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This document reports the accomplishments of Glacier Bay National Park & Preserve (NPP) staff who participated in the joint NPS and EPA Climate Friendly Parks (CFP) Workshop in October 2005. In conjunction with their Environmental Management System (EMS) planning, Glacier Bay NPP developed the following commitments to reduce greenhouse gases and criteria air pollutants through the climate friendly management of transportation and energy, as well as increased outreach and education efforts.

THE CHALLENGE OF CLIMATE CHANGE

Climate change presents significant risks and challenges to the National Park System. Imagine Glacier National Park in Montana without any glaciers, or vast sections of the freshwater Everglades submerged by rising seas. Imagine a large scale transformation of the glacier that formed Glacier Bay to a fjord as the ice melts, along with a widespread alteration of the unique ecosystem that attracts so many people to Glacier Bay NPP. These scenarios are all potential consequences of future climate change. While climate change could benefit some parks, bringing longer seasons for camping and other temperate-weather pursuits, providing longer growing seasons for many plants, and improving conditions for species at the northern limits of their range, it is predicted that Glacier Bay NPP will likely not benefit from these changes.

Since the last peak of glacier mass, the Little Ice Age, which lasted from approximately 1750 to 1850, Glacier Bay NPP has lost approximately 600 cubic miles (2,500 cubic km) of ice.¹ When Glacier Bay was first charted in 1794, it was described by Captain George Vancouver as "a small five-mile indent in a gigantic glacier that stretched off to the horizon."² The Grand Pacific Glacier, the glacier credited with the creation of Glacier Bay, is now more than 65 miles from the mouth of the bay. As the ice rapidly diminishes in Glacier Bay NPP, the change from a glacier-filled valley to fjord as the ice melts is

¹ Selleck, Jeff. *A Spectrum of Challenges*. National Resource Year in Review-2004. National Park Service, April, 2005. Online. National Park Service. Available: http://www2.nature.nps.gov/YearinReview/01_A.html.

² National Park Service. *Nature & Science Overview*. Glacier Bay National Park and Preserve web site. Online. National Park Service. Available: <http://www.nps.gov/glba/pphtml/nature.html>.

only one of the effects of climate change that will be realized in the park. The rapid loss of ice has led to a dramatic vertical land rise as the land is released from the weight of the ice and could potentially set off earthquakes because the Earth's tectonic plates are more prone to shift without the extreme pressure of the ice. In addition, the invasion of new plant and animal species as new land and sea are exposed has intrigued scientists for years. Although it is debatable whether these changes are due simply to naturally occurring regional climate change or to an increase in greenhouse gases causing an acceleration of global climate change, it is clear that Glacier Bay NPP is undergoing a massive transformation.

Scientists cannot predict the severity of future climate change or its impacts with certainty. However, the current warming trend suggests that the problem is real and should be taken seriously. Average global temperatures on the Earth's surface have increased about 1.1°F since the late 19th century, and the 10 warmest years of the 20th century all occurred in the last 15 years of the century; a warming trend that has continued to this day. The single leading cause of this warming is linked to the buildup of greenhouse gases in the atmosphere—primarily carbon dioxide, methane, and nitrous oxide—which trap heat that otherwise would be released to space.

Many scientists believe that the continued addition of carbon dioxide and other greenhouse gases to the atmosphere is likely to raise the Earth's average temperature more rapidly in the next century; a global average warming of 4-7°F by the year 2100 is considered likely. Rising global temperatures would further raise sea level and would affect all aspects of the water cycle, including snow cover, mountain glaciers, timing of spring runoff, water temperature, and aquatic life. Climate change also could affect human health, alter crops, animal habitats, and many other features of our natural and managed environments.

GREENHOUSE GAS AND CRITERIA AIR POLLUTANT EMISSIONS AT GLACIER BAY NATIONAL PARK & PRESERVE

Naturally occurring greenhouse gases (GHGs) include carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and water vapor. Human activities (e.g., fuel combustion in stationary and mobile sources, agriculture, and waste generation) increase the concentrations of these gases in the atmosphere. In addition, there are other more powerful GHGs—hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆)—called high-global warming potential (high-GWP) gases that are created in smaller quantities by industrial processes such as aluminum, iron, and steel production. While GHGs contribute to climate change on a global scale, the impacts of criteria air pollutants (CAPs) are more typically local and regional in nature. CAPs, which lead to numerous air quality and public health problems, include sulfur dioxide (SO₂), nitrogen oxides (NO_x), volatile organic compounds (VOC), particulate matter (PM₁₀ and PM_{2.5}), and carbon monoxide (CO).

