included above is the cost associated with personnel needed to install and maintain meters, to collect grab samples, and analyze data. A more detailed budget, including various cost scenarios, will be developed in the full protocol.

Streamflow

Justification/Issues Being Addressed

Streamflow is a critical monitoring component of aquatic ecosystems and habitats because many chemical and physical variables are influenced directly or indirectly by discharge volume. For instance, changes in water quality, eutrophication, nutrient and sediment transport are all dependent on streamflow. Decreases in streamflow are associated with increased water temperatures, decreased concentrations of dissolved oxygen, and increased concentrations of chemicals. Streamflow also has important implications for receiving marine ecosystems and habitats. Coastal habitats are important rearing and feeding grounds for many species of fish, mammals, and birds. Variation in the volume and temporal patterns of release of freshwater and nutrients into these important habitats can have profound impacts on coastal marine ecosystems. For example, marine habitats where glaciers or glacial streams meet the sea have been shown to be regions of exceptionally high productivity and biodiversity within Glacier Bay National Park and Preserve (Robards and others, 2003). Streamflow has also been identified as important to estuarine and marine circulation patterns, salinity stratification, and primary productivity (Royer 1982; Royer et al. 2001; Etherington et al. 2007).

It is also important to describe a stream's flow regime, a factor which is cited with increasing frequency as a critical variable that structures aquatic ecosystems and habitat (Poff and Ward 1989; Richter et al.1996; Baron et al. 2002). An ecologically relevant definition of flow regime includes the frequency, magnitude, duration, and timing of high and low flows, as well as the rate of change and interannual variation of streamflow. Changes in streams or streamflow can be used as indicators of changes in climate, basin dynamics, and land use, but only with an accurate and long-term analysis of streamflow regime.

Specific Monitoring Objective to be Addressed by the Protocol

Determine status and trends of streamflow in select SEAN streams – the Indian River (SITK), the Taiya River (KLGO), and the Bartlett River (GLBA).

Basic Approach

Streamflow is measured as discharge of water within a river channel past a specific point for a given time interval. Streamflow gaging stations typically consist of a pressure sensing transducer fixed to the stream bed at a known elevation. The transducer measures the elevation of the stream's water surface, which is recorded by a data logger. A relation between water surface elevation (stage) and discharge is established by measuring streamflow over a range of stage. Once this relationship is well defined, a rating curve can be developed and streamflow can be computed from the stage data and rating curve. Periodic streamflow measurements are required to adjust for changes in channel morphology, debris, and aquatic vegetation growth, all of which may significantly alter the relation between stage and discharge. In order to keep discharge estimates accurate, six to nine discharge measurements spanning the full range of flow should be taken each year. Moderate and low flows can be measured by wading using current meters and top setting wading rods, however, measuring high flows or flood flows is essential to development and refinement of rating curves. These measurements will need to be conducted by

boat or from bridges using conventional current meters in combination with a bridge crane, reel, and sounding weight or using acoustic Doppler current profilers (ADCP). The ADCP is capable of measuring discharge from a moving boat and would be essential to making discharge measurements when no bridge is available from which to suspend a traditional current meter. The USGS has developed extensive protocols for making discharge measurements and operating stream gages (Rantz et al. 1982a, 1982b). Protocol developed for SEAN streamflow monitoring will draw from these protocols.

Principal Investigators and NPS Lead

U.S. Geological Survey, Juneau and Anchorage offices
SITK: Geoffrey Smith
GLBA: Chad Soiseth
KLGO: Dave Schirokauer

Development Schedule, Budget, and Expected Interim Products

Optimally, streamflow monitoring should be continuous. Continuation of streamflow monitoring on streams previously gaged by the USGS (Indian River and Taiya River) is recommended for the following reasons: 1) stage/discharge ratings may already be available 2) the value of streamflow data increases with longer time series, and 3) the location of these gages facilitates frequent visits, which are essential to producing accurate and complete data sets. An additional gage will be installed on the Bartlett River near Gustavus.

Maintaining a USGS stream gage in Alaska presently costs between $25,000 and $40,000 annually, which is cost-prohibitive for the network. SITK has engaged in a partnership with the City and Borough of Sitka, Alaska Department of Fish and Game, and possibly the USFS to reestablish gages on the Indian River. This process requires local personnel conducting discharge measurements and downloading data and contracting to have stage and discharge data computed and archived. Initial cost for SEAN was $10,000, which represented 59% of the total cost of $17,000 for the first year of the project. SEAN's contribution in FY 2008 will be $8,000. The City and Borough of Sitka and Alaska Department of Fish and Game are expected to contribute about $3,000 each. KLGO is considering a similar arrangement for the Taiya River and has submitted a NRPP funding proposal to initiate the process. The Cost of a Teledyne RD Instruments Rio Grande ADCP meter for high discharge measurements is about $23,400.

Ideally, additional stream gages in remote locations would be established; however, the necessity of frequent visits and the costs associated with maintaining remote stream gages is likely to preclude gaging of additional streams.

Glacial Dynamics

Justification/Issues Being Addressed

Glaciers are principal *raisons d'etres* for the initial establishment of GLBA, and are fundamental backdrops for both GLBA and KLGO history and biology. In both parks, glaciers have been and continue to be principal direct and indirect determinants of landforms, scenery, successional state, and ecological pattern/process. In GLBA, glaciers are key interpretive resources.

Ice is a habitat unto itself. It mediates the release of freshwater into marine and terrestrial systems, and continues to be responsible for occasional catastrophic meltwater releases in both parks. Changes in glacial extent and mass balance serve as proxies for climate change, and historically and prehistorically have had major influences on the congeniality of the landscape for human habitation and trade routes to the continental interior.

This protocol is directly related to several other Vital Signs (e.g., Weather and Climate, Landform and Landcover, Freshwater Physiochemical Water Quality, Freshwater Streamflow, Oceanography, and Kittlitz's Murrelets), but will be limited to specific properties and outputs of ice masses. For the purposes of this vital sign, "Glacial Dynamics" is defined as "changes in extent, configuration, mass balance and meltwater/iceberg output of glaciers within or directly influencing GLBA and KLGO". SEAN recognizes the considerable cost and technical challenges associated with mass balance estimation. For that reason, SEAN will focus on monitoring glacial extent, but will retain detailed plans contained in the Phase 3 Report in the event that future funding becomes available for more detailed measurements. Glacier extent will be measured in conjunction with the VS for Landform and Landcover.

Specific Monitoring Objective to be Addressed by the Protocol

Determine (by direct measurement or modeling/proxy) changes in glacial extent and configuration of selected glaciers in GLBA and KLGO.

Basic Approach

This general photogrammetric survey will be conducted by way of targeted analysis of the decadal remote imagery described in the Landform and Landcover PDS. It applies to all GLBA glaciers and all glaciers that contribute meltwater to either unit of KLGO.

The survey will be conducted once each decade, using the best available satellite or high-altitude imagery. This survey will occur at the end of the summer ablation season to allow accurate placement of the equilibrium line and to take advantage of the maximum yearly exposure of lowland features. The extent of contributory snowfields, equilibrium line position, extent and configuration of ice below that line, and terminal position of each glacier will be mapped with accuracy of at least $\pm$10m. The first iteration of this survey will produce a basemap to which future changes can be compared. More frequent attention will be considered on a case-by-case basis for capturing details of events such as surges and outburst floods.

Rationale: 1) Given recent rates of change in the extent, elevation and mass balance of the region's glaciers, and given that the proposed measures for the most part integrate multi-year changes, this interval should be adequate to capture major variations in aerial extent in most systems. 2) Satellite or high-altitude photogrammetry is chosen for its cost-effectiveness, and it is entirely benign in terms of impacts to ecosystems or users. 3) A decadal timescale will capture most significant change except for specific cases.

Particular attention (finer-scale documentation) will be paid to certain low-elevation glaciers/features in order to capture important details of ice frontal character and associated geomorphic and vegetational change. In order of relative priority these are: 1) Burroughs Glacier (two ends); 2) termini of Rendu and Carroll Glaciers; 3) Topeka Glacier; 4) Hugh Miller and Geikie Glacier remnants; and 5) the ice-filled portion of the Desolation Valley currently separating the lower Alsek River and Grand Plateau Glacial Lake. *Rationale:* 1) These isolated, low-elevation ice systems are particularly sensitive to (and will effectively reflect) detailed changes in ice frontal character and associated glacial geomorphology and vegetational succession. 2) These important changes can be readily observed by more detailed analyses of the same remote imagery used above. 3) In particular, glaciologists have recently theorized that with continued thinning of Grand Plateau Glacier, it may be possible that the lower channel of the Alsek River could be "pirated" to the east of the Deception Hills sometime in the future, to enter the Gulf of Alaska via the current Grand Plateau Glacial Lake outlet; such an event would have profound effects upon the Dry Bay ecosystem.

The present work by Molnia (in prep, 2007) extending the long series of on-the-ground monitoring of glacial termini in Glacier Bay proper begun by Field in 1925 (data in park files) will be continued. This will also be repeated on a decadal timescale (independent of the Landform and Landcover PDS). *Rationale:* This work complements the above remote approach and is important for capturing details of ice frontal character and associated geomorphologic and vegetational change.

Principal Investigators and NPS Lead

Expert glaciologist/hydrologist (to be determined)
NPS: Sharman (GLBA) and/or Schirokauer (KLGO)

Development Schedule, Budget, and Expected Interim Products

See Landform and Landcover PDS.

Intertidal Communities

Justification/Issues Being Addressed

SITK has approximately 50 acres of foreshore intertidal zone within the city of Sitka. The low gradient, cobble/gravel, semiprotected beach provides an arguably unique habitat for the area. It hosts a diverse marine fauna and flora, with over 219 species of invertebrates and 85 species of marine algae. The northernmost known populations of two red algae have been observed at the site: *Chondracanthus exasperatus* (Turkish towel) and *Scinaia confusa*. The area contributes to the productivity and diversity of the local area, which is situated within one of the richest in the northeast Pacific. The SITK intertidal zone comprises nearly half the acreage of the park.

Intertidal areas are biologically sensitive habitats and vulnerable to disturbance. Threats to the intertidal resources of the park include trampling from intense visitor use. A high percentage of the park's 300,000 annual visitors explore this zone. Other threats to the integrity of the intertidal zone include a proposed deepwater cruise ship dock to be built adjacent to the park boundary, which would stand 24 feet high and extend 300 feet into Sitka Sound. Continuous vessel traffic occurs in the area, and cruise ships anchoring just off the park shore. Together they present a risk of oil spills and other discharges. Boat groundings are also a constant threat and several have occurred in the park in recent years.

The park's General Management Plan states that protection of the intertidal zone is one of the highest natural resource priorities. Desired future conditions in the plan state that "..intertidal habitats and resources are preserved, protected, and interpreted" and natural processes "..are allowed to continue unimpeded in the tidal zone." Inventorying and monitoring the intertidal zone also helps the park achieve the Marine Water Quality GPRA goal (Ia4B). Intertidal monitoring protocols are being developed and tested by USGS (Irvine and Madison 2008) to give the park the tools to detect species distribution trends over time, information necessary to assure these resources remain healthy. If particular intertidal zones are determined to be at risk, GLBA could adopt similar intertidal monitoring methods.

Specific Monitoring Objectives to be Addressed by the Protocol

1. Determine the status and trends of intertidal species composition and distribution for the SITK intertidal zone.

2. Determine trends in the occurrence and distribution of invasive/non-native intertidal invertebrates and macroalgae

Basic Approach

The goal of this vital sign is to develop probability-based sampling plan and protocols that would enable robust monitoring of the intertidal invertebrate biota of SITK. A probability-based design will allow the results of the discrete sampling to be extrapolated to the entire defined intertidal region of the park. Also, the particular sampling methods will be designed to target different elements of the intertidal biota, such as sessile plants (primarily marine algae) and invertebrates, small mobile invertebrates, and select large mobile invertebrates.

The sampling frame is defined as the intertidal region extending from the western side of the park to the Indian River and encompassing the area from the mean higher high water (MHHW) level to the 0 m (0 ft) tide level. The horizontal length of the beach at the MHHW level was measured in 1999 and was approximately 1 km; this line is termed the "horizontal segment line" and defines the uppermost border of the sampling frame. This length included extents of beach that were judged as not available for sampling due to the presence in the intertidal zone of large depressions (i.e., pools at low tide) that were the result of historic gravel excavations. These areas were excluded from the sampling frame.

Fifteen permanent, vertical transects from the MHHW to the 0 tide level will be systematically selected across the one kilometer beach each year. Three types of sampling along each transect are used to accommodate different types of species. In brief:

- Sessile species – point samples are taken every meter along each transect, and cover for each species is estimated by the total counted on the transect divided by the number of points sampled.
- Large macroinvertebrates – total counts are taken for one-meter wide bands on both sides of each transect. The variable of interest is density of species (counts/ area sampled).
- Small mobile species – quadrats (size varies by species) are taken systematically along transect and counts/area or density are monitored. Six or more quadrats will be sampled on each transect.

The sampling units (i.e., transects) differ in length as the width of the intertidal zone varies across the beach. The number of point samples and the size of sampled area for band samples will be proportional to transect lengths. For quadrat sampling, equal numbers of samples will be taken regardless of transect length. Using density as the monitoring measure (transect count/total number of points *or* transect count/band area) will standardize units across transects, but will not correct for the fact that each transect contains a different amount of information. That is, longer transects provide more information than shorter transects. The selected analysis method will be adjusted for this difference.

Principal Investigators and NPS Lead

SITK: Geoffrey Smith, NPS Lead
USGS:BRD: Dr. Gail Irvine

Development Schedule, Budget, and Expected Interim Products

It is anticipated that intertidal monitoring in SITK will be completed every two to three years. The protocol is still being tested; final parameters and methods have not yet been determined. A power analysis on initial sampling data has allowed assessment of the protocol to detect trends for predominant species. Results indicate an 80% probability to detect +10% annual changes in abundance with an alpha of 0.05; the ability to detect -10% is not as uniformly satisfactory.

Estimated costs:

Item	Cost
Marine Ecologist (familiar with sampling method and knowledgeable of intertidal flora and fauna)	$6,500
Biotechnician	$2,000
Equipment	$500
Data Analysis	$1,000
Total (every 2-3 years)	**$10,000**

In-kind support from SIKT will include the participation of the park biologist and volunteers as part of the sampling teams, logistics support, and use of the park's meter tapes, GPS unit, and other equipment.

Kittlitz's Murrelets

Justification/Issues Being Addressed

The Kittlitz's murrelet (*Brachyramphus brevirostris*), hereafter KIMU, is a small rare seabird (Family *Alcidae*) that ranges across coastal Alaska and parts of the northeast coast of Russia (Day et al. 1999). During the summer breeding season, KIMU forage on pelagic schooling fish or invertebrates near the outflows of tidewater glaciers or glacial streams (Day and Nigro 2000). Nesting behavior is also associated with glacial habitats, with the few nests ever found located in recently de-glaciated areas with sparse vegetation (Day 1996). Because of their strong association with glacial habitats, KIMU are closely linked to several national parks in Alaska. In fact, the National Park Service is a steward to the global population of KIMU: the best estimates indicate that over 20% of the world's population reside seasonally or year-round within Glacier Bay and Wrangell-St. Elias National Parks alone (van Vliet 1993). KIMU are a species of management concern as a result of substantial declines across their range, including some areas where declines have exceeded 70% (USFWS 2006). In 2007, the USFWS upgraded KIMU to a Listing Priority 2 for listing under the Endangered Species Act due to widespread and dramatic declines across their range. The population in Glacier Bay National Park is estimated to have declined 80% since the early 1970's. As KIMU are intricately linked to glacial habitats (both marine and terrestrial), their trends in abundance and productivity likely reflects the changes in marine productivity and glacial dynamics (both of which are proposed for monitoring under the Oceanography, Marine Predators, and Glacial Dynamics vital signs).

Specific Monitoring Objectives to be Addressed by the Protocol

1. Generate population abundance estimates that, at a minimum, achieve 90% power (at α=0.05) to detect a 50% change in population within the next 10 years.

2. Determine annual and long-term trends in KIMU within Glacier Bay proper by generating population estimates every summer using at-sea surveys and a line transect methodology.

3. Quantify annual variation in spatial distribution of KIMU occurrence within Glacier Bay proper.

4. Adapt and implement the existing KIMU monitoring design developed in Icy Bay, WRST, (Kissling et al. 2007) for Glacier Bay proper to achieve the monitoring and sampling objectives identified above and to maximize inference scope.

Basic Approach

KIMU are highly patchily distributed within their habitats, and thus it is important to develop a survey protocol that captures this variability. Sampling will involve a series of at-sea surveys conducted on several occasions during the summer months. Multiple surveys throughout the summer will help identify the peak in numbers of KIMU for timing of future surveys and ensure that surveys capture temporal variability of KIMU within the park. Surveys will consist of two types of transects to capture the spatial variability in distribution: Shoreline transects will be placed within 200 m parallel to shore for individuals distributed 'along shore'. Pelagic transects

will be placed perpendicular to shore approximately 2 km apart, varied in length according to width of the bay or fjord, and ended at 200 m from shore (following Kissling et al. 2007). Surveys will be conducted during two one-week survey periods with transect direction and order changing among surveys; surveys will not occur if weather conditions are unacceptable (high winds or sea state/Beaufort scale > 2. Surveys will occur between 0700 and 2100 using a vessel at least 6 m boat in length moving at a speed of about 10 km/hr using two observers and one boat driver. For both shoreline and pelagic surveys, observers will record all *Brachyramphus* murrelets within an unlimited distance on either side of the boat and 300 m ahead of the boat. For each observation, the following data will be recorded: group size, age category (see below), location (air or water), activity (e.g., flying, on water), and distance (m) to the group. Based on plumage characteristics, each murrelet will be categorized as definite AHY, probable AHY, unknown, probable HY, or definite HY (following Kuletz and Kendall 1998); it will also be noted if murrelets are holding fish in their bills. Depth (m), sea conditions (Beaufort scale), precipitation, ice cover (%), and swell height will be recorded every 30 minutes or as conditions changed. A voice-activated recording system that integrates geodata (from geographic-positioning system) will be used by recording observational data with location and time.

The data from the initial surveys will then be compared with historical surveys conducted within Glacier Bay proper and from other surveys in Icy Bay, WRST (Kissling et al., 2007) and utilized in a power analysis to estimate sampling design power under different conditions of sampling (detectability, transect length, size of population change, etc.).

Principal Investigators and NPS Lead

NPS: Scott Gende and Brendan Moynahan
USFWS: Michelle Kissling
UAF: Mark Lindberg

Development Schedule, Budget, and Expected Interim Products

2008- NPS collaborate with UAF, USFWS, ADF&G, and CDFW to develop a survey protocol in GLBA using previous survey results conducted by USGS and ADF&G, and from surveys conducted in Icy Bay, WRST.

2009 Surveys in GLBA for protocol development ($ provided by SEAN and USFWS); Analysis of pilot data, conduct power analysis, meet with partners to discuss survey design.

2009-2010 Peer review, finalize, and implement monitoring protocols ($ to be determined)

Landform and Landcover Dynamics

Justification/Issues Being Addressed

Landscape structure is the base upon which physical and ecosystem processes function. The composition, quantity, patch configuration, and juxtaposition of terrestrial landscape components (landcover and landform types) control energy and material flow, inputs to marine systems, habitat availability, and wildlife movement patterns. Changes in landform and landcover types occur rapidly in SEAN parks in response to climate-mediated glacial retreat and primary succession, isostatic rebound, tectonic activity, wild-land fire, and insect outbreaks. Anthropogenic change adjacent to parklands (such as stream bank hardening, development, road construction, and timber production) also influence landscape dynamics, albeit at lower intensity and rates than parks in more developed parts of the country.

Monitoring long-term changes in landforms and landcover types will help managers establish the 'big-picture' view of the parks and the surrounding landscapes on which park resources and processes depend. The National Park System Advisory Board suggested "resource management should be addressed in a broader context" (NPS 1993).

