Assessing Potential Resource Use Conflicts Between Wildlife and Recreationists in Gwaii Haanas National Park Reserve, British Columbia

By

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ABSTRACT

Gwaii Haanas National Park Reserve and Haida Heritage Site, located off the northwest coast of British Columbia, represents a remote wilderness and cultural experience for many visitors. Ecological integrity is a priority for Canadian national parks that requires effective management of tourism and visitation, which constitute internal threats to many parks. I developed a GIS-based method to examine patterns of visitor use and identified potential conflict areas by determining how intensively used zones coincided with seabird colonies and Peregrine Falcon eyries. Overnight sites and travel activity are spatially and temporally heterogeneous over the Gwaii Haanas landscape and vary with visitor types. Wildlife sites, near attraction sites, were most susceptible to refuge boundary violations with peaks occurring during July and August, which is consistent with the pattern of visitor entry. Recommendations for park managers are framed within a spectrum of management options and challenges associated with marine reserve management.

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1 INTRODUCTION

Gwaii Haanas National Park Reserve and Haida Heritage Site, located in the southern portion of Haida Gwaii (also known as the Queen Charlotte Islands) off the northwest coast of British Columbia (Figure 1), is for many a place of wonder, wildness and cultural exploration. Its many unique flora and fauna that are distinct from mainland taxa (Cowan 1989) and its strong Haida cultural heritage act as a draw for those seeking a remote wilderness experience. Yet, as demand for ecotourism and recreational opportunities in national parks increases (Eagles 2001), park managers are challenged to implement visitor management and resource protection strategies that ensure a quality experience without compromising the ecological integrity of the protected area.

The revised Canada National Parks Act (Canada 2000), states that "maintenance or restoration of ecological integrity, through the protection of natural resources and natural processes, shall be the first priority of the Minister when considering all aspects of the management of parks." The integration of ecological integrity into a legal context recognizes a new emphasis for park management. However, the utility and implementation of ecological integrity into all components of park planning and management can only occur with a clear definition and the ability to operationalise the term. Since its conception, discussion surrounding its complex definition (Noss 1995) and subsequent application as an operational tool continue (Ulanowicz 2000). The Canada National Parks Act (2000) states that,

> 2. (1) "ecological integrity" means, with respect to a park, a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of

native species and biological communities, rates of change and supporting processes.

Although ecological integrity is a priority for park management, numerous stressors currently threaten the integrity of Canada's national park system. Stressors that lead to loss or degradation of ecological integrity can originate within the national park itself or outside of its boundaries. A survey of 38 national parks and national park reserves found that nearly all were experiencing some form of stress leading to significant ecological impacts (Parks Canada Agency 2000a). External threats including global warming, acid rain, forestry practices and mining, are contrasted with internal threats, such as the spread of non-native species, visitor and tourism facilities and increased visitor use. In the most recent State of the Parks Report, 24 of the then 36 parks, including Gwaii Haanas, indicated that tourism and visitor facilities were causing significant ecological impacts (Parks Canada Agency 1998). Additionally, the cumulative effects from multiple threats may interact synergistically, resulting in a total effect that is greater than the sum of the predicted impacts of the individual effects. In an assessment of the impact of recreational pursuits on waterfowl, shore-based fishing and sailing considered simultaneously decreased the habitat available for waterfowl leading to displacement whereas singularly no effect was determined (Bell and Austin 1985). Recreational pursuits may exhibit synergistic effects and could lead to significant ecological stresses thereby affecting the ecological integrity of the natural environment (Parks Canada Agency 2000b).

1.1 Visitor Use and Protected Areas – A Potential Conflict?

Visitation and tourism are internal stressors with potential negative impacts but are simultaneously legitimate uses of national parks possessing a strong historical foundation. Tourism opportunities and recreational pursuits were the premise for the creation of Banff National Park in 1885, Canada's first national park, and constitute an historical and existing use of national parks (Wilkinson 2003). The Canada National Park Act (2000) states:

> 4. (1) The national parks of Canada are hereby dedicated to the people of Canada for their benefit, education and enjoyment, subject to this Act and the regulations, and the parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations.

Although human uses of national parks have been and will continue to be an important component of Canadian heritage, they are juxtaposed against a legislative backdrop that prioritises ecological integrity. The potential for compatibility of these two goals exists but visitor use of national parks requires adherence to the priority management goals of ecological integrity and a clear linkage to park values (Dearden 2000). However, the potential for resource use conflict within national parks is related in part to multiple and at times competing conceptions of valid uses and roles of national parks by society (Eagles et al. 2000) often with a division occurring between social and ecological functions of national parks (Dearden 1995), as is often the case with tourism in national parks. This identifies a continuous challenge for park managers to balance appropriate types and levels of human activity within the context of ecological integrity.

1.1.1 Human Dimensions of Protected Areas Research

To effectively manage for ecological integrity and satisfaction of the visitor experience it is necessary to understand parameters of visitor use in national parks. An understanding of human use dimensions such as use levels and user characteristics is identified as a critical component to effective protected areas management (McVetty 2002). Visitor use surveys of protected areas have not generally examined use patterns from a spatial perspective but have focused on single summary statistics, such as the number of visitors (Wing and Shelby 1999). Protected areas managers recognise the necessity of integration of spatial user information for effective management yet the challenge of tracking and recording visitor travel (Wang and Manning 1999; Wing and Johnson 2001) and limited human and financial resources (Wilkinson 2003) often preclude its compilation. However, as patterns of recreational use are seldom distributed uniformly across a landscape, especially in larger areas, certain regions may be used more intensively than others. Where this pattern of use distribution is paralleled by a comparable heterogeneous distribution of sensitive ecological resources, the likelihood of differential impacts is heightened.

Application of a Geographic Information System (GIS) to assess spatial visitor distribution patterns is increasingly recognised as a valuable visitor monitoring tool (Hinterberger et al. 2002). Analysis of visitor flows and densities provides managers with a visual tool to identify more densely used regions, for example along trail systems, and can be further applied to estimate and predict where inter-user conflicts are or may occur (Wing and Shelby 1999; Hinterberger et al. 2002). To identify potential areas where visitor crowding may lead to inter-user conflicts, GIS applications include spatial analyses of visitor distributions and patterns based on visitor monitoring data (Jaakson 1989; Schryver 1994; Hinterberger et al. 2002), or those data in conjunction with attitudinal surveys (Confer et al. 1992; Falk et al. 1992). The use of simulation modelling of recreationist behaviours with a GIS provides managers with a predictive tool to help identify spatial locations of potential conflicts such as crowding between user groups that may result from various management alternatives (Gimblett et al. 2001, 2002). More recently, monitoring of human activities in a marine protected area over time garnered baseline information of human uses and enabled an assessment of conservation measures applied to protect an endangered species (Karamanlidis et al. 2004). Recognising the value of these advances, a priority for park managers is filling the knowledge gap associated with human uses of parks (Freimund and Cole 2001) to provide recreation opportunities while protecting natural ecosystems.

1.2 Recreation Impacts to Wildlife

A general increase in the number of visitors to protected areas and national parks has led to increasing concerns that human presence in these areas are also negatively affecting wildlife (Flather and Cordell 1995). Recreational activities may indirectly affect wildlife, or may lead to direct impacts through exploitation and disturbance events (Knight and Cole 1995a; Hammitt and Cole 1998). Non-consumptive recreational activities, which lack an intention to remove or permanently affect wildlife (Duffus and Dearden 1990), such as wildlife viewing, hiking and boating, are often perceived as benign in terms of environmental impact. Yet, they are increasingly implicated in their ability and potential to negatively harm wildlife (Boyle and Samson 1985). The prevalence of non-consumptive recreational activities in protected areas signals a need to comprehend their potential effects if they are to be avoided and mitigated.

1.2.1 Wildlife Responses to Human Disturbance

As a conceptual framework to understand wildlife responses to disturbance, the risk disturbance hypothesis proposes that human-induced disturbance be viewed as an analogue to predation risk (Frid and Dill 2002). This hypothesis predicates that animals should find a fitness maximising balance between avoiding disturbance and other activities that contribute to fitness such as foraging, feeding and parental care (Frid and Dill 2002). In the presence of a potential disturbance, it is expected that responses by wildlife will be greater where the perception of risk is heightened. It is, therefore, in the individual's best interest to minimise the costs of disturbance while maximising the probability of survival (Ydenberg and Dill 1986). For the purposes of this project, disturbance is defined as a change "in an animal's behaviour from patterns occurring without human influences" (Frid and Dill 2002). In recent years, the value of research assessing the impacts of human-induced disturbance of wildlife has gained importance in tandem with an increasing concern for species and biodiversity conservation (Hockin et al. 1992; Hill et al. 1997; Carney and Sydeman 1999).

Disturbances may affect wildlife at the individual, population or community level. Although population level impacts are argued to be of most interest and value to conservationists (Nisbet 2000), individual responses have been studied more extensively due, in part, to the difficulty in assessing higher-level impacts. Immediate wildlife responses to human-induced disturbance may promote energetically costly behaviours mediated through, for example, behaviour modification of foraging and breeding behaviours. Individual responses provide insight into both population and community level responses. Ultimately, human-induced disturbance may lead to avoidance of suitable and/or preferred habitats situated in high risk areas (Gill and Sutherland 2000) and declines in reproductive success (Burger et al. 1995), thereby potentially affecting wildlife at the population level.

A range of wildlife responses to disturbance exist and include shifts in daily activity behaviours and patterns, changes in breeding behaviours and decreases in breeding success. Disturbance events result in a reduction in time spent feeding and a concurrent increase in vigilance behaviours (Burger 1981, 1986; Galicia and Baldassarre 1997; Burger and Gochfield 1998) and an increase in flight behaviours (Korschgen et al. 1985; Hohman and Rave 1990; Havera et al. 1992) for coastal birds and ducks. A review of recreational disturbance on raptors found that disturbance episodes altered foraging behaviours and nest attentiveness patterns, led to nest abandonment and reduced productivity (Knight and Skagen 1988). As well, increased rates of vigilance behaviours in Bald Eagles (*Haliaeetus leucocephalus*) led to a decrease in feeding efficiencies (Knight and Knight 1986) and increased flight avoidance responses (Stalmaster 1983).

In a literature review of disturbance impacts to avian species, 90% of reviewed papers indicated that the main reason for lower breeding success was nest abandonment and increased predation of eggs and young (Hockin et al. 1992). Additional studies of disturbance to seabirds indicate that investigator activities negatively affects hatching success and productivity of Tufted Puffins (*Fratercula cirrhata*) (Piatt et al. 1990), Leach's Storm-Petrel (*Oceanodroma leucorhoa*) (Blackmer et al. 2004) (both known to breed in Gwaii Haanas), Least Auklets (*Aethia pusilla*) (Pierce and Simons 1986) and Black Guillemots (*Cepphus grille*) (Cairns 1980).

Human-induced disturbance constitutes a major threat to raptors (LeFranc and Millsap 1984) and may result in disruption to breeding behaviours resulting in decreased reproductive success. Recreational activities can lead to nest site abandonment in Peregrine Falcons (*Falco peregrinus*) (Olsen and Olsen 1980) and Ferruginous Hawks (*Buteo regalis*) (White and Thurow 1985) and can lead to declines in nest vigilance (Fyfe and Olendorff 1976; Suter and Jones 1981; Bortolotti et al. 1984). Decreased reproductive rates were correlated with human disturbance in Osprey (*Pandion haliaetus*) (Reese 1977; Swenson 1979; Van Daele and Van Daele 1982) (Although other research has refuted these findings (Poole 1981)). These inconsistencies may be attributed to additional factors not explicitly considered in the experimental design, such as timing and type of disturbance (Knight and Skagen 1988), and highlights the necessity of their explicit inclusion.

1.2.2 Factors Influencing Wildlife Responses

The range of responses by wildlife to human induced disturbance suggests a variety of causal factors. The perceived risk, by an individual, associated with a disturbance is partially a function of 1) factors that characterise the disturbance stimulus and 2) characteristics of the attribute receiving the impact (Cole and Landres 1996). Where a perceived risk of a disturbance is greater, it is expected that a stronger behavioural response will be elicited (Frid and Dill 2002). Disturbance stimulus characteristics include distance, type of activity, timing, frequency and behaviour (Knight and Cole 1995b).

The distance between wildlife and human activities may influence the perception of risk and possibly result in avoidance responses or agonistic behaviours in birds. Quantification of the flight initiation distance, defined as the distance between a predator or a perceived predator and an animal when it takes flight (Ydenberg and Dill 1986), is frequently applied as a disturbance indicator by behavioural ecologists and wildlife managers. Researchers have determined flight initiation distances in several avian species and subsequently instituted buffer distances from which people are excluded (Erwin 1989; Rodgers and Smith 1995, 1997; Burger 1998; Rodgers and Schwikert 2002; Ronconi and St. Clair 2002). Previous research of raptor responses to human-induced disturbance has lead to identification of flight distances for various raptors including Peregrine Falcons (Richardson and Miller 1997). Some authors have suggested delimiting buffers based on an agitation distance, referring to the distance at which wildlife respond physiologically to a human event (McGarigal et al. 1991; Camp et al. 1997), but others apply the alert distance, at which wildlife respond by typical alert behaviours such as cessation of feeding and increased vigilance (Fernandez-Juricic et al. 2001). Proponents of the latter methods argue for these more conservative approaches that allow wildlife a reaction zone in which they may adapt their behaviour to human presence (Fernandez-Juricic et al. 2001). Determination of disturbance threshold levels can directly inform sustainable recreation policies by delimiting spatial buffer zones where visitor exclusion should occur to minimise or eliminate the disturbance. This approach may be beneficial where the management goals include coexistence of wildlife and recreationists.

The type of activity pursued also contributes to differential behavioural responses. Boating activity has been found to elicit flushing in breeding colonial waterbirds (Rodgers and Smith 1995; Ronconi and St. Clair 2002), diving ducks (Kahl 1991) and wintering Bald Eagles (Knight and Knight 1984), and a significant reduction in the proportion of eagles feeding occurred following exposure to recreational boating events within 200 m of the feeding site (Skagen 1980). Eagles flushed significantly more often by boats that approached more slowly or were louder than when boats were fast moving or quieter (McGarigal et al. 1991).

Frequency of the disturbance activity is an important additional factor contributing to increased behavioural responses by shorebirds, seabirds (Robert and Ralph 1975; Burger 1986; Klein et al. 1995; Verhulst et al. 2001; Blackmer et al. 2004) and by Peregrine Falcons (Ratcliffe 1980). Although a high frequency of use typically elicits a greater negative impact, even low levels of disturbance may result in negative impacts to avian species. For example, in areas characterised by lower levels of water-based human activity, eagles demonstrated significantly higher sensitivity as measured by flushing response relative to higher use areas (Russell 1980) perhaps indicating a role for habituation and/or tolerance of the species in question. Additionally, breeding Ospreys were more vulnerable to human disturbance in remote locations subjected to sporadic human activities compared to areas where use was more frequent and consistent (Poole 1981). It has been suggested that pelagic ground-nesters on remote islands may exhibit increased sensitivity (Rodgers and Smith 1995). Relative to other national parks, Gwaii Haanas receives fewer visitors. Yet, as these findings indicate, low use intensity does not guarantee negligible or non-existent impact.

