Glacier Bay

National Park Service
U.S. Department of the Interior

Glacier Bay National Park
and Preserve

Research/Resource Management Program

Current and Recently Completed Projects

Glacier Bay National Park and Preserve

Division of Natural and Cultural Resources

June 2004

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NOTE: Each research project leader working in the park is required to file an Investigator's Annual Report (IAR) with the National Park Service. The report describes the work accomplished during the previous field season and provides a brief summary of the results. These reports are contained in a searchable database available to the public through the following NPS research website:

http://science.nature.nps.gov/research/ac/ResearchIndex

The IAR for a project may contain more information than is presented in this research summary document.

Marine Ecosystem Management

Investigating movements, habitat use, and foraging ecology of harbor seals in Glacier Bay National Park

Gail Blundell, Alaska Department of Fish and Game (ADF&G)

Scott Gende, NPS

Glacier Bay National Park has historically supported one of the largest breeding populations of harbor seals (*Phoca vitulina richardsi*) in Alaska. However, the number of harbor seals in the park has declined by more than 70% since 1992, with a total decline of approximately 6,500 seals. The magnitude and rate of decline exceed all currently documented declines of harbor seals in Alaska.

The cause of decline may be specific to the park or the nearby region: in contrast to the population trend in Glacier Bay, harbor seals in two other areas of southeastern Alaska (near Sitka and near Ketchikan) are stable or increasing. Continued decline may result in the listing of this population as threatened or endangered. Recent genetic analyses suggest that the population of harbor seals in the Glacier Bay area is a genetically distinct stock. A reduction in genetic diversity has already been demonstrated for declining populations of harbor seals in Prince William Sound, and similar effects are likely for this population, given the higher rates of decline.

Unfortunately, very little is known about the ecology, life-history, movements, and behavior of harbor seals in Glacier Bay, so it is difficult to discern causal factors contributing to the decline, and thus difficult to develop effective management strategies. Hypothesized reasons for the decline include increased human disturbance, elevated rates of predation, nutritional stress due to changes in prey base, disease, or contaminants. However, before leading hypotheses can be identified, other hypotheses eliminated, and additional causal effects assessed, basic ecological and behavioral data need to be collected.

The first phase of this study will begin this examination of potential causal factors contributing to the decline of harbor seals in Glacier Bay. The research began in April 2004 with an extensive trapping effort to instrument seals with long-term internal VHF transmitters and external VHF 'head-mount' transmitters. Researchers have now begun tracking the movements, habitat use, and foraging ecology of seals, using radio receivers in boats and fixed wing aircraft along with two automated data loggers placed on shore. With this technique, researchers hope to learn aspects of the seals' life history that may shed some light on possible causes for their declining numbers.

For more information on the harbor seal declines in Glacier Bay, go to:
http://www.nps.gov/glba/InDepth/learn/preserve/projects/seal/index.htm

For more information on the Alaska harbor seal research program, go to:
http://www.fakr.noaa.gov/protectedresources/seals/researchplan0503.pdf

Underwater acoustic monitoring in Glacier Bay National Park

Christine Gabriele, NPS

Although NPS has a variety of resource concerns related to vessel traffic, park managers are particularly concerned about the potential disturbance of endangered humpback whales by vessel noise. In May 2000, park staff and U.S. Navy acousticians installed an underwater listening device – called a hydrophone – in the entrance of Glacier Bay. The hydrophone transmits underwater sounds through a cable to a computer workstation at park headquarters in Bartlett Cove. The hydrophone detects natural sounds such as wind and waves as well as human-caused sounds, primarily boat traffic. Acousticians can determine whether the sounds recorded are rain, an outboard engine, or a cruise ship, and have begun to analyze and summarize the data and provide reports to the Park.

The specific objectives of the research are to:

- Describe ‘natural underwater sounds" such as wind, rain, and marine mammal vocalizations
- Describe vessel-generated sounds (frequency, loudness, duration, and how far the sound travels) in lower Glacier Bay
- Determine the frequencies and loudness of vessel-generated sound that whales and other marine life are exposed to
- Determine how vessel numbers, speed and other operating parameters affect underwater sound

Park staff are interested in learning what, if anything, can be done to minimize sound disturbance of marine mammals in the park. The data gathered during this study will help park managers fine-tune vessel management regulations. Once researchers have determined the proportion of underwater noise that comes from vessels, the sound levels marine mammals are exposed to, and how much variability in sound levels there is on a daily basis, the park will work with Navy acousticians to develop "noise goals." These goals will then help guide the park’s vessel management practices.