Selecting the appropriate temporal frequency, spatial extent, spatial resolution, and thematic detail is challenging without first prioritizing the landscape attributes of interest and understanding the rate and magnitude at which these landscape components change. In many cases the rate and scale of change of landscape components are poorly understood or unpredictable. Climate change is adding uncertainty to the dynamics of broad scale physical and ecologic processes.

Cost issues are also important considering the need to monitor other vital signs through the SEAN I&M program. Development of a cost effective protocol will advance our knowledge on the rate at which landscape components are changing, and quantify changes in the abundance and juxtaposition of important landscape components and patterns. However, some landscape attributes are likely to be missed due to the timing, spatial resolution, or technical constraints of image interpretation or image coverage (e.g. cloud cover).

Landform dynamics was ranked 5th among all of the potential vital signs evaluated by the SEAN. Key reasons for monitoring landscapes include:

1. Parks are exceptionally dynamic: they experience rapid rates of glacial retreat, and isostatic rebound rates are the highest in the world, and rapid rates of succession occur on newly ice-free lands
2. Proglacial lakes on newly exposed land represent potential geohazards
3. Watercourse morphology evolves rapidly due to glacial outburst floods, highly variable sediment loads, isostatic rebound, tectonic activity, and changing climate
4. The parks include tsunami-affected coast-line
5. Shifts in the amount and juxtaposition of habitat types are driven by climate change, isostatic rebound, glacial retreat, and dynamic water courses
6. Parks need early warning of large-scale community shifts and vegetative life-form

changes to allow for responsive management

Specific Monitoring Objectives to be Addressed by the Protocol

1. Determine long-term status and decadal trends in the areal extent and configuration of key land-forms within, and on lands influencing, SEAN parks.

2. Complete the extent mapping component of the Glacial Dynamics monitoring protocol.

3. Determine status and long-term trends in the areal extent and configuration of plant community types at broad botanical levels within, and on lands influencing, SEAN parks.

4. Determine status and long-term trends of selected key landscape metrics (e.g., proportion of area in different cover types, number and density of patches, mean patch size) of NPS lands within and on adjacent lands influencing SEAN parks.

Basic Approach

This protocol requires periodic mapping of the landscape components of interest. Ideally, monitoring landscape dynamics would use two basic approaches. The first approach would focus on a retrospective analysis to evaluate historic changes of landscape patterns and conditions. Although this is not an essential part of developing this protocol, it would inform the development of the protocol by refining and helping to prioritize the list of landscape components for future mapping efforts. The second step would focus on mapping current through future conditions by obtaining current satellite imagery, and classifying and mapping landscape components. Minimum resolution of imagery used would be comparable to IKONOS imagery (4 meter 4 band or better). Key landform types targeted for change detection include:

a. Moraine deposits
b. Glacier extent
c. Firn-lines
d. Terraces
e. Fluvial deposits
f. Proglacial lakes
g. Alluvial deposits
h. Accretion zones on river systems
i. Shoreline features
j. Erosion zones on river systems
k. River channel migration
l. Plant communities

Available information concerning landscape change work already being conducted in Southeast Alaska would be gathered prior to initiating any new work. All historic interpretation would be conducted as funding became available.

Every 10 years full mapping of landcover and landform types and analysis would be conducted for all network parks using high-resolution spacebourne imagery. Each decadal iteration will likely take two years to complete. Steps include: 1) image acquisition, 2) mapping/image

processing, 3) accuracy assessment, 4) change analysis, and 5) reporting and publication of results.

Protocol development will also consider whether to increase temporal resolution and decrease spatial resolution to detect change in a key set of landscape attributes that may change quickly, or to assess effects of unpredictable or catastrophic events (e.g., outburst floods) that occurred since the preceding mapping cycle. This approach would use LandSat, ASTER or other course resolution spacebourne imagery to map a subset of features during the mid-point of each decadal cycle.

Seasonality of images would be determined to maximize the ability to differentiate between major plant community types and identify all key landform types. Remote sensing methods are also use to detect firn-line (an important glacial feature used to calculate mass-balance); however, more investigation is needed to see if the same imagery can be used effectively for landcover/landform mapping. Acquisition of cloud free imagery is difficult in Southeast Alaska. Commercial satellites will be tasked for multiple years until cloud free scenes of the area of interest are acquired during appropriate phonological condition. NPS staff in the Alaska Regional Office would be the most efficient at acquiring imagery for the I&M networks and could be responsible for submitting imagery requests and contracting.

A description of the area of inference is not relevant to this vital sign, because monitoring is ultimately a census, not a probabilistic sample. The full boundary extent, plus a significant buffer, will by mapped for GLBA. For KLGO and SITK, the protocol will describe mapping the entire watersheds in which the parks occur.

Principal Investigators and NPS Lead

To be determined.

Development Schedule, Budget, and Expected Interim Products

Development of protocol could be closely linked to development of regional or national protocol. Budget figures are rough estimates.

YEAR	BUDGET	TASKS/PRODUCTS	PERSONNEL
YEAR 1	$0	**Protocol Development:** Coordinate with other networks and the Regional and National programs to select methods. Craft a regional plan and schedule of imagery acquisition that leverages cyclic regional mapping funds to match with I&M network's imagery needs.	SEAN Lead & Coordinator, Regional Coordinator
YEAR 2	$0 $50,000	**Protocol Development:** Hold scoping meeting to determine landscape attribute of interest. Work with National, regional and other Networks to develop SEAN draft protocols and plan to refine protocols. Acquire Imagery	SEAN Lead, Coordinator, Regional Coordinator, AK Regional GIS Staff
YEAR 3	$75,000	**Protocol Development:** Implement mapping program. Hire GS-9/11 for 11 months or use the CESU to implement program and finalize draft protocols. Produce reference condition GIS dataset for future (or past to present) change detection analysis.	Mapping specialist or CESU Agreement for mapping and protocol documentation, SEAN Lead & Coordinator, Regional Coordinator, AK Regional GIS/I&M Staff
YEAR 4	$20,000	**Protocol Development:** Peer review and finalize and publish protocols. Finalize GIS and map products.	Mapping specialist or CESU Agreement for mapping and protocol documentation, SEAN Lead & Coordinator, Regional Coordinator, AK Regional GIS/I&M Staff
YEAR 7	$30,000	**Optional Protocol Development:** Acquire and interpret LandSat ASTER imagery	Mapping specialist or CESU Agreement for mapping and protocol documentation, SEAN Lead & Coordinator, Regional Coordinator, AK Regional GIS/I&M Staff
YEAR 11	$60,000	**Protocol Implementation:** Acquire Imagery	
YEAR 12	$85,000	**Protocol Implementation:** Implement mapping program. Hire GS-9/11 for 12 months or use the CESU to implement program and finalize draft protocols. Produce time point 2 condition GIS dataset. Conduct change detection analysis and complete final report	Mapping specialist or CESU Agreement for mapping and protocol documentation, SEAN Lead & Coordinator, Regional Coordinator, AK Regional GIS/I&M Staff
YEAR 17	$30,000	**Optional Protocol Development:** Acquire and interpret LandSat ASTER imagery	
YEAR 21	$60,000	**Protocol Implementation:** Acquire Imagery	
YEAR 22	$85,000	**Protocol Implementation:**	

Marine Contaminants

Justification/Issues Being Addressed

It is believed that SEAN's marine waters are of exceptional quality, and that park marine waters can serve as a pristine reference against which other NPS marine waters can be compared. Marine contaminants are clearly anthropogenic and are widely recognized as threats to pristine marine ecosystems. Monitoring marine contaminants serves 2 primary purposes: (1) tracking contaminant loads over time, in coordination with Airborne and Freshwater Contaminants), and (2) maintaining a biannually updated baseline assessment of contaminant levels, useful in the event of an acute impact (e.g., vessel spill).

Specific Monitoring Objectives to be Addressed by the Protocol

Document and track marine contaminant levels through long-term sampling of blue mussels in GLBA and SITK and in conformance with methods in-place at the MusselWatch site at KLGO.

Basic Approach

The recommended approach consists monitoring of select contaminants through assays of blue mussels at selected sites in GLBA and SITK. In 2007, SEAN funded a baseline marine contaminants project (Tallmon 2007) sampled intertidal blue mussels (*Mytilus trossulus*) from several sites in GLBA (both within Glacier Bay and in outside waters) and at SITK and KLGO. Mussels provide an excellent time-integrating bio-proxy for a broad spectrum of marine water pollutants (persistent organic pollutants, polycyclic aromatic hydrocarbons, and metals). The protocol followed was similar to that of NOAA's nationwide Mussel Watch Program (http://www8.nos.noaa.gov/cit/nsandt/download/mw_monitoring.aspx). A single representative site will be selected from the Glacier Bay locations, and a SITK site will be similarly selected. These sites will be monitored in alternate years (mid-summer), starting in 2009. Every attempt will be made to encourage NOAA to add these sites to its larger Mussel Watch Program.

Principal Investigators and NPS Lead

GLBA: Lewis Sharman
SITK: Geof Smith

Development Schedule, Budget, and Expected Interim Products

YEAR	TASK/PRODUCTS	PERSONNEL	SEAN BUDGET ($)
Year 1	Acquire existing (NOAA) marine contaminants protocol, select sampling locations, purchase sampling supplies, and contract a laboratory for analyses. Develop data harvesting strategy. Collect bi-annual contaminants samples, and report results.	GLBA/SEAN staff	$500 for contaminant sampling supplies. $7,500 (3 samples x 2,500) for contaminants sample analysis/shipping.
Year 3	Repeat sampling every other year.	GLBA/SEAN staff; USGS; SITK staff	$500 for contaminant sampling supplies. $7,500 (3 samples x 2,500) for contaminants sample analysis/shipping.

Marine Predators

Justification/Issues Being Addressed

Marine mammals and seabirds in GLBA are among the most emblematic and readily observable wildlife in the park. A large proportion of these species are also of particular management concern, due either to conservation status iconic or charismatic characteristics. Many visitors to GLBA both aspire and expect to observe a variety of seabirds, cetaceans, and pinnipeds. Top trophic-level predators (including marine mammals and seabirds) can serve as an index of ecosystem health because they assimilate and reflect the dynamics of populations at lower trophic-levels.

Specific Monitoring Objective to be Addressed by the Protocol

Determine long-term trends in the abundance and spatial distribution of marine birds and mammals within GLBA proper using grid-based sampling of at-sea surveys twice each summer stratified by along-shore (shoreline) and pelagic line transects that covers approximately 10% of the marine habitat.

Basic Approach

Two approaches can be taken for surveys of top marine predators. First, a monitoring program can focus on the dynamics of a single species, with a sampling design focused on maximizing precision in population estimates by accounting for spatial and temporal process error and minimizing observation error. Although single-species approaches tend to maximize precision and minimize time needed for trend detection, they do not, by definition, account for changes in the dynamics of other species. Too, because population trends of a single species probably will not reflect the dynamics of all components of an ecosystem, it is problematic to use of such trends to infer ecosystem state or condition. A second, alternative approach is to survey a number of upper trophic species simultaneously using systematic transects. This approach is not likely to generate high-precision population estimates for any single species with concomitant rapid trend detection. However, the marine predator community simultaneously results in trend estimates for large number of species or guilds, which, together, are more likely to reflect ecosystem dynamics. This approach would also generate data on species that may not currently be of management concern but might ultimately be of significance as management or understanding of ecosystem linkages evolves.

Between 1999 and 2003 boat-based surveys for marine birds and mammals were conducted annually in and around Glacier Bay proper by USGS. These surveys were originally designed to inventory forage fish and associated predators such as seabirds and marine mammals, and to assess important areas of marine predator concentration in Glacier Bay. However, they also served as a means of surveying multiple species of marine birds and mammals for understanding long-term trends. These systematic surveys were conducted in June of each year covering nearly 30% of total marine habitat, covering the entire shoreline and sampling the offshore with a fine-scale grid. A subset of June transects was surveyed in November of 1999 and repeated in March for four years (2000-2003).

Recent analysis of this data by USGS (Drew et al. 2007) revealed that for most species transect lengths in the 4-8 km range are the best statistical compromise between low variance among a small number of sample units with more normally distributed properties (long transects) and high variability among a large number of sample units with binary properties (short transects). Transect lengths of 4-8km also reflect typical patch sizes for marine bird species present in GLBA. Not surprisingly, stratification (2 levels: nearshore and offshore) increases precision of estimates for many species. Also, simulations showed that sampling approximately 30% of the original survey area provided fairly consistent population estimates for most species, with the exception of highly aggregated species such as Surf Scoters (*Melanitta perspicillata*). For all species, coefficients of variation (CVs) increased rapidly as coverage decreased below 30% of the original effort, suggesting that reasonable power to detect change could occur with a reduction of survey effort by 70%. Monitoring cost would be reduced somewhat, though not nearly proportionate to the reduction in effort; samples would be collected over the same spatial area (Glacier Bay proper), and travel time would not change dramatically. Although this approach will provide trend data for a larger number of species, because marine bird and mammal surveys are inherently variable, if sampling continued at levels used in the 1999-2003 baseline surveys, sufficient power to detect, a 50% decline in abundance would require 15-25 years. Protocol development will focus first on identifying the species of greatest interest to GLBA, then designing the sampling effort to maximize power to detect changes in those species.

Principal Investigators and NPS Lead

NPS: Brendan Moynahan
USGS: John Piatt
USGS: Gary Drew

Development Schedule, Budget, and Expected Interim Products

2008-2012: NPS collaborates with USGS to develop and refine survey protocol and implement surveys.

Oceanography

Justification/Issues Being Addressed

GLBA is quintessentially a marine park. Along with weather, glaciers, and landform, oceanography drives the park's ecosystems and entirely dominates the dynamics of many biological communities. A number of the SEAN Vital Signs applicable to GLBA (e.g., Marine Predators, Intertidal Invertebrate Communities, Kittlitz's Murrelets) are themselves directly or indirectly influenced by oceanography. By monitoring marine water mass characteristics, managers can detect changes that are likely to influence the condition of resources of many types throughout the region. Oceanographic monitoring is important to understanding the Southeast Alaska marine system, the linkage between atmospheric and oceanic systems, and the implications of climate change in high-latitude systems.

Standard oceanographic data are universally recognized among marine scientists as essential to understanding how ocean waters move and behave, and thereby drive the associated biology. Along with water column stability and nutrient availability, the availability of light drives primary productivity which then controls the dynamics of secondary productivity and indeed the entire marine trophic web. Ocean acidification (declining pH) is one result of global warming/climate change (increasing atmospheric carbon dioxide concentration) that may have profound effects on marine ecosystems.

An excellent long-term (15 y) dataset of oceanographic parameters has accumulated from a series of 2-7 cruises per year during which standard CTD (Conductivity, Temperature, Depth) casts have been made at 24 permanent stations in Glacier Bay and adjacent waters in Icy Strait. It is believed that GLBA's marine waters are of exceptional quality, and that park marine waters can serve as a pristine reference against which other NPS marine waters can be compared.

Specific Monitoring Objective to be Addressed by the Protocol

Measure spatial and temporal oceanographic trends in water temperature, salinity, turbidity, pH, dissolved oxygen, light penetration, and primary productivity in marine waters of Glacier Bay proper.

Basic Approach

The recommended approach consists of two elements: (1) periodic measurement of standard oceanographic parameters in Glacier Bay proper, and (2) development and implementation of a system to harvest others' oceanographic data from outside Glacier Bay proper.

(1) Standard Oceanography
With technical assistance from the USGS, GLBA has developed and implemented a detailed protocol describing CTD casts to measure water temperature, salinity, photosynthetically active radiation (PAR), optical backscatterance (OBS – turbidity), and chlorophyll-*a* fluorescence (proxy for phytoplankton concentration = primary productivity index) throughout the water column at 24 permanent stations (Hooge et al. 2003, Etherington et al. 2007). The stations extend from just outside the mouth of Glacier Bay proper (the Bay's source waters in Icy Strait)

up to the heads of both the East and West Arms. They are generally mid-channel and equidistant, sampling a range of depths from sills to deep basins across the Glacier Bay distance-from-tidewater-glaciers/turbid-outwash-streams gradient. Stations are visited seasonally every year, generally during spring (Mar.-Apr.), summer (July), fall (Oct.), and winter (Dec.-Jan.). Initially the cruises were made using a large (50-ft.), relatively slow (10 kts.) vessel, but in recent years it has been discovered that the cruises can usually be accommodated by an adequately-equipped smaller (30-ft.), faster (25 kts.) vessel, allowing the entire transect to be accomplished in two days during all but the winter season. In winter, poor weather and limited daylight often require a larger vessel and/or an additional day. This protocol, with the modifications/additions immediately below, will be adopted by the SEAN.

Important revisions to this protocol include addition of dissolved oxygen and pH probes to the CTD instrument. Two stations (Geikie Inlet) should be removed from the current transect to reduce sampling time, to be replaced by 1-2 new stations (Icy Strait source water).

(2) Data Harvest
Collecting oceanographic data from outside Glacier Bay proper requires a large vessel and is cost-prohibitive for the SEAN. Nevertheless, these "outer waters" mix freely with adjacent park waters and are critically important to understanding the dynamics of the park's marine ecosystem. Any data from Icy Strait, Cross Sound, or the Outer Coast (out to 100 km) will be harvested from other agencies/institutions (e.g., NOAA, University of Alaska, ADF&G) and analyzed/archived to become part of a long-term record used to elucidate trends. An example data source is the Alaska Ocean Observing System (AOOS).

Principal Investigators and NPS Lead

NPS: Lewis Sharman
USGS: John Piatt, Alaska Science Center

Development Schedule, Budget, and Expected Interim Products

YEAR	TASK/PRODUCTS	PERSONNEL	SEAN BUDGET ($)
Year 1	Refine existing GLBA oceanographic protocol to include added probes/parameters and stations. Purchase dissolved oxygen and pH sensors and add to CTD instrument package. GLBA provides vessel support and CTD. Develop SEAN oceanographic data archive. Continue annual sampling (4 cruises/year). Develop data harvesting strategy.	GLBA/SEAN staff; USGS	$5,000 for DO and pH probes. $10,000 for quarterly sampling operation (annual cost)

Weather and Climate

Justification/Issues Being Addressed

Climate – the average weather conditions over a long period of time – is widely recognized as one of the most fundamental drivers of ecological condition. Accordingly, SEAN identified weather and climate as an important Vital Sign. SEAN encompasses strong climate gradients driven by elevation and geography and driven by maritime influences. These climate gradients are intrinsic to the ecosystem patterns and vegetative and faunal communities found in network parks. In general, Alaska has a sparse dispersion of climate monitoring sites (Simpson et al. 2002). Currently, the few permanent long-term climate monitoring sites in SEAN region are biased towards low elevation areas of human habitation bordering the parks, and there are large regions within SEAN parks (particularly GLBA, due to size and topography) with no climate monitoring stations at all. Strategic deployment of climate stations in the SEAN parks will provide data not heretofore available on the climate patterns in the parks. This dataset is a covariate of fundamental importance when analyzing observed changes in the freshwater, marine, and terrestrial plant and animal communities. In addition, the climate stations may provide real-time weather data, which would be of immediate use in park operations. Climate data from the SEAN will also contribute significantly to understanding of Alaska climate by filling in some of the big gaps in the existing multi-agency climate monitoring station network, and by contributing to accurate measurement of winter precipitation.

Specific Monitoring Objective to be Addressed by the Protocol

Determine variability and long-term trends in climate for all SEAN parks through monthly and annual summaries of descriptive statistics for selected weather parameters, including air temperature, precipitation, snow depth, and wind speed and direction.

Basic Approach

The SEAN Weather and Climate protocol will mirror the approved protocols produced by the Central Alaska and the Southwest Alaska Networks. The basic approach for meeting the objectives will be to (1) ensure that all existing long-term stations in and around the network continue to operate and produce high quality data; (2) add new climate stations in areas that are not currently represented, including year-round precipitation gauges; (3) ensure that the maintenance and calibration of the stations and sensors is a priority; (4) engage in partnerships with state and federal agencies involved in climate and weather monitoring in SEAN and also with university researchers interested in high latitude climate changes; (5) ensure that the data produced by the new SEAN stations is available for use by NPS staff, researchers, and the public via the internet, and (6) archive the digital data with the Western Regional Climate Center (WRCC).