Characteristics of the focal species under investigation contribute to the variability in wildlife responses. Wildlife responses to human activity and disturbance in particular can vary depending on the species, age, sex and group size. Shorebirds and seabirds that congregate in large flock sizes at certain times of the year may be more vulnerable to human activity due to this congregating behaviour (Batten 1977; Burger 1986; Rodgers and Smith 1995). This conspicuous behaviour may lead to increased visibility to potential predators and humans while a fixed breeding location increases the cost of relocating. Disturbance during the breeding season is typically considered the most vulnerable period in the life-history of a species and can lead to nest abandonment and decreased reproductive success (Burger 1981; Major 1990; Gloutney et al. 1993). This justifies the consideration of the temporal pattern of recreational use and its potential impacts.

1.2.3 Human-Wildlife Conflict Models

Natural resource management typically requires the integration of information from a variety of disciplines due to its often complex nature and multiple use requirements. Through integration of these information types, it is possible to model resource use within national parks and identify potential incompatibilities or conflicts between resource users. Although application of this general framework to recreation-related impact assessments and protected areas management has progressed slowly (Kliskey 2000), there is a shift towards applications integrating spatial components of tourism and visitor uses with wildlife attributes.

Through the identification of regions of overlap between focal species habitat use and spatial patterns of visitation, management recommendations have focused on visitor impact management strategies such as spatial re-distribution of visitor use and closures in areas of high habitat suitability (Harris et al. 1995; Suchant and Schafer 2002). Additional studies have explicitly incorporated temporal components into potential conflict modelling because certain life-cycle periods, such as breeding, are more sensitive than others (Kramer and Roth 2002). As the importance of coastal regions and adjacent waters for human use rises, especially with respect to recreation (Burger 1991), the integration of these information types from a marine perspective will continue to increase in importance. Two such examples are research assessing marine reserve violation by whale-watchers and recreational boaters through application of a GIS (Jelinski et al. 2002) and the monitoring of marine human activity in relation to an endangered species in a protected area (Karamanlidis et al. 2004).

The preceding studies highlight the importance of integrating biological and human use dimensions. Adoption of standardised methodologies in the assessment and identification of potential conflict areas is important so that comparisons of the extent and nature of human uses between protected areas can occur. However, it is necessary to recognise that each protected area represents a unique combination of social and ecological variables. The goal of my research project was to develop a GIS-based approach to assess visitor use patterns within Gwaii Haanas and to identify potential conflict areas with focal wildlife species, which include seabirds known to breed in Gwaii Haanas (Table 1) and Peale's Peregrine Falcon (*Falco peregrinus pealei*). Assessment of the recreational human use dimensions of Gwaii Haanas is based on data collected from visitor surveys administered by park personnel, which includes a map of the protected area where respondents are directed to indicate marine-based travel routes and overnight locations. All commercial tour operators working within Gwaii Haanas are required to complete trip logs with information comparable to that of the visitor surveys. The specific objectives of my research project follow.

1.3 Research Objectives

Objective 1: TO CHARACTERISE SPATIAL AND TEMPORAL VISITOR USE PATTERNS WITHIN GWAII HAANAS.

1. WHAT ARE THE DATES OF ENTRY, TRAVEL MODES, NUMBER OF VESSELS, LENGTH OF STAY AND GROUP SIZE OF VISITORS TO GWAII HAANAS?
2. WHAT ARE THE SPATIAL PATTERNS OF OVERNIGHT USE WITHIN GWAII HAANAS AND HOW DO THEY COMPARE BETWEEN VISITOR TYPES?
3. WHAT ARE THE TEMPORAL AND SPATIAL PATTERNS OF WATER-BASED TRAVEL ACTIVITY WITHIN GWAII HAANAS AND HOW DO THEY COMPARE BETWEEN VISITOR TYPES?

There is a concerning paucity of research examining the extent of visitor use in protected areas, especially where current park policies advocate random camping, such as Gwaii Haanas (Cole and Monz 2004). Consequently, decisions and management strategies are based on incomplete knowledge and threaten effective park management. Identification of human use patterns can serve as a surrogate measure of potential impact, assuming that increasing use correlates with increasing human impact. Although typically indicators of ecological integrity relate to biophysical attributes, disturbance indicators, such as the frequency of human use, are some of the most salient indicators of ecological integrity (Noss 1995). The quantification of human uses within a marine environment has been described as a 'contextual indicator' of extractive and non-extractive uses, such as recreation, which are known to negatively affect biotic and/or abiotic marine conditions (Pomeroy et al. 2003).

The marine region surrounding the terrestrial portions of Gwaii Haanas is the location of the proposed Gwaii Haanas National Marine Conservation Area Reserve. With Royal Assent of the Canada National Marine Conservation Areas Act in 2002

(Canada 2002), an understanding of human influences and use trends within the marine realm is especially timely. The National Marine Conservation Areas Act confers authority for the establishment and management of National Marine Conservation Areas within Canada. To fulfil their functions to protect sensitive areas and to ensure ecologically sustainable use, the establishment of use zones, which regulate and restrict activities temporally and spatially, are often applied as management tools in marine protected areas (Kelleher 1999). Understanding the spatial and temporal extent of current human uses within the proposed National Marine Conservation Area can inform zone designation and Gwaii Haanas personnel identify this as a current research gap (Golumbia 2001). Delineation of spatial and temporal uses according to visitor type (independent versus commercial visitors) will allow for visitor specific management recommendations. This research will provide novel baseline information pertaining to the current recreational uses of the marine portion of Gwaii Haanas.

Objective 2: TO IDENTIFY POTENTIAL AREAS OF CONFLICT BETWEEN SEABIRD COLONIES AND PEALE'S PEREGRINE FALCON AND VISITOR USE PATTERNS WITHIN GWAII HAANAS.

1. DO POTENTIAL CONFLICT AREAS EXIST BETWEEN WILDLIFE AND A) OVERNIGHT VISITOR USE AND B) WATER-BASED TRAVEL ACTIVITY PATTERNS?
2. HOW DO THE POTENTIAL CONFLICT AREAS COMPARE BETWEEN THE VISITOR TYPES?

Visitor use and focal wildlife habitat use that spatially and temporally coincide are potential conflict areas. An identification of potential conflict areas can inform and direct managerial decisions related to both maintenance of ecological integrity and management of the visitor experience. Recommended management actions for Peregrine Falcons in the Gwaii Haanas Terrestrial Ecosystem Conservation Strategy include rigorous monitoring of nests in close proximity to high use areas or travel corridors (Golumbia 2001). Additionally, recommended research for Gwaii Haanas includes the identification of seabird colonies that are located in close proximity to elevated human uses including boat traffic, preferred travel routes and preferred overnight sites (Golumbia 2001). However, identification of high use areas and travel corridors is a prerequisite to appropriate allocation of monitoring efforts and identifies a research and knowledge gap.

Objective 3: TO PROVIDE MANAGEMENT ALTERNATIVES AND RECOMMENDATIONS WHERE VISITOR USE IS POTENTIALLY INCOMPATIBLE AND CONFLICTS WITH SEABIRD COLONIES AND PEREGRINE FALCON EYRIES.

Acknowledging human uses as a part of park management, there is a need to implement proactive strategies that minimise potential inter-user conflicts, for example between recreationists using different vehicle types, and wildlife disturbance through management of recreational activities. An increased understanding of current visitor travel patterns within Gwaii Haanas will identify those areas of current and future potential conflicts. This will contribute to Parks Canada's and Gwaii Haanas' mandate to plan and manage visitor use for the purposes of maintaining ecological integrity. The proposed research will provide recommendations to minimise disturbance such as appropriate temporal and spatial buffer zone restrictions for seabird colonies and Peale's Peregrine Falcon. The recommendations will be embedded within an adaptive management framework that incorporates continued monitoring as an approach to further our understanding of human-wildlife conflicts.

2 METHODS

A GIS-based approach was developed to identify potential conflict areas occurring between recreationists and wildlife. This required an analysis of visitor use patterns, including overnight and travel activity patterns, and a subsequent spatial integration with known Peregrine Falcon eyries and seabird colonies to assess the areas of potential conflict in Gwaii Haanas. The following chapter includes a brief description of the natural and cultural features of significance associated with the Gwaii Haanas study area, an account of the focal wildlife species including a description of conservation status and threats and culminates with a discussion of the conceptual framework applied to this research and the methods of analysis.

2.1 Study Area

Gwaii Haanas National Park Reserve and Haida Heritage Site (hereafter Gwaii Haanas), established in 1996, is located in the southern portion of Haida Gwaii, British Columbia. It includes over 200 islands and islets with over 1600 km of shoreline and comprises a land area of 1495 km^2, representing approximately 15% of the terrestrial region of Haida Gwaii (Parks Canada Agency 2001). Presently only the terrestrial regions of Gwaii Haanas are protected under the Canada National Parks Act (Canada 2000). With establishment of the proposed Gwaii Haanas National Marine Conservation Area Reserve, protection will be conferred to the approximately 3400 km^2 of adjacent marine space (Figure 1).

Gwaii Haanas belongs to the Coast Mountains and Island physiographic region (Meidinger and Pojar 1991) and is one of two national park reserves representative of this area (Parks Canada Agency 1997). It is comprised of 3 terrestrial zones including the Coastal Western Hemlock zone. This zone is delineated into the Coastal Western Hemlock Very Wet Hypermaritime subzone, which occurs on the lower elevations of the west coast. Characterised by bog woodlands, this subzone also supports sparse forests of western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*) and western redcedar (*Thuja plicata*). The lowlands on the eastern portion of the islands belong to the Coastal Western Hemlock Wet Hypermaritime subzone, distinguished by productive coastal rainforests of western hemlock, Sitka spruce, and western redcedar. Typical vegetation of the Mountain Hemlock zone, located between 500-650 metres, includes mountain hemlock (*Tsuga mertensiana*) and yellow cedar (*Chamaecyparis nootkatensis*). The Alpine Tundra zone occurs above elevations of 650 metres, is of limited occurrence and is dominated by a mosaic of heath species and exposed rock (Meidinger and Pojar 1991; Westland 1994).

Haida Gwaii and Gwaii Haanas in particular, support numerous unique flora and fauna that are distinct from mainland taxa. This includes several disjunct endemic or rare species of plants found predominantly in habitats characteristic of higher elevations (Calder and Taylor 1968; Douglas 1996), a number of disjunct and endemic bryophyte species (Schofield 1989) and eight endemic sub-species of land mammals (Foster 1965; Cowan 1989). Four endemic bird sub-species are found on Haida Gwaii and contribute to the seventy-one species of avifauna observed nesting on these islands (Cowan 1989). The relative isolation of the archipelago from the mainland and the persistence of a partial refugia during the Wisconsin glaciations are possible factors contributing to the high degree of endemism found on these islands (Moodie and Reimchen 1976; Scudder and Gessler 1989; Hetherington et al. 2003).

In addition to unique terrestrial characteristics, Gwaii Haanas contains distinctive natural features associated with its marine environment. Situated within the Pacific Maritime Ecozone, the proposed Gwaii Haanas National Marine Conservation Area Reserve will include waters of the eastern Hecate Strait and the western Queen Charlotte Shelf Marine Regions, which contain resources of significance for both marine and terrestrial species. Marine foraging areas comprised of fish and zooplankton species support sea mammals and globally and nationally significant populations of seabirds (Campbell et al. 1990). Although many seabirds rely on marine food resources, terrestrial regions provide important nesting and staging habitats, demonstrating the inter-dependencies that certain wildlife have on the different ecosystems.

Over 10,000 years of human inhabitation by the Haida First Nations has contributed to the rich cultural heritage of Gwaii Haanas. Cultural resources include over 50 Haida village sites and 500 cultural sites such as burial sites and rock shelters. Based on their cultural and natural significance, five Haida Gwaii Watchmen sites have been established and are staffed by Haida, ensuring that protection and continued interpretation of the living Haida culture occurs. Three Haida Gwaii Watchmen Sites are located within the boundaries of Gwaii Haanas and include Hlk'yah GaawGa (hereafter referred to as Windy Bay), Gandl K'in Gwaayaay (hereafter referred to as Hotspring Island) and SGang Gwaay, while K'uuna Ilnagaay (hereafter referred to as Skedans) and T'aanuu Ilnagaay (hereafter referred to as T'aanuu) are located just outside Gwaii Haanas' boundaries (Figure 1). These sites are major cultural attractions for visitors to Gwaii Haanas (Vaske et al. 1996). In addition to Haida culture, with the arrival of Europeans to the region over 200 years ago, post-contact cultural sites primarily related to resource extraction operations such as mining and fisheries, have become points of interest during a visit to Gwaii Haanas.

Distinctive natural and cultural features justify the protection of Gwaii Haanas under national park reserve status and function as attractions to potential visitors. Classified as a wilderness park, Gwaii Haanas offers opportunities for remote outdoor experiences. Although Gwaii Haanas is effectively accessible all year round, the main season for visitation is May through September and includes independent, commercial multi-day and commercial day-tour visitors. Activities undertaken while in Gwaii Haanas include visitation of Haida Gwaii Watchmen sites, wildlife-viewing, fishing, kayaking, sailing, motorboating and hiking (Vaske et al. 1996). Travel to and within the park is limited to boat or plane and a relative lack of terrestrial trail networks and other onshore infrastructure constrains the majority of human impact within the coastal zones (Harper et al. 1994).

2.2 Rational for Focal Species Selection

Analysis of the full complement of wildlife species found in Gwaii Haanas was not feasible. Instead, focal species were selected based on the following criteria: the level of knowledge associated with the species ecology and habitat use, conservation status, known susceptibility to human disturbance and data availability. The focal species selected include Peale's Peregrine Falcon and 11 species of colonial nesting seabirds. Existence of the predator-prey relationship between Peregrine Falcons and burrowing seabirds strengthens the selection of focal species from a community ecology perspective. This recognises that cascading effects from disturbance to one species may affect species at a different trophic level, such as where the interactions between predators and prey are evident.

2.2.1 Peregrine Falcon, *pealei* Subspecies

Habitat Requirements

Peale's Peregrine Falcon, considered a marine raptor due to its strong reliance on marine ecosystems, ranges from the Aleutian Islands to southern Vancouver Island (Kirk and Nelson 1999). In Canada, Peale's Peregrine Falcons breed on Haida Gwaii and the northern regions of Vancouver Island, typically nesting in close proximity to colonial nesting seabirds. Burrowing seabirds are the primary prey for Peale's Peregrine Falcons and are hunted at sea within several kilometres of the falcon's nesting site (Kirk and Nelson 1999). Breeding and rearing of young generally occurs between April and September. Eggs are laid in early April followed by a 31-33 day incubation period. Chicks are capable of flight approximately 41-44 days after hatching, but depend on both parents for food supplementation for several weeks after they have left the nest (Fraser et al. 1999). Breeding sites are most often associated with the cliff ledges of islands but nests have been observed in trees and within the headlands of the Queen Charlotte Islands and northern Vancouver Island (Campbell et al. 1977). Cliff heights suitable for nesting range between 12 and 366 m, although nests typically occur between 23 and 38 m (Campbell et al. 1990). Nest coverage on cliff ledges varies from full exposure to partial shelter by tree roots, salal, rocks and mosses. Habitat requirements for non-breeding Peale's Peregrine Falcons include regions that support seabirds and other small to medium sized birds, as well as beaches, tidal flats, reefs, islands, marshes, estuaries and lagoons (Campbell et al. 1990). This subspecies depends on both terrestrial and aquatic resources due to its terrestrial breeding and primarily aquatic feeding behaviours.

