Southeast Alaska Inventory and Monitoring Network
National Park Service - U.S. Department of the Interior

Marine Ecosystems Monitoring Scoping Workshop

Summary Report

Chiska Derr, Coordinator, Southeast Alaska Network (SEAN)

Chris Fastie, Ecologist, Middlebury College

March 2006

Marine Workshop
2 - 4 February 2006
Goldbelt Hotel, Juneau, Alaska

Workshop planning, facilitation, logistics, and recording services provided by:

Sheinberg Associates
Juneau, Alaska

Southeast Alaska Network (SEAN)
National Park Service

Marine Ecosystem Monitoring Scoping Workshop

February 2-3, 2006

Meeting Summary

Table of Contents

1.0 Introduction 1

2.0 NPS Inventory and Monitoring Program 2

3.0 Marine Ecosystem Models 3

3.1 Panelist Presentations 3

3.2 Discussion Points 11

3.2.1 Phytoplankton and zooplankton relationship and effect on food web 11

3.2.2 Influence of glacial outwash on marine ecosystem 11

3.2.3 Can the I&M program address poorly understood systems or processes? 12

3.2.4 Human Drivers of Change 12

3.2.5 Written comments on the conceptual ecosystem models 12

4.0 Insights and Advice from other Alaska Park Networks 13

5.0 Identify Monitoring Objectives, Questions and Vital Signs for the SEAN Marine Ecosystem 16

6.0 Identifying SEAN Monitoring and Vital Sign Priorities 30

6.1 Themes Identified 30

6.2 Panelists Remarks 31

6.3 Discussion Points during Question/Answer and Closing Session 38

6.3.1 More Specific Monitoring Suggestions. 38

6.3.2 Strategic and creative uses of funding 39

6.3.3 Ships of Opportunity. 39

6.3.4 Partnerships – Sharing the data and the data management work. 40

6.3.5 Value of Glacier Bay as a marine laboratory 40

6.3.6 Monitoring program should evolve, as more is known about the marine environment 41

Appendix A. Marine Scoping Workshop Agenda 42

Appendix B. Participant List 45

Appendix C. Annotated Marine Bibliography 47

National Park Service
Southeast Alaska Network (SEAN)

Marine Ecosystem Monitoring Scoping Workshop

February 2-3, 2006
Juneau, Alaska

Meeting Summary

1.0 Introduction

The National Park Service (NPS) has established an Inventory & Monitoring (I&M) program to provide high quality information to park managers on the current status of the park natural resources and on long-term trends. National parks that are geographically linked and have similar natural resource characteristics have been grouped into monitoring networks. The Southeast Alaska Parks Network (SEAN) includes Glacier Bay National Park and Preserve (GLBA), Klondike Gold Rush National Historical Park (KLGO), and Sitka National Historical Park (SITK). SEAN is now developing the I&M program for these parks.

On February 2-3, 2006, 18 scientists with expertise in Southeast Alaska's marine ecosystems gathered in Juneau to assist SEAN in identifying monitoring objectives, questions, and vital signs to include in the I&M program for the network's marine ecosystems.[1] In the I&M context, 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".

Workshop participants also discussed and refined ecosystem models being developed for the network. The workshop agenda (Appendix A), list of participants (Appendix B) and annotated bibliography (Appendix C) are attached.

The desired outcomes for the marine workshop were:

1. Understand the national and SEAN I&M program purpose, framework, process and terms.
2. Discuss and refine conceptual marine ecosystem models.
3. Identify the important marine monitoring objectives and questions for SEAN.
4. Identify candidate marine vital signs to monitoring.
5. Discuss specifics of what and how to monitor.

[1] SEAN hosted workshops focusing on the network's freshwater ecosystems in February 2005 and on its terrestrial ecosystems on January 31-February 1, 2006.

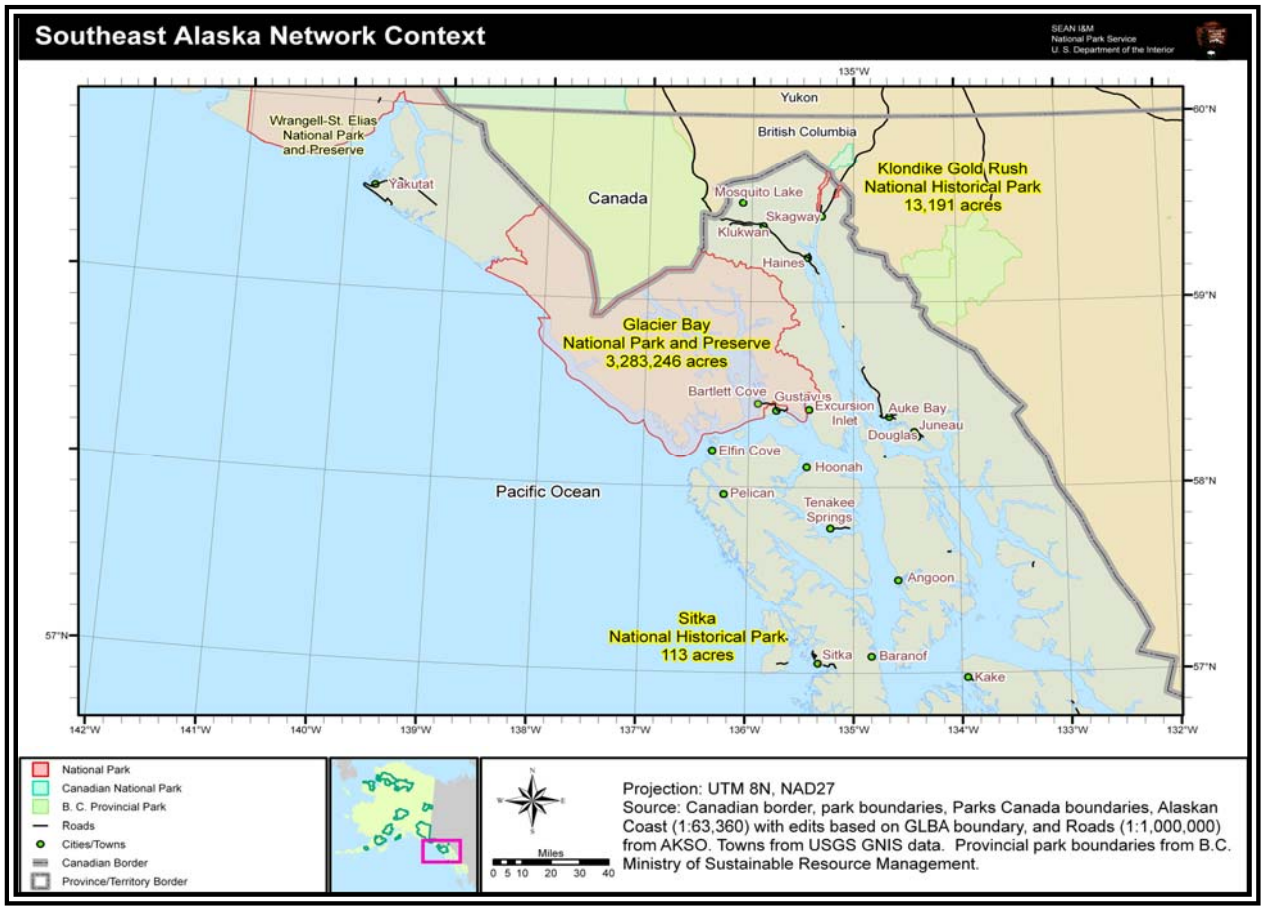
2.0 NPS Inventory and Monitoring Program

The workshop began with an overview of the NPS I&M Program and SEAN's progress in developing an I&M program for the network. The three speakers for this session were:

- *Sara Wesser, NPS, Alaska Regional Coordinator, Inventory and Monitoring Alaska;*
- *Chiska Derr, NPS, SEAN Coordinator*; and
- *Susan Boudreau, NPS, Chief of Resources, Glacier Bay National Park and Preserve*.

This introductory session set the context for work to be accomplished during the meeting. The Workshop Notebook distributed before the meeting included material to accompany the presentations. The speakers' PowerPoint presentations are available from the SEAN coordinator.

The following figure shows the locations of the three national parks included in the Southeast Alaska Network.



The purposes of the national I&M Program are to:

- Inventory - provide a systematic set of baseline information about the condition of park resources, and
- Monitor - periodically determine status and trend in the condition of a subset of park resources (e.g. "vital signs") over time.

Monitoring efforts are intended to provide early warning of impending threat to resources and ecosystems; identify and understand meaningful change in natural systems characterized by complexity, variability and surprises; and assess the efficacy of park management efforts. Through monitoring of vital signs parks will track a set 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.

SEAN is following a three-phase planning process to prepare its I&M program. The phases are:

- *Phase I*: Define monitoring goals and objectives; begin the process of identifying, evaluating, and synthesizing existing data; develop draft conceptual ecosystem models; hold vital signs scoping workshops; and determine preliminary monitoring questions.
- *Phase II*: Refine the conceptual ecosystem models and select "vital signs" that will be monitored as indicators to detect change.
- *Phase III*: Determine the overall sample design for monitoring; develop protocols for monitoring; and produce a data management plan for the network.

This marine monitoring workshop will help SEAN accomplish elements of both Phase I and Phase II. The discussion and outcomes from the SEAN I&M workshops will also benefit other NPS efforts, including the inventory and monitoring chapter of the Glacier Bay Integrated Science Plan (ISP), the Coastal Cluster Program, and existing park-sponsored monitoring.

3.0 Marine Ecosystem Models

3.1 Panelist Presentations

This session focused on the newest additions to the suite of ecosystem models being developed for SEAN. Greg Streveler and Dan Lawson described models that were introduced in draft form at the Freshwater Scoping Workshop in February 2005. Since that time, these models have been refined and extended to include the marine realm. Jim Bodkin described a conceptual model developed for the Glacier Bay marine system which could be used to organize our knowledge about marine species and resources and to select candidates for monitoring programs.

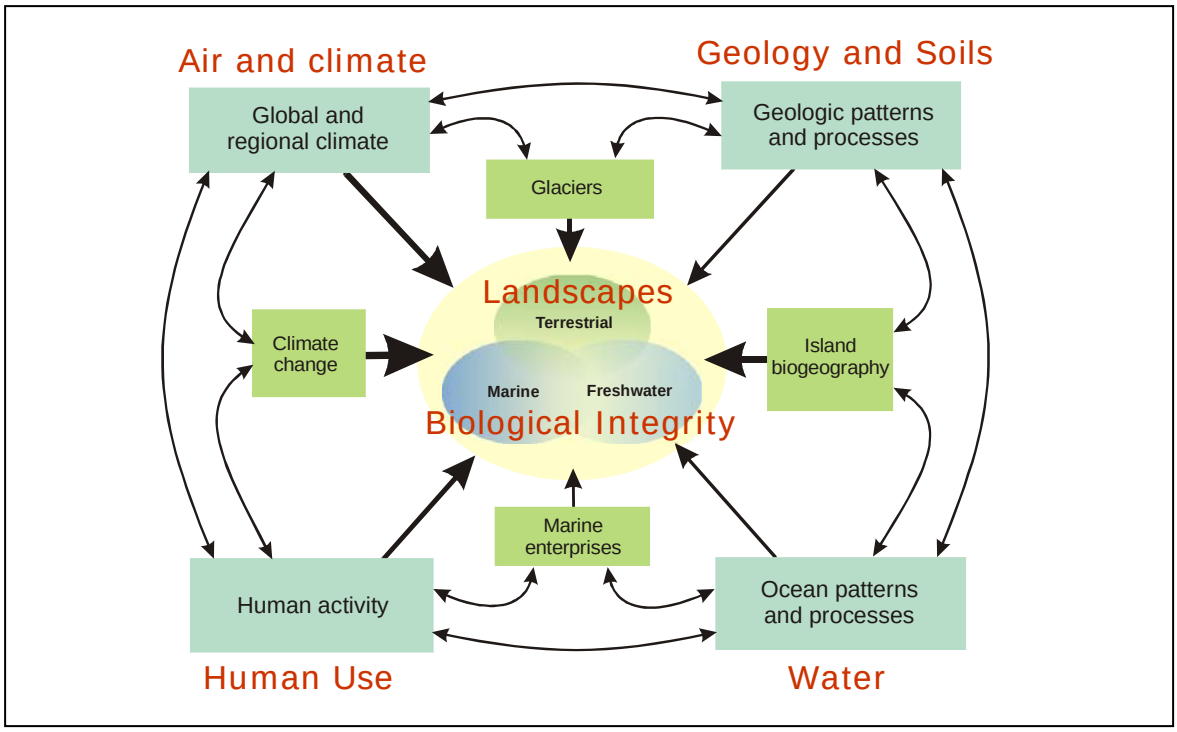
The panelists were:

- *Chris L. Fastie, Middlebury College* – Introduction and description of a few of the general ecosystem models.
- *Greg Streveler, Icy Strait Environmental Services* – Origins of Southeast Alaska's marine environments, with a focus on Glacier Bay
- *Dan Lawson, Cold Regions Research and Engineering Laboratory* – Glacial influences on marine environments at SEAN parks.
- *Jim Bodkin, USGS AK Science Center Biological Science Office* – A Glacier Bay conceptual marine ecosystem model.

Chris Fastie - Description of a few of the general models

Chris Fastie reviewed three of the conceptual models of Southeast Alaska's ecosystems that he and others have been developing for the last two years. The models assist with ecosystem monitoring, because they facilitate scientific thinking about the environmental drivers that make SEAN ecosystems the way they are now, and the environmental drivers that are most likely to cause change in the ecosystems. The focus of the conceptual modeling effort is now changing from one of describing how park ecosystems work, to using the models to help choose vital signs to monitor and to defend those choices.

The SEAN holistic model (see figure below) includes the four categories of environmental drivers considered to have the strongest influence on SEAN parks. These are climate, geologic processes, oceanic processes, and human activity, each at a corner of the diagram. Overlain on this diagram (in red) are the six broad categories of vital signs from the NPS Inventory and Monitoring Program. All vital signs selected will be assigned to one of these categories. This illustrates that all of the environmental drivers considered to be important to SEAN parks, including physical processes, are candidates to be vital signs. The NPS Ecological Monitoring Framework which includes the six broad categories does a poor job of explicitly including marine systems. Therefore, many potential vital signs for SEAN's marine component will be assigned to the "Water" category.



Holistic model: Drivers of change with EMF Level 1 categories (in red). Climate, geologic processes, ocean processes, and human activity are the four major driving forces shaping ecosystem components and ecosystem processes in Southeast Alaska. Thicker radial arrows indicate greater influence.

In discussion, one workshop participant asked if it was possible to include a temporal component to some elements of the model, since not all of the drivers of change operate at the same rate or influence the ecosystems at the same timescale. Chris acknowledged that point, but did not know whether that would be possible to represent graphically.