The Alaska Region climate monitoring issues are consistent statewide and benefit from shared resources and established partnerships. SEAN will use foundation documents drafted by the WRCC (Davey et al. 2007) to design and develop a strategy that will focus on high latitude climate issues and remote operations. A robust, integrated Alaska NPS climate monitoring program will be more valuable and efficient and serve to describe the climate of Alaska

holistically and provide a more complete understanding of the complexities of this system that affects Alaska National Parks.

The WRCC will archive and disseminate the data. The hourly data from the automated stations will be disseminated for public viewing and use (in near real-time) via the internet. WRCC maintains a dynamic website complete with data querying capacity. Data products available on the WRCC website are daily summary (with wind chill and heat index), monthly summary, time series graphs, wind rose graphs and tables, data lister, data inventory, and station metadata. We have entered into a MOU with WRCC through which they will develop web-based tools to develop reports and analysis that is specific each user's needs, as well as a standard template for annual reporting.

Principal Investigators and NPS Lead

Principal Investigators and Park Leads:
GLBA: Lewis Sharman
KLGO: Dave Schirokauer
SITK: Geoffrey Smith

Collaborator:
Pam Sousanes, Denali National Park and Preserve

Development Schedule, Budget, and Expected Interim Products

In 2008, SEAN will begin identifying candidate weather station sites (3-5 candidate sites in GLBA and 2-4 sites in KLGO) and will select equipment for purchase in 2009. The NWS station at the Sitka airport will meet the weather monitoring needs for SITK. Also in 2008, SEAN will draft the monitoring protocol and establish a partnership with the WRCC to formalize the implementation and data reporting processes. Final site selection will occur in 2009 and stations will be deployed in 2010.

Appendix D

Southeast Alaska Network
Board of Directors Charter

I. Introduction

This document establishes a Board of Directors for the Southeast Alaska Inventory and Monitoring Network. Its purpose is to outline the procedures by which the Board will implement and manage the long-term vital signs monitoring program and thereby fulfill one component of the Natural Resource Challenge.

The Southeast Alaska Network consists of three units of the National Park Service, Glacier Bay National Park and Preserve, Klondike Gold Rush National Historical Park, and Sitka National Historical Park. A four-member Board of Directors will consist of the superintendent of each park, and the Alaska Regional Inventory and Monitoring (I&M) Coordinator. The Southeast Alaska Network I&M Coordinator and the Alaska Regional Science Advisor will serve as non-voting members of the Board.

II. Responsibilities of the Board of Directors

The Board of Directors (The Board) shall oversee the development and implementation of a comprehensive long-term monitoring program for the Southeast Alaska Network. It shall be responsible for directing the inventory and monitoring program of the network and for decisions concerning planning, budgets, personnel, schedules, reporting, and program accountability. The Board shall insure that the monitoring program is built upon a collaborative vision for the network and considers the mandates, needs, interests, and goals of all park units.

The Board shall work to maintain the integrity of Vital Signs Monitoring funds and staff and assure that monitoring resources are not diverted or reassigned to other programs. Additionally, The Board shall ensure that park staff selected to participate in the Southeast Alaska Network are fully committed to vital signs monitoring and establish personnel appraisal systems that reward Network cooperation. Ultimately, The Board shall respond to what we have learned through long-term monitoring and instigate new management actions or modify existing management actions where necessary to protect or restore park ecosystems.

III. Procedures

Board Meetings: Any member can call meetings of the Board, but there will be at least one formal meeting annually. Meetings may be held in person or by teleconference. The Board may also choose to decide matters by electronic mail with the consent of all voting members. At the first meeting, the Board shall elect a Chair who shall be responsible for calling and conducting future meetings. The Southeast Alaska Network I&M Coordinator shall serve as staff to the Chair to arrange meetings and logistics, produce agendas, record and distribute the minutes of board meetings, and coordinate efforts between the Board and the Technical Committee.

Alternates and Quorums: If either park superintendent cannot attend or otherwise participate in a meeting of the board, they may assign an alternate. The attendance of both superintendents or their alternates shall be required to constitute a quorum.

Decision Making: Actions of the Board will require the unanimous consent of the voting members. If the Board cannot reach a consensus decision, the matter will be referred to the Regional Director. All decisions will be documented with responsible individuals and deadlines identified, as appropriate.

Technical Advisory Committee: The Board shall create a Technical Advisory Committee to provide technical assistance and advice to the Board. The Technical Advisory Committee is a linkage between scientists and managers, between NPS and other natural resources agencies, and is crucial to establishing a shared vision of desired ecosystem conditions, for specifying how the vision can be achieved, and for monitoring and measuring progress toward goals. The Technical Advisory Committee is comprised of natural resource managers and scientists (including scientists from outside of the NPS who work in the parks and are familiar with park issues) and chaired by the Southeast Alaska Network I&M Coordinator. The Committee is a working group, decision-making, and technical oversight body. The Alaska I&M Coordinator, Southeast Alaska Network Coordinator, the Chief of Resources from Glacier Bay, the Natural Resources Specialists from Klondike Gold Rush and Sitka are the core decision-making body. Park and Alaska Support Office (AKSO) scientists named to the committee will contribute technical support and attend meetings as needed. The Board, with guidance from the Southeast Alaska Network Coordinator, will ensure that membership of the technical committee is reflective of the resource issues, management challenges, and ecological breadth encompassed by the Southeast Alaska Network.

Specific tasks of the Technical Advisory Committee will include:

1. Compile and summarize existing information about park resources,
2. Plan and conduct a scoping workshop to develop a strategic monitoring plan,
3. Develop a strategic monitoring plan,
4. Evaluate proposals, sampling designs, methods and protocols,
5. Provide guidance and resources needed to sustain on-the-ground inventory and monitoring efforts,
6. Assist the Southeast Alaska Network I&M Coordinator in the preparation of the Annual Work Plan and Annual Report,
7. Assist the Southeast Alaska Network I&M Coordinator in planning and conducting a Five Year Program Review.

The products and recommendations of the Technical Advisory Committee will be presented to the Board for discussion and approval or modification. Sustained collaboration, interaction, and commitment among members of the Technical Advisory Committee are essential for the Network to achieve the goals of long-term vital signs monitoring. To facilitate this process, The Board delegates the Network I&M Coordinator with the responsibility for establishing protocols for the operation and performance of the Technical Advisory Committee. This responsibility will include setting standards for: 1) communication among Committee members; 2) procedures

for reviewing and commenting on plans and reports; 3) establishment of timelines; and 4) making final determinations on the selection of sampling designs, monitoring strategies, and implementation schedules.

Monitoring Plan: The Network Coordinator and the Technical Advisory Committee shall prepare a strategic monitoring plan for the network that identifies vital signs to be monitored, justification for why these were selected, sampling protocols, staffing needs, and data management strategy. This plan shall be developed in accordance with WASO guidelines as to content and timeline for delivery of interim and final products.

Annual Work Plan: Working with appropriate subgroups and others, the Southeast Alaska Network I&M Coordinator will present a proposed Draft Annual Work Plan to the Board for discussion, modification and approval in time to meet the due dates outlined below. The Annual Work Plan will identify specific accomplishments and products, responsible individuals and deadlines, an I&M program budget to which park or office funds are assigned, and additional and potential funding sources (both NPS and others). The Draft Annual Work Plan will follow WASO specifications for such work plans, and will be submitted to WASO, through the Regional Director, by November 8th each year. A Final Annual Work Plan will be submitted to WASO by January 31 each year.

Annual Report: Working with appropriate subgroups and others, the Southeast Alaska Network I&M Coordinator will present a proposed Annual Report to the Board for discussion, modification and approval. The Annual Report will detail specific accomplishments and products, lessons learned, coordination with others and a budget summary and will follow WASO specifications for such reports. A detailed accounting of all I&M program funds assigned to each park and office will be appended to the Annual Report. This Annual Report will be widely distributed and posted at appropriate websites on the Internet. The Annual Report will be submitted to WASO, through the Regional Director, by November 8th each year.

Five Year Program Review: Beginning at the end of fiscal year 2009 and every five years thereafter, the Network will undertake a comprehensive program review to be conducted by national and regional NPS specialists, as well as qualified independent specialists from other agencies and organizations. The purpose of this review will be to evaluate accomplishments and products, protocols used for gathering data, data management, fiscal management, and staffing. The Program Review shall provide the principal basis for any significant changes in program direction, as well as reassignment of resources to any park or office.

IV. Amendments

The Board may amend this Charter at any time by unanimous vote.

Approval Signatures

Superintendent, Glacier Bay National Park and Preserve — Date: 2/10/03

Superintendent, Klondike National Historical Park — Date: 2/10/03

Superintendent, Sitka National Historical Park — Date: Feb 10, 2003

Alaska Regional I&M Coordinator — Date: 2-10-03

Amendment 1 (October 2005)

This amendment designates a Point of Contact (POC) for the Southeast Alaska Network (SEAN) NPSpecies database as follows:

I. Justification

The National Park Species database (NPSpecies) is one of a suite of Service-wide databases developed by the Inventory and Monitoring Program (I&M). NPSpecies is designed to document the occurrence of vertebrate, vascular plant and other species in national park units, and to substantiate these occurrence records by scientifically credible, high-quality references, vouchers, and observations. The master version of NPSpecies is a password-protected, web-based system which is accompanied by a PC-based version that can be run from an individual computer using Microsoft Access.

The National Park Service-wide I&M Program has requested that parks designate Points of Contact (POC) for managing NPSpecies data for each park. This amendment designates the SEAN Data Manager as the POC for all three park units within Southeast Alaska Network. In July 2004 the SEAN Data Technician, under the guidance of the Data Manager, began to populate the NPSpecies and verify information. By the end of FY 2005 it is anticipated that a first iteration of vascular plant and vertebrate species lists will be completed and can be reviewed and certified.

II. SEAN NPSpecies Point of Contact Roles

The SEAN POC will:

1. *Manage web-based NPSpecies access.* The POC will acquire login and password codes for all network park staff needing access to NPSpecies;

2. *Advise park staff on NPSpecies use.* The POC will assist with questions users may have on how to query or manipulate NPSpecies data;

3. *Oversee conversion of legacy data sets into formats compatible with NPSpecies.* The POC will work with park staff to add any appropriate information to NPSpecies;

4. *Ensure any new NPSpecies-related data collected from I&M or park projects are incorporated into NPSpecies.* The POC will work with I&M cooperators, WASO staff, and park resource management staff to ensure that NPSpecies is updated to reflect new data;

5. *Ensure that sensitive data identified by park/network scientists are designated as such, and that access to these data are restricted to the appropriate level.* The POC will ensure that these sensitive records are appropriately coded in NPSpecies and distribution limited appropriately;

6. *Make species lists available for review by appropriate individuals.* The completeness and accuracy of species-list data in NPSpecies will be assessed by qualified reviewers as needed;

7. *Work with the network parks to ensure that new species vouchers destined for entry into Automated National Catalogue System (ANCS+) are also entered into NPSpecies;* and

8. *Ensure that current species nomenclature is used for park species lists and is compatible among network parks.*

III. NPSpecies Point of Contact Designation

By this amendment the SEAN I&M Program Data Manager is designated as the NPSpecies POC on NPSpecies issues and management for each of the three park units within SEAN. As POC for each park the SEAN Data Manager will fill the roles listed under Section II of this agreement. A centralized effort at the network level helps ensure high quality control standards and relieves park resource management staff from many of the ongoing tasks related to NPSpecies database management. The SEAN Data Manager will serve in the POC role for each park until such time that park species list development and certification is complete. At this juncture individual parks will have the choice of taking over the role of POC or continuing with designation of the SEAN Data Manager as the park POC.

CHARTER

BOARD OF DIRECTORS
SOUTHEAST ALASKA INVENTORY AND MONITORING NETWORK (SEAN)

Approval Signatures

Jamie Patrick Lee — 10/7/05
Superintendent, Glacier Bay National Park and Preserve — Date

10/7/05
Superintendent, Klondike Gold Rush National Historical Park — Date

10/7/05
Superintendent, Sitka National Historical Park — Date

Sara Wesser — 10/7/05
Inventory and Monitoring Coordinator, Alaska Region — Date

Appendix E

Justification, Policies, and Legislative Authorities for Long-Term Monitoring

Justification for Integrated Long-Term Monitoring

Knowing the condition of natural resources in national parks is essential to the NPS's mission to manage park resources "unimpaired for the enjoyment of future generations." Park managers entrusted with stewardship of our public lands have long known that decision-making related to protecting ecosystems is complex. They need relevant, up-to-date information to understand how the condition of park resources is changing over time in response to natural processes and human activities. At the most basic level, we cannot evaluate appropriate ecosystem function, assess impairment, or develop an appropriate management responses when the bounds of natural variability are not known, because we cannot identify when conditions are outside an expected range of variation. Similarly, without the fundamental perspective, reliable identification of resource trends is difficult.

In 1992, the National Research Council (1992) reviewed the natural resource management program of the NPS and concluded that "if the National Park Service is to meet the scientific and resource management challenges of the twenty-first century, a fundamental metamorphosis must occur within its core." That metamorphosis materialized when the NPS implemented a strategy to standardize inventories and monitoring of natural resources on a programmatic basis throughout the agency. The effort was undertaken to ensure that the approximately 270 park units with significant natural resources possess the resource information needed for effective, science-based, managerial decision-making and resource protection. The national strategy consists of a framework comprising three major components:

1. Completion of basic natural resource inventories in support of future monitoring efforts;
2. Creation of experimental Prototype Monitoring Programs to evaluate alternative monitoring designs and strategies; and
3. Implementation of operational vital signs monitoring in all natural resource parks.

A fundamental goal of the NPS is to protect or maintain natural ecosystem structure and function in national parklands. Alaska national park units are among the last remaining wilderness areas in the world—large enough to support naturally occurring ecological and evolutionary processes. These parks have been viewed as ecological reference sites that provide us with unique insights into the functioning of ecosystems, in which the effects of humans are minimized (Arcese and Sinclair 1997).

National park managers across the country confront increasingly complex and challenging issues, and are asked to provide scientifically credible data to defend management actions. Protecting and managing parks' natural resources requires a coordinated, ecosystem-level approach because most parks are open systems, with threats such as air and waterborne contaminants or invasive species originating outside of park boundaries. Furthermore, no single spatial or temporal scale is appropriate for all system components and processes (Levin 1992); the appropriate scale for understanding and effectively managing a particular resource will likely vary with the subject resource, and in some cases may require a regional, national, or international effort to understand and effectively manage. National parks themselves are part of larger ecosystems and must be managed in that context.

Natural resource monitoring provides site-specific information necessary to understand and identify changes in complex, variable, and imperfectly understood natural systems. This assists scientists and managers in determining whether observed changes are within natural ranges of variability or may be indicators of unwanted human influences. Thus, monitoring provides a basis for understanding and identifying meaningful change in natural systems characterized by complexity, variability, and surprises. Monitoring data help to define the normal limits of natural variation in park resources and provide a basis for understanding observed changes. Monitoring results may also be used to detect trends that may lead to impairment and to identify the need to initiate or change management practices. Understanding the dynamic nature of park ecosystems and the consequences of human activities is essential for management decision-making to maintain, enhance, or restore the ecological integrity of park ecosystems and to avoid, minimize, or mitigate ecological threats to these systems (Roman and Barrett 1999).

The intent of the NPS monitoring program is to track a subset of park resources and processes, known as "vital signs." Vital signs are determined to be the most significant indicators of the ecological condition of a specific resource that is important to each park. This subset of resources and processes is part of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," and the various ecological, biological, and physical processes that act on these resources. In situations where natural areas have been so highly altered that physical and biological processes no longer operate (e.g., control of fires and floods in developed areas), information obtained through monitoring can help managers understand how to develop the most effective approach to restoration or, in cases where restoration is impossible, ecologically sound management. The broad-based, scientifically sound information obtained through natural resource monitoring will have multiple applications for management decision-making, research, education, and promoting public understanding of park resources.

Role of Inventory, Monitoring, and Research in Resource Management

Monitoring is a central component of natural resource stewardship in the National Park Service and, in conjunction with natural resource inventories and research, provides the information needed for effective, science-based managerial decision-making and resource protection (Figure 1.2). The network approach facilitates collaboration, information sharing, and economies of scale in natural resource monitoring and provides parks with a minimum infrastructure for natural resource monitoring that can be built upon in the future.

The most widely identified application of monitoring is that of enabling managers to make better informed management decisions (White and Bratton 1980, Croze 1982, Jones 1986, Davis 1989, Quinn and van Riper 1990). For example, monitoring rates of coastal shoreline erosion and accretion can help park managers assess risks to archeological sites or aid in decisions regarding the placement of backcountry cabins or other structures.

Monitoring provides a tool to address issues that occur at multiple sites in a park or multiple parks within a network, rather than addressing site-specific problems individually. From such a holistic view, managers can develop general principles and guidelines that can be applied broadly to a particular type of issue.

In large wilderness park units, an important application of monitoring information is simply to gain insight into how complex park ecosystems function (Croze 1982). By gathering data over long periods, correlations between different attributes (such as predator and prey populations) become apparent, and resource managers gain a better general understanding of the ecosystem. In turn, this knowledge may support the development of desired conditions and management actions when resource conditions fall outside of a desirable state.

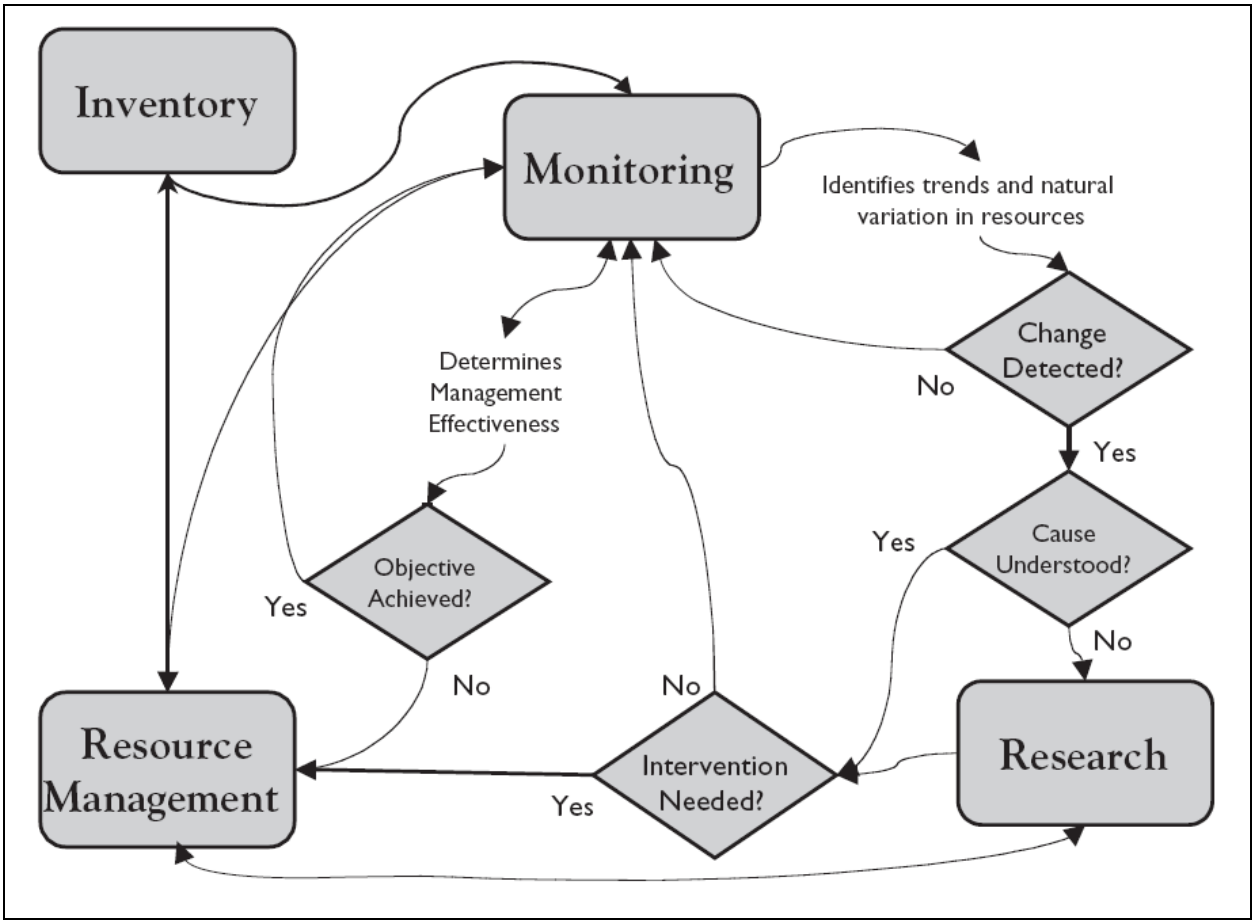

Figure ***Error! No text of specified style in document.****. Relationships between monitoring, inventories, research, and natural resource management activities in national parks (from McCluskie and Oakley 2005).*

Similarly, some authors suggest that it is important to document changes for the sake of familiarity with the resources (Halvorson 1984, Croze 1982). The responsibility of resource managers includes an awareness of changes in resources under their stewardship, even if no specific management decisions or actions are involved. For example, a park may want to monitor succession in areas where glaciers are retreating even if resource managers do not contemplate active management of the vegetation. Understanding of such natural processes better allows managers to detect changes that may be anthropogenic and appropriate for direct management decision or action.