Glacier Bay NPP is the fifth national park to complete an inventory of its GHG emissions and the twenty-sixth park to complete an inventory of its CAP emissions. However, the GHG and CAP inventory completed for Glacier Bay NPP is unique in the sense that this was the first Climate Friendly Parks (CFP) inventory that was performed almost completely autonomously by a park using the Climate Leadership in Parks (CLIP) tool. A draft version of the CLIP tool, completed in the spring of 2005, was used by EPA and NPS contractors to perform an emissions inventory at Everglades NP in June 2005, but Glacier Bay NPP is the first park in which park staff completed the majority of the emission inventory using the CLIP tool. Autonomous completion of emission inventories by park personnel using the CLIP tool is an important goal of the CFP program. The CLIP tool guides park personnel through the steps involved in estimating emissions, automates the calculations, and generates summary reports and reduction targets for the park. By enabling parks to develop their own inventories and action plans, EPA and NPS hope to expand the CFP program to many more parks than would otherwise be possible.

THE CLIMATE LEADERSHIP IN PARKS (CLIP) tool is an interactive, user-friendly spreadsheet model that will be distributed to the national parks. The CLIP tool gives park staff the information they need to calculate and reduce GHG and CAP emissions, which result from park activities including, among others, energy consumption, visitor transportation, and waste management.

Greenhouse Gas Emissions

The following summary of GHG emissions for Glacier Bay NPP was estimated for stationary combustion, highway vehicles and non-road equipment, marine vessels, wastewater treatment, and incinerated waste. Park entities responsible for these emissions include park operations, visitors (primarily via cruise ships), Glacier Bay Lodge & Tours (the parks primary concessionaire), and other concessionaires. Glacier Bay NPP's total GHG emissions in 2004 were 13,747 metric tons of carbon equivalent (MTCE). As Table 1 demonstrates, marine vessels represent the greatest source of GHG emissions (97 percent of total), followed by stationary combustion (2 percent of total). Of marine vessel GHG emissions, 63 percent (8,360 MTCE) result from operating cruise ships within park boundaries. Visitors entering the park in private marine vessels account for approximately 24 percent (3,179 MTCE) of marine vessel GHG emissions,

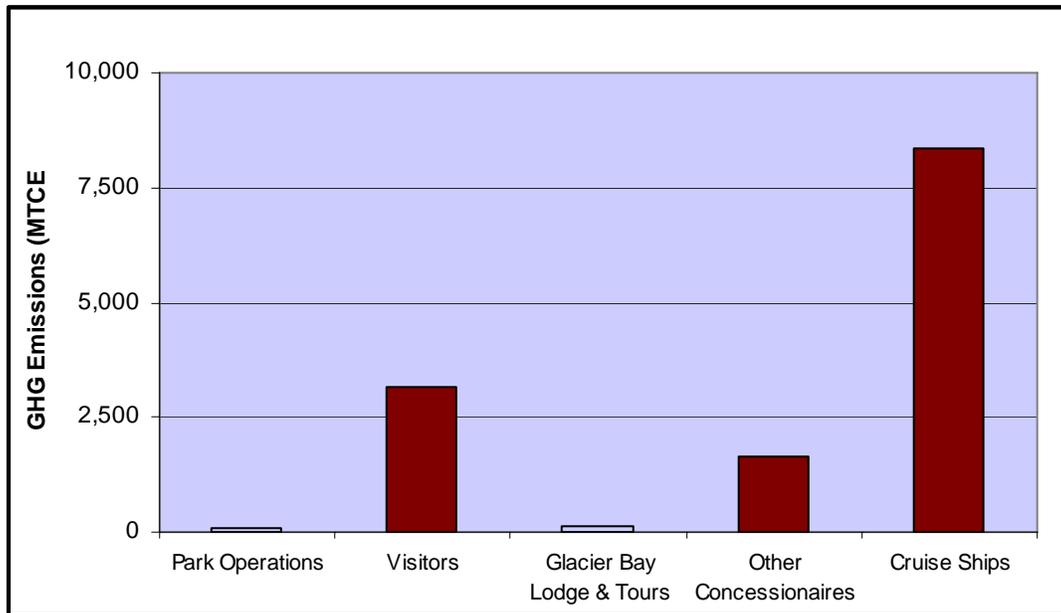
while charter and tour vessels operated by concessionaires other than Glacier Bay Lodge & Tours account for approximately 12 percent (1,654 MTCE) of marine vessel GHG emissions (Figure 1).