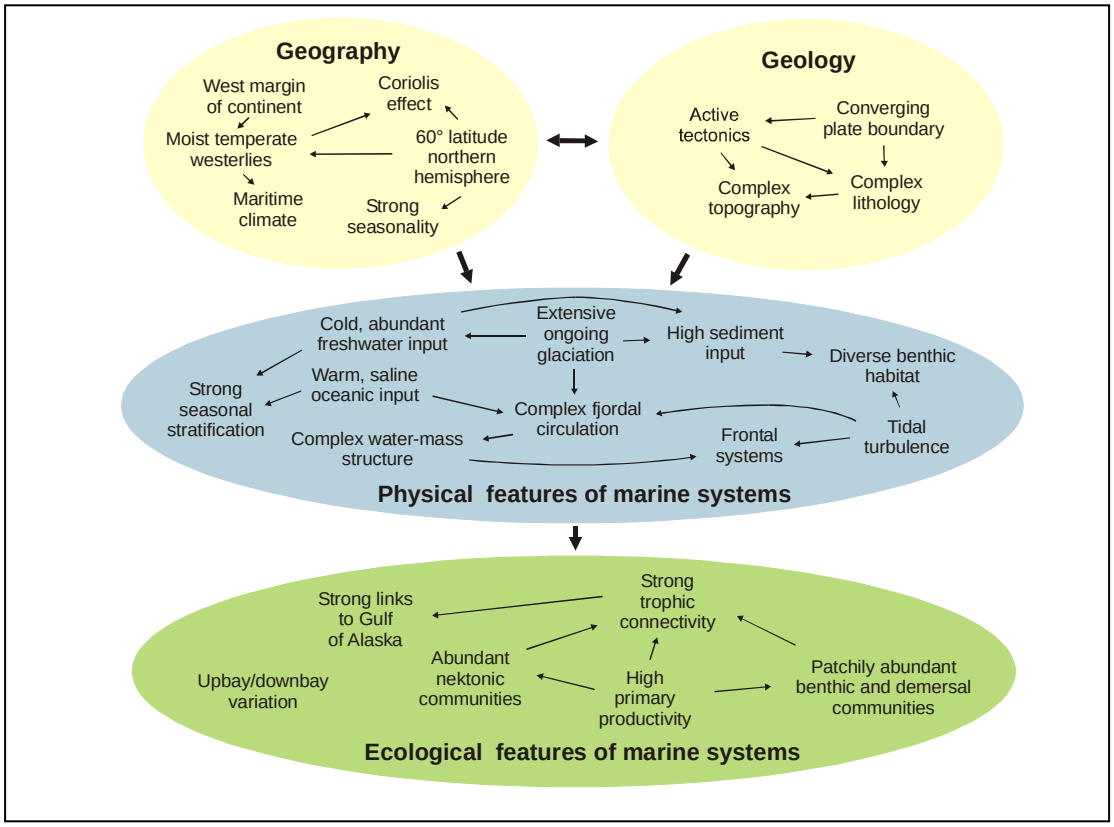
Greg Streveler - Origins of Southeast Alaska's marine environments, with a focus on Glacier Bay

Greg Streveler presented a general model of Southeast Alaska's marine ecosystem. Greg described how the geographic and geological processes at work in Southeast Alaska create a physical landscape that strongly influences which types of ecological features can develop.

Geography. Southeast Alaska's geographic position on the globe generates the region's prevailing westerly winds and currents. These westerly forces create the region's maritime climate with its moderate temperatures and abundant moisture.

Geological processes. Geologic processes in Southeast Alaska are a fundamental driver of the terrestrial ecosystem. The region sits at the convergence boundary of the North American and Pacific crustal plates. The collision of the plates is complicated by a rotation in the Pacific plate, which has left a great diversity of rock types and ages throughout Southeast Alaska and along Alaska's Gulf Coast. Active tectonic processes cause uplift and the development of steep coastal topography. In the last three million years, Gustavus has

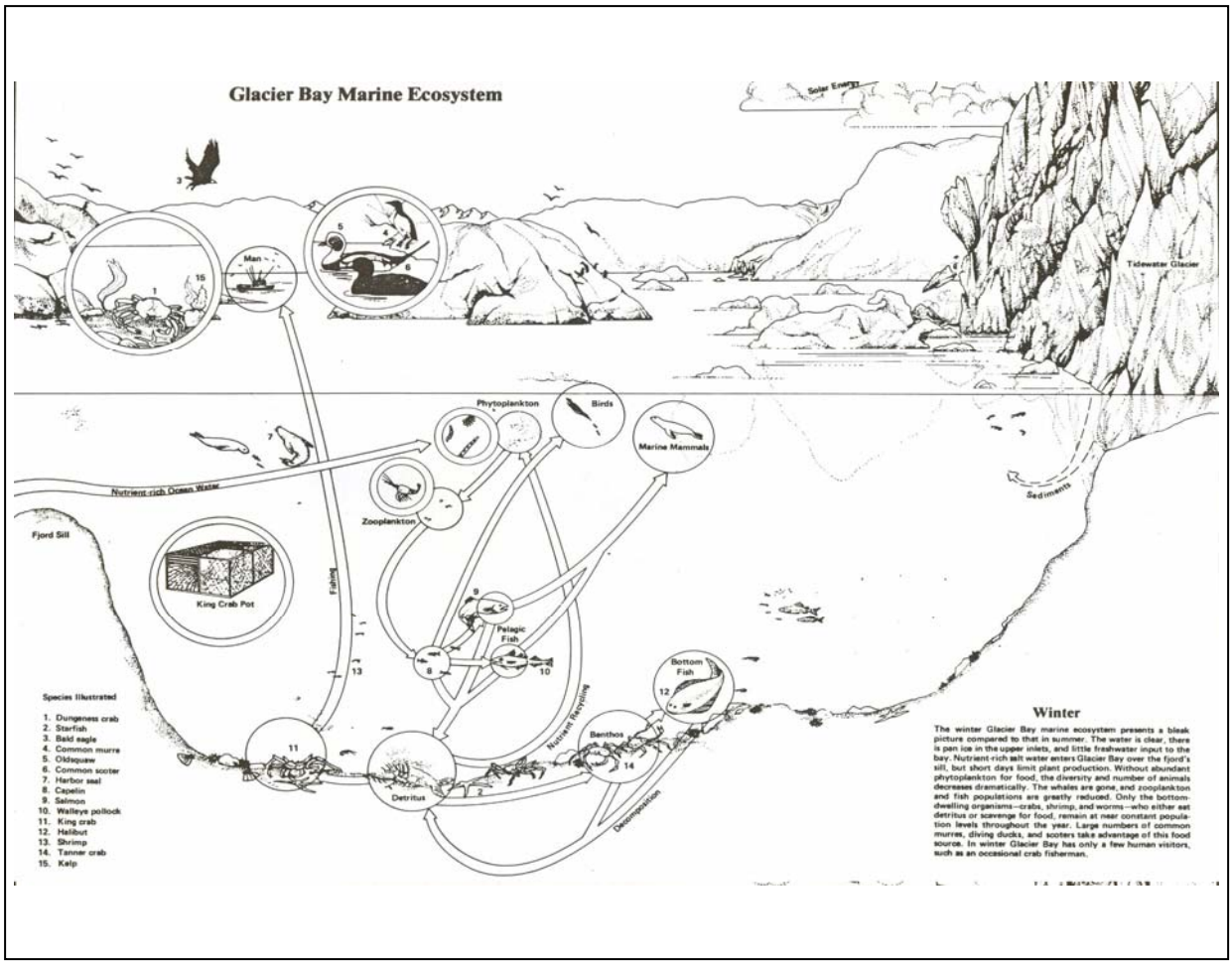
risen 3 to 5 kilometers, the Fairweather Mountains have risen 7 to 15 kilometers, Sitka 5 to 6 kilometers, and Skagway about 20 kilometers. This geologic picture, combined with the region's geography, has created an intense glacial history in the SEAN parks.



Influences on ecological features of marine systems. Greg Streveler developed this diagram to apply primarily to Glacier Bay. This version includes changes made in response to comments made at the SEAN Marine Scoping Workshop.

Marine Ecosystem. Relatively warm and low-salinity waters abut the coast with an energy input that tends to force them into the inner channels. In those inner channels there is freshwater input from the extensive, maritime-climate induced, glaciation. There is thus a collision between two fundamentally different water masses. In a fjord like Glacier Bay the freshwater input forms a stratified surface layer that is always receiving input and moving down-inlet, entraining underlying saltwater as it flows. There also tends to be upwelling at the glacier fronts. Add very strong tidal energy and complex topography, and complex water mass structure results that generates internal tidal waves and frontal systems that concentrate phytoplankton.

Greg cites Hooge & Hooge (2002) and Hale & Wright's (1979) ecosystem models that emphasize GLBA's high marine productivity. This generated a lot of discussion from the group. All agree there is a long period of high primary productivity in GLBA in addition to the major spring-summer peak of productivity. The nature of the phytoplankton and zooplankton relationship was examined, and the vertical transport of productivity from the surface to the bottom was discussed, as well as the patchiness of benthic accumulations.



Conceptual model of Glacier Bay ecosystem interactions in winter. From Hale and Wright 1979.

Ginny Eckert noted that Greg's perspective starts with the land and glaciers and moves down and out to the marine, whereas her view starts with Southeast Alaska's connection to the Gulf of Alaska and from there moves to the inside waters. She suggests that the Gulf of Alaska be put on the model somewhere. Also, in the marine ecosystem there are linkages related to the many species with huge migrations and multiple life phases; this is a connectivity feature to add to the model.

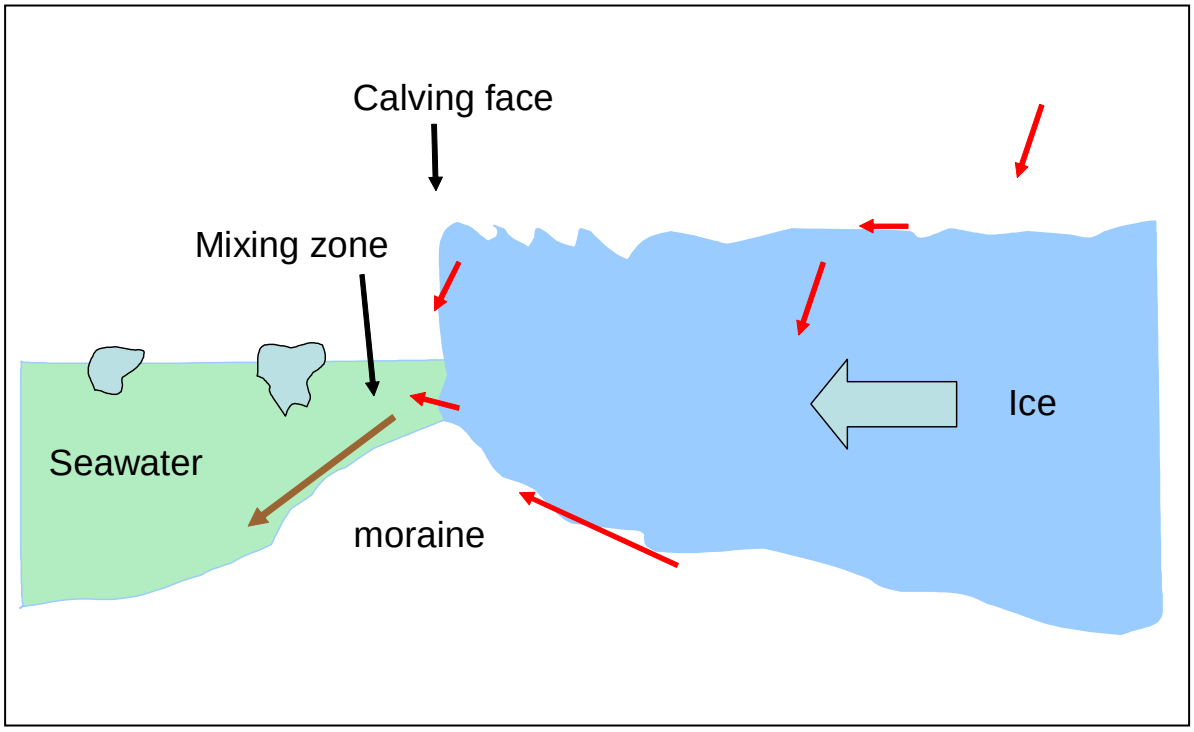
Jim Taggart commented that Sitka is near the bifurcation zone of where larger regional currents split and go north and south. The movement of this bifurcation zone due to climate changes in the future could have a large impact on parts of the Southeast Alaska marine ecosystem. In this respect, Sitka is in a unique location as a long-term monitoring site.

Dan Lawson - Glacial influences on marine environments at SEAN parks.

Dan Lawson discussed a model of current and past glaciers and glacial dynamics. Submarine topography is the direct result of both erosion and deposition by ice. Today, tidewater glaciers terminate directly in fjords while terrestrial glaciers terminate on land

and produce freshwater streams that flow into the ocean. Glaciers influence each of the ecosystem types - marine, terrestrial, and freshwater. For the marine ecosystem, the most important aspect is what is being discharged from glaciers (via meltwater and direct sediment discharge). The water contains solutes, nutrients, organics, and sediments which build up morainal deposits in the marine environment. A diagram of the tidewater/marine environment margin showed submarine moraines pushed forward by glaciers. The advance or retreat of a glacier terminus is a net effect of the amount of ice moving from the accumulation zone, the amount of calving that occurs at the terminus, and the amount of melting that occurs at the interface between seawater and ice. Recent studies show that this interface is very important in actually melting the face and producing fresh water. The other source of fresh water is through the drainage system - from the surface, within, and beneath the ice. The sediment released is very coarse-grained material deposited immediately by streams and fine-grained material which is dispersed in a plume that floats across the top of the seawater.

We need to consider how glaciers are interacting now with the marine environment, and how and what might happen in the future.



The tidewater margin of a fjord glacier. Red arrows indicate water flowing onto, through, under, and out of the face of the glacier. Brown arrow indicates the deposition of coarse sediments. Adapted from Dan Lawson's presentation at the Marine Scoping Workshop.

Jim Bodkin - Glacier Bay Conceptual Bay Ecosystem Model

Jim Bodkin presented a marine ecosystem model that represents the relative influence of six processes that affect marine populations (see figure below). The model can be used to identify species for which we have either a relatively good or relatively poor understanding

of the processes structuring its populations. It can also reveal which processes are important for a large number of species. This approach has been applied in the Gulf of Alaska as part of the GEM program of the Exxon Valdez oil spill Trustee Council. The model is the conceptual basis of a process to select species and metrics for large-scale nearshore monitoring and research.

