

Glacier Bay National Park Science Advisory Board: Final Report

Research and Monitoring Needs
Relevant to Decisions Regarding
Increasing Seasonal Use Days for Cruise Ships
in Glacier Bay

Prepared by the
Glacier Bay Vessel Management
Science Advisory Board

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Acronyms

ACSI	Alaska Cruise Ship Initiative
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
CRM	Cultural Resources Management
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FEIS	Final Environmental Impact Statement
LAC	Limits of Acceptable Change
MMPA	Marine Mammal Protection Act
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
PAH	Polycyclic aromatic hydrocarbon
PTS	Permanent shift in hearing threshold
TCPs	Traditional Cultural Properties
TTS	Temporary shift in hearing threshold
US	United States
USFS	United States Forest Service
USGS	United States Geological Survey

Executive Summary

Glacier Bay National Park and Preserve is accessed by a variety of motorized watercraft, including cruise ships and tour, charter and private vessels. These vessels provide the primary means for visitors to view the Park's glaciers, scenery and wildlife, and to experience its wilderness and other natural values. Management of vessel access, including determining the appropriate number of vessels allowed in the bay each season, requires Park managers to balance the need for visitor access with the need to protect the Park's physical, biological and sociocultural resources and values, including the visitors' experience.

The Final Environmental Impacts Statement (FEIS) for Vessel Quotas and Operating Requirements in Glacier Bay completed in 2003 set seasonal use days for cruise ship visits during the 92-day June-August quota season at 139 ships, with a maximum of two cruise ships per day. However, it also provided the possibility for the Park to increase seasonal use days up to 32 percent during the 92-day June-August quota season, from 139 ship to a maximum of 184 (two ships per day each day), based on scientific and other information and applicable authorities. In May and September, the seasonal use day quota for cruise ships is set at 92 ships, with potential for an increase up to 122.

The Record of Decision for the FEIS suggested that Park managers seek the assistance of a Science Advisory Board, to:

- Assess whether sufficient information exists to provide for an informed decision as to whether an increase in seasonal use days would impact the physical, biological and sociocultural resources and values of the Park; and if necessary, to
- Recommend a framework for scientific research that will lead to a better understanding of these potential impacts, and will help frame criteria defining the environmental and social conditions to be met before a decision is made regarding increasing seasonal use days for cruise ships in the Bay.

By invitation of the Park Superintendent, eight state and federal agency scientists volunteered to serve on a Science Advisory Board to accomplish these objectives. The Board conducted literature reviews, consulted with peer scientists on selected topics, and contributed their professional knowledge to analyze existing research findings and recommend a focused framework for future research and monitoring. Topics addressed by the Board included potential impacts of increased cruise ship visitation on the Park's underwater soundscape, air and water quality, marine living resources, cultural resources, visitor experience, and on local and regional socioeconomics. In addition to developing a framework for future research, for some topic areas the Board made recommendations regarding management measures to prevent, control, or mitigate potential impacts, for Park managers' consideration.

Findings and Recommendations

The Science Advisory Board evaluated existing research and concluded that an increase in seasonal use days for cruise ships in Glacier Bay could potentially affect aspects of the Park's physical, marine biological and sociocultural environments. However, insufficient scientific information exists to definitively conclude the nature, magnitude or significance of effects. The scientific literature provided findings related to impacts of motorized vessels on marine physical and biological environments, and on the sociocultural environments of park and tourism areas. However, much of this work examined impacts from vessels other than cruise ships, on different biological communities, with different sociocultural issues, and in environments much different than Glacier Bay.

To improve the base of knowledge that will inform future cruise ship management decisions in Glacier Bay, the Board is recommending that Glacier Bay National Park and Preserve support the studies identified in the research framework presented in Section 5.0 of this document. The Board has not prioritized the studies listed in the research framework, but is willing to work with the Park to set priorities among projects.

The research framework recommends specific studies to provide information needed to answer key management questions regarding the potential effects of increasing seasonal use days of cruise ships on the Park resources and values. The framework focuses on areas where:

- Existing research is extremely limited and is needed to fill significant information gaps (e.g., sociocultural research specific to Glacier Bay National Park and Preserve);
- Research could readily build on existing work to yield fruitful results (e.g., further delineation of the underwater soundscape and effects of sound on marine biota);
- Important baseline data is lacking that could inform future management decisions about cruise ship visitation or practices (e.g., marine contaminants, air quality); and/or
- Modeling, combined with focused research, could test for demonstrable biological effects on species that are sensitive to disturbance or are of management concern (e.g., population-level effects on marine species).

The Board crafted a research framework that can meaningfully contribute to the Park's base of knowledge and help inform its management decisions in the near-term. The Board recommends that before increasing seasonal use days for cruise ships in Glacier Bay, the Park take the time necessary to implement the research framework, and determine if results of new scientific research are sufficient to help frame decision-criteria that would define the environmental and social conditions under which an increase in seasonal use days for cruise ships could be allowed.

With regard to the timing of the research program, it is important to note:

- For research related to visitor experience and local and regional socioeconomic impacts (Sections 4.5.2 and 4.5.3), it is essential that cruise ship levels remain unchanged for a minimum of one complete season (May–September) to provide for collection of baseline data during a representative year, to fully inform a decision about an increase in seasonal use days.
- Studies of potential impacts on the marine biological environment would generally require multiple years to produce findings. To focus information-gathering wisely, particularly on critical issues that may affect a population’s long-term viability in the Park, the Board recommends an initial effort, to: 1) identify marine species that have been studied extensively, particularly under disturbance, and that offer reasonable potential for identifying disruptions in energy balance or survival rates compared to normal variability, and 2) use modeling to determine whether there is a reasonable probability that any disturbance effects on the species’ survival, fecundity and demographics could be detected through research (Section 3.5). The Board anticipates it would take at least two years to assemble the data to construct these models, evaluate the feasibility and worth of conducting specific studies, and finalize research designs. In the near-term, these initial modeling efforts would help scientists and Park managers judge the potential for both immediate and longer-term impacts on marine species, determine the level of scientific uncertainty in research in these areas, and determine the need for and feasibility of longer-term data gathering.

In the research framework described fully in Section 5.0, the Board recommends that the following studies be undertaken:

Physical Environment

1. Studies to further develop the knowledge base related to cruise ship noise in Glacier Bay, and the sound exposures and durations experienced by marine species (Section 5.2.1, P-1 through P-4).
2. Collection of baseline data for marine contaminants (e.g., metals, polycyclic musk compounds, hormones) that may be present in Glacier Bay’s marine waters, benthic sediments, and marine biota; and for air quality emissions (Section 5.2.1, P-5 through P-8).

Marine Biological Environment

3. Cataloguing and evaluation of potential impacts of cruise ship sound on the behavior, physiology and communication of selected species (Section 5.2.2, MB-1).
4. Assess the probability of disturbance of different marine species by assessing their degree of interaction with cruise ships (Section 5.2.2, MB-2).

5. Use of modeling efforts to determine the potential for:
 - Reduced cruise ship traffic to benefit the population abundance of selected species, through reduced encounters with cruise ships and reduced strike rates;
 - Physiological responses of selected species to disturbance, that could cause higher energetic costs, potentially effecting survival, fecundity and population viability; and
 - Disturbance-induced behavioral responses of selected species that could result in a shift in distribution to areas outside of the Park.

The results of these modeling efforts would be used to determine if there is a reasonable probability that effects could be detected through research, inform decisions regarding whether to pursue additional research, and assist with research designs (Section 5.2.2, MB-3).

6. Monitoring of marine mammal and bird populations, to provide a baseline for evaluation of future changes in population, focusing on species most likely to use habitats frequented by cruise ships (Section 5.2.2, MB-4).

Sociocultural Environment

7. Inventory of archaeological sites and traditional cultural properties and examination of their sensitivity to physical disturbance from cruise ship traffic (Section 5.2.3, SC-1 and SC-2).
8. Preparation of an ethnographic description of the Huna Tlingit and their relationship to Glacier Bay, accompanied by a field study to better understand the cultural and spiritual concerns of the clan with cruise ship traffic in Glacier Bay (Section 5.2.3, SC-3 and SC-4).
9. Surveys of Park visitors to collect a wide-range of data relative to their experience as a visitor in Glacier Bay and the acceptability of Park conditions, including their perception of cruise ship sightings, crowding, visibility and noise quality (Section 5.2.4, SC-5 through SC-7).
10. Economic modeling and analysis of the effects of increasing cruise ship visitation in Glacier Bay on travel patterns throughout the Southeast region, with implications for local port communities and Alaska tourism operators (Section 5.2.4, SC-8 and SC-9).

The Science Advisory Board offers to further assist Glacier Bay National Park and Preserve to develop requests for proposals, assist in establishing research protocols for work done directly by the Park, and review proposals and study products. The Board can also assist the Park in applying research and monitoring results to the development of criteria defining the environmental and social conditions to be met before a decision is made regarding increasing seasonal use days for cruise ships in the Bay.

1.0 Introduction

Glacier Bay National Park and Preserve is responsible for determining the optimal number of motorized watercraft, including cruise ships and tour, charter, and private vessels to meet demand for access into park waters, allowing for a range of high-quality opportunities for visitors while protecting park resources. Management of vessel access, such as determining the appropriate number of vessels allowed in the bay each season, requires Park managers to balance the benefit provided through visitor access, with the need to protect the Park's physical, biological and sociocultural resources and values, including visitors' experiences.

Vessel management is guided by the Final Environmental Impact Statement (FEIS) for Vessel Quotas and Operating Requirements and the resulting Record of Decision signed November 21, 2003, which determined vessel quotas for cruise ships and other tour vessels in the park. The Record of Decision adopted Alternative 6, the preferred alternative developed as a result of comments from the public and the cruise line industry on the Draft EIS.

Alternative 6 maintains the current daily maximum number of cruise ships in the park, and set the seasonal use days for the June-August season at 139 ships. However, the alternative provides for possible increases in seasonal use days up to 32 percent during the 92-day June-August season, from 139 ships to a maximum of 184 (two ships per day, every day), based on scientific and other information and applicable authorities. In May and September, the seasonal use day quota for cruise ships is set at 92 ships, with potential for an increase up to 122.

The Record of Decision states:

“The determination of whether to increase seasonal use day quotas for cruise ships will rely on criteria that define the environmental and social conditions to be met before any additional seasonal use days are approved. These criteria will be based on the results of and guidance provided through studies that examine the effects of vessels on all park resources and visitor experience. Studies will be identified in a research framework developed with the assistance of a science advisory board. This research framework will identify the studies necessary to provide information regarding the effects of vessel traffic on the environment and develop monitoring information necessary for park management [Emphasis added].”

The FEIS describes the studies and monitoring already underway or recently completed in Glacier Bay related to determining appropriate levels of vessel traffic (all vessels, including private boats and kayaks) to protect the Park's resources. It also notes the need for future studies and monitoring relative to

vessel noise, potential impacts to humpback whales and harbor seals, air quality, visitor use, and the effectiveness of vessel operating requirements.

1.1 Vessel Management Science Advisory Board

Glacier Bay National Park and Preserve established the Vessel Management Science Advisory Board in 2004 to recommend a research framework identifying studies needed to inform the Park in its future decisions about cruise ship visitation in the bay. To ensure compliance with the Federal Advisory Committee Act, invitations to serve on the Board were sent only to recognized tribal, state or federal government entities. However, the Board was free to solicit expert opinion or advice from others to aid in the formulation of the Board's recommendations.

Science Advisory Board members who participated in the preparation of this report and its recommendations, and their affiliations and areas of expertise, are:

Physical Environment

- Mr. Blair Kipple, Naval Surface Warfare Center, U.S. Navy, Bremerton, Washington
- Ms. Carolyn Morehouse, (formerly) Commercial Passenger Vessels Environmental Compliance Program, Alaska Department of Environmental Conservation (ADEC), Juneau, Alaska

Biological Environment

- Dr. Gail Blundell, Harbor Seal Research Program, Division of Wildlife Conservation, Alaska Department of Fish and Game (ADFG), Juneau, Alaska
- Mr. James Bodkin, Research Wildlife Biologist, U.S. Geological Service (USGS), Anchorage, Alaska
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- Mr. John Jansen, Wildlife Biologist, National Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA Fisheries, Seattle, Washington

Human Sociocultural Environment

- Dr. Lee Cerveny, Research Social Scientist, Pacific Northwest Research Station, USDA Forest Service (USFS), Seattle, Washington
- Dr. Robert Schroeder, Regional Subsistence Coordinator, Alaska Region, USFS, Juneau, Alaska

The Board met in October 2004 and January 2005 in Juneau, and in May 2005 in Gustavus, including a day spent aboard the cruise ship *Vollendam* touring the vessel, observing typical operations in Glacier Bay, and meeting with Holland America Cruise Line personnel. Board members consulted via telephone and email as they conducted their evaluation and prepared recommendations, and provided for some review of draft

products by peers in their field of study and with park staff. The Board met twice in September 2005 via teleconference to finalize its recommendations.

In preparing this report, the Board arranged for independent contractors to prepare literature reviews of primary and “gray” literature (including unpublished reports and study summaries) on subject areas particularly germane to assessing impacts of cruise ships on park resources. Literature reviews were prepared on the following topics: impacts of contaminants on biological resources, vessel disturbance of marine mammals, vessel disturbance of marine birds, impacts of cruise ships on lower trophic levels, and impacts of cruise vessels on visitor experience. While not exhaustive, these literature reviews assisted the Board by assessing the state of current literature, particularly studies completed since the 2003 FEIS. The literature reviews are appended to this report.

1.2 Board Objectives and Tasks

There were two main objectives of the Science Advisory Board. The first objective was to assess whether sufficient information exists that would provide for an informed decision as to whether a seasonal increase in cruise ship traffic would impact the physical, biological or sociocultural resources and values in Glacier Bay National Park and Preserve. The second objective was to develop a framework for scientific research that would lead to a better understanding of these potential impacts, and would help frame criteria defining the environmental and social conditions to be met before a decision is made regarding increasing seasonal use days for cruise ships in the Bay.

To accomplish these objectives, the Board defined and undertook these main tasks:

1. Review relevant research/literature and summarize research findings related to impacts of cruise ship visitation on the Park’s physical, biological and sociocultural resources and values.
2. Conduct a “gap analysis” – Identify topics for which there is a gap in existing knowledge relevant to determining the effects of increasing cruise ship seasonal use days on Park resources and values.
3. Recommend a research and monitoring framework and other appropriate actions (e.g., modeling, additional analyses) that would address these information gaps, particularly with studies that are specific to the resources and conditions in Glacier Bay.
4. Where appropriate, recommend best management practices to prevent, control or mitigate cruise ship impacts.

Before beginning its work, the Board reviewed available background information concerning categories of Glacier Bay visitors, trends in visitation, and estimates of potential near-term increases in visitation through 2008. This review is presented in Appendix A.

The National Park Service's mandate and many federal laws restrict activities that may cause 'impairment' or 'significant negative impact' to federally-managed resources. The Board's focus has been to recommend a research framework that would detect and elucidate impacts, and assist the Park in judging the magnitude and significance of any effects. It will be the responsibility of Park management to determine whether these impacts or effects would constitute impairment or a significantly negative impact to Park resources and values.

The Board made a number of assumptions about cruise ship management and practices in Glacier Bay that influenced which topics were emphasized in the evaluation and the research framework. For example, the Board assumed that cruise ships generally follow a mid-channel route, cruise at approximately the same speed, and generally travel in the same areas during each entry. To some degree, these characteristics of cruise ship operation make it easier to assess possible impacts compared to private vessels which operate in many more areas in Park waters (including near shore areas) and vary considerably in size, speed and behavior. Empirical validation of these assumptions is desirable through direct monitoring of cruise ship movements. The Board also assumed continuation of management measures that apply speed restrictions in designated whale waters, and prohibit wastewater, bilge and ballast water discharges in Glacier Bay.

1.3 Organization of the Research Framework

This report evaluates and identifies research and information needs and recommends a program of work that should be accomplished in each of the following topic areas. The topic areas are drawn from the 2003 FEIS, with focus on the most likely areas of potential impact from cruise ships on park resources. Topic areas addressed in this report include:

- Section 2.0: Physical Environment
 - Underwater Soundscape
 - Air Quality
 - Water Quality
- Section 3.0: Marine Biological Environment
 - Marine Mammals
 - Marine Birds
 - Lower Trophic Level Species
- Section 4.0: Human Sociocultural Environment
 - Cultural Resources
 - Visitor Experiences and Wilderness Resources
 - Local and Regional Socioeconomics

For each topic area, the report section includes:

- Key Management Questions: Questions that should be addressed by focused scientific research, monitoring or other work to inform Park management decisions.
- Research Findings: A summary of existing research findings relevant to the key management questions, and identification of “gaps” in current research and knowledge.
- Research and Information Needs: Identification of information that would fill the identified “gaps” in knowledge and help Park managers more fully address key management questions.
- Management Recommendations: For some topic areas, management measures to prevent, control or mitigate potential impacts, recommended for the Park’s consideration.
- Proposed Research Framework: At the end of each section (2.0, 3.0 and 4.0), recommended research or monitoring to address key management questions, respond to identified information needs, and inform Park managers in their future decisions regarding cruise ship seasonal use days.

Finally, Section 5.0 of this report summarizes the Board’s findings and recommended research framework for all topic areas, as well as the recommended management measures.

2.0 Physical Environment

2.1 Introduction

The objective of the research framework for the physical environment is to evaluate existing research findings relevant to the impacts of cruise ship activity on the underwater soundscape and the air and water quality of Glacier Bay, and to recommend a program of research to provide more complete information about potential impacts.

This section addresses directly-measurable effects on the physical environment of Glacier Bay, such as potential changes in sound levels, particulates in the air, or chemical elements in the water, sediments and biota. However, there is a strong connection between this section of the research framework, and those that follow. For example, changes in sound levels or impacts on water quality may affect the behavior and health of marine organisms (see Section 3.0). Changes in air and sound quality may impact the experiences of visitors using the bay, and impact the quality of its wilderness resources (Section 4.0).

2.2 Underwater Soundscape

The term *underwater soundscape* refers to the underwater sound environment experienced by an underwater organism in a location of interest over some period of time. The sources of sound, whether natural or manmade, their intensity, variability, and duration are all factors that contribute to the underwater soundscape. The natural soundscape must be defined to fully determine the effects of manmade noise on the underwater sound environment. Park managers must consider whether cruise ships represent a significant impairment to the natural levels of ambient sound in Glacier Bay – particularly if an additional 45 ship visits (increase from 139 to 184) occur each summer season. Of particular importance is whether such changes might affect marine life commonly found in the park.

This section discusses the knowledge base and information needs relative to the physical attributes of Glacier Bay's underwater soundscape; specifically, how sound behaves underwater in Glacier Bay and how changes in vessel numbers would affect the bay's underwater physical environment. The focus is on evaluating whether research is needed to be able to model and understand how additional cruise ship use would change the park's underwater sound environment.

The issue of how changes in underwater sound might affect the Park's marine biological resources is addressed in Section 3.0 Marine Biological Environment. It is also notable that there has been no quantification of sound generated by cruise ships that is experienced by visitors "above water." This issue is considered in Section 4.0 Human Sociocultural Environment.

Key Management Questions

How do cruise ships presently affect the underwater soundscape of Glacier Bay?

How would increasing the number of cruise ship entries affect the underwater soundscape?

Research Findings

A review of past research pertinent to the effects of cruise ships on the underwater soundscape of Glacier Bay reveals many topics that are well understood and others that are less developed. Topics that are well understood include:

- The physics of underwater acoustics including sound propagation, modeling multiple sound sources, and mechanics of ship-related sound sources;
- Underwater ambient noise – in general, and specific to areas in the lower Bay; and
- Source acoustic levels from a number of types of cruise ships.

Research areas that are not well developed and for which additional research is needed include data on underwater ambient sound in mid- and upper-Glacier Bay areas; sound associated with thrusters and new propulsion types; evaluation of extent of exposure of marine species to elevated noise from cruise ships; and monitoring of acoustic trends under different vessel use patterns. These information needs are described in more detail below.

Underwater acoustics. The physics of underwater acoustics, including sources of ambient noise, sound propagation, underwater acoustic modeling, and other features are well developed and covered in a number of classic texts (Urick 1983, Kinsler et al. 1982, Clay et al. 1977, Morse et al. 1987). Nearly all elements of physical acoustics that would be called upon for acoustic assessments in Glacier Bay are thoroughly treated in the general literature. In addition, Malme et al. (1982) published specific acoustic propagation properties for Glacier Bay (as well as observations about Glacier Bay's underwater soundscape, including contributions from both manmade and natural sound sources).

Underwater ambient noise. Underwater ambient noise in general has also been thoroughly studied over the past several decades and reported in the general literature. Several studies have characterized ambient noise in Glacier Bay (Malme et al. 1982, Kipple and Gabriele 2003). Both natural and manmade contributions to the underwater sound environment were addressed. As a result, much is presently known about the range of underwater sound levels and relative contributions of vessel and natural sounds for the lower bay. Additional work in the upper bay is warranted.

Cruise ship source levels. Kipple and Gabriele (2002; 2004) reported on underwater sound levels and spectral content of a number of cruise ships that commonly visit Glacier Bay. With the cooperation of these vessels, acoustic measurements were conducted in controlled conditions at two speeds, providing a fairly good working knowledge of the range of sound characteristics for cruise ships. However, underwater sound characteristics of cruise ship thrusters and azipod vessels have not been established. The sound signatures associated with new designs of cruise ships with significantly different propulsion systems should be established when any such vessels begin operating in Glacier Bay National Park.

The total time that cruise ship sound influences the Glacier Bay soundscape should be established for a single vessel transiting the bay and for cases where two vessels are transiting the same general area of the bay at the same time. The latter condition occurs often, and would occur daily if the proposed seasonal cruise ship quota is adopted.

Sound exposure levels. Some studies, including Frankel (1998, 2000), Malme (1984, 1987), Richardson (1986, 1991, 1995), and others, estimate sound exposure levels for several species of whales for various types of manmade sound. Only Erbe (2003) has established these levels for cruise ships. It would be feasible and beneficial to estimate exposure levels for marine life to cruise ship sound, using available data and the science cited above. Such estimates should be established so that sound exposure levels and durations are available for assessing acoustic impacts on marine life in Glacier Bay.

Information Needs

Based on the survey of existing research and current knowledge outlined above, areas where additional information is needed related to the underwater soundscape of Glacier Bay and possible cruise vessel effects are listed below. Some topics require new research, whereas others simply require existing data to be catalogued and applied to Glacier Bay. Information needs include:

1. Documentation of ambient underwater sound for relevant areas in mid- and upper-Glacier Bay.
2. Sound levels for cruise ship thrusters, azipod propulsion vessels, and cruise ships with new propulsion types whose sound levels have not been measured.
3. A quantitative acoustic analysis that establishes the difference between one-cruise ship and two-cruise ship days, including duration of cruise ship sound influence.
4. Determination of separation distances between cruise ships and high priority marine species to provide data to input into modeling of acoustic exposure to cruise ship noise.
5. Estimates of sound exposure levels and durations for common cruise ship types, given an assumed range of separation distances between vessels and marine life.

6. If cruise ship entries in Glacier Bay are increased, continue monitoring acoustic trends in lower Glacier Bay to compare to existing (baseline) vessel noise data for the lower bay.
7. When the Vessel Quota and Operating Requirements regulatory changes are implemented, monitor ambient noise in the lower bay and compare to the results of the 2000-2002 lower bay soundscape study. These changes are expected to include increases in private vessel traffic, and different regulation of traffic in lower Glacier Bay which could significantly affect lower bay ambient noise, even without any changes in cruise ship seasonal use days.

These information needs are further evaluated and addressed in the focused research framework proposed in Section 2.5.

2.3 Water Quality

Marine water quality issues related to cruise ships include the potential for impacts caused by wastewater discharges (treated wastewater, bilge and ballast water), anti-fouling paints, air emissions that may precipitate into marine water, and accidental oil discharges. Cruise ships are not currently allowed to discharge wastewater or bilge water in the park, and they do not exchange ballast water in park waters. While an accidental oil spill is possible, it is sufficiently unlikely to require a research focus.

This report does not recommend extensive research of potential impacts to marine water quality from cruise ships. There is reduced potential for marine water quality impacts to occur in the park, due to management restrictions in place to prohibit discharges and prevent impacts. However, research findings relative to these issues are summarized, baseline studies of potential contaminants recommended, and the continuation of park management actions that reduce the potential for water quality impacts is supported.

Key Management Questions

How would increasing the seasonal use day quota for cruise ships affect the marine water quality of Glacier Bay?