In the meantime, one unexpected bonus of this study has been the first-ever opportunity to record humpback whale "song" in Glacier Bay. Humpback whale song is thought to be a male breeding display that is prominent in their wintering grounds, and previously considered to be quite rare in the feeding areas. It is called a song because it is a long, complex vocalization that repeats in a predictable pattern. Whale song recordings from Glacier Bay have been made only in the fall, when perhaps the hormonal changes that spur whales to migrate are beginning to occur. More information on these whale vocalizations and some example recordings can be found at:
http://www.nps.gov/glba/InDepth/learn/preserve/projects/acoustics/sounds/index.htm

For more information on the acoustic monitoring program at Glacier Bay, go to:
http://www.nps.gov/glba/InDepth/learn/preserve/projects/acoustics/index.htm

Population characteristics of humpback whales in Glacier Bay and adjacent waters

Christine Gabriele, NPS

Every year since 1985, National Park Service (NPS) biologists have conducted an annual monitoring program to systematically characterize the humpback whale population in Glacier Bay and Icy Strait. Each summer, NPS biologists document the number of individual whales, as well as their residence times, spatial and temporal distribution, reproductive parameters and feeding behavior. These data are used to monitor long-term trends in the population's abundance, distribution, reproductive rates and to characterize the non-biological features of their feeding habitat such as water depth and sea surface temperature. In addition, human-whale interactions including strandings, entanglements in fishing gear and disturbance by vessels and aircraft are documented opportunistically. Photographic identification data are shared with other researchers studying North Pacific humpback whales through a central data repository in the National Marine Mammal Laboratory in Seattle, Washington. In addition, whale distribution data are used locally by park biologists to determine when and where special NPS vessel course and speed restrictions ("whale waters") should be implemented each summer in Glacier Bay.

For more information on the humpback whale monitoring program, go to:
http://www.nps.gov/glba/InDepth/learn/preserve/projects/whale/index.htm

Ecological relations between sea otters and benthic marine communities in Southeast Alaska: inventory and monitoring of shallow benthic communities in Glacier Bay

Jim Bodkin, USGS Alaska Science Center

Mike Donnellan, NPS

Since 1995, the number of sea otters in Glacier Bay proper has increased from around 5 to more than 1800. Sea otter distribution is mostly limited to the mid to lower bay south of Sandy Cove, and is not continuous within that area. Concentrations occur in the vicinity of Sita Reef and Boulder Island, and also on the west side of the bay between Pt. Carolus and Rush Pt. While there have been occasional sightings north of Sandy Cove, large portions of the bay remain unoccupied by sea otters. However, recolonization is occurring rapidly.

As sea otters colonize Glacier Bay, they can be expected to profoundly impact intertidal and subtidal benthic invertebrates such as clams and sea urchins, as well as algae and other species. This project seeks to describe: 1. The abundance and distribution of sea otters within and near the park; 2. The feeding habits of sea otters within and near the park; and 3. The structures and functions of benthic communities in the park that may be affected by the arrival of sea otters. These would include species composition, distributions, abundances, and size class distributions. This study will establish baselines at sites that likely will be impacted by sea otters, as well as a set of control sites. After a suitable period of habitation by sea otters, sites will be resampled and the effects and their magnitude will be determined. Data from this study will establish a population growth

rate for sea otters within the park. It will also identify important habitat for the otters as well as key food sources.

More information on the sea otter effects research and sea otter population assessment can be found at:
http://www.nps.gov/glba/InDepth/learn/preserve/projects/otters/otter_report_index.htm

Distribution and abundance of Kittlitz's murrelets in Glacier Bay National Park and the effects of vessel disturbance on feeding behavior

John Piatt, USGS Alaska Science Center

Marc Romano, USGS Alaska Science Center

Populations of Kittlitz's murrelets (KIMU) have declined by more than 80% during the past 10-20 years. As a result, environmental groups have petitioned the US Fish and Wildlife Service to list the Kittlitz's murrelet under the Endangered Species Act. Similar declines have also been observed in Glacier Bay National Park, where perhaps a quarter of the world population resides. Documented sources of mortality for KIMU across their range include oil spills and gillnet mortality. However, these factors are largely absent in Glacier Bay, where the population has plummeted in recent decades. Undocumented potential causes of KIMU mortality include loss of foraging habitat to glacial recession, natural changes in food abundance, and vessel disturbance in core foraging areas.

This study will attempt to determine if vessel disturbance is affecting Kittlitz's murrelet distribution and abundance in Glacier Bay proper. Researchers will accomplish this by monitoring murrelet distribution, abundance and foraging at key areas where cruise ships and smaller vessels traditionally travel, and compare this with areas where vessels are absent. The effects of vessel disturbance on Kittlitz's murrelets will then be studied at several locations within the Bay.