Status and Threats

Peale's Peregrine Falcon is a species of special concern at the national level (COSEWIC 2001) and is Blue-listed (vulnerable) in the province of British Columbia

(B.C. Species and Ecosystems Explorer 2003). Both at-risk rankings are assigned to species that are not immediately threatened but are of special concern due to particular sensitivities to human activities or natural events. In the case of Peale's Peregrine Falcon, their small population size is limited primarily by availability of seabird prey (Kirk and Nelson 1999). In Haida Gwaii, seabird populations have been negatively affected predominantly by the introduction of mammalian predators and are susceptible to changes in ocean temperatures and impacts associated with oil spills (Kirk and Nelson 1999). Additional identified threats to peregrines include human disturbance, poaching and accidental mortality (Ministry of Water, Land and Air Protection 2000).

Human associated disturbance has been identified as a primary threat to raptor populations (LeFranc and Millsap 1984). Impacts to raptors, both direct and indirect, can yield physical harm, habitat modification and disruption of normal behaviours (Richardson and Miller 1997). In addition, the degree of disturbance may be related to timing (for example during the breeding season), type of and intensity of human use (Joslin and Youmans 1999). Human disturbance related to recreational activities is a potential threat within Gwaii Haanas (Golumbia 2001). Preference for breeding habitat located on cliffs of the shoreline fringe and location of seabird colony prey sources in Gwaii Haanas may overlap with access points to camping sites, sites of high visitor interest and areas that receive increased travel activity.

Loss of eggs or nestlings or nest abandonment may result if disturbance occurs during the sensitive nesting period. Recreational activities, such as rock climbing, undertaken during the nesting season of Peregrine Falcons can lead to nest abandonment and birds may refuse to breed when humans have been in the vicinity of nesting sites (Olsen and Olsen 1980). An increase in rates of visitation or a change in visitor behaviour would be likely to lead to increased levels of disturbance to falcons and their prey species. This highlights the importance of assessing the degree of overlap, indicative of potential conflict areas, between human activities and habitat use by Peale's Peregrine Falcon.

Data Description and Assumptions

The Peregrine Falcon data used in this report are a compilation of published ground observations obtained from 1919 through to 2000 (Patch 1922; Cumming 1931; Beebe 1960; Schultze 2000). The data were compiled by Gwaii Haanas National Park Reserve and accessed as an unpublished draft database that was last updated in 2001. The data are reliable for 1:20,000 scale mapping, which is the scale of the Gwaii Haanas base map. Visitor activities were assumed to influence nest site selection in addition to nesting and breeding behaviours and therefore all known nest sites, even if not currently occupied, were included as a conservative estimate of all potential nest site locations.

2.2.2 Seabirds

Although not a taxonomic or evolutionary grouping of species, seabirds are characterised by use of terrestrial regions typically only for breeding, spending the remainder of the year on the open ocean. Many species breed in colonies that can range widely in terms of number of pairs. Life-history characteristics include delayed sexual maturity, small clutch size and increased longevity relative to land birds.

Approximately 750,000 seabirds nest in Gwaii Haanas representing about 15% of the seabirds nesting in the British Columbia (Harfenist et al. 2002). These numbers include 13 species of seabirds (Table 1) while over 100 bird species are found within the protected area. The most abundant breeding seabird in Gwaii Haanas is Cassin's Auklet (*Ptychoramphus aleuticus*) with approximately 136,000 pairs representing 10% of the species' global population (Rodway 1991). Haida Gwaii is the only breeding location within Canada for Ancient Murrelets (*Synthlibormaphus antiquus*) with 122,000 pairs found in Gwaii Haanas, representing about 30% of the species' global population (Harfenist et al. 2002). Together, Cassin's Auklet and Ancient Murrelet account for approximately 78% of the total seabird populations nesting in Gwaii Haanas and are both provincially Blue-listed species (B.C. Species and Ecosystems Explorer 2003). From a global and national perspective, this demonstrates the important conservation role that Gwaii Haanas plays with regards to these two species. The storm-petrels account for 18% of the seabird populations nesting in Gwaii Haanas while the remaining seabird species listed in Table 1 represent the residual 5% (Westland 1994).

Although intra- and inter-species variation exists, the breeding season generally occurs between April and September. Preferred breeding habitat depends on the species (Table 1). Seabird species typically nest within proximity to the shoreline on landforms accessible to humans, which potentially places them at increased risk of disturbance when human use of the coastal waters and shoreline occurs.

Despite its remote location, the habitats and seabird species that Haida Gwaii and Gwaii Haanas, in particular, support are not immune to threats. Within this region, threats to seabird individuals and populations potentially include introduced species, offshore oil and gas drilling, environmental pollutants, commercial fishing, habitat loss, habitat degradation, tourism and recreation (Parks Canada Agency 1998; Golumbia 2001; Harfenist et al. 2002). Seabirds, the primary prey of Peregrine Falcons, may also be sensitive to recreational disturbance by humans and may elicit similar responses to Peregrine Falcons, such as sensory disturbance and nest abandonment (Hill et al. 1997; Carney and Sydeman 1999; Nisbet 2000).

Data Description and Assumptions

The seabird colony data used in this report were accessed as unpublished databases and was compiled by Harfenist et al. (2002). All original data sources are included in the Literature Cited section and data are reliable to 1:20,000 scale mapping. Data collection efforts for each species varied so only the most recent year of data for a known colony was included. The data are indicative of presence only and not presence/absence. Colonies may consist of a single species or multiple seabird species. Occurrence of a single species versus multi-species colony is assumed to be weighted of equal importance and therefore the seabird colony site was applied as the unit level of analysis with no differentiation undertaken at the species level.

2.3 Visitor Use Characteristics

Effective visitor management requires the compilation and assessment of various information types including the spatial and temporal distribution of visitors. The first component of this research involved an assessment of the following research questions:

1. WHAT ARE THE DATES OF ENTRY, TRAVEL MODES, NUMBER OF VESSELS, LENGTH OF STAY AND GROUP SIZE OF VISITORS TO GWAII HAANAS?
2. WHAT ARE THE SPATIAL PATTERNS OF OVERNIGHT USE WITHIN GWAII HAANAS AND HOW DO THEY COMPARE BETWEEN VISITOR TYPES?
3. WHAT ARE THE TEMPORAL AND SPATIAL PATTERNS OF WATER-BASED TRAVEL ACTIVITY WITHIN GWAII HAANAS AND HOW DO THEY COMPARE BETWEEN VISITOR TYPES?

2.3.1 Visit Attributes

All visitor use components of the research project were based on survey data from the 2001 season submitted to Gwaii Haanas staff. Overnight and day trip visitors to Gwaii Haanas are required to register before commencing a trip into the park reserve boundaries. During the registration process and mandatory orientation session, overnight independent visitors are provided with an independent visitor use survey to be returned upon completion of their trip. The survey was designed and administered by

Gwaii Haanas staff with the intent of informing park managers of visitor use dimensions within the park boundaries. The survey includes a questionnaire assessing trip satisfaction levels, visit characteristics and a map for detailing overnight locations and marine-based trip routes while in the park reserve boundaries. However, the spatial and temporal patterns of travel activity patterns have to date not been assessed. Of 520 registered independent overnight visitors, 217 surveys were remitted resulting in a 42% survey return rate. Visitors often travel in groups and of the 217 returned surveys, 105 (48%) unique travel groups were represented. When considering each unique travel group on its own, 68% of the survey respondents indicated an explicit travel route and overnight site locations while in the protected area with the remaining indicating only overnight site locations.

In addition to the independent visitor, people may visit the protected area facilitated by a commercial tour operator. Until 2004, commercial travellers did not receive a comparable survey as independent visitors, however, all commercial tour operators are required to register and submit trip logs for all trips completed within the protected area. Similar to the independent visitor survey, the commercial trip logs require operators to indicate camp site and/or mooring site locations and marine-based travel routes taken while travelling within the protected area.

Both independent and commercial visitors' registration sets were analysed to provide visitor profiles and identify patterns of use including date of entry, length of stay, travel mode undertaken while in the protected area, number of vessels used and group size. For the purposes of this project, visitors to Gwaii Haanas include all registered independent and commercial travellers and exclude numbers associated with Gwaii Haanas staff, researchers, non-registered travellers or fishers travelling through the national park reserve.

2.3.2 Patterns of Overnight Use

As part of its visitor management strategy, Gwaii Haanas maintains a random camping policy for visitors. Camp site locations are not designated and visitors are encouraged to camp at accessible locations along the coast, on sites not previously used. The objective of this policy is to disperse camping so that no one area or site is significantly impacted, thus minimising degradation to both the natural environment and the visitor experience (Gwaii Haanas National Park Reserve 2003). Although the intent is to disperse camping, there is reason to believe that camp site use is patchy. Spatial and temporal camp site use patterns provide a measure of impact to the camped areas (Cole 1992; Cole and Monz 2004). When combined with ecological information, such as proximity to sensitive species or sensitive habitats, it may indicate those locations of conflict between these different uses.

To facilitate the spatial analysis of camp use areas, all camp use areas less than 500 m from another camp use area were aggregated. The aggregated camp use areas are herein referred to as camp sites. This aggregation resulted in a reduction from 437 and 171 camp use areas to 182 and 65 camp sites for independent and commercial trips, respectively. Independent and commercial camp use areas were combined and aggregated together resulting in a reduction from 608 camp use areas to 204 camp sites. At each camp site, the number of visitor user nights was measured as the number of visitors at a camp use area multiplied by the number of nights. I assumed that the higher the number of visitor user nights, the greater the potential impact. Spatial trends in camp site use patterns were assessed for independent visitors and commercial visitors separately and together.

Visitors often moor vessels and overnight on the water rather than overnight at terrestrially based camp sites. Similar to the camp site assessment methodology, all moor use areas for both commercial and independent visitors were aggregated based on a 500-m radius and are herein termed moor sites. This reduced the number of moor use areas from 109 and 273 to 42 and 69 for independent and commercial trips, respectively. Independent and commercial moor use areas were combined and aggregated together resulting in a reduction from 382 moor use areas to 85 moor sites. Aggregations and visitor use assessments of independent and commercial trips were undertaken both individually and combined. The total number of nights and number of vessels at each moor site were assessed over the whole season of use.

2.3.3 Travel Activity Patterns

The explicit travel routes indicated by both independent visitors and commercial operators on the surveys were manually digitised using ArcView GIS 3.2a© (Environmental Systems Research Institute (ESRI) 2000) onto a base map of Gwaii Haanas. Where more than one survey for one independent group was submitted a visual assessment and approximation of all routes combined was made. Each trip was comprised of one or more travel route segments, each joined by nodes representing either the camp or moor use area point location. To facilitate temporal analyses, Julian dates (where January 1, 2001 is defined as the start date and is equivalent to day 1 through to December 31, which is recorded as day 365, in a non-leap year) were added as attributes to all travel route segments and overnight locations.

Independent visitors are not required to indicate the number of vessels used on their trips and therefore certain assumptions regarding the number of vessels per trip were made. Where powerboat or sailboat vessels were the identified travel mode, it was assumed that only one vessel was used regardless of the total number of visitors in the group. Where kayak was indicated as the travel mode it was assumed that each individual travelled in a single vessel and therefore the maximum number of possible vessels was indicated. Assuming the maximum number of possible vessels is the most conservative estimate of impacts and was verified based on personal observations and discussions with researchers working in the park reserve.

Trip and vessel numbers for both visitor types were re-scaled according to survey return rates and proportion of surveys completed in full to provide an estimate of actual use and to avoid underestimates of use. For independent visitors, re-scaling factors were calculated based on 1) the survey return rate, as 42% of all visitors responded, and 2) a correction factor for incomplete surveys that did not indicate explicit travel routes. This corresponds to a correction factor of 2.396 and 1.478, respectively. Commercial trips also required corrections for incomplete trip logs, which corresponds to a correction factor of 1.484. The correction factors were applied to both overnight use data and travel activity data. It was assumed that trips logs without explicit travel routes were similar in terms of route characteristics over space and time to surveys that indicated routes. Application of the correction factor enables comparisons between the different visitor types as it effectively considers them as populations rather than samples, which is necessary given the differential uncompleted logs between visitor types and the return rate of independent surveys.

Identification of Use Zones

The identification of aquatic based travel activity patterns involved an assessment of frequency of travel occurring within discrete aquatic travel corridors of Gwaii Haanas. These aquatic travel corridors were defined based on a priori knowledge of known travel routes and discussions with Gwaii Haanas staff concerning areas believed to receive relatively higher volumes of aquatic-based vessel traffic (A. Gajda and P. Bartier, personal communication, 2003). Additional considerations included known locations of seabird colonies and Peregrine Falcon eyries. Travel corridors were designed to be functional from a managerial perspective, with the intent of facilitating monitoring related recommendations, and therefore variability in corridor size was considered appropriate. Where delimitation of smaller corridors was necessary a minimum distance of 500 m from seabird colonies was chosen based on current provincial (B.C.) wildlife viewing guidelines for seabird colonies (Ministry of Water, Land and Air Protection 2002). The recommended buffer zone requirements for Peregrine Falcon nest sites range from 400 to 1,600 m (Johnson 1988; Richardson and Miller 1997; Ministry of Water, Land and Air Protection 2002). Development of the provincial wildlife viewing guidelines was based on consultations with expert opinion from provincial wildlife and habitat specialists and from the literature (see Harper and Eastman (2000)). I chose to apply the maximum threshold distance of 1,600 m (Richardson and Miller 1997) where required in delimiting the spatial extent of the travel corridors. Prior to analyses, the discrete aquatic travel corridors template was distributed for comment and approved by committee members and Gwaii Haanas staff.

Monthly and seasonal use levels for each discrete travel corridor were calculated based on the number of vessels passing through each area. While Gwaii Haanas is open all year round the majority of use occurs between the months of May through October, which is the period implied when assessments based on seasonal use are indicated. Temporal and spatial travel activity patterns of commercial and independent visitors were assessed separately and combined. Assessment of travel activity patterns were undertaken for commercial and independent multi-day trips, however, commercial day and transport trips were excluded from the analyses due to data constraints. Levels of use were classified into one of three categories: low, medium and high.

2.4 Potential Conflict Analyses

An identification of potential resource use conflicts between recreationists and wildlife requires integration of human use dimensions information, assessed through Objective 1, and biological parameters, specifically, Peregrine Falcon nest sites and seabird colonies. The amalgamation of these two information types provides a platform for modelling potential conflict zones (Figure 2), defined as areas where simultaneous human use and disturbance-sensitive wildlife use overlap. Although not a direct measurement of impact to the avifauna species, it can be used to target future monitoring. Areas of potential conflict were assessed based on proximity analyses between wildlife sites and overnight use areas and spatial overlay analyses between wildlife sites and vessel activity movements. To achieve the second research objective of identifying potential areas of conflict between visitors to Gwaii Haanas and wildlife resource use the following questions were posed:

1. DO POTENTIAL CONFLICT AREAS EXIST BETWEEN WILDLIFE AND A) OVERNIGHT VISITOR USE AND B) WATER-BASED TRAVEL ACTIVITY PATTERNS?
2. HOW DO THE POTENTIAL CONFLICT AREAS COMPARE BETWEEN THE VISITOR TYPES?

Research assessing the impact of human disturbance to bird species often dictates the delimitation of buffer zones – a spatial zone of visitor exclusion so that wildlife disturbance is minimised or does not occur. As discussed in the introduction, flushing of avian species is an observable behavioural consequence of human presence. Flight initiation is often exhibited more frequently as the distance between the wildlife individual in question and the potential disturbance stimulus decreases. Delimitation of buffer zones are typically based on species and site-specific flight initiation distances (Rodgers and Smith 1997; Carney and Sydeman 1999). Site-specific attributes, which include disturbance or use history, may contribute to differential responses within a species providing further rational for species and site-specific investigations (Burger and

Gochfield 1983). However, as with many aspects of planning and managing for conservation, the prevalence of data gaps often lead to situations where managers are required to make decisions based on incomplete information. Recent research suggests that flight initiation distance is a species-specific trait and in the absence of assessments combining both of these features (species and site-specific assessments), the implementation of buffer zones based on research from a related or similar species may be warranted as guidelines (Blumstein et al. 2003).