Research Findings

This section evaluates the potential for water quality impacts from general cruise ship operations in a marine environment (see also Appendix B). As noted above, the likelihood of impacts in Glacier Bay is lessened by current precautionary management requirements, such as the important prohibition of wastewater discharge in the park. Research findings related to water quality impacts are summarized below, in large part to demonstrate the importance of continuing to exercise caution in cruise ship practices to protect the Park's marine water quality.

Treated wastewater. Park management currently does not allow the discharge of treated black or gray wastewater in Glacier Bay.¹ This prohibition is endorsed by the Science Advisory Board to continue to protect marine water quality in the bay.

In other areas of Alaska, cruise ships are generally allowed to discharge treated black and gray wastewater continuously, if the vessel has continuous discharge certification from the U.S. Coast Guard and meets State and federal water quality standards. Cruise ships are tested twice per month to keep their continuous discharge status.

Cruise ships are tested for priority water pollutants once per season. Large ship sampling data collected by the Alaska Department of Environmental Conservation (ADEC) show that the undiluted treated wastewater discharges from cruise ships exceed Alaska's water quality standards for zinc, nickel, copper and ammonia. However, dilution caused by movement of the ships is expected to enable the ships to meet water quality standards.²

There is fairly recent toxicological concern about the discharge of polycyclic musk compounds (found in products such as sunscreen, perfumes and soap) and pharmaceuticals as components of treated wastewater. No data exists on the occurrence of such micro-contaminants in cruise ship discharge; they are unregulated and unmonitored in wastewater discharges from cruise ships. However, the literature provides evidence that these products are found in other sources of treated effluent (Kolpin et al. 2002, Pedersen et al. 2005).

There is limited information on the potential effects and susceptibility of different organisms to polycyclic musk compounds. Research has demonstrated that concern is warranted for toxic effects on aquatic species (Balk and Ford 1999, Daughton 2004, Luckenbach 2005, Schreurs et al. 2004). Polycyclic musk compounds can disrupt endocrine systems, bioaccumulate in marine organisms, and become biomagnified up food webs to higher trophic level species (Rimkus 1999, Schreurs et al. 2004).

Pharmaceuticals in treated wastewater can include such substances as synthetic hormones, acetaminophen, caffeine, and other substances. Synthetic hormones resemble natural hormones and can disrupt endocrine function in aquatic organisms (Witorsch 2002). Hundreds of chemicals that have estrogenic activity have been released into the environment (Colborn et al. 1993) and over the past decade increased public concern over wildlife and human health effects have resulted in research to identify endocrine disrupting compounds and their effects (Stancel et al. 1995, Jimenez 1997, Petit et al. 1997).

The Alaska Cruise Ship Initiative (ACSI) sponsored by ADEC evaluated the issue of hormones discharged from cruise ships into Alaska waters in 2002. The ACSI Panel recommended that DEC sample cruise ship wastewater for hormones, but did not

¹ Black water is wastewater from toilets and medical facility drains. Gray water is wastewater from laundry, galley and accommodations.

² For more information on dilution from moving ships see *The Impact of Cruise Ship Wastewater on Alaska Waters* November 2002 at http://www.dec.state.ak.us/water/cruise_ships/pdfs/impactofcruiseship.pdf

recommend methods for sampling. To date, State sampling has not occurred. The Park should keep abreast of any sampling for hormones or other endocrine disruptors conducted by the State, and should consider the potential for endocrine disrupting impacts from all wastewater sources at the Park.

Ballast Water. Large ships do not discharge ballast water into Glacier Bay. This prohibition is endorsed by the Science Advisory Board to continue to protect marine water quality in the bay.

Anti-fouling agents. Anti-fouling agents are used to prevent attachment and growth of organisms on hulls, anchor chains, etc. Tributyltin is widely used in paint as an anti-fouling agent and its impact in the marine environment has been well recognized for years. Given the low toxicity threshold observed for tributyltin on marine organisms (Fent 1996), the possibility exists that tributyltin leaching from cruise ships could be detrimental to marine life in Glacier Bay. Organisms that appear to be most susceptible are benthic species (Fent 1996, Labare et al. 1997). Predator species (e.g., sea otters) that eat these benthic organisms can be at risk for increased exposure and effects, such as reduced disease resistance (Kannan et al. 1998).

Oil. Oil could potentially be released into Glacier Bay from a cruise ship in three ways: accidental major oil spill, minor oil spill from a malfunctioning oil-water separator or emergency situation (where oil is deliberately released), or a regulated discharge of bilge water that has been treated by an oil-water separator but still contains very low levels of oil compounds.

Oil is composed of polycyclic aromatic hydrocarbons (PAHs), some of which are able to bioaccumulate in tissue. Laboratory studies have shown that even low-level oil exposure can cause detrimental impacts to marine organisms (Carls et al. 1999). Long-term low-level exposure to diluted oil (through ingestion, filter-feeding, across gills, etc.) can result in physiological changes such as endocrine disruption, immune alteration, and potentially cancer. Organisms most susceptible to chronic, low-level exposure appear to be those associated with sediment. Peterson et al. (2003) reported that long-term population impacts were observed in sediment-affiliated species (fish, sea otters, sea ducks) as well as pink salmon many years following the Exxon Valdez oil spill. Studies have shown that low-level PAH exposure during fish development causes decreases in egg/larval survival (Carls et al. 1999) as well as reduced marine survival to maturity (Heintz et al. 2000).

Acute exposure to a significant oil spill would result in mortality across a wide range of marine taxa (seabirds, sea otters, fish, crustaceans) as evidenced by the Exxon Valdez oil spill.

Information Needs

1. There has been no baseline data collected on the presence and levels of contaminants in the park's marine waters, sediments, and the producers and

consumers in the marine food web. Baseline data should be collected to allow Park managers to assess changes in contaminant levels that may occur, due to either permitted or accidental discharges in the bay. Data should be collected for metals, micro-contaminants (polycyclic musk compounds, pharmaceuticals), tributyltin and other organotins, and polycyclic aromatic hydrocarbons.

This information need is addressed in the focused research framework proposed in Section 2.5.

Management Recommendations

1. It is recommended that Glacier Bay continue to require no discharge of wastewater, bilge and ballast water in the bay. Advanced wastewater treatment systems certified for continuous discharge are an improvement to earlier treatment systems, but upsets have occurred. Advanced systems have been used for less than five years and the long-term reliability is unknown. Even though cruise ships with continuous discharge systems are required to monitor discharge twice per month, there is a delay between testing and result notification that could delay awareness of a system malfunction.
2. It is recommended that if the Park considers allowing cruise ships with advanced wastewater treatment systems to discharge within Glacier Bay, it should give approval only after the cruise ship submits data from representative discharges showing a minimum of five years of successful, continuous (year-round) operation, and after protocols and regulatory standards have been established to protect against impacts from polycyclic musk compounds and pharmaceuticals.

2.4 Air Quality

There are two separate issues dealing with air quality: compliance with ambient air quality standards, and the production of haze which affects visibility in the park. Ambient air quality standards are based on potential human health effects. Haze is primarily an aesthetic issue, but may have secondary health and environmental impacts. The effect of haze on visitor experience in the Park is discussed in Section 4.3.3.

Key Management Questions

How do cruise ships presently affect the air quality of Glacier Bay, relative to compliance with ambient air standards and production of haze?

How would increasing the number of cruise ship entries affect the air quality of Glacier Bay, relative to compliance with ambient air standards and production of haze?

Research Findings

Ambient Air Standards. Large cruise ships emit air emissions, which are products of combustion from the fossil fuels burned. Large ships typically burn heavy residual oil, which generates higher levels of carbon dioxide, sulfur dioxide and nitrogen oxide in air emissions than combustion of distillate or gaseous fuels. Most ships burn residual oil containing high levels of sulfur, generally 1.5-2.8% by weight. Cruise ships may burn 100 tons of fuel per day (USCG 1998). A few cruise ships operating in Alaska have gas turbines that use fuel with a sulfur content of 0.5% by weight or less, which results in cleaner air emissions.

Cruise ships are not considered to be air emission sources under the federal Clean Air Act. Ships are not required to have State Air Quality Permits and do not have to submit fuel certifications (detailing the type of fuel used and its chemical content) to the State. Neither the State or federal government have the legal authority under the Clean Air Act to impose a limit on the sulfur content of the fuel burned on cruise ships.

Although cruise ships emit air pollutants in Glacier Bay, they can be expected to generally be in compliance with ambient air quality standards because most air pollutants (with the exception of sulfur dioxide) are evaluated for compliance with a 24-hour cumulative standard. Since cruise ships are not stationary for 24-hours, the likelihood of exceeding these 24-hour standards is low.

The ambient air standard for sulfur dioxide has a three-hour cumulative limit. While ships would be expected to meet this standard due to mixing of emissions in the air while underway, there is a possibility of exceeding the ambient sulfur standard at the end of a fjord, particularly when two ships are present. Air mixing may be reduced in fjords, resulting in a higher probability of an inversion which could trap air emissions.

Cruise ship air emissions are not monitored in Glacier Bay National Park. However, monitoring conducted of cruise ships docked in Juneau in 2001 was well below the Ambient Air Quality Standards.³

Haze. Haze impairs visibility in all directions over a large area. When haze is present, the distance that one can see is limited because of tiny particles in the air absorbing and scattering sunlight, which in turn degrades color, contrast, and clarity of the view.

Some types of particles such as sulfates scatter more light and create more haze, particularly in humid conditions. Some pollutants, which form haze, have been linked to serious health problems like respiratory illness and environmental damage such as acid rain. However, a possible effect of haze on Glacier Bay is its aesthetic impact, which may affect visitor use and enjoyment of the park. This issue is addressed in Section 4.3 Visitor Experiences and Wilderness Resources.

³ Report located at <http://info.dec.state.ak.us/DECPermit/ACSIReport.pdf>

To address haze impacts in national parks and wilderness areas, in July 1999 the Environmental Protection Agency (EPA) enacted a “Regional Haze Rule,” which manages for haze impacts in designated Class I areas. Alaska has four Class I areas subject to the rule.⁴ In these areas, the State must develop long-term plans for reducing pollutant emissions that contribute to visibility degradation and establish goals aimed at improving visibility. None of these areas are in Southeast Alaska. Given that the possibility of haze exists in the Park, and that the presence of haze may impact visitor experience, Glacier Bay could choose to operate as a regional haze area, even though it was not included in the federal legislation. Should haze be found to occur, the Park could develop a long-term plan for controlling haze, and apply air emission limits in the vessel management process to reduce or eliminate haze.

Information Needs

1. Monitoring data on ambient air quality conditions and sulfur dioxide levels for areas in the upper fjords (e.g., near Margerie Glacier), where cruise ships congregate and stay for an extended period of time.
2. Stack testing data from cruise ships operating within Glacier Bay, representing several ship configurations, including: standard marine propulsion engines with auxiliary engines for hoteling, marine engines that power both hoteling and electric motors, and turbine engines.
3. Cruise ship air emission opacity data, to inform planning and management decisions about the frequency or severity of haze.

These information needs are addressed in the focused research framework proposed in Section 2.5.

Management Recommendations

1. It is recommended that Glacier Bay National Park require cruise ship companies to submit fuel certifications to the Park and recognize ships burning fuel with <1.50% sulfur by weight in management decisions.
2. It is recommended that Glacier Bay National Park operate as a Class I regional haze area and develop a long-term plan for reducing pollutant emissions that contribute to visibility degradation and establish goals aimed at improving visibility.

⁴ Denali National Park and Preserve, Tuxedni Wilderness Area, Simeonof Wilderness Area, Bering Sea Wilderness Area.

2.5 Proposed Research Framework for the Physical Environment

The discussion above examined existing research findings regarding potential impacts on the physical environment associated with cruise ship visitation to Glacier Bay, and outlined a range of information needs in this topic area. The Board recommends that the Park support the following specific studies to address these information needs.

Underwater Soundscape

- P-1 Ambient Underwater Sound. Monitor and document ambient underwater sound for relevant areas in mid- and upper-Glacier Bay. These results will be used in acoustic models for these areas.
- P-2 Sound Level Data. Further develop the cruise ship acoustic knowledge base by establishing sound levels for cruise ship thrusters, and ships equipped with azipod propulsion and other new propulsion types. Determine acoustic differences between single cruise ship and two cruise ship days through acoustic monitoring and modeling.
- P-3 Sound Exposure Assessment. Conduct a study of separation distances between cruise ships and marine species. Establish sound exposure level and duration estimates for common cruise ship types and separation distances.
- P-4 Acoustic Monitoring. Continue acoustic monitoring in lower Glacier Bay so that data are available to assess soundscape trends, if vessel use levels change.

Water Quality

- P-5 Baseline Contaminant Data. Collect baseline data for contaminants in Glacier Bay's marine waters, benthic sediments, and for organisms that are producers and consumers in the marine food web. Data should be collected for metals, micro-contaminants (polycyclic musk compounds, pharmaceuticals), tributyltin and other organotins, and PAHs.

Air Quality

- P-6 Air Quality Monitoring in Sensitive Locations. Monitor ambient air quality conditions and sulfur dioxide levels, in accordance with EPA regulations, for areas in the upper fjords (e.g., near Margerie Glacier), where cruises ships congregate and stay for an extended period of time.
- P-7 Representative Air Emission Stack Testing. Conduct stack testing for representative cruise ships operating within Glacier Bay, including several ship configurations: standard marine propulsion engines with auxiliary engines for hoteling, marine engines that power both hoteling and electric motors, and turbine

engines. Compare stack testing results with the air emissions factors used in the analysis of air quality impacts in the FEIS, to verify those findings.

P-8 Opacity. Collect cruise ship air emission opacity data.

3.0 Marine Biological Environment

3.1 Introduction

The objectives of the research framework for marine biological resources are to evaluate the existing base of scientific knowledge related to the potential impacts of cruise ships on marine biota in Glacier Bay, and to recommend modeling, research and monitoring to assess the consequences to marine biota if cruise ship activity is increased. The framework recommends that research focus on marine species sensitive to disturbance, likely to be disturbed, or of management concern (e.g., those that may be declining in abundance.) Although cruise ships may potentially impact a diversity of marine organisms, the Board focused its efforts, based on the feasibility of studies and current state of the literature, on marine mammals, marine birds and the lower trophic level species that support these populations.

There has been considerable research on the impacts of vessels and other anthropogenic disturbance on birds, mammals and fish, in a diversity of marine habitats. However, differences in study design, environmental variables, disturbance types and regime, species-specific response patterns, and a lack of consistent reporting of the responses make it difficult to interpret these results in the context of impacts from cruise ships on marine organisms in Glacier Bay. Current knowledge indicates general trends in the reactions of marine organisms to vessel disturbance. However, the purpose of the research framework is to build a stronger body of knowledge through research that would be directly applicable to the specific conditions and species in Glacier Bay.

Disturbance effects on organisms are generally considered to result in one or more levels of response. These potential responses are:

- No response (e.g., a response is absent or at a level that cannot be detected).
- Behavioral response, in which the behavior of an individual or group is observed to change (e.g., startle response, change in distribution, change in feeding behavior).
- Physiological response, in which an individual experiences physiological indicators of stress or reaction to disturbance (e.g., increased respiration or pulse rate).
- Demographic response, in which a disturbance affects the vital rates of the population (i.e., survival, reproductive success), which in turn may affect the population's stability and potential for growth.

It is generally more difficult to detect physiological or demographic responses (compared to behavioral responses), and to detect population-level impacts (compared to impacts to an individual). Research may document changes in an animal's behavior in response to

disturbance. However, to judge the significance of potential impacts from disturbance, it is important to determine if behavioral responses are linked to physiological changes that could result in demographic impacts. Effects on future population levels may be the most relevant and important response to understand, but they are also the most difficult to detect and measure.

As illustrated in Figure 1, research into potential impacts on marine organisms from increased cruise ship traffic should include three primary approaches:

- Conduct initial energetic and demographic-based modeling to investigate the potential for population-level responses of selected species to increased cruise ship traffic;
- If advisable based on model outcomes, design and implement empirical investigations of primarily behavioral and physiological responses at the individual-level, that could result in long-term population effects; and
- Monitor populations of selected species to detect trends in abundance over time.

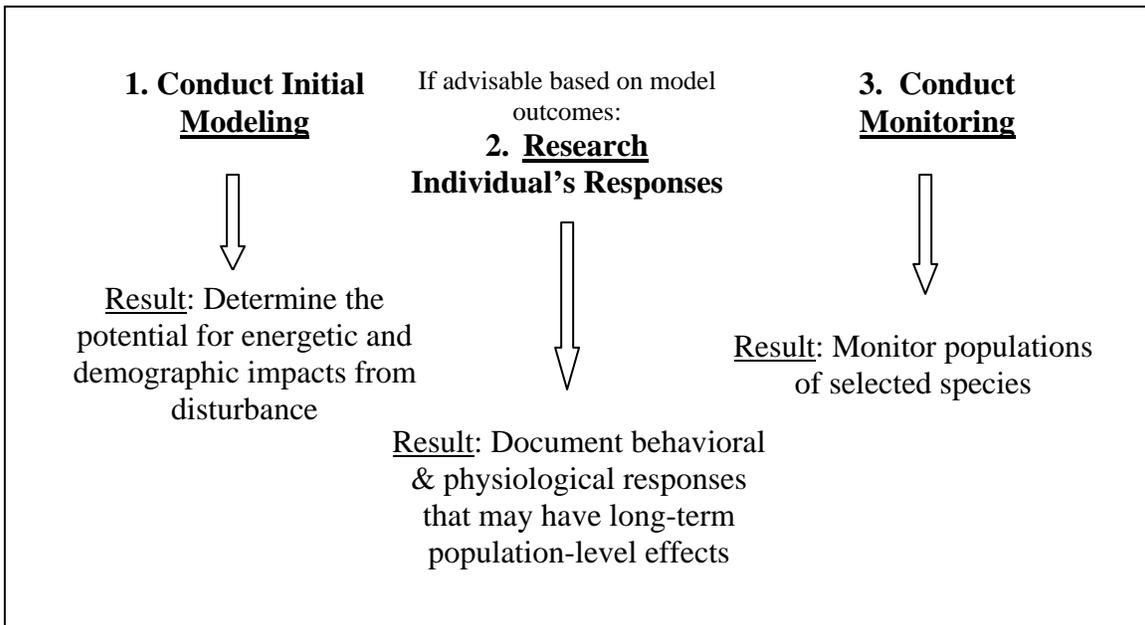


Figure 1. Outline of the three-tiered modeling, research and monitoring framework recommended to understand the effects of increased cruise ship traffic on the marine biological environment in Glacier Bay.

The status of existing research, information needs and recommended management measures are included in each subsection below. In Section 3.5, the Board presents its recommended research framework for the marine biological environment, which focuses on key information needs that can be effectively addressed through research, monitoring and modeling.

3.2 Marine Mammals

The FEIS concluded, as a result of consultation with NOAA, that vessel traffic (including all vessel types) in Glacier Bay would regularly disturb humpback whales and Steller sea lions (both listed as threatened species under the Endangered Species Act), as well as other marine mammals in Glacier Bay protected under the Marine Mammal Protection Act (MMPA).⁵ The effect of all vessel management alternatives evaluated in the FEIS on marine mammals were judged to be “moderate,” as vessels would disturb individual animals, but would not be expected to reduce abundance or overall population stability.

The Board notes that, while minor to moderate behavioral disruptions may not result in any immediate impacts of biological significance, repetitive minor reactions even within a species’ normal behavioral repertoire could result in a cumulative impact that is biologically significant (NOAA Fisheries, Section 7 consultation, Vessel Management EIS, Glacier Bay). For example, a seemingly inconsequential shift in a species’ behavior or habitat use due to disturbance by cruise ships may, over a number of years, lead cumulatively to a lower abundance of that species in Glacier Bay.

A reduction in abundance in the Park, if it occurred, may not be out of compliance with MMPA regulations, but may nevertheless fail to comply with the NPS’ governing mandate for the Park. The Park may choose to manage for potential impacts to a species at a localized level, notwithstanding global population levels.

To inform the Park’s future decisions about increasing cruise ships seasonal use days, the Board considered four main issues relevant to marine mammals:

- Behavioral responses to cruise ships, that include disturbance and displacement of marine mammals due to vessel presence, changes in the Bay’s underwater sound environment, or other disturbance factors.
- Physiological responses to of individuals to disturbance.
- Demographic consequences, including long-term changes in populations due to behavioral and physiological responses to disturbance.
- Frequency and effects of vessel strikes.

These issues are evaluated below and are further addressed in Appendix C.

Key Management Questions

How might a potential increase in seasonal use days of cruise ships affect the behavior of marine mammals in Glacier Bay, especially causing displacement or disturbance of animals?

How might disturbance impacts affect the physiology of marine mammals in Glacier Bay, including their energy expenditures?

⁵ This consultation included all vessel types using Glacier Bay, not solely cruise ships.

What are the likely long-term demographic consequences to marine mammals, in terms of reduced fecundity and survival, which can potentially result from behavioral and physiological responses to cruise ships, to an increase in seasonal use days of cruise ships in Glacier Bay?

How might a potential increase in seasonal use days of cruise ships affect the likelihood and consequences of vessel strikes on marine mammals in Glacier Bay?

Research Findings

Marine Mammal Behavioral Responses. There are a number of studies that have documented changes in marine mammal behavior in the presence of marine vessels (Appendix C). Studies have shown that vessel traffic, even large vessels that do not follow animals and do not change speeds or direction, can appreciably modify the behavior of marine mammals. Typically, these behavioral changes have been described as avoidance reactions and alarm/startle responses. Responses include increased alertness and temporarily abandoning haul-outs in the case of pinnipeds, and changes in swimming speeds, respiration rates, and direction of travel (usually away from the vessel) for cetaceans.

Potential displacement from areas important for key behaviors, such as feeding or migration, or disruption of sensitive behaviors such as rearing offspring and mating is also of particular concern as such displacement may have population-level effects. If disturbances are frequent and disruptive enough to cause animals to expend additional energy and allocate less energy to behaviors necessary for survival, it may threaten the long-term viability of the population (Gill et al. 1996) (See Section 3.2.4 Demographic Impacts).

There is currently limited data available that *directly addresses* the potential impacts of cruise ships on the behavior of marine mammals, particularly among species present in Glacier Bay. The few studies conducted in Glacier Bay (and nearby Disenchantment Bay) show several clear responses of harbor seals to approaching cruise ships: 1) when cruise ships approach within 500 meters, seals abandon ice floes with increasing frequency; 2) cruise ships disturb seals at greater distances, though with lessened intensity, than smaller boats; and 3) seals abandon ice floes at greater frequency as cruise ships approach them more directly (Calambokidis et al. 1985, Mathews 1994, Lewis and Mathews 2000, Jansen et al. 2003).

NOAA Fisheries' National Marine Mammal Laboratory recently completed a three-year study assessing cruise ship disturbance on harbor seals at Disenchantment Bay, where cruise ship entries and movements are unregulated. NOAA will release a report addressing medium to large-scale effects (e.g., potential shifts in distribution and abundance of seals) for the first year of the study in early FY06. Though more robust for detecting vessel effects within a population, these studies have so far been cross-sectional in nature and have therefore not tracked the responses of known individuals over time.

Following on such studies, longitudinal sampling of fewer known animals can provide the input parameters necessary for modeling energetic costs of disturbance relative to daily energetic requirements. These measures can then be incorporated into models that investigate the fitness consequences at the individual- and population-level.

The majority of the literature is focused on smaller vessels whose behavior, speed, and size all differ dramatically from cruise ships. It is problematic to relate research findings regarding small-vessel impacts to management decisions regarding cruise ships. Moreover, it may not be accurate to extrapolate impacts across species, or other factors that vary over time and space, such as weather, tidal stage, species life-history, and degree of habituation to ships (among others).

Cruise ship noise, in addition to visual stimuli, is a mechanism of disturbance that must be specifically considered in management decisions. Key elements of the relationship between the underwater soundscape and effects on marine biological resources include: natural or ambient underwater sound levels, underwater sound levels from vessels, acoustic propagation, sound levels experienced by the species of interest, duration of exposure to elevated sound, and the direct and indirect effects experienced by species of interest.

Examples of direct effects on species from increasing underwater sound could include impacts to normal behavior (affecting feeding, rearing of young, resting or social interaction), as well as measurable physical stress (e.g., changes in blood chemistry), temporary shifts in hearing threshold (TTS), permanent shifts in hearing threshold (PTS), and tissue damage due to acoustic pressures. Indirect effects could include masking of acoustic cues used for communication or prey location, and effects on the abundance and distribution of prey species (e.g., forage fish). With regard to marine mammals, these concepts are addressed in a general sense (but not specific to impacts from cruise ships in Glacier Bay) in several recent texts, including Richardson et al. (1995) and National Research Council reports (2003, 2005).