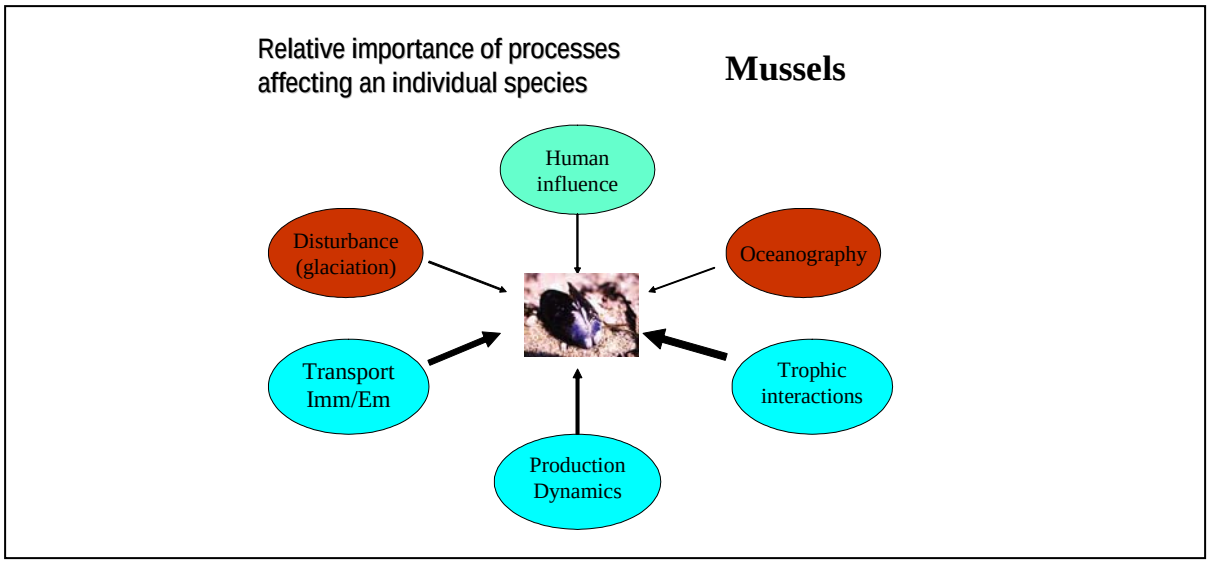
Three Marine Communities. Jim described three communities within the marine system – the nearshore, offshore, and deep benthic communities. Distinctions between the nearshore, benthic, and offshore communities are not distinct. For example, there is exchange of waters, nutrients, eggs, larvae, and juveniles between these three communities, as well as active movement of organisms through migration and changes in their life cycles. In general, primary productivity in the offshore system is driven by carbon fixed by phytoplankton. The phytoplankton fuel zooplankton, and both of these feed higher tropic levels, largely filter feeding planktovores. Forege fish often serve as the conduit of further energy transfer to the mammalian and avail apex comsumers. Nutrients are generally considered to be limiting. The nearshore system is supported to a large extent through the primary production of macro algae. Transfer of energy is mediated largely through sessile benthic invertebrates such as mussels, clams, urchins and crabs. Substrate and light penetration are limiting factors. The deep benthic communist is relatively poorly described and understood in Glacier Bay.

Processes Influencing Marine Communities. Six very broad processes affect the marine communities:

1. Human influence
2. Disturbance (e.g. glaciation)
3. Oceanography (e.g. physical, biological, climatic)
4. Transportation (active and passive immigration, emigration, and migration)
5. Production dynamics (reproduction, growth and survival)
6. Trophic interactions (e.g. predation, grazing, and decomposition)

Oceanography, transportation and production dynamics are considered important influences of the offshore food web. Less important are trophic interactions, human influence and disturbance. For the nearshore food web, trophic interaction, transportation and immigration (e.g., sea otters moving into GLBA in recent decades), production dynamics, and human influences are considered mid-level to high important. Oceanography and disturbance may be less important than in offshore communities.

An analysis of the relative importance of each of the processes on individual species or populations can also be performed. An example using mussels is shown.



The thickness of the radial arrows indicates the assumed relative importance of six processes on populations of mussels. Adapted from Jim Bodkin's presentation at the SEAN Marine Scoping Workshop.

Using the Model. This model can be used to help to:

- Identify processes that are important to communities or species;
- Identify similarities and processes between systems;
- Identify similarities and processes among taxa; and
- Make reasoned and objective decisions about species to monitor and processes to study.

A model-generated matrix can be created to rank (low, medium and high) the relative influences of important processes on several hypothetical species (see below). The evaluation criteria are:

- Strength of the interaction between a species and a process;
- Historical data available;
- Is the resource of management concern; and
- Feasibility of obtaining metrics on this resource (including cost).

	PROCESS					
Species	Human	Ocean	Trophic	Prod.	Trans.	Dist
M	l	l	H	h	h	m
C	h	l	H	m	m	l
U	m	l	H	m	m	l
Cr	h	m	M	m	h	l
S	l	l	M	h	l	l
St	m	l	M	l	l	l

A scientist asked whether a process important to a species would become even more important if it is deemed particularly susceptible to change. Jim answered that no, they tried to keep it simple. This, and things such as incorporating a temporal or spatial element into the model would increase model complexity.

3.2 Discussion Points

3.2.1 *Phytoplankton and zooplankton relationship and effect on food web*

The nature of the phytoplankton/zooplankton relationship during the seasonal peak was examined. When there are abundant zooplankton in the pelagic bloom, the amount of phytoplankton that makes it to the benthic community is greatly reduced. When there are not very many zooplankton, and there are abundant phytoplankton in the spring bloom, there can be a very strong pulse of phytoplankton that end up in the benthic community. The benthic community and the pelagic community can be in opposition.

Greg Streveler asked Jim Bodkin if he thought there was a standing food base that sustains the ecosystem in times of the year when the phytoplankton is low. Jim responded that there is an accumulation, but the benthic ecosystem is very, very patchy. The "patchy abundance" at the bottom of the Greg's model needs emphasis in terms of meta-population dynamics and the productivity of patches over relatively large spatial scales. There will also be areas in the basin that are very productive and areas at a similar depth and sediment type that are not. Vertical transport of productivity from the surface to the bottom is more efficient in some areas than others. To capture this conversation, Greg suggested he will add vertical transport of patchy primary productivity to his model. Pelagic food chains can capture and reduce, or accelerate, the amount of transport. This is also something that is likely to change temporally as the suite of zooplankton changes through time.

3.2.2 *Influence of glacial outwash on marine ecosystem*

A scientist asked whether there exist any measurements of the organics and nutrients in glacial outwash to the marine environment. Dan Lawson noted that there have been attempts (Ross Powell and Ellen Cowan in GLBA to look at carbon), but no detailed study. Ginny Eckert noted that she and Lisa Eisner collaborated in 2004 with John Piatt to do a series of oceanographic surveys looking at nutrients and other trophic levels. They won't be able to link anything to the glacier itself, but can describe a pattern of higher nutrients closer to glaciers. The data are limited, though. This is a largely unexplored area; something is going on there - look at the aggregation of seabirds and fish at the glacial edge. Lewis commented that he has discounted any direct nutrient/carbon contributions by glaciers in the past and it is interesting to hear how they may contribute to productivity as sources. Jim Taggart noted that while it can't be linked to glaciers, there are detectable signatures of different carbon sources in crabs.

3.2.3 *Can the I&M program address poorly understood systems or processes?*

Not much is known about the deep benthic community. Can the I&M program address systems that are poorly understood? In response, Sara Wesser noted that there is room, but not if the justification is curiosity alone. There must be a compelling reason why such understanding is important. We have significant gaps in information that matter.

3.2.4 *Human Drivers of Change*

There are two scales of human drivers that affect these ecosystems. At the top are global-level influences: people affecting the land and water in ways that cause changes to global biogeochemical cycles such as transferring carbon from biomass or fossil fuels into the atmosphere. In extreme cases these influences can cause loss of species, populations, or even an ecosystem. This hasn't happened in Southeast Alaska, but it has happened in other places in the world. The other scale of human impacts or drivers is regional and local, including both consumptive and non-consumptive uses within the parks or near them. In Fastie's models, the thickness of the arrows shows the relative influence of drivers, and for the marine ecosystem, consumptive use may be more significant than for the terrestrial or freshwater ecosystems.

3.2.5 *Written comments on the conceptual ecosystem models*

Immediately following the session on conceptual ecosystem models, workshop participants were asked to write any comments or suggestions relevant to the models and their utility for the vital signs selection process. Ten participants, including most of the invited guests, submitted responses. Several responses stressed points that were made in the discussion session about omissions in the depictions of marine ecological processes in Southeast Alaska. Each of the following four points was made by two to four participants.

- Ecological processes in Glacier Bay cannot be understood without explicit reference to the strong connections between the Bay and waters outside the Bay including Icy Strait and the Gulf of Alaska.
- Trophic interactions, which drive the transfer of energy and nutrients through food webs, are central to understanding ecological stability or change in marine ecosystems.
- The coupling between pelagic and benthic communities driven by the settling of phytoplankton-fixed energy and nutrients into the benthic zone is a crucial ecological link.
- The huge range of temporal and spatial scales over which marine ecological processes function should be acknowledged. It is important to know the scale or rate that is being addressed by a model or a monitoring question.

Other comments made by single participants included a reminder that while phytoplankton-based primary productivity is important in the pelagic zone and macroalgae-based productivity is restricted to the nearshore zone, phytoplankton-based productivity is also important in the nearshore zone. Another participant pointed out that

diel migrations of forage fish between benthic, pelagic, and epi-pelagic zones complicate the assignment of these species to particular communities or habitats. A comment about the holistic model of environmental drivers affecting SEAN parks suggested that this model be used as a roadmap to the other models, making it more clear how the models relate to one another.

4.0 Insights and Advice from other Alaska Park Networks

Alan Bennett, Southwest Alaska Network (SWAN) Coordinator for the NPS Inventory and Monitoring program presented information on what SWAN and other park networks in Alaska have accomplished and lessons learned.

There is no single grand monitoring plan that is applicable across a whole host of networks.

In Southwest Alaska there are 1,200 miles of marine coastline on the western side of northern Gulf, some steep, some shallow. There is a long intertidal zone, and lots of diversity. There is very little research or monitoring data. Mean high water is the boundary of all SWAN parks. Most parks have extensive private land inholdings (native village corporations, regional village corporations). Human-use related issues include clear-cut logging and the threat of oil spills with region-wide park impacts. Earthquakes have had major effect restructuring the park intertidal zone, which are represented in the SWAN models. One park is very remote on the Alaska Peninsula, and SWAN expects to do very little on-the-ground monitoring there.

SWAN process milestones were:

1. Review and summarize past and present park resource monitoring (2002).
2. Develop monitoring questions and objectives (pre-workshop). What do we really want to know about these parks that we want to monitor.
3. Develop conceptual models.
4. Hold series of scoping workshops.
5. Refine conceptual models.
6. Refine monitoring questions and objectives (post workshop).
7. Produce and prioritize a final list of vital signs. Process - first layer based on ecological significance and relevance to management issues, second layer based on feasibility. A small technical committee subgroup reworked the long vital sign list down to a shorter list of three categories. They didn't eliminate lower ranking vital signs. If another agency was already doing something and it was not too expensive to add on to what they were doing, SWAN would consider it even if it was lower priority. Things may fall off the list as they

learn more. For example, river otters are poorly understood, but they might be a good indicator of forage fish. SWAN is conducting surveys to determine whether there are enough to monitor. They are finding that there are not many otters in Katmai, so they may fall off the list.

SWAN has finished its Phase I, II and III program development and reporting and is now on to monitoring. Alan listed the following insights about developing an I&M program during his presentation and in response to questions.

- Define your niche, especially with marine coastal. Eliminate out redundancy.
- Define terms for vital signs - have a common understanding of what you're talking about and why it's important.
- Establish focus, boundaries – For marine resources, SWAN decided to focus scoping on the intertidal zone, the mean high water mark. For freshwater, the scoping focus was large multi-lake freshwater flow systems. (Not all experts agreed. For example, some suggested focusing on headwater streams and tundra ponds, but this was not where park managers wanted to look because these areas were not places that linked to park mandates or enabling legislation.)
- Define spatial and temporal focus - baseline monitoring (coastal mapping).
- Identify a unifying concept**.** (SEAN has done a good job of this.) List the processes that are drivers of change for monitoring. SWAN's unifying principle was the flow of water and the implications of that (transport of nutrients, invasive species, pollutants, etc.).
- Make choices on what to monitor based on broad principles. Try to have interchangeable teams to go out park by park to do monitoring with a common agenda or protocol.
- If SWAN could do it again, they would not prioritize and rank vital signs based on ecological and management significance. The first 12 networks used these criteria, but the next generations of networks are coming up with matrixes for weighing things in a more productive way. His advice is:
    a) simple is better,
    b) use in-house people (park staff and technical committee), and
    c) know when to quit.

- Keep in mind that vital signs which are amenable to monitoring enhance the likelihood of routine, sustained, and cost-effective monitoring. Some monitoring programs are behind schedule because of stringent protocols. Don't fall into the trap of specifications that are too tight.
- The Ecological Monitoring Framework (EMF) hasn't been the best tool. Alan can understand the advantages of using it nationally to roll-up vital signs for reporting, but be creative if the EMF doesn't work for other purposes.

- SEAN will get more utility from vital sign lists if they are bundled in packages of integrated vital signs, particularly when writing later chapters of the monitoring plan. This helps operationally, financially, staff wise and with logistics. In some cases, SWAN has one protocol that addresses an entire suite of vital signs.
- Some vital signs were selected almost entirely because of management importance. Brown bears are an example. One could argue ecologically for selecting brown bears but also argue against selecting them. Another example is volcanoes in Katmai and Aniakchak. Up to 20% of the vital signs selected were "just there" and didn't emerge from meaningful analysis of models.
- Park mandates in Katmai and Aniakchak are specific on the role of those parks in long-term research monitoring (observing the effects of succession of post volcanic landscapes). SWAN benefited from having that push; GLBA also has that same language. Also, SWAN did not have a lot of ongoing species-specific research, so that influenced their more objective, broad vision.

- SWAN scientists had a vision that the program be broad and not species-focused. For example, in most parks, wildlife biologists were already surveying moose and caribou, but knew little about how habitat was changing. Knowledge of the habitat trajectory, the context, is missing. Caribou may be declining, and it may be that that is simply the world we are looking at. There may be fewer caribou because the lichen communities are successionally changing into alder thickets. SWAN is going to seek the answer to these questions when it initiates vegetation monitoring. Park managers want this. The parks can provide intensive annual caribou and moose surveys but they need monitoring program help for broader-based monitoring projects that use MODIS imagery to provide a broad scale picture of changes in duration of ice cover on large freshwater systems, changes in snow melt dates, and spatially how that's playing out over landscape that is affecting Dall sheep. This is an example of how the SWAN I&M program is heavily invested in broad based monitoring rather than species specific monitoring.

- SWAN is writing protocols that incorporate monitoring for more than one vital sign simultaneously. Just because there is an integrated protocol or standard operating procedure, there is still leeway to not implement all aspects. The protocols can be flexible, even though packaged. There's utility in the effort to develop a single overarching narrative that speaks to the whole integrated set of vital signs. SWAN also may develop protocols that they may not use now due to lack of funding, waiting for a partner, or other reasons.

- A good percentage of SWAN vital sign monitoring is being done by other entities. For example, their top vital sign (out of 38) is sockeye salmon, but SWAN is not spending any money on it because ADF&G is doing surveys. They are paying to develop a protocol to monitor sockeye salmon to have

ready, in case they have to do something. A lot of agencies are fairly stable, and probably aren't going anywhere.