Survey results will provide park resource managers with abundance and distribution data for the species. Accurate population and density estimates will allow comparison with previously collected data to assess population trends. Foraging behavior information will provide data on Kittlitz's murrelet use of park forage resources. Vessel disturbance observations will help determine if Kittlitz's murrelets are negatively affected by vessel traffic within the bay. This will include categorizing the pattern of vessel traffic at several important KIMU foraging areas in Glacier Bay, and quantifying the immediate effect of vessel disturbance on individual KIMU by recording the vessel approach distance that elicits a change in behavior. This information will allow park managers to make informed decisions regarding management of vessel traffic within the park.

Testing the effectiveness of a high latitude marine reserve network: a multi-species study seeking to quantify the effects on population structure following commercial fishing closures and to define movements within Glacier Bay National Park, Alaska

Jim Taggart, USGS Glacier Bay Field Station

The commercial fishing closures in Glacier Bay created a network of five marine protected areas, which vary in shape and range in size from 40 to 280 km^2. Data on the effectiveness of marine protected areas are especially limited from high latitude ecosystems. Because of the proximity of closed areas to areas that are still fished, the opportunity exists in Glacier Bay to test the effectiveness of a marine reserve network as a marine conservation management tool.

One of this project's goals is to measure the transfer rate of Pacific halibut (*Hippoglossus stenolepis*), Tanner crab (*Chionoecetes bairdi*), and red king crab (*Paralithoides camtschaticus*), between the newly created reserves and the adjacent areas remaining open to commercial fishing. A second long-term goal is to measure detailed movement patterns of crab and halibut so that we can identify essential habitat, seasonal changes in distribution, migration patterns, and changes in movement and habitat requirements with ontogeny. For the first time, advances in telemetry are making it possible to measure these population processes.

To accomplish this, we will tag king and Tanner crabs and halibut within multiple reserves and outside the reserves with sonic tags and then measure their movements among the reserves by deploying submersible data loggers along the reserve boundaries, creating ultrasonic gates. The data loggers will record tagged animals that move across the reserve boundaries. The location of tagged animals will be periodically determined by visiting these stations and downloading the data, as well as by systematically searching with towed hydrophones.

As of Spring 2004 the project had tagged 31 Tanner crabs and 30 king crabs, and radio tracking is beginning to reveal their movements.

Brand resighting survey of Steller sea lions in Southeast Alaska

Tom Gellat, Alaska Department of Fish and Game (ADF&G)

The Steller sea lion program of the Alaska Department of Fish and Game annually marks sea lions with permanent brands for individual identification. Resightings of these individuals are used to estimate population characteristics such as survival and reproductive rates as well as for examination of dispersal rates. South Marble Island and Graves Rocks in Glacier Bay National Park are prominent sea lion haulouts, and branded animals from the nearby Forrester Island rookery have been sighted in each location in previous years. More importantly, sea lions branded in the western stock (see below) may have a greater likelihood of appearing on these sites compared to others in southeast Alaska. Satellite telemetry data indicates that animals do travel between the two populations.

The Steller sea lion is currently listed as an endangered species west of Cape Suckling, Alaska (western stock) and as threatened in the eastern stock, which inhabits southeast Alaska. The two populations are genetically distinct based on mitochondrial DNA analyses. The western population has experienced a decline in excess of 80 percent over the last 30 years, while the eastern population has increased slightly. The reasons for these trends are unknown. By comparing different parameters between the populations, we hope to find measurable factors that might help explain the population differences.

The scat samples collected at the two Glacier Bay National Park sites will be used in a long term study of prey remains conducted by Dr. Andrew Trites at the University of British Columbia. This work will compare diet between the two populations and between years. A spatial or temporal difference in diet could lead to other hypotheses explaining the population trend differences.

For more information on the coordinated Steller sea lion research project, go to: http://www.fakr.noaa.gov/omi/grants/brothers/sitevisit.htm

Humpback whale entanglement rates in fishing gear in Southeast Alaska

Janet Doherty, NPS

The primary objective of this study is to estimate the rate of non-lethal entanglement in fishing gear for humpback whales in southeastern Alaska. To do this, the project leader will examine photographs of individual whales for entanglement-related scarring. University of Alaska Southeast biologist Jan Straley and Glacier Bay National Park biologists have collaborated since the late 1970's on photographic identification studies of the unique patterns on the ventral surface of the flukes of humpback whales in southeastern Alaska. This extensive, long-term data set includes demographic information such as the sex, age, and historic feeding areas of individual whales. These data will facilitate the second objective, which is to identify any particularly vulnerable segments of the population. A third objective is to describe the location of scarred and unscarred whales in relation to the location of fishing gear that is deployed during the seasons during which whales are present. Data on fishing gear distribution are available from the National Marine Fisheries Service and the Alaska Department of Fish and Game. The fourth objective is to calculate the reporting rate of whale entanglements to the NMFS Alaska Region stranding database based on the entanglement scar data from this study.