Existing research addresses the auditory capabilities of marine mammals studied in captivity, as well as evidence of reaction and non-reaction of some types of marine life to various manmade sources of sound. Limited data are available on hearing sensitivities for species including killer whales, beluga whales and harbor seals that have been studied in captivity (NOAA 2004; Richardson et al. 1995). A significant limitation is that many of these studies, particularly for marine mammals, involve very small sample sizes. No data exist for humpback and bowhead whales, but projections of hearing sensitivities for some of these animals have been offered (Richardson and Malme 1993; Malme et al. 1983, 1988; Erbe 2003; Clark and Ellison 2003).

It is clear that sound can cause changes in marine mammal behavior at the individual-level, and numerous researchers have linked avoidance behavior to manmade underwater sounds. Typical types of observed disturbances have included changing swim speed and direction; changing acoustic call patterns; area avoidance; cessation of feeding; disruption of resting; and changing surfacing, diving, and blow patterns (NRC 2005; Baker et al.

1982, 1983, 1989; Bauer and Herman 1986.) In some cases, increased vessel or industrial activity has caused marine mammals to avoid affected areas until after the activity subsides. These studies include calving humpback whales in Hawaii (Salden 1988) and migrating gray whales (Malme et al. 1984).

Some marine mammals use acoustic cues to locate food, avoid predators, navigate, and for communication purposes such as mother-offspring interactions and coordinated feeding. When vessel noise exceeds ambient sound levels it can mask important acoustic cues. The mid-range sound frequency regions used by marine mammals for communication overlap more with vessel noise frequencies than would high-frequency echolocation, so it is more likely that vessel noise would impair communication than echolocation (Bain and Dalheim 1994). While some investigators such as Erbe (2003) have explored this subject, research directly addressing impacts of manmade sound is rare. As mentioned in Section 2.2 above, it is feasible to model the level of sound reaching an animal of interest, given knowledge of the vessel source levels and typical propagation. But the question of whether a sound is audible and interferes with the reception of other acoustic cues is more complex. Such models would require hearing threshold sensitivity data for important species, which is largely lacking for the marine species of interest in Glacier Bay.

Habituation may be an important aspect to disturbance (including both visual and sound) that could reduce disturbance effects. Once habituated, disturbance effects may be reduced for resident individuals, however the perception of risk from disturbance may vary seasonally even for habituated individuals, depending upon life-history events (e.g., when raising offspring.)

Marine Mammal Physiological Responses. A disruption of normal behavior can signal an immediate change in an animal's physiology, such as elevated respiration or pulse rates, or can alter its physiology due to longer term consequences of the behavioral shift, such as energetic stress caused by reduced feeding. No studies have evaluated the physiological responses of marine mammals to cruise ship disturbance or other vessel disturbance in Glacier Bay.

Though research is limited, methods have been developed for detecting physiological responses of marine mammals to acoustic or visual disturbance using stress indicators measured in blood (National Research Council, 2005; Thomas, 1990). However, case studies involving acoustic disturbance are rare and the National Research Council has recommended further research involving these techniques. To date, most research has inferred disturbance from observed shifts in behavior. A quantifiable method using blood chemistry (in conjunction with remote sampling) would allow for greater objectivity in detecting stress.

Current knowledge indicates that it is unlikely that sound emissions from cruise ships cause direct physical damage to marine mammal hearing. Given the knowledge of vessel sound levels, natural sound levels, estimates of exposure levels, and numerous behavioral observations for cases studied outside of Glacier Bay, Richardson and Malme (1993)

states that actual auditory damage, at least for baleen whales, is unlikely even at short distances. This statement is perhaps supported by numerous cases where whales have approached vessels at close range.

Potential Demographic Consequences. Population trajectories of most marine mammals are poorly known in Glacier Bay. Some species are experiencing opposing trajectories, with harbor seal populations declining and sea otter and Steller sea lion populations increasing. While humpback whales are increasing overall in the Pacific Ocean, numbers of whales in Glacier Bay are variable.

While behavioral and physiological responses to disturbances can be detected and measured (at least in some species), the long-term impacts, if any, of such responses have received little attention. Some disturbances may be minor, but those that disrupt important activities such as feeding, resting, reproduction and parenting might play a critical role in survival. Disturbances that result in an energetic cost, such as preventing an animal from gaining or conserving resources, may adversely affect the animal's survival and fecundity, leading to population-level impacts.

Despite the fact that behavioral changes in response to sound stimuli have been documented, the National Research Council (2005) states that “although some of these changes become statistically significant in given exposures, it remains unknown when and how these changes translate into biologically significant effects at either the individual or population level.” Note too that the same NRC report states: “No scientific studies have conclusively demonstrated a link between exposure to sound and adverse effects on a marine mammal population.”

These studies highlight the difficulty in directly linking disturbance to demographic impacts. Models that incorporate behavioral disturbance and physiological impacts to estimate demographic change are perhaps the best tool for estimating long-term demographic shifts in population structure. On the other hand, the Board recognizes that despite increases in seasonal cruise ship traffic, the number of some marine species in Glacier Bay has increased (e.g., Steller sea lions) or has no apparent relationship to cruise ship levels (e.g., humpback whales). Studies should be carefully designed (with sufficient statistical power, model sensitivity) to establish accurate estimates of demographic effects and thus determine whether a lack of significant results merely represents a lack of power (statistical) or is truly an absence of effect.

Vessel Strikes. Vessel strikes result in injury and mortality to individual mammals and, although rare, provide perhaps the most direct and irrefutable evidence of an impact from vessels (Doherty and Gabriele 2001, 2003, 2004; Laist et al. 2001). The most comprehensive review to date on the subject of collisions between ships and whales concluded that strike probability may be reduced when ships maintain speeds under 14 knots, and if ships generally avoid habitats of high whale densities (Laist et al. 2001). The authors further speculate that whales may be more prone to ship strikes if they are engaged in activities such as feeding.

Glacier Bay currently implements an adaptive management program to reduce the probability of whale strikes in the park. Increasing the number of cruise ships entering the park would increase the number of strikes that could randomly occur. The park initiates speed restrictions in areas where whales are aggregated, and ships are required to maintain mid-channel routes to avoid nearshore areas. As ship strikes in the Bay are rare, it may be difficult to ascertain what additional factors (e.g., habituation of whales to ships, foraging activity) may further contribute to the probability of ship strikes in the park.

Information Needs

1. Research findings on behavioral disturbance are insufficient to determine whether the proposed increase in cruise ship entries into Glacier Bay would result in a biologically significant disturbance or displacement of marine mammals. The few studies that have been conducted in Glacier Bay and nearby Disenchantment Bay indicate that some species (e.g., humpback whales and harbor seals) exhibit an immediate behavioral response to vessel traffic (including cruise ships).
2. Empirical evidence is lacking to determine whether physiological responses to behavioral disturbance or stress caused by cruise ships could compromise the survival or reproductive success of individual marine mammals, or affect the long-term viability of populations within the Park. In development of the research framework (Section 3.5), the Board emphasizes that studies of behavioral response to disturbance should be coupled with estimates of physiological and or demographic impacts; otherwise, the potential long-term effects of the disturbance are unclear.
3. To fully understand the potential for behavioral and physiological responses, there is a need to better understand the potential for changes in the underwater sound environment to affect marine mammals, including:
 - Establishing a catalog of hearing sensitivity data for marine mammal species common to Glacier Bay. Explore means of obtaining hearing sensitivity data for species where current knowledge is insufficient. In a general sense, a similar call for this type of data has been made by the National Research Council on several occasions (1994, 2003, 2005).
 - Comparing known cruise ship sound levels to levels that are known to cause behavioral and physiological responses in marine mammals. In the absence of species-specific data regarding disturbance, compare sound levels to the harassment exposure levels included in the MMPA. These estimates should also be considered relative to sounds produced by other vessels in the park to ascertain whether reactions of animals is a product of cruise ship sounds or other manmade sources.
 - Comparing spatial overlap between cruise ships and high priority species. Assess possibility that animals spend less time in areas when ships are present.

- Performing acoustic cue and acoustic communication masking analyses for species and conditions specific to Glacier Bay.
4. Estimates of marine mammal abundance in Glacier Bay through routine monitoring of population numbers is needed to validate potential demographic consequences of anthropogenic disturbances in Glacier Bay over time.
 5. There is a need to examine the possible link between a disruption in behavior and a physiological cost as it pertains to long-term impacts on the survival, fecundity, and site fidelity of marine mammals. For example, using an animal's metabolic rate it may be feasible to estimate the energy expended by an individual during a particular behavioral disturbance or physiological reaction, or of a missed feeding opportunity, and thus estimate the energetic cost of disturbance. These additional energetic costs could then be incorporated into models investigating the potential for demographic consequences of disturbance at both the level of the individual and the population.
 6. Modeling is needed to estimate the probability of vessel strikes on marine mammals in Glacier Bay.⁶ The modeling effort must consider the probability of detection of a struck animal, the probability of a ship striking a whale in the Park, and the probability that an animal would die should an impact occur (among other factors).

These information needs are further evaluated and addressed in the focused research framework proposed in Section 3.5.

Management Recommendations

The Board recommends that the Park take the following management actions to prevent and mitigate the potential impacts of cruise ship activity on marine mammals in Glacier Bay:

1. It is recommended that the Park continue to apply measures to reduce potential interactions between ships and marine mammals, including managing ship locations to reduce disturbance to areas where sensitive life-stages occur (e.g., harbor seal pup-rearing areas), and speed reduction and adaptive management of ship routes based on the distribution and behavior of whales. These measures likely reduce the frequency and potentially the severity of impacts.
2. Based on acoustic modeling and the outcome of research on acoustic related behavioral and physiological responses, the Board recommends that the Park consider the need to establish vessel underwater sound level guidelines and acoustic limits for vessels operating in Glacier Bay.

⁶ In conservation recommendations made during the FEIS process in 2003, NOAA Fisheries expressed concern regarding the potential for collisions to occur.

3.3 Marine Birds

The FEIS concluded that vessel traffic in Glacier Bay would result in moderate level effects on marine birds. The most notable effects would be disturbance in areas where brood-rearing harlequin ducks, molting waterfowl, and foraging marbled and Kittlitz's murrelets are known to concentrate. However, the FEIS noted that private vessels are more likely to disturb marine birds than larger cruise vessels, as private vessels travel widely throughout the Bay and regularly enter nearshore areas used by birds.

To inform the Park's future decisions about increasing cruise ships seasonal use days, the research framework relative to marine birds must address four main issues:

- Behavioral responses, including disturbance and displacement, of marine birds
- Physiological responses to disturbance experienced by individual marine birds.
- Demographic consequences, including long-term changes in populations, due to the behavioral and physiological responses to disturbance.
- Frequency and effects of vessel strikes on marine birds.

These issues are evaluated in the following analysis and addressed through recommendations in the research framework. They are further addressed in Appendix D. This section closely parallels the findings and the approach recommended for marine mammals in Section 3.2 of this report.

Key Management Questions

How might a potential increase in seasonal use days of cruise ship affect the behavior of marine birds in Glacier Bay, especially with respect to displacement or disturbance of animals?

How might disturbance affect the physiology of marine birds in Glacier Bay, including their energy expenditures?

What are the likely long-term demographic consequences to marine birds in terms of reduced fecundity and survival, which can potentially result from behavioral and physiological responses to an increase in seasonal use days of cruise ships in Glacier Bay?

How might a potential increase in seasonal use days of cruise ships affect the likelihood and consequences of vessel strikes on marine birds in Glacier Bay?

Research Findings

Behavioral Responses. While there is considerable literature regarding avian responses to disturbance by motorized vessels, there have been no studies specific to disturbance caused by cruise ships. Scientific research has focused primarily on the visual

disturbance caused by vessel presence. This body of literature has developed due to management needs that include development of buffer zones to effectively isolate birds from vessel disturbance.

As summarized in Appendix D, scientists have documented a variety of avian behavioral responses to vessel disturbance, including altered behavior states and change in social structure. The visual disturbance caused by vessel presence has caused increased alert behavior, flight, scattering, swimming and reduced foraging. In some studies, birds have become habituated to the disturbance, and their behavioral responses to disturbance have stabilized over time.

Avian responses to vessel disturbance vary across species and with variable factors such as age, breeding status, and season. Environmental factors such as tide stage and time of day can also influence bird response. Closer vessel approaches and higher vessel speeds generally cause greater disturbance.

Physiological Responses. The physiological response of avian species to visual disturbance caused by vessels has not been well studied. However, it is important to note that measurements of physiological response may be a better indicator of impact from vessel disturbance than visual observation of avian behavioral responses. Data on physiological response would improve the ability to estimate energetic costs associated with vessel disturbance, and model the potential for demographic impacts. Instantaneous physiological measures are retrievable from individual birds via radio telemetry technology (Ely et al. 1999).

Demographic Impacts. Few studies have investigated the effects of vessel disturbance on population levels of marine birds. Demonstrated effects include increased potential for predation on offspring and increased mortality of offspring. Less overt impacts range from delayed breeding due to the need to spend more time foraging enroute to breeding locations (to replace energy lost due to avoidance behaviors), and reduced use of habitats adjacent to vessels (measured as reduced abundance). Disturbances that are energetically costly to individuals may influence long-term population stability and growth.

Information Needs

1. As with marine mammals, the body of research on behavioral disturbance does not presently offer sufficient applicable findings to determine whether the proposed increase in cruise ship entries into Glacier Bay would result in a biologically significant disturbance or displacement of marine birds. A comprehensive assessment of which species utilize areas that are also visited by cruise ships, which would increase the potential for impacts on these species, is also lacking.
2. Likewise, empirical evidence is lacking about whether physiological reactions, such as a stress response, to behavioral disturbance could compromise the survival or reproductive success of individual marine birds, or affect the long-

term viability of populations within the Park. In development of the research framework (Section 3.5), the Board emphasizes that studies of behavioral response to disturbance should be coupled with estimates of physiological and or demographic impacts; otherwise, it is unclear as to the potential long-term effects of the disturbance.

3. Estimates of marine bird abundance in Glacier Bay, through routine monitoring of population numbers, is needed to validate potential demographic consequences of anthropogenic disturbances over time.
4. There is a need to examine the possible link between a disruption in behavior and a physiological cost as it pertains to long-term impacts on the survival, fecundity, and site fidelity of marine bird populations. For example, using an animal's metabolic rate it may be feasible to estimate the energy expended by an individual during a particular behavioral disturbance or physiological reaction, or of a missed feeding opportunity, and thus estimate the energetic cost of disturbance. These additional energetic costs could then be incorporated into models investigating the potential for demographic consequences of disturbance at both the individual- and population-level.
5. Modeling is needed to estimate the probability of vessel strikes on marine birds in Glacier Bay and their consequences, if any, to the populations using the Park.

These information needs are further evaluated and addressed in the focused research framework proposed in Section 3.5.

3.4 Lower Trophic Level Species

The question of impacts to lower trophic level species in Glacier Bay, including marine fish and invertebrates, is particularly important to the survival and population dynamics of higher trophic level organisms, such as marine birds and mammals. If cruise ships impact the abundance or distribution of prey species, it is likely their consumers (grazers/predators) would also be impacted.

Key Management Questions

How might an increase in cruise ship numbers affect lower trophic level species?

Would impacts experienced by lower trophic level species translate into impacts to species of concern higher up the food web?

Research Findings

There is limited data available to understand the impacts of cruise ships to lower trophic level species. Research shows that there is potential for effects on fish behavior and (to a lesser extent) physiology, particularly due to underwater sound impacts. However, there

has been no assessment of whether changes in the distribution, behavior, productivity or survival of lower trophic level species would affect species higher up the food web.

Multiple studies have documented changes in fish behavior, particularly avoidance reactions and alarm/startle responses, in the presence of ships (see Appendix E). A number of researchers have demonstrated that fish may be physically affected by sound, such as through damage to their hearing (McCauley et al. 2003). Others have demonstrated that they respond to sound, including vessel sound, by changing their distribution, shifts in swimming behavior, and startle responses (Suzuki et al. 1980; Pearson et al. 1992; Engas et al. 1995). Somewhat limited data are available on hearing sensitivities for a number of fish that have been studied in captivity (NOAA 2004; NRC 2003).

Popper et al. (2001) and Wiese and Marschall (1990) also proposed that invertebrates are capable of sensing and perhaps responding to sound, as well as to water flow and vibration. Some species may not be able to avoid approaching cruise ships and may be subjected to higher sound levels than species that have the ability to retreat away from vessel sound sources.

There is no research testing for physiological impacts from general ship disturbance to lower trophic level species. However, in general, stress responses can cause physiological changes in animals and there is the possibility that a stress response could cause a physiological impact (e.g., release of stress hormones) in lower trophic-level species.

Effects of large-scale ship wakes on the marine environment, including lower trophic species are largely unknown (Jude, et al., 1998; Wolter and Arlinghaus, 2003). Egg and larval stages appear to be most vulnerable to direct impacts from ship disturbance. Physical forces such as wave energy, return currents, and shear stress can cause direct fish mortality as well as dislodgement and redistribution of eggs (Jude et al., 1998; Wolter and Arlinghaus, 2003). Some larval reef fish use ambient sound as a settlement navigational cue (Tolimieri et al., 2002), which could be impacted by added noise.

The issue of whether impacts to lower trophic level species, if they occur, would translate into impacts on higher trophic level species of concern (e.g., marine mammals and birds) in Glacier Bay is not well understood. Prey abundance and distribution almost certainly influences the viability and success of marine mammal and bird populations. However, the status and population dynamics of important prey species in Glacier Bay are unknown. Identifying the primary dietary needs of species of marine mammals and birds would help identify which forage fish species are most important (or under what conditions they are important) and thus which lower trophic level species to study and monitor.

Information Needs

1. To determine the potential for cruise ship noise to impact lower trophic level species, hearing sensitivity data for lower trophic level species common to Glacier Bay should be catalogued, and compared with known cruise ship sound levels in Glacier Bay.
2. There is a need to determine the primary forage fish species of importance to marine mammals and birds, and to monitor population status and trends for these species.

These information needs are further evaluated and addressed in the focused research framework proposed in Section 3.5.

3.5 Proposed Research Framework for the Marine Biological Environment

To fully address the question of what effects (if any) additional cruise ship visitation would have on marine mammals and birds in Glacier Bay, scientists and managers need more information about impacts that would compromise a species' vital rates (survival and fecundity) or result in shifts in a species' distribution to areas outside of the Park boundaries. Trying to design effective and feasible studies to obtain this information poses very difficult scientific challenges.

In considering what would be the most effective research framework to address these complex information needs, the Board discussed the following points:

- Very few studies have explicitly examined behavioral changes in marine species as a result of cruise ship traffic. In addition, demonstrated linkages between observed changes in behavior, and physiological or demographic processes that might affect a population in the long-term, are generally lacking. The Board emphasizes that behavioral measurements must be coupled with estimates of physiological and or demographic impacts; otherwise, the potential impact of the disturbance regime on long-term populations of marine species in the Park is unclear.
- The natural variability of marine biological processes affecting populations in Glacier Bay is high. Other vessels may also impact species of concern. Therefore, it may be difficult to distinguish effects caused by cruise ships from those caused by natural variability, other motorized vessels, or other factors.
- Impacts to marine organisms are likely reduced by Park management measures related to cruise ships. Examples of these regulations include prohibition of discharging wastewater in the park, reduction in areas open to cruise ship transit

(e.g., to reduce disturbance of harbor seals during pup rearing), and speed reductions and adaptive management of ship routes based on the distribution and behavior of whales. These regulations have likely reduced the frequency and potentially the severity of impacts from cruise ships.

- Research studies to detect and measure physiological or demographic impacts from increased cruise ship disturbance could take many years to develop and implement. It could be technologically complex, time-consuming and expensive to measure and record responses of individual organisms or groups (e.g., measuring physiological changes in individual animals). Individuals' responses may be subtle, or difficult to detect, quantify, or extrapolate to a population-level. Moreover, the statistical power to detect a common response across individuals is hampered by small samples and variability across individuals. Models would be needed to link data about disturbance-induced behavioral responses with physiological responses, and to determine possible demographic effects with sufficient certainty. As an example, the Natural Research Council (2005), in reviewing how to determine when noise causes biologically significant effects, concluded that "current knowledge is insufficient to predict which behavioral responses to anthropogenic sounds will result in significant population consequences for marine mammals" and suggested models for predicting such impacts may be up to 10 years in the future.
- Lack of data does not constitute lack of effect. The full range of potential impacts to the marine biological environment from increases in cruise ship visitation may not yet be fully identified, due to a lack of directed research or an incomplete understanding of the types of impacts that may occur. For example, the impacts of underwater sound on biological resources were not prominently recognized until recently.

Due to these considerations, the Board recognizes that cruise ships may not have impacts that can be detected in the near-term for many marine species. The following research framework suggests approaches that, while they might not yield conclusive results in the near-term, will help scientists and Park managers judge the potential for both immediate and longer-term impacts, determine the level of scientific uncertainty and where it will likely persist even after extensive study, and determine the need for and feasibility of longer-term data gathering. The Board recommends that the Park support the following studies:

- MB-1 Effects of Changes in Underwater Soundscape. Continue to collect, catalogue and evaluate information that will further elucidate the likelihood and potential for increases in underwater sound to impact marine biota. Work should include:
- a. Establish a catalog of hearing sensitivity data (behavioral and physiological) for marine species common to Glacier Bay. Explore means of obtaining hearing sensitivity data for species where current knowledge is insufficient.

- b. Compare cruise ship sound exposure levels to levels that are known to cause physiological effects or behavioral responses in marine mammals and other marine species. In the absence of species-specific data, use the MMPA harassment exposure levels as a starting point. This analysis should focus on high priority species and on areas frequented by cruise ships.
- c. Perform acoustic cue and acoustic communication masking analyses for species and conditions specific to Glacier Bay.
- d. Meaningful acoustic exposure thresholds are needed to assess potential impacts due to changes in the Glacier Bay soundscape. The Park should encourage research that aims to establish acoustic exposure thresholds based not only on behavioral observations, but also on direct physiological and biochemical indicators of stress. Since stress indicator monitoring in marine species is presently a difficult and developing area of study, it is not certain that such research will be fruitful in the near term. Nevertheless, the research community is urged to move forward with the hope that results of this type can be used in the sound exposure assessments recommended above when the data become available.

MB-2 Assess Potential for Disturbance for Marine Species. Assess the probability of disturbance from cruise ships to different marine species in the park by assessing the degree of their interaction with cruise ships. Recognize that some species may be obvious candidates for study because they are both easily detected and are well studied (e.g., humpback whales), while the interaction and disturbance potential of other species that are less visible and not easily studied may not be as obvious (e.g., schools of forage fish).

MB-3 Modeling to Determine Effects on Populations and Densities of Marine Species. As noted above, effects on marine mammal and bird populations due to cruise ship activity may be very difficult to detect and quantify. Population-level effects would likely result from cumulative impacts over time, which are difficult to measure with precision. To focus this area of inquiry, the Board recommends, as a first step, modeling efforts to inform and guide the design of later research related to potential impacts on marine species. Modeling would be used to determine the potential for:

- a. Reduced cruise ship traffic to benefit the population abundance of selected species, through reduced encounters with cruise ships and reduced strike rates;
- b. Physiological responses of selected species to disturbance (physical, visual or acoustic), that could cause higher energetic costs, potentially affecting survival, fecundity and population viability; and
- c. Disturbance-induced behavioral responses of selected species that could result in a shift in their distribution to areas outside of the Park.

These modeling efforts should consider species that meet three criteria: 1) there is sufficient data available on distribution and energetics, not exclusive to Glacier

Bay, to provide input to the models; 2) a significant portion of a discrete population is likely to be exposed to cruise ships (see MB-2 above); and 3) a disturbance response (behavioral or physiological) has been documented previously and can be used to estimate the energetic overhead or shift in distribution due to disturbance.

With regard to further research on physiological responses that could affect species' population (see (b) above), modeling would initially be used to estimate the likelihood that scientific research would be able to empirically detect such impacts. Scientists would use the results of the modeling to: 1) determine whether there is a reasonable probability that effects on survival and fecundity could be detected through research, 2) decide whether to pursue additional research, and if so, 3) design a research program examining demographic impacts.

For example, if it is assumed that harbor seals spend up to 20% more time in the water when cruise ships are within 5 kilometers, then this behavioral shift would result in an increase in the animal's daily energetic overhead (amount of increase would depend on body surface area, insulation, and water temperature). This increase in the animal's energy budget may effect its survival and fecundity. Given the natural variability in seals' haul-out behavior, and assuming a reasonable number of samples, the model would calculate the likelihood of being able to detect a 5%, 10%, 20%, 50%, etc., increase in time in the water, or more useful still, an increase in the seal's metabolic rate. If the model determined that the likelihood for detecting even large changes in one of these parameters through research was *small*, scientists and managers may place a low priority on such field studies. Conversely, if the model indicated that the probability of detecting such changes through research was *high*, then field research to investigate these types of responses to disturbance may be merited.