5.0 Identify Monitoring Objectives, Questions and Vital Signs for the SEAN Marine Ecosystem

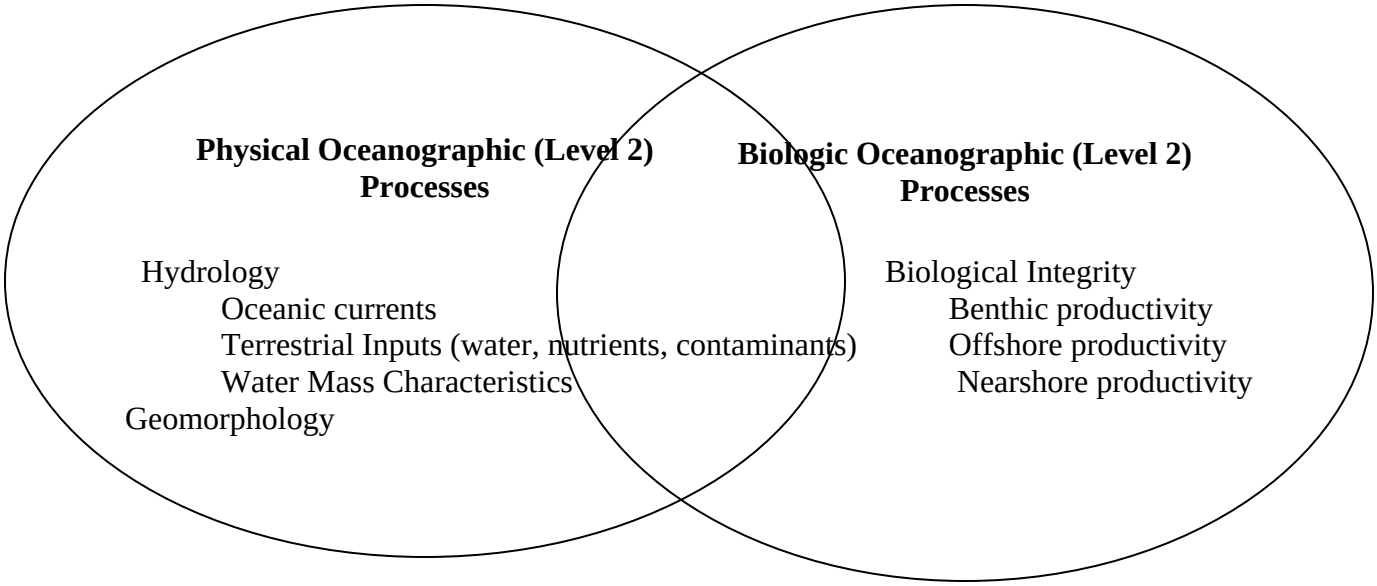
As earlier I&M networks identified their vital signs, it became apparent that many vital signs are common among networks. To promote communications, collaboration and coordination among networks and with other programs and agencies, and to combine results for national reporting, vital signs selected by other networks have been organized into an hierarchical Ecological Monitoring Framework (EMF) table. This organizational tool nests vital signs within three levels, which progress from general to specific. The broad, Level 1 categories are:

- Air and Climate
- Geology and Soils
- Water
- Biological Integrity
- Human Use
- Landscapes (Ecosystem Patterns and Processes)

In preparation for this workshop, the SEAN technical committee created a draft, or "straw man," EMF of potential monitoring objectives and questions, and potential vital signs. Workshop participants were encouraged to use this straw man EMF to stimulate thinking in key monitoring categories, but to not spend time worrying about the final organization of the tables. Workshop participants spent a full day of the two day workshop filling in and discussing the EMF. They did this by dividing into two smaller groups to discuss and refine the EMF, and then reporting their work to the other group.

Both small groups were quite frustrated with the EMF Level 1 and 2 categories and the inherent bias toward the terrestrial ecosystem. While this may not be surprising given that most national parks do not have jurisdiction over marine waters, it nonetheless raised questions about the utility of the EMF for the SEAN Network. Some found the EMF context so frustrating that they had difficulty conceptualizing the marine ecosystem's functioning and processes. Consequently, each small group reorganized the framework within which it discussed marine monitoring objectives, questions and vital signs. The groups took similar approaches. They viewed key aspects of the marine ecosystem to fit under Water (Level 1)" - physical oceanographic processes and biologic oceanographic processes. Hydrology and geomorphology could be under physical processes while biological integrity could be a under biologic processes. (See graphic below).

WATER (Level 1)



The EMF categories under biological integrity were again frustrating to one of the small groups. They felt that food webs did not easily fit within the framework. The key issues, for which categories should exist, are the spatial, temporal, and for some the vertical, distribution and patterns of productivity through time and space. This small group considered this category from an energy flow perspective - primary production, secondary production, and higher level production productivity in the offshore and nearshore environments. The other small group similarly organized its thinking about biological integrity under the three trophic levels - deep benthic, offshore and nearshore. Ideally there would be some selected vital signs at each trophic level (primary production, secondary production, and in the apex level) and within each food web, that would be good coverage.

Despite the frustrations, approach and thinking described herein, the results of each small group's work have been 'plugged' back into the national EMF for the purposes of this meeting summary. All comments from both small groups are recorded in the marine EMF table that follows. As the network holds subsequent meetings to rank, select, and prioritize vital signs, they will use these ideas generated by the scientific experts participating in this workshop, and in the freshwater and terrestrial vital signs scoping workshops. The contents of the EMF will continue to be revised as the SEAN I&M program develops. The table below represents a snapshot in time, not a refined, final product.

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
Air and Climate	**Air Quality**	Objective A. Understand the natural range of variability in air quality across SEAN parks and determine if there are any air quality concerns.		• Air quality monitoring is low priority for marine ecosystem. However, it is important to have air quality data (current and historic) to monitor change in other environments (freshwater & terrestrial) and to put current data into context. Need baseline data. Need historic data (ice cores, snow chemistry). • GLBA has a three-year dataset with baseline data measurements for mercury in precipitation at Bartlett Cove. It is feasible to look at mercury contamination in snow, if that is an important vital sign. • Are there any global research or monitoring efforts related to air quality that might need a station in GLBA? Outreach to them. • Visibility is not an ecological concern for the marine environment *per se*. It is a potential impact to human experience of the park. • POPS and mercury are the two most important vital signs. Collect this data through use of fat bags (SPMDs - Semi-Permeable Membrane Devices) which can be used in the water or in air. Another idea is to use water surface micro-layer sampling to look for aerial contaminants in water. Analyze the micro-layer to determine whether it contains organics, metals, etc., presuming air deposition. This has been done in Chesapeake Bay but is very expensive - would only do once every ten years. • In GLBA they are looking at gull eggs for Hg and other likely atmospheric pollutants. They are doing this with fulmars at St. Lazaria where pollutants are picked up in wintering areas and transferred to their eggs. • Because many pollutants bioaccumulate in apex marine predators, one could conduct opportunistic sampling of carcasses. Potential partners include NOAA (the Marine Mammals Stranding Network). They collect tissue samples which are archived but not analyzed due to cost. The tissues are in a super deep freeze, so you can go back and analyze them later. The NADP (National Atmospheric Deposition Program) and a land-based program stationed in Juneau (UAS) sample a whole suite of things.
		What are the status and trends in wet and dry deposition?		
		What are the status and trends in atmospheric pollutants? (One small group deleted this question.)	POPS, organics, mercury	
		Are contaminants brought by airborne vectors affecting marine organisms?	Mercury content in mussels.	
	Weather & Climate	Objective B. Understand the natural range of variability in climate patterns across SEAN parks.		
		1. "Big Picture Climate": What are the trends in offshore climate patterns? (Need to define offshore. Group takes it to mean Gulf of Alaska/Icy Strait/Cross Sound.)	Light (PAR, seasonal & daily variations), wind speed and direction, precipitation, temperature, Pacific Decadal Oscillation, Arctic oscillation	• 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 - Island effect • Sources of offshore climate data -- Need to look at what other agencies can provide to
		2. "SE AK Region": What are trends in spatial and temporal patters in climate in Southeast Alaska?	Monitor basic climatic parameters at stations at and above sea level (temperature, precipitation, wind speed and direction, barometric pressure, light (PAR, seasonal & daily variation)	
		3. One group changed the question to "Local to SEAN Parks:" What are the spatial and temporal patterns in climate across SEAN & "regionally" across GLBA? Other group did not change it: How do weather patterns vary among regions in GLBA (e.g., East Arm, West Arm, central, lower…) and throughout SEAN?	Monitor basic climatic parameters at stations at and above sea level (temperature, precipitation, wind speed and direction, barometric pressure, light (PAR, seasonal & daily variation), stream discharge (as a surrogate for precipitation) Use land-based weather stations, keep Lawson's network going (it measures	

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
			precipitation - but not snow, temperature, solar radiation).	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.
		4. Historic climate: How does modern climate relate to historic & paleoclimatic trends?	Tree rings, lake sediment cores, marine sediment cores, cave deposits.	
		One group changed question to: 5. Is climate change having an effect on the SEAN marine environments? Other group did not change question. What are the indicators of marine climate change?	Water column stratification, change in species composition and biomass, timing of spring bloom, timing and volume of freshwater input (salinity), sea surface temperature (surface and bottom), bioresponse (e.g., change in species, distribution or biomass that may be indicators of changing sea temperatures; Salmon? Kelp? Zooplankton?), PDO, direction and speed of Alaska Coastal Current.	
Geology and Soils	**Geo-morphology**	Objective C. Understand effects of Pleistocene, Little Ice Age and active glaciations on SEAN ecosystems. Understand effects of recent ongoing glaciations on SEAN marine ecosystems.		• In its discussion of Level I topic Geology and Soils, the group continually emphasized that geomorphology encapsulates a range of physical processes, resulting in modification of habitat that will have subsequent implications for biological communities. Thus, recommended vital signs may be monitoring evidence of physical processes occurring (e.g., sedimentation rates), or monitoring the biological response (e.g., changes in biological community species composition). The biological vital signs may also be repeated in the Level I topic Biological Integrity section.
		One group revised it to: How have past glacial cycles affected marine environments? ---------- One group revised it to: How does recent ongoing glaciation affect the marine environment?	Isostatic rebound, glacial deposits, lake sediment cores, marine sediment cores. ---------- Isostatic rebound, sediment load, bottom characteristics (sediment type and micro-topography).	• Need datasets to characterize prehistoric glacial cycles. ---------- • Paleo and historic data was considered inventory data by one small group and so not addressed.
		One group changed question to: How do the presence of and the advance and retreat of tidewater and terrestrial glaciers affect the marine ecosystem? Other group felt question was okay as is: How do tidewater glaciers affect marine ecosystems? ---------- How do marine dynamics change after tidewater glaciers ground?	Tidewater & terrestrial glacier extent and movement, fjord extent, depth & substrate, calving rates, dissolved nutrients, upwelling, freshwater discharge & flux, sediment flux and spatial deposition, sedimentation rate, coastal ice, debris dynamics, bioresponse (e.g., changes in intertidal biological communities). ---------- Calving rates, nutrients, upwelling that causes unique circulation patterns with freshwater entrainment, marine algae community bandwidths (GEM protocol?)	• Tidewater glacial face hydrodynamics (especially carbon, dissolved nutrients, sediment) are really important.
		Objective D. Understand how sedimentation from stream erosion, transport processes, glacial stream runoff and longshore currents affect estuaries and the marine system.		
		How are marine processes affected by changes in	Bathymetry/seabed topography (e.g., sill	• Need to finish the benthic map for GLBA. Fill data gap in benthic mapping (between

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
		bathymetry?	depth), substrate composition, water currents, sedimentation rates, benthic mapping, bioresponse (e.g., movement, transport, settlement of selected benthic species, such as barnacles, mussels).	greater depth and shallow benthic map, there is an unmapped "gap").
		How are marine biological processes affected by the water column's physical properties and dynamics?	Light, dissolved nutrients, currents, suspended sediments, salinity, bioresponse (e.g., data regarding species response to any change).	• Question and vital signs might belong under the level 1 category "Water."
		What are the changes in the nearshore geomorphic features?	Changes to deltas, beaches, offshore bars, sediment supply rates, total organic carbon, sediment grain size, changes in the vertical horizontal components, and speed of longshore currents.	
		How do longshore currents affect shoreline processes?	Deposition/erosion rates, nearshore currents, bioresponse (e.g., intertidal species composition).	• Would need to have baseline information about shoreline, and monitor changes. Examples (given by SITK) of potential to affect shoreline processes could be construction of a deepwater dock, airport runway expansion, affects of storm surge in the harbor, other developments that change currents. Noted that change in longshore currents might not be due to a particular development, but could be due to changes in climate or wind patterns that affect the currents.
	Subsurface Geologic Processes	Objective E. Understand subsurface processes occurring in the marine environment.		
		How do groundwater processes affect intertidal communities? ---------- Where are and what are the effects of density flows and slope failures, and current winnowing?	---------- Sediment grain size maps, depositional mapping, benthic mapping, sediment rates.	• Not sure this is important.
	Soil Quality			
				• Make sure that the soil mapping being done for GLBA addresses the location of benthic "soils" that could support eelgrass beds. There is a need for parks to map the distribution of eelgrass, and this may be one opportunity to get that information through an inventory that is already planned and funded.
Water	**Hydrology**	Objective F. Understand oceanographic processes influencing the marine ecosystem.		
		How do ocean currents affect marine processes? How do the three levels of ocean currents - large, medium and small scale - affect marine processes?	Oceanographic surveys (surface-to-bottom profiles = temperature, salinity, light, turbidity, chl-a, dissolved oxygen). Need to refer to Servicewide "core parameters". Wave and tidal data, model currents (Acoustic Doppler Current Profiles - ADCP), spring bloom.	• 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. • Install thermosalinographs on ships of opportunity.

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
				• May be able to use Water Quality program funding for current data. • The 3 vital signs: PDO, where Alaska Coastal current bifurcates, timing of the spring bloom, are also directly connected to climate. • Large-scale currents - Alaska Coastal Current (know very little about it in Southeast Alaska; a lot of the work understanding it is linked to where oil spills may happen, and that is not in Southeast). Medium-scale ocean currents - also are not well known in Southeast Alaska; an example is the bifurcation in the current near Sitka that Taggart mentioned. How it changes temporally is unknown. Small-scale currents - those within the parks and in front of the parks. • 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).
		How do streams and other freshwater (e.g., groundwater, overland flow) affect nearshore marine processes and biota? ---------- What and where is the contribution of freshwater terrestrial input, in space and time, into the marine ecosystem? ---------- What are the water mass characteristics?	Estuarine circulation dynamics, stream flow (stream gauge data), salinity, CTD (conductivity-temperature-depth) profiles (depth effects in water column), sediment flux (measure quantity) coupled with stream velocity and stage gives net material movement, suspended sediments, bathymetric profiles of submarine fans to determine rate and extent of bedload deposition.---------- Water quality, water quantity, nutrients, and contaminants.---------- Use water chemistry and water biology as ways to monitor water mass.	• 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.
	Water Quality	Objective G. Understand the natural range in variability of marine water quality parameters.		• The funding source for Water Quality monitoring program will drive the water quality monitoring program and protocols.
		What are the spatial and temporal variability of water chemistry components?	Dissolved oxygen, pH, salinity, temperature, light, turbidity, suspended sediment load. Most important vital signs to monitor: nitrate, phosphate and ammonia nutrients; silica, pH (also gives info on global warming), carbon (interrelationships become apparent when you know where the C is and what type it is).	• Add thermosalinographs on ships of opportunity (with flourometer nutrient sensor). • Add moorings for temporal component.
		What is the spatial and temporal variability of nutrients such as nitrate, phosphate, ammonia, and silicate (for diatoms)? (When and where does upwelling occur?	Dissolved nutrients, chl-a distribution, species composition and size fractionation of phytoplankton (size of plankton is	• Nutrients drive phytoplankton bloom dynamics and marine productivity dynamics generally. • Look at NOAA Auke Bay SE Coastal Monitoring program data.