Avian species have received much scientific investigation concerning the ecological impacts of human disturbance. However, the majority of the colonially nesting seabirds in Gwaii Haanas have not been included in studies aimed at experimental determination of buffer zones. Recently established provincial (B.C.) wildlife viewing guidelines are based on scientific research and expert knowledge (Ministry of Water, Land and Air Protection 2002). Current provincial wildlife viewing guidelines recommend a 500-m buffer around colonial seabird nests that excludes humans, pets and motorised watercraft. The minimum approach distance for Peregrine Falcons based on provincial guidelines is 500 m (Ministry of Water, Land and Air Protection 2002) while a literature review of management strategies for protecting raptors recommended a median distance for buffer zone establishment for Peregrine Falcon eyries of 800 m (range = 800 -1600 m, n = 5) (Richardson and Miller 1997). Additionally, core area restriction recommendations around suitable Peregrine Falcon nesting sites ranged from 400 m to 900 m (Johnson 1988).

To predict the locations of wildlife most likely affected by disturbance, a series of proximity analyses between overnight visitor use sites (camp and moor sites) and seabird colonies and Peregrine Falcon eyrie locations were conducted. Based on the variability of recommended buffer distances, 250-m, 500-m, 750-m, 1000-m and 1500-m buffer zones, or wildlife viewing minimum approach distances, for Peregrine Falcon eyries and seabird colonies were used. Proximity analyses of independent and commercial visitor types were performed individually and on both visitor types combined. Results include spatial identification of camp and moor sites located within 500 m from wildlife sites (based on Ministry of Water, Land and Air Protection recommendations), a comparison of the number of wildlife sites within each proximity distance category, and proximity assessments of overnight sites taking into account their frequency of use.

To identify potential areas of conflict between aquatic based travel activity patterns, intersections of the digitised travel routes with seabird colonies and Peregrine Falcon eyries buffered by 500 m and 800 m (Peregrine only) were performed. The number of intersection events was recorded on a monthly basis and cumulatively for all months combined. As each intersection event may be comprised of one or more vessels, additional analyses quantified the number of vessels intersecting wildlife sites on a monthly basis and for all times combined to detect temporal variations. Assessments were performed on both commercial and independent trips separately and combined. An estimation of the frequency of potential disturbance events at the various wildlife sites is required to predict those sites that are most likely to be disturbed. Analyses and interpretation of the results relied on the assumption that negative impact or behavioural responses are greater at closer distances and with a greater intensity of use. These results will provide an indication of those wildlife sites where recreational use within Gwaii Haanas, specifically in the form of aquatic based vessel activity, overlaps with wildlife resource uses. The identification of wildlife sites located in potential conflict areas will inform management recommendations and future monitoring priorities for Gwaii Haanas.

3 RESULTS

3.1 Visitor Use Characteristics

3.1.1 Visit Attributes

For the 2001 season of operation, independent visitors to Gwaii Haanas were 27% of all registered visitors and the remaining 73% corresponded to commercial visitors (n =1945). Independent and commercial trips represented 45% and 55% of all visitor user nights, respectively. Day trips represented 61% of all commercial trips; this included both transportation trips of visitors into and out of Gwaii Haanas and day touring visits. In contrast, day trips corresponded to 2% of registered independent visits. Commercial day trips and transport trips were excluded from the assessment of travel activity due to a lack of information.

The peak periods of use by recreationists as measured by the frequency of trips entering Gwaii Haanas were July through August for both independent and commercial trips. The mean date of entry for independent and commercial trips was July 19th and July 22nd, respectively. May, September and October received fewer trips relative to the peak months of use, indicating lower use during the shoulder seasons (Figure 3). Omitting all day trips, the mean number of nights spent in Gwaii Haanas was 8.2 (range 1-24) for independent trips and 4.9 (range 1-14) for commercial trips (Figure 4). The average group size of independent trips was 3.2 people with a maximum of 12 people compared with an average group size of 7.5 people and a maximum of 19 for commercial travellers.

Travel to and within the national park reserve boundaries is primarily water-based although a small percentage of commercial trips involve aircraft (Figure 5). Both commercial and independent trips rely on similar modes of water-based travel, which include sailboats, kayaks and powerboats. Independent travel modes included canoes, although this represented only 2% of all trips. The majority of independent trips relied on kayaks (65% of all independent trips) followed by sailboats (17%) and powerboats (15%). In contrast, the majority of commercial trips relied on the use of powerboats (71%), sailboats (16%) and kayaks (8%). The commercial trips that relied on powerboats included transportation trips (39% of all commercial trips), day trips (22%) and overnight trips (10%). The mean number of vessels per trip was 2.6 (range 1-12) and 1.6 (range 1-19) for independent and commercial trips, respectively. Over 90% of commercial trips required the use of only one vessel. This is attributed to the high percentage of trips that use powerboats and that involve transportation of numerous individuals at one time.

3.1.2 Patterns of Overnight Use

I applied the aggregate camp use area method to estimate the number of camp use sites (see page 25 for method description). The number of camp use areas was reduced from 437 to 182 camp sites for independent trips and from 171 to 65 for commercial trips. The majority of camp sites received a cumulative seasonal use of 100 user nights or less when visitor types were analysed separately or combined (Figure 6). Overnight camp site use by independent visitors appeared to be greater relative to commercial camp site use as measured by the frequency of camp sites falling within categories of higher use level categories. From a spatial perspective, independent overnight camping patterns were well dispersed along the Gwaii Haanas coastline although some clustering occurred near the Haida cultural sites of T'aanuu, Hotspring

Island and Windy Bay, as well as the Burnaby Narrows area (Figure 7). Although commercial trip camping sites were fewer and less diffuse throughout Gwaii Haanas relative to independent trips, they were concentrated near Windy Bay, Hotspring Island and Rose Harbour (Figure 8). When camp sites of both visitor types were combined those with greater than 100 user nights were generally located adjacent to T'aanuu, Windy Bay, Hotspring Island, SGang Gwaay, Rose Harbour and the northern and southern boundaries of Burnaby Narrows (Figure 9).

The total number of moor use areas was 273 for commercial trips and 109 for independents, corresponding to 69 and 42 moor sites, respectively, once the aggregate method was applied (see page 26 for method description). The majority of moor sites accessed by independent and commercial trips received less than 25 visitor user nights over the entire season of operation (Figure 10). Although the proportion of use within each use category is similar between visitor types, commercial trips utilised a greater number of moor sites than did independent trips. When moor use areas of both visitor types were combined and aggregated, a larger proportion of moor sites was in the high use level categories (greater than 50 user nights over the entire season) and indicates a preference for the same moor sites between visitor types. Generally, moor sites were dispersed throughout Gwaii Haanas. Independent overnight use was more diffuse and covered a broader area of the park reserve compared to commercial trips with more commercial trips mooring throughout Burnaby Narrows than independent trips (Figures 11 and 12). The areas surrounding Hotspring Island and Rose Harbour contained concentrations of higher moor user nights for both visitor types analysed separately and combined (Figure 13).

3.1.3 Travel Activity Patterns

Visitor movement occurs differentially within Gwaii Haanas. Twenty-three percent of all corridors, representing 11% of the proposed National Marine Conservation Area Reserve (Figure 14), had over 1200 occurrences of vessel activity during the 2001 season. This high vessel activity occurred adjacent to the Haida cultural sites of T'aanuu, which is also adjacent to a major access area into Gwaii Haanas, Windy Bay, Hotspring Island and SGang Gwaay, as well as Burnaby Narrows. The corridor adjacent to Rose Harbour and some of the corridors bordering the coastline were also in the high use category. Twenty-two percent of all corridors, representing 8% of the proposed National Marine Conservation Area Reserve, were classed as medium in terms of vessel activity, which ranges from 601 to 1200 vessel occurrences for all months of use. These corridors included some of the sheltered inlets, corridors south of Ramsey Island in the central region of Gwaii Haanas and corridors south of Burnaby Narrows.

Vessel-based travel varied spatially when visitor types were analysed separately and when vessel frequencies were summed for all months. For independent visitors, 29% of the corridors received medium amounts of vessel occurrences (>600 vessels <1201), representing 16% of the proposed National Marine Conservation Area Reserve, and 8% of the corridors represented high amounts of vessel activity (>1200 vessels), representing 2% of the proposed Marine Conservation Area Reserve (Figure 15). The medium use corridors included the majority of corridors located directly adjacent to the coastline and SGang Gwaay whereas high use corridors included those adjacent to T'aanuu and Hotspring Island. A greater proportion of corridors fell within medium and high use categories for independent trips compared to commercial trips. Commercial trips comprised 10% of all corridors in the medium use category and the corridor adjacent to Rose Harbour was classified as a high use area (>1200 vessel occurrences).

These classified corridors respectively represent 6% and 1% of the proposed National Marine Conservation Area Reserve. Medium use corridors, as measured by commercial travel included those adjacent to the Haida Gwaii Watchmen sites of Hotspring Island and SGang Gwaay (Figure 16). Spatial patterns of use levels were generally consistent between visitor types with concentrations occurring in proximity to cultural sites although use levels appeared to be more concentrated in the southern portion of Gwaii Haanas for commercial visitors relative to the northern region.

Frequency of vessels along travel corridors varied on a monthly basis when visitor trip types were combined (Figure 17). A general shift is observed from the shoulder season of May, September and October, months that had high numbers of corridors with low or no vessel frequencies, to increased representation of corridors in the medium and high categories for the months of June, July and August. Twenty-eight percent or more of the corridors in each of June, July and August had between 151 and 300, i.e. a medium level of activity, occurrences of vessel activity. Vessel frequencies reached high use (> 300 vessel occurrences) in certain corridors from May through August, however, the maximum use was in July when 43% of all corridors represented high use levels (Figure 18).

Temporal distribution for each visitor type generally exhibit the trends observed of both visitor types combined. The number of corridors falling within higher level of use categories increased during the peak months of use, July and August, for each visitor type (Figures 19 and 20). Monthly trends of the two visitor types indicate a greater proportion of higher use categories for independent multi-day trips compared to commercial multi-day trips. I focused on July because it had the greatest total vessel activity overall and examined spatial differences between types of visitors. Eight percent of all corridors had high vessel activity for commercial trips compared to 35% of all corridors when independent trips were considered. High vessel activity for commercial trips occurred in the southern portion of the park reserve along corridors surrounding SGang Gwaay and Rose Harbour, as well as corridors along Hotspring Island (Figure 21). High vessel use for independent trips included corridors adjacent to all Haida Gwaii Watchmen sites and the majority of the corridors adjacent to the terrestrial regions of Gwaii Haanas (Figure 22).

3.2 **Potential Conflict Analyses**

3.2.1 **Overnight Use Sites**

Both the non-aggregated (use areas) and aggregated overnight use sites (i.e. camp sites) produced similar results and hence I focus on results of the aggregated sites. Both overnight use sites and wildlife sites located within incremental distances of one another were identified and, as expected, both increased with increasing search distance (Figures 23 and 24). For spatial analyses involving seabird colonies, when the search distance is doubled from 250 m to 500 m, the total number of unique sites located within that distance increases nearly four times from 14 to 46 sites, with visitor types combined (Figure 23). This is the anticipated relationship because when the search distance is doubled the area increases 4 times as a function of πr^2, the area of a circle. This latter figure represents nearly a quarter of all seabird colonies located within Gwaii Haanas. Twenty camp sites and 10 moor sites contributed to this potential conflict zone designation for seabird colonies within a 500-m zone, an increase from 7 and 1 within a 250-m zone, respectively. With an increasing search distance, the number of colonies within specified distances of both a camp and a moor site increases as well. On average, of those overnight sites within the search distance to a colony, 1 moor site is within 1.3 colonies and 1 camp site is within distance of 1.6 colonies. Commercial and independent overnight sites analysed separately indicate that independent camp sites contribute to a higher proportion of seabird colonies within specified distances than commercial camp sites whereas commercial moor sites contribute to a higher proportion of colonies within the distance criteria relative to independent moor sites (Figure 25). This is anticipated as the number of independent camp sites is greater than commercial camp sites and commercial moor sites outnumber independent moor sites.

A lower number of Peregrine Falcon eyries located with Gwaii Haanas may contribute to the consistently lower number of eyries relative to seabird colonies, except at 250 m, identified in the potential conflict analyses (Figure 24). When the distance is increased from 250 m to 500 m the number of falcon eyries located within that distance nearly doubles from 9 to 16 eyries representing nearly a fifth of all eyries located within the national park reserve. This represents the absolute potential impact contributed by both campers and those groups that use moors for eyries within this distance category. Sixteen camp sites and 1 moor site contributed to this potential conflict zone designation for falcon eyries within a 500-m zone, an increase from 9 and 1 within a 250-m zone, respectively. For both seabirds and falcons, the number of moor sites in proximity to a wildlife site within each distance category is considerably lower than the number of camp sites, which is an expected outcome due to the low number of moor sites relative to camp sites. Visitor types analysed separately indicate that a higher proportion of eyries are within the distance thresholds due to independent camp sites relative to commercial ones whereas commercial moor sites contribute to a higher proportion of falcon eyries within the distance criteria relative to independent moor sites (Figure 25).

From a spatial perspective, within a distance of 500 m, 15% of all camp sites (visitor types combined) were located in proximity to at least one wildlife site of interest (Figure 26). Ten percent were located within proximity to a minimum of one seabird colony whereas 7% were within 500 m of a falcon eyrie. Five camp sites were located within 500 m of both a seabird colony and a falcon eyrie and were clustered around the Haida Gwaii Watchmen sites of Hotspring Island and SGang Gwaay. The majority (84%) of all camp sites located within 500 m of wildlife sites received less than 101 visitor user nights over the entire season, another 10% received between 101 and 200 visitor user nights and the remaining 6% received greater than 200 visitor user nights. Of the 5 camp sites located within 500 m of both a seabird colony and a falcon eyrie, four received less than 101 visitor user nights and the fifth received 146 user nights. Lack of detection of a spatial pattern of moor sites in proximity to wildlife sites was likely due to the low number of moor sites compounded with their general location in inlets where presence of seabird colonies and eyries has not been noted (Figure 27). Although the number of seabird colonies and eyries near both a camp and a moor site was relatively low, proximity to both overnight sites is indicative of a potential conflict and is informative for monitoring purposes.

3.2.2 Travel Activity

The percentage of seabird colonies intersected by visitor trips within a 500-m radius varied among months when visitor types were analysed collectively (Figure 28). The change in percentage of seabird colonies intersected by visitor trips is consistent with the pattern of entry of visitors into Gwaii Haanas. As more visitors enter the park reserve, a greater number of seabird colonies were intersected by a minimum of one recreational visitor trip. During July, the month with the highest number of seabird colony intersections, 83% of all seabird colonies received at least one trip occurrence within a 500-m buffer. During the shoulder season months of May, September and October, the percentages of seabird colonies intersected were lower than all other months. Although inter-species variability with respect to the breeding season exists, April through September constitutes the general breeding period for seabirds within Gwaii Haanas (Harfenist et al. 2002). For all months except for August and September, the percentage of seabird colonies intersected by independent trips was greater than commercial trips. However, the percentage of unique colonies intersected within a one-month period generally increased when visitor types were combined, suggesting differences in spatial travel patterns between visitor types.