Another use of monitoring information involves convincing others to make decisions benefiting national parks (Johnson and Bratton 1978, Croze 1982). Some aspects of monitoring may focus

on documenting specific internal or external threats. For example, parks and neighboring coastal landowners may monitor concentrations of hydrocarbons in marine benthic invertebrates to document the effects of offshore oil and gas activities on nearshore intertidal communities. In that case, the information may convince local governments, Native corporations, industries, or even courts of law to make or enact regulations benefiting national parks.

Monitoring sensitive species, wilderness-dependent species, or entire communities in relatively undisturbed wilderness park units can provide park managers, stakeholders, and the public with a kind of "canary in the mine"—an early warning of the effects of human activities before they become noticeable in more impacted areas (Davis 1989, Wiersma 1984). For example, locations initially free from local sources of pollution may show a more pronounced response to the effects of long-range transport and deposition of airborne contaminants than adjacent developed areas. Early detection may allow managers to take successful remedial action that would be difficult or impossible later on.

Finally, a monitoring program can provide basic background information that is needed by park researchers, public information officers, interpreters, and those wanting to know more about the area around them (Johnson and Bratton 1978). Data such as basic weather and climate information, plant phenology, and records of major disturbances (such as volcanic eruptions and landslides) are useful on a periodic basis to those working in or visiting the parks.

NPS Policies and Mandates that Link Monitoring and Management of Parks

The enabling legislation establishing the NPS and its individual park units clearly mandates, as the primary objective, the protection, preservation, and conservation of park resources in perpetuity for the use and enjoyment of future generations (NPS 1980). NPS policy and pertinent legislation (National Parks Omnibus Management Act of 1998) require that park managers know the condition of natural resources under their stewardship and monitor long-term trends in those resources to fulfill the NPS mission of preserving parks unimpaired (Figure 1.1; see Summary of Laws, Policies, and Guidance). The laws and management policies that follow provide the mandate for inventories and monitoring in national parks.

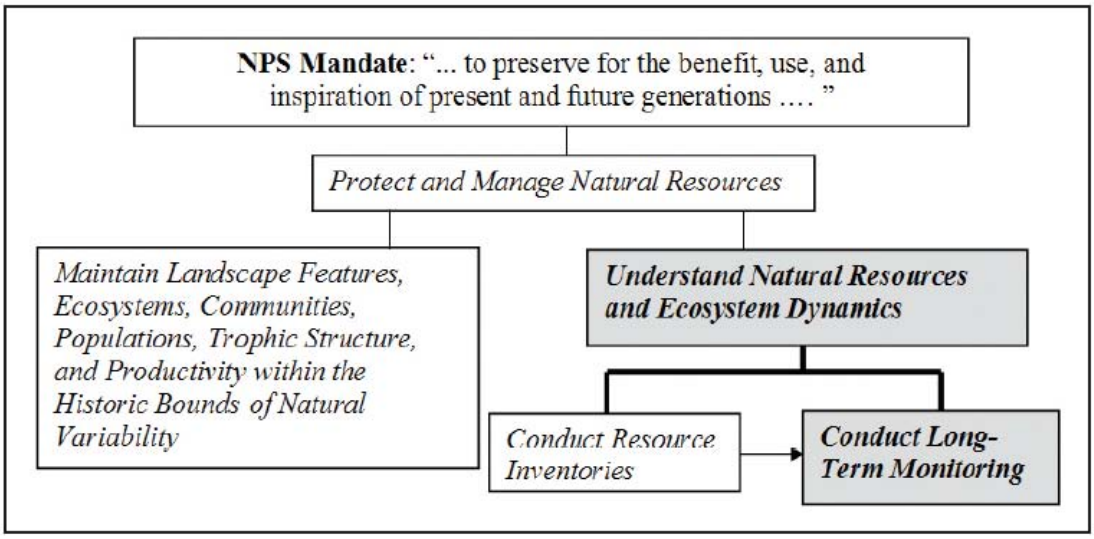

Figure 2. Relationship between park mandates, resource protection, and long-term monitoring.

The mission of the NPS (NPS Organic Act, 1916) is:

"*...to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purposes of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.*"

Congress strengthened the NPS's protective function and provided language important to recent decisions about resource impairment when it amended the Organic Act in 1978 to state that *"the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established…."*

More recently, the National Parks Omnibus Management Act of 1998 established the framework for fully integrating natural resource monitoring and other science activities into the management processes of the National Park System. The act charges the Secretary of the Interior to "*continually improve the ability of the National Park Service to provide state-of-the-art management, protection, and interpretation of and research on the resources of the National Park System,*" and to *"assure the full and proper utilization of the results of scientific studies for park management decisions*." Section 5934 of the Act requires the Secretary of the Interior to develop a program of "*inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources*."

Congress reinforced the message of the National Parks Omnibus Management Act of 1998 in its text of the FY 2000 Appropriation Bill:

"The Committee applauds the Service for recognizing that the preservation of the diverse natural elements and the great scenic beauty of America's national parks and other units should be as high a priority in the Service as providing visitor services. A major part of protecting those resources is knowing what they are, where they are, how they interact with their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data."

The 2006 NPS Management Policies updated previous policy and specifically directed the Service to inventory and monitor natural systems:

"Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will evaluate possible causes and effects of changes that might cause impacts on park resources and values. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions."

Further, *"The Service will:*

- *Identify, acquire, and interpret needed inventory, monitoring, and research, including applicable traditional knowledge, to obtain information and data that will help park managers accomplish park management objectives provided for in law and planning documents;*
- *define, assemble, and synthesize comprehensive baseline inventory data describing the natural resources under NPS stewardship, and identify the processes that influence those resources;*
- *Use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals;*
- *Analyze the resulting information to detect or predict changes (including interrelationships with visitor carrying capacities) that may require management intervention and to provide reference points for comparison with other environments and time frames; and*
- *Use the resulting information to maintain--and, where necessary restore-- the integrity of natural systems (2006 NPS Management Policies).*

Additional statutes that provide legal direction for expending funds to determine the condition of natural resources in parks, and that specifically guide the natural resource management of Network parks include the following:

- Taylor Grazing Act 1934;
- Fish and Wildlife Coordination Acts, 1958 and 1980;
- Marine Mammal Protection Act 1972;
- Wilderness Act 1964;
- National Historic Preservation Act 1966;
- National Environmental Policy Act 1969
- Clean Water Act 1972, amended 1977, 1987;
- Endangered Species Act 1973, amended 1982;
- Migratory Bird Treaty Act 1974;
- Forest and Rangeland Renewable Resources Planning Acts, 1974 and 1976;
- Mining in the Parks Act 1976;
- American Indian Religious Freedom Act 1978;
- Archaeological Resources Protection Act 1979;
- Federal Cave Resources Protection Act 1988;
- Clean Air Act, amended 1990; and
- Wild and Scenic River Act 1990.

Appendix F

The Conceptual Foundations for Monitoring In the Southeast Alaska Network

Conceptual Foundation for Monitoring

The SEAN embodies a vast, diverse, and dynamic landscape that changes through space and time in response to inputs of energy and materials, natural events, and the influence of humans. Monitoring at such large geographic scales requires a framework for understanding relationships between components and processes of interacting ecosystems and the human activities that affect them. For example, to understand how park ecosystems respond to adverse effects arising from human activities we need to be able to distinguish between changes that fall within and outside the range of natural variability for a reference time period. This requires scientifically sound information on ecosystem status and trends acquired through long-term monitoring. Short-term monitoring provides an incomplete picture because annual fluctuations may reflect variables that cycle through decades such as precipitation patterns, temperature regimes, or predator and prey populations. This is particularly true in subarctic regions, such as in Southeast Alaska, where biological processes are relatively slow. In consideration of this, our conceptual foundation provides a guide for monitoring and research.

Landscape-Based Monitoring: Why is it Important to Have a Landscape Perspective?

Theories developed to support studies of ecosystems are different from those that form a basis for studies of the ecology of landscapes (Sanderson and Harris 2003). A key difference is that time and space are rarely independent variables in ecosystem studies, even in watersheds. The SEAN landscape is a heterogeneous land area composed of interacting ecosystems that differ structurally in the distribution of species, communities, energy, and materials. This perspective is important for park managers in that the organisms that can exist (including their movement patterns, interactions, and influence on ecosystem processes) are constrained by the sizes, shapes, and patterns of interspersion of habitat across the landscape.

Landscape ecology is a science that explores how a heterogeneous combination of ecosystem attributes is structured, functions, and changes. Four principles of landscape ecology have particular importance for long-term monitoring in large Alaska national parks. These landscape principles deal with time, place, disturbance, and species. We discuss each principle below.

Time Principle

Ecological processes function at many timescales, some long and some short; and ecosystems change through time. The time principle has several important implications for monitoring. First, the current composition, structure, and function of park ecosystems are, in part, a consequence of previous events or conditions that occurred decades to centuries to millennia earlier. Second, the full ecological effects of human activities often remain unseen for many years because of the time it takes for a given action to propagate through components of the system. Finally, the imprint of natural disturbance or a land use may persist on the landscape, constraining processes or species occurrence and abundance for decades or centuries (Dale et al. 2000).

We need to understand how the temporal dynamics of landscape change in parks affect ecological structure and process. Short-term ecological events that we observe every day often have their origins in transient, rare, slow, or subtle processes. Similarly, ecosystem response to

natural and human-induced events may be cyclical, directional, episodic, or catastrophic. It is extremely difficult for humans to sense changes occurring over decades. Magnuson (1990) coined the term "the invisible present" to refer to the loss of information and tendency for misinterpretation when we fail to observe the present in appropriate timescales.

In the invisible present one finds timescales of the invasion of non-native plants and animals; bioaccumulation of toxins such as mercury; shifts in metapopulation dynamics of large mammals; and carbon dioxide-induced global climate change. These and other events move too slowly to be appreciated in real time, yet their accumulation results in real change over decades.

In the past, natural resource research and management in Alaska parks has been characterized by short-term (1 to 3 year) projects, and in most cases, frequent staff turnover. Short-term projects or breaches in continuity associated with park staff turnover confound interpretation of annual fluctuations in populations that may reflect such variables as precipitation patterns, temperature regimes, predator populations, or natural cycles.

Place Principle

Local climatic, hydrologic, edaphic, and geomorphologic factors as well as biotic interactions strongly affect ecological processes and the abundance and distribution of plants and animals at any one place. Local environmental conditions reflect location along gradients of elevation, temperature, salinity, longitude and latitude, and the multitude of mesoscale physical, chemical, and edaphic factors that vary within these gradients.

Ecological systems are characterized by multiple drivers acting at multiple scales, complex patterns of spatial variability, and unidentified thresholds. Because ecological processes and responses depend on the spatial context of an observation as well as on its temporal context, the analogy of an "invisible place," as with the invisible present, may be appropriate.

Park resource studies often are conducted at small spatial scales due to logistical constraints and costs, and often in response to management issues that are perceived to be localized. In field surveys, park biologists often make observations at different sites with the aim of relating biological response variables (i.e., the abundance of a species or the structure of an ecological community) to environmental variables. However, the ability to take a Network-wide view is important because when the same system is observed at several spatial scales, completely different characteristics in the distribution of organisms can be revealed (Turner et al. 1989).

Reciprocal relationships often exist among landscape structure and composition and ecological processes (Dale et al. 2000). To understand the relation between pattern and process requires that we move beyond simple descriptions at local scales to a broader assessment at multiple spatial scales. For example, monitoring programs that target a few parameters or a single entity, such as brown bear distribution or glacial extent, have limited value for understanding ecological processes, modeling, forecasting change, and developing scenarios to protect park resources. By monitoring a range of physical, chemical, and biological variables through time, it is possible to gain an understanding of how ecosystems function and respond to change. Additionally, coupling monitoring with research and modeling makes it possible to predict what might happen in the future and, where possible, devise appropriate management response strategies.

Disturbance Principle

It is imperative that we understand, and in some cases quantify, the drivers of change in ecological systems. These drivers include both ongoing natural processes, such as weather and interannual climatic variability, and random disturbances. Understanding the importance of the influence and magnitude of different drivers of change, the collective influence of multiple stresses, the ecological consequences of the changes, and the feedbacks between ecosystems and their physical environments (e.g., composition of the atmosphere or ocean, land use, water quality, sediment flux) is critical to the development of strategies for monitoring.

A disturbance is an event that disrupts ecological systems, changes landscape patterns, and can impose both temporal and spatial heterogeneity on ecological systems. Disturbance events are usually episodic, such as avalanches or wildfires, or stochastic (random), such as earthquakes. Episodic disturbances are part of the natural variability of a system, whereas stochastic disturbances change the trajectory of a system and may promote changes outside of a reference range of natural variability.

Disturbance has many important effects on communities and ecosystems, including enhancing or limiting biological diversity, initiating succession, and creating landscape patterns that influence many ecological factors, from movements and densities of organisms to functional attributes of ecosystems (Forman 1995).

Major natural disturbances, such as earthquakes or floods, can have sudden and widespread effects on Network parks. The concept of geoindicators describes common earth processes that, in less than a century, are liable to change in magnitude, direction, or rate, enough to affect ecosystem condition and landscape structure (Berger and Iams 1996). In addition, human-induced disturbances, such as oil spills, have similar potential to exert sudden, widespread, and long-lasting change.

Species Principle

Species respond to change, signal change, or directly affect ecological systems and landscapes in diverse ways. Indicator species (such as harbor seals, *Phoca vitulina*) are important because their condition indicates the status of a larger functional group of species, reflective of the status of key habitats, or symptomatic of the action of a stressor. Keystone species (such as sea otters, *Enhydra lutris*) have greater effects on ecological processes than would be predicted from their abundance or biomass alone (Power et al. 1996). Ecological engineers (such as beavers, *Castor canadensis*) alter the habitat and, in doing so, modify the fates and opportunities of other species (Naiman and Rogers 1997). Umbrella species (such as brown bears) either have large area requirements or use multiple habitats and thus overlap the habitat requirements of many other species. Link species (such as sockeye salmon, *Oncorhynchus nerka*) exert critical roles in the transfer of matter and energy across trophic levels or provide critical links for energy transfer within complex food webs. Trophic cascades occur when changes in the abundance of a focal species or guild of organisms at one trophic level propagate across other trophic levels, resulting in dramatic changes in biological diversity, community composition, or total productivity.

Changes in the abundance and distribution of focal species are diverse and can affect ecosystems through such processes as competition, mutualism, dispersal, pollination, and disease and by

modifying habitats and abiotic factors. For example, brown bears are an important vector for transferring marine nutrients to riparian forests, through dissemination of partially eaten salmon carcasses and salmon-enriched wastes (Ben-David et al. 1998, Hilderbrand et al. 1999a). To the extent that this process affects productivity and species composition in riparian forests, interactions of salmon and bears may be characterized as keystone interactions controlling the long-term structure and dynamics of riparian communities (Helfield and Naiman 2002).

Because effects of keystones are diverse and involve multiple steps, they are often unexpected despite their fundamental importance to biological diversity and ecosystem dynamics (Paine 1995, Power et al. 1996). The depletion or removal of a keystone species can radically change the diversity and trophic dynamics of a system. Changes in land use that affect keystone species may spread well beyond the boundaries of a land-use unit. Because the SEAN parks adjoin international, state, National Forest, Native American, and private lands, developments or management actions taken outside parks may create habitats unfavorable to some species and favorable to others, create barriers to movement or dispersal, introduce new predators or competitors, or change existing trophic relationships.

A non-native species can assume a focal species role and cause numerous effects on an ecosystem. Nonnative species have altered community composition and ecosystem processes via their roles as predators, herbivores, competitors, pathogens, or vectors of disease and through effects on water balance, productivity, and habitat structure (Drake et al. 1989).

Conceptual Ecological Models

Most generally, ecology is the study of the distribution and abundance of plants and animals and their interaction with the environment on levels from cellular to ecosystem (Krebs 1985). Other variables – both biotic and abiotic elements of the ecosystems – may be useful in learning about a vital sign and explaining distribution and abundance. In this Appendix, we discuss our use of conceptual models to represent our understanding of the basic structure and function of SEAN ecosystems.

Ecological monitoring programs are designed and implemented based on an understanding of how the subject ecosystems function. Based on both knowledge and assumptions, this understanding should be explicitly presented in conceptual models, so that it is available for discussion, evaluation, and ultimately for refinement through incorporation of information gained through monitoring (Maddox et al. 1999). Indeed, development of conceptual models is a key requirement of the Vital Signs Monitoring Program for each network. Conceptual models play several useful roles in monitoring program design, including:

- Formalizing current understanding of the context and scope of the ecological processes important in the area of interest;
- Expanding our consideration across traditional discipline boundaries;
- Integrating biotic and abiotic information and processes; and
- Facilitating communication among scientists from different disciplines, between scientists and managers, and between managers and the public (Thomas 2001).

Within the SEAN monitoring program, the development of conceptual models had the specific purpose of guiding the process of vital signs selection. A critical role of the models is to identify the principal drivers of change – both natural and anthropogenic – in network ecosystems. With the drivers of change identified, the types of ecological changes most important for park managers to detect can be determined, based on their inherent importance or their influence on receptors of particular significance. The process of deciding which changes (and of what magnitude) the network wants to be able to detect will help form the foundation for vital sign selection.

This appendix, then, represents our current understanding of the salient elements and processes of ecosystems of the SEAN parks. In this appendix, we present 12 conceptual ecosystem models developed with several cooperating researchers. Two pervasive themes of these models are (1) the linkages between the physical and biotic realms, and (2) the substantial interactions among terrestrial, freshwater, and marine ecosystem components in Southeast Alaska. The overlap of terrestrial, freshwater, and marine environments is represented by mapping the major habitat types in the SEAN parks in Figure 2.1. Most of the habitats shown depend on more than one environment. Although this is not unique to Southeast Alaska, deep marine incursions and abundant precipitation make marine and freshwater influences equal to the terrestrial in coastal areas of this region, where all three SEAN parks are located. This relationship among environments represented by the three overlapping ovals of Figure 2.1 is carried forward in several of the conceptual models that follow.