Killer whale population assessment and photo-identification of winter humpback whales in northern Southeast Alaska.

Dena Matkin, Private Researcher

This multi-year monitoring effort focuses on defining the population size, structure, and range of killer and humpback whales by collecting photographs of killer whale dorsal fins and humpback whale tail flukes. Other aspects include incidental collection of whale vocalizations, feeding habits, and interactions with fisheries. The study shares information with researchers, the National Park Service, and the public.

Larval abundance and settlement of Dungeness crabs in Glacier Bay

Ginny Eckert, University of Alaska Southeast (UAS)

Dungeness crab (*Cancer magister*) is a commercially important species in Alaska, particularly in Southeast Alaska. However, little is known about its early life history in this region. This proposed study is a continuation of a project started in 2000 to determine the timing of Dungeness crab larval abundance and settlement in Glacier Bay. The study will address the settlement and recruitment of Dungeness crab larvae in a marine protected area.

Wilderness/Backcountry Management

Assessing wilderness conditions at Glacier Bay National Park

Allison Banks, NPS

Tania Lewis, NPS

The purpose of this project has been to assess current backcountry conditions within Glacier Bay proper. The project has included assessing campsites for risk of bear encounters, inventorying selected wildlife species (black and brown bear, shoreline nesting birds) and their habitats, and monitoring the impacts of human presence on the shoreline. The data will be analyzed to create a profile of current and potential backcountry ecosystem impacts, social conditions, and relative risks of bear encounters. Results will be used to develop the park's backcountry management plan.

Field work for the bear habitat and campsite condition projects started in May 2001 and ended in September 2002. Staff documented bear sign including rub trees, root and tuber digs, mark trails, etc. at 120 beaches and evaluated habitat quality, potential for bear displacement, and bear/human encounter risk at 162 campsites. Principle Investigator Tom Smith of the US Geological Survey Alaska Science Center is currently analyzing the data and preparing a final report on this project.

Opportunistic recording of nesting bird activity including defensive behavior, displaying males, nests, juvenile birds, and feeding behaviors at known campsites was started in 2002. In 2003 a more comprehensive shore nesting bird project was begun by John Piatt of the Alaska Science Center that will replace this aspect of the project. That field work will continue in 2004.

Physical impacts from human use such as social trails, fire and tent rings, vegetation trampling, litter and human waste were mapped at 269 campsites on 136 beaches during 2003. All locations were entered into the park's GIS database. Most sites showed minimal impact from campers. The most heavily used sites were near attractions such as active tidewater glaciers and fresh water sources. Data analysis is complete, with a final report in draft as of June 2004. A campsite monitoring protocol specific to Glacier Bay shorelines will result from this project.

An evaluation of campsites at Glacier Bay National Park: predicting bear-human conflicts and bear displacement potential

Tom Smith, USGS Alaska Science Center

Steve Partridge, USGS Alaska Science Center

The purpose of this research is to minimize bear/human conflict by collecting information that can be analyzed to predict areas where people are most likely to encounter bears, and using the results to reduce the likelihood of conflicts between people and bears in Glacier Bay.

Two-person crews kayaked along Glacier Bay's beaches in the summers of 2001 and 2002, visiting campsites and assessing their risk factors for bear encounters. These included quality of bear habitat (key bear forage items), bear travel concerns (physical features that influence the likelihood of a bear traveling through a campsite), visibility and other sensory concerns (e.g. noise from streams), along with obvious bear sign (digs, scat, tracks).

Technicians have surveyed 120 beaches for signs of bear use, and have conducted risk assessments at 162 campsites throughout the bay. At each site they have recorded bear sign and bear habitat potential along with other site characteristics. The data will help biologists gain an understanding of bears' use of these campsites, and will provide park managers with recommendations on how to reduce bear/human conflicts.

Work will continue in 2004 to further determine if habitat characteristics at selected study sites are predictive of observed bear activity patterns. Eight study site locations will be selected throughout the bay. Remote cameras will be deployed at these sites to determine bear activity rates (i.e. bear presence/minutes monitored). In addition, detailed study of bear diets will be accomplished through scat and hair analysis and direct observation to determine what proportion of what foods make up bears' diet in Glacier Bay. Species composition and biomass of forage items within selected plots will also be determined. These data will be incorporated into the project GIS and will be incorporated into a bear management plan.

For more information on this project, go to:
http://www.nps.gov/glba/InDepth/learn/preserve/projects/bears/habitatresearch.htm

Human disturbance of coastal marine birds nesting in Glacier Bay National Park, Alaska

John Piatt, USGS Alaska Science Center

Marc Romano, USGS Alaska Science Center

Glacier Bay contains a diverse assemblage of marine birds that use the bay for nesting, foraging, and molting. However, the distribution of most marine birds is not well known, making it difficult to address the potential for disturbance from human activities.