The use of this initial modeling approach does not address the uncertainty regarding whether shifts in behavior and physiology would ultimate effect population levels, as animals may compensate for these effects. But, having identified a likely mechanism of impact through modeling, multi-year studies could be better designed to establish links between individual behavioral responses, physiological responses, and population rates with the goal of reducing this uncertainty.

Modeling may indicate that natural variability is high and that the ability of scientific studies to detect changes is consistently low. Such findings would reconfirm the inherent uncertainty in any ecological study where species are responding to numerous factors simultaneously. Still, these findings may be useful in the context of a precautionary approach, where managers seek to reduce the chance of concluding that vessels have no effect when indeed an effect does occur, an approach supported by the U.S. Congress with respect to threatened and

endangered species [House of Representatives Conference Report No. 697, 96th Congress, Second Session, 12, (1979)].

MB-4 Monitoring of Populations. Routinely monitor marine mammal and bird populations, focusing on species most likely to use areas frequented by cruise ships (see MB-2), and keep abreast of research that evaluates changes in populations in response to natural variables (i.e., not due to anthropogenic disturbance).

4.0 Human Sociocultural Environment

4.1 Introduction

This section concerns possible impacts of increased levels of cruise ship visitation on the human sociocultural environment of Glacier Bay National Park. The Glacier Bay Science Advisory Board identified three main topic areas for its sociocultural review: cultural resources, visitor experience, and local and regional socioeconomics. The Board's review and findings for these topic areas is presented below. The Board recognizes that there are other potential sociocultural impacts of cruise ship visitation levels. These would include impact to the general cultural existence value of Glacier Bay National Park as a pristine ecosystem; Americans who may never visit Glacier Bay have an interest in its condition. Similarly, the Board did not pursue general sociocultural, political or economic implications of the rapid and continuing increase in cruise ship tourism on society, culture and economy.

For each of the three topic areas, the Board reviewed existing impact literature and applied findings to cruise ship visitation in Glacier Bay. The review dealing with impacts on cultural resources relied on the excellent material presented in the FEIS, Board scientists' long research experience with the Huna Tlingit, as well as discussion with other social scientists who have a general expertise with Native culture in Southeast Alaska and social scientists who have significant experience with the Huna relationship with Glacier Bay and Huna Tlingit natural resources issues, and relevant literature.

The review of visitor experience relied heavily on the lead scientist's expertise and familiarity with relevant literature concerning sociocultural aspects of large scale tourism and her recently completed field research on impacts of tourism in Southeast Alaska communities, which included a Hoonah case study (Cervený 2004). A literature review was conducted related to visitor experience and planning methods used on state and federal lands to manage different visitor populations (Appendix F). In addition to the literature review, the lead scientist contacted representatives from the Alaska visitor industry. The visitor experience section was peer reviewed by scientists with expertise in this area and was improved by incorporation of reviewer comments.

The socioeconomic portion of this section identifies key issues that need to be considered regarding local and regional socioeconomic effects, but a complete analysis of economic impacts was beyond the scope of this report. The Board recommends that an economist assist in identifying detailed informational needs, recommending appropriate economic models to apply for analysis of Glacier Bay, and suggesting efficient methods of collection of economic data. The socioeconomic section of this report benefited from a partial peer review from an economist specializing in recreation and tourism on public lands. In addition, contacts were made with several local officials and tourism providers in Southeast Alaska to discuss economic implications of increases in cruise ship visitation.

Many of the issues discussed in this section overlap with topics discussed in the sections concerning the physical and biological environments. For example, noise effects and air emissions from cruise ships (addressed in Section 2.0) have implications for visitor experiences. Biological impacts could affect subsistence⁷ use of Glacier Bay's natural resources by Huna Tlingit hunters, fishers and gatherers. In addition, cruise ships may impact wildlife behavior and affect the experiences of visitors engaged in wildlife viewing.

4.2 Cultural Resources

This section addresses potential implications of increased cruise ship volume on the National Park Service's identification and management of the Park's cultural resources and on the representation of Huna Tlingit historic and cultural ties with the Glacier Bay ecosystem.

The FEIS discusses the enabling legislation that established Glacier Bay National Park and Preserve and directs its management. The presidential proclamations that created and expanded the monument in 1925 and 1939 emphasized protection of the geophysical features of Glacier Bay. The Alaska National Interest Lands Conservation Act of 1980 expanded the protected area, established National Park designation, and provided guidance concerning park management. This guidance, along with direction in the Organic Act, concerns "conserving... natural and historic objects" and "preserving... nationally significant... historic, archeological...[and] cultural...values."

Taken together, the Park's enabling legislation provides authority to manage human use of the Park consistent with the conservation and preservation of its cultural resources. These resources may include archeological sites and traditional cultural properties as well as the ethnographic association of the Huna Tlingit with the land and natural resources within Park boundaries.

This evaluation of the science and management considerations associated with cruise ship activity in the bay provides the opportunity to begin to address the evolving view of the relationship of Native people with Glacier Bay National Park and Preserve. Park management has begun to appreciate the close ties of the Huna Tlingit with their Glacier Bay ancestral homeland and to acknowledge the Tlingit history and rich ethnography of Glacier Bay. This Tlingit involvement in Glacier Bay predates designation of the Glacier Bay conservation unit, and Tlingit cultural ties to the bay remain strong and active. Recognizing and protecting this Tlingit heritage is a purpose of the Park.

⁷ The word "subsistence" as used in this report refers to the pattern of use of fish, marine invertebrates, wildlife, birds, and plants for sustenance and for social and cultural purposes by the Huna Tlingit. The customary and traditional uses of these species groups is a priority use on Federal lands and waters under the Alaska National Lands Conservation (ANILCA) Title VIII of Act of 1980, *Subsistence Management and Use*, except on any portion of Federal public lands which was permanently closed to such uses on Jan. 1, 1978. Because Glacier Bay National Park lands and waters were permanently closed at that time, subsistence uses do not have a legal or regulatory priority in Glacier Bay National Park lands and waters under ANILCA.

Cruise ship and much smaller volume tour boat visitation has become the main way that visitors experience Glacier Bay. Together, these modes of visitation account for approximately 95% of total park visitation. Because of this overwhelming concentration of park visitation through cruise ships, Park Service's visitation management has become focused on this use of the park. How well cultural and ethnographic material is presented to this user population and how well the impacts of cruise ship visitation are managed will strongly affect the preservation and conservation of the Park's Native cultural resources.

4.2.1 Identification and Management of Cultural Resources within the Park

Key Management Questions

How might increased cruise ship presence affect identification and management of cultural resources within Glacier Bay?

What is the direct physical effect of increased cruise ship presence on the cultural resources of Glacier Bay?

Research Findings

The FEIS lists 32 archeological sites that have been catalogued in Dundas Bay and Glacier Bay. Additional sites may exist at other park locations along Icy Strait, the outer coast, Lituya Bay, and Dry Bay that are not likely to be affected by vessel management quotas reviewed in the FEIS. A thorough archeological survey of park lands has not taken place, and additional archeological resources are likely present within Park boundaries. Oral history information indicates the approximate location of a number of sites that have not yet been scientifically investigated. Furthermore, human habitation and subsistence processing sites in Southeast Alaska have generally been found close to coastal subsistence harvesting areas. Because of changes in sea level, isostatic rebound, and tectonic uplift, what were coastal sites may now be under water or high above existing beach areas. This has made identification of archeological sites and thorough cataloging of park archeological resources difficult. Scientific excavation and description of sites has been limited.

The FEIS identifies 15 places that may qualify as Traditional Cultural Properties (TCP) under the National Historic Preservation Act (NHPA).⁸ Considering the extent of use of the area by the Huna Tlingit, this listing likely does not encompass all of the sites within the Park that may qualify. TCPs may include sites with archeological remains—habitation sites, hunting and food processing sites, and graves—as well as sites of cultural significance not associated with archeological remains. Existing ethnographic documentation and Tlingit oral history indicates that most coastal areas of the park were used, during ice free conditions. Preliminary compilation of Tlingit names for areas

⁸ National Register Bulletin 38 (1990) provides guidelines for listing TCPs; King (2003) provides a more recent discussion of how TCPs have been listed under the NHPA and how Federal agencies have managed listed TCPs.

within the park and collection of stories concerning specific locations provide information that may result in further sites qualifying as TCPs. The Huna Tlingit have recorded approximately 250 Tlingit place names for features within Glacier Bay National Park; additional ethnographic work with Tlingit in Hoonah and Yakutat and with elders of the Chookaneidi, Dakdeintaan, Kaagwaantaan and Wooshkitan clans from other communities will likely yield additional names. Collection of oral history, cultural stories, and sacred or mythic accounts for the Glacier Bay park area are fragmentary at the present time (see Emmons 1991, Swanton 1909, Suttles 1990, for overview information on Tlingit society and culture).

Tlingit culture includes a developed conception of property or 'at' oow'. Traditional property includes land areas, streams and fishing banks, houses, as well as the symbolic property of songs, regalia, emblems, and names. Most significant property belongs to clans, clan house units, and communities or kwaan. Tlingit culture's well developed concept of 'at' oow' differs from western concepts of ownership and generally refers to rights and obligations connected with 'at' oow' rather than property that may be bought or sold in a market. Clan territories, fish and wildlife harvesting and processing sites, house sites, burial sites, as well as sites where notable historic or mythic events took place, could all be 'at' oow.' Many traditional Tlingit geographically referenced properties or 'at' oow' may qualify as TCPs (see Dauenhauer 1987 and 1994 for a discussion of 'at' oow').

The FEIS adequately summarizes the written documentary sources of information available at the time of its preparation. However, some important written sources have been completed since the FEIS was prepared. Recent work includes the more complete listing of Tlingit place names for Glacier Bay that has been prepared by the Huna Indian Association (Moss 2005) and the cultural and archeological investigations in the lower bay that have showed close alignment between the last glaciation and its retreat with Tlingit oral history of displacement from and reoccupation of Glacier Bay (Montief and Conner 2004).

Furthermore, although the FEIS refers to important oral history material (Dauenhauer 1987, 1994), it gives greater emphasis to written historical material from published sources, than to Native oral history and orally transmitted accounts. Additional cultural and historical material may exist in unpublished form at the Huna Indian Association, Huna Heritage Association, and other organizations. Oral accounts including stories and songs, many of which may be 'at' oow' of Hoonah clans, may be the main and most important sources of information concerning Tlingit history and ethnography concerning Glacier Bay. Within Tlingit society these oral histories and their presentation at ceremonial occasions, and not the written record, continue to be the authoritative accounts of Glacier Bay. Better use should be made of the indigenous material in understanding the Tlingit history of Glacier Bay.

Depending on site location, increased cruise ship traffic would probably not physically degrade known and likely archeological sites or TCPs in the Park. Most sites and properties are located on the coast. Waves, storms, extreme tides, glacial sedimentation,

landslides, ecological succession, and other natural events may alter archeological sites or Traditional Cultural Properties. Scaled against these natural forces, the physical impact of cruise ships on sites and properties is expected to be limited. The physical effects of cruise ship wakes, soundscapes, air and water emissions may be minor. Some Huna Tlingit perceive that stack emissions may have deleterious effects on mountain goats and other resources used for subsistence. Increased cruise ship traffic may also have an effect on the cultural use of sites, particularly if they are in use for traditional ceremonies, clan educational activities or subsistence harvesting.

Information Needs

Glacier Bay National Park and Preserve has neglected to undertake a thorough examination of Park cultural resources. Surveys and listings of archeological sites and of potentially eligible Traditional Cultural Properties with the Park are incomplete. No Cultural Landscapes Inventory has been conducted for Glacier Bay. Without knowledge of archeological sites and potential TCPs within Glacier Bay, assessment of impact on these cultural resources is problematic. Work is not presently scheduled that will address these areas of lack of knowledge.

The Board recommends that the Park take immediate steps to fill the significant gap in its inventory of the location and status of its cultural resources and to ensure their proper management. The following tasks are recommended:

1. All archeological sites and potential TCPs should be identified. Any sites found to be sensitive to physical disturbance from cruise ship traffic should then be listed in a Cultural Resource Management Plan. Cultural and subsistence use of archeological sites and TCPs may be adversely affected by increased cruise ship traffic. If necessary, management direction should minimize physical disturbance to identified sites, as well as disturbance to cultural and subsistence use.
2. Some Huna Tlingit perceive that stack emissions may affect mountain goats and other resources used for subsistence. This issue and other pollution concerns should be investigated and resolved.

Management Recommendations

1. It is recommended that Glacier Bay National Park and Preserve develop a thorough Cultural Resources Management (CRM) plan to adequately understand, protect, and represent park cultural resources. Because most of the cultural resources in the bay concern Huna Tlingit history, occupancy, subsistence use, and mythology, the Hoonah Indian Association should be a partner in developing the Cultural Resources Management Plan.

As part of a Cultural Landscapes Inventory or the equivalent, a comprehensive archeological survey, likely guided by Huna oral history, should be undertaken before sites are effectively lost. As part of this inventory or as an independent

effort, Traditional Cultural Properties should be identified and proposed for listing under the National Historic Preservation Act.

The CRM plan would comprehensively identify and describe park cultural resources and provide management guidelines. The CRM plan could direct National Park Service to develop interpretative materials that accurately (and hopefully interestingly) portray the cultural resources of the bay.

The CRM plan may find that modification of cruise ship visitation will be needed to avoid impact on some TCPs and to allow certain traditional cultural activities to take place. Examples could include traditional ceremonial sites, story telling sites, or subsistence activities where cruise ship presence could interfere with cultural events.

4.2.2 Huna Tlingit Relationship with Glacier Bay

Key Management Questions

How might increased cruise ship presence affect the representation of Huna historic and cultural ties to Glacier Bay.

Research Findings

The FEIS reviews the limited existing ethnographic information concerning Tlingit culture, society, and involvement in Glacier Bay. Unfortunately, a thorough ethnographic description and analysis of the Huna Tlingit and their association with Glacier Bay has not been undertaken.

Frederica deLaguna's *Under Mt. Saint Elias* (1972) concerning the Yakutat Tlingit and their territory provides an example of a reasonably complete ethnography. This work was based on careful interviewing of Yakutat Tlingit and may be seen as a meticulous compilation of traditional Tlingit knowledge. Academic researchers, government agencies, as well as the Yakutat Tlingit themselves, regularly use this work as a reference text concerning northern Tlingit adaptation and traditional use of land and resources.

Similar detailed ethnography concerning the Huna Tlingit and their territory would provide excellent baseline information concerning the Huna Tlingit cultural resources associated with Glacier Bay. Without this level of thorough description, assessing the potential impact to Tlingit cultural resources is also problematic. Ethnographic work is not underway at this time to provide the needed documentation of Tlingit involvement in Glacier Bay.

Relying heavily on oral histories, Native cultural traditions are threatened by the passage of time. At the time of the enabling legislation that established what is now Glacier Bay National Park in 1925 and the legislation that expanded its boundaries in 1939, Glacier Bay was very actively utilized by the Huna Tlingit. After years of exclusion, however,

there are many fewer Tlingit who have had the opportunity to learn the Tlingit story of Glacier Bay first hand on site. Much of this Tlingit story remains accessible in the oral histories, songs, and emblems of the Huna Tlingit clans, however, this is a threatened cultural resource. The point of this discussion is that Tlingit cultural resources may require management actions to insure their preservation. Just as Tlingit cultural resources could be lost through inattention and the passage of time, they may be maintained and strengthened through sound management.

The rapid expansion of tourism in the park and the emphasis on a ‘story of Glacier Bay’ that focuses on geophysical and biological processes has tended to devalue and diminish Huna cultural presence in the bay and to under represent Huna history of occupation and subsistence use of Glacier Bay.

There are understandable historical reasons for this emphasis. The original withdrawal of the land and water that would be designated as Glacier Bay National Monument and later as Glacier Bay National Park was made to recognize the very special glacial recession and geophysical properties of the bay. The Huna Tlingit were not strong parties in deciding issues concerning the withdrawal; except for assimilated Tlingit tribal members, the Huna Tlingit were not recognized as citizens until 1924. Their interests were represented by the Bureau of Indian Affairs. Catton’s (1995) administrative history of the park documents the continuous efforts of the Huna Tlingit to work with Federal managers to gain recognition of their tie to the bay. The early policies of exclusion of the Huna Tlingit from the bay and the lack of acknowledgement of their tie to the bay were consistent with national policies aiming at assimilation and acculturation of Native Americans. Thankfully, national direction concerning Native Americans has changed.

The Huna Indian Association has voiced its opposition to increased cruise ship visitation to Glacier Bay, and a number of Hoonah residents have expressed concerns in passing to the lead scientist. The tribe and its membership may believe that important cultural and spiritual issues are at hand with the possible increase in cruise vessel traffic in Glacier Bay. These issues may include respect for glaciers and sites of spiritual significance to the Huna Tlingit, diminution of cultural involvement of the Huna Tlingit at sites important to the tribe, some of which may be eligible for Traditional Cultural Property listing, and progressive disenfranchisement of the Huna Tlingit from their cultural homeland. Some Huna Tlingit ‘at’ oow’ and practices concerning provision of wild foods from clan areas now within Glacier Bay may have protection under the American Indian Religious Freedom Act of 1978 and related legislation. Other issues mentioned concern impacts to fish and wildlife important for subsistence and increases in permitted land and water use activities that are not in accord with traditional Tlingit values. These issues have also been raised in meetings and hearings concerning Glacier Bay management.

The presentation of the Huna Tlingit historical and cultural ties to the bay to Glacier Bay visitors is not well developed or authoritative. The park has supported carving of a traditional canoe that is on display at Bartlett Cove, and National Park Service interpreters now provide some information on Tlingit culture and history to cruise ship

visitors. A cultural center at Bartlett Cove has been in the planning stage for some time. Some cruise lines, including Holland America Line, have funded Tlingit interpreters through Huna Heritage Foundation and other organizations. This includes presentation of educational material concerning Native use of the bay and its resources. Visitors, however, may continue to find available material limited. A recent ranking of National Parks by *National Geographic Traveler* (Tourtellot 2005) gave Glacier Bay National Park a lowered rank (scored 13-15th among the top 16 parks in Canada and United States) because “the native Tlingit story of 9,000 years of adaptation is not being told.” A Canadian park in the Queen Charlotte Islands was ranked first, largely because of its effective portrayal of Native culture.

The FEIS suggests that the increased levels of cruise ship tourist visitation have had deleterious effects on the Huna Tlingit’s cultural ties to Glacier Bay. Clearly, cruise ship tourism has become the dominant human activity in the bay, at least in terms of persons visiting the bay. Huna Tlingit presence in the bay occurs at very low levels, perhaps too low to maintain cultural continuity with the area identified by the FEIS as the Hoonah homeland.

As cruise ship visitation has become the main way that visitors experience Glacier Bay, cruise promotional and interpretive materials provide the main vehicle for telling the full cultural and human story of Glacier Bay. The park’s shift in emphasis to include more of the rich Native heritage of the bay and cruise lines presentation of cultural material will be important elements in recognizing, maintaining, and enriching the cultural resources of the park and in acknowledging the park’s Native American heritage.

Nationwide, the National Park Service has been entrusted with the management of many cultural and historical parks and has shown its professional ability to preserve and protect cultural resources while managing visitation. At least some of the cultural and historical parks pursue active co-management strategies through which Native Americans whose territory is now part of a National Park are able to participate and direct management of their cultural resources.

Information Needs

The Vessel Management Plan provides an opportunity to refocus the park’s attention and actions with regard to interpretation of its cultural resources. Adequately addressing Huna Tlingit cultural and historic ties to Glacier Bay may require developing different goals and objectives for the park from those that have guided its management since the enabling legislation events of 1925, 1939, and 1980. Essentially, this would mean revising the “story of Glacier Bay” from one where the main emphasis is on geophysical processes to one that includes the rich archeological, historic, and contemporary relationship of Native peoples with Glacier Bay land and resources.

To more fully embrace, document and interpret the rich history of Huna Tlingit habitation and relationship with Glacier Bay, the Science Advisory Board recommends:

1. The National Park Service support an in-depth ethnographic description focused on the Huna Tlingit and their relationship with Glacier Bay. Such a work would provide lasting documentation of Huna Tlingit culture similar to that provided by de Laguna's *Under Mount Saint Elias* for the Yakutat Tlingit.
2. A field study be undertaken to verify and better understand the cultural and spiritual concerns with cruise ship vessel traffic in Glacier Bay. This study would conduct interviews with tribal council members and with clan elders who are responsible under traditional Tlingit law and practice to represent the interests of their clans. The study objective would be to more fully describe Huna Tlingit concerns with cruise ship visitation, assess the level of likely impact, and mitigate impacts if feasible. Cruise ship visitation levels would need to be rethought if impacts were shown to result in a likely impairment of cultural resources.

Management Recommendations

1. It is recommended that Glacier Bay National Park consider revising or amending its general management plan and the plan's objectives and actions to more formally include preservation of Native cultural resources as a purpose of Glacier Bay National Park. Development of a revised or amended plan should include Hoonah Indian Association government representatives and tribal clan leaders.
2. It is recommended that Glacier Bay National Park improve and expand the interpretation of the Huna Tlingit cultural history and contemporary use of park areas it provides to visitors. Further, that the park encourage more accurate and complete interpretation by concessionaires through concession negotiations and awards.

4.3 Visitor Experience and Wilderness Resources

This section deals with the impacts of cruise ships and the potential increase of 32 percent in cruise ship activity on the experiences of Park visitors and the use of wilderness areas and resources. In shaping a policy decision that determines the level of cruise ships allowed to enter Glacier Bay, it is important to identify the natural and social conditions considered acceptable or appropriate for visitors of various kinds and in various spatial and temporal settings. An increase in cruise ship entries will have immediate implications on Park settings. The effects of this policy decision will impact different visitor groups in various ways and to different degrees.

By establishing a baseline for acceptable Park visitation conditions, it will be possible to predict the effects of changes in those conditions with respect to cruise ships. This requires understanding visitor motivations, expectations, activities and experiences in Glacier Bay. Directed research is needed to establish an understanding about desired Park conditions and the levels of change that would be acceptable to various visitor segments. It is problematic to recommend increases in cruise ship entries without considering the current effects of cruise ships on Park visitors.

Many frameworks exist to help understand the implications of change on natural and social conditions within a national park setting, and to judge the extent to which these changes are acceptable. The “limits of acceptable change” (LAC) framework is especially useful for dealing with conflicting recreation goals and behaviors in wilderness settings, where managers must balance the management of recreation uses and maintenance of natural conditions (Stankey, et al. 1985; McCool 1996; Cole and McCool 1997). The LAC frameworks establish indicators and standards of acceptable natural and social conditions and develop a strategy for protecting those conditions. Social “indicators” are measurable variables that define the level of resource protection and the type of visitor experience desired. By identifying and monitoring the selected indicators, resource managers can evaluate when established standards of quality have been met, altered, or exceeded. An LAC framework could be employed to understand visitor tolerance to changes in physical and social conditions in Glacier Bay. Planning tools such as Visitor Impact Management (VIM) (Graefe et al. 1990), and Visitor Experience and Resource Protection (VERP) (Manning et al. 1995) refine the concept of social carrying capacity for use in managing park visitors.

These frameworks help park managers determine when and how often it is appropriate for visitors of various types to encounter cruise ships in the park and under what social and biophysical conditions cruise ships are deemed acceptable. With this information, park managers can make informed decisions about an acceptable level of cruise ships and the ramifications of this policy decision on park users.

Section 4.3 was developed based on a review of scientific literature dealing with visitor experiences and wilderness resources, and reports dealing with visitor management and monitoring. The literature review looked at existing empirical research that deals with the potential effects of cruise ships on visitors to national parks and protected areas (Appendix F). Several telephone contacts were made with key informants in the Alaska tourism industry. These conversations helped to raise awareness among Board members of issues pertinent to Glacier Bay and guided subsequent efforts to construct a research framework for considering visitor experiences in Glacier Bay.

4.3.1 Cruise Ship Sightings

Key Management Questions

How do cruise ship sightings in Glacier Bay affect the experiences of park visitors?

How might an increase in cruise ship sightings affect the experiences of park visitors?

Research Findings

Addressing the key management questions requires an understanding of what visitors seek when they come to Glacier Bay. Visitors to Glacier Bay have different goals, motivations, and expectations for the park conditions they encounter and the experiences they desire. These expectations may be based on marketing materials, information

provided by park managers, or preconceived notions about what conditions are appropriate in a national park setting or what is commonly expected in Alaska. To some extent the type of experience visitors encounter is reflected in the type of trip they have planned to Glacier Bay, whether it is a guided commercial kayak tour, a solo backcountry camping expedition, or day-boat excursion.

