

ations, and repeated attempts to approach whales, seals, and penguins for viewing could interfere with biologically important activities such as feeding and, over time, cause animals to abandon or avoid areas traditionally used for such purposes.

**Science and Science Support Operations.** Many tourists are interested in visiting and seeing first-hand the kinds of science being done at research stations operated by different countries in the Peninsula area. Such visits can interfere with the daily routine of station personnel and, if they occur frequently, may interfere with station operations if passengers are not well educated before going ashore and supervised while on shore. In some cases, repeated visits may interfere with or compromise on-going research. For example, visitors simply turning lights on or off in areas where experiments are being done to determine the effects of light on plankton, krill or other organisms can affect the study results.

Most national program managers have established restrictions on station visits, and procedures for structuring those visits to avoid or minimize possible impacts on station operations and personnel. Such actions are the responsibility of the individual program managers and were not considered by the workshop.

#### **4. SITE VARIABLES AFFECTING POSSIBLE CUMULATIVE EFFECTS**

The nature and severity of the possible cumulative impacts of ship-based tourism will depend in part on the characteristics of the sites visited. The following are ten site characteristics identified by the workshop participants.

**1. Biological Diversity at the Site.** As noted earlier, many tourists visit Antarctica to see wildlife. Thus, sites with large numbers of multiple species of penguins, flying birds, and seals are more likely to be visited than sites with smaller numbers of fewer species. As noted below, the frequency of visits and numbers of visitors are two of the principal factors determining the likelihood of cumulative impacts.

**2. Location Relative to the Distributional Ranges of the Species Present.** Sites with the greatest diversity of flora and fauna are likely to be in areas where the ranges of multiple species overlap. Species' distributions generally are determined by geographically variable environmental factors, such as the presence of ice-free areas at critical times in their breeding cycle and the absence of competing species. Thus, species at the margins of their distributional ranges may be more subject to stress and vulnerable to disturbance-related effects than species near the centers of their distributional ranges.

**3. Robustness of the Species Present.** Some species of flora and fauna will be more vulnerable or sensitive to repeated disturbance than others. As a general rule, mosses and lichens are more likely to be damaged or destroyed by trampling than are grasses. Conversely, penguins and flying birds that lay eggs and hatch chicks early in the austral spring before the beginning of the tourist season are less likely to have these vital processes interrupted than birds that lay eggs and hatch chicks later in the year.

**4. Availability of Open Space.** Some visitor sites have restricted access areas and little or no space for visitors to walk without disturbing wildlife or trampling vegetation. Other sites have more open, unoccupied areas permitting access to the sites and viewing of flora and fauna with less risk of disturbance. The risk of disturbance also will vary depending on the locations of access beaches, walking trails, and observation sites relative to the locations of penguin colonies, flying bird nesting sites, seal haul-outs and breeding colonies, and plant communities.

**5. General Topography.** The physical characteristics of sites subject to repeated visits also can play a role in determining the nature and severity of cumulative impacts. Sites with limited access and long or steep climbs to get to points of interest are less likely to be visited than sites with easier access. However, climbing steep hills can dislodge rocks and gravel, which in turn can alter the flow of rain- and melt-water and promote erosion. Likewise, if access to certain points of interest is easier through bird colonies or plant communities, visitors understandably may take the easier route through these areas if they have not been adequately briefed before coming ashore and are not well supervised while on shore.

**6. Novelty of the Site.** Some sites will be of interest to tourists because of some unique or novel feature. In the Antarctic Peninsula area, there are only a few accessible sites, for example, that have breeding colonies of crested penguins. Likewise, Deception Island is one of the few places in the world where ships can enter a water-filled caldera of a volcano. Such areas are likely to be visited more frequently than areas lacking such novelty.

**7. Ice and Weather Conditions.** Although several parts of the Antarctic Peninsula are accessible by air, most parts are accessible only by sea. Thus, the predictability of and variability in sea ice and weather conditions play a major role in determining when and how frequently certain sites can be visited. For example, sites where sea ice does not normally break-up until late in the austral summer, or where break-up may not occur at all in some years, are less likely to be visited than sites where access is more predictable. Likewise, sites where rain, fog, or wind are common, or where weather conditions can change rapidly, pose safety risks and are unlikely to be visited as often as sites

where weather conditions are generally better and less likely to deteriorate rapidly.

**8. Availability of Safe Anchoring or Waiting Sites.** One of the keys to successful ship-based tour operations is the ability to get passengers ashore, safely and quickly, at selected sites. Thus, sites with good, calm-water anchorages or waiting areas close to where passengers are put ashore are likely to be visited more frequently than areas where access is difficult or dangerous. Similarly, there is less risk of ships being blown on shore or being hit by icebergs in areas with protected anchorages.

**9. Acoustic Characteristics.** Sounds produced by ship and small-boat engines, fathometers, hull vibration, etc. can affect the behavior and, if loud or long-lasting, damage the hearing of animals both on land and in the water. Sound can be focused or dissipated depending upon the physical characteristics of the environment around the source. In embayments, for example, sound may be reflected off the bottom and shoreline, such that it converges or is focused in areas within or adjacent to the embayment. Sound similarly can be bounced off points of land and be focused in certain areas, depending upon the location of the source relative to the contour of the land. Thus, acoustic disturbance, like other forms of disturbance, may vary from site to site.

**10. Location of Comparable Sites Nearby.** One of the attractions of Antarctica to tourists is its largely unaffected wilderness quality. To maximize the “wilderness experience,” tour operators generally endeavor to avoid taking passengers to areas where other ships are likely to be seen, particularly if they are embarking or disembarking passengers. Therefore, areas in which there are a number of sites with comparable wildlife or other points of interests beyond the sight of each other are likely to be visited more frequently than sites where other tours are likely to be encountered. On the other hand, each site in such areas may be visited less frequently than would a novel site if nothing comparable is nearby.