This project will provide a comprehensive assessment of marine bird distribution and breeding sites in Glacier Bay. It will evaluate backcountry visitor impacts on ground

nesting marine birds. Marine bird shoreline nest sites will be located and mapped. Productivity in sample nest sites exposed to high levels of human use will be compared to productivity in areas with little human use to determine the extent of camper impacts. From this, we will develop an index of disturbance risk by area.

Marine bird distribution on the water will be determined by standardized transect methods. These data will be compared to existing data on camper and boater use patterns, using Geographic Information System (GIS) to determine where humans are likely to impact seabird reproduction and distribution. Results from this project will be incorporated into the park's forthcoming backcountry management plan as well as revisions to the park's vessel regulations and the annual Superintendent's compendium.

Exotic Plant Inventory and Control

Jeff Heys, NPS

The project is part of an Alaska-wide effort to control exotic plants in national parks under the direction of the Alaska Exotic Plant Management Team. Part of Glacier Bay's mission in its enabling legislation is the study of plant community development following glacial retreat. In line with this mission, it is important to examine the potential for exotic plants to colonize such early-successional, disturbed habitats. In the summer of 2004, an initial survey will be performed of the bay by the project leader and a park staff-person. The survey will focus on the areas with the greatest onshore visitation rates (especially campsites). In addition, when populations of exotic plants are found that are still small enough to be easily controlled and/or threatening enough to warrant concern, they will be removed from the site using manual methods. This effort will therefore comprise a combination of reconnaissance and control.

Coastal Monitoring/Mapping

Alaska coastal resources inventory and mapping program

Lewis Sharman, NPS

The primary goal of the Coastal Mapping Program has been to gather and make easily accessible information about a variety of marine coastal resources for the marine shorelines of Glacier Bay National Park and Preserve, Klondike Gold Rush National Historical Park, Sitka National Historical Park, and Wrangell-St. Elias National Park and Preserve. This project will also result in the development and distribution of a comprehensive protocol for field mapping, inventory data collection, and integrating coastal resources information into a GIS.

The information produced by the mapping project will help guide subsequent research and management of park coastal resources, including:

- Evaluation and response to natural vs. anthropogenic change;
- Response to large environmental disasters such as oil spills;
- Protection of sensitive natural resources;
- Identification and preservation of archaeological and cultural resources;

- Design and selection of a companion long-term monitoring protocol and sampling sites.

The grand total of shoreline mapped and inventoried in this 7-year project has been approximately 970 shoreline miles, which includes all of Glacier Bay proper, park shores in Icy Strait and Cross Sound including Dundas Bay, Lituya Bay and other relatively protected shores on the park's outer coast. The project has also mapped all of the Klondike Gold Rush National Historical Park and Sitka National Historical Park shorelines. This has involved the mapping of over 6000 discrete shoreline segments with associated detailed resource information, 21,000 ground photos, and 305 georeferenced aerial photos. All of these have been linked together in a database that can instantly display any desired shoreline information to park managers, researchers, and the public.

For more information on the coastal mapping project, go to:
http://www.nps.gov/glba/InDepth/learn/preserve/projects/coastal/index.htm

Development of coastal monitoring protocols and process-based studies to address landscape-scale variation in coastal communities of Glacier Bay National Park and Preserve

Gail Irvine, USGS, Alaska Science Center

Complex assemblages of marine intertidal life, both plant (algae) and animal (invertebrates), inhabit the park's 1100 plus miles of shoreline. These intertidal and subtidal invertebrates and plants provide structure to the shoreline habitat, and many of the invertebrates are important components of the diets of creatures ranging from sea birds to bears and wolves. However, while these biologically rich and productive communities are facing increased anthropogenic pressures, it is difficult at the present time to determine if observed changes in species or habitat are a result of natural forces or are caused by human impacts. The goal of this multi-park project is to design monitoring protocols that can accurately determine the amount of change in the abundance and distribution of intertidal organisms over various time scales and a variety of habitat types.

The completion of four years of sampling of 25 intertidal monitoring sites in Glacier Bay has allowed power analysis of the ability to detect trends in species abundances. Power analyses were conducted for the three major sessile species or species groups: barnacles, the mussel (*Mytilus trossulus*), and the brown alga (*Fucus gardneri)*. These analyses indicated that the sampling has high power to detect 10% annual changes in these species/groups. Comparisons were made of the relative ability of different sampling schemes (e.g., the number of sites, number of transects, use of transects vs. quadrats, etc.) to detect change. This analysis, combined with further discussion, will facilitate the decisions that managers need to make in designing a long-term monitoring program.