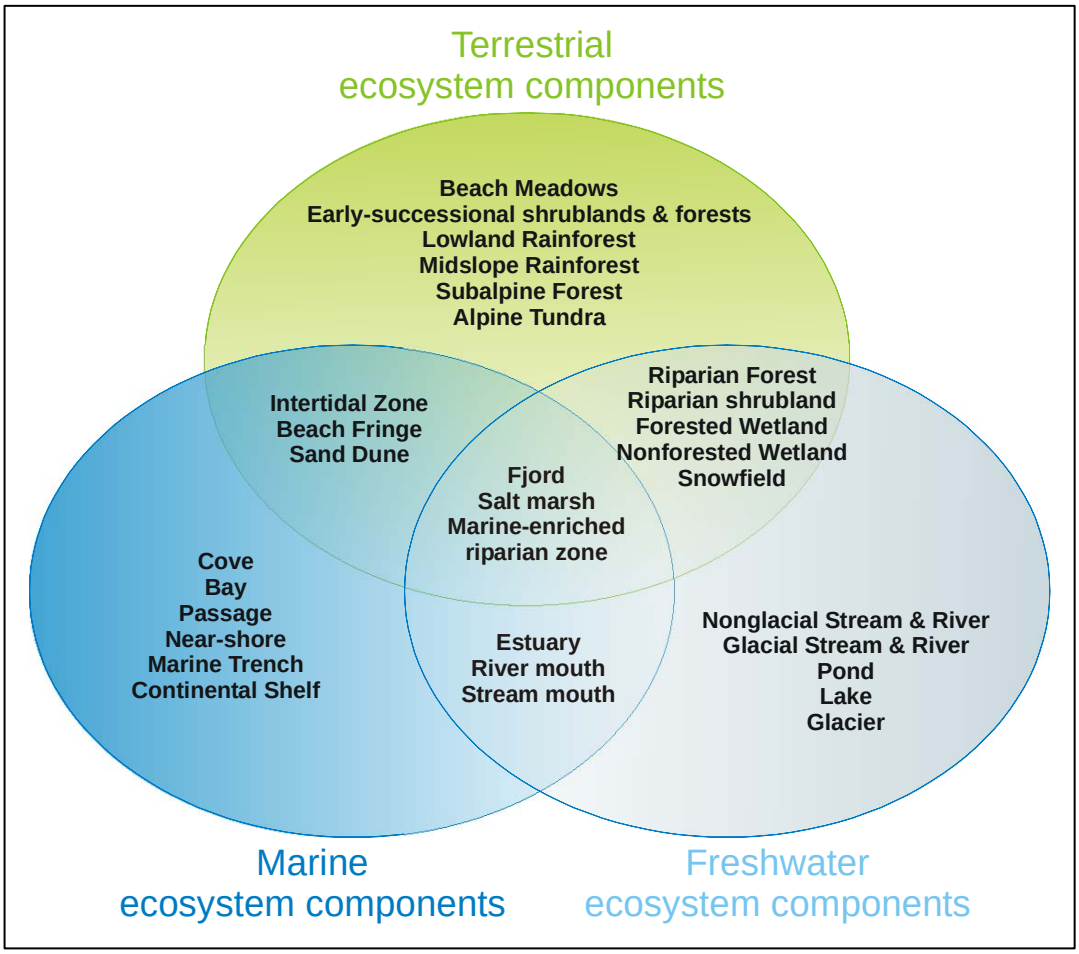

Figure 1 Important ecological features within the three ecosystem components in Southeast Alaska. Habitats can be associated with a single ecosystem component or with an overlap where two or three of the components come in contact. Most habitats exist in mature states and also in earlier stages of primary or secondary succession.

Ecological Context

Global Setting of Southeast Alaska Parks: Far-field Drivers of Change

Many habitats in Southeast Alaska are as wild and pristine as any in the world. However, human enterprise has caused changes that affect every place on earth (Vitousek et al. 1997). Thus, the relatively natural environments of Southeast Alaska operate within a regional and global system of physical and biological drivers that have been altered by human activity. Human enterprise has transformed much of the Earth's surface, altered its biogeochemical processes, and eliminated or redistributed species and populations (Vitousek et al. 1997). Three important consequences of these changes are climate change, loss of ecosystem processes and habitats, and loss of species, populations and communities (Figure 2).

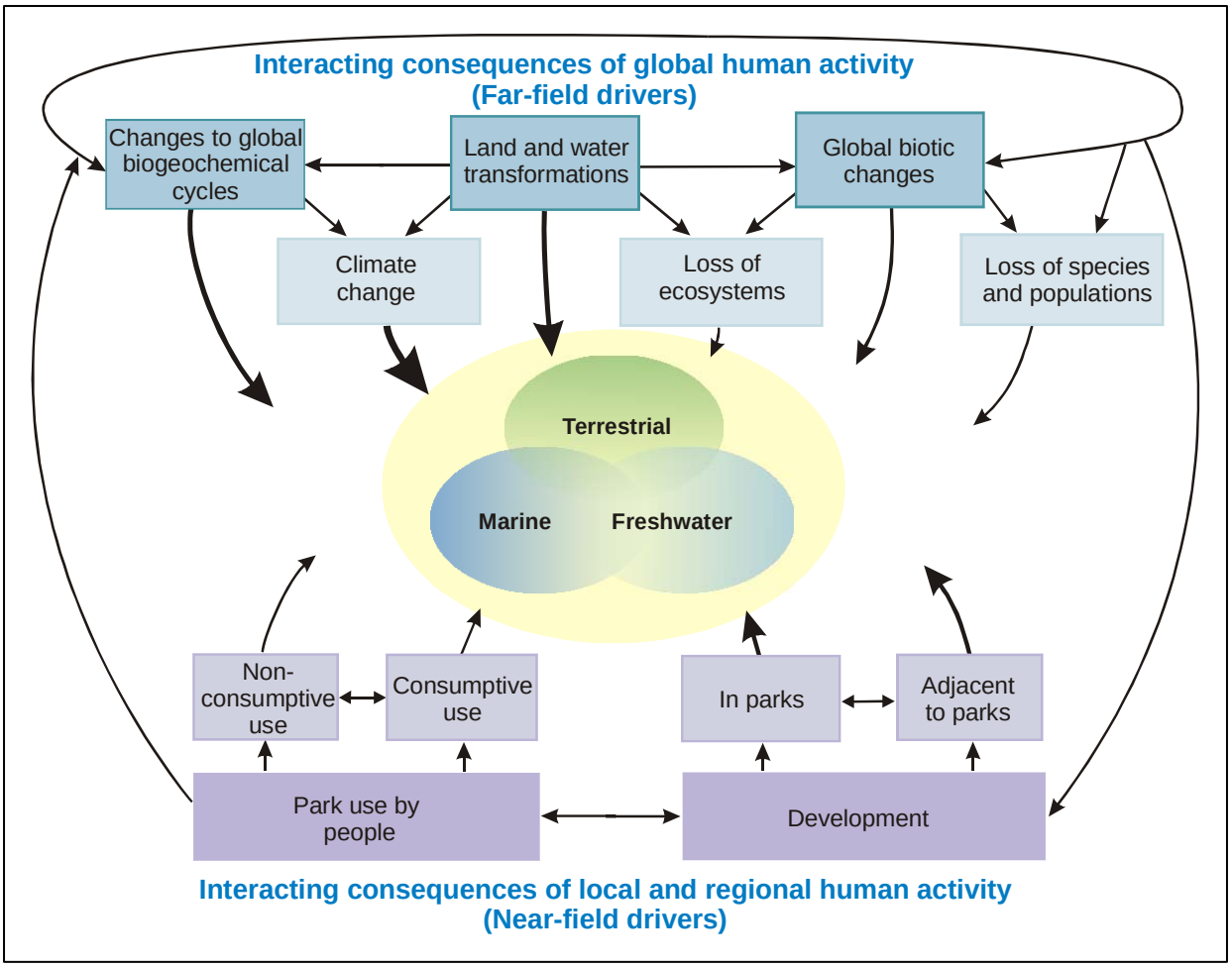

Figure 2. Resource preservation concerns. Far-field (top) and near-field (bottom) drivers of change that are likely to threaten resources in Southeast Alaska (thicker arrows indicate greater concern). The transformation of the earth's surface, oceans, and atmosphere has driven changes in global biogeochemical cycles and the biotic makeup of ecosystems. The interaction of these types of changes has resulted in global climate change, and the loss of ecosystems, communities, populations and species around the world. At the local and regional level, park use and development can result in stresses on natural systems.

Land transformation around the world has altered global biogeochemical cycles by transferring large quantities of carbon from fossil fuels and biomass into the atmosphere, and by fixing nonreactive atmospheric nitrogen (N_2) into reactive compounds (e.g., nitrous oxide, nitric oxide, ammonia) that contribute to the greenhouse effect and can alter plant nutrient status. The effects of carbon- and nitrogen-based greenhouse gases have already contributed to global climate change (Houghton et al. 2001), and continued changes threaten to alter natural competitive balances in plant and animal communities and initiate new disturbance regimes.

Land transformation is also responsible for global biotic changes caused by the harvest of plants and animals, habitat conversions and fragmentation, and freshwater diversion. Although

Southeast Alaska has been generally insulated from the loss of local species, populations, and ecosystems, it is not immune to this type of damage.

Local Resource Preservation Concerns: Near-field Drivers of Change

At the local and regional scale there are several activities that have the potential to negatively impact park resources. Human activity in and near the parks is a primary resource preservation concern. Local human activity is unlike other resource preservation concerns because there is greater potential for managing human activity to modify environmental effects. There are two categories of human activity that are most likely to affect natural and cultural resources in network parks: development in and near parks, and use by park visitors (Figure 2.2).

Consumption of natural resources by park visitors can be responsible for damage to and/or overharvest of plants or animals, leaving waste and refuse in parks, soil compaction, and introduction of invasive or exotic species to park habitats (Figure 2.2). In the SEAN parks, the most important potential environmental effect of these stressors is disturbance of wildlife and subsequent changes in plant and animal populations. Other important effects include the establishment and spread of invasive species and altered successional pathways. The noise, crowding, or refuse left by park visitors in formerly pristine areas can be an aesthetic concern for other visitors.

Although generally less threatening than other concerns, research activity or resource management activity can influence natural environments. Field-based research activity may result in changes in populations and communities, alterations in successional pathways, and degraded visitor experiences. Research and management can also lead to increased public awareness of ecological issues, ecological restoration projects, and protection of threatened resources.

Drivers of Environmental Change

Holistic Model

We have identified four broad categories of environmental factors that influence the current environmental conditions in Southeast Alaska and that are most likely to drive ecological changes in the future (Figure 2.3). These four drivers are climate, geologic processes, ocean processes, and human activity.

1) *Climate.* The regional climate has a controlling affect on the landscape of Southeast Alaska, supporting the highly productive coastal rainforest and its denizens, supplying snowfall to feed alpine glaciers, creating myriad wetland and freshwater ecosystems, and influencing marine processes.

2) *Geological processes and patterns.* The geology, geography, and landforms of the coastal region determine how the regional climate interacts with the land or water to shape a particular ecosystem. Dramatic coastal mountains and islands of the Alexander Archipelago dominate the landscape and create a spatially complex system of marine and terrestrial environments.

3) *Ocean processes and patterns.* The processes and patterns of the ocean support productive and diverse marine ecosystems and strongly influence the weather, biochemistry, and biota of freshwater and terrestrial systems. All SEAN parks are adjacent to marine waters, and Glacier Bay includes an internationally significant marine reserve with strong connections to surrounding unprotected marine systems.

4) *Human activity.* Human activity (past and present, near and far) has affected all ecosystem components in Southeast Alaska and has great potential to drive changes in those components in the future. For example, human effects on global climate and the unpredictable risk of resulting climate changes may produce the most serious future concern.

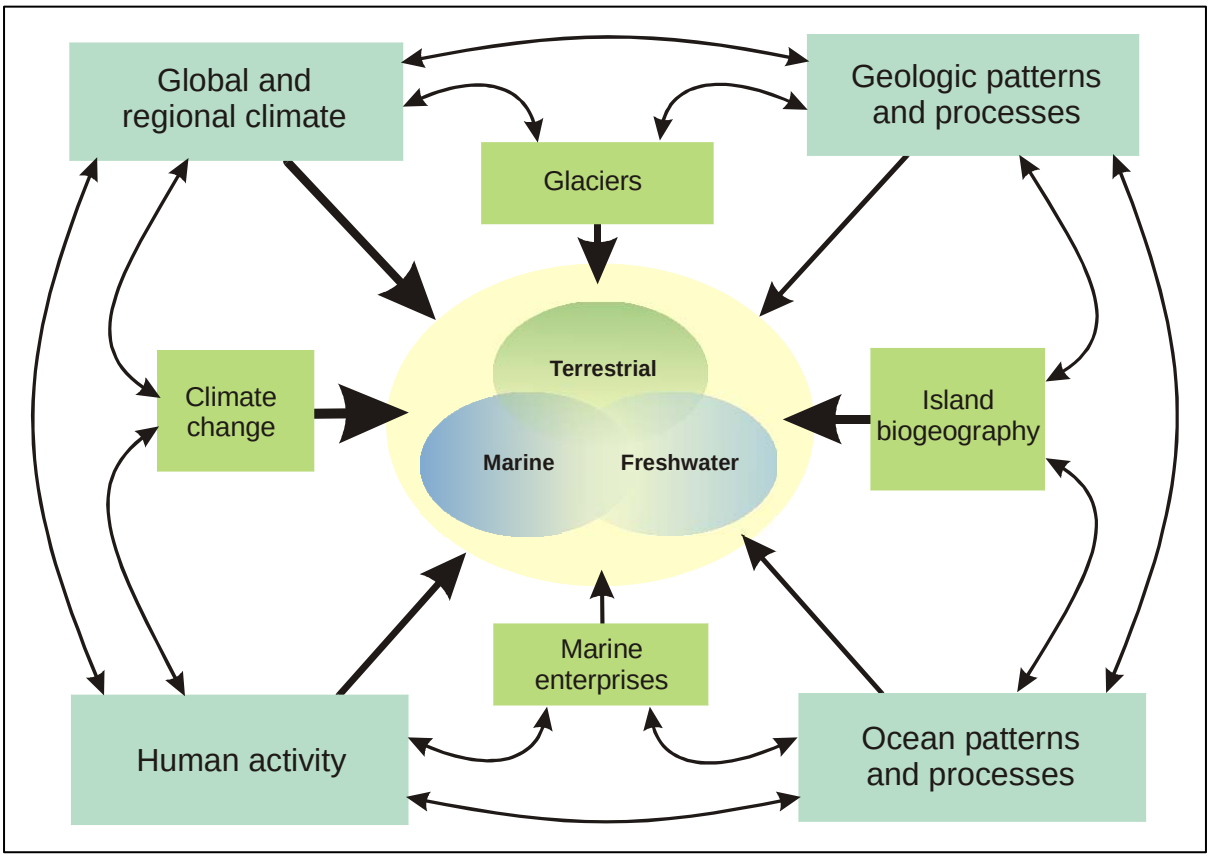

Figure 3. Holistic model: Drivers of change. Climate, geologic processes, ocean processes, and human activity are the four major driving forces shaping landscapes and ecosystems in Southeast Alaska. Thicker radial arrows indicate greater influence.

Interactions among the four major drivers in Figure 2.4 produce four more specific influences on ecosystem components in Southeast Alaska:

1) *Climate change*. The long-term influence of humans on global and regional climate (Houghton et al. 2001) is expected to cause substantial changes in the climate of Southeast Alaska during the current century. We consider the potential for climate change to be the most important anthropogenic driver of landscape change. The potential environmental stresses caused by the predicted course of global warming could cause unprecedented change in all of the ecosystems of Southeast Alaska.

2) *Island biogeography.* The geographic interaction between land and sea in the coastal landscape of Southeast Alaska creates a unique spatial matrix of islands, peninsulas, mainland landmasses, and the marine and freshwater ecosystem components that connect them. The natural fragmentation of the land and marine waters in Southeast Alaska makes the concept of island biogeography useful for prediction of undesirable change and identification of management strategies to mitigate that change.

3) *Glaciers.* The interaction of regional climate and geography produces the conditions responsible for Southeast Alaska's extensive glaciation. Glaciers, in turn, influence the local climate, modify terrain, produce unique wildlife habitats, and discharge water, ice, sediment, and organic material into freshwater and marine systems. Glaciers have strongly influenced the natural and cultural resources of all three SEAN parks.

4) *Marine enterprise.* Coastal habitats in direct contact with marine waters are vulnerable to the environmental impacts of human activity at sea. Oil spills and other impacts resulting from commercial fishing, maritime transport (including cruise ship traffic), and coastal development in support of this maritime activity are potential threats throughout Southeast Alaska.

Physical Drivers in Southeast Alaska

Key Environmental Drivers

Two dominant drivers – wetness and disturbance – influence the major ecological communities in Southeast Alaska (Figure 4.4). On land, near-constant wetness drives the development of plant communities and soils that are strongly influenced by autogenic (self-produced) processes. For example, leaching of rainwater through continuously accumulating organic soil horizons drives the development of an impervious soil horizon. This paludification leads to poorly drained soils and the plant communities that can tolerate them. Disturbance – whether by glaciers, downslope movement, windstorms, or insects – drives ecosystems in the opposite direction, creating younger, simpler systems. Compared to mature ecosystems, recently disturbed successional systems are able to sequester fewer resources, and nearby hydric systems receive the exported nutrients and energy. The results are lakes and streams that are more productive than their young successional setting would suggest. Adding to this temporal trend is the pronounced effect of large populations of anadromous fish which bring marine nutrients and energy into young and old streams, lakes, and adjacent terrestrial ecosystems.

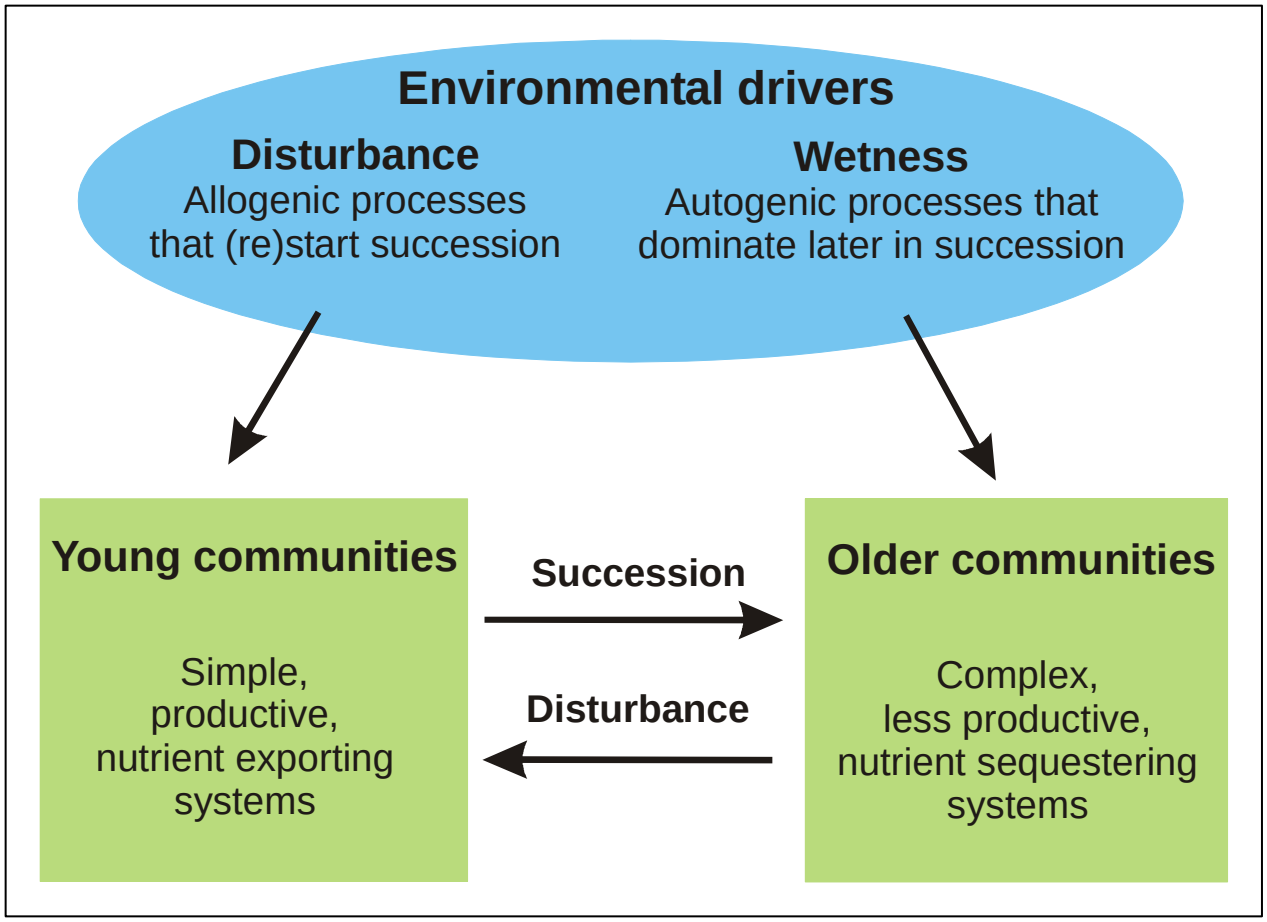

Figure 4. Key environmental drivers. Disturbance and wetness are two fundamental drivers of the development of environments in Southeast Alaska. Wetness allows for abundant lakes, streams, wetlands, and mesic or hydric terrestrial environments. Disturbance modifies all environments and replaces mature communities with simpler, more productive, young communities. Adapted from G. Streveler, unpublished.