The monthly frequency of intersections between visitor trips and seabird colonies differed by travel mode and trip type. Most intersections of seabird colonies by independent trips for each month were associated with kayakers, whereas sailboat vessels were responsible for the majority of intersections by commercial trips in all months (Table 2). Sailboats followed by powerboats were the two vessel types responsible for the next highest number of intersections, in decreasing order, for independent trips except during August and September where intersections by powerboats were higher. The number of intersections varied with vessel type for commercial trips from sailboats, kayaks and powerboats, in decreasing order of number of intersections. A comparison of intersection events between the two visitor types reveals that except for commercial sailboat trips, the number of intersections by independent trips was higher for all other vessel types relative to commercial trips.

Because each intersection event may be comprised of more than one vessel, quantifying the number of vessels intersecting a colony will provide additional information necessary for delimiting wildlife sites in potential conflict areas. Table 3 identifies the percentage of seabird colonies in different quantitative categories of intersections based on the number of vessels and by month. Percentage of colonies intersected from low to higher categories of vessel intersections followed the pattern of visitor entry into Gwaii Haanas, with a peak occurring during July. From a spatial perspective, colonies with a higher frequency of vessel intersections are typically located close to the attraction sites of SGang Gwaay and Hotspring Island, as well as Rose Harbour, Burnaby Narrows and adjacent to the coastline. Ten percent of all seabird colonies were not intersected over the entire season and were located predominantly on the less travelled outer western shores of Gwaii Haanas.

The percentage of falcon eyries intersected by a minimum of one visitor trip varied during the main season of park reserve operation when visitor trips were combined. Based on a 500-m buffer, 58% of all known eyries were intersected at least once in June and August in contrast to 27% and 23% of all eyries in May and September, respectively (Figure 29). An increase in the buffer size from 500 to 800-m corresponded to an increase in the percentage of eyries intersected with 76% intersected in August followed closely by June and July, in decreasing order of magnitude (Figure 30). For both buffer sizes during May, June and September, the percentage of eyries intersected by commercial trips was greater than that by independent trips whereas for the months of July, August and October independent trips contributed to a higher percentage of intersected eyries. The percentage of eyries intersected by both visitor types combined was always greater than when visitor types were analysed separately, providing further indication of differences in spatial travel patterns between the two visitor types. The majority of eyries not intersected by recreational trips were located on the outer western coast of Gwaii Haanas and the southern parts of Kunghit Island.

The monthly number of intersections of falcon eyries by visitor trips in Gwaii Haanas differed depending on travel mode and visitor trip type based on a 500-m buffer (Table 4). The majority of intersections by independent trips for each month were associated with kayakers whereas sailboat vessels were responsible for the majority of intersections by commercial trips in all months. The number of intersections varied with travel mode for independent visitors from kayak, sailboat, powerboat and canoe, in decreasing order of magnitude. Similarly, the number of intersections varied with travel mode for commercial trips with sailboats, followed by kayak and powerboats, in decreasing order of magnitude. The peak number of trip intersections occurred in July, followed by August and then June, which is consistent with the pattern of visitor entry. Similar patterns exist when applying an 800-m buffer around eyries, although the calculated number of intersections events was greater than for the 500-m buffer, as would be expected (Table 5).

Incorporating the number of vessels into intersection quantification indicates that the highest percentage of eyries intersected occurred in June and August, applying a 500-m buffer (Table 6). Although a smaller percentage of eyries were intersected in July, of those sites that were traversed, a larger proportion was intersected by a greater number of vessels compared to June and August. Based on an 800-m buffer zone, analyses indicate a shift in the percentage of colonies intersected from low to higher categories of vessel intersections comparable to the pattern of visitor entry into Gwaii Haanas (Table 7). Similar to the 500-m buffer analyses, a smaller percentage of eyries was intersected in July but more of these sites received a higher number of intersection events with 8% of eyries in July receiving between 300 and 600 vessel intersections. Those eyries with a higher frequency of vessel intersection events were generally located in the area surrounding Hotspring Island and adjacent islands, Rankine Island and the area surrounding Windy Bay. In comparison to the percentage of seabird colonies intersected, on average the percentage of eyries intersected (based on 500-m and 800-m buffers) according to vessel number was lower for each month and during the total season.

The potential conflicts focus on those sites intersected by trip events and vessel activity. Although not all seabird colonies or falcon eyries located within a travel corridor received comparable levels of intersections, a number of factors may contribute to this pattern and therefore a more coarse level of analysis identified those wildlife sites falling within corridors according to use levels regardless of whether an intersection event occurred. Tables 8 and 9 indicate the percentage of wildlife sites located within corridors, stratified according to use, regardless of whether a defined intersection event occurred. The vessel frequencies that correspond to the corridor use levels are indicated in Table 10. Similar to previous results, July has the highest percentage of seabird colonies and falcon eyries in high use zones followed by August. Generally, a larger proportion of seabird colonies were located in higher use categories in all months compared to falcon eyries. The spatial location of the corridors varied depending on the specific period of analysis and the estimated use level. For each faunal grouping, the general location of the corridors in the high use category included the Haida Gwaii Watchmen sites of T'aanuu, SGang Gwaii and Hotspring Island, the corridor along the coastline of the southern portion of Gwaii Haanas bordering Hecate Strait and the corridor bordering the northwest section of Kunghit Island. Additional corridors of importance in terms of quantification of elevated use levels for seabird colonies included Windy Bay and Rose Harbour.

4 DISCUSSION

The general outcomes of this research indicate that spatial and temporal variations in recreational patterns exist in Gwaii Haanas. Visitor use is primarily concentrated in proximity to Haida Gwaii Watchmen sites and directly adjacent to certain portions of the coastline. Based on their higher use intensity, these are regions of potential resource use conflict between recreationists and the focal wildlife species. This chapter focuses on the most probable determinants of these findings.

4.1 Visitor Use Characteristics

4.1.1 Patterns of Overnight Use

Overnight visitor use patterns within Gwaii Haanas occur along spatial gradients with variations dependent on the visitor type. Use intensity of terrestrially based camp sites is higher for independents compared to commercial visitors, which is consistent with the proportion of vessel types classified by visitor type; kayaks are the dominant vessel type of independent visitors and do not typically require the use of moor sites. Conversely, an increased reliance on transportation requiring the use of mooring buoys (powerboats and sailboats) provides a rational for the higher number of moor sites accessed and their relatively higher user nights by commercial trips. Overnight sites, especially those accessed by independents, proliferate throughout the wilderness landscape; a pattern that is a possible ramification of the random camping policy adhered to by Gwaii Haanas whereby visitors are not restricted to camp or moor in set locations. Additionally, commercial operators typically rely on a subset of pre-identified overnight sites and adhere more rigidly to itineraries, which is a possible explanation for the less expansive distribution of overnight use sites. Convergence of overnight sites occurred in proximity to Haida Gwaii Watchmen sites and these sites had relatively higher visitor user nights, which confirm the draw of these cultural sites to many visitors.

Although sites with relatively higher visitor user nights may indicate an elevated negative impact, the relationship between use and impact is not linear. Previous research demonstrates that even at low use, camp use area impacts, which commonly include soil compaction, erosion, loss of vegetative ground cover and compositional change, can be high (Cole 1992). Based on this relationship, restricting use to low use levels may not result in concomitant declines in impact. Independent visitors present a concern unique from commercial visitors, because they appear to exemplify the "random" camping policy by the spatial expanse of their overnight patterns.

4.1.2 Travel Activity Patterns

Understanding the spatial dimensions of use within protected areas requires assessment of park use on a park-by-park basis. The outcomes of the analysis of marine-based travel activity indicate that spatial and temporal variations within the boundaries of the proposed National Marine Conservation Area Reserve exist. These outcomes present a baseline level of use related to travel activity of recreationists within the proposed park reserve boundaries based on a lack of previous research of this nature for Gwaii Haanas. Variations in spatial and temporal travel activity are explained by 1) attraction sites acting as 'hot spots', 2) differences between visitor types and 3) correlations with the pattern of visitor entry.

The pervasiveness of travel activity concentrations occurring in the waters neighbouring Haida Gwaii Watchmen sites and Rose Harbour is explained by the prevalence of attraction sites bordering those corridors. These attraction sites in essence act as hot spots for travel and visitation within the park and are areas where potential visitor crowding and conflict with wildlife are more likely to occur. Previous research confirms Haida Gwaii Watchmen sites as draws for visitors (Vaske et al. 1996). Additionally, high use corridors occurred adjacent to coastlines, a pattern that is most probably explained by the tendency for vessels, especially kayaks, to travel in close to the coastline due to oceanographic factors, potential inclement weather and ensuing safety concerns. Additional concentrations in the southern corridors are most likely related to the presence of Rose Harbour and SGang Gwaay and are compounded due to a lack of alternate routing options.

Although concentrations of use occur near attraction sites, an examination of travel activity patterns of each visitor type separately found that corridors were categorised differentially in terms of use levels from a spatial perspective. One possible reason for these anomalies may be that commercial visitors pursue trips with operators that adhere to pre-defined routes and overnight sites whereas independent trips are not similarly constrained. Additionally, the relatively high use intensity from commercial trips in the southern portion is most likely attributed to tour packages offering visits to this region. It is clear that independent trips collectively travel in a spatially extensive manner and that their trip frequencies are greater than commercial multi-day trips. Yet because visitor trip patterns were based solely on multi-day trips, a large segment of the recreation population, the commercial day and transport trips, was absent from the analyses. Caution is therefore required when comparing actual use levels between visitor types because the estimated commercial use is unquestionably an underestimate. As well, these trips are motorised, hence concern exists for their enhanced potential to disturb wildlife.

Temporal variation in vessel activity was consistent with the pattern of visitor entry for both independent and commercial visitors. This clearly characterises use periods based on a shoulder season of lower use and a peak season with a relatively high use. Where concern exists that elevated use contributes to a decline, below some acceptable threshold, in the quality of the visitor experience or a resource condition, a temporal re-distribution of use is one possible management strategy. However, based on the often increased sensitivity of breeding wildlife to disturbance and the soils and vegetation during the rainy season, this strategy is not advisable.

4.2 Potential Conflict Analyses

4.2.1 Overnight Use Sites

The approach undertaken to delineate potential conflict regions was to identify overnight humans use sites and wildlife sites located within a specified distance from one another with a purpose to inform managers of spatial and temporal designations for monitoring priorities. Based on a 500-m distance, nearly a quarter of all seabird colonies and close to a fifth of all falcon eyries were located near a camp and/or a moor site. This provides an estimate of the absolute potential impact that overnight users have on a large number of ecologically sensitive wildlife sites. The majority of identified wildlife sites were clustered within the areas surrounding all Haida Gwaii Watchmen sites. Because camping is currently prohibited on Hotspring Island, the adjacent islands are popular with visitors, contributing to this area's conflict zone designation.

SGang Gwaay and the islands directly to the north appeared as a 'hotspot' for seabird colonies due to the appearance of clustering of overnight sites within the distance specifications. Previous research indicates that SGang Gwaay is an ecologically significant area as it contains preferred nesting habitat for numerous seabird species (Rodway 1991). Six overnight use sites were situated on the islands or in the waters directly adjacent to the terrestrial component. Although one falcon eyrie is located on this complex of islands, it was located beyond the 500-m distance boundary. While SGang Gwaay and the surrounding islets have been closed since 2001 for reasons of ecological sensitivity, this area is a high priority for monitoring for both ongoing visitor and wildlife use to ensure compliance of these management regulations is achieved.

Additional areas of concern include Windy Bay (Peregrine Falcon), Bischof Islands (seabirds), Gordon Islands (seabirds) and the central park region including Bolkus, Rock Islets, Swan Islets and the entrance to Burnaby Narrows (seabirds). Burnaby Narrows, an ecologically sensitive intertidal zone is officially closed to overnight use and adjacent entrances contained a number of use sites and wildlife sites, contributing to its priority status. Areas with high densities of seabird colonies, such as Bolkus Islands, did not have high numbers of overnight sites. These regions are generally characterised by rocky beaches and are not desirable overnight spots, unless required in the case of emergency (Westland 1994). Although Bolkus Islands have been closed to visitors since 2001 due to cultural sensitivity, continued use of even small numbers of overnight sites may contribute to an elevated risk of disturbance and these areas require diligent monitoring due to their high densities of seabird colonies.

Within each distance category, the number of overnight use sites in proximity to seabird colonies was consistently higher relative to those in proximity to falcon eyries, except for the 250-m distance category. For both falcon eyries and seabird colonies, more camp sites than moor sites were within the specified distance thresholds. The low number of moor sites within proximity to wildlife sites is related to an apparent preference of sheltered inlets for moor sites where waters are typically calmer and safer.

These areas are not generally representative of preferred nesting habitat for the focal wildlife species (Westland 1994), explaining the low number of moor sites culpable for potential conflict zone classification. Perhaps these areas are important foraging sites. However, a lack of data does not enable firm conclusions. As well, the total number of moor sites is low relative to camp sites and it was expected that potential conflict zones associated with moor sites would be low.

The actual number of independent overnight sites near wildlife sites exceeded commercial sites and potentially results from the different, perhaps more flexible, behaviours of independents versus commercial trips. In a comparison between visitor types, the percentage of wildlife sites within distance categories was greater for independent campers relative to commercial campers and was greater for commercial sites relative to independent moor sites. This relationship was consistent for seabird colonies and falcon eyries and may result from the spatial expansiveness of independent camp sites, repeated use of certain camp sites by commercial operators and the elevated number of commercial trips using moor sites. Relative to random anchoring of boats by visitors, locating mooring buoys at sites previously assessed for impact potential throughout Gwaii Haanas may be considered an appropriate site management strategy to minimise wildlife disturbance.

4.2.2 Travel Activity

The number of wildlife sites intersected on a monthly basis increased in tandem with the pattern of visitor entry, which peaks during July. With visitor types explicitly delineated, the number of unique wildlife sites is consistently less than when visitor types are analysed collectively on a monthly basis. This provides evidence that while a certain amount of overlap in activity patterns exists, distinctive spatial patterns occur between visitor types and that the potential for disturbance risk to wildlife is elevated in tandem with this change in number of visitors entering the park reserve. Visitors to Gwaii Haanas are typically seeking a wilderness experience characterised by solitude, self-discovery and nature observation (Vaske et al. 1996). Hence, one explanation for the increase in number of wildlife sites intersected is that people are perhaps self-regulating their movement patterns to take advantage of more isolated areas in a quest for these experiential attributes. Potential wildlife conflict assessments indicate that at the 500-m and 800-m (for Peregrine Falcon only) distances, violation of buffers occurred for each month and increased with an increase in number of visitors entering the park. These findings appear to indicate that buffer boundaries are likely to be intersected in proportion to the number of trips. The ramifications of this finding include that buffer zone distances be established to represent zones of visitor exclusion, but, without proper management, such as education or enforcement, boundary violation is almost certainly inevitable.

While it is beyond the scope of this study to assess whether this proliferation of human use negatively affects wildlife in the form of disturbance episodes, as the season of operation enters its peak, the zone of influence appears to broaden. Whether this elicits a negative response from wildlife is contingent on a number of factors, which include integrating what is occurring within a larger regional context. Studies indicate that not only is it necessary to determine whether wildlife exhibit a negative behavioural response to humans but that determining the severity, or importance of the response requires knowledge of availability of alternate habitat (Gill et al. 2001). Should visitor use extend into wildlife habitat to an extent where little alternate habitat is available, the potential for impact of a disturbance event may become elevated.