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
		Important during growing season, especially).	indicator of nutrient concentrations), zooplankton biomass and distribution levels (indicator of nutrients).	• EMAP (EPA) program sampled Southeast Alaska in 2004 - all water chemistry and nutrients measured, 40 stations.
		Objective H. Determine the concentration of contaminants in marine ecosystems.		
		What is the concentration of contaminants in a well-chosen proxy species (bio-assay)?	Contaminant levels in intertidal mussels (Mussel Watch program), fish tissue (salmon, as a possible vector of toxins from Gulf of Alaska), and resident marine mammal blood/tissue. Seals (breeders), crab (higher level).	• 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?
		What are the concentrations of contaminants in unconsolidated inter- and subtidal benthic sediments?	Contaminant levels in intertidal mussels (Mussel Watch program), fish tissue, resident marine mammal blood /tissue, and sediments. One group deleted almost all the vital signs above and listed sediment samples, bottom fish, select infauna.	• May be part of Mussel Watch program. • There are well-established protocols for sediment contamination.
		What are the concentrations of contaminants being released into the marine environment from known pollution sources?		• There are different potential sources in each Park. Managers need to determine appropriate monitoring parameters. • Include remote sensing data. • Sitka: wastewater treatment plant, fish processing plants, docks, cruise ships, other boats/ships, urbanization, non-point source runoff. • KLGO - lead, heavy metals. • GLBA - Bartlett Cove treated wastewater outfall, vessels, Excursion Inlet fish processing plant runoff?
		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)?	Macro- and micro-organisms. Bacteria, viruses, fecal coliform, HABs (harmful algal blooms).	• Addressed under Biological Integrity, not Water Quality. • Dive surveys and transects, video surveys and transects, SITK - eelgrass bed mapping.
				• Addressed under Biological Integrity, not Water Quality.
Biological Integrity	**Invasive Species**	Objective I. Determine if any marine invasive species are present.		
		Are there any near- or offshore marine invasive species present, and are they increasing in area or abundance?	Atlantic salmon, algae, exotic eelgrasses, green crab One group listed most important as Atlantic salmon and green crab.	• 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. 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.
	Infestations and Diseases	Objective J. Understand effects of marine infestations and diseases.		• Suggested that "infestations" should be defined.

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
		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?	Paralytic shellfish poisoning (PSP), fecal coliform (SITK), avian flu, diseases from farmed salmon, viruses, other HABs, incidence of tumors, reproductive health, incidence of parasites, frequency of diseased animals.	• 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*.
		Are harmful algae blooms (HABs) affecting marine ecosystems?	HABs – monitor in shellfish.	
	Focal Species or Communities	Objective K. Understand how key marine species and communities are responding to changes in habitat.		• NOTE: The small group determined that it would be important to identify vital signs within each trophic level (primary, secondary, apex) and within each marine food web (nearshore, pelagic, deep benthic). Therefore, the chart includes questions and vital sign recommendations that follow that structure (rather than the "community-related" questions and vital signs preliminarily drafted by the technical committee, which have been deleted below). • GLBA is a highly protected area (jurisdiction over marine waters!) in a non-protected region. But marine ecosystem not protected due to its connectivity. So, monitor meta-populations, conserve - think regionally, monitor some things regionally and at a smaller scale, get whoever else is monitoring in Southeast Alaska to include GLBA. • Need a regional marine conservation model. The elements are metapopulations, fluid dynamics and transport, and transport food chains (with different scales, pelagic and benthic). Dialogue is too species-focused. • The group recommended referring to the October 2004 Integrated Science Plan workshop, Marine subgroup, for a fairly complete list of focal species and communities. • The group commented that it would be time-consuming, expensive and labor intensive to monitor a suite of species representing all trophic levels and food webs, but would be very valuable to the parks. • In addition to monitoring different species in different trophic levels, also need to monitor their trophic interactions (e.g., who is eating whom, and how is that affecting the marine ecosystem?).
		Are the composition, distribution or abundance of organisms within the primary production trophic level of the marine food web changing and, if so, how?	Factors affecting phytoplankton: light, nutrients, temperature. Phytoplankton community: species composition (diatoms, dinoflagellates, small phytoplankton), growth rate, health, biomass. Macroalgal community: species (especially *Fucus*, *Alaria*, *Nereocystis*), biomass, growth rate. Eelgrass: presence/absence, distribution.	• Very expensive to collect information on health of phytoplankton.
		Are the composition, distribution or abundance of organisms within the secondary production trophic level of the marine food web changing and, if so, how?	Micro-zooplankton (20-200 micrometers): species, biomass quantity and distribution, health, growth rates.	• Expensive, time-consuming, no existing data. • Forage fish diet (stomach contents) could be an indirect measure of zooplankton.

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
			Zooplankton (>200 micrometers): species, biomass quantity and distribution, health, growth rates.	
		Are the composition, distribution or abundance of organisms within the apex trophic level of the nearshore marine food web changing and, if so, how?	Grazers (clams, mussels, urchins): growth rates (measure of productivity), size, relative abundance, distribution. Invertebrate predators (seastars, predatory snails): diet, relative abundance, distribution. Harlequin ducks: relative abundance, distribution. Black oystercatchers, sea otters: diet, productivity, relative abundance, distribution. Nearshore fishes (herring spawn [Sitka], gunnels): relative abundance, distribution.	
		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?	For all species: species composition, distribution, relative abundance. Fish – species that leave GLBA (salmon) and those that don't – age classes, recruitment, diet (stomach contents), fish size. Colonial seabirds (kittiwakes [see existing GLBA dataset], pigeon guillemots, oystercatchers) – number of eggs (measure of productivity), diet, chick provisioning. Sea otters – age classes, recruitment, age at death. Harbor seals. Whales.	• There is good data that relate the productivity in the consumer to the species composition and relative abundance of prey in their diet. There are measures that link the trophic levels, so you are not simply monitoring forage fishes or a seabird, you are monitoring a relation between those two. That is a valuable tool to incorporate into a monitoring program. • Does studying trophic interactions really tell you anything about the health of the park? Couldn't changes in those interactions between two species be unrelated to human activity? Response: Can't rely on a single metric, or a single predator-prey relationship. But if you look at diet of kittiwakes, and oystercatchers, and puffins and guillemots, you gain a breadth of knowledge from which to make inferences about broad-scale changes. • For whatever species you are monitoring, once you "have the thing in hand," describe everything you possibly can about it: is it pregnant, is it brooding, has it reproduced yet? • Interest in doing ecosystem modeling, but likely don't have sufficient data for the effort. • Direct sampling – fishing. • Indirect sampling – look at the diets of predators (seabirds, predatory fishes, mammals [fatty acid analyses for mammal diets -- expensive!]) – stomach contents, bird nest remnants.
		Are the composition, distribution or abundance of organisms within the apex trophic level of the deep benthic marine food web changing and, if so, how?	Crab: size, relative abundance, distribution (may help identify areas where extra primary production sinks to the benthos). *Modiolus* (deep benthos mussel): distribution, expansive monocultures.	• Look at diets, indicators of trophic interactions: fatty acid analyses, isotopic analyses. • Group felt they did not have as much expertise within the membership to suggest vital signs related to the deep benthos food web.

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
			Sleeper sharks & rockfish: diet, relative abundance distribution.	
		Objective L. Understand the spatial and temporal (and for some the vertical) distribution and patterns of offshore and nearshore productivity (through time and space).		
		Primary productivity: What are the spatial distribution, timing, intensity and nature of phytoplankton blooms?	Timing, duration, and intensity of the bloom, species composition. Chl-a, some indicator species, species size.	
		Primary productivity: With information about blooms (not just the spring bloom), where does it go, how does it move through time and space and disperse?		
		Primary productivity: What are the spatial distribution, timing, intensity and nature of nearshore productivity?	Macroalgae (GEM), seagrasses (SITK, Icy Strait/Cross Sound/GLBA outer coast).	• Algae specialist is Peter van Tamelin (UAS).
		Objective M. Understand the spatial ,vertical, and temporal patterns of secondary productivity.		
		Secondary productivity: Who is the primary productivity feeding? Where is it trickling to in the food chain?	Organic carbon, pristane and phytane levels.	• This could be related to phytoplankton blooms, or it could be a broader question. • Use sediment traps and direct sampling of phytoplankton.
		Secondary productivity: Who is the primary productivity in the nearshore feeding?	Invertebrates (mussels, barnacles), keystone grazers- sea urchins, small crustaceans.	
		Objective N. Understand the food web, the spatial and temporal patterns of higher-level productivity.		
		What are the relative abundance and trophic positioning of key species?	Selected fishes, marine birds (kittiwakes), marine mammals. Sea otters, seastars, smaller grazers (arthropods), black oystercatchers, seaducks - harlequin (keystone species), many marine birds.	• 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. • Look for indicators that are going to reflect big regime changes. • Partners - Jeff Short, NOAA @ Auke Bay Lab - monitoring secondary production (No, the Parks do not have his information). • John Pyatt, USGS, primary productivity with seabirds and did some of that in GLBA (Yes, the Parks do have his information). • Chris Gabriele. • Yumi Arimitsu.
		Note: All of Objective K and its questions and vital signs were replaced w/ K-1,2,3 by one small group. But questions and ideas scientists wrote on sheets at beginning of meeting are captured below. Are pelagic fish community composition, distribution or relative abundance changing?	Pelagic fish communities: capelin, sandlance, juvenile pollock, myctophids, herring, juvenile salmonids (baseline exists Robards et al. 2003, Arimitsu et al. 2003) Do isotopes change in key species?	• Baseline survey + periodic (5-10 years).
		If so, how are these changes in specific components of pelagic fish communities influencing other marine, terrestrial or freshwater ecosystem components?		• Predator distribution, ship-based transects (e.g., murrelet surveys).
		How are macro-invertebrate or algal intertidal and subtidal communities changing?	Macro-invertebrates, algae, salt marsh, tie in with terrestrial animals?	• Dive surveys, establish transects.
		How are the distribution and extent of intertidal and supratidal meadows changing (creation of new meadows, disappearance of old ones)?	Beach meadows, landcover mapping.	

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
		How are the vegetation zones within intertidal and supratidal meadows changing (due to isostatic rebound)?	Vegetation composition, landcover, select circular plot sampling, see terrestrial literature.	• Baseline completed. How often resurvey?
		Is benthic habitat or habitat-forming invertebrates changing?		• Fish dive transects, trawls, etc.
		Seabirds? Wintering/migrating shore/water birds?		• Marine mammal surveys/population, reproduction studies.
		Are key species successfully reproducing and recruiting?		• Productivity plots/seabirds.
		Determine community-level ecological processes for primary and secondary producers.	Benthic vs. pelagic food chains - which are dominant? Isotopic, fatty acid and pristane analyses.	• This is an important research question. Couple with monitoring component for primary and secondary producers recommended above. • Seal population/productivity work (Matthews).
		What are the population trends of marine mammals?	Harbor seals, sea otters, harbor porpoise, humpback whales, killer whales.	• Harbor seals and sea otters best to monitor (park-specific processes).
		Is estuarine productivity changing over time?		
		Do patches of productivity shift over time?		
		Are there specific areas to monitor for productivity and health-related matters in the biological food web due to the vast differences within the parks and in the region?		
	At-risk Biota	Objective O. Understand population trends of at-risk biota.		
		What are the population trends of at-risk biota?	Humpback whales, Steller sea lions, red tree corals/associated communities, eelgrass beds, critical reproductive aggregations, Kittlitz's murrelets (crabs, other?), harbor seals, black oystercatchers.	• Humpback whales are increasing in abundance. • Sea lion in GLBA? • Eelgrass/SITK.
Human Use	**Point-Source Human Effects**	Objective P. Understand how park and preserve ecosystems are affected by point-source human activities.		
		Are vessel discharges (intentional and accidental) affecting marine organisms or processes?	Hydrocarbons and other toxins, human sewage, exotic species, number and distribution of vessels in the park, water chemistry, *E. coli*. Correlate monitoring efforts with vessel numbers and transit paths. Data regarding the specific location and activity of other point sources. Different for each park.	• This question is too limited in its reference to "vessel discharges". Should consider other potential point sources. Same suite of vital signs regarding marine water quality impacts are essentially the same. • 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). • Ballast water must be discharged offshore, not in SEAN parks (per MARPOL). Therefore, suggest removing ballast water as a vital sign. • Are there any in-park or nearby permitted discharges and permit monitoring requirements?
		Do we have adequate information to be able to explicate the effects of an oil spill (to conclusively separate changes due to a spill from natural variability)?	Species composition, relative abundance and distribution of marine organisms. Look at Exxon Valdez Oil Spill (EVOS) protocols and other studies for species to monitor.	• 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

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
				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.
		What are the effects of development and urbanization?		
	Non-point Source Human Effects	Objective Q. Understand how park and preserve ecosystems are affected by non-point source activities.		
		How are the type and volume of marine debris changing on park beaches?	Marine debris, animal carcasses, nets, frequency/number of entanglements.	• Could use a simple, relatively inexpensive protocol (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.
		How frequently do seabird and marine mammal mortalities relate to ingestion of or entanglement in marine debris?	Seabird and marine mammals (for evidence of injury).	• Continue existing data-gathering; contributing to an existing data clearinghouse.
		What and where are the convergence zones for marine debris? Is marine debris impacting resources (e.g., entangling bears, sea lions, whales, seabirds) or visitors?		• Not a marine ecosystem issue; related to visitor experience.
	Consumptive Use	Objective R. Understand whether human consumption of natural resources is adversely affecting marine ecosystem components.		
		Are the current levels of marine resource harvest sustainable?	Sport-caught (recreational and charter): salmonids, crab, marine invertebrates (clams, sea cucumbers). Commercial harvest: salmon, halibut, crab, rockfish, lingcod, weathervane scallops, commercial by-catch Marine mammal harvest - otters and seals (outside park). Migratory bird & egg harvest (outside park). Clam and sea cucumber harvests.	• 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.
		How do populations change in the absence of harvest?	Surveys throughout park. Identify where harvest occurs and does not occur.	• Regional numbers and scale are important.
		What is the movement of harvested marine species in and out of the park?		
	HumanUse	Objective S. Understand how park and preserve ecosystems are affected by local and regional human activities.		

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
		How and why are visitor numbers, activities, methods of human use & access, and locations of human use & access changing?	Need data on all users (including vessels, aircraft, hikers, etc.) - numbers, distribution, access points, activities, etc. Sound production.	• 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).
		Are human activities (including NPS, National Guard, USGS, visitors) having an effect on marine resources? What are the effects of visitor use on marine resources?	Whale watching, human use of critical habitat (e.g., ground-nesting bird habitat), beach/shoreline erosion and other impacts, intertidal zone impacts, bioresponse (community changes, species disturbance – marine mammals and birds), key foraging areas.	
	Landscape Dynamics	Objective T. Understand how changes in marine and terrestrial topography affect park terrains.		• NOTE: The small group did not discuss the Level 1: Landscapes (Ecosystem Pattern and Processes) Chart. The following notes were made by individual group members at the beginning of the session.
		What are the successional trends of marine communities in relation to changes in marine and terrestrial geology and topography?	Various marine communities, key underwater topographic features (glacial sills, etc.), tidewater glacier movement, rebound, tectonic activity, etc.	• Make sure substrate age and distance from glacier are considered in design. Carefully consider the degree of linear correlation between these two, and how important (and whether important) they are to the questions being asked. • Benthic surveys- dive and video, establish transects for periodic surveys. • Several of these questions are research (vs. monitoring) questions.
		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?	Benthic invertebrates/algae. Recolonization. Decolonization. Nearshore food webs. Change to food webs. Algal communities (look at GEM protocol).	
		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?	Beach extent, composition, bench height, loss of shorelines (e.g., bays).	
	Extreme Disturbance Events	Objective U. Understand how extreme disturbance events affect marine communities and processes.		
		How do extreme disturbance events such as marine storms, tsunamis and earthquakes affect park lands, especially coastal areas?	Marine storm events, tsunamis, earthquakes, landslides, outburst floods, slope processes, runoff (sediment, freshwater).	• Low priority, unpredictable. • Post-event mapping/satellite imagery, ground truth plots, long-term plot establishment. • Maybe "document" when it occurs; difficult to "monitor." • Objective and question are good, move to Geomorphology.
	Soundscape	Objective V. Understand how the marine ecosystem responds to human generated sound.		
		What are the trends in under- and above water sound?	Underwater sound, above water sound, marine mammal behavior and population trends.	• 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.
		Are marine mammals or other animals adversely affected by under- and above water sound?	Seabird behavior and population trends, forage fish behavior and population trends, humpback whale behavior and population trends.	
	Viewscape	delete		• Not relevant to marine animals. • Specialty study (i.e., Pt. Adolphus whale study).