Origins of Terrestrial and Freshwater Features

A combination of factors has given rise to the Southeast Alaska landscape of small, complex watersheds, and a great diversity of habitat types and community ages. Primary among these factors is a geographic location where moist, temperate air masses produce a maritime climate coupled with complex lithology and extreme topography associated with an active tectonic plate boundary (Figure 2.5). Glacial activity is an important consequence of these factors. Glaciers are a conspicuous element of today's environments and have been modifying the landscape for millennia. Long histories of intense glacial activity and relative sea level fluctuation have further increased the topographic and geomorphic diversity.

The result is a variety of terrestrial environments from lowland to alpine, and from well-drained to wetland (Figure 2.5). Steep terrain, active glaciers, lethal forest insect pests, and severe

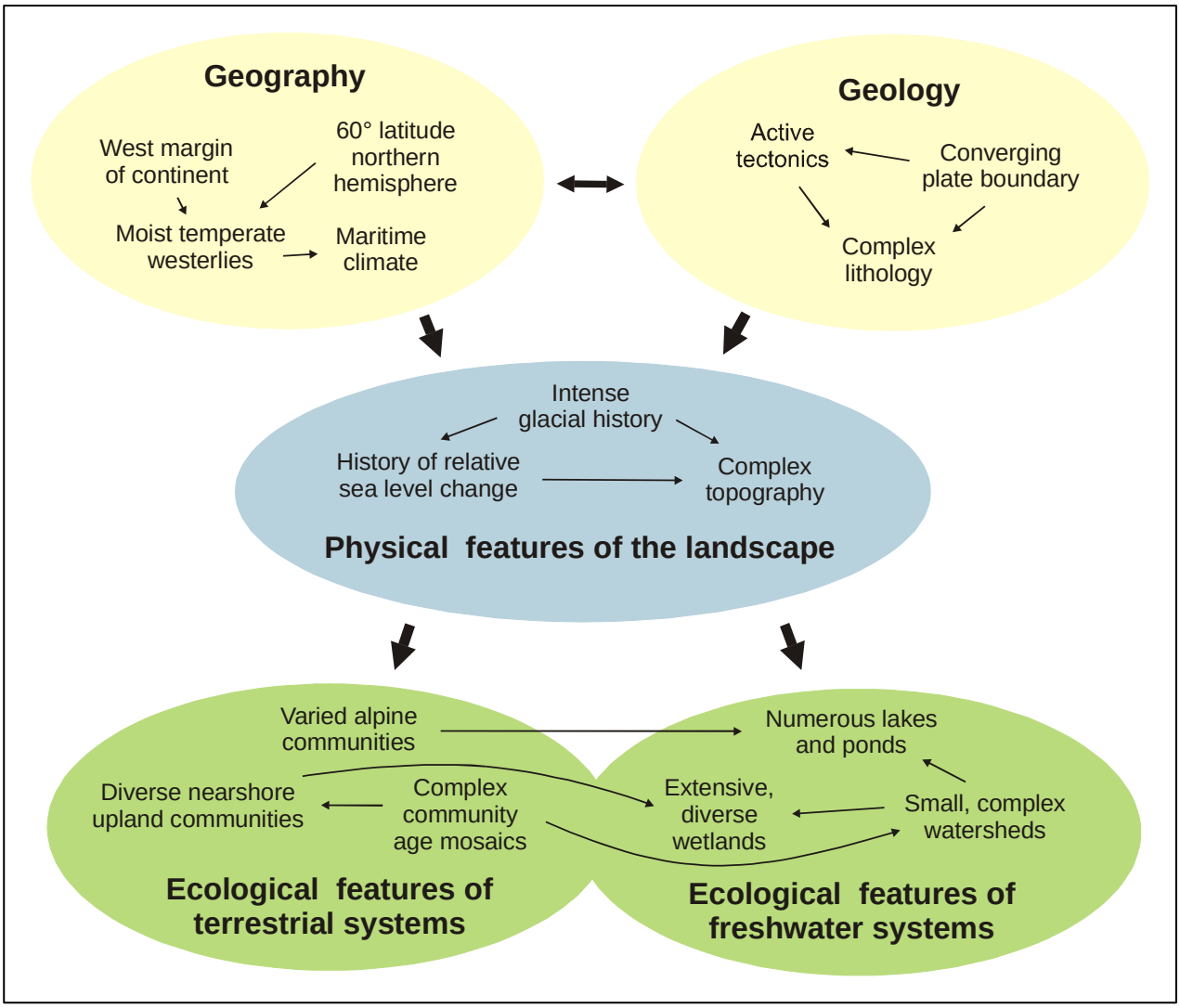

Figure 5. Origins of Southeast Alaska Network terrestrial and freshwater features. The geography and geological processes of Southeast Alaska produce a unique suite of environments characterized by small, complex watersheds, diverse mesic and hydric communities, and a complex mosaic of community ages. Adapted from G. Streveler, unpublished.

weather subject these diverse plant communities to repeated disturbances and produce a complex mosaic of community ages, further enhancing landscape and biotic diversity.

Regional Influences on Marine Systems of Southeast Alaska

A combination of factors has given rise to the high productivity and community diversity in marine environments of Southeast Alaska. Primary among these factors are a regional maritime climate with strong seasonality, and the deeply divided coastline which generates insularity, complex circulation, and diverse benthic habitats (Figure 2.6). At Glacier Bay, glacial activity has produced a fjord system with cold, sediment-rich freshwater input that contributes to complex water-mass structure and strong seasonal stratification. Diverse nektonic, benthic, and demersal communities are supported by high productivity of phytoplankton or macroalgal populations.

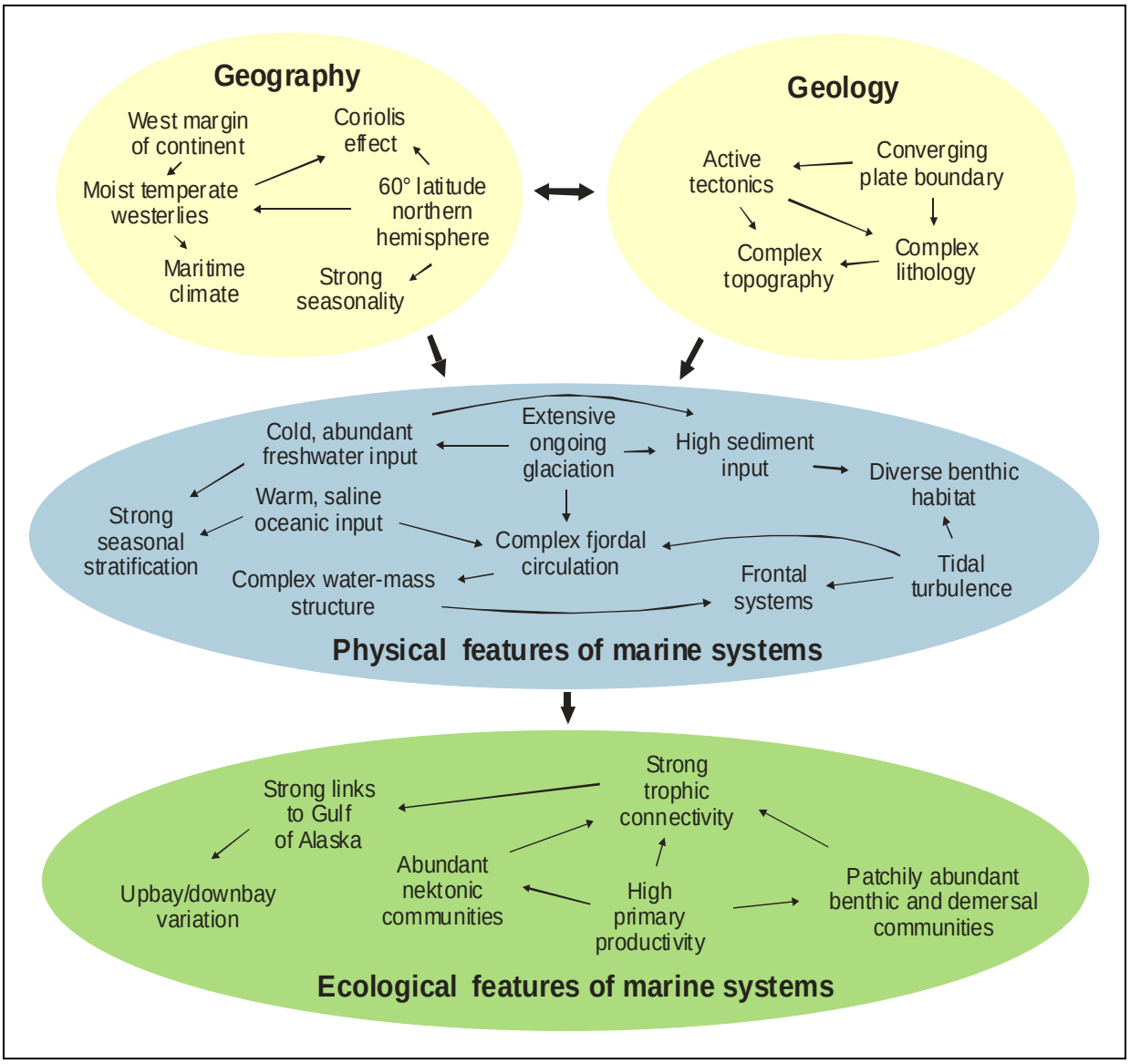

Figure 6. Influences on marine systems in Southeast Alaska. The geography and geology of Southeast Alaska's coastal waters produce a unique suite of physical influences which allow high productivity and diversity in marine habitats. This diagram is based primarily on the environments at Glacier Bay. Adapted from G. Streveler, unpublished.

Ecosystem Interactions

In this section, we discussed the key ecological processes and settings that generate the patterns and processes that we observe today, and we describe the mechanisms by which processes occurring in one realm (i.e., freshwater, marine, or terrestrial) are interconnected with those in another. In Southeast Alaska, many of these processes are closely related to active primary succession in a post-glacial context.

Succession in Freshwater

Successional development in SEAN streams

New streams and lakes are created as retreating glaciers expose fresh terrain (Figure 2.7), and a delay in biotic development in those waterways is mediated by high sediment load and variable flow rates associated with unvegetated watersheds. These processes are dampened by upstream lakes, which trap sediment and moderate flow, allowing stream communities to stabilize sooner (Milner 1997). The successional development of aquatic plant and animal communities is closely tied to the concurrent development of adjacent terrestrial plant communities (Milner et al. 2000). As vegetation colonizes stream banks, the addition of organic matter into streams promotes invading communities of stream invertebrates. The early input of leaves and catkins from shrubs is followed by the accumulation of coarse woody debris in stream channels. This debris provides cover for fishes and supports colonization by anadromous salmonids. The input of marine nutrients and energy from spawning salmonids to stream and riparian environments accelerates the development of stream invertebrate communities and creates a positive feedback to stream primary and secondary productivity.

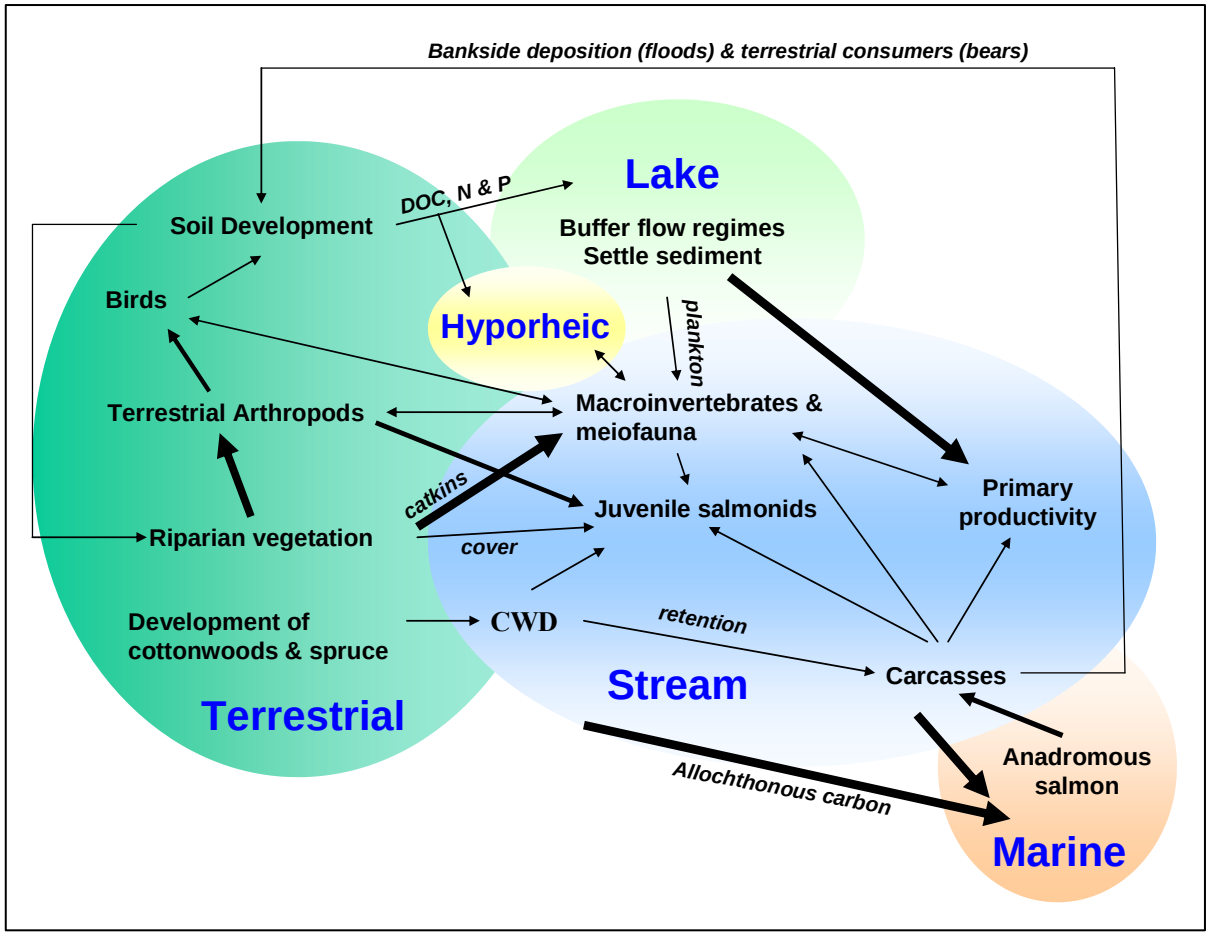

Figure 7. Primary succession in streams. The productivity and diversity of fish and invertebrate communities in streams is strongly linked to nearby terrestrial, hyporheic, lake, and marine environments. The strength of the relationships (represented by arrow thickness) changes with time from this early successional snapshot. Adapted from Milner et al. 2000.

Glacial activity in the upper reaches of a watershed can affect stream development for hundreds or thousands of years after streamside surfaces become ice-free. In Glacier Bay and Klondike Gold Rush, sediment-rich glacial streams traverse lowlands occupied by forest ecosystems that have been developing for more than 10,000 years. Productivity in these streams will remain low until sediment sources are reduced. Where lakes associated with active alpine glaciers are in the watershed of such streams, rapid ablation (the reduction in volume of a glacier due to melting and evaporation) of glaciers and snowfields in the last 30 years may have increased the potential for glacial-lake outburst flooding. Catastrophic downstream flooding and debris flows have resulted from increased meltwater and higher lake levels behind loosely consolidated and saturated alpine moraines. The Taiya River in Klondike Gold Rush has experienced at least three glacial lake outburst floods in the last 120 years, most recently in 2003.

Southeast Alaska watersheds that have been free of major glaciation for thousands of years, such as the Indian River in Sitka, tend to have mature riparian forests, and rivers tend to flow clear during most of the year. These mature rivers generally drain steep topography and are cold and swift. Their beds tend to be made up of gravel, cobbles, and boulders with a low amount of fine deposits such as silt. This provides multiple surfaces and habitat for a diverse benthic community. The silt-free interstitial spaces within gravel and cobble substrates allow surface water to flow through the hyporheic zone which delivers dissolved oxygen to invertebrates, salmonid eggs and newly emerged fry, removes waste products, and provides protection from strong current and predators (Edwards 2001).

In mature rivers, rock and other underwater surfaces exposed to sunlight in swift, clear, well-oxygenated streams develop a thick biofilm matrix consisting of diatoms, cyanobacteria, bacteria, fungus, protozoans, and other organisms. This biofilm collectively becomes a food source for benthic macroinvertebrates, particularly for scraper-grazer aquatic insects such as flat-bodied mayflies and some caddisflies (Murphy 2001). Dense coniferous and alder forests along streams like the Indian River drop a considerable amount of leaves, bark, catkins, cones and other types of coarse particulate organic matter (CPOM) into the waterway. Microbial action begins to break down this material, making it more palatable as food for a diverse array of shredder aquatic insects (e.g., caddisflies, craneflies, and stoneflies) (Wiggins 2004). Some macroinvertebrates from the shredder group opportunistically shift feeding habits to utilize salmon carcasses (which supply marine-derived nutrients) when they are present in the stream. As this large quantity of CPOM is broken down and digested, it becomes fine particulate organic matter (FPOM) and is a food source for collector-gatherer and filter-collector aquatic insects (e.g., mayflies, caddisflies, blackflies). The energy sources of biofilm and terrestrial plant inputs in the stream support a diverse macroinvertebrate community which, in turn, supports several aquatic insect predator species (e.g., stoneflies and caddisflies). Invertebrates are the major energy transfer link between sun-based primary production (biofilm and riparian forest) and fish in stream ecosystems. Juvenile salmonids feed primarily on drifting invertebrates belonging mainly to the scraper-grazer and collector-gatherer functional feeding groups (Murphy 2001).

The Indian River and other rivers with old-growth and mature secondary growth forests in their riparian zones are significantly influenced by large trees that fall directly into and across the stream. This large woody debris (LWD) creates relatively immobile log barriers, log jams, and

root wads that stabilize the river channel, provide cover, and form pools, all of which are critical for juvenile salmonid survival (Naiman et al. 2000, Montgomery and Buffington 2001). Stable submerged wood surfaces provide an important substrate for macroinvertebrates and the rich biofilm that grows on it is an important food source for scraper-grazer insects. Large woody debris also helps to physically retain CPOM and FPOM.