Inventory/Monitoring Program

Inventory of vascular plants of Glacier Bay National Park and Preserve (Southeast Alaska Network)

Matthew Carlson, Alaska Natural Heritage Program (AKNHP)

The National Park Service is conducting a vascular plant inventory to document the occurrence, distribution, and relative abundance of plants occurring in the Southeast Alaska Network (Glacier Bay National Park, Klondike Gold Rush National Historic Park, and Sitka National Historic Park). The inventory was developed to provide baseline information for future monitoring and management of natural resources within the parks. It is part of a nationwide National Park Service program to document the species present in national parks across the country.

In 2001 and 2003, the Alaska Natural Heritage Program (AKNHP) conducted vascular plant field inventories in Glacier Bay National Park and Preserve. The primary goal was to document greater than 90% of the vascular plant species expected to occur within the parks, as well as to improve our understanding of current species distributions. The inventory targeted diverse habitat types and poorly-sampled areas. The AKNHP visited eight diverse ecogeographic regions and sampled intensively within these regions from late June to mid-August, 2001 and late June to early July in 2003. A total of 555 specimens were collected, recorded, pressed, and curated. 333 individual species are represented, 172 are new records for the park, and an additional 44 represent verifications of previously unvouchered reports. A number of finds were significant range extensions or species of conservation concern, while several others are very rare in Alaska but more widespread in western North America.

For more information on the NPS Inventory and Monitoring Program, go to:
http://www1.nature.nps.gov/protectingrestoring/IM/inventoryandmonitoring.htm

Glacier Bay National Park and Preserve landcover map

Jess Grunblatt, NPS

The land cover project is part of the Inventory and Monitoring Program of the NPS, which seeks to provide reliable and consistent scientific information to assess the status and trends in condition of national park ecosystems. Land cover mapping is conducted with the goal of providing basic vegetation information that is useful for making resource management decisions on a park-wide basis.

Landcover mapping is being accomplished using aerial and satellite photographic methods and subsequent interpretation, which includes "ground truthing" to verify the accuracy. During the 2001 field season, detailed physical and botanical information were collected at 497 sites throughout the Park. In addition, at each site photos were taken and the location was recorded using GPS. The landcover classes to be interpreted have been finalized and photo interpretation work is continuing. All delineations are

being mapped with both landcover and NWI class names. Only vegetated landcover types are being interpreted. It is expected that the interpretation will be completed in 2004.

Geology/Glaciology/Climate

Documenting changes in the glaciers, landscapes, and associated ecosystems of Glacier Bay National Park and Preserve, Alaska through repeat photography

Bruce Molnia, USGS

The purpose of this multi-year project is to reoccupy historical photo-point locations in every fiord of Glacier Bay and retake photos of Glacier Bay's glaciers and associated landscapes. The new images obtained from these locations can then be compared to historical images collected from the identical locations. The historical images, which date from 1891 to 1980, were done by several different groups: early explorations, geological and glacier investigations, climbers, government aerial surveys. These historical images serve as a visual base against which to compare glacier movement, vegetative succession, sedimentation, erosion, etc. All these characteristics have undergone dramatic change over the decades in response to climate, glacial recession, and other factors. Our initial results document how vital an interpretive tool these photographic comparisons can be.

More than 40 historical photo locations were visited, with at least one located in each inlet and fiord of the Bay. The photo pairs show that in the East Arm, post-Little Ice Age retreat has continued without significant interruption into the 21st century. In the West Arm, retreat continued until about the start of the 20th century, when the behavior of the larger glaciers in each fiord began to differ. Some began to advance, while others continued to retreat, a pattern that continues today. During the 20th century, some of the smaller glaciers in the West Arm have experienced multiple cycles of advance and retreat, often on decadal timescales. The larger West Arm glaciers appear to respond to climate forces on century time scales.

The photos document that advancing glaciers in the park today are located in the northwestern part of the bay and on the outer coast; both are in a maritime climate area. These advancing glaciers are closer to a moisture source and have source areas at higher elevations. In the East Arm, glaciers are generally retreating, and the climate regime may be much more continental than that of the advancing glaciers. Photo comparisons also show that some glaciers have completely disappeared during the 20th and 21st centuries.

A variety of products are being developed and will soon be available. These include: a GIS, a website, several Power Point presentations, and a description of the changes noted.

Landslide-induced wave hazard assessment, Tidal Inlet, Glacier Bay National Park

Gerald Wieczorek, USGS

Photographic evidence shows that the landslide above the northern shore of Tidal Inlet moved sometime after AD 1892 and before AD 1919. This project is performing field

and aerial photographic examination of landslide features to determine the initial age of landslide movement as well as to assess the potential for renewed landslide activity. Precision GPS measurements of the landslide will be made over a period of several years to provide an indication as to whether the landslide is currently moving and how fast. Researchers are also examining vegetation on the southern shoreline of Tidal Inlet to determine whether the landslide has previously generated large waves. A detailed three-dimensional wave modeling is currently in progress to assess the potential wave height and velocity of a wave that could hypothetically travel beyond Tidal Inlet into the West Arm of Glacier Bay. Such a wave could pose a potential risk to cruise ships and other vessel traffic.