Incorporating visitor trip type and vessel mode into potential conflict analyses revealed differences in the frequency of intersection events. The frequency of intersection events delineated according to vessel mode and visitor trip types consistently corresponded with the proportion of vessels used by each user group. Most likely at the resolution employed it would have been difficult to detect differences in actual travel behaviour, in part due to the level of detail provided by the respondents. Although the number of independent trip intersections was generally greater than commercial trips, this may not indicate fewer actual intersections by commercial trips but may have resulted from the exclusion of commercial day and transport trips from the analyses.

When in Gwaii Haanas, a variety of vessel modes are employed which vary with respect to speed and noise production. These factors may influence travel patterns and potential impact to wildlife. Based on their increased speed and noise, powerboats have been implicated as posing an elevated risk of disturbance to wildlife such as birds (Rodgers and Schwikert 2002; Ronconi and St. Clair 2002). While vessels characterised by amplified noise may present an increased disturbance potential, quieter vessels such as kayaks may pose a similar threat. Their combined attributes of increased manoeuvrability and relatively inconspicuous nature in terms of noise may contribute to an element of surprise and may act to increase the risk of disturbance. Although beyond the scope of this project, the inclusion of vessel type as a factor contributing to a behavioural response to disturbance requires further assessment.

Spatial location of wildlife sites intersected by visitor trips, similar to potential conflict analyses of overnight sites, were typically located in proximity to the attraction sites of SGang Gwaay, Hotspring Island, Rose Harbour and Burnaby Narrows. Those sites classified as a receiving no intersections over the season of operation were principally located along the western coastline of Gwaii Haanas. These areas are characterised by rugged terrain and inclement weather conditions and are infrequently travelled by recreational visitors.

This analysis was limited to breeding sites for seabird species and Peregrine Falcons, based on the comprehensive nature of these data sets. Although a paucity of data exists on at-sea habitat use for both seabirds and peregrines (Harfenist et al. 2002), it is likely that where marine-based visitor travel is coincident with marine areas containing important food sources for the wildlife species in question, a potential conflict may exist, especially should this overlap occur where travel activity is relatively high. As more information becomes available, integrating suitable habitat parameters in addition to known wildlife breeding sites into the potential conflict model would strengthen its predictive capabilities.

5 IMPROVEMENTS AND FURTHER RESEARCH

This research project provides baseline data on visitor travel activity within the marine regions of the proposed National Marine Conservation Area Reserve. Baseline data characterising spatial and temporal patterns of visitor use and activity levels is a reference point for comparison of future monitoring assessments and is essential for management of protected areas. As a pilot research project, integration of a "lessons-learned" approach would facilitate future research and monitoring efforts. Two directions of complementary research will follow a discussion of suggested improvements.

Improvements target a variety of research stages including survey design and data entry. Changes related to survey design include: 1) requesting independent visitors and commercial operators to indicate the number of vessels used; and 2) explicit instructions requesting survey respondents to, in as much detail as possible, indicate their travel route including day trips taken while in Gwaii Haanas. These changes will increase the reliability of the information, will allow park staff to evaluate additional information relevant to park management issues and will reduce the assumptions associated with the current work. For example, as a conservative measure, all kayak visitors were assumed to travel in single versus double kayaks. This may have resulted in an overestimate of vessel activity especially for independent visitors that generally travel by kayak.

Effective visitor management necessitates various types of information such as number of visitors, user demographics and spatial and temporal distribution of visitors. Methods employed to assess and quantify spatial and temporal visitor distributions include aerial photography, direct observation and visitor surveys (Hammitt and Cole

1998). Methodology of the current research project enabled the use of pre-existing surveys and application of a GIS for spatial analyses. This passive monitoring technique, which includes the use of surveys and visitor trip logs (Kenchington 1990), was relatively cost-effective although concerns exist related to human error associated with spatial referencing. However, this concern applies primarily where a finer scale of resolution is desired to promote a more detailed understanding of spatial patterns. My approach provides a coarse scale assessment of use, an appropriate scale given the research objectives and considerations for implementing recommendations. A corollary of the GIS model, applied to assess visitor activity patterns and identify conflict zones within Gwaii Haanas, is to perform field surveys and record direct observations of use. The two complementary approaches will enable an evaluation of their effectiveness on the basis of accuracy and consistency.

Both national parks and National Marine Conservation Areas are created through legislative tools under the auspices of the Parks Canada Agency. Although national parks involve protection of the resource base, National Marine Conservation Areas adhere to a management philosophy incorporating conservation and protection with ecologically sustainable uses (Canada 2002). This results in a broader suite of activities defined as acceptable within National Marine Conservation Area bounds and may include commercial fishing and shipping, amongst other uses. Currently, recreationists, researchers, Haida people and commercial fishers access the waters within the bounds of the proposed Gwaii Haanas National Marine Conservation Area Reserve. Research should be conducted to assess the relative contribution of these types of human activity within the proposed National Marine Conservation Area Reserve. Given the potential for inter-user group conflicts, current knowledge gaps include areas frequently accessed by fishers for resource extraction, anchoring sites and route trajectories. As well, undertaking potential conflict analyses that incorporate commercial day and transport trips is required to better understand travel activity patterns of a full complement of recreational visitors segmented by visitor type. As these trips are typically short in duration and stops at known wildlife sites may be a focal component of a tour, analyses may reveal differential patterns and lead to further refinement of management actions. Assessment of these elements of human activity will provide a more comprehensive depiction of current uses of the region and would inform National Marine Conservation Area Reserve zoning plans or other planning initiatives.

Previous research indicates that assessments of wildlife responses to recreationists require analyses on a species and site-specific basis (Burger and Gochfield 1983; Rodgers and Schwikert 2002). The buffer distances that I applied to wildlife sites were based on provincial wildlife viewing guidelines and previous research (Johnson 1988; Richardson and Miller 1997; Ministry of Water, Land and Air Protection 2002). These buffer distances may apply to the Gwaii Haanas landscape, but a site-specific evaluation of the disturbance thresholds of the focal wildlife species to various forms of recreational activity will provide relevant estimates of distance thresholds for this park. This does not underscore the reliability of the current work as it provides an indication of the areas most likely to receive potential boundary violations. Application of these distances as visitor exclusion zones contributes to effective visitor management strategies that will ultimately help to eliminate or decrease the impact of internal stressors, such as visitor use.

6 CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Given the primary goal of managing for ecological integrity within the context of national parks, adequate information and monitoring tools are required to balance visitor management and resource protection. External stressors to the ecological integrity of national parks are numerous, but they are often outside the jurisdictions of the managing agency. This highlights the necessity and often increased focus by managers on those stressors that arise from internal sources in ways that adhere to the goal of ecological integrity and are appropriate given the specific management objectives and conditions of the park.

At the park systems level, the Canada National Parks Act and various strategic policies direct park management. At the park level, a Park Management Plan guides and implements management decisions. All management plans should contain an ecological vision, ecological integrity indicators and provisions for visitor use, amongst other requirements (Canada 2000). The Gwaii Haanas vision provides direction for the management of human uses because it states that, "With the coming of summer, visitors from all over the world begin to arrive. Each one of them shares the sensation of being the first person to set foot here." (Archipelago Management Board 1996). Typical of backcountry areas, remote Gwaii Haanas includes minimal facilities, thus the solicited visitor experience reflects opportunities for solitude, nature observation and spiritual endeavours (Parks Canada Agency 2004). This is in contrast with frontcountry recreational experiences where the focus of attraction is often an activity or modifications to the environment, such as more extensive visitor facilities, and not the natural setting per se (Marion and Farrell 1996). Frontcountry areas are characterised by different settings and services such as more visitor facilities, generally increased ease of access, higher visitor numbers and an acceptability of higher use levels (Rollins 1998). The unique social standards and the ecological functions that backcountry regions possess, such as wildlife refuges, and the directives indicated in Gwaii Haanas' interim management plan give it a distinction that requires management strategies sensitive to these attributes.

Although managing to maintain a distinctive backcountry experience includes certain unique considerations, the overall direction of national park management is concerned with the maintenance of ecological integrity. To ensure that the internal stressor of visitor use does not escalate into an actual threat to the ecological integrity of protected areas and is contained within acceptable limits, park managers rely on visitor management strategies. The goal of visitor management strategies is to manage visitors to ensure the quality of the visitor experience is maintained and the ecological significance of impacts is minimised.

Park managers possess a variety of strategies to manage visitors and their associated impacts, targeting the intensity of use, the type of use, the location and timing of use, as well as activity regulation (Hammitt and Cole 1998). Currently, Gwaii Haanas has a daily restriction on the number of visitors allowed entry into the park with the use quotients divided between commercial and independent visitors. As well, an annual maximum number of visitor user nights constrain use levels; however, this value is nearly three times the actual use levels and is recognised as a theoretical limit (Gwaii Haanas National Park Reserve 2003). Current strategies employed by Gwaii Haanas that target location and timing of use include a random camping policy, various overnight stay closures and provision of buoys at certain locations.

During visitor orientation, Gwaii Haanas' random camping policy is clearly stated – visitors are not required to camp in designated spots and are encouraged to avoid sites where others have previously camped. The results of this policy are evident from the spatially dispersed location of camp sites that proliferate throughout Gwaii Haanas (Figure 9). A policy of dispersed use is one spatial strategy applied by park planners and managers to minimise visitor related impacts (Table 11). A spatial dispersal strategy applied to overnight use areas may spread use over a larger area. If the number of use areas remains constant, the ecological impacts to the use sites over the entire park area will generally not shift as even at low use levels impacts to soil and vegetation are typically high (Cole 1992). However, where dispersal techniques increase the total number of use areas, the relationship between use and impact becomes more complex. In both cases, a probable outcome is an increase in wildlife disturbance events. The conditions that predicate success for the dispersed use strategy include low use levels, a high compliance rate of visitors with regard to low impact camping methods and highly resistant sites (Hammitt and Cole 1998). While Gwaii Haanas may have a lower number of visitors relative to other parks, results from the campsite monitoring program revealed that although less than 1% of the land base was impacted from campsite use, 71% of the monitored sites were classified as highly or extremely sensitive to human disturbance (Gajda et al. 2000). In addition, over half exceeded the accepted impact standards and were in need of management intervention.

My evaluation of the spatial nature of camp and moor sites of Gwaii Haanas indicates that a pattern of spatial dispersion is evident, but concentrations of use occur near Haida sites. Travel activity patterns indicate similar results. This is not surprising given that achieving the outcomes of spatial dispersion is difficult due to low compliance of visitors and a tendency for use concentrations to evolve (Echelberger et al. 1983). A question that follows from the above, with regards to camping is, 'Is the random camping policy achieving its intended goal of minimising impact?' because it appears that: 1) impact standards are being exceeded based on campsite monitoring; and 2) use is concentrated in some areas.

In contrast to management tools that emphasise dispersed use, a spatial containment strategy aims to limit the area of resource impact by aggregating use resulting in fewer accessible sites (Hammitt and Cole 1998). This strategy is widely applied within a protected areas context and is particularly suitable in higher use zones (Leung and Marion 1999; Marion and Farrell 2002). Additional evaluation of campsite impacts and associated management strategies indicate that designating sites in the more heavily used and popular regions of a park is more effective to decrease campsite impacts than a dispersal strategy (Williams and Marion 1995). Moreover, the 1995 Gwaii Haanas Visitor Survey found that visitors perceive a designated site policy to minimise camping impacts and the majority of respondents prefer a combination of designated and dispersed camping sites (Vaske et al. 1996). Previous research assessing the appropriateness of visitor management strategies to a marine reef environment concluded that a containment strategy was an effective measure to minimise impacts associated with marine areas receiving high levels of visitor use (Marion and Rogers 1994). Dispersing recreational use did not figure prominently because it allowed for infiltration of people into areas otherwise unused creating opportunities for potential impacts. However, undesirable attributes of this strategy in a wilderness environment include restrictions of the perception of visitor freedom through site designation, while the creation of facilities may be inappropriate and contrary to a wilderness ethic. Additional trade-offs associated with a non-random camping policy are related with safety issues specific to Gwaii Haanas – visitors must be permitted to camp in any accessible location should a hazardous weather situation arise.

A final spatial strategy is that of spatial segregation which seeks to minimise conflicts between visitor groups and environmental attributes, such as wildlife, by re-distributing use. The closure of the Burnaby Narrows intertidal region to camping within Gwaii Haanas is an example of this strategy (Table 11). Use segregation is often applied within marine protected areas implemented through zoning as a tool to ensure the compatibility of multiple uses. A multiple-use zoning approach separates conflicting resource uses such as commercial fishing and recreation, and ensures successful high-level protection of certain areas (Day 2002).

Methods employed to specifically minimise the risk of recreationist and wildlife conflicts include spatial dispersal, spatial containment or spatial segregation. Typically, spatial segregation strategies are implemented to protect wildlife from disturbance through implementation of buffers or larger visitor exclusion zones. While establishment of the specific buffer size depends on the species, amongst other factors (Blumstein et al. 2003), adhering to a standard buffer dimension based on the most conservative estimate will facilitate implementation, enforcement and compliance measures. It is also important that guidelines incorporate a temporal component, because their effectiveness tends to increase when integration occurs with spatial restrictions (Richardson and Miller 1997). Concentrating visitor use to specific marine regions may not be a feasible option in Gwaii Haanas whereas advising and ensuring visitors remain at set distances from wildlife may allow for continued exploration of this landscape. Although my study did not address the specific determination of buffer zones, currently visitor patterns lead to violation of provincial wildlife viewing guidelines indicating that further research aimed at assessing the effect of travel activity on seabirds and peregrines is required. However, until further work is undertaken implementing zones of visitor exclusion surrounding seabird colonies and Peregrine Falcon eyries is warranted.

Based on my findings, independent campers are implicated in a higher percentage of wildlife sites designated as potential conflicts than commercial campers are whereas the opposite is true for moor site users. There appears to be a positive relationship between the number of overnight sites accessed and the number of wildlife sites assigned potential conflict zone designations. Given this relationship and the high camp site fidelity by commercial operators this raises a concern regarding the effectiveness of a random camping policy.

Based on assessments of travel activity, there is no justification to warrant management of visitor types differentially because both appear to violate buffer distance boundaries proportional to the number of vessels used. However, visitor behaviour and ensuing impact may vary between groups depending on the vessel mode. Currently, the use of powerboats is prevalent and is the dominant mode of transportation by commercial operators. The ability for powerboats to change direction and speed with little notice contributes to their unpredictability, a feature that can increase the likelihood of an adverse behavioural response by wildlife (Taylor and Knight 2003). As boat speed is identified as an important factor in predicting flushing response (Ronconi and St. Clair 2002), small adjustments to speed of travel when in proximity to seabird colonies would minimise potential impact from humans and is a guideline applied when viewing other marine wildlife (Jelinski et al. 2002). According to the strategic management plan, non-motorised transportation is encouraged and aircraft use within the park reserve boundaries is to be minimised, although no current restrictions apply (Archipelago Management Board 1996). In conjunction with the delimitation of buffer zones surrounding wildlife sites, imposing travel speed limits when in proximity to these sites is warranted.