Level 1	*Level 2*	*Potential Marine Monitoring Objectives & Questions*	*Potential Marine Vital Signs*	*Comments, Ideas, Measures, Costs/Feasibility, Partners, Threats, Other…*
	Nutrient Dynamics	Objective W. Understand how trends in nutrient dynamics affect marine communities.	NPZ models or trophic dynamic models (EcoSim) to resolve.	• Very important regarding primary production. • Limited nutrient data collected in GLBA (summer 2002 - Taggart; summer 2004 - Piatt not yet analyzed). • Sonar fish school tracking/mapping (USGS/Piatt/Dragoo surveys). • This is a research question.
		What are the spatial and temporal patterns in nutrients?	Primary productivity (a note about the suggested vital sign above: "rates?" this hasn't been done. Look at cores [Cowan, et al.] for organic carbon and diatom distribution. NO_3, PO_4, NH_3, Ammonia? Silicate?	
		How does nutrient availability affect marine resources? This is a research question.		
	Energy Flow/Productivity	Objective X. Understand how the flow of energy affects the marine ecosystem.		
		Are park resources influenced by bottom-up or top-down processes? What are the primary and secondary production processes and how do they change?	Food webs, chl-a, carbon.	• Is up-bay carbon (and/or nutrients) advected or produced *in situ*? Important research question.

6.0 Identifying SEAN Monitoring and Vital Sign Priorities

At a final workshop session, each invited scientist (non-Technical Committee member) was invited to participate in a panel session and to take five minutes to respond to the following questions:

1. What are the ten most important vital signs to monitor for the SEAN network?
2. If the SEAN network had $50,000 annually to spend in *each* of the three parks for monitoring of the marine ecosystem:
    - What is the most important monitoring information to collect?
    - Why?
    - What approach(es) should be taken to collect that information?

6.1 Themes Identified

The following monitoring themes and/or approaches were mentioned by several panelists. These themes and approaches and the reason they were suggested are explored in more detail in the panelists' remarks (Section 6.2) and in follow up discussion (Section 6.3).

- **Recognize strong connection and interrelationships between the SEAN parks' marine ecosystems and the rest of Southeast Alaska, the Gulf of Alaska and beyond.** It is not possible to separate what is going on in GLBA's marine environment from this larger context. The network must use data from regional monitoring programs to support SEAN monitoring, and should consider collecting and compiling its monitoring data in a manner that is complementary to on-going programs.
- **Partner, leverage funding, "mine data," use modeling, and target information gaps to expand effectiveness.** Since network funding will be limited, it will be essential for SEAN to use every possible strategy to meet its monitoring needs. Partnering with other entities and/or leveraging funds to get additional work done or to support collection of long-term datasets will stretch dollars. It will be essential to mine data, create accessible databases, disseminate information, and use modeling and other techniques to determine where important data gaps need to be filled, before spending scarce funds to collect more data.
- **Spend funding strategically.** It will likely be necessary to develop a strategic funding plan, allowing SEAN to accomplish one or two top priorities each year, rather than trying to spread funding throughout all parks, focus ecosystems, or scientific disciplines each year. The network will need to closely consider its purpose and objectives in determining funding priorities.

- **Monitor human use.** Information on human use is key background data needed to interpret the reasons for change in the parks' natural environments. These data are particularly important for SITK and KLGO where human induced impacts may be the primary driver of ecosystem change. Much data exists already and it is generally inexpensive to collect. SEAN should continue to gather human use data and make sure it is accessible. The network should implement monitoring to assess impacts where appropriate (e.g., SITK intertidal transects to assess trampling; KLGO hooligan run to assess sensitivity to human disturbance)
- **Collect baseline contaminants data.** Several panelists discussed the importance of collecting baseline contaminant data for SEAN parks, from areas most likely to be impacted by accidental oil spill or other pollution sources. Monitoring for total hydrocarbons was suggested, as well as metals and other organics as appropriate.
- **Set up weather stations.** A number of the panelists suggested establishing stations to gather weather data, not to monitor global warming, but to provide important climatic background data needed to interpret change. Existing weather stations have been found by researchers to be lacking, particularly in characterizing the climatic variability within GLBA. Several panelists recommended that SEAN spend one year of funding (or approximately $150,000) to set up weather stations to fill this gap. They also noted that weather data are important to all ecosystems in the SEAN parks (marine, freshwater, terrestrial). However, other panelists argued that weather stations should not be a high priority for funding on their own; collecting climate data could use a substantial portion of the network budget and would not monitor change occurring in the parks' biological ecosystems.
- **Build upon GLBA's physical oceanography dataset.** GLBA has a dataset of physical oceanographic measurements that should be fully used and built upon with collection of additional data.
- **Monitor biological processes (not specific species).** Implement monitoring that will detect change in biological processes (e.g., trophic interactions, productivity) that are indicators of biological ecosystem integrity, rather than simply monitoring specific species.

6.2 Panelists Remarks

Jim Taggart, U.S. Geological Survey

Jim Taggart noted the importance of stepping back and thinking about Southeast Alaska regionally, from a conservation model perspective. In Southeast Alaska's marine ecosystem, there is one marine national park (GLBA) and two national parks with small coastal zones (KLGO and SITK). The remainder of the marine ecosystem is generally not within a conservation or reserve status. In addition, marine habitats in Southeast Alaska tend to be very patchy. The region's marine fauna is composed of many separate metapopulations that intermingle in their larval stages but are largely separated from one another as adults.

Putting these realities together, it becomes clear that the long-term viability of the marine ecosystem in GLBA depends on effective conservation of marine resources throughout Southeast Alaska. If there is degradation of marine resources in the region, the park's marine environment is going to degrade as well.

Jim offered the following specific suggestions:

- **The question of "where" to monitor is more important in the marine ecosystem that "what" to monitor** – Coastal processes are generally very large scale. It will be important to replicate monitoring over a broad geographic scale (regional, or even broader). This argues for the network inspiring interagency collaboration, so we get the types of regional datasets that are needed, and so that GLBA becomes a part of those larger regional databases. The network will want to be able to compare the data it is collecting with other regional information sources. One example of this is sea lion monitoring; make sure it occurs in GLBA so it is part of the broad dataset and then the park can compare its populations to the rest of Southeast Alaska.
- **Focus on monitoring ecological processes, rather than specific species** – For example, monitor vital signs that help you understand whether food webs are changing (e.g., isotope and fatty acid analyses) – as a way to see if there is some kind of local regime shift. Another example would be monitoring how separate metapopulations of a species are functioning through time, such as genetic exchange between metapopulations of king crab.
- **Gather weather data** – If additional funds are available after that need is met, use it to team with other entities that can bring more to the table (funding, capacity) to accomplish more.

Ginny Eckert, University of Alaska

Ginny Eckert agreed with the points made by Jim Taggart, above. Additional specific recommendations include:

- **Marine Reserve Monitoring** –GLBA is unique in that it is a large, high latitude, multi-species no-take marine reserve. Monitoring plans should take this status into account. GLBA presents an unprecedented opportunity to design and manage a marine reserve effectively, to inform the design and management of future marine reserves, and to determine the effectiveness of reserves on species that live within and migrate in and out of the reserve.
- **ShoreZone Project** – GLBA should participate in the ShoreZone project. The project provides low elevation aerial video mapping of the entire shoreline and verbal/text annotation of what is observed in overflights by a team of natural scientists. The result is a qualitative video description of the nearshore marine environment, not quantitative, and is accessed via a Geographic Information System (GIS). The team categorizes the substrate, geology and biology that is living on the substrate (e.g., kelp forests, eelgrass, mussel bands, *Fucus*, etc.) With regard to the physical environment, the mapping generally characterizes exposure, aspect, slope, etc. This is an existing protocol that has been used in

KLGO and SITK, and much of northern Southeast Alaska. GLBA is a gap. The process should probably be repeated every ten years to document changes. In discussion it was noted that GLBA already has a more information-dense nearshore database generated through the Coastwalking project conducted throughout the park. Similarly, GLBA coastlines in Cross Sound and the entire outer coast were ShoreZone mapped during the summer of 2005In response, the value of having a comprehensive, compatible dataset collected with the same protocols is very helpful for regional comparisons and demonstrates support for interagency partnerships.

- **Historic datasets** – Regardless of which parameters are monitored, SEAN should focus on building and using historic datasets. The network could support and partner with entities that have already been collecting useful data. For example, the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) has been doing intertidal monitoring from California to Alaska and have two sites on GLBA's outer coast.
- **Fill monitoring gaps** – The SEAN I&M program should gather and serve as a clearinghouse for other monitoring and data-collection projects, and then should fill in important monitoring data gaps. The network should compile the priority vital signs suggested through this process and then determine which of these are not being monitored by other entities.
- **Weather data are a major gap** – Having better data on wind speed, direction, precipitation over the spatial extent of GLBA would support ongoing research and monitoring and increase the power of analyses and conclusions. Suggest using the funding to set up weather stations on land and water in GLBA, and possibly one to two in each of the other parks. In discussion, Jim Taggart agreed that installation of weather stations should be a top priority for SEAN funding.

Lisa Eisner, NOAA Auke Bay Laboratory

Lisa Eisner identified the following top priorities for monitoring information related to SEAN's marine environment:

- **Physical oceanography** – Understanding physical oceanography must be a priority. Do modeling with existing GLBA physical oceanography datasets (limited spatially, 10-year coverage, perhaps accomplish by involving a graduate student) and identify the data gaps. Do small amount of modeling for KLGO and SITK. Pull together and incorporate all available datasets, including small disperse data such as that collected by regional hatcheries, as well as other regional data (e.g., NOAA's Icy Strait transects [data since 1997]). Must have weather data and current meter measurements.
- **Interaction of climatic conditions with physical oceanography** – Argued for need for additional climate data.
- **Primary producers** – Monitor primary production, which can be accomplished with electronic equipment to some extent.
- **Top-level predator** – Determine if there is a key predator species that would be a

good indicator of ecological change. If so, monitor.

- **Climate change/global warming** – It's important to monitor species groups or processes that could be used to detect climate change/global warming. We didn't spend enough time on this issue during the workshop, and Lisa thinks it's timely and applicable, particularly since some glaciers are currently receding at a rapid rate.

Deborah Rudis, U.S. Fish and Wildlife Service

Deborah Rudis identified the following top priorities for monitoring information related to SEAN's marine environment:

- **Climate** – Important to have more comprehensive weather data for the SEAN parks, including solar radiation. Noted that interior national parks seem to have more complete climate monitoring; why not in Southeast parks?
- **Physical oceanography** – Need baseline data on physical oceanographic conditions including water currents, temperature fluctuations, pH, etc.
- **Trophic interactions of key species** – Select indictor species from different trophic levels to monitor (e.g., invertebrates, several species of fish, birds, marine mammals). Could be monitored through a series of less formal projects, perhaps carried out by graduate students, or through a more comprehensive program such as the predator surveys conducted by the USGS.
- **Oil spill anticipation and preparation** – It is not a question of *if* a spill will occur that will impact a SEAN park, just *when*. The network should identify the oil collection and convergence zones within the parks. Within particular areas (two to three areas), collect detailed baseline information about the intertidal community (species composition, abundance, distribution) and baseline total hydrocarbon levels in sediments and tissues (about $300 per sample). It is possible to collect and archive samples for later analysis, if necessary.
- **Other pollution effects** – It is important to be able to detect change in organism health from oil spills and other sources of water pollution. For SITK particularly, the network should collect baseline data on *E. coli*, pathogens and pharmaceuticals, to detect possible impacts from the water treatment plant and other urban sources. For GLBA, consider metal samples ($300/sample). Sample a range: in the middle of the tourist season in areas trafficked by boats, as well as in areas thought to be pristine.

Jim Bodkin, USGS Alaska Science Center, Biological Sciences Office

Jim Bodkin agreed with the previous comments regarding viewing the SEAN parks in the context of the Southeast Alaska region, the Gulf of Alaska, and the Pacific Ocean. Jim encouraged the NPS to undertake its monitoring efforts in a manner that is as consistent as possible with monitoring activities going on outside the parks, to increase the utility and power of the datasets. In other words, follow the example SWAN is setting by fitting

marine modeling in the Gulf Ecosystem Monitoring (GEM) and other monitoring contexts. He identified the following top priorities for monitoring information related to SEAN's marine environment.

General Concepts

- **Use remote sensing** – Remote sensing will continue to become an even stronger tool and is less expensive than hands-on alternatives.
- **Use historic datasets** – It is important to take advantage of prehistoric and retrospective data.
- **Human influences** – In KLGO and SITK, focus monitoring on potential human influences, particularly on potential effects on intertidal and nearshore communities. Design monitoring protocols that may elucidate causes of observed changes.
- **Focus on variation in life history as an indicator of ecosystem health** – Monitor measures of life history processes (e.g., birth, death, and movements of organisms) in each of the well-recognized food webs. If each of these components is operating within normal bounds, that can be taken as an indicator of ecosystem health. If not, that may be an indicator of change or impact.
- **A different view on climate monitoring** – Recognize that it would be very expensive to measure atmospheric environmental variables, such as climate. Use large scale datasets. If you put all of your funding into monitoring weather, all you will know is what the weather is doing. You won't know what the biological responses to weather are.

Specific Monitoring Recommendations

- **Monitor biological communities** – Continue the historical physical oceanography dataset, and expand it to include biological oceanography. For GLBA, consider the following package, which could be accomplished for about $200,000 at dozens of sites, repeated annually, and would be consistent with SWAN monitoring:
    - Monitor fish and seabird diets (stomach contents) to evaluate productivity in the offshore community.
    - Survey marine birds and mammals to assess distribution, abundance and species composition of those taxa.
    - Monitor harbor seals, black-legged kittiwake, pigeon guillemots and fishes to evaluate productivity (primarily through reproductive rates).
    - Monitor macroalgae productivity, distribution, abundance and species composition (*Fucus, Alaria, Nereocystis*) and eelgrass.
    - Measure growth rates for invertebrates (clams, mussels) as integrators of productivity.

- Look at sea otter and oystercatcher diets as indirect measures of subtidal and intertidal invertebrate populations.
- Beach seine fishes, for species composition and relative abundance.

The USGS has recently budgeted to accomplish a similar suite of activities in the Gulf of Alaska, partnering with the EVOS, GEM, and SWAN programs.

- **Glaciers** – Monitor relevant aspects of glacial geology.
- **Deep benthos** – If possible, explore and describe the deep benthic environment.