Long-term tidewater and terrestrial glacier dynamics, glacier hydrology, and Holocene and historic glacier activity in Glacier Bay

Daniel Lawson, Cold Regions Research and Engineering Lab (CRREL)

The fundamental objectives of our long-term investigations in Glacier Bay are to better understand the regional and global factors, especially climate, that control terrestrial and marine systems. This project continues research of glaciologic, sedimentologic, hydrologic, oceanographic and geophysical processes of tidewater and terrestrial glaciers. Specific objectives include: analyzing fresh and salt water properties; calculating sediment flux and how it responds to glacier dynamics; evaluating sedimentation rates; and measuring the isotopic composition (oxygen and hydrogen) of precipitation, surface water, ground water and glacier ice to assess the hydrologic cycle, weather and storm patterns.

Physical, climatic and oceanographic studies provide an important baseline for studying the potential impacts of short-and long-term changes in climate on park resources and for addressing the impacts of vessel traffic including accidents with fuel discharges. Our analytical data are essential to defining glacier influences over oceanographic parameters including sediment and fresh water discharges that strongly affect marine ecosystems.

Current climatic trends are being monitored and analyzed at 26 weather stations deployed across the park. We are also investigating the park's glacial history and paleoclimate by analyzing sedimentary deposits and radiocarbon dating of stumps, logs and soils. We are developing a tree-ring chronology of the last 9,000 years, a dendroclimatological record that will be a unique record for subarctic North America. We will define past changes in climate using modern climate data for calibration, and determine how ice advance and recession responded to such changes. These data will complement archaeological research, defining where Native villages may have been located during recorded and pre-recorded history, and verifying Tlingit legends. Our databases are coded for inclusion in the Glacier Bay GIS so that Park staff can use our results to examine resource issues and so the data can be available to other researchers.

Paleoclimate investigations using tree-ring and sedimentologic records continue in the East Arm, West Arm and lower Glacier Bay. Our radiocarbon dates on wood, peat and soils range from 300 to 12,900 years BP., with representative tree sections from the present to 9000 years BP. Results to date at CRREL's tree-ring lab indicate these data

may provide the longest Holocene tree-ring record for Southeast Alaska. Multiple sites are investigated each summer in each inlet, with traverses up valleys feeding each inlet. We also find new samples along the shore zone as isostatic uplift brings stumps above high tide. Stumps still rooted in Reid, Wachusett and Muir Inlets document at least three periods of ice advance and retreat over the last 9000 yrs.

The current data set, which is still incomplete for spatial coverage of the park, suggests that certain areas in the upper reaches of the East and West Arms were ice-free during different times, and these areas would have been available for habitation. Understanding when specific localities within the park were ice-free over the past 10,000 years has implications for better understanding the history of the Native populations, as it may allow a focused search for evidence of native habitation.

Oceanography

Glacier Bay oceanographic patterns

Lisa Etherington, USGS Glacier Bay Field Station

The project involves the monitoring and analysis of oceanographic patterns along the glacial chronosequence in Glacier Bay. Glacier Bay exhibits large spatial and temporal differences in oceanographic patterns due to complex fjord and estuarine processes, the recent history of glaciation, and large numbers of tidewater glaciers. To detect and understand anthropogenic disturbance to this marine ecosystem requires a baseline examination of the amount of spatial and temporal variability in the oceanographic properties within this fjord estuarine system, as well an understanding of the factors that are most influential in driving these patterns**.**

This year represented the tenth year of field sampling for this monitoring program, and consisted of six surveys of twenty-four stations located throughout Glacier Bay. A sampling profile with salinity, temperature, chlorophyll-a concentration (proxy for phytoplankton abundance), light penetration, and turbidity is taken at each station at one meter intervals from surface waters to bottom depths (to 300m).

For more information on the oceanography of Glacier Bay and associated research, go to: http://www.nps.gov/glba/InDepth/learn/preserve/projects/documents/OceanFactSheet.pdf

Glacier Bay National Park seafloor mapping and classification: linkages with biological patterns and processes

Lisa Etherington, USGS Glacier Bay Field Station

The primary objective of this project is to investigate the geological characteristics of the biological habitats of halibut, Dungeness crab, king crab, and Tanner crab within Glacier Bay National Park. Ocean floor bathymetry and sediment type are the building blocks of marine communities. Bottom type and shape affect the kinds of benthic communities that develop in a particular environment, as well as the oceanographic conditions that communities are subject to. Habitat classification of shallow water regions of Glacier Bay will provide crucial information on the relationship between benthic habitat features

and the abundance of benthic prey items for a variety of marine predators, including sea ducks, sea otters, and other marine mammals.