Methods to achieve the various strategies include indirect versus direct management approaches. Indirect approaches attempt to influence visitor behaviour whereas direct approaches are regulatory in nature. Indirect approaches include education and entry fees and are contrasted with direct management techniques such as rationing use intensity (group size and length of stay limits), zoning, increased enforcement and activity restrictions. Especially in wilderness environments, the application of direct management strategies is typically relied on as a measure of last resort because concerns exist surrounding the constraints they may pose to visitors' perceived freedom (Hendee et al. 1990). Visitor education is one of the key tools currently applied by Gwaii Haanas to achieve its management objectives. However, given Parks Canada's mandate to prioritise ecological integrity, where concerns regarding the maintenance of the ecological or cultural integrity of an area exist, implementation of spatial restrictions and regulations, such as closures and buffer zones, are justified.

The fields of marine reserve design and management and the application of visitor management strategies to marine environments are largely in their infancy relative to terrestrial protected systems. Although current management of Gwaii Haanas is constrained to the high tide mark, the proposed Gwaii Haanas National Marine Conservation Area Reserve will expand Gwaii Haanas' jurisdictional boundaries to include the marine region. Marine environments pose a number of unique management challenges for park managers. Marine systems are inherently complex and dynamic and it is therefore difficult to predict how they respond to perturbations (Eagles and McCool 2002). A limited understanding of processes governing marine systems and a lack of baseline biophysical data for marine areas further contribute to knowledge gaps. Marine protected areas, such as National Marine Conservation Areas, are characterised by multiple entry points and a lack of visible boundaries, which both facilitate an ease of access and contribute to challenges associated with enforcement and successful monitoring (Eagles and McCool 2002). Implementing a high protection zone or a buffer surrounding wildlife breeding sites requires that visitors, or other human users, are able to visually estimate the boundary distance while on the water so that boundary violation does not occur. However, research has shown that marine reserve boundary violations are often high, partially based on the difficulty with delineating boundaries in an aquatic environment (Jelinski et al. 2002). Notwithstanding these additional challenges, applying an adaptive management framework to ensure continuous learning is recognised as an appropriate strategy.

Exposure to internal stressors that may compromise the integrity of the protected area provides evidence that the establishment of protected areas is not sufficient to ensure their long term protection. Management strategies that seek to minimise negative impacts are required to effectively balance various park uses to adhere to the broader management goal of ecological integrity. A determination of the most appropriate visitor management strategy is a typically complex process and is beyond both the scope of the present research and requires input from all stakeholders. Managing wilderness settings for the maintenance of ecological integrity, visitor's perception of freedom and wilderness attributes almost categorically ensures that the determination of appropriate management actions will involve a challenge. However, as our knowledge of internal park uses expands, contributions to the field of visitor impact management will follow suite.

SUMMARY OF MONITORING RECOMMENDATIONS

- Based on the elevated use intensities of various corridors, monitoring of focal wildlife species should include those situated within the corridors adjacent to Hot spring, SGang Gwaay, Rose Harbour, T'aanuu, Burnaby Narrows, Bolkus Islands and the Rankine corridor.
- Increased monitoring efforts of seabird colonies and Peregrine Falcon eyries are recommended during July and August, the peak months of use.
- SGang Gwaay, an area of importance for seabirds, requires continued monitoring to ensure compliance with current closures to visitor overnight use.
- Annual campsite monitoring and inter-annual comparison of impact conditions is recommended. This will help to inform the effectiveness of the current dispersed use strategy.

SUMMARY OF MANAGEMENT RECOMMENDATIONS AND FUTURE CONCERNS

Gwaii Haanas presents a heterogeneous park landscape in terms of visitor use patterns and potential conflict areas for wildlife, which has explicit implications for visitor management and pro-active mitigation of potential conflicts.

- Overnight use sites appear to contribute differentially to potential conflict zones according to visitor type. The spatially expansive use of Gwaii Haanas by independent campers warrants a re-examination of the effectiveness of the random camping policy.
- Designating visitors to use specified moor sites may minimise potential disturbance events to wildlife and to the ocean floor. This will require the installation of additional moor buoys a minimum of 500 m from seabird colonies and falcon eyries throughout the proposed marine reserve area at accessible and sheltered sites.
- Travel activity patterns of multi-day visitors appear to differ depending on visitor type but not in ways that warrant the application of different management strategies.

- Based on their conservation status, a precautionary approach is warranted to ensure impacts are avoided to focal species wildlife sites. Until further research is undertaken, a minimum buffer zone of 500 m for seabird colonies and Peregrine Falcon should be delimited based on the current provincial wildlife viewing guidelines. Furthermore, restrictions to travel speeds of vessels, especially motorised travel modes, may reduce potential disturbance to focal wildlife sites.
- A continued emphasis on indirect management techniques, especially visitor education is advocated. Information to incorporate into the visitor orientation includes:
    - Emphasise the sensitivity of environmental parameters, such as seabird colonies, and illustrate the possible impact visitors may have to wildlife.
    - Inform visitors of areas where they can expect to see more people, both on land and on water, so that visitors possess realistic expectations and the quality of the visitor experience is maintained.
- Based on the degree of uncertainty associated with our knowledge of recreational effects and the functioning of natural ecosystems, adopting an adaptive management approach is recommended. This ensures continued learning of ecological responses and refinement of management actions and their associated objectives.

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FIGURES

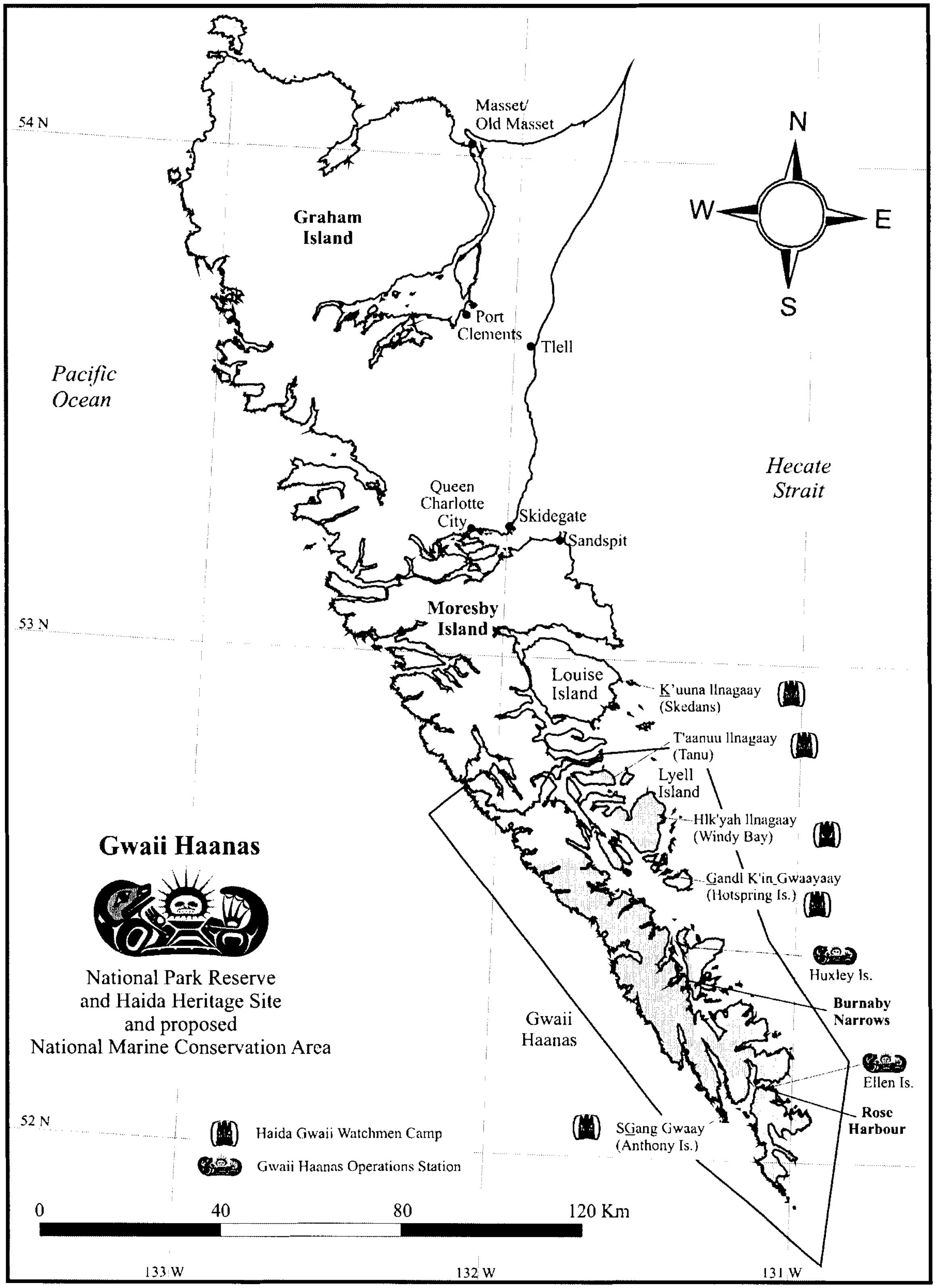

Figure 1. Gwaii Haanas National Park Reserve and Haida Heritage Site, the proposed National Marine Conservation Area boundaries and major points of interest (Used by permission ©Parks Canada/Parcs Canada).

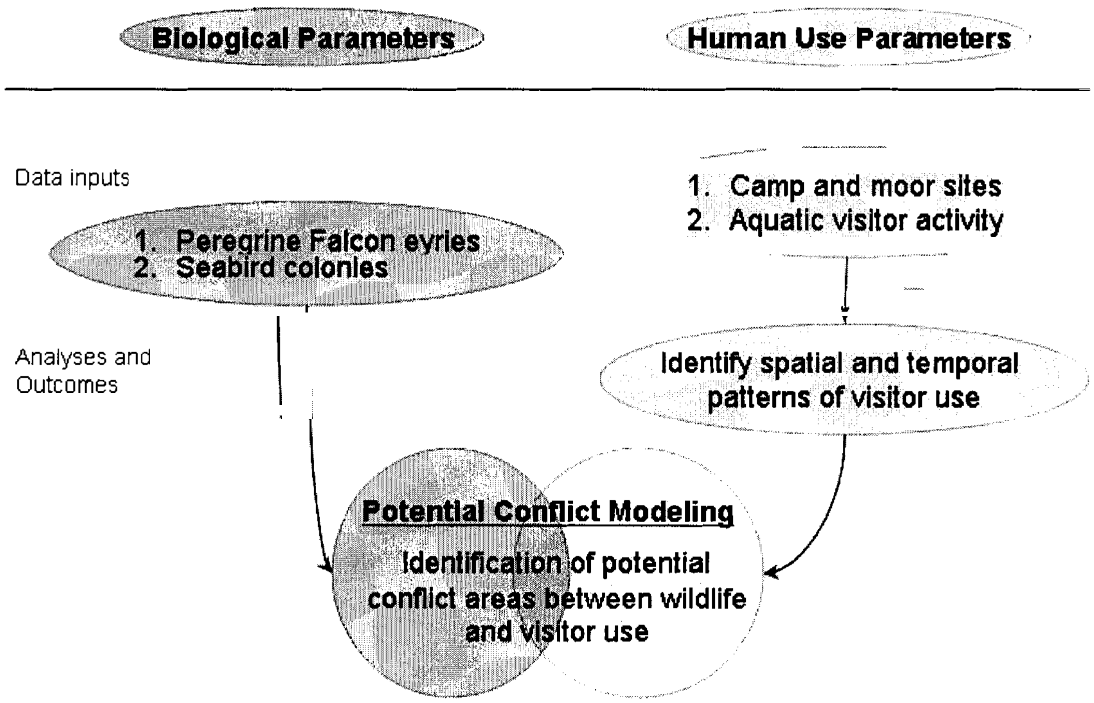

Figure 2. Conceptual framework for identification of potential conflict areas between recreationists and wildlife.

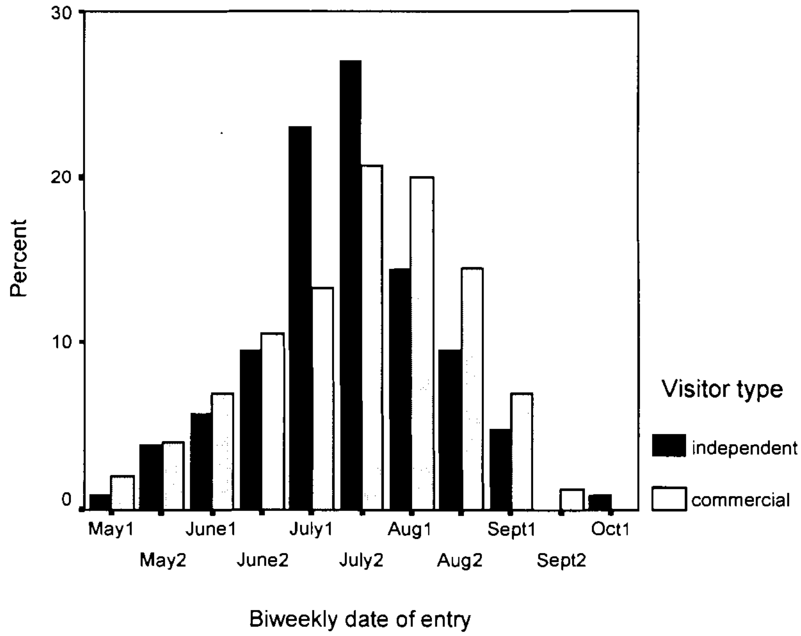

Figure 3. Percentage of visitors entering Gwaii Haanas for the 2001 season. Percentage for each visitor type relative to itself and not for commercial and independent trips combined.

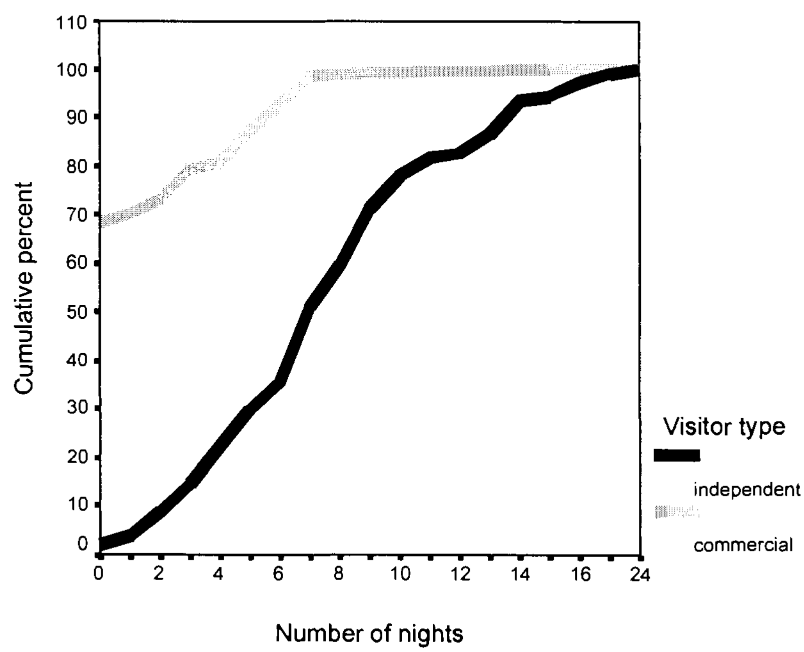

Figure 4. Cumulative percentage of number of nights spent in Gwaii Haanas according to visitor type.