Table 1 – Glacier Bay NPP’s GHG emissions (MTCE) by source and emitting entity

Emitting Entity	Stationary Combustion	Highway Vehicles and Non-road Equipment	Wastewater Treatment	Waste	Marine Vessels	Gross Emissions
	Park Operations	222	30	1	2	
Visitors	NA	NE	NA	NA	3,179	3,179
Glacier Bay Lodge & Tours	111	6	NA	NA	116	234
Other Concessionaires	NA	NA	NA	NA	1,654	1,654
Cruise Ships	NA	NA	NA	NA	8,360	8,360
Gross Emissions	333	36	1	2	13,375	13,747

(NE=not estimated. NA=not applicable)

Figure 1 – Marine vessel GHG emissions by emitting entity



Criteria Air Pollutant Emissions

Sources of CAP emissions for this study included stationary sources (e.g., burning of fossil fuels for heating, cooking, and electricity generation; fuel-storage tank emissions; and wastewater treatment), highway vehicles and non-road equipment, and marine vessels. Table 2 and Figure 2 present the results of Glacier Bay’s CAP emission inventory, wherein NO_x is the most emitted gas. Sixty percent of NO_x emissions result from cruise ships, which are also the largest source of CO, the second most emitted gas, and SO₂, the third most emitted gas. Most of the remaining emissions of these gases occur through the operation of other marine vessels in the park. However, a small

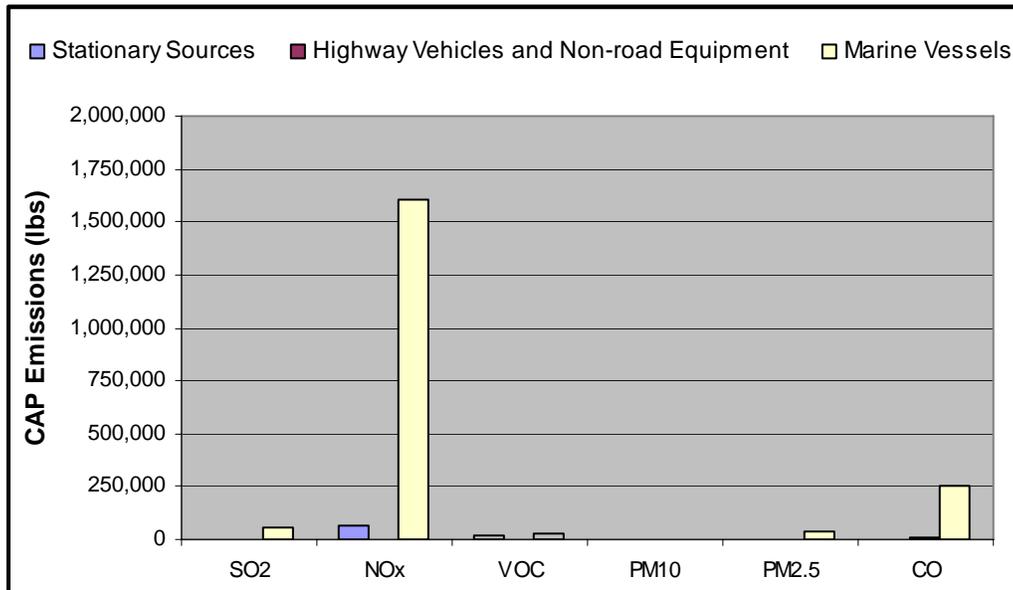
percentage (3 percent) of NO_x emissions results from the combustion of fossil fuels at the park's stationary sources. Park operations are responsible for the highest level of VOC emissions, which result primarily from fuel storage tanks.

Table 2 – Glacier Bay NPP's CAP emissions (lbs) by gas and emitting entity

Emitting Entity	SO ₂	NO _x	VOC	PM ₁₀	PM _{2.5}	CO
Park Operations	308	47,831	19,450	378	72	43,470
Visitors	12,369	380,500	9,285	NA	9,684	60,110
Glacier Bay Lodge & Tours	635	37,132	2,857	195	351	2,126
Other Concessionaires	6,460	198,224	4,578	NA	5,034	30,509
Cruise Ships	33,324	1,009,645	16,770	NA	25,361	130,518
Gross Emissions	53,096	1,673,332	52,939	573	40,502	266,733

(NA=not applicable)

Figure 2 – CAP emissions (lbs) by source and gas



In summary, the operation of marine vessels within the park is by far the largest source of both GHG and CAP emissions. For GHGs, marine vessels account for 97 percent of the park's total emissions. Among marine vessels, cruise ships account for 61 percent of the park's total GHG emissions, 60 percent of the park's total NO_x emissions, and 49 percent of the park's total CO emissions. Emissions from cruise ships are high due to strong park visitation – more than 350,000 individuals visited Glacier Bay in 2004 and nearly all of these visitors entered the park via cruise ships. Therefore, while cruise ships are the park's highest emitter, they also offer the greatest opportunity for park staff to conduct outreach activities aimed at educating the public on climate change, pollution, and the benefits of emission reductions.