Successional Development of Lakes

A study of 33 lakes at Glacier Bay ranging in age from 10 to 13,000 years has indicated how their successional development is closely tied to the ecological development of the land in the surrounding watershed (Engstrom et al. 2000). Water arriving in very young lakes travels through a sparsely vegetated watershed with poorly developed soils (Figure 2.8). In this environment, overland flow and groundwater flow become rich in soil carbonates and dissolved solids (base cations including Ca^{2+} and Mg^{2+}), which are carried into streams and lakes. As terrestrial succession proceeds in the watershed, vegetation and soils develop and nitrogen and organic carbon are dissolved in surface and subsurface water and carried into lakes. This causes lakes to become more acidic, more fertile, richer in dissolved organic carbon (DOC), and capable of supporting diverse aquatic food chains. After 1,000 to 3,000 years, soil hardpans form beneath organic soil horizons in the watershed and reduce penetration of precipitation into groundwater. Increased overland flow and interflow through highly organic, mature soils brings additional acidic and organically enriched water to lakes. This causes further increases in DOC, continued decreases in pH and dissolved solids, and reduced biological activity. Thus, lakes eventually become less fertile and less productive as they mature, even as carbon and nutrients accumulate in the surrounding landscape. These results emphasize the dependence of lake development on plant succession and soil development in the surrounding terrestrial environment (Engstrom et al. 2000).

There are no true lakes in Sitka or Klondike Gold Rush, however, intermittent ponds are seasonally present in both parks. Sitka ponds are dependant on rainfall and may completely dry up in the summer. When late summer and fall rains return to the area, ponds refill and are colonized by caddisflies adapted to life in temporary water bodies (*Lenarchus* and *Limnephilus*). Adaptations included diapause that delays sexual maturity in adults until the shorter days of late summer triggers egg development during the season when rains become more frequent, eggs deposited in damp substrates or on the underside of damp logs, eggs and larvae that remain within a thick gelatinous (mucopolysaccharide) matrix that can resist dissociation for several months until ponds refill, rapid larval development, and wide dispersal of adults (Wiggins 2004). These caddisflies put on most of their growth in the fall and winter and complete their larval life cycle by early summer when ponds begin to dry up.

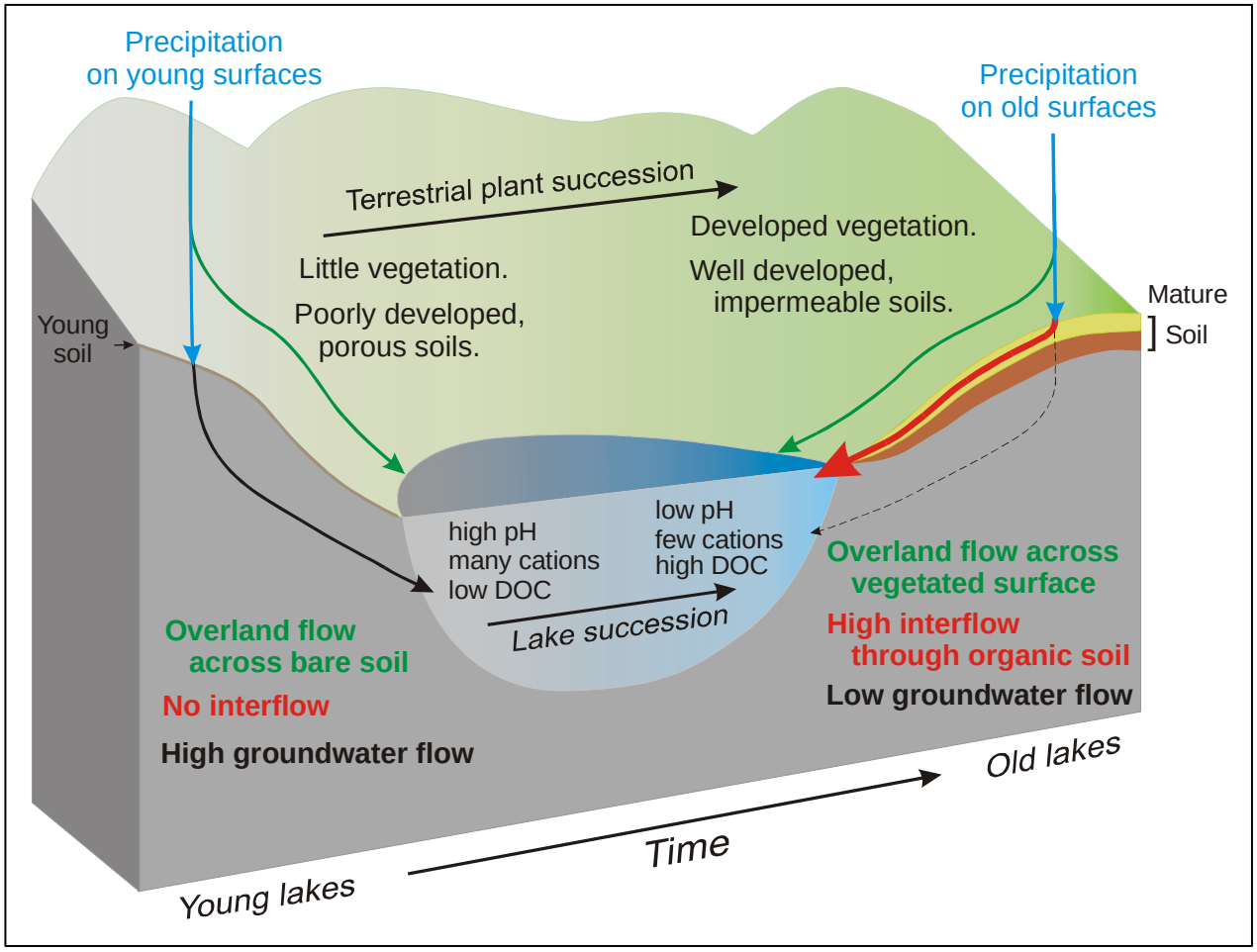

Figure 8. Lake and watershed primary succession. Early in terrestrial succession at Glacier Bay, soil carbonates and dissolved solids (e.g., Ca2+ and Mg2+) are transported into streams and lakes. As vegetation and soils develop, more nitrogen and organic carbon are carried into lakes. After 1000-3000 years, soil hardpans reduce penetration of precipitation into groundwater. Adapted from Engstrom et al. 2000.

Primary Succession on Land

Terrestrial Plant Succession Following Glacial Recession

Two centuries of glacial recession at Glacier Bay has produced a landscape with plant communities in various stages of primary succession. These communities allow inference about the processes that determine how plant communities are assembled through time, both at GLBA and at the relatively older communities of SITK and KLGO. The geographic location of a site recently exposed by retreating glaciers influences the site's climate, soil characteristics, and landscape position (Figure 2.9). Landscape position (a site's spatial relationship to physical and ecological features) affects the rate of substrate stabilization and the proximity of mature vegetation which could supply seeds for colonizing plant populations (Fastie 1995). At Glacier Bay, these factors have varied from place to place, resulting in substantial variability in the composition of early plant communities. As succession proceeds, the ability of early plant

populations to fix atmospheric nitrogen and the activity of herbivores influence interactions among plants (e.g., competition and facilitation) (Chapin et al. 1994). Differences among sites in early nitrogen fixation and in the consequent accumulation of soil nitrogen lead to long-term differences in ecosystem function. Therefore, predicting the pathways and endpoints of terrestrial ecological succession at any site requires knowledge of landscape-scale patterns.

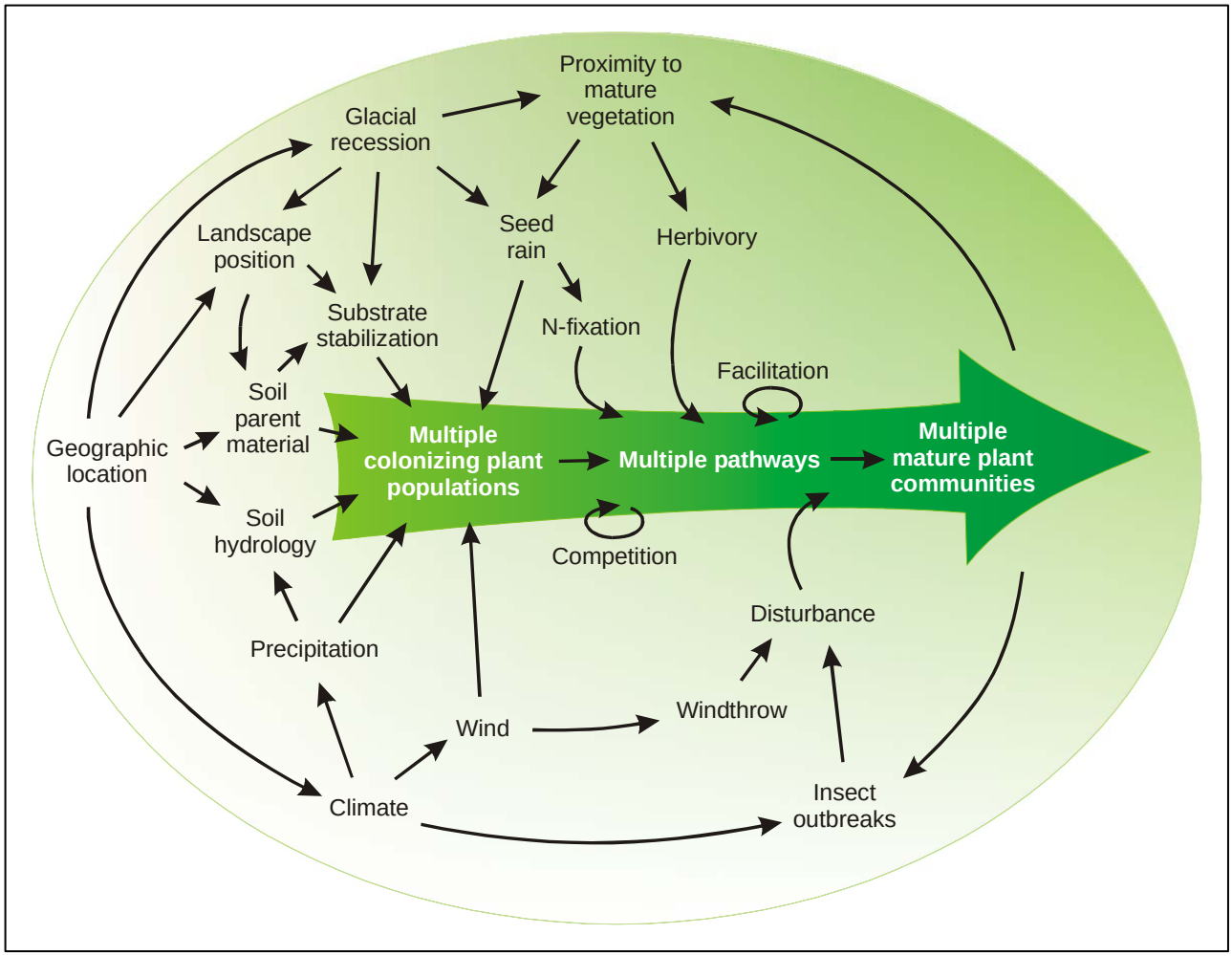

Figure 9. Terrestrial plant succession following glacial recession. At SEAN parks, the location of a site recently exposed by retreating glaciers influences the site's climate, soil characteristics, and landscape position. The variability of these factors at Glacier Bay can produce multiple successional pathways. Biotic interactions (e.g., competition, facilitation, herbivory) influence the developing plant communities. Adapted from Chapin et al. 1994 and Fastie 1995.

The Marine Environment

The Glacier Bay Marine Ecosystem

At least six major ecosystem processes are recognized as important determinants of the structure and function of the Glacier Bay marine ecosystem. A model focusing on these processes was

developed for Glacier Bay by Bodkin et al. (2004). The generality of this model makes it useful for describing ecological interactions in any marine system in Southeast Alaska. The six processes included in the model (Figure 2.10) are:

1. Human influences
2. Oceanography
3. Trophic interactions
4. Production dynamics
5. Transportation
6. Disturbance (e.g. glaciation)

The application of this model is based on current understanding of the relative importance of each of the ecosystem processes in regulating the abundance and structure of populations. The model is intended to be used to answer the question: *What is the relative magnitude of influence of each ecosystem process on the population abundance and structure of a species?* Through a process of repeatedly asking this question for individual species, it is possible to identify populations for which there is either a relatively good or a relatively poor understanding of structuring processes, and to identify processes that are important across populations. These processes are broadly defined (e.g., production dynamics can incorporate reproduction as well as survival), and other processes (e.g., competition, life history traits, sources of propagules) may be fundamental in structuring some populations. These processes often are not independent, and complex interactions can be expected.

The Transfer of Marine-derived Nutrients and Energy to Riparian Systems

Anadromous salmonid fishes return annually to streams in each of the network parks. Adult salmon return after multiple years as marine predators and die in the streams after spawning (Figure 2.11). These large runs of fish bring important nutrients (e.g., nitrogen and phosphorous) and energy (caloric food value) from the ocean to the freshwater ecosystem (Gende et al. 2004). Some of these nutrients and energy become part of the aquatic food web through scavenging by invertebrates (Lessard et al. 2003), predation on eggs, or uptake by plants. Terrestrial animals, including brown and black bears, river otters, gulls, and bald eagles, prey on live fish or scavenge dead fish. Animal waste and uneaten fish on and near the stream banks provide marine nutrients to riparian vegetation and the terrestrial food web (Ben-David et al. 1998). The water current flushes uneaten carcasses back to marine waters, and in combination with the eventual out-migration of young salmonids, much of the marine-derived nutrients and energy in the stream may be eventually returned to the ocean. Nevertheless, a portion becomes incorporated in the terrestrial ecosystem and gradually migrates even beyond riparian areas.

Productivity in the Intertidal Zone

The intertidal zone is a component of all three parks. Although the areal extent of the intertidal zone is small relative to the marine or terrestrial ecosystems it borders, its high species diversity and productivity make it ecologically important to a large number of terrestrial and marine animals. The particular combination of plants and animals present in the intertidal zone depends in part on a variety of physical factors, including latitude, exposure to the open sea, ocean

currents and fronts, and proximity to tidewater glaciers and turbid outwash or clearwater streams (Figure 2.12). Biotic interactions within the communities and interactions with land and sea animals (e.g., predation, herbivory) further modify the biotic diversity. Communities of intertidal plants and animals are subject to environmental stresses associated with daily tidal fluctuations, physical disturbance by weather events, and predation or herbivory from marine or terrestrial animals. The influx of cold, sediment-laden freshwater and icebergs from nearby tidewater glaciers influences the composition, structure, and productivity of these communities (Sharman 1988). Although they are well adapted to natural disturbance, these communities are highly vulnerable to new types of disturbance caused by human activity on land or at sea. For example, trampling by foot or vehicle traffic, changes in nearshore currents caused by docks and other shore-fast structures, and marine oil spills are threats to intertidal communities.

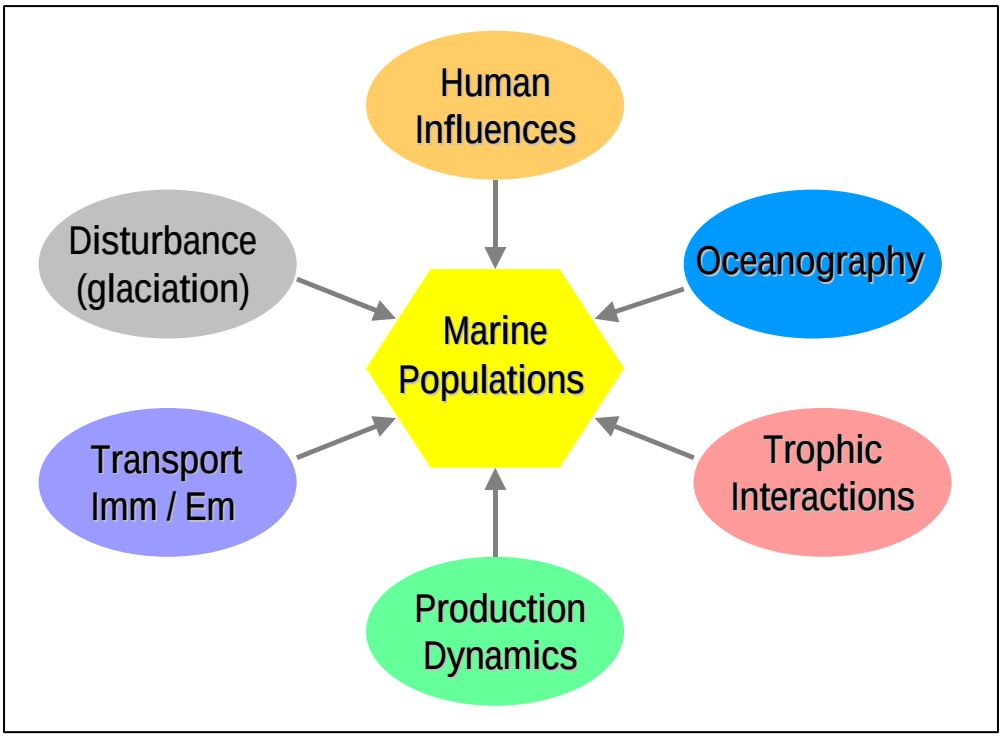

Figure 10. Influences on Marine Populations. Six major processes that are thought to be significant influences in determining the species composition, abundance, and age composition of the marine organisms that compose up the biological component of the Glacier Bay marine ecosystem. This model also applies well to the marine environments associated with SITK and KLGO. From Bodkin et al. 2004.

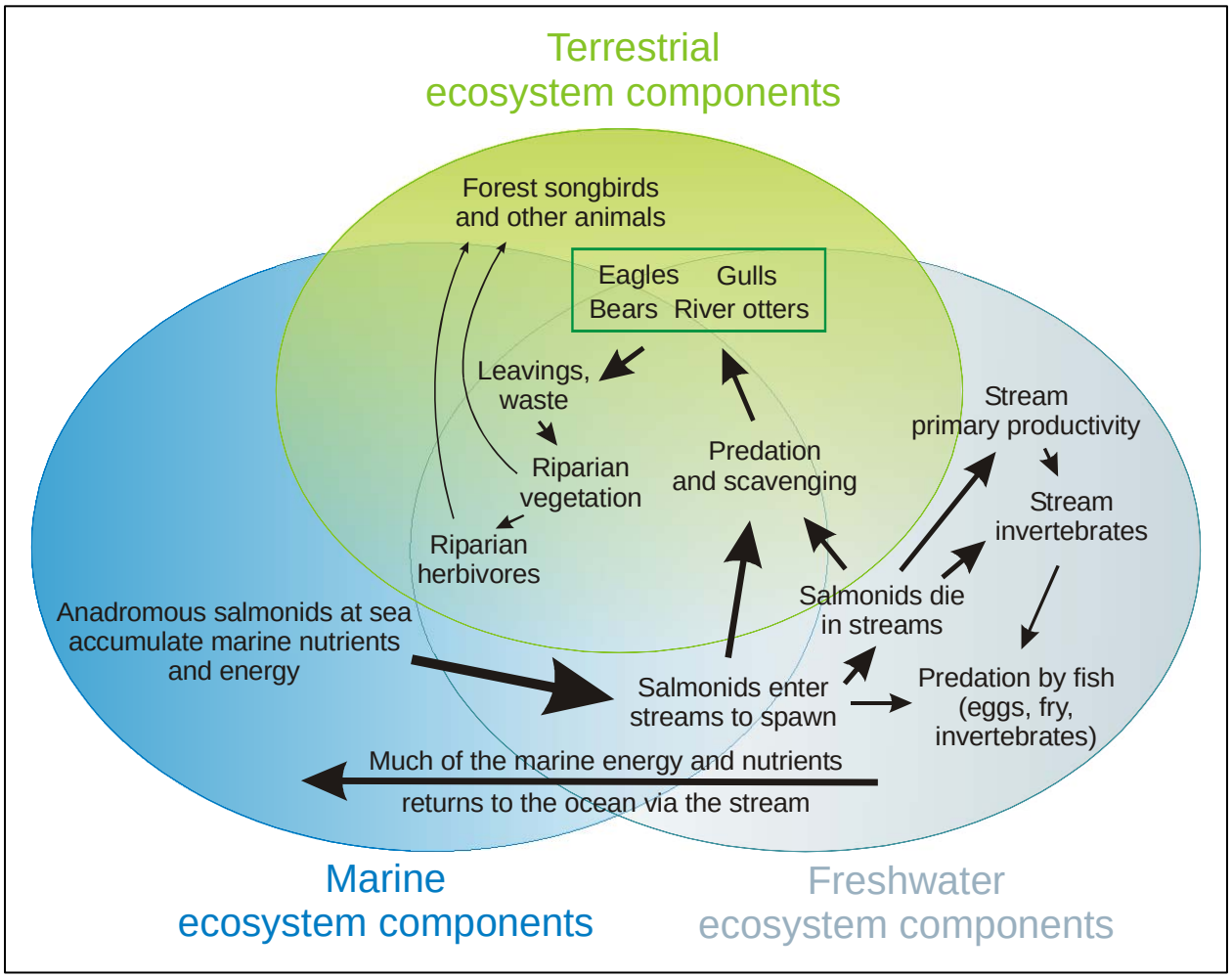

Figure 11. Marine-derived nutrients. Beginning with marine predators such as anadromous salmonids (left), energy and nutrients are accumulated at sea, delivered to streams, cycled through freshwater and terrestrial organisms, and are ultimately returned to the sea to begin the cycle again. Thickness of arrow represents the relative input of marine derived nutrients, which are gradually diluted by terrestrial or aquatic nutrient sources.