Greg Streveler , Icy Strait Environmental Services

Greg Streveler focused his recommendations primarily on the SITK and KLGO marine environments:

- **SITK intertidal transects** – SITK should focus its monitoring on potential human impacts on the intertidal (e.g. trampling). Greg's recommendation is that the park establish permanent transects, measure and monitor sessile species (susceptible to trampling), monitor impacts from domestic and feral dogs and cats (particular impact to mink and otter). Establish transects in an area of less human use (such as Stargaven) for comparison.
- **KLGO health and productivity**– KLGO is largely a freshwater-impacted system in its intertidal. There is a pulse of productivity in spring when hooligan come and later when salmon arrive. Another pulse of transient energy occurs in fall, with migrations. Hooligan are very sensitive to disturbance by human activity. KLGO should monitor the health and success of that run. To monitor salmon, the park could construct a temporary weir to count numbers. For migratory birds, continue data collection on birds during migration (continue Jeff Mow's dataset). Consider six indicator species that come through at different times of the year and use different areas of the park, such as western sandpipers, surf scoters, dunlins. Monitor marine mammals' use of hooligan and salmon, especially seals and sea lions.
- **GLBA** – Greg deferred to earlier speakers. Noted that big-eyed skates might be considered a "mine canary" in the marine system. The species reproduces slowly, is readily caught as by-catch. Sleeper shark may also be a species to watch as an indicator of marine ecosystem health and change. Greg noted that there was much social pain inflicted when commercial fishermens' livelihoods were permanently excluded from GLBA. It is important to follow that large-scale, expensive experiment in marine conservation with something positive. The SEAN monitoring program presents an opportunity to contribute something positive through this new marine reserve.

Dan Lawson, Cold Regions Research and Engineering Laboratory

Dan Lawson offered the following advice on priorities for SEAN's marine monitoring program:

- **Partner and use existing data** – Since funding is limited, it will be essential to look for partnerships and "mine" existing historic and prehistoric datasets. There have been many researchers gathering data about GLBA glaciers over the past years (Ross Powell, Bill Field, Austin Post); make sure all of those data are collected, managed, accessible for analysis to boost the power of more current monitoring.
- **Strategic financing** – Develop a strategic approach to accomplishing top priority monitoring. For example, spend the full Year 1 budget (approx. $150,000) to install additional weather stations, Year 2 on monitoring physical oceanographic processes, and Year 3 to accomplish the biological oceanography processes recommended by Jim Bodkin (above)
- **Physical oceanographic processes** – GLBA has some datasets that need to be compiled and modeled. Design a sampling scheme for representative environments to build on what the dataset already contains.
- **Contaminants** – Agrees that baseline contaminant levels should be collected.
- **Human use** – Human populations and their impacts are worth pursuing, are easy and low-cost to monitor.
- **Stream discharges** – Monitor stream discharges, which is important information for both the marine and freshwater ecosystems.

Alan Bennett – Southwest Alaska Network

Alan Bennett urged SEAN to create its own identity as a monitoring organization and resist the temptation to just try to fill gaps and plug holes in data. It is important for the network to assume a few key roles in the process that develops its identity. It will be a challenge to manage the integrated flow of information and turn it into products that park managers and scientists can use. Data collection and management is an important network role. Make sure that what can be learned from existing datasets is mined, made available and understood, before launching into collecting still more data.

Alan agrees that collection of data on physical parameters is something that could be useful across all SEAN parks, including weather data, water quality, contaminants.

For SITK and KLGO, suggest monitoring based on stressors (human activity), particularly impacts to estuaries. Citizen "coast watchers" could be a ready set of extra eyes and ears to help with monitoring and stewardship. Citizen involvement is the ultimate way to link people to the parks and inform them of science programs.

6.3 Discussion Points during Question/Answer and Closing Session

The final workshop session offered an opportunity for all the workshop participants, including the SEAN Technical Committee members, to ask questions of the scientific experts/panelists, and to discuss final points regarding development of the SEAN I&M program.

6.3.1 *More Specific Monitoring Suggestions.*

In response to a request that the panelists more specifically recommend vital signs (particularly focal species), panelists suggested and discussed the following:

- Work with species for which there are existing, historic datasets on which to build (e.g., clams, mussels, seals, several species of fish, seabirds).
- Monitor the rate of growth of primary producers (e.g., diatoms) to characterize marine ecosystem productivity. In discussion, it was questioned whether there has been enough research done on biological oceanography to help focus a monitoring program on vital signs that would be feasible, affordable and meaningful.
- Consider using the same species as those being monitored as part of the Exxon Valdez Oil Spill (EVOS) program in Prince William Sound. For GLBA, harlequin ducks and black oystercatchers are good candidates, since they have been heavily used in other studies and there is a large database (nest counts, diet, contaminant levels). Kittiwakes could be suitable for GLBA because of their use of habitat at the face of glaciers (which could be subject to change) and the fact that there are historic databases and research.
- Monitor bottom fish, since they feed in and on sediment.
- Participate in the existing Mussel Watch program.
- Install permanent sites in the intertidal zone in all three parks and monitor the species composition, abundance and distribution of macroalgae and a suite of invertebrate species, selected based upon the substrate type (e.g., mussels on hardsubstrate, clams on mud substrate). Review the protocols being used in the Gulf of Alaska and extend the same protocols to SEAN monitoring. Rather than focusing too specifically on a list of target species, record whatever is there to get the maximum information. Regarding clams, it was noted that recruitment can naturally be very episodic over a span of decades, so it may not be a good indicator of shorter-term habitat impacts.
- SITK noted that they are developing protocols for monitoring macroalgae, benthic invertebrates and substrate in its 50 acres of intertidal zone. Weather stations are adequate for their needs. What more should they do? Testing for contaminants was recommended; may be possible to use local college students.

As a caution, one speaker noted that monitoring protocols used by other agencies may not meet SEAN's monitoring objectives and capabilities. Existing protocols may call for annual monitoring of parameters. SEAN will need to focus on long-term change, and

may monitor sites at five to ten year intervals. This limitation also needs to be considered when thinking about partnerships with other agencies or organizations.

The group discussed the value of monitoring river otters as a species that uses all three ecosystems (marine, freshwater, terrestrial). It was noted that river otter have a role in transferring marine-derived nutrients (MDN); however, the ecological importance of MDN has not been proven and the group agreed it was not a sufficient reason to select the otter as a vital sign. It would be difficult to determine population numbers, but could evaluate diet from spraint (droppings) and reproductive success from litter size. Monitoring otters would primarily give information on whether or not they are susceptible to habitat disturbance, and to what extent. It may be possible to collect data from trapped otters.

6.3.2 *Strategic and creative uses of funding*

The network will need to carefully consider its purpose and objectives in determining its priorities for funding. If the purpose is to detect short-term change to inform park management, then monitoring would need to be repeated on a shorter timeframe. If the purpose is to detect change over longer timeframes, then repeat intervals can be longer. Similarly, the network will need to consider what level of certainty is needed in monitoring. It may be most prudent to monitor a few things well, with high certainty, than to spend money in areas with less certain results and application.

Looking for information needs common to the marine, freshwater and terrestrial environment could be a useful strategy. Vital signs that address all three environments and their interface should be high priorities for the network.

The group discussed the need to use funding strategically and creatively. It may be possible to save on travel costs by combining multiple purposes into each trip (e.g., collect as much data as you can "once you are out there"). "Ships of opportunity" (see below) could be a creative and inexpensive tool for obtaining additional data.

SEAN could consider developing monitoring programs that could be conducted every three to five years, within the budget limitations. For example, use $100,000 in one year to conduct marine bird and mammal predator surveys, take physical oceanography measures, and collect data on other vital signs. In subsequent years, focus on other vital signs.

6.3.3 *Ships of Opportunity.*

To collect physical oceanographic data in expensively, SEAN should investigate installing thermosalinographs (to measure surface temperature (T), salinity (S), and other parameters) on ships of opportunity, such as the daily tour boat. Estimates of surface phytoplankton biomass could also be acquired by adding instruments such a chlorophyll a fluorometer to this system. From GLBA, the network could get a daily up/down bay measurement of very informative and valuable water mass.

To collect physical oceanographic data inexpensively, SEAN should investigate installing onboard automatic samplers or sensors on "ships of opportunity," such as the daily tour boat. From GLBA, the network could get a daily, automatic up/down bay transect that would be very valuable. Other ships of opportunity include GLBA's three ranger boats, charters, and tour vessels. Boats that routinely visit the same sites every day of every season offer the possibility of monitoring continuity.

The SEAN data manager would have to ensure that the data are processed and analyzed. It was noted that temperature and salinity data are inexpensive to collect ($3,000) and simple to process. Current meters are more expensive ($5,000-7,000) and would require some expertise to operate. Automatic transect data should be complemented with data from permanent mooring sites, that would continuously sample and record data to give a stronger temporal component to the physical oceanography database.

6.3.4 *Partnerships – Sharing the data and the data management work.*

An effective strategy for accomplishing more with limited dollars can be to partner with other entities to conduct monitoring, or to analyze data collected by the network. One opinion was that the network should not feel that it is responsible for analysis of every dataset that it collects. Channel Islands National Park has accrued "amazing datasets" that have been analyzed by graduate students and other parties. The network would need to make the data accessible to the public, invite their use, and make arrangements with others to follow through with analysis. Providing a central data warehouse and clearinghouse would be a very valuable service and would reap benefits to the network. The network coordinator noted that that's one of the intended future functions of the network.

In reply, others cautioned that a lot of data are collected that are never fully analyzed or reported. The network cannot afford for that to happen. This argues for SEAN tackling fewer, more targeted monitoring tasks from start to finish, rather than relying on partnerships and networking to create results.

There are opportunities for SEAN to partner with researchers to encourage them with funding or other support to continue (or reinitiate) their work, and to benefit from their data collection and analyses. The network could work with long-term researchers and their institutions to encourage continuation of long-term ecological datasets; encouraging that type of lineage (passing the research from person to person over time) at local institutions such as the University of Alaska Southeast or the NOAA Auke Bay Laboratory may make sense.

6.3.5 *Value of Glacier Bay as a marine laboratory*

It is unusual for national parks to have such a large marine component, as is found at GLBA. The network needs to make sure that the NPS understands that the lack of commercial fishing and the designation of wilderness waters make GLBA a special place in terms of monitoring and research. Other entities wondering about how marine reserves work and what they accomplish will look to GLBA for data and conclusions.

6.3.6 *Monitoring program should evolve, as more is known about the marine environment*

There are elements of the marine ecosystem that are quite well known and others where less research has been done (such as biologic oceanography and the deep benthic environment). Just because these elements are less known, does not mean they're not important. Initial monitoring may focus on ecosystems that are better known, to benefit from historic datasets and to facilitate interpretation of the causes for observed change. However, as more becomes known, the network should adjust its program to phase in monitoring for these ecosystems. The deep benthic is probably where the majority of the faunal biomass resides in GLBA, yet is won't likely be the subject of initial monitoring.

Appendix A. Marine Scoping Workshop Agenda

Southeast Alaska Network (SEAN)
National Park Service
Marine Ecosystems Monitoring
Scoping Workshop

2 February - 3 February 2006
Juneau, Alaska – Goldbelt Hotel
Agenda

Desired Workshop Outcomes

1. **Understand the National and SEAN Inventory and Monitoring (I&M) Program purpose, framework, process and terms.**
2. **Discuss conceptual marine ecosystem models.**
3. **Discuss what the important monitoring objectives and questions are for the SEAN Parks marine ecosystem, and why they are important.**
4. **Identify candidate vital signs to accomplish this monitoring.**
5. **Discuss specifics of what and how to monitor.**

Thursday, 2 February 2006		
ARRIVAL, CONTINENTAL BREAKFAST AND WELCOME		
7:30-8:10 am		Continental Breakfast Available, Goldbelt Hotel
8:15 am		Welcome and Introductions *Chiska Derr, Southeast Alaska Network Coordinator*
8:30 am		Review of Agenda and Notebooks *Barbara Sheinberg, Meeting Facilitator, Sheinberg Associates*
SETTING THE CONTEXT *Related Material at Tab 2 in Notebook*		
8:45 am		Overview of: 1. National Park Service mission 2. National inventory and monitoring (I&M) program 3. SEAN vital signs monitoring program and this workshop's purpose 4. SEAN timeline and organization 5. SEAN biological inventories 6. SEAN water quality monitoring 7. Integrating other park programs and the SEAN I&M Plan Question and Answer Session. *Sara Wesser, Alaska Regional Coordinator, Inventory and Monitoring Alaska*

		Chiska Derr, Southeast Alaska Network Coordinator
9:45 am		Relationship between Glacier Bay National Park and Preserve Integrated Science Plan (ISP) and SEAN I&M Program. *(see Tabs 2 and 7 in notebook)* *Susan Boudreau, Chief of Resources, Glacier Bay National Park*
10:00 am		Break
MARINE ECOSYSTEM MODELS *Review material at Tab 4 in Notebook before February 2*		
10:20 am		Introduction and description of a few of the general models *Chris L. Fastie, Middlebury College* (10 min) The origins of SE Alaska's marine environments with a focus on GLBA *Greg Streveler, Icy Strait Environmental Services* (10 min) Glacial influences on marine environments at SEAN parks *Dan Lawson, Cold Regions Research and Engineering Laboratory* (10 min) The Glacier Bay conceptual ecosystem model *Jim Bodkin, USGS AK Science Center Biological Science Office* (20 min) Questions and discussion (30 min) Participants complete questionnaire (10 min)
12:00 pm		Catered Lunch, Goldbelt Hotel
SWAN INVENTORY AND MONITORING PROGRAM *Examples from other Networks at Tab 5 in Notebook*		
1:15 pm		Insights and advice from Southwest Alaska Network (SWAN) I&M Program (20-30 min) *Alan Bennett, Southwest Alaska Network (SWAN) Coordinator* Question and Answer Session (15 min)
IDENTIFY MONITORING OBJECTIVES, QUESTIONS AND VITAL SIGNS FOR SEAN MARINE ECOSYSTEM *Prior to February 2, please review and enter your ideas onto the draft Marine Ecosystem - Ecological Monitoring Framework Table at Tab 5 in Notebook*		
2:00 pm - 5:00 pm (Break ~ 3:30 pm)		Introduction and Group Exercise to begin filling-in draft Marine Ecosystem - Ecological Monitoring Framework (EMF) Table Facilitated large and small group work to identify monitoring objectives, questions and vital signs for SEAN Park's marine ecosystem. For the rest of the day and through early afternoon tomorrow, we will be considering, by Level I EMF Category: 1. What conditions or key elements should be documented to indicate marine ecosystem integrity? 2. What should be monitored to determine the range of variability in the marine ecosystem's response to natural and human drivers? 3. What should be monitored to identify the thresholds that would trigger a need to implement focused research, corrective/adaptive management, and/or mitigation measures?
5:00 pm		Adjourn for day
6:00 pm		**CATERED DINNER** Participants gather at local restaurant (to be announced) for dinner.