Several studies report the motivations of visitors to Glacier Bay. Backcountry user studies from 1978 showed that the most important factors related to enjoyment of the backcountry experience were: opportunities for wildness, viewing glaciers, and solitude (Johnson 1979). In a 1984 study, glacier-viewing topped the list, followed by wildness opportunities, and seeing wildlife (Salvi and Johnson 1985). Tour vessel passengers noted similar motivations, with somewhat less emphasis on wildness and solitude. A 1989 study of tour vessel visitors found that the three most important motivations for coming to Glacier Bay were: viewing glaciers, viewing wilderness scenery, and viewing wildlife (Johnson 1989). These same three variables topped the list in a 1999 study of Bartlett Cove visitors, which included both backcountry users and tour vessel guests (Littlejohn 2000). Of somewhat less importance to respondents in both the 1989 and 1999 studies was the idea of experiencing wilderness in Glacier Bay, demonstrating the secondary importance of these wilderness attributes for tour and charter vessel guests.

Visitors will tolerate changes to their desired environment in Glacier Bay to different degrees. What is an acceptable number of cruise ship sightings to one visitor group may not be to another. Most visitors (87 percent) to Glacier Bay are first-time visitors (Littlejohn 2000). These first-timers may lack preconceived notions about cruise ship encounters during their trip. They will not have a previous visit with which to compare their experiences and likely use their first visit as a baseline for measuring the quality of future trips.

The frequency, duration, and quantity of cruise ship sightings may play a role in shaping a visitor's satisfaction with the Glacier Bay experience. Thus, the ultimate number of cruise ships entering the park may be less important than the distribution of those ships in time and space. Two ships arriving simultaneously may or may not have more of an impact on visitors than ships on a staggered schedule. The degree of impact may depend on a variety of factors, including size of the tour vessel and the itinerary of the vessel viewing the cruise ship. The Vessel Quota policy currently permits at least one cruise ship to enter Glacier Bay on every calendar day from June 1 to August 31. In 2004, there were two daily cruise ship arrivals for three days each week. The proposed increases would permit a maximum of two ships daily.

Existing visitor studies conducted in Glacier Bay provide an overall impression of visitor encounters with cruise ships and the effect of these encounters on their experience of Glacier Bay. These studies measured overall impressions of backcountry users (Johnson 1979; Salvi and Johnson 1985; Littlejohn 2000) and tour vessel passengers (Johnson 1989; Littlejohn 2000), allowing some comparisons among these visitor segments. They provide the only known research that has dealt with visitors perceptions of cruise ships. No published studies have measured impressions of cruise ship passengers related to the sightings of other cruise ships in Glacier Bay, or in any other setting.

Tour vessel users. The studies indicate that tour vessel users are more tolerant of cruise ship sightings than backcountry users. In a 1989 survey of day-boat passengers, 41 percent preferred to see no ships or fewer ships than they actually sighted, while 25 percent said the level sighted was about right. Among guests interviewed, 61 percent saw at least one ship during their visit to Grand Pacific Glacier. The actual effect of seeing these ships was mixed. While 20 percent said the ships detracted from their experience, 23 percent felt that it added to the quality of their visit, and most were neutral. Thus, while a substantial proportion of tour vessel passengers preferred not to see cruise ships or to see fewer ships, the actual sighting of ships did not detract from the visitor experience for 80 percent of visitors traveling on tour vessels in 1989 (Johnson 1989).

A 1999 study of park visitors confirmed these trends (Littlejohn 2000). For tour, charter, and private vessel passengers, 78 percent saw at least one cruise ship daily and 24 percent said it detracted from their experience. When queried about what aspects of cruise ship sightings detracted from the experience, issues mentioned included noise, air emissions, and visual impacts.

A mechanism used in the 1989 study provides an interesting measure for understanding the level of cruise ship sightings tolerated (Johnson 1989). The study showed that the 'pleasantness' of the Glacier Bay experience declined for tour vessel passengers, with an increase in sightings of other vessels, particularly cruise ships. Data showed that seeing no (zero) ships was considered 'pleasant' to passengers. Seeing one ship was neutral, but more than one sighting of a cruise ship during a visit to Glacier Bay was progressively unpleasant. Similar results were found for sightings of other vessels, such as tour boats, charter boats, and others. (Only kayak sightings maintained a roughly even level of 'pleasantness' with increased sightings, suggesting that respondents found kayak groups congruous with the setting.) This is an important finding for our understanding of tolerance to cruise ship sightings. These data suggest that more than one ship sighting creates an unpleasant experience for tour vessel passengers. No similar data exist for other park visitors; such data would be useful to understand reactions of all visitor segments.

Backcountry users. Studies of backcountry users in 1978, 1984 and 1999 depicted several notable trends related to cruise ships, suggesting that backcountry users are sensitive to cruise ship sightings. Backcountry campers least preferred seeing cruise ships during their trip compared to other types of vessels. In 1978, 45 percent of backcountry campers preferred to see no or fewer cruise ships during their trip. Another 42 percent said the amount of cruise ships was 'about right.' In 1984, 52 percent of campers preferred to see no or fewer cruise ships, while 36 percent felt that cruise ship viewings were about right. In 1984, many campers (69 percent) cited disturbances to their visitor experience related to watercraft or aircraft. Craft viewed as most disturbing to backcountry campers were small airplanes, cruise ships, and tour vessels. Among backcountry users surveyed in 1999, 78 percent saw at least one ship daily (Littlejohn 2000). Of these, 44 percent of backcountry visitors indicated that seeing cruise ships detracted from their experience.

Comparison between tour vessel passengers and backcountry users in 1999 shows that backcountry users are particularly sensitive to cruise ship sightings. While of high quality and rigor, these studies of backcountry users are more than 20 years old. New data is needed to understand the effects of cruise ship sightings on backcountry users, especially given changes in the number and size of cruise ships since 1984, and changes in speed restrictions, travel corridors, and access to biologically sensitive areas.

Information Needs

1. Current visitor surveys are needed to understand *visitor motivations* for traveling to Glacier Bay and expectations for the type of experience desired among a variety of park users. Existing research examines visitor motivations and expectations through 1999. Periodic visitor monitoring efforts will help to understand changes in visitor motivations and expectations for Glacier Bay. These baseline measures are important for understanding how the presence of cruise ships may affect visitor expectations.
2. Current data is needed to understand the *effects of cruise ship sightings* on the visitor experience for each visitor segment to Glacier Bay, including other cruise ship passengers and backcountry users. Data are needed to measure the extent to which cruise ship sightings added to or detracted from (disturbed) the visitor experience. New data could be compared with earlier research to develop an historical perspective. Information is needed about the effects of cruise ship sightings among variously-sized ships, as well as sightings of different duration, frequency and level, and the presence of other vessels (including other cruise ships) in various park settings. It is recommended that the 1989 methodological approach to measuring the effects of cruise ship sightings on the pleasantness of the visitor experience be repeated for all visitor segments. These levels, when compared over time can help to establish standards of quality for cruise ship sightings among various visitor groups.
3. Data is needed to understand the *acceptability of cruise ship sightings* among various visitor segments, including backcountry users, tour vessel visitors, and passengers on charter and private vessels, as well as cruise ship passengers. These data would help to develop an understanding of social and individual norms associated with cruise ship sightings in Glacier Bay. Information is needed about the acceptability of cruise ships sightings among ships of various sizes, as well as the duration, frequency, and number of sightings, and the presence of other vessels in various park settings. Respondents also may be queried about the acceptability of other factors shaping the park setting.

Management Recommendations

1. Empirical data shows that visitor satisfaction may decline as the quantity, frequency, and duration of visitor encounters increases. This is particularly characteristic of backcountry users, who typically desire a more primitive or remote park experience. If the proposed research demonstrates significant

negative effects among visitor groups, the Board recommends that periodic opportunities be provided during peak season for visitors to experience the park with zero, one, and two ships daily.

4.3.2 Crowding, Congestion and Displacement

Key Management Questions

To what extent do Glacier Bay visitors, including backcountry users, perceive areas of the park to be crowded or congested?

How might an increase in seasonal use days of cruise ships affect perceptions of crowding and congestion in both designated Wilderness and non-wilderness areas?

How might a potential increase in seasonal use days of cruise ships affect the geographic distribution of park visitors?

Research Findings

Crowding is a concept in which the number or type of persons (or vessels) encountered in a natural area exceeds one's personal standard. *Congestion* refers to the physical conditions that take place during high density use, such as a lack of space for a vessel to travel, stop, or turn around safely (Lime et al. 1996). Crowding and congestion in parks and recreation areas often occurs when visitor volumes increase and there are limited points of access, narrow transportation corridors, confined areas, or places of high visitor interest. Park management guidelines promote the provision of "quality, uncrowded visitor experiences" (NPS 1984:16). The quotas and travel restrictions established in 2003 limit the total volume of vessel traffic as a way to preserve a quality visitor experience.

A significant body of research suggests that when recreation users perceived crowding, there may be an associated decline in the quality of the visitor experience (Manning 1985). For certain recreation activities in national park and protected areas, there often is an inverse relationship between crowding and quality of experience (Ditton et al. 1983). Crowding is a relative concept. The degree of perceived crowding and the subsequent effects of that crowding on the quality of the recreation experience may vary widely among various types of recreation users, groups of various sizes, socio-demographic characteristics, site features, mode of transportation, and many other variables (Ditton et al. 1983). These types of variations have been well-documented in a variety of settings and activity types, such as backpacking, rafting, boating, and others (Manning 1985).

Displacement is defined as a process in which people move away from places that are changing in ways they consider to be unacceptable (Anderson and Brown 1984; Becker 1981). Visitors stop using a recreation site or destination because the shift in activities or conditions are no longer acceptable to them (Hall and Cole 2000). Displacement can be seen as an indicator that crowding is occurring in parts of the park. Research has shown

that displacement is a coping mechanism for crowding or conflict among resource users, and that it can lead to situations of stress and a decline in the visitor experience (Manning and Valliere 2001). Displacement can be measured by surveying park users and tour operators and studying routes of tour operators and visitors over time.

The presence of cruise ships and other vessels may contribute to perceptions of crowding or congestion at tidewater glaciers along the cruise ship route, where cruise ships and tour vessels congregate. Variation in vessel volume at highly desirable sites occurs throughout the day, depending on cruise ship schedules and timing of sunset, sunrise, or weather conditions. Comments in previous visitor studies suggest that visitors on tour vessels observed crowding near glaciers (Johnson 1989; Littlejohn 2000). In addition, tour operators interviewed for this report mentioned that the presence of cruise ships and other vessels at tidewater glaciers diminished the viewing experience for their guests and led to perceptions of crowding. They also mentioned the necessity of moving to less crowded areas to preserve the quality of the visitor experience. Backcountry users surveyed in 1984 did not indicate a high level of crowding, with 63 percent saying that the park was 'not crowded' which was consistent with findings in 1979 (Salvi and Johnson 1985). However, 64 percent of backcountry users surveyed felt that the number of watercraft and aircraft sighted is a 'strong' or 'great' contribution to their perception of crowding. An increase in seasonal cruise ship quotas may increase the frequency of perceived crowding.

Some park visitors may be displaced by crowding, particularly in popular areas visited by cruise ship and other vessels. Displacement of visitors can lead to competition for spaces and user conflicts among tourism providers and visitors seeking opportunities for solitude in Glacier Bay. An increase in cruise ship levels may cause tour operators to shift itineraries over time, leading to a potential increase in user conflicts in more remote areas of the park, and perhaps contribute to a loss of perceived solitude in wilderness and non-wilderness areas. Commercial guides may be spending more time with guests in remote areas in search of wilderness values. This displacement of visitors can lead to competition for spaces and a decline in social conditions in wilderness areas of the park. Although cruise ships are absent from wilderness waters, their presence may be felt by backcountry users indirectly.

No existing research has investigated crowding or density issues in association with cruise ships. In particular, no such research exists that explores density issues associated with cruise ships in marine parks or protected areas. Thus, the effects of cruise ships on perceptions of crowding or congestion in natural areas are unknown. Because of the scale of cruise ships compared to other tour vessels, some of the findings and assumptions of the recreational crowding literature may have limited applicability. However, the methodological approaches used to study crowding could be adopted for use in Glacier Bay.

In particular, what is not known is the relation between ship size (scale) and perceived crowding, especially in areas with narrow fjords. It is entirely possible that one ship and a couple of smaller tour vessels could be considered enough to feel 'crowded' under these

unique physical conditions. Without conducting studies geared to developing indicators of crowding and congestion specific to Glacier Bay, there is no way of knowing what conditions and ship levels are conducive to crowding.

Information Needs

1. A study is needed to measure *perceived crowding* in various areas of the park and the effects of crowding on the quality of the visitor experience. The proposed study would investigate perceived crowding among various park visitors within sample areas that present a range of conditions and physical features to establish crowding norms. In addition to on-site data collection in Glacier Bay, this study also could incorporate a methodology used in other studies of crowding in recreation areas that asks respondents to comment on perceived crowding using hypothetical illustrations, such as digitally enhanced photographs that represent a variety of conditions. These data will allow managers to determine standards and indicators of *acceptable levels of visitors use* along portions of the cruise ship route and in designated Wilderness.
2. Ongoing monitoring of crowding can be conducted in concert with other visitor monitoring efforts to insure that crowding has not exceeded standards defined in the proposed research. Park concessionaires can provide data on a seasonal or annual basis about areas where crowding has been an issue. Monitoring should occur both in wilderness and non-wilderness areas of the Park.
3. User patterns in the Park also can be monitored for evidence of displacement. Park managers can provide data showing trends in backcountry permit applications and user patterns to analyze changes in visitor days in wilderness areas over time. Park concessionaires and visitors on private vessels can provide information about their planned routes and identify routing modifications based on perceived crowding. Concessionaires and independent visitors also can be asked to identify areas where visitor use has increased.

Management Recommendations

1. The Board recommends that studies on crowding, congestion, and displacement be undertaken to determine whether or not visitors perceive crowding and under what conditions this is occurring. If Park visitors perceive crowding under the current quota system, Park managers may want to weigh the benefits and costs of maintaining current levels to provide opportunities for visitors to experience the park under less crowded conditions. This research will provide baseline standards that reflect desired park conditions among visitor groups, in wilderness and non-wilderness areas of the park, with respect to vessel volumes in specific settings.

4.3.3 Visibility/Haze

Key Management Questions

How might a potential increase in cruise ship entries affect visibility for Glacier Bay visitors in all areas of the park?

How does perceptibility of haze affect the quality of the visitor experience in Glacier Bay in wilderness and non-wilderness areas of the park?

The National Park Service aims to perpetuate the best air quality possible to preserve natural and cultural resources and sustain visitor enjoyment. Cruise ships emit visible plumes while traveling throughout Glacier Bay, resulting in layered haze. Because plume haze is discharged higher into the atmosphere, through a stack, it produces an inversion layer often visible as a hazy band. The quality, consistency, duration, frequency, and level of these plumes varies depending on many factors, including the weather, topography, ship engine characteristics, ship size, and the presence and proximity of other vessels. Air quality issues are discussed in Section 2.4. This section deals with visitor perceptions of haze associated with cruise ships and its appropriateness in national park settings. Many questions need to be addressed related to the amount of visible haze and the effects on the visitor experience within all visitor segments. In addition, it remains unclear how an increase in cruise ship visitation affects characteristics of haze.

Research Findings

Clean air is one of the top four desirable qualities for national parks among visitors (NPS 1998). A significant body of research exists on the issue of visibility and air quality in national parks, including a major National Academy of Sciences study “Protecting Visibility in National Parks and Wilderness Areas” (1993). Scientists have conducted research to understand human perceptibility of haze and to determine thresholds for visibility of haze. Studies have used a combination of on-site data and digitally enhanced photographs of scenic vistas to determine perceptibility thresholds (Loomis et al. 1984; Mace and Loomis 1995). These studies concluded that visitors are sensitive to low haze levels.

Several studies have linked perception of haze with a decline in enjoyment of national parks. A study on haze in national parks showed that 80 percent of park visitors believed that clear air and visibility were extremely important to the quality of their recreation experience (NPS 1998). The value of visibility to park visitors can be measured in two ways – by looking at visitor preference for air quality conditions, or at their willingness to pay for certain conditions. One study showed that improving visibility at national parks would enhance the enjoyment of parks for 95 percent of respondents (Chestnut and Rowe 1990). Ninety percent of respondents were willing to pay something for visibility protection in national parks. Another study showed that when visibility in parks declined, visitors reduced time spent in the park and the number of visits (MacFarland et al. 1983). Other studies have shown that visitors who perceived conditions to be hazy enjoyed the parks less than those who did not (Schulze W.D. et al. 1983). One study showed

definitively that air pollution detracted from visitor enjoyment, drawing attention to the importance of air quality in national parks (Mace et al. 2004).

Before 2003, no visibility studies had been performed in Glacier Bay. Previous visitor studies identified air emissions from cruise ships as something that detracts from the visitor experience. Backcountry users mentioned air pollution as a feature of the park they found disturbing (Johnson 1984). Tour vessel passengers in 1989 mentioned that pollution from the ships detracted from their experience in the park (Johnson 1990). In the 1999, 20 percent of visitors said that stack emissions from cruise ships detracted from their experience in the park, while 79 percent said haze had no effect on them (Littlejohn 2000). Park officials have conducted monitoring efforts for opacity, reduction in visibility resulting from emissions, since 1990. However, there have been no systematic data collection efforts to understand how Glacier Bay visitors perceive visible air emissions from ships and the effect of seeing haze on the quality of their experience.

Information Needs

Research is needed to determine what amount of haze visitors find acceptable in various conditions and when perceived haze has exceeded acceptable levels.

1. Research should be conducted among various types of park visitors to establish *perceptibility indicators* for Glacier Bay under various conditions and settings, to determine sensitivity to haze among visitor segments, including backcountry users. Visitor perceptions can be linked with actual opacity readings. Of particular interest is whether there is a difference in haze perceptibility between one ship and two ships. Methodologies used in previous studies can be employed, that combine on-site measurements with digital images. Haze perceptibility should be explored in designated Wilderness and non-wilderness areas.
2. Research should be conducted to determine the *effects* of visible haze on the experiences of various types of park visitors, including backcountry users, who may be more sensitive to haze. These potential effects on enjoyment of the park should be analyzed by representatives from all five visitor segments to assess whether certain visitor groups are more sensitive to changes in visibility.
3. Ongoing monitoring of visitor perceptions of haze and the effects of haze on visitor enjoyment should be conducted to evaluate conditions both in designated Wilderness and non-wilderness areas of the park.

Management Recommendations

1. The Board recommends that the above studies be completed to develop visibility standards for park visitors under existing cruise ship quotas and to ascertain whether the volume of cruise ships affects the perceptibility of haze. Park managers may consider ways to provide opportunities to visit the park without visible haze. In addition, technological developments that reduce haze impacts should be rewarded in the concessionaire bidding process.

4.3.4 Noise Quality

Key Management Questions

How do Glacier Bay visitors currently perceive cruise ship noise in various areas of the park, including designated Wilderness and non-wilderness areas?

How does the perceptibility of cruise ship noise affect the quality of the visitor experience in Glacier Bay?

How might a potential increase in cruise ship entries affect the perceptibility of noise among visitors to Glacier Bay?

Research Findings

The National Park Services has stated their committed to the protection of a natural soundscape in the park. The Sound Preservation and Noise Management order directs park managers to protect, maintain, or restore the natural soundscape resource. Natural soundscapes are highly valued by visitors to national parks (Mace et al. 2004). The acceptability of sounds varies among listeners and their expectations for conditions.

Studies of visitors to national parks have shown that most visitors (91 percent) believe that enjoying natural soundscapes and quiet are compelling reasons to visit national parks (McDonald et al. 1995). The impacts of human-made sounds in natural settings depend on physical properties of the sound, characteristics of topography and climate, and characteristics of the human listener (Harrison et al. 1980). Harrison (1974) found that noise perception of recreation visitors varied, based on whether the visitor was involved in the noise-producing activity, was engaged in another recreational activity at that site, or was a bystander. Another study of four-wheel drive users, hikers, and picnickers found that increased noise levels resulted in a greater tendency for conflicts to erupt among users (Dellora et al. 1984). Research has shown variation among recreation users with different goals and behaviors. Backpackers were more sensitive to human-produced noises in a natural setting than were road-side campers (Kariel 1980).

Studies of noise from aircraft overflights showed that visitors to natural settings are sensitive to low levels of human-associated noises and that this noise detracts from the visitor experience (Mace et al. 2000). Noise effects can intrude on visitor enjoyment of a natural area (Cessford 2000). Studies on the psychology of noise perception show that the perceived meaning attached to a noise affects the degree of disturbance (Mace et al. 2000). In other words, noise from a military air flight over a natural area may have different meaning from that of a flight-seeing tour or a rescue plane. Individuals evaluate the appropriateness of various sounds for the natural setting. The ways these noises are interpreted are based on individual experience and personal values as well as desires to maintain certain conditions within a given setting.

Visitor studies have identified surface noise emanating from cruise ships as a factor that detracted from the visitor experience. Engine noise from the cruise vessel and announcements from the public address system have most often been identified as disturbances to the visitor experience. In the 1984 study of backcountry users, 90 percent of those who had said they were disturbed by watercraft found noise to be disturbing (Salvi and Johnson 1985). The 1999 study of visitors also raised the issue of noise from vessels. Among respondents 20 percent were disturbed by vessel noise (Littlejohn 2000).

Noise is a particular concern at popular stops along the main cruise ship corridor in the west arm of Glacier Bay, where noise from engines, generators, and the onboard interpreters on the public address system can be heard by passengers of nearby vessels. In the FEIS, several areas were identified that were associated with vessel noise, including Tarr Inlet, the entrance to Johns Hopkins Inlet, and the entire central channel route of the west arm, which is the primary route for cruise ships. Surface noise, particularly from the public address system, has been known to carry several miles (NPS 2003). Noise is of particular concern for visitors who desire wilderness qualities. Motorized vessels of all types reduce enjoyment of backcountry users, especially in non-motorized areas. By increasing seasonal use days, daily limits on some days would increase from one to two ships, increasing the duration in which human-made noises, such as public address systems and engine noise are audible in the park.

Information Needs

Research is needed to measure audibility of surface sounds associated with cruise ships to park visitors and the effect of ship noise on the visitor experience.

1. A study is needed to develop a model for understanding the perception of cruise-ship noise by park visitors. Data should be collected among all visitor segments. One model, the System for Prediction of Acoustic Detectability (SPreAD), was developed to understand characteristics of sound and their effect on recreation users in natural settings (Harrison et al. 1980) and could be adapted and applied to Glacier Bay. Data is needed from a sample of areas in the park, including designated Wilderness and non-wilderness areas, as well as proximate to and distant from the main cruise ship route.
2. Information is needed to understand how the perception of noises from cruise ships affects the quality of the visitor experience in Glacier Bay. This study could result in establishing the quantity and/or character of cruise-ship noise that is acceptable to various visitor segments. Once the levels of acceptability are established, standards can be created for use in future measuring and monitoring.
3. Ongoing monitoring of visitors is needed to insure that visitor standards for acceptable noises have not been exceeded.

Management Recommendations

1. Standard indicators of noise acceptability can be established through baseline research. It is recommended that if the Park considers increases in cruise ship visitation, it also consider measures that could be taken by cruise lines to ensure that the noise standards are not exceeded. For example, adaptations in the technology or use practices of the public address system could be made (e.g., use of earphones).

4.3.5 Scale of Ships

Key Management Questions

How do visitor encounters with ships of a larger scale affect the experience of park visitors?

How would an increase in cruise ship levels affect the nature and intensity of vessel encounters with vessels of increased scale?

Encounters between visitors on smaller vessels with large cruise ships may lead to some decline in visitor satisfaction among those visitors on tour vessels, charter vessels, and private vessels. Data from visitor studies conducted in 1984 and 1989 suggested that the size of cruise ships encountered detracted from the visitor experience. In addition, informal conversations with tour operators and feedback from recent park visitors on charter vessels suggest that the size of the ship encountered played a role in shaping the quality of the visitor experience.

Cruise ships take up some portion of the scenic viewshed in areas where they are traveling or idling. Non-cruise visitors must include the ship in their scenic viewing experience. Visitors on smaller vessels often time their arrivals and departures around the cruise ship schedules to avoid large wakes originating from the ship. Efforts avoiding the ship can cause some stress or anxiety among boaters under certain conditions. In some cases, avoiding the cruise ship and its high-wake zone adds travel time or physical exertion to the trip. Tour vessels that coincide with the passing of two cruise ships find their concerns about safety, navigation, and viewshed are doubled during these encounters. Furthermore, there may be different meanings or symbols assigned to larger vessels than smaller vessels encountered. The size of vessels also may contribute to perceptions of crowding (see Section 4.3.2).