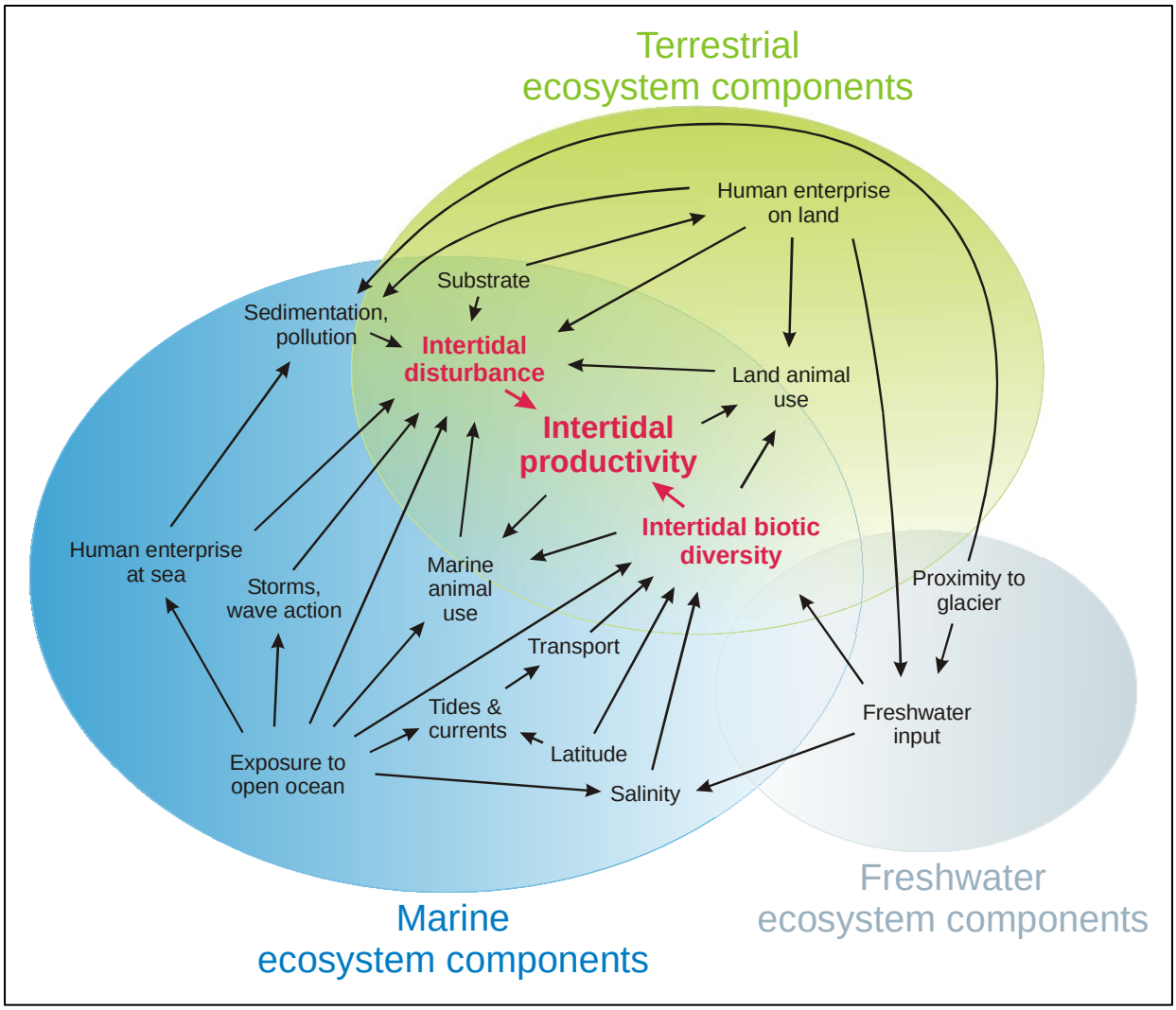

Figure 12. Intertidal zone. Productivity in the intertidal zone depends on the particular biotic community present at the site and the disturbances that stress that community. Adapted from Sharman 1988.

Appendix G

Sampling Design Considerations for Long-term Monitoring in the Southeast Alaska Network: Concepts and Definitions

Status and Trend

A common objective for all SEAN monitoring is to determine the status and trends in Vital Signs. Status is defined as a measure of an attribute, condition, or state, and applies to specific points in time. Trend is a directional change over time in an attribute, condition, or state. Status estimates inform management of current levels or amounts of a resource attribute, and determine departure from desired conditions and remediation needs. Trend estimates indicate direction and rate of change, which in turn inform management of potential levels of an indicator in the near term, and the need for remediation planning and implementation. Both status and trend are statistical estimates, and are typically reported as a mean and variance.

Defining the Population of Interest

Statistically valid survey designs are the most defensible means to make inference from samples to a larger population (Schreuder et al. 2004, Edwards 1998, Neusser et al. 1998, Cochran 1977). Central to survey designs is the explicit identification and description of this larger, finite population, which is termed the target population. The target population explicitly bounds the basis for selecting samples and for making inference. In some situations, however, areas of the target population cannot be sampled (e.g., due to accessibility issues, cost, or safety concerns). In such situations these areas are eliminated from consideration, and the remaining area is termed the sampled population. Sample selection, and inference of status and trend then are bounded by the finite, sampled population. This process of identifying and defining the target and sample population is an initial and critical step in crafting a reliable sampling design.

Drawing a Sample

Because a sample is used to make inference to a larger population, it is imperative that the sample be representative of the population of interest (Lohr 1999). Three broad approaches to obtaining samples of a population include probability-based, judgment, and convenience sampling. Probability-based sampling is the most defensible, because it applies sampling theory and some form of randomization to the selection of sampling units (EPA 2002). Randomization ensures a reduction in potential bias compared to judgment or convenience sampling, thus increasing the validity of extending inference from a sample to the finite population. Each sampling unit in the finite population has a known probability of being included in sample. This probability can be uniform, or it can vary among groups of units, and it can be used to weight observations when making inference to the larger population.

With judgment and convenience sampling, statistical inference is limited to the sites actually sampled. Making inference beyond these sites is subject to selection bias, which can be mitigated if the relationship between sampled and unsampled units is reasonably modeled (e.g., known environmental associations). Bias may be minimal if a large portion of the finite population is actually used in these sampling approaches and if sampling units are spatially balanced. Typically, there is no credible way to determine the degree of bias of non-random selection methods, thus it is best to limit the scope of inference to the areas sampled.

Types of Sample Frames

A sample frame is the collection of all possible, non-overlapping sample units of the finite population, and is used in the selection of sample locations. There are various types of sample frames. The SEAN uses three types of frames:

1) An *area frame* uses geographic boundaries to delineate a given sample unit. An example of an area frame is a map of all intertidal areas in the SEAN park units. The map serves as the basis for drawing a probability sample.
2) A *list-based frame* is a list of possible sample units, derived from inventories or intimate knowledge of the extent of a resource. An example would be a list of all glaciers in the SEAN park units. The list-based frame is used to draw probability samples, or all units of the list are selected for monitoring (i.e., census).
3) *Index sites* are a special case of the list-based frame, used to collect information on areas or points that were based on judgment in order to yield adequate data on a particular Vital Sign. These samples are usually selected as "representative" sites, and – given the lack of probability sampling - statistical inference is limited to the areas monitored given. Given limited monitoring resources and large, inaccessible land areas, the SEAN employs this type of frame in monitoring 5 of the 12 Core Program Vital Signs.

Spatial Allocation of Samples

Many approaches can be used to select a sample over space, but most are variations on a few basic themes. The SEAN monitoring effort will use three approaches: simple random sampling, systematic sampling, and a Generalized Random Tessellation Stratified sampling scheme.

In *simple random sampling*, units are selected from the population of sample units via a random process. Each sample unit has the same probability of being included in the sample.

Systematic sampling is a method in which one sample unit is typically selected at random, and subsequent units are selected according to a systematic pattern. Systematic sampling is often used to achieve spatial balance and to avoid the potential for clusters of samples in close proximity. This can occur through a purely random process such as simple random sampling. However, systematic sampling can introduce some bias if the properties of interest are aligned along a gradient. When prior information about a resource is known, systematic sampling also may be less efficient, and stratification is sometimes warranted (see below).

Stratification

Stratification consists of dividing a population into subsets (strata) and selecting an independent sample from each. Stratification can result in substantial gains in the precision of parameter estimates when samples from within strata are more homogeneous than between strata (Cochran 1977). Common strata include elevation (e.g., low, high), aspect, or habitat type. Additionally, stratification is often used when there is a desire for separate parameter estimates for individual strata.

For the initial set of the SEAN's monitoring protocols, stratification was not deemed necessary. As protocols are developed, stratification needs will be evaluated as part of protocol research and

development. This is typically performed by examining for differences in variance estimates among plausible strata.

Temporal Allocation of Samples

The temporal allocation of samples is specified as the revisit design. The revisit design indicates the time of the initial visit and the frequency of subsequent visits to sampling units of a panel. A panel is a collection of sample units which are visited in the same monitoring event. Multiple panels often are used to spread out sampling units in space and in time. Sample effort can be rotated among panels through time, which effectively rotates field effort among sample units and, therefore, space. The way in which units in the population become members of a panel is called the membership design (McDonald 2003). The notation commonly used for revisit designs is a pair of digits, where the first digit is the number of consecutive occasions on which a panel is sampled and the second is the number of consecutive occasions on which a panel is *not* sampled (McDonald 2003). For example, if a single panel is visited on every sampling occasion, its revisit design can be expressed as [1-0]. The notation [1-0, 1-4] signifies that units in one panel are visited on every occasion, and units in a second set of panels are visited once every five occasions.

Revisit designs must ensure an ability to retain a representative sample across time. Temporal shifts in resource conditions (e.g., variation in population density) due to localized natural (e.g., successional development) and anthropogenic processes (e.g., social trailing) can degrade the representativeness of the original sample. Additionally, the act of monitoring can inadvertently introduce bias into status and trend estimates, such as trampling in vegetation monitoring plots. Balancing these considerations with optimal approaches to status and to trend estimation further complicates revisit designs. Repeat visits to sampling units emphasize trend estimation, because trend determination requires information from the same unit(s) over time. Frequently visiting sampling units to optimize trend estimation can risk sample-unit fatigue and resultant bias and may also fail to buffer against localized temporal shifts in patchy resource conditions (because spatial balance is compromised when a frequent revisits to capture temporal variation is favored over spatial distribution of samples to capture spatial variation). A large sample size and a high degree of spatial balance, however, can guard against the latter. Conversely, monitoring different units each sampling occasion to reduce observer impacts and localized effects is inefficient for detecting a trend because of the additional among-unit variance component. A combination of panels with varying levels of revisit frequency (e.g., relatively frequent to only once) with a spatially balanced membership design is a prudent approach to limit the effects of localized changes (i.e., maintain sample representativeness) and observer impacts while balancing the efficiency of status and trend estimates.

Sample Size and Power

Sample size and power are major concerns in monitoring efforts. In general, sample size should be large enough for a reasonable probability of detecting changes of management or conservation importance, but not unnecessarily large (Fry 1992). Where appropriate, *a priori* power analyses and/or simulations are used to estimate sample sizes. An *a priori* power analysis is a statistical calculation using existing data that is made prior to initiating monitoring (Thomas and Krebs 1997). Because these data provide an estimate of variability captured by proposed metrics, power analyses can be used to estimate sample sizes needed to detect trends in the data

with a desired level of precision. An important interplay exists between cost, sample size, and sampling methods. Different sampling methods have different costs, and yield data of differing quality and reliability. Variation within data reflects a combination of process (or "true") natural variation in the parameter of interest, and sampling variation (or sampling error, caused by imprecision in measurement, sample size, observation error, or faulty data recording).

Where existing data are available, *a priori* power analysis is employed to determine sample-size needs for the SEAN monitoring. Where data are not available, frequent assessment of ongoing monitoring (e.g., frequent estimation of the coefficient of variation as data are collected and sample size increases) is used to ensure adequate samples or to adjust sampling efforts.

Integrative Considerations

Where possible, and primarily for the four freshwater water quality Vital Signs, the SEAN monitoring program emphasizes colocation of Vital Sign monitoring locations, and covisitation. Colocation refers to monitoring multiple Vital Signs at the same physical locations. Covisitation refers to recording observations on multiple Vital Signs during a sampling occasion. Both offer an obvious benefit of operational efficiency. Overall time and costs for plot set up and sampling are reduced when measuring multiple Vital Signs at the same place and time.

Synoptic measures can provide important insights into ecological processes with direct application to management, in three ways. First, monitoring both drivers and receptors aids in interpreting mechanisms of observed changes. This information could lead to the identification of resource conditions for which mitigation actions would be effective (e.g., understanding whether patterns of invasive plant establishment are due to human disturbance vs. climate-driven change). Second, synoptic measures enhance the understanding of causes and consequences of interactive behaviors. Interactions among ecological attributes will manifest as one of two primary behaviors. Additive behaviors are expressed as opposing or parallel trends among indicators. Complex behaviors vary from nonlinear to chaotic, and occur in response to exceedance of thresholds, for particular combinations of state conditions, or as a response to exceeded thresholds (Michener et al. 2001). Third, where lack of precision masks statistically significant change, the collective consistency in trends among Vital Signs can provide a weight-of-evidence indication of change. Taken together, synoptic measures minimize confounding factors and enhance assessments of such subtle (but potentially important) trends. These weight-of-evidence approaches (see Burton et al. 2002) will be used to maximize inference strength and data integration across Vital Signs. Similarly, we will also explore options for constructing and using Bayes Nets (Marcot et al. 2006, McCann et al. 2006) for integrating and updating knowledge over time; Bayes Nets would be useful both in using monitoring data to support park-level decision-making and also to test and refine the conceptual models that serve as the underpinnings to our monitoring approach.

Response Design

A response design directs how to record the response (Vital Sign metric) within each sampling unit, which includes choosing a method of measurement and an optimum shape and size of units (Stevens and Urquhart 2000). In area sampling, for instance, a complete count or measurement of elements within a sampling unit often is not possible, especially when elements are mobile organisms. Even sessile organisms such as plants may be overlooked if sampled during a time

when features used for identification are not present or if organisms are present but below ground (e.g., in dormancy). A probability sample of units may still result in a biased estimator of trend if bias is associated with the response design.

The probability of detecting an individual or species within a sampling unit, given it is present, is called probability of detection or detectability. Incomplete detectability occurs due to perception and availability bias, both of which contribute to sampling error (Marsh and Sinclair 1989, Pollock et al. 2004).

Perception bias arises when there is a failure to detect an individual or species that is available for detection (i.e., detection probability is nonzero). For instance, individuals left unrecorded due to their lack of identification features at the time of recording observations and measures results in perception bias. Methods such as capture-recapture (Pollock 2000) and distance sampling (Buckland et al. 2001) account for this component of individual detectability (see also Williams et al. 2002). Nichols et al. (1998) offered an approach to estimate this component of species detectability in community metrics such as species richness.

Availability bias results when individuals or species are present but unavailable for detection (i.e., detection probability is zero). For example, an availability bias would result from the failure to record plant species because they were dormant and underground during a sampling occasion. Conducting surveys from the same platform when multiple platforms are more appropriate may induce availability bias. For instance, repeat aerial surveys of bald eagle nests may miss more nests than a combination of aerial and ground surveys, where the latter method may detect nests obscured by dense vegetation. There has been recent activity in developing methods to account for availability bias (e.g., Pollock et al. 2004).

Failing to properly account for individuals' or species' detectability will lead to biased trend estimation. The magnitude of this bias relative to the specified level of change and to the variability of the estimator will determine whether the level of bias should be a concern. However, estimates or a realistic range of estimates of detectability bias and variability are required to confirm this relationship. Bias also may be ignored if the observed change is proportional to the true change (and if the relationship between observed change and true change does not vary over time), but this relationship is far from guaranteed, even if standardized methods are used, because relationships between parameters of interest are often complex (Thompson 2002). If detection bias has a large influence on the performance of a trend estimator, a true change cannot be distinguished from a false trend generated by temporal changes in detection rates. Biases of this sort can have a deleterious effect on natural resource decisions (Moore and Kendall 2004). Attention to incomplete detectability is critical to ensure that SEAN monitoring results are unbiased. Whenever possible, the SEAN response designs will incorporate methods to properly account for incomplete detectability.

Appendix H

The 36 Priority Vital Signs for the Southeast Alaska Network

Ecological Monitoring Framework					
Level 1	**Level 2**	**SEAN VITAL SIGN**	**SEAN PARKS**		
			GLBA	**KLGO**	**SITK**
Air and Climate	Air Quality	**Airborne Contaminants**	●	●	●
		Visibility and Particulate matter	+	+	+
	Weather and Climate	**Weather and Climate**	●	●	●
Geology and Soils	Geomorphology	**Glacial Dynamics (extent)**	●	●	
	Hydrology	**Streamflow**	●	●	●
		Oceanography	●		
Water	Water Quality	Freshwater Benthic Macroinvertebrates and Algae	+	+	●
		Freshwater Contaminants	●	●	●
		Freshwater Water Quality	●	●	●
		Marine Contaminants	●	●	●
Biological Integrity	Invasive Species	Invasive/Exotic Animals	+	+	+
		Invasive/Exotic Plants	○	○	○
	Infestations and Diseases	Pests and Diseases	+	+	+
	Focal Species or Communities	Bald Eagles	+	+	+
		Bears	+		
		Biodiversity of Select Groups or Assemblages	+	+	+
		Breeding Land Bird Populations	+	+	+
		Forage Fishes	+	+	
		Harbor Seals	+		
		Intertidal Communities	+	+	●
		Killer Whales	+		
		Marine Predators	●		
		Kittlitz's Murrelets	●		
		Salmonids	+	+	+
		Ungulates	+		
		Western Toads	+	○	
		Wetland Communities	+	+	+
	At-risk Biota	Humpback Whales	○		
		Steller Sea Lions	+		
Human Use	Consumptive Use	Consumptive Use	+	+	+
	Visitor and Recreation Use	Human Uses and Mode of Access	○	○	○
	Soundscape	Airborne Sound	+	+	+
		Underwater Sound	○		
Landscapes (Ecosystem Patterns & Processes)	Landscape Dynamics	**Landform and Landcover**	●	●	●
		Phenology	+	+	+
		Plant communities	+	+	+

● Vital Signs for which the network will develop protocols and implement monitoring using funding from the Vital Signs or water quality monitoring programs. These Vital Signs represent the Core SEAN Program.

○ Vital Signs that are currently being monitored by a network park, another NPS program, or by another federal or state agency using other funding. The network will collaborate with these other monitoring efforts. These Vital Signs represent the Secondary SEAN Program.

\+ Vital Sign occurs in this park but will not be monitored at this time due to higher priorities and staff and funding limitations

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS D-171, September 2008

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