HOW GLACIER BAY IS RESPONDING TO CLIMATE CHANGE

Recognizing the significance of climate change and its potential to alter many aspects of the park, including long-term sustainability of park resources and land, workshop participants proposed three sectors in which climate change mitigation and air pollution reduction actions could be incorporated. These sectors include transportation, energy management, and outreach and education. Based on these three areas, the group broke into three teams which then developed short and long-term “climate friendly” objectives and targets with realistic visions of success that would be undertaken by Glacier Bay NPP’s employees and overseen by the park’s Environmental Management Team (EMT).

After the objectives and targets were established, each team determined the project(s) that would achieve those objectives and targets, along with the associated actions, timelines, parties responsible, and desired results for each project. These objectives and targets were integrated into Glacier Bay NPP’s EMS and the park elected to include greenhouse gas reduction as an important component of its EMS. Glacier Bay NPP’s goals as a Climate Friendly Park bring more visibility to this issue while serving as a statement of the park’s commitment to reducing human-caused threats to the natural environment.

THE CLIMATE FRIENDLY PARKS PROGRAM is funded through an interagency agreement between the U.S. Environmental Protection Agency and the National Park Service. The program encourages and enables national parks and, in the future, entities such as state and local parks, refuges, schools and universities, zoos and aquariums, and science museums, to develop both short and long-term, comprehensive strategies to reduce their greenhouse gas (GHG) and criteria air pollutant (CAP) emissions. Furthermore, the program entails a commitment on the part of the participating park to educate the public about what actions the park is taking to mitigate its GHG and CAP emissions.

STRATEGY 1: REDUCE FUEL USE AND GHG EMISSIONS FROM TRANSPORTATION SOURCES

As inventory results indicate, over 97 percent of greenhouse gas (GHG) emissions within Glacier Bay NPP are due to mobile combustion. Consequently, the reduction of fuel use and GHG emissions from transportation within the park is a significant focus for Glacier Bay NPP’s climate friendly efforts.

Reduce the Impact of Large Passenger Vessels

Due to the unique marine environment, most visitors to Glacier Bay NPP arrive by cruise ships and large touring vessels. In order to encourage the cruise ship industry to adopt more stringent emission guidelines, Glacier Bay NPP staff proposed a 50 percent reduction in NOx emissions, 10 percent reduction in GHGs, and reductions in CAP and SOx emissions from large vessels by 2015 through the following action plan:

- Refine and revise baseline emissions estimates by cruise ships, then distribute those estimates to all park staff and interested community members.
- Promote the use of International Maritime Organization’s GHG index for tracking ship emissions to educate cruise-ship operators.
- In future cruise ship contracts, incorporate selection criteria favoring contract proposals committed to reducing GHG/CAP emissions.

Reduce the Impact of Park Marine Vessels

Glacier Bay NPP has one ten-mile stretch of road in the park that connects to the neighboring community of Gustavus. Subsequently, much of the travel by park employees within the park is via marine vessels. In an effort to curb the park's annual GHG and CAP emissions, Glacier Bay NPP has committed to promote the use of advanced emissions technology in park and concessionaire vessels by:

- Replacing two-stroke engines with more efficient four-stroke engines through the completion of a review program for vessel engine purchase.
- Incorporating biodiesel and ethanol fuels into purchasing contracts for park marine vessels, and making modifications in fuel tank farm and delivery management to accommodate alternative fuels.

Reduce the Impacts from Park & Concessionaire Vehicles, & Other Mobile Equipment

In addition to the marine sources of emissions, Glacier Bay NPP elected to focus on non-marine emissions produced by park and concessionaire vehicles, and other mobile equipment in the park. Using the 2004 baseline of emissions from their GHG & CAP inventory, the park commits to reduce emissions 10 percent by 2010 through the proposed action items:

- Replace five existing park vehicles with electric or hybrid electric vehicles.
- Replace existing vehicles with smaller, more efficient, conventional technology vehicles by setting up a review program for vehicle and equipment purchases.
- Incorporate biodiesel and ethanol procurement language into fuel contracts, and modify fuel tank farm and delivery management to store and dispense alternative fuels.