Research Findings

There has been some research in recreation management literature on the effects of encountering parties of different sizes or scales. Stankey (1973) identified factors influencing carrying capacity perception and found that large party size of wilderness users have a negative impact on satisfaction of individual users, due to perceptions that the large group size may be inappropriate in a wilderness area, cause ecological damage, or contribute to feelings of crowding. It is problematic to transfer results of studies

conducted among backpackers to tour vessels, unless comparisons are being made between human backpackers and giants. A large party of hikers may not translate easily to the concept of a cruise ship, which is a means of transportation carrying a high volume of visitors in one vessel.

Data from earlier studies of Glacier Bay visitors provide an indication of the importance of scale. In 1984, 60 percent of respondents indicated that they had experienced some disturbance by watercraft during their trip. Of these, 26 percent mentioned that the size of the craft was disturbing. In the 1989 study of tour vessel guests, Johnson (1990) found that of those visitors who were disturbed by seeing cruise ships (10 percent), the size of the ship was the most disturbing aspect, although no explanation beyond this was provided to indicate what aspect of the ship size was most detrimental.

Johnson's visitor study in 1989 showed that passengers on tour vessels preferred to see kayaks rather than large tour vessels and cruise ships (Johnson 1990). Twenty percent of respondents indicated that seeing a cruise ship detracted from their experience, compared to 12 percent for sighting tour boats, 10 percent for sighting pleasure boats and 2 percent for sighting kayaks. This linear decline in percentage of respondents who perceived that sightings of vessels detracted from their experience suggests that the size of the vessel is an important variable. These findings suggest the need for data to understand visitor perceptions of vessels of different sizes and their effects on the visitor experience.

The issue of scale may be somewhat unique to Glacier Bay National Park, the only marine park in the U.S. that permits access to cruise ships. The size of cruise ships has increased over time (see Appendix A.). Visitor studies in the 1980s were conducted when ships carried fewer than 1,000 passengers on average. New ships being deployed by the cruise lines carry 3,000 or more passengers. As these ships are assigned to Alaska in coming years, the issue of scale in Glacier Bay is not likely to dissipate.

Information Needs

1. Information is needed to understand how visitors of various types react to encounters with large cruise ships. Survey techniques can elicit information about how visitors evaluate ships of different sizes and the effects of these sightings on their experience in Glacier Bay. Methods of equivalency may be used to determine how many tour vessels (as well as charter vessels, private vessels, and kayaks) are equivalent to the sighting one large cruise ship. Standards may be developed to understand special issues of crowding associated with large ships.

4.3.6 Wildlife Viewing

Key Management Questions

How does the presence of cruise ships affect the ability of park visitors to view wildlife in designated Wilderness and non-wilderness areas of Glacier Bay?

How might an increase in cruise ship levels affect opportunities for wildlife viewing in Glacier Bay?

Research Findings

Opportunities for wildlife viewing are highly valued by visitors to Alaska and to Glacier Bay. Visitor surveys in 1979, 1984, and 1989 indicated that wildlife viewing was among the top three priorities for visiting Glacier Bay. Marine mammals, eagles, and bears are of greatest interest to visitors. Protection of viewing opportunities for visitors to see wildlife species is of high priority to park officials because it contributes significantly to the quality of the visitor experience and provides an opportunity for education and interpretation of natural resources, which are critical park goals. Cruise ships provide an opportunity for thousands of visitors to see wildlife, albeit from a distance, and to learn something about wildlife resources with the aid of a park interpreter. An overall increase in ship levels will increase the number of wildlife viewing opportunities for park visitors on cruise ships. Such increases could affect viewing opportunities for other park visitors.

In the EIS process for vessel requirements, several concerns were raised about how motorized vessels affect wildlife and diminish opportunities for wildlife viewing. The presence of cruise ships does impact the behavior of marine mammals and other wildlife species (see Section 3.0).

No known research exists that has investigated the effects of cruise ships on wildlife viewing opportunities in a marine protected area. The ultimate effects of cruise ship seasonal use day increase on wildlife viewing would depend on data from studies of effects on cruise ships on wildlife behavior. If cruise ships are correlated with stress and population decline within Glacier Bay, then wildlife viewing opportunities would be diminished.

Information Needs

1. Monitoring data to assess the quality, frequency, and duration of wildlife viewing opportunities for all visitor segments would help to provide ongoing measure of visitor-wildlife interactions in Glacier Bay. The survey of backcountry users in 1984 asked visitors to evaluate their wildlife sightings (Salvi and Johnson 1985). This study could provide a model for future surveys on wildlife sightings and may provide a kind of baseline for measuring trends in wildlife viewing frequency. These questions could be adapted to create a monitoring tool for periodic use to assess the quality of wildlife viewing opportunities for all visitor segments to the park.

Management Recommendations

1. Wildlife viewing is an important aspect of a Glacier Bay experience for all types of park visitors. The Board recommends that the effects of cruise ships on marine and terrestrial wildlife be monitored on an ongoing basis to understand aspects of species health, viability and behavior. There is no evidence that suggests wildlife

opportunities have changed as a result of the increase in number or size of large cruise ships. But this is an area that should be monitored and studied on a long-term basis.

4.3.7 Ruggedness and Wildness

Key Management Questions

How do cruise ships contribute to an overall perception of ruggedness and wildness in Glacier Bay National Park?

How might a potential increase in cruise ship levels affect visitor perceptions of the ruggedness or wildness of Glacier Bay?

Research Findings

Comments from visitor studies in the 1980s and 1990s suggest that not all visitors believe that cruise ships belong in Glacier Bay. Existing visitor studies reveal that park visitors are mixed about their reactions to cruise ship sightings in the park setting. While some were content with the volume of ships visiting, few wanted to see the number of ships increased. Monitoring studies suggested above may help to provide more current data on visitor reactions to cruise ship sightings.

One issue is the extent to which cruise ships contribute to an overall perception of ruggedness and wildness in the park. Wildness refers to qualities in keeping with a natural landscape that is untrammelled and free from human control (Landres et al. 2000). The 1984 General Management Plan described the need to:

ensure patterns of use that enable visitors to enjoy and understand the natural features, making use of recreational opportunities consistent with preservation of ongoing natural processes; balance forms of access and use to obtain a feeling of the ruggedness and wildness of this dynamic landscape and the solitude that early inhabitants found... (NPS 1984:16).

There is no discussion in the 1984 management plan about how to determine whether cruise ships are compatible with a feeling of “ruggedness and wildness.” There have been no studies conducted within the park that identify elements that contribute to or detract from visitors’ perceptions of ruggedness and wildness.

In addition, the 1984 plan called for “*basic facilities, services, and size levels necessary and appropriate to serve visitor needs and be consistent with the area’s setting and purpose.*” With regard to the built environment in the park, emphasis is placed on a design quality in harmony with the park’s history and atmosphere (NPS 1984: 16). These design qualities apparently apply to fixed park facilities at Bartlett Cove, not cruise ships, tour vessels, or other mobile facilities. There is no discussion in the management plan about the appropriateness of cruise ships (as part of the built environment) in Glacier Bay.

Comments from visitor studies suggest that some visitors believed that cruise ships should be restricted because their presence is inconsistent with their perception of wilderness values (Littlejohn 2000). The extent to which various types of visitors agree with this view is unknown. Research is needed to explore visitor perceptions of ruggedness and wildness and the appropriateness of cruise ships in the park environment. Visitors to Glacier Bay have not been queried specifically about the extent to which various features of Glacier Bay promote naturalness or ruggedness. Research among backcountry users conducted in Wrangell-St. Elias National Park found the importance of wilderness attributes such as wildness and remoteness to be an essential component of the visitor experience (Kneeshaw et al. 2004).

Information Needs

1. A study is recommended to understand the role of cruise ships in promoting park values of ruggedness and wildness. This research will help to further understand the role of cruise ships in shaping the park character. This study will ascertain how cruise ships contribute to or detract from perceptions of ruggedness and wildness in the national park setting. Data collection about visitor perceptions of ruggedness and wildness can be conducted in combination with other data collection efforts. A study conducted in Wrangell-St. Elias National Park as visitors to reflect on their park experience with respect to various wilderness attributes, including wildness, primitiveness of conditions, vastness, opportunities for freedom, and others (Kneeshaw et al. 2004). This approach is recommended for use in Glacier Bay to assess the presence of similar opportunities.

Management Recommendations

1. Decisions by park managers to increase cruise ship levels may find it useful to consider the role of cruise ships in shaping and perpetuating park character and the extent to which cruise ships contribute to values of ruggedness and wildness.

4.3.8 Other Considerations

Maintaining Visitor Balance

National parks and protected areas in North America were created based on the assumption that they were available to all people (Eagles et al. 2002). The philosophy of opening public lands to a variety of visitors is consistent with democratic values of the nation and in some cases may play a role in distributing recreation impacts more broadly. Research has pointed to the issue of social equity in recreation, which emphasizes the importance of maintaining a variety of user types in proportions deemed acceptable for a particular natural area. If changes occur to that area, proportions of recreation users may be maintained through visitor planning processes and park policies. Research has shown that homogenization of recreation experiences due to the domination of a more high-volume visitor activity in some natural areas has occurred, resulting in the need to

actively manage these areas to provide for a variety of experiences (Dustin and McAvoy 1982; Schreyer and Knopf 1984).

An increase in cruise ship levels affects the overall balance of park visitors. According to the park mission discussed in the General Management Plan, park managers should provide opportunities for a broad range of visitors and vessel types to enjoy park resources (NPS 1984:16). Cruise passengers represented 91.6 percent of all visitors to Glacier Bay National Park in 2004 and roughly 16 percent of all vessel traffic (see Appendix A). If the number of cruise ship vessels arriving in Glacier Bay were increased, there would be a subsequent increase in both the number of cruise ship vessels and the proportion of cruise vessels relative to others. Some consideration may be given to how an increase in vessel levels would affect the balance of park visitors.

Cruise ships have been part of Glacier Bay's visitor history since the 1960s and thus do not constitute a new attribute of the park. Different kinds of visitors are attracted to different types of parks and protected areas. Overall impressions about the character of natural areas are gained through advertising and word of mouth sources (Littlejohn 2000; Kneeshaw 2004). The image of the national park is also cultivated by the National Park Service, the tourism industry, and the media, which influences visitors making decisions about whether to visit the park. Being an Alaska destination creates additional expectations among visitors about the nature and frequency of wildlife encounters and presence of vast, uninhabited landscapes. Some portion of visitors desires an opportunity to experience Glacier Bay while maintaining qualities and conditions consistent with a wilderness experience. Some who find cruise ships incongruous with national parks may desire to visit Glacier Bay without the presence of cruise ships. Others may choose not to visit Glacier Bay because they do not expect to have the type of wilderness experience they desire. In short, there may be displacement of prospective visitors to a national park, who have predetermined that the park character may not be consistent with their recreation goals.

As a marine-based national park, Glacier Bay is a scarce resource that is highly valued among visitors of all kinds. An increased emphasis on cruise-based visitation would suggest that a greater proportion of visitors have their experiences mediated by the tourism industry. There is a limited amount of visitors experiencing direct, unmediated contact with Glacier Bay as a wilderness place. A smaller portion of visitors, including private boaters and backcountry users, which numbered fewer than 3,000 in 2004, experience Glacier Bay from their own perspective, without having their trip packaged by the tourism industry.

The expanded presence of cruise ships would likely have implications for persons planning trips to Glacier Bay, potentially conveying the image of Glacier Bay as a cruise destination and not a national park with equal access to other tourism segments. The increase in cruise ship levels and in the volume of cruise visitors beyond 2003 levels may further solidify the predominance of cruise ships. This greater emphasis on cruise ships could potentially discourage some prospective visitors, resulting in another form of

displacement, in which future park visitors may be discouraged from visiting due to perceptions that the park caters to cruise ships.

Glacier Bay management objectives strive for a balance of park uses, suggesting the importance of this issue. Once steps are taken by park managers to encourage growth of one visitor sector over other, it can be hard to reverse this momentum. In consideration of future decisions to increase the number of cruise ships permitted to enter Glacier Bay, the Board recommends that the issue of balance and proportion of various types of visitors be evaluated. Park managers also may seek a balance of opportunities for both mediated and unmediated experiences of the Park.

Visitor Management Models

Visitor management research has described the numerous ways in which visitor activities and impacts can be managed in a park or protected area. Tools such as the Recreational Opportunity Spectrum (ROS) have been used in national park settings to provide spatial, temporal, and other zones to provide quality visitor experiences for a wide variety of visitors (Clark and Stankey 1979; USDA Forest Service 1982). Zoning is a method used to deploy visitors over a geographic area to allow for uses of various intensities. Zoning involves identifying important recreation values and opportunities desired in a park setting and allocating the provision of values and opportunities across a landscape through facilities development and use policy (Eagles et al. 2002). In addition, techniques such as pricing, facilities development, regulation, education, and allocation can be used to provide opportunities to a variety of park visitors (McCool 1996).

In addition to ROS, other visitor management frameworks exist. The Limits of Acceptable Change and Visitor Impact Management frameworks both involve the development of a strategic plan based on defined limits of acceptable change with indicators of change used to monitor various biophysical and social conditions. Visitor Experience Resource Protection utilizes a carrying capacity framework to ensure the quality of visitor experiences and results in prescriptive management zones for visitor use. The Management Process for Visitor Activities used by Parks Canada is a hierarchical decision-making model. (Eagles et al. 2002).

The Board strongly advises park managers to use existing visitor management frameworks designed to plan and allocate visitor use, including backcountry visitors, in time and space throughout the park, using mechanisms such as zoning and scheduling. These mechanisms can be developed by park planners using existing models and implemented through the concessionaire permit process. Such tools help to promote quality visitor experiences among a variety of park users and may consider providing opportunities to a variety of park users.

4.4 Local and Regional Socioeconomics

This section deals with the socioeconomic effects of cruise ship visits to Glacier Bay and the role of cruise-based tourism in shaping the regional economy, with implications for

Alaska communities. Research on the economic impacts of cruise ships on the regional economy is needed to provide the basis for understanding potential economic impacts of cruise ship visits to Glacier Bay. A research plan is then explained, with distinct discussions for regional economic effects, effects on Southeast Alaska communities, and the economic role of tourism providers.

This section considers economic effects of potential increases in cruise ship vessel quotas as they are felt in the Southeast Alaska region. The scope of this report does not consider the effects of these policies on corporate revenues for cruise lines or other tourism providers outside the region. Nor does it deal with economic effects of cruise ship travel to Glacier Bay on the domestic economy. Changes in cruise ship quotas would likely have significant financial repercussions for cruise lines and the supporting tourism industry. In addition, the report does not deal with the net change in economic benefits for visitors to Glacier Bay. Instead, the focus of this section is on the implications of increased ship entries for local communities and tourism providers, as well as the economic costs and benefits to the region. This report emphasizes the use of standard economic analysis to understand changes in net benefits, as well as changes in net income and employment for the region, and to the extent possible on the community level.

This research framework was developed based on a cursory review of literature dealing with economic effects of tourism on local and regional economies and economic aspects of national parks and natural areas. Issues raised in the FEIS were considered. In addition, contacts were made with officials in the Alaska tourism industry, tribal organizations, native corporations, and public officials. These discussions raised awareness of economic issues pertinent to Glacier Bay and guided efforts to construct a research framework for considering socioeconomic effects of cruise ship visits to Glacier Bay. There were no additional funds for a comprehensive literature review on economic issues, nor did the Board include a member with formal economics expertise. This section should be viewed as a preliminary effort to identify relevant socioeconomic concerns. It is strongly recommended that the Board work with an economist with knowledge about the role of tourism in the Southeast Alaska economy.

Several operating assumptions were made in the development of this framework. Some of these may be treated as hypotheses to be tested in future research. These are:

- An increase in cruise ship quotas could, but would not necessarily cause an increase in total ship visits to Alaska. Although cruise lines may deploy new ships to Alaska in response to an increase in vessel quotas, it is more likely that existing ships in the fleet would alter their itineraries in response to the increase in Glacier Bay entries. An increase in entries to Glacier Bay might encourage ships to divert their itineraries from Southcentral Alaska.
- A trip into Glacier Bay takes one full day from the industry standard 7- and 11-day itineraries. The addition of Glacier Bay to a cruise ship schedule would likely result in the omission of other stops on the current ship schedule. Displacement is likely to occur as ships eliminate or abbreviate port visits to allow for the

inclusion of Glacier Bay in the schedule. This displacement has economic implications for Southeast Alaska ports and the region (See next bullet, below).

- The reduction of vessel speeds in Glacier Bay as a result of the 2003 FEIS keep cruise ships in the park an additional three hours, which means that time must be made up en route to or from Glacier Bay. The addition of Glacier Bay to a cruise ship itinerary may mean shortening docking hours in other port communities, with economic implications.
- The potential reduction of cruise ship port calls and docking times will result in a decline in overall visitor spending to the region. More guest dollars will likely be captured by the vertically integrated cruise line, rather than feed into the regional economy. Displaced port communities and the Southeast Alaska region will experience a decline in direct visitor spending as well as the indirect (multiplier) effects of visitor spending.
- The newly available permits to enter the park would likely be in high demand by cruise lines. The increase in cruise ship entries could affect pricing, marketing, and the packaging of destinations region-wide. If more cruise lines and more ships include Glacier Bay in their itinerary, this would necessitate alterations to existing tourist activities elsewhere throughout the region. Changes in pricing and packaging would have implications for both cruise lines and consumers, as well as the regional economy.
- The expansion of quota limits to allow more ships into Glacier Bay may add overall economic value to the Alaska cruise experience, by increasing visitor's willingness to pay. cursory analysis of cruise pricing suggests that consumers pay more for cruises in Glacier Bay than for comparable cruises in southeast Alaska that do not include Glacier Bay. A more comprehensive analysis of pricing strategies would more precisely ascertain how much a visit to Glacier Bay is worth in terms of visitor willingness to pay.
- The increase in cruise ship entries suggests an expansion in supply (of entries) and a potential decline in price, based on principals of supply and demand. Increase in supply can possibly lead to a decline in consumer price, depending on the sensitivity of demand to price. Thus, if more cruise ships enter Glacier Bay, prices of Glacier Bay itineraries could decline, depending on the influence of other factors affecting price. These effects are not considered in this analysis, but have implications for the regional economy. A decline in cruise price might allow guests to spend more money onboard or on shore during their Alaska visit.
- An increase in cruise ship entries to Glacier Bay impacts National Park Service revenues. A \$5 head fee generated an estimated \$1.7 million to the park budget in 2004. In addition, a \$1 interpretation fee charged to cruise passengers generated \$338,426 to offset costs for the interpretation program. A 32 percent increase in cruise ships will increase NPS revenues proportionally, providing an additional

\$500,000 or more to the National Park Service, with modest increases in administrative costs. Increased cruise levels could also affect local employment, creating the need for additional seasonal interpreters and administrative staff.

- An increase in cruise ship visits to Glacier Bay could affect other tourism providers, such as small cruise lines and tour vessels, who bring visitors to Glacier Bay. Price competition and economies of scale can make it difficult for smaller companies to compete for clients. An increase in cruise ship entries will expand the options for cruise guests desiring a trip to Glacier Bay, benefiting the large cruise ships. In addition, tour operators in other ports may be affected by permit increases, due to displacement, or consumer choice. (For example, consumers may opt not to participate in a glacier sight-seeing tour in another Alaska port, because they viewed glaciers in Glacier Bay.)
- An increase in cruise ship visitation to Glacier Bay could result in an increase in visitor perceptions of crowding, noise effects, and haze (See Section 4.3). Perceived changes in conditions may affect visitor's willingness to pay (WTP) for a Glacier Bay visit, which could have economic implications for the region. If conditions decline, visitors may be less willing to pay for an Alaska cruise than under current conditions.
- There is a certain economic benefit for permittees in holding a Glacier Bay permit that goes beyond the administrative cost of the permit fee. Firms invest significant resources in the permit application process and in demonstrating compliance with park regulations.

The discussion of socioeconomic factors associated with the potential increase in vessel quotas is divided into three areas: regional economic effects, local economic effects, and effects on tour operators.

4.4.1 Regional Economic Effects

Key Management Question

How might an increase in the cruise ship entries to Glacier Bay affect the regional economy?

The overall effect of an increase in cruise ship entries is unknown. Research is needed to weigh various factors influencing inputs to the regional economy. Cruise ship entry increases may encourage ships to alter their current itineraries to include a visit to Glacier Bay, resulting in displacement of some port communities. Speed restrictions in the park also may cause ships visiting Glacier Bay to reduce docking times elsewhere. These effects could result in a net reduction in visitor spending into the Southeast Alaska region and a potential increase in benefits to the cruise lines. The region would likely experience both a net reduction in direct visitor spending as well as the indirect spending

or multiplier effect generated by direct spending. This potential reduction in spending can be measured using input/output analysis.

Several factors may offset this potential reduction in visitor spending. First, increased entries in Glacier Bay may result in cruise ships being diverted from a cross-gulf itinerary to a Southeast Alaska route. This redirection could have positive economic repercussions for Southeast Alaska. Second, if cruise trip prices to Glacier Bay decline because of the increase in permit supply, consumers will have extra disposable income to distribute to the region during their visit to Alaska. Third, the increase in cruise ship quotas to Glacier Bay could benefit the regional economy if more visitors are drawn to Alaska as a result of the expanded access to Glacier Bay. Greater possibility of visiting Glacier Bay at a lower price may attract prospective cruise visitors away from other global cruise destinations. Economic analysis is needed to measure these potential effects.

Another potential economic effect of an increase in entries is related to the quality of the visitor experience. With more limited access to Glacier Bay (under current levels), visitor enjoyment of that exclusive experience is great. This can be measured in terms of visitor willingness to pay. If the visitor experience of Glacier Bay is diminished because of the effects of additional cruise ships, visitors will be less willing to pay for that experience. Thus, an increase in entries could lessen the perceived worth of that exclusive Glacier Bay experience. Such disturbances, if severe enough, can translate into an overall reduction in visitors to Glacier Bay and perhaps to Southeast Alaska, which would have implications for the regional economy. The monitoring of visitor satisfaction proposed in Section 4.3 will determine visitor perceptions of change in park conditions.

Increased permit levels for large cruise ships could result in changes in net benefits for other tourism providers, such as small cruise lines, tour vessel operators, and outfitter guides using Glacier Bay. In addition, tourism providers in other parts of Southeast Alaska could experience declines in revenues as a result of increases in cruise ship visits in Glacier Bay. Declines may be experienced due to competition for clients desiring to visit Glacier Bay. They also may occur due to the displacement of visitors from other ports and other tourist activities. (For example, visitors stopping in Skagway may no longer desire to visit a nearby glacier since they have already seen glaciers in Glacier Bay.) Declines in revenues affect regional employment and income, and have implications for sales tax revenues. Affected tour operators and their employees may be year-round Alaska residents, seasonal residents, or non-residents.

Research Findings

Findings from studies in similar settings that have analyzed the historical effects of increased entries, permits, quotas, or other allocation tools should be reviewed to understand the effects of these policy changes on pricing, consumer behavior, and the behavior of the firm (permit-holder). Literature on consumer choice behavior will help to illustrate factors affecting price (price elasticity of demand). (Cruise ship itineraries often are used as an example of the trade-offs consumers make between itineraries.) Results from these studies may be useful to model or predict how cruise lines may react to the

increase in Glacier Bay entry permits. Studies of competition among tourism providers and concessionaires operating on publicly held lands and resources may illustrate important economic factors with regional implications.

Models that predict the influence of scheduling changes on the regional economy may help to predict economic effects of changes in ship itineraries. A study being planned in the Chugach National Forest will provide an economic analysis of changes in travel patterns over a broad region. This study methodology may be applied to Glacier Bay.

Information Needs

The factors listed below should be examined and weighed to understand the complexity of economic relations associated with cruise ship visitation in Glacier Bay.

1. Economic analysis is needed to determine the effects of current cruise ship visitation to Alaska on regional income and employment. An economic model that predicts changes in travel patterns as a result of an increase in Glacier Bay permits will predict the subsequent effects of permit increases on the regional economy. Input-output models could be used to estimate regional effects of cruise ship visitation under current conditions and with future travel scenarios. This study would focus on two components:
 - Analyzing scheduling trends of cruise ships resulting from the increase in entries in 1997 to understand how entry increases affected secondary cruise ports; and
 - Measuring local economic impacts of the shifts in cruise ship schedules for secondary port communities in terms of changes in income and employment and aggregating changes for the region.
2. Data is needed to understand how changes in permit allocation affect cruise prices.
 - By examining and comparing prices of current cruises that incorporate a Glacier Bay visit versus those that do not (using identical or similar criteria, such as ship size and features, class of service, room size, trip length, season) the comparative worth of a Glacier Bay visit can be estimated.
 - Historical analysis on the effects of an increase in Glacier Bay entries in 1997 from 106 to 132 could provide a model for understanding how a change in entries influences price, and in turn, how that affects consumer choice. In other words, measuring the price elasticity of demand for Glacier Bay cruises.
3. Monitoring of visitor perceptions of crowding, visibility, noise quality, and cruise ship sightings (as proposed in section 4.3) will help to determine whether elevated cruise ship levels are associated with changes in park conditions from the perspective of various visitor segments. Visitor surveys should include measures

of visitor willingness to pay for a Glacier Bay experience, given changes in park conditions.