Friday, 3 February 2006		
ARRIVAL AND CONTINENTAL BREAKFAST		
7:30-8:15 am		Continental Breakfast available, Goldbelt Hotel
8:15 am		Agenda Update
8:30 am		Facilitated large and small group work to continue identifying monitoring objectives, questions and vital signs for SEAN Park's marine ecosystem.
10:30am		Break
10:50 am		Reassemble as large group. Report-out on work completed.
12:00 pm		Catered Lunch, Goldbelt Hotel
1:15 pm		Facilitated Large Group Discussion /summary/fill-in gaps.
2:30 pm		Break
2:45 pm		**PANEL DISCUSSION (**2-3 minutes each) *Chris Fastie, Dept. of Biology, Middlebury College* *Dan Lawson, Cold Regions Research and Engineering Laboratory* *Greg Streveler, Icy Strait Environmental Services* *Jim Bodkin, USGS AK Science Center Biological Science Office* *Ginny Eckert, University of Alaska* *Lisa Eisner, Auke Bay Laboratory, NOAA* *Deb Rudis, US Fish and Wildlife Service* *Jim Taggart, US Geological Survey* *Alan Bennett, National Park Service* The Question: If you had $50,000 annually to spend in *each* of SEAN's three parks to accomplish marine monitoring: a) What would you do, b) Why would you do it, and c) Tell a little about the approach you'd take. Question and Answer/Group Discussion.
4:15 pm		Break
MEETING WRAP-UP AND ADJOURNMENT		
4:30 pm		Wrap-up, What's Next, Closing Remarks
5:00 pm		Adjourn

Appendix B. Participant List

National Park Service - Southeast Alaska Network
Marine Scoping Meeting
February 2-3, 2006 - Juneau, Alaska

Alan Bennett
Alan_Bennett@nps.gov
907-644-3681
National Park Service
240 West 5th Avenue
Anchorage, AK 99501

Jim Bodkin
james_bodkin@usgs.gov
907-786-3550
USGS
AK Science Center Biological Science Office
1011 E. Tudor Rd., MS 701
Anchorage, AK 99503

Susan Boudreau
Susan_Boudreau@nps.gov
907-697-2640
Glacier Bay National Park
PO Box 140
Gustavus, AK 99826

Chiska Derr
Chiska_Derr@nps.gov
907-364-2621
National Park Service
3100 National Park Rd.
Juneau, AK 99801

Ginny Eckert
ginny.eckert@uas.alaska.edu
907-796-6450
University of Alaska Southeast
11120 Glacier Highway
Juneau, AK 99801

Lisa Eisner
Lisa.Eisner@noaa.gov
907-789-6602
National Oceanic and Atmospheric Administration
Auke Bay Laboratory
11305 Glacier Highway
Juneau, AK 99801

Chris Fastie
cfastie@middlebury.edu
802-352-9028
Dept. of Biology Middlebury College
2878 Upper Plains Rd
Salisbury, VT 05769

Scott Gende
Scott_Gende@nps.gov
907-364-2622
National Park Service
3100 National Park Rd.
Juneau, AK 99801

Meg Hahr
Meg_Hahr@nps.gov
907-983-9228
Klondike Gold Rush National Historical Park
PO Box 517
Skagway, AK 99840

Dan Lawson
Daniel.E.Lawson@erdc.usace.army.mil
907-384-0510
Cold Regions Research and Engineering Laboratory
PO Box 5646
Fort Richardson, AK 99645

Deborah Rudis
Deborah_Rudis@fws.gov
907-780-1183
U.S. Fish and Wildlife Service
3000 Vintage Blvd., #201
Juneau, AK 99801

Lewis Sharman
Lewis_Sharman@nps.gov
907-697-2623
Glacier Bay National Park
PO Box 140
Gustavus, AK 99826

Geof Smith
Geoffrey_Smith@nps.gov
907-747-0182
Sitka National Historical Park
500 Geodetic Way
Sitka, AK 99835

Greg Streveler
grigori@gustavus.ak.us
907-697-2287
Icy Strait Environmental Services
PO Box 94
Gustavus, AK 99826

Jim Taggart
jim_taggart@usgs.gov
907-364-1577
U.S. Geological Survey
3100 National Park Rd.
Juneau, AK 99801

Sara Wesser
Sara_Wesser@nps.gov
907-644-3558
National Park Service
240 West 5th Avenue
Anchorage, AK 99501

OBSERVING/ATTENDING FROM AUKE BAY LAB:

Molly Sturdevant
molly.sturdevant@noaa.gov
907-789-6041
Auke Bay Lab
11305 Glacier Hwy
Juneau, AK 99801

Joseph A. Orsi
joe.orsi@noaa.gov
(907) 789-6034
Auke Bay Lab
11305 Glacier Hwy
Juneau, AK 99801

Appendix C. Annotated Marine Bibliography

Biomonitoring and Assessments (Dan Bogan)

Barbour, M.T. 1997. The re-invention of biological assessment in the U.S. *Human and Ecological Risk Assessment,* **3,** 933-940.

Barbour, M.T., W.F. Swietlik, S.K. Jackson, D.L. Courtemanch, S.P. Davies, and C.O. Yoder. 2000. Measuring the attainment of biological integrity in the USA: a critical element of ecological integrity. *Hydrobiologia,* **422/423,** 453-464.

Karr, J.R. 1993. Defining and assessing ecological integrity: beyond water quality. *Environmental Toxicology and Chemistry,* **12,** 1521-1531.

Climate Change (Dan Lawson)

Alley, R.B., 2004, Abrupt climate change. Scientific American, November, p. 63-69.

This article examines the geologic record of abrupt, extremely rapid changes in climate that have taken place in the past. Abrupt change is just that – many degrees C change in decades or less that have affected the climate globally, lasting hundreds or more years before climate returned to a ”normal” state. The author not only examines the environmental consequences of such rapid changes, but also explores the social and economic impacts and how they might affect modern society. This article is written by one of the most knowledgeable scientists working on paleoclimate change and it is written in layman’s terms. A good read and I highly recommend it!

National Research Council, 2003, Abrupt Climate Change: Inevitable Surprises. National Academy Press, 230pp.

Prepared by the Committee on Abrupt Climate Change, this report reviews and analyses available data on climate and paleoclimate from diverse sources on the existence in the past of rapid and sudden changes in climate. Such changes occurred over periods of several years to tens of years with significant cooling (-5 to –10 C) during this time, followed by recovery to warmer climate over a hundred or more years. They examined the paleoclimate record and concluded the inevitability of such changes, as well as the consequences for society. The Committee made recommendations for further research and urge recognition that such changes may occur in the future. This technical treatment is well written and provides an important perspective on potential global changes in climate that might in the short term affect Glacier Bay ecosystems.

Glaciers and Ice Sheets (ice dynamics, processes, environment) (Dan Lawson)

Alley, R.B., Lawson, D.E., Larson, G.J., Evenson, E.B., and Baker, G.S., 2003, Stabilizing feedbacks in glacier-bed erosion. Nature, 424, 758-760.

This article presents a hypothesis on how the configuration of the bed, and in particular the slope of overdeepenings, control glacier hydrology, erosion and deposition and in particular how glacier’s are “graded” like streams.

Lawson, D.E., 1979, Sedimentological analysis of the western terminus region of the Matanuska Glacier, Alaska. CRREL Report 79-9, 121pp.

Detailed analysis of how a modern glacier erodes, transports and deposits sediment in moraines.

Lawson, D.E., 1993, Glaciohydrologic and glaciohydraulic effects on runoff and sediment yield in glacierized basins. CRREL Monograph 93-2, 122pp.

A review and synthesis of the hydrology and hydraulics of glaciers, emphasizing data and analyses of modern glaciers and ice sheets.

Ostrem, G. and Brugman, M., 1986, Glacier mass-balance measurements: A manual for field and office work. Saskatoon, Saskatchewan, Canada; National Hydrology Research Institute, NHRI Science Report No. 4, 224pp.

Everything you ever wanted to know about monitoring glaciers, including mass balance (accumulation, ablation), climate, discharge, sediment yield, surveying, data reduction and analysis, remote sensing and other techniques.

Paterson, W.S.B., 1994, Physics of Glaciers (3rd Ed.), New York, Pergamon Press. Classic text on glacier dynamics.

Glacier Monitoring (Roman Motyka)

Arendt, A.A., K.A. Echelmeyer, W.D. Harrison, C.S. Lingle, and B. Valentine. 2002. Rapid wastage of Alaska glaciers and their contribution to rising sea level. *Science*, **297**, 382-386.

Fountain, A.G., Krimmel, R.M., and Trabant, D.C., 1997, A strategy for monitoring glaciers: U.S. Geological Survey Circular 1132, 19 p.

Mayo, L.R., D.C. Trabant, and R.S. March, 2004. A 30-year record of surface mass balance (1966-95), and motion and surface altitude (1975-95) at Wolverine Glacier, Alaska. *U.S. Geol. Surv. Open-File Report* 2004-1069, 105 p. plus CD.

Motyka, RJ, S O'Neel, C Connor, and K Echelmeyer, 2002. 20th Century thinning of Mendenhall Glacier, Alaska, and its relationship to climate, lake calving, and glacier run-off. *Global and Planetary Change*, ***35***(1-2) 93-112.

Neal E. Neal E.G., M. Todd Walter, C. Coffeen. 2002. Linking the pacific decadal oscillation to seasonal stream discharge patterns in Southeast Alaska. Journal of Hydrology 263, 188-197.G., M. Todd Walter, C. Coffeen. 2002. Linking the pacific decadal oscillation to seasonal stream discharge patterns in Southeast Alaska. Journal of Hydrology 263, 188-197.

Glacial Sediments, Landforms and Terrain (Dan Lawson)

Benn, D.I. and Evans, D.J.A., 1998, Glaciers and Glaciation. New York, Arnold, 734pp.

Extensive treatment on the glacial environment, emphasizing processes of glaciers and their landform/terrain associations.

Menzies, J.(ed.), 1995, Modern Glacial Environments: Processes, Dynamics and Sediments. Boston: Butterworth-Heinemann, 621pp.

Menzies, J.(ed.), 1996, Past Glacial Environments: Sediments, Forms and Techniques. Boston: Butterworth-Heinemann, 598pp.

The previous two books edited by John Menzies consist of multiple chapters by leading scientists in each of the fields so covered by each chapter. In the first book modern glacial and glacial marine environments are covered, with an emphasis on the processes of the glacier and its sub-environments. The second covers the various depositional environments and their products and the types of landforms develop by past glaciers and ice sheets.

Paleoclimate (Dan Lawson)

Bradley, R.S., 1999, Paleoclimatology: Reconstructing climates of the past. New York, Academic Press, 610pp.

The author explains the basic methods, technique and data sources of reconstructing the climate of the past, emphasizing the late Quaternary period of the last 120,000 yrs. The information provides a background on how and why "monitoring and inventorying" of paleoclimatic data are critical to understanding current climatic trends and predicting future changes in climate and how such changes may ultimately affect ecosystems.

Grove, J. M., 1988, The Little Ice Age. New York, Methuen Press, 498pp.

An extensive treatment of the Little Ice Age and in particular how the changes in climate during this recent cold period affected society and its environment. The author discusses evidence and data for the LIA from across the globe. Grove's treatment includes both measured, quantifiable data sources as well as recorded history in literature, journals, paintings and other sources. It is a most complete picture of the life and times of the Little Ice Age, and perhaps a glimpse of the future.

Mackay, A., Batterbee, R., Birks, J., and Oldfield, F. (eds.), 2003, Global change in the Holocene. London, Arnold, 598pp.

Examines changes during the Holocene period that have implications for changes within Glacier Bay that have affected glaciation, habitation and ecosystems of the last ~12,000 years.

Wiles, G., D'Arrigo, R. D., Villalba, R., Calkin, P.C. and Barclay, D.J., 2004, Century-scale solar variability and Alaskan temperature changes over the past millennium. Geophysical Research Letters, 31, paper L15203, 4pp.

Recent article on changes in temperature in south central over the past 1000 years. References cited provide links to other relevant Alaskan studies.

Fritts, H.C., 1976, Tree Rings and Climate. New York, Academic Press.

This is the standard reference for methods of tree ring analysis and its application to delineating climate.

Cook, E.R., and Kairiukstis, L.A., 1990, Methods of Dendrochronology: Applications in the Environmental Sciences. Boston, Kluwer Academic.

The chapters in this book discuss various applications of tree ring studies to environment and ecology.

Surficial Processes and Landforms (Dan Lawson)

Easterbrook, D. J., 1999, Surface processes and landforms. Prentice Hall, Upper Saddle River, NJ (2nd Ed), 546pp.

This is a basic text on geologic processes and landforms that covers those physical environments common to the SEAN. The text is well written and illustrated, and is a good reference.

Tidewater Glaciers (Dan Lawson)

Syvitski, J.P.M., D.C. Burrell, and J.M. Skei (1987a). Fjords, Processes and Products, Springer-Verlag, New York, 379 pp.

This is an advanced text on the physical and chemical oceanography of fjords.

Powell, R.D. and Molnia, B. F., 1989. Glacimarine sedimentary processes, facies and morphology of the south-southeast Alaska shelf and fjords. Marine Geology, 85(2-4)359 – 390.

This article discusses the first and second order controls on tidewater glacier dynamics and specifically on processes of sedimentation and depositional systems. Specific examples are presented from Glacier Bay.

Powell, R.D. and Domack, E.W., 1995. Glaciomarine Environments, Chapter 13. In Menzies, J. (ed.), Glacial Environments - Processes, Sediments and Landforms (621 p.). Butterworth-Heinmann, Boston: 445-486.

Book chapter presenting the basic aspects of tidewater glacier environments and that of the immediate fjord environment into which they discharge. Examples cited from Glacier Bay.

Meier, M. F. and Post, A., 1987. Fast tidewater glaciers. Journal of Geophysical Research, 92(B9), 9051 – 9058.

Excellent article on physical aspects of tidewater glacier flow and their advance and retreat.

Post, A., 1975. Preliminary hydrology and historic terminal changes of Columbia Glacier. U.S. Geological Survey Hydrologic Investigations, HA-559.

First discussion of the tidewater glacier cycle by Post.

Various Marine References (Deb Rudis)

Adams, S.M., Editor. 2002. *Biological Indicators of Aquatic Ecosystem Stress*. Amer. Fish. Soc. 644pp.

Blanchettte, C.A. 1997. Size and survival of intertidal plants in response to wave action: a case study with Fucus gardneri. Ecology 78(5):1563-1578.

Eisenhardt, E. 2003. Marine protected area monitoring technique: an example from San Juan County. Proc. of the Georgia Basin/Puget Sound Research Conference. p.1-25 www.psat.wa.gov/publications/03-proceedings/PAPERS/ORAL/10a_eise.pdf

Kjelleberg, S., T.A. Stenstrom and G. Odham. 1979. Comparative study of different hydrophobic devices for sampling lipid surface films and adherent microorganisms. Marine Biology 53(1):21-25.

Miller, D.J. and A.C. Cheshire. 1999. An analysis of the use of video assessment for the survey of soft bottom epibenthic communities. The Impact of sand dredging on benthis community structure at the Port Stanvac Dredge Site 1:1-25. Pub. Dept. Environ. Biol., Univ. Adelaide, Adelaide, 5005, Australia.

Solandt, J-L., et. al. DRAFT. An assessment of subtidal surveys carried out at Campomanes Bay, Negros Occidental www.coralcay.org/science/publications/phillipines_m_2001_sncdp_campomanes.pdf

Teem, J. 2002. Comparison of diver survey methods at Pt. George, Shaw Is., WA Marine Fish Ecology 492, Friday Harbor Lab www.fish.washington.edu/classes/fish492/fall2002/JasonT.pdf

Van Vleet, E.S. and P.M. Williams. 1980. Sampling sea surface films: a laboratory evaluation of techniques and collecting materials. Limnology and Oceanography 25 (4):764-770.

Wright, J.P. and C.G. Jones. 2004. Predicting effects of ecosystem engineers on patch-scale species richness from primary productivity. Ecology 85(8): 2071-2081.

Yang G. –P., watanabe S., Tsunogai S., 2001. distribution and cycling of dimethylsulfide in surface microlayer and subsurface seawater. Marine Chemistry 76 (3):137-153

Zador, S. and J.F. Piatt. 1999. Populations and productivity odf seabirds at South Marble Island, Glacier Bay, Alaska, during May - July, 1999. USGS and U. Wash report. www.absc.usgs.gov/research/seabird_foragefish/products/reports/1999re~1.pdf