The study will focus on eight areas in Glacier Bay that represent sand, mud, boulder, cobble, and bedrock habitats at different depths (<80m for sidescan, < 400 m for multibeam), different slopes, and widely-varying current regimes. Side-scan sampling and acoustic profiling will occur in six sites that represent both the full range of benthic habitats in the lower bay as well as in the shallow (<80 m) mid-bay habitats. The multi-beam echosounding survey will be conducted in an area extending from the entrance of Glacier Bay at Icy Strait to the upper end of the main bay at Tlingit Pt. and half way up Muir Inlet.

Wildlife Management

Effects of food-limitation in a high density moose population on the Gustavus Forelands, Alaska.

Kevin White, Alaska Department of Fish and Game (ADF&G)

The overall objective of the proposed study is to determine how variation in forage quality, availability and spatial distribution might affect moose body condition (and by extension productivity) in an increasing, high-density moose population in the Gustavus forelands. This proposed research is designed to address key information needs relating to the effects of food-limitation on population dynamics of moose in Gustavus, with implications for populations in Glacier Bay National Park as well as throughout Southeast Alaska.

The project will look at seasonal distribution and movement patterns for moose that winter in the Gustavus forelands area. Additionally, by monitoring a combination of individual space use patterns (via GPS radio-collars), seasonal changes in body condition, and home range-specific habitat conditions, we will evaluate linkages between habitat quality and body condition. At the population-level, we will evaluate a suite of moose population and habitat measures in order to test the extent to which this population is food-limited and, more specifically, whether food-limitation is more acute in winter or summer. Assessment of the above hypotheses will be aided via comparative analyses with other moose populations in Alaska and elsewhere for which similar data have been collected. This research product will serve as the basis for developing habitat carrying capacity estimates and evaluating population management objectives for the Gustavus moose population.

This study will take place primarily outside of Glacier Bay NP; however some aspects of the study may involve requests for access to NPS lands and collaboration with NPS staff.

Commercial/Recreational Fishing

Develop commercial and sport fisheries harvest information for a cooperative management plan

Chad Soiseth, NPS

The purpose of this project was to develop commercial and sport fisheries harvest information that will inform a cooperative fisheries management plan (FMP) for Glacier Bay National Park. The plan is to be jointly developed with the Alaska Department of Fish and Game. While the FMP will include both sport and commercial fisheries, project objectives were revised from the original proposal to focus more on sport fisheries. Recent resolution of the commercial fishing issue in Glacier Bay, continued local sensitivity to commercial fishing issues, and recent (2001) changes in state statistical area boundaries to coincide with the national park boundary were all factors in the decision to focus more on recreational fishery issues.

The project was broken down into the following components (project objectives):

- Investigate and evaluate Chinook salmon presence in the Dundas and Seclusion rivers.
- Develop and implement an outer waters vessel survey method to identify and document vessel traffic in park waters outside Glacier Bay Proper.
- Design and implement a charter fishery creel survey program in Elfin Cove and Gustavus to assess effort and harvest in Park waters.
- Develop and test a program to estimate recreational fishing effort, location, catch and harvest for private anglers in Glacier Bay proper.

The chinook salmon survey was completed in 2002 through an interagency agreement with the Biological Resource Division of USGS, Alaska Science Center. Outer waters vessel activity surveys were completed in 2001, 2002 and 2003 by NPS staff with nearly $40 K in contributed flight costs to local OAS certified air charter companies. The charter fishery creel surveys and Glacier Bay proper private angler surveys were completed in 2002 and 2003 through a cooperative agreement with the University of Washington School of Marine Affairs and Cooperative Ecosystems Studies unit.

Results are being analyzed and a report is anticipated by August, 2004

Fresh Water Ecosystems

Colonization and development of biotic communities in streams following glacial recession

Alexander Milner, University of Alaska

This multi-year research project is designed to understand the environmental variables driving the development of biological communities in streams that are formed following glacial recession. The work has continued the long term study of macroinvertebrate colonization in Wolf Point Creek that was begun in 1977. Another stream, Stonefly Creek in Wachusett Inlet, has recently been included in the study. Macroinvertebrate

samples have been collected at Stonefly Creek and Wolf Point Creek to continue the long term record of development. Water temperature recorders were downloaded and then recalibrated. Salmon spawners counts were made for the three streams. Numbers of pink salmon in Wolf Point Creek were again close to 10,000. A stream gauge was established at the mouth of the stream to monitor discharge and stream temperature.