4.4.2 Local Economic Effects

Key Management Question

How does an increase in the number of cruise ships to Glacier Bay impact local economies in Southeast Alaska communities?

An increase in entries to Glacier Bay likely will alter the schedules of some Alaska cruise ships and cause subsequent changes to port communities hosting cruise ships. Ships on 7-day itineraries typically have four days in Alaska. Standard cruise ship itineraries include stops in Juneau, Skagway and Ketchikan, leaving one day for another port or attraction. Cruise ships may opt to stop in Sitka, Icy Strait Point (Hoonah), Wrangell, Haines, Prince Rupert, or Glacier Bay. They also may head toward Yakutat to visit Hubbard Glacier, or travel up Tracy Arm, near Juneau, to view tidewater glaciers there.

Cruise Ports. One full day spent in Glacier Bay is a day *not* spent in another Alaska port community or natural attraction. An increase in Glacier Bay entries is not likely to affect Juneau, Ketchikan, or Skagway; however, some ports are likely to be displaced by the increase in permits to Glacier Bay. Analysis of previous increases in Glacier Bay entries suggests that scheduling and docking changes occurred with ramifications for secondary Alaska ports. For example, in 2000, Valdez was an active cruise port for Holland America. An increase in permits to Glacier Bay that year meant a stark decline in cruise visitation to Valdez, from 41 ship visits in 1999 to 21 in 2000. Changes in allocations also may have affected Sitka, which experienced a precipitous decline in cruise traffic between 1997 and 2000. Secondary ports within the Inside Passage compete with each other for cruise stops. The addition of Glacier Bay onto the cruise ship itinerary intensifies this competition.

A sudden decline in cruise ship visits can have a significant effect on the local economy, as several examples from Southeast Alaska have shown. Many Sitka businesses shut down when Holland America altered the routes of three ships in 1997. Haines businesses also suffered in 2001 when the number of cruise ship passengers fell from 187,000 to 40,000, when Royal Caribbean unexpectedly cancelled callings. The constellation of tourism providers and support industries that build up to cater to cruise visitors can represent a significant portion of the local economy. In Haines, for example, 21 percent of workers were employed in the leisure and hospitality industry in 2002. A quick shift in scheduling can affect hundreds of local jobs and businesses in affected communities.

Glacier Destinations. In addition to community visits, an increase in Glacier Bay entries may affect other areas featuring tidewater glaciers. Ships not visiting Glacier Bay typically divert to Tracy Arm or Hubbard Glacier to provide the opportunity for guests to view glaciers from the ship. An increase in entries may mean a reduction in ship visits to these attractions, which could alter both routes and docking times in neighboring ports.

(For example, if a ship does not visit Hubbard Glacier, near Yakutat, it may spend more time in Sitka or Hoonah.) It will be difficult to predict accurately how the entry increase may affect ship schedules. However, analysis of entry increases in 1997 could provide some indication.

A less obvious effect of the increase in vessel entries for Glacier Bay may be that guests are less likely to visit glaciers on their shore excursions. Perhaps after spending an entire day in Glacier Bay, a guest may be not desire to spend another full day at Davidson Glacier – a popular shore excursion for Skagway visitors, or in Tracy Arm, which is accessible from Juneau. Instead, visitors may opt for a train excursion or prefer shopping, having had their fill of glaciers in Glacier Bay. Again, these changes would need to be monitored over time.

Icy Strait Communities. An important consideration for park managers is how an increase in vessel entries may affect neighboring communities in Icy Straits. Hoonah (Icy Strait Point) is the only Icy Strait community that hosted large cruise ships in 2005. This new destination opened in 2004 and initially catered to one cruise line, Royal Caribbean, although others may begin to visit in 2006. This destination was designed to handle a maximum of one cruise ship daily and five cruise ships weekly. An increase in vessel quotas could mean that ship visits also could increase in Hoonah. The destination's proximity to Glacier Bay makes it a convenient stopping point for ships waiting to enter the park. If ships cut back on trips to see glaciers at Hubbard Glacier and Tracy Arm, they may have more time to spend in nearby Hoonah. With increased fuel prices, reduction in travel distance has significant economic repercussion for companies planning itineraries. Hoonah represents a close-by and convenient alternative directly enroute to the park. An increase in ship stops in Hoonah will have significant economic benefits for the community. The addition of one ship per week, for example, will contribute an additional \$180,000 per week, assuming passengers spend \$100 in port. These economic benefits also occur with changes to the sociocultural environment in Hoonah, which have been measured in other studies (Cerveny 2004, 2005). However, another possibility is that ships currently visiting Hoonah may skip the stop if granted additional vessel entries to Glacier Bay. In other words, they may substitute Glacier Bay for Hoonah, with potentially negative economic benefits for the community.

Neighboring communities of Gustavus, Pelican and Elfin Cove do not benefit significantly from the presence of large cruise ships in Glacier Bay. Icy Strait residents employed by park concessionaires may be affected by the potential increase in cruise traffic, although it is difficult to say whether these will be positive or negative effects. If an increase in cruise ships has a negative effect on aspects of the visitor experience among guests of other tour vessels, the quota changes could hurt local businesses, which in turn would have local economic impacts. However, those Icy Strait residents working for the National Park Service or as cruise ship interpreters in Glacier Bay may see an increase in employment opportunities resulting from the greater presence of cruise ships.

Research Findings

Relevant studies should be identified that analyze the local effects associated with changes in vessel quotas for cruise ships in a national park or protected area, and the effects on the local economy. Some useful research has been done examining the complex economic relations between destination communities and the cruise ship industry in the Caribbean (Wood 2000; Pattullo 1996). This research will need to be consulted to predict firm behavior. Studies that examine changes in ship travel patterns in response to new opportunities to visit attractions (such as national parks) will be useful to develop a model for travel patterns in Southeast Alaska.

Marketing research may be available that discusses competition between large and small cruise ships, and how a decline in cruise ticket prices for large ships may affect the small cruise market. This research would be useful to predict how smaller tourism providers could fare if more large ships were able to enter Glacier Bay.

Some existing economic studies may shed light on the implications of an increase in cruise vessel entries on the quality of the visitor experience, based on visitor's willingness to pay (Manning et al. 2002). These studies may help to identify factors that would lead to a decline in willingness of visitors to pay for a trip to Glacier Bay. Some research exists that looks at visitors' willingness to pay for clean air and a quiet soundscape (Chestnut and Rowe 1990; Williams 1991).

Information Needs

To understand the economic effects of an increase in cruise ship entries to Glacier Bay, research and monitoring of socioeconomic data is needed. Several variables may be identified as key indicators that should be measured on an annual basis to determine the economic implications of allocation changes.

1. Economic analysis is needed to determine the effects of current cruise ship visitation to Alaska on local income and employment. An economic model that predicts changes in travel patterns as a result of an increase in Glacier Bay permits will help to estimate the subsequent effects of permit increases on the local and regional economy. Input-output models could be used to estimate local and regional effects of cruise ship visitation under current conditions and with future travel scenarios. This study would focus on two components:
 - Analyzing scheduling trends of cruise ships resulting from the increase in entries in 1997 to understand how entry increases affected secondary cruise ports; and
 - Measuring local economic impacts of the shifts in cruise ship schedules for secondary port communities in terms of changes in income and employment.

2. Data is needed to determine the extent to which local employment is tied to the cruise ship industry in Glacier Bay National Park and assessing the role of local businesses in providing services to cruise ships as concessionaires.
3. Monitoring is needed to understand how Hoonah may be uniquely affected by increased allocations in Glacier Bay, due to its proximity and the presence of a cruise-based tourism attraction. Variables to be measured include cruise ship arrivals, sales tax revenues, and tourism-related employment.
4. Monitoring is needed to understand how local tourism providers may be affected by the presence of cruise ships. It is recommended that an indicator group of tour operators be identified to provide ongoing feedback to park officials about the economic implications of cruise ship activity for small tourism providers.

Management Recommendations

1. The potential economic effects of increased cruise ship entries are complex and multifaceted. Research is needed to identify the implications of increased cruise ship entries on other Alaska ports. Monitoring of key socioeconomic variables will be important to measure changes in the local and regional economy that may be associated with an increase in vessel entries. The Board recommends that baseline data be collected in 2006 to measure local economic effects of permit increases. In addition, the Board recommends that any proposed increases in cruise vessel entries occur incrementally, so that socioeconomic indicators may be monitored and changes to local economies can be predicted, managed, and mitigated by local officials.

4.4.3 Additional Effects: Tourism Providers

As noted above, tourism providers operating in Glacier Bay may be affected by changes in allocation to large cruise ships. These effects may be felt in several ways. First, increased competition from the large cruise lines with expanded access to permits could negatively impact tour and charter vessels. Large cruise ships operate at economies of scale and thus can charge customers competitive prices for an Alaska cruise. To some extent, large cruise lines compete for customers with the small cruise lines and day tours. Small cruise lines typically charge comparatively higher prices for what is advertised to a more intimate Alaska experience, including the potential for up-close encounters with nature and wildlife in Glacier Bay. Customers desiring a trip to Glacier Bay will have more options to choose from if permit limits are increased for large cruise lines. And, if prices on large cruise ships fall with the increase in entries, it will be more difficult for small cruise lines and tour operators to compete with the large cruise ships. These factors could result in loss of market share for small cruise lines and tour operators competing with the large cruise vessels.

There may be economic implications associated with the potential increase in cruise ship sightings among smaller tour operators in the park. Data from previous studies suggests

that backcountry users prefer to experience Glacier Bay with a modest amount of cruise ships. Tour operators interviewed for this report described the efforts they make to avoid significant contact with cruise ships. An increase in cruise ship sightings could diminish their experience of Glacier Bay, possibly affecting their willingness to pay comparatively higher prices for going to Glacier Bay on a smaller vessel. Studies describing the potential effects of cruise ship sightings on the visitor experience are needed to estimate whether there is a decline in willingness to pay.

Other factors related to the increase in cruise ships may affect the visitor experience in the park. If visibility and noise quality diminish with the increase in cruise ship levels, guests on smaller cruise ships may opt to avoid Glacier Bay. Numerous examples exist in the tourism literature using the destination life-cycle model, showing that escalating visitation levels can lead to deterioration of physical and social conditions, which eventually can result in a decline in visitor volume, with immediate economic implications for tourism providers (Butler 1980; Cooper 1992). A decline in park conditions could have a subsequent negative impact on other tourism providers.

The expanded presence of large cruise ships in the park may affect economic opportunities for other park concessionaires providing direct services to the cruise lines. A small number of tourism providers and economic entities may provide services directly to large cruise lines entering Glacier Bay. One example is Huna Totem Corporation, which provides cultural interpreters for Holland America and Royal Caribbean ships to Glacier Bay. An increase in cruise ship entries will require a greater number of interpreters, which could benefit local businesses.

Elevated levels of cruise ships in Glacier Bay also could have a positive effect on tourism providers. A portion of guests on smaller cruises and participating in tours first came to Alaska on cruise ships and returned on a subsequent visit to enjoy Alaska as an independent visitor or participate in a package tour. If entry levels to Glacier Bay increase, more Alaska cruise passengers will be exposed to Glacier Bay, potentially creating a greater market for return visitors. If impressed with conditions in Glacier Bay, some of these cruise passengers may want to return on other types of vessels. They also may encourage friends to travel to Alaska. Data on the precise proportion of visitors on tour and charter vessels who have previously arrived on a cruise ship would be helpful to understand the relationship between these two market segments.

Information Needs

1. Data is needed on a periodic basis to understand the relationship between changes in the quality of the visitor experience and visitor willingness to pay for a Glacier Bay trip. Monitoring data is needed to understand whether visitors perceive a decline in park conditions related to the increase in cruise ships, based on their willingness to pay.
2. Market research would help to determine the extent to which large cruise vessels and small tour vessels (including small cruise ships) compete for customers and

whether the increase in cruise ship entries puts smaller vessels at an unfair advantage.

3. A marketing study of non-cruise tourist segments would help to determine what percentage of visitors first came to Glacier Bay on a cruise ship and the role of that visit in shaping future trips to Glacier Bay.

Management Recommendations

1. Little actual data has been collected in Glacier Bay about the economic effects of large cruise travel on tourism providers operating in or around Glacier Bay. The potential for an increase in one market segment to overshadow or overwhelm another is significant. The Board urges park managers to pay special attention to the implications of cruise ship entry level increases on the smaller tourism providers and concessionaires who depend on the provision of a quality visitor experience for their economic livelihood.

4.5 Proposed Research Framework for the Sociocultural Environment

The discussion above examined existing research and information about potential sociocultural impacts associated with cruise ship visitation to Glacier Bay, and outlined a range of information needs in this topic area. The Board recommends that the Park support the following specific studies in 2006 to meet these information needs.

For research related to visitor experience and socioeconomic impacts (Sections 4.5.2 and 4.5.3), it is essential that cruise ship levels remain unchanged for a minimum of one season to provide for collection of baseline data during a representative year, to fully inform a decision about an increase in seasonal use days.

4.5.1 Cultural Resources

Identification and Management of Cultural Resources Within the Park

SC-1 Archaeological Sites and Traditional Cultural Properties. A study plan should be developed and implemented to identify all archeological sites and potential TCPs and examine their sensitivity to disturbance. Any sites found to be sensitive to physical disturbance from cruise ship traffic should be listed in the Cultural Resource Management Plan (see Section 4.6.1). If necessary, management direction should minimize physical disturbance to identified sites.

SC-2 Effect of Stack Emissions on Subsistence Resources. The possible effect of stack emissions on subsistence resources should be examined. Some Huna Tlingit perceive that stack emissions may affect mountain goats and other resources used for subsistence. This issue and other pollution concerns should be resolved in the Cultural Resource Management Plan (see Section 4.6.1).

Cultural Resources: Huna Tlingit Relationship with Glacier Bay

- SC-3 Ethnography of Huna Tlingit. It is recommended that the National Park Service support an in-depth ethnographic description focused on the Huna Tlingit and their relationship with Glacier Bay. Such a work would provide lasting documentation of Huna Tlingit culture similar to that provided by de Laguna's *Under Mount Saint Elias* for the Yakutat Tlingit.
- SC-4 Cultural and Spiritual Concerns with Cruise Ship Traffic. A field study be undertaken to verify and better understand the cultural and spiritual concerns with cruise ship vessel traffic in Glacier Bay. This study would conduct interviews with tribal council members and with clan elders who are responsible under traditional Tlingit law and practice to represent the interests of their clans. The study objective would be to more fully describe Huna Tlingit concerns with cruise ship visitation, assess the level of likely impact, and mitigate impacts if feasible. Cruise ship visitation levels would need to be rethought if impacts were shown to result in a likely impairment of cultural resources.

4.5.2 Visitor Experience

The discussion concerning visitor experience presented in Section 4.3, above, identified a large number of information needs. The Board believes that these information objectives can be met through two research studies and an on-going monitoring program. The two studies should be undertaken in 2006, prior to any increases in cruise ship entries. To better illustrate how studies concerning visitor experience might be undertaken, the Board has taken the initiative to outline how each of these two studies might be structured in some detail.

- SC-5 Visitor Experiences and Acceptability of Park Conditions. The Park should undertake a study to establish baseline information for understanding the many aspects of the visitor experience in Glacier Bay. The study will help to determine visitor motivations and expectations, as well as the effects of various park features and conditions on the quality of the visitor experience. The study will also establish a framework for understanding park conditions deemed both preferable and acceptable by various visitor groups and establish the limits of acceptable changes that could take place in park conditions without diminishing the visitor experience.

Methodology. Conduct intercept surveys with park visitors of all visitor segments. Data collection involves a brief intercept interview with visitors prior to entering Glacier Bay, including visitor profile, motivations, and expectations. Respondents may be given a longer, more detailed, mail-back survey that they fill out and return after their trip to Glacier Bay or from home.

Sample. Includes park visitors of all major visitor segments: backcountry users, private boaters, charter vessel passengers, tour vessel passengers, and cruise ship visitors.

Survey Topics. The intercept survey conducted by interview would address: *visitor profile* (demographic variables, origins of traveler, number of trips to Alaska, number of trips to Glacier Bay, number of trips to national parks), *visitor motivations* (for coming to Alaska and to Glacier Bay), *visitor preferences* (for park conditions in wilderness and non-wilderness settings; willingness to pay for certain park conditions); *visitor expectations* (for activities in Glacier Bay, for wildlife viewing, air and noise quality, vessel sightings, and wilderness qualities).

The mail-in survey would address: *trip characteristics* (transportation used in Glacier Bay, days/overnights in Glacier Bay, areas visited in Glacier Bay, primary activities in Glacier Bay); *vessel sightings* (frequency, duration, volume, quality; effects on visitor experience; types/locations of vessel sightings considered inappropriate; effects of larger ships vs. smaller ships; acceptability of vessel sightings); *crowding and congestion* (perception of crowding in park overall, perception of crowding in particular areas; crowding effects on visitor experience); *visibility and noise quality* (perception of vessel noise in park, perception of vessel noise in particular areas, effects of noise perception on visitor experience, perception of haze in park, perception of haze in cruise ship corridors, effects of visibility on visitor experience); *wildlife viewing opportunities* (frequency, location, quality); *wilderness values* (opportunities and barriers for wilderness experiences, effects of cruise ship on wilderness values, compare and contrast with other national parks in Alaska and US); *park management* (perception of potential management actions and of potential increase in cruise ships volume); and *trip satisfaction* (including satisfaction with Glacier Bay, park management, tour experience, vessel encounters, noise quality and visibility, and wilderness and wildlife viewing opportunities). The survey should also include a measure of visitors' *willingness to pay* for changes in various park conditions. This survey tool would then satisfy information needs identified in both Section 4.3 and 4.4.

SC-6 Study of Visibility and Noise Quality in Wilderness and non-Wilderness Areas.

The goal of this study is to understand how visitors perceive both noise effects from cruise ships and haze in the park. The study will sample visitors from diverse visitor segments in a variety of sample sites to understand the perception of noise and haze features, visitor sensitivity to noise and haze, the acceptability of various degrees of noise and haze, and the effects of noise and haze on the visitor experience.

Methodology. Identify sample sites in a variety of park settings representing a range of features, including: (a) non-motorized waters; (b) wilderness waters; (c) non-wilderness waters; (d) West arm vs. East arm; (e) Cruise ship turnaround areas (e.g., Tarr Inlet; Johns Hopkins Inlet).

Sample. Includes park visitors of all major visitor segments: backcountry users, private boaters, charter vessel passengers, tour vessel passengers, and cruise ship visitors.

Tasks. Study tasks would include measuring the audibility of cruise ship (and other vessel) noise in sample areas, from the visitor perspective, and note the qualities and quantities of noise that are perceived by visitors. Discern which types of noises augment the visitor experience and detract from the visitor experience; and measuring visitor perception of haze in sample areas and assess visitor sensitivity to haze, using approaches tested in Grand Canyon and other national parks.

SC-7 Monitoring of Visitor Experience. In addition to the research listed above, several variables related to the visitor experience should be identified and monitored on an ongoing basis to understand how changes in cruise ship volumes affect aspects of the visitor experience. These include: visitor satisfaction, cruise ship sightings, visibility standards, noise effects, wildlife sightings, backcountry permit applications, and backcountry user patterns.

4.5.3 Local and Regional Socioeconomics

SC-8 Economic Model of Cruise Ship Travel in Alaska. An economic model of cruise ship travel patterns and the potential shifts in itineraries is needed to understand how a change in cruise ship entries will affect the regional economy. This study would investigate how, given current itineraries and cruise ship capacity, travel patterns are likely to change, considering such issues as current demand, the price responsiveness to demand, how changes in the supply will affect price, and how it will affect net visits to Glacier Bay and the Southeast Alaska region. The study also will look at how displacement of cruise ship dockings will alter income and employment in local port communities and aggregate these for the region. Historical analysis on the effects of an increase in Glacier Bay entries in 1997 from 106 to 132 could provide a model for understanding how a change in allocation affects cruise ship scheduling and its subsequent economic effect on local and regional economies.

SC-9 Analysis of Competition Economic Welfare among Alaska Tourism Operators. A study is needed to predict the economic effects of cruise ship entry increases on other tour operators in Alaska. This study will examine market share and competition among tour operators bringing customers to Glacier Bay, to understand how increases in permits favoring one sector (large cruise lines) will affect other sectors (small cruise lines, tour operators.) Second, the economic model of cruise ship travel (SC-8, above) will predict how other cruise ship ports will be affected by permit increases in Glacier Bay, allowing economists to suggest how these changes affect local, non-local, and seasonal tour operators and their employees. This study also will develop tools for predicting how Glacier

Bay visits affect consumer choices to participate in shore excursions in other ports. Results may be examined both at the local and regional level.

5.0 Science Advisory Board Recommendations

5.1 Introduction

The Science Advisory Board evaluated existing research and concluded that an increase in seasonal use days for cruise ships in Glacier Bay could potentially affect aspects of the Park's physical, marine biological and sociocultural environments. However, insufficient scientific information exists to conclude definitively the nature, magnitude and significance of effects. Existing scientific literature provides data and findings related to impacts of motorized vessels on marine environments, and on the sociocultural environments of park and tourism areas. However, much of this work examined impacts from vessels other than cruise ships, on different biological communities, with different sociocultural issues, and in environments much different than Glacier Bay National Park and Preserve.

Sections 2.0, 3.0 and 4.0 of this report provide essential background information to the research recommendations listed in this section, and explain the Board's findings and conclusions in greater detail. For some topic areas, these sections also present the Board's recommendations for management measures that would prevent, control or mitigate potential impacts for Park managers' consideration. The recommended management measures are consolidated at the end of this section.

5.2 Recommended Research

To improve the base of knowledge that will inform future cruise ship management decisions in Glacier Bay, the Board is recommending that Glacier Bay National Park and Preserve support the studies identified in this research framework. The research framework recommends a combination of scientific studies, modeling efforts and monitoring. Scientific research will be designed to provide improved understanding of the potential effects of cruise ships by controlling for particular environmental variables to increase the power of statistical models to test for effects. For topic areas where experimental approaches may be logistically impractical and/or unable to control for the most critical variable, modeling and/or monitoring may be a more effective approach. Monitoring of selected resources and attributes of the Park is recommended to document baseline conditions under the current cruise ship management scenario and to detect changes if management is changed in the future. The Board has not prioritized the various studies listed in this section, but is willing to work with the Park in the future to set priorities among research projects.

The research framework recommends specific studies that will provide information needed to answer key management questions regarding the potential effects of increasing seasonal use days of cruise ships in the Park. The research framework focuses on topic areas where:

- Existing research is extremely limited and is needed to fill significant information gaps (e.g., sociocultural research specific to Glacier Bay National Park and Preserve);
- Research could readily build on existing work to yield fruitful results (e.g., further delineation of the underwater soundscape and effects of sound on marine biota);
- Important baseline data is lacking that could inform future management decisions about cruise ship visitation or practices (e.g., marine contaminants, air quality); and/or
- Modeling, combined with focused research, could test for demonstrable biological effects on species that are sensitive to disturbance or are of management concern (e.g., population-level effects on marine species).

The Board crafted a research framework that can meaningfully contribute to the Park's base of knowledge and contribute to its management decisions in the near-term. The Board recommends that before increasing seasonal use days for cruise ships in Glacier Bay, the Park take the time necessary to implement the research framework, and determine if results of new scientific research are sufficient to help frame decision-criteria that would define the environmental and social conditions under which an increase in seasonal use days for cruise ships could be allowed.

With regard to the timing of the recommended research program, it is important to note:

- For research related to visitor experience and socioeconomic impacts (Sections 4.5.2 and 4.5.3), it is essential that cruise ship levels remain unchanged for a minimum of one complete season (May–September) to provide for collection of baseline data during a representative year, to fully inform a decision about an increase in seasonal use days.
- Studies of potential impacts on the marine biological environment would generally require multiple years to produce findings. To focus information-gathering wisely, particularly on critical issues that may affect a population's long-term viability in the Park, the Board recommends an initial effort, to: 1) identify marine species that have been studied extensively, particularly under disturbance, and that offer reasonable potential for identifying disruptions in energy balance or survival rates compared to normal variability, and 2) use modeling to determine whether there is a reasonable probability that any disturbance effects on the species' survival, fecundity and demographics could be detected through research (Section 3.5). The Board anticipates it would take at least two years to assemble the data to construct these models, evaluate the feasibility and worth of conducting specific studies, and finalize research designs. In the near-term, these initial modeling efforts would help scientists and Park managers judge the potential for both immediate and longer-term impacts on marine species, determine the level of scientific uncertainty in research in these areas, and determine the need for and feasibility of longer-term data gathering.