STRATEGY 2: REDUCE EMISSIONS THROUGH ENERGY MANAGEMENT

Improving energy efficiency and implementing alternative energy sources all reduce park-based fuel use, lower emissions, decrease electricity consumption, and offer monetary benefits for the park. Glacier Bay NPP has made efficiency a priority in energy management decisions.

Reduce Emissions through an Energy Audit & Implement an Energy Management Program

As a park that generates all of the energy it uses and does not purchase electricity from an outside source, Glacier Bay NPP recognizes that energy management is an important area to target for emissions reductions. In order to address energy use, Glacier Bay NPP plans to conduct an energy audit by October 2006 in collaboration with the University of Alaska – Fairbanks. With a completed energy audit, the park will prepare an energy management plan by December 2007 for Glacier Bay NPP.

Reduce Emissions from Energy Sources

As part of their energy management plan, the park plans to implement best available means to reduce emissions from its current facilities and focus on alternative fuel and technology. The strategy includes the following action items:

- Investigate the viability of using 80 percent bio-diesel in park operations.
- Install a high efficiency boiler unit with the goal of decreasing replacement frequency by 50 percent and doubling the efficiency of the unit.
- Explore the plausibility of installing emissions controls on existing generators by July 31, 2006.

Achieve Zero Emissions

In addition to the measures outlined above, Glacier Bay NPP chose to set a long-term goal of achieving zero emissions from internal park energy management activities. The park's first target regarding this goal is to develop a report on renewable energy alternatives, which will include a strategy for viable renewable and alternative energy options at the park, by December 31, 2007.

STRATEGY 3: INCREASE CLIMATE CHANGE OUTREACH AND EDUCATION

Climate change is a complex issue, often ignored and minimally understood by the public. With a thorough understanding of the benefits of reducing greenhouse gas emissions in the park, Glacier Bay staff can demonstrate, as interpreters and educators, the park's efforts to be climate friendly.

Incorporate Climate Change Issues into Educational Programs for Staff

By establishing an employee climate change education program, Glacier Bay empowers park staff to integrate climate change knowledge and mitigation actions in their daily routines. This also enables more climate-friendly communication with the public. Through education, the park hopes that 80 percent of all park staff will be able to understand and communicate a consistent and non-confusing message about climate change. The park plans to take the following actions to achieve this goal:

- Summarize and incorporate findings of the Climate Friendly Workshop for all park staff.
- Inventory and review existing climate-change materials.
- Develop consistent and non-confusing climate change message and develop materials for seasonal interpretive-staff training.
- Introduce materials to all staff.

Develop Climate Change Educational Programs for Public

During peak season, hundreds of people visit Glacier Bay NPP daily, with the majority of visitors arriving on cruise ships. Park staff realizes that through their interpretive programs, they have an immense opportunity for public education. Cruise ships are currently required to provide environmental education to their passengers, and the Glacier Bay NPP staff hopes to incorporate a climate-change component. Additionally, because Glacier Bay NPP plays an important role within its community, staff hopes to be

a leader in climate change education outside of the park. Park staff designed the following action items to address public education:

- Identify potential target audiences and appropriate techniques educating those audiences on the regional effects of climate change.
- Prioritize audience based on resource availability and feasibility in time frames.
- Network and outreach with professional colleagues to maintain a consistent message and accurate material content.

CONCLUSION

Glacier Bay NPP is already being significantly affected by climate change. This report summarizes the operational actions that the park has committed to in response to this important challenge. Important among these are actions to significantly reduce fuel use and emissions from transportation and to improve energy efficiency in buildings. Glacier Bay NPP recognizes that these actions alone will not prevent the changes predicted from climate change and have therefore placed a high priority on education and outreach as well.

The Climate Friendly Workshop at Glacier Bay National Park & Preserve served as an important enhancement mechanism for Glacier Bay NPP's established EMS. Realistic environmental commitments created by Glacier Bay staff and approved by the park's EMT will significantly reduce the park's GHG and CAP emissions in the coming years. However, the greatest impact Glacier Bay NPP will have on climate change is the effectiveness and extent of climate change education available to the public at the park.

An ultimate objective of this action plan is to have Glacier Bay NPP model climate friendly behavior for its visitors. The more climate friendly information that the park can convey to the public, the more likely the public will be to respond through direct action. The park faces an uncertain future due to the possible effects of climate change. However, addressing the issues of climate change and air pollution through direct action and education can have far-reaching, positive consequences for the park's future.