The Board offers to further assist Glacier Bay National Park and Preserve to develop requests for proposals, assist in establishing research protocols for work done directly by the Park, and review proposals and study products. The Board can also assist the Park in applying research and monitoring results to the development of criteria defining the environmental and social conditions to be met before a decision is made regarding increasing seasonal use days for cruise ships in the Bay.

5.2.1 Physical Environment

Existing research has characterized the potential for cruise ships (and other vessels) to increase underwater sound levels in Glacier Bay, with the potential for effects on marine biota. The Board is recommending additional work that can be accomplished in the near-term, to catalogue and apply existing information and collect additional sound data, to increase the Park's ability to model and evaluate the extent to which marine biota are affected by underwater sound increases.

With regard to marine water quality, the Board finds that the potential for impacts are not great, given the current restrictions on wastewater and other discharges in the Bay. However, baseline data for marine contaminants is lacking and should be collected.

Data is also lacking to compare air emissions with ambient air quality standards (particularly for sulfur dioxide) and to inform any planning or management that the Park may wish to do regarding emission opacity and haze.

Underwater Soundscape

- P-1 Ambient Underwater Sound. Monitor and document ambient underwater sound for relevant areas in mid and upper Glacier Bay. These results will be used in acoustic models for these areas.
- P-2 Sound Level Data. Further develop the cruise ship acoustic knowledge base by establishing sound levels for cruise ship thrusters, and ships equipped with azipod propulsion and other new propulsion types. Determine acoustic differences between single cruise ship and two cruise ship days through acoustic monitoring and modeling.
- P-3 Sound Exposure Assessment. Conduct a study of separation distances between cruise ships and marine species. Establish sound exposure level and duration estimates for common cruise ship types and separation distances.
- P-4 Acoustic Monitoring. Continue acoustic monitoring in lower Glacier Bay so that data are available to assess soundscape trends, if vessel use levels change.

Water Quality

- P-5 Baseline Contaminant Data. Collect baseline data for contaminants in Glacier Bay's marine waters, benthic sediments, and for organisms that are producers and consumers in the marine food web. Data should be collected for metals, micro-contaminants (polycyclic musk compounds, pharmaceuticals), tributyltin and other organotins, and PAHs.

Air Quality

- P-6 Air Quality Monitoring in Sensitive Locations. Monitor ambient air quality conditions and sulfur dioxide levels, in accordance with EPA regulations, for areas in the upper fjords (e.g., near Margerie Glacier), where cruise ships congregate and stay for an extended period of time.
- P-7 Representative Air Emission Stack Testing. Conduct stack testing for representative cruise ships operating within Glacier Bay, including several ship configurations: standard marine propulsion engines with auxiliary engines for hoteling, marine engines that power both hoteling and electric motors, and turbine engines. Compare stack testing results with the air emissions factors used in the analysis of air quality impacts in the FEIS, to verify those findings.
- P-8 Opacity. Collect cruise ship air emission opacity data.

Recommended research relative to aesthetic effects of haze and effect on the human sociocultural environment of the Park is discussed in Section 5.2.3.

5.2.2 Marine Biological Environment

To address the question of what effects (if any) additional cruise ship visitation would have on marine mammals and birds, scientists need more information about whether behavioral and physiological responses exhibited by these species to disturbance by cruise ships or other indirect impacts (such as changes in abundance and distribution of their prey) would cause changes in populations of species in the Park over time. It will be scientifically challenging to determine this, due to natural variability in populations, the technical difficulty of empirically recording responses (e.g., measuring physiological changes in individual animals in response to cruise ship activity), the potential subtlety of the animals' responses, and the uncertainty involved in extrapolating data collected on a daily or seasonal basis to predict long-term cumulative effects.

The research framework suggests approaches that, while they may not yield conclusive results in the near-term, will help scientists and Park managers judge the potential for impacts and the need for and feasibility of additional research. The Board recommends the following:

- MB-1 Effects of Changes in Underwater Soundscape. Continue to collect, catalogue and evaluate information that will further elucidate the likelihood and potential for increases in underwater sound to impact marine biota. Work should include:
- a. Establish a catalog of hearing sensitivity data (behavioral and physiological) for marine species common to Glacier Bay. Explore means of obtaining hearing sensitivity data for species where current knowledge is insufficient.
 - b. Compare cruise ship sound exposure levels to levels that are known to cause physiological effects or behavioral responses in marine mammals and other marine species. In the absence of species-specific data, use the MMPA harassment exposure levels as a starting point. This analysis should focus on high priority species and on areas frequented by cruise ships.
 - c. Perform acoustic cue and acoustic communication masking analyses for species and conditions specific to Glacier Bay.
 - d. Meaningful acoustic exposure thresholds are needed to assess potential impacts due to changes in the Glacier Bay soundscape. The Park should encourage research that aims to establish acoustic exposure thresholds based not only on behavioral observations, but also on direct physiological and biochemical indicators of stress. Since stress indicator monitoring in marine species is presently a difficult and developing area of study, it is not certain that such research will be fruitful in the near term. Nevertheless, the research community is urged to move forward with the hope that results of this type can be used in the sound exposure assessments recommended above when the data become available.
- MB-2 Assess Potential for Disturbance for Marine Species. Assess the probability of disturbance from cruise ships to different marine species in the park by assessing the degree of their interaction with cruise ships. Recognize that some species may be obvious candidates for study because they are both easily detected and are well studied (e.g., humpback whales), while the interaction and disturbance potential of other species that are less visible and not easily studied may not be as obvious (e.g., schools of forage fish).
- MB-3 Modeling to Determine Effects on Populations and Densities of Marine Species. As noted above, effects on marine mammal and bird populations due to cruise ship activity may be very difficult to detect and quantify. Population-level effects would likely result from cumulative impacts over time, which are difficult to measure with precision. To focus this area of inquiry, the Board recommends, as a first step, modeling efforts to inform and guide the design of later research related to potential impacts on marine species. Modeling would be used to determine the potential for:
- a. Reduced cruise ship traffic to benefit the population abundance of selected species, through reduced encounters with cruise ships and reduced strike rates;

- b. Physiological responses of selected species to disturbance (physical, visual or acoustic), that could cause higher energetic costs, potentially affecting survival, fecundity and population viability; and
- c. Disturbance-induced behavioral responses of selected species that could result in a shift in their distribution to areas outside of the Park.

These modeling efforts should consider species that meet three criteria: 1) there is sufficient data available on distribution and energetics, not exclusive to Glacier Bay, to provide input to the models; 2) a significant portion of a discrete population is likely to be exposed to cruise ships (see MB-2 above); and 3) a disturbance response (behavioral or physiological) has been documented previously and can be used to estimate the energetic overhead or shift in distribution due to disturbance.

With regard to further research on physiological responses that could affect species' population (see (b) above), modeling would initially be used to estimate the likelihood that scientific research would be able to empirically detect such impacts. Scientists would use the results of the modeling to: 1) determine whether there is a reasonable probability that effects on survival and fecundity could be detected through research, 2) decide whether to pursue additional research, and if so, 3) design a research program examining demographic impacts.

For example, if it is assumed that harbor seals spend up to 20% more time in the water when cruise ships are within 5 kilometers, then this behavioral shift would result in an increase in the animal's daily energetic overhead (amount of increase would depend on body surface area, insulation, and water temperature). This increase in the animal's energy budget may effect its survival and fecundity. Given the natural variability in seals' haul-out behavior, and assuming a reasonable number of samples, the model would calculate the likelihood of being able to detect a 5%, 10%, 20%, 50%, etc., increase in time in the water, or more useful still, an increase in the seal's metabolic rate. If the model determined that the likelihood for detecting even large changes in one of these parameters through research was *small*, scientists and managers may place a low priority on such field studies. Conversely, if the model indicated that the probability of detecting such changes through research was *high*, then field research to investigate these types of responses to disturbance may be merited.

The use of this initial modeling approach does not address the uncertainty regarding whether shifts in behavior and physiology would ultimate effect population levels, as animals may compensate for these effects. But, having identified a likely mechanism of impact through modeling, multi-year studies could be better designed to establish links between individual behavioral responses, physiological responses, and population rates with the goal of reducing this uncertainty.

Modeling may indicate that natural variability is high and that the ability of scientific studies to detect changes is consistently low. Such findings would reconfirm the inherent uncertainty in any ecological study where species are responding to numerous factors simultaneously. Still, these findings may be useful in the context of a precautionary approach, where managers seek to reduce the chance of concluding that vessels have no effect when indeed an effect does occur, an approach supported by the U.S. Congress with respect to threatened and endangered species [House of Representatives Conference Report No. 697, 96th Congress, Second Session, 12, (1979)].

MB-4 Monitoring of Populations. Routinely monitor marine mammal and bird populations, focusing on species most likely to use areas frequented by cruise ships (see MB-2), and keep abreast of research that evaluates changes in populations in response to natural variables (i.e., not due to anthropogenic disturbance).

5.2.3 Human Sociocultural Environment

There has been little or no research that specifically evaluates the sociocultural impacts of cruise ship visitation specific to Glacier Bay, including surveys of sensitive cultural resources, consultation with traditional users of Glacier Bay, visitor surveys, and economic analyses of Park decisions related to cruise ships on local communities, the region, and Alaskan tour providers. The Board is recommending research projects that can be successfully conducted in the near-term (2006-07) to remedy this significant gap in knowledge. The results of this work will inform Park managers about the character, magnitude and potential significance of impacts to the Park's sociocultural environment that would result from an increase in cruise ship visitation.

Identification and Management of Cultural Resources Within the Park

SC-1 Archaeological Sites and Traditional Cultural Properties. A study plan should be developed and implemented to identify all archeological sites and potential TCPs and examine their sensitivity to disturbance. Any sites found to be sensitive to physical disturbance from cruise ship traffic should be listed in the Cultural Resource Management Plan (see Section 4.6.1). If necessary, management direction should minimize physical disturbance to identified sites.

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Cultural Resources: Huna Tlingit Relationship with Glacier Bay

- SC-3 Ethnography of Huna Tlingit. It is recommended that the National Park Service support an in-depth ethnographic description focused on the Huna Tlingit and their relationship with Glacier Bay. Such a work would provide lasting documentation of Huna Tlingit culture similar to that provided by de Laguna's *Under Mount Saint Elias* for the Yakutat Tlingit.
- SC-4 Cultural and Spiritual Concerns with Cruise Ship Traffic. A field study be undertaken to verify and better understand the cultural and spiritual concerns with cruise ship vessel traffic in Glacier Bay. This study would conduct interviews with tribal council members and with clan elders who are responsible under traditional Tlingit law and practice to represent the interests of their clans. The study objective would be to more fully describe Huna Tlingit concerns with cruise ship visitation, assess the level of likely impact, and mitigate impacts if feasible. Cruise ship visitation levels would need to be rethought if impacts were shown to result in a likely impairment of cultural resources.

Visitor Experience

- SC-5 Visitor Experiences and Acceptability of Park Conditions. The Park should undertake a study to establish baseline information for understanding the many aspects of the visitor experience in Glacier Bay. The study will help to determine visitor motivations and expectations, as well as the effects of various park features and conditions on the quality of the visitor experience. The study will also establish a framework for understanding park conditions deemed both preferable and acceptable by various visitor groups and establish the limits of acceptable changes that could take place in park conditions without diminishing the visitor experience.

Methodology. Conduct intercept surveys with park visitors of all visitor segments. Data collection involves a brief intercept interview with visitors prior to entering Glacier Bay, including visitor profile, motivations, and expectations. Respondents may be given a longer, more detailed, mail-back survey that they fill out and return after their trip to Glacier Bay or from home.

Sample. Includes park visitors of all major visitor segments: backcountry users, private boaters, charter vessel passengers, tour vessel passengers, and cruise ship visitors.

Survey Topics. The intercept survey conducted by interview would address: *visitor profile* (demographic variables, origins of traveler, number of trips to Alaska, number of trips to Glacier Bay, number of trips to national parks), *visitor motivations* (for coming to Alaska and to Glacier Bay), *visitor preferences* (for park conditions in wilderness and non-wilderness settings; willingness to pay for

certain park conditions); *visitor expectations* (for activities in Glacier Bay, for wildlife viewing, air and noise quality, vessel sightings, and wilderness qualities).

The mail-in survey would address: *trip characteristics* (transportation used in Glacier Bay, days/overnights in Glacier Bay, areas visited in Glacier Bay, primary activities in Glacier Bay); *vessel sightings* (frequency, duration, volume, quality; effects on visitor experience; types/locations of vessel sightings considered inappropriate; effects of larger ships vs. smaller ships; acceptability of vessel sightings); *crowding and congestion* (perception of crowding in park overall, perception of crowding in particular areas; crowding effects on visitor experience); *visibility and noise quality* (perception of vessel noise in park, perception of vessel noise in particular areas, effects of noise perception on visitor experience, perception of haze in park, perception of haze in cruise ship corridors, effects of visibility on visitor experience); *wildlife viewing opportunities* (frequency, location, quality); *wilderness values* (opportunities and barriers for wilderness experiences, effects of cruise ship on wilderness values, compare and contrast with other national parks in Alaska and US); *park management* (perception of potential management actions and of potential increase in cruise ships volume); and *trip satisfaction* (including satisfaction with Glacier Bay, park management, tour experience, vessel encounters, noise quality and visibility, and wilderness and wildlife viewing opportunities). The survey should also include a measure of visitors' *willingness to pay* for changes in various park conditions. This survey tool would then satisfy information needs identified in both Section 4.3 and 4.4.

SC-6 Study of Visibility and Noise Quality in Wilderness and non-Wilderness Areas.

The goal of this study is to understand how visitors perceive both noise effects from cruise ships and haze in the park. The study will sample visitors from diverse visitor segments in a variety of sample sites to understand the perception of noise and haze features, visitor sensitivity to noise and haze, the acceptability of various degrees of noise and haze, and the effects of noise and haze on the visitor experience.

Methodology. Identify sample sites in a variety of park settings representing a range of features, including: (a) non-motorized waters; (b) wilderness waters; (c) non-wilderness waters; (d) West arm vs. East arm; (e) Cruise ship turnaround areas (e.g., Tarr Inlet; Johns Hopkins Inlet).

Sample. Includes park visitors of all major visitor segments: backcountry users, private boaters, charter vessel passengers, tour vessel passengers, and cruise ship visitors.

Tasks. Study tasks would include measuring the audibility of cruise ship (and other vessel) noise in sample areas, from the visitor perspective, and note the qualities and quantities of noise that are perceived by visitors. Discern which types of noises augment the visitor experience and detract from the visitor

experience; and measuring visitor perception of haze in sample areas and assess visitor sensitivity to haze, using approaches tested in Grand Canyon and other national parks.

- SC-7 Monitoring of Visitor Experience. In addition to the research listed above, several variables related to the visitor experience should be identified and monitored on an ongoing basis to understand how changes in cruise ship volumes affect aspects of the visitor experience. These include: visitor satisfaction, cruise ship sightings, visibility standards, noise effects, wildlife sightings, backcountry permit applications, and backcountry user patterns.

Local and Regional Socioeconomics

- SC-8 Economic Model of Cruise Ship Travel in Alaska. An economic model of cruise ship travel patterns and the potential shifts in itineraries is needed to understand how a change in cruise ship entries will affect the regional economy. This study would investigate how, given current itineraries and cruise ship capacity, travel patterns are likely to change, considering such issues as current demand, the price responsiveness to demand, how changes in the supply will affect price, and how it will affect net visits to Glacier Bay and the Southeast Alaska region. The study also will look at how displacement of cruise ship dockings will alter income and employment in local port communities and aggregate these for the region. Historical analysis on the effects of an increase in Glacier Bay entries in 1997 from 106 to 132 could provide a model for understanding how a change in allocation affects cruise ship scheduling and its subsequent economic effect on local and regional economies.

- SC-9 Analysis of Competition Economic Welfare among Alaska Tourism Operators. A study is needed to predict the economic effects of cruise ship entry increases on other tour operators in Alaska. This study will examine market share and competition among tour operators bringing customers to Glacier Bay, to understand how increases in permits favoring one sector (large cruise lines) will affect other sectors (small cruise lines, tour operators.) Second, the economic model of cruise ship travel (SC-8, above) will predict how other cruise ship ports will be affected by permit increases in Glacier Bay, allowing economists to suggest how these changes affect local, non-local, and seasonal tour operators and their employees. This study also will develop tools for predicting how Glacier Bay visits affect consumer choices to participate in shore excursions in other ports. Results may be examined both at the local and regional level.

5.3 Consolidated Management Recommendations

The Science Advisory Board offers the following recommendations regarding Park management that may help prevent, control or mitigate impacts to the Park's resources and values evaluated in this report:

Physical Environment

1. It is recommended that Glacier Bay continue to require no discharge of wastewater, bilge and ballast water in the bay. Advanced wastewater treatment systems certified for continuous discharge are an improvement to earlier treatment systems, but upsets have occurred. Advanced systems have been used for less than five years and the long-term reliability is unknown. Even though cruise ships with continuous discharge systems are required to monitor discharge twice per month, there is a delay between testing and result notification that could delay awareness of a system malfunction.
2. It is recommended that if the Park considers allowing cruise ships with advanced wastewater treatment systems to discharge within Glacier Bay, it should give approval only after the cruise ship submits data from representative discharges showing a minimum of five years of successful, continuous (year-round) operation, and after protocols and regulatory standards have been established to protect against impacts from polycyclic musk compounds and pharmaceuticals.
3. It is recommended that Glacier Bay National Park require cruise ship companies to submit fuel certifications to the Park and recognize ships burning fuel with <1.50% sulfur by weight in management decisions.
4. It is recommended that Glacier Bay National Park operate as a Class I regional haze area and develop a long-term plan for reducing pollutant emissions that contribute to visibility degradation and establish goals aimed at improving visibility.

Marine Biological Environment

5. It is recommended that the Park continue to apply measures to reduce potential interactions between ships and marine mammals, including managing ship locations to reduce disturbance to areas where sensitive life-stages occur (e.g., harbor seal pup-rearing areas), and speed reduction and adaptive management of ship routes based on the distribution and behavior of whales. These measures likely reduce the frequency and potentially the severity of impacts.
6. Based on acoustic modeling and the outcome of research on acoustic related behavioral and physiological responses, it is recommended that the Park consider the need to establish vessel underwater sound level guidelines and acoustic limits for vessels operating in Glacier Bay.

Sociocultural Environment

7. It is recommended that Glacier Bay National Park and Preserve develop a thorough Cultural Resources Management (CRM) Plan to adequately understand, protect, and represent park cultural resources. Because most of the cultural

- resources in the bay concern Huna Tlingit history, occupancy, subsistence use, and mythology, the Hoonah Indian Association should be a partner in developing the Cultural Resources Management Plan.
8. It is recommended that Glacier Bay National Park consider revising or amending its general management plan and the plan's objectives and actions to more formally include preservation of Native cultural resources as a purpose of Glacier Bay National Park. Development of a revised or amended plan should include Hoonah Indian Association government representatives and tribal clan leaders.
 9. It is recommended that Glacier Bay National Park improve and expand the interpretation of the Huna Tlingit cultural history and contemporary use of park areas it provides to visitors. Further, that the park encourage more accurate and complete interpretation by concessionaires through concession negotiations and awards.
 10. Empirical data shows that visitor satisfaction may decline as the quantity, frequency, and duration of visitor encounters increases. This is particularly characteristic of backcountry users, who typically desire a more primitive or remote park experience. If the proposed research demonstrates significant negative effects among visitor groups, the Board recommends that periodic opportunities be provided during peak season for visitors to experience the park with zero, one, and two ships daily.
 11. The Board recommends that studies on crowding, congestion, and displacement be undertaken to determine whether or not visitors perceive crowding and under what conditions this is occurring. If Park visitors perceive crowding under the current quota system, Park managers may want to weigh the benefits and costs of maintaining current levels to provide opportunities for visitors to experience the park under less crowded conditions. This research will provide baseline standards that reflect desired park conditions among visitor groups, in wilderness and non-wilderness areas of the park, with respect to vessel volumes in specific settings.
 12. The Board recommends that the above studies be completed to develop visibility standards for park visitors under existing cruise ship quotas and to ascertain whether the volume of cruise ships affects the perceptibility of haze. Park managers may consider ways to provide opportunities to visit the park without visible haze. In addition, technological developments that reduce haze impacts should be rewarded in the concessionaire bidding process.
 13. Standard indicators of noise acceptability can be established through baseline research. It is recommended that if the Park considers increases in cruise ship visitation, it also consider measures that could be taken by cruise lines to ensure that the noise standards are not exceeded. For example, adaptations in the technology or use practices of the public address system could be made (e.g., use of earphones).

14. Wildlife viewing is an important aspect of a Glacier Bay experience for all types of park visitors. The Board recommends that the effects of cruise ships on marine and terrestrial wildlife be monitored on an ongoing basis to understand aspects of species health, viability and behavior. There is no evidence that suggests wildlife opportunities have changed as a result of the increase in number or size of large cruise ships. But this is an area that should be monitored and studied on a long-term basis.
15. Decisions by park managers to increase cruise ship levels may find it useful to consider the role of cruise ships in shaping and perpetuating park character and the extent to which cruise ships contribute to values of ruggedness and wildness.
16. The potential economic effects of increased cruise ship entries are complex and multifaceted. Research is needed to identify the implications of increased cruise ship entries on other Alaska ports. Monitoring of key socioeconomic variables will be important to measure changes in the local and regional economy that may be associated with an increase in vessel entries. The Board recommends that baseline data be collected in 2006 to measure local economic effects of permit increases. In addition, the Board recommends that any proposed increases in cruise vessel entries occur incrementally, so that socioeconomic indicators may be monitored and changes to local economies can be predicted, managed, and mitigated by local officials.
17. Little actual data has been collected in Glacier Bay about the economic effects of large cruise travel on tourism providers operating in or around Glacier Bay. The potential for an increase in one market segment to overshadow or overwhelm another is significant. The Board urges park managers to pay special attention to the implications of cruise ship entry level increases on the smaller tourism providers and concessionaires who depend on the provision of a quality visitor experience for their economic livelihood.

6.0 Conclusion

To assist Glacier Bay National Park and Preserve in future management decisions related to seasonal use days for cruise ships visiting the Park, the Vessel Management Science Advisory Board has prepared:

- A summary and assessment of existing scientific information relevant to determining potential impacts on the physical, marine biological and sociocultural resources and values of the Park; and
- A framework for near-term scientific research that will lead to a better understanding of potential impacts, and will help frame criteria defining the environmental and social conditions to be met before a decision is made regarding increasing seasonal use days for cruise ships in the bay.

Research should begin as soon as feasible. The Board recommends that before considering an increase in seasonal use days for cruise ships in Glacier Bay, the Park take the time necessary to implement the research framework, and determine if results of new scientific research are sufficient to help frame decision-criteria that would define the environmental and social conditions under which an increase in seasonal use days for cruise ships could be allowed. It will be particularly important to keep cruise ship levels unchanged for a minimum of one representative year, to establish a baseline condition for essential socioeconomic research. In other topic areas, more time may be needed to conduct initial work (e.g., modeling of potential marine biological impacts) and to determine if new research could help define criteria to guide a decision about the magnitude and significance of any potential impacts to Park resources and values from increasing cruise ship numbers. The Park may consider extending the current seasonal use quota (or a reduced quota) for an additional period of study, if the aforementioned research or possible new findings point to specific criteria or highlight a need for additional data.

The Board has appreciated the opportunity to provide its recommendations to the Park on these important and complex key management questions related to decisions regarding potential increases in seasonal use days of cruise ships in Glacier Bay. It offers its continued assistance, as the Park implements the research framework, evaluates research findings, and applies the new information generated to its management decisions regarding cruise ship visitation.

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Appendices

- A. Categories of Glacier Bay Visitors and Visitor Trends
- B. Potential Impacts of Contaminants Derived from Cruiseships on the Biological Resources of Glacier Bay, prepared by Myra Finkelstein, PhD, Department of Environmental Toxicology, University of California, Santa Cruz, California.
- C. Potential Impacts of Cruiseships on the Marine Mammals of Glacier Bay, prepared by Julie Mocklin, NOAA, Seattle, Washington.
- D. Potential Disturbance of Marine Birds from Cruise Ships, prepared by Alison Agness, University of Washington, Seattle, Washington.
- E. Potential Impacts of Cruiseships on the Lower Trophic Level Species of Glacier Bay, prepared by Myra Finkelstein, PhD, Department of Environmental Toxicology, University of California, Santa Cruz, California.
- F. Visitor Experience in Glacier Bay National Park & Preserve: A Literature Review and Discussion, prepared by Debra L. Clausen, Sundberg & Clausen.