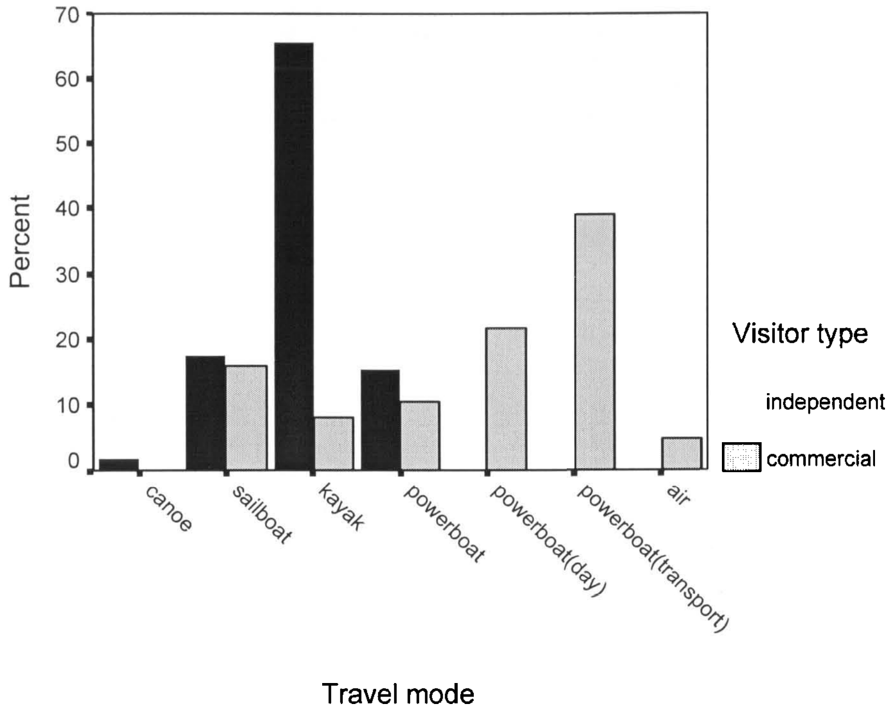

Figure 5. Travel mode as a function of visitor type.

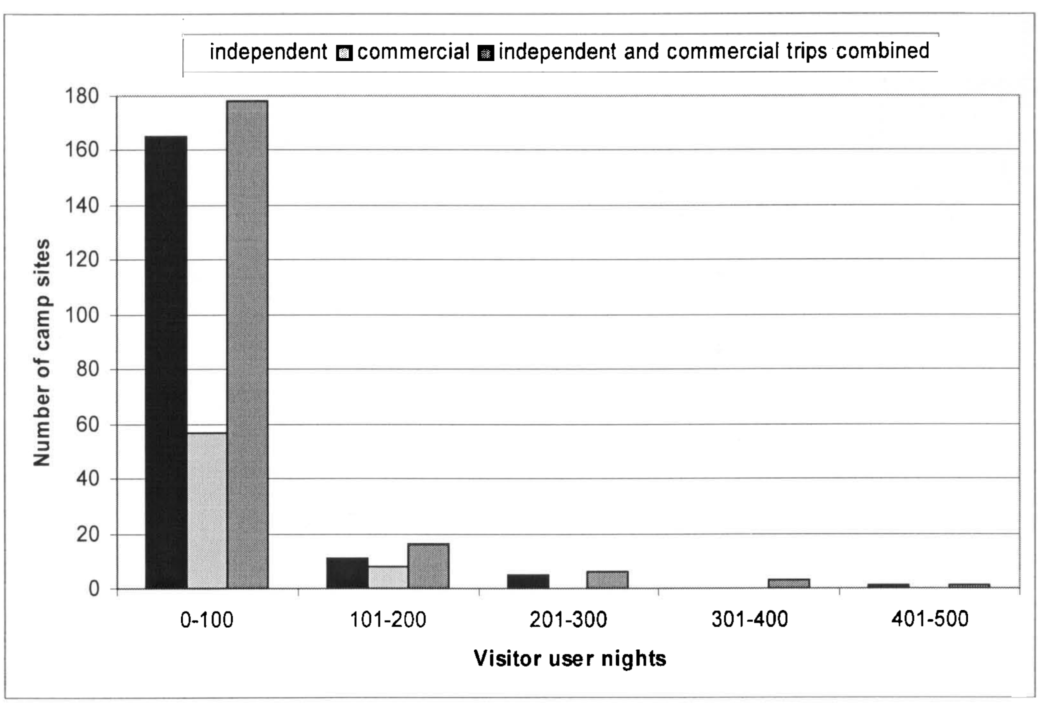

Figure 6. Number of camp sites receiving different intensities of use for visitor types. "Combined" category represents the aggregation of all independent and commercial camp use areas into camp sites.

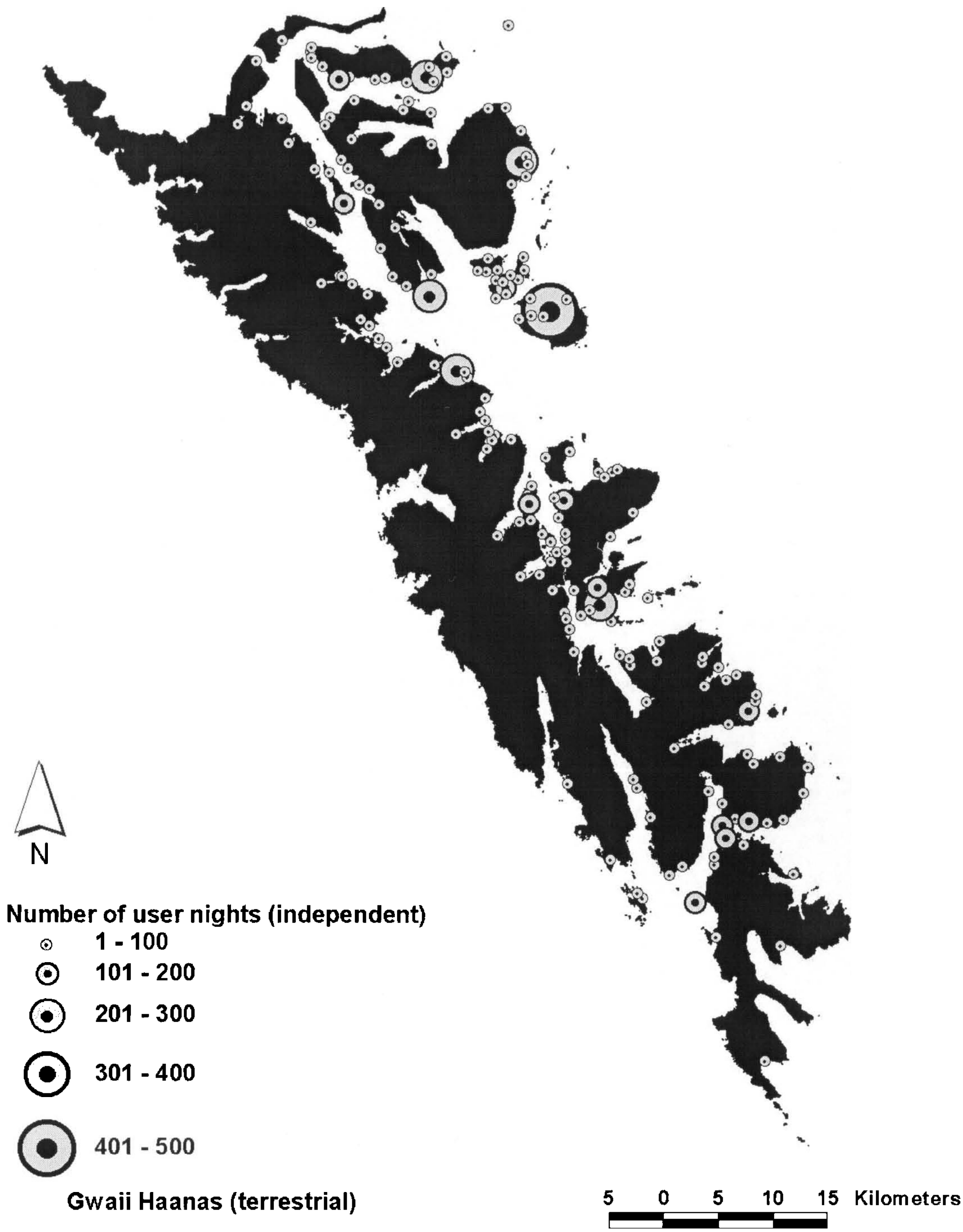

Figure 7. Total number of independent user nights at camp sites during the 2001 season.

Figure 8. Total number of commercial user nights at camp sites during the 2001 season.

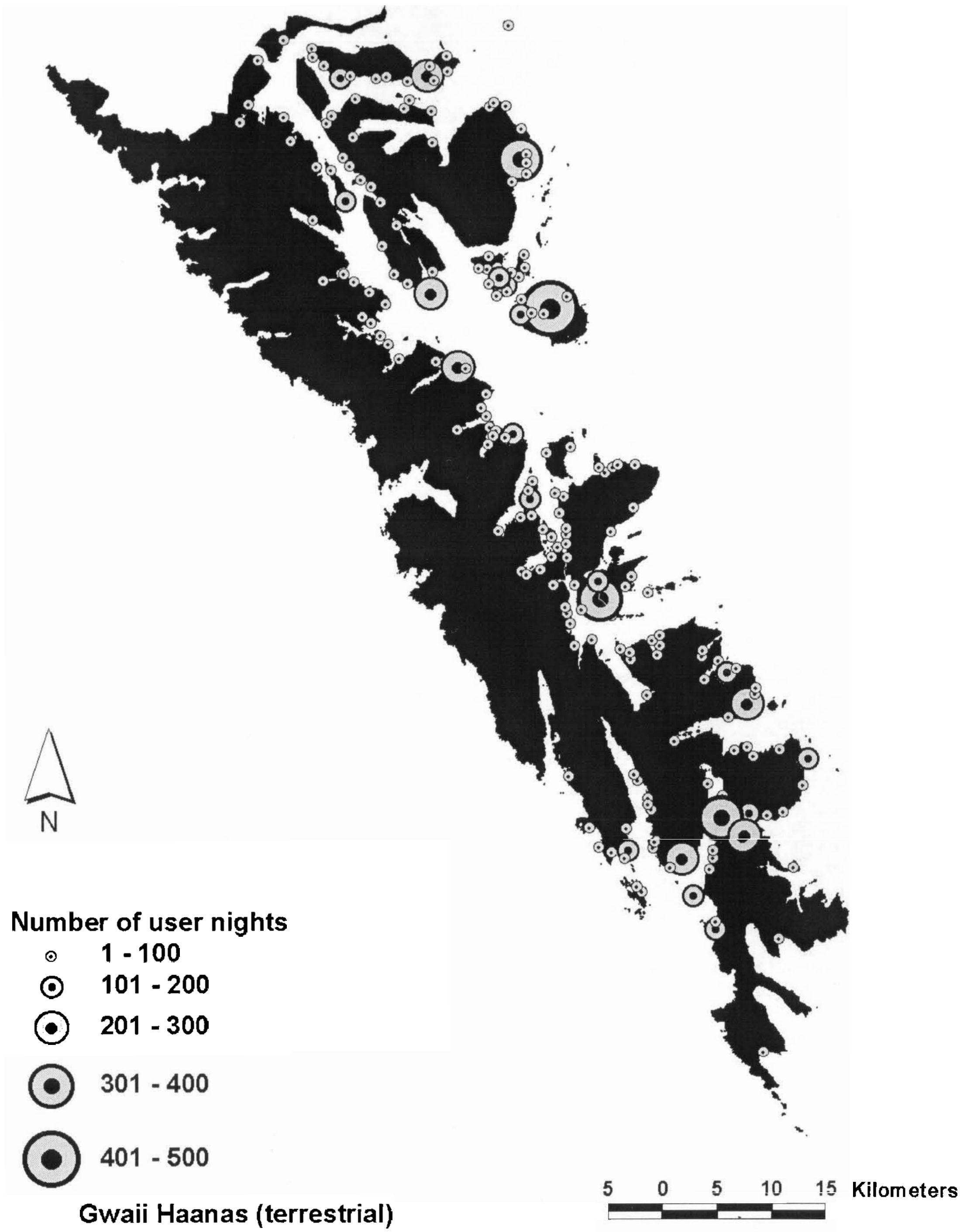

Figure 9. Total number of user nights at camp sites during the 2001 season by commercial and independent visitors combined. "Visitors combined" represents the aggregation of all independent and commercial camp use areas into camp sites.

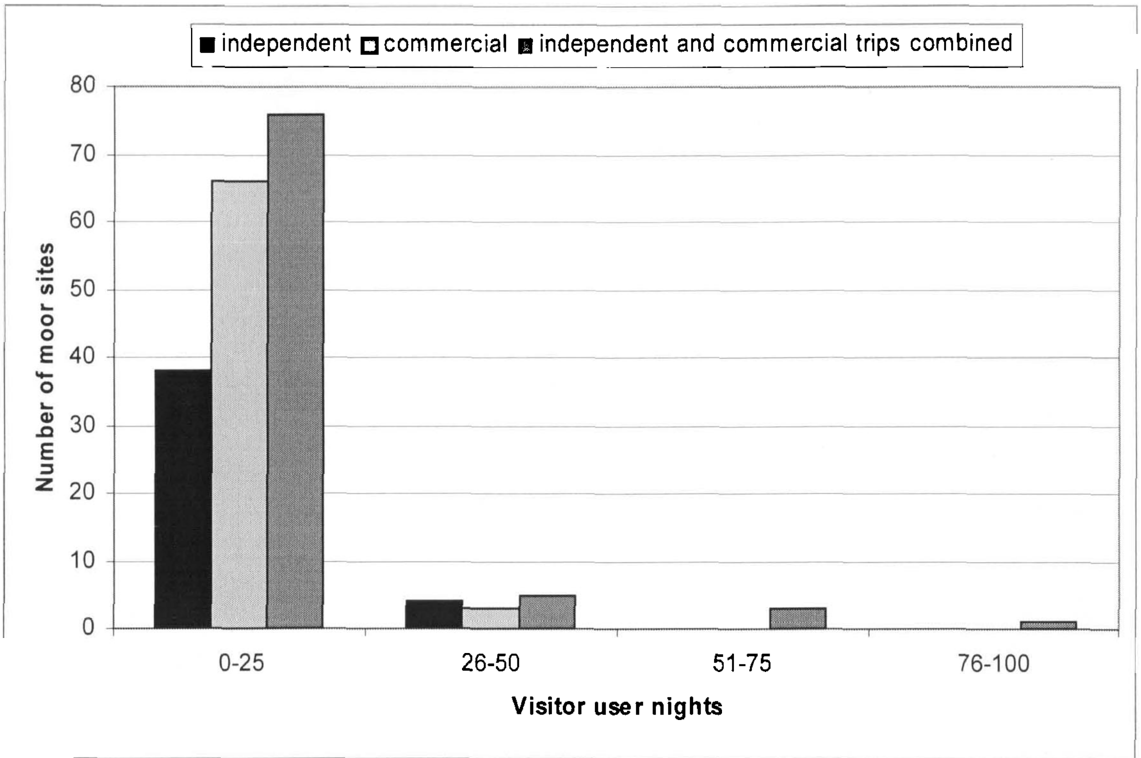

Figure 10. Number of moor sites receiving different intensities of use for visitor types. "Combined" category represents the aggregation of all independent and commercial moor use areas into moor sites.

Figure 11. Total number of independent user nights at moor sites during the 2001 season.

Figure 12. Total number of commercial user nights at moor sites during the 2001 season.

Figure 13. Total number of user nights at moor sites during the 2001 season for independent and commercial visitors combined. "Visitors combined" represents the aggregation of all independent and commercial moor use areas into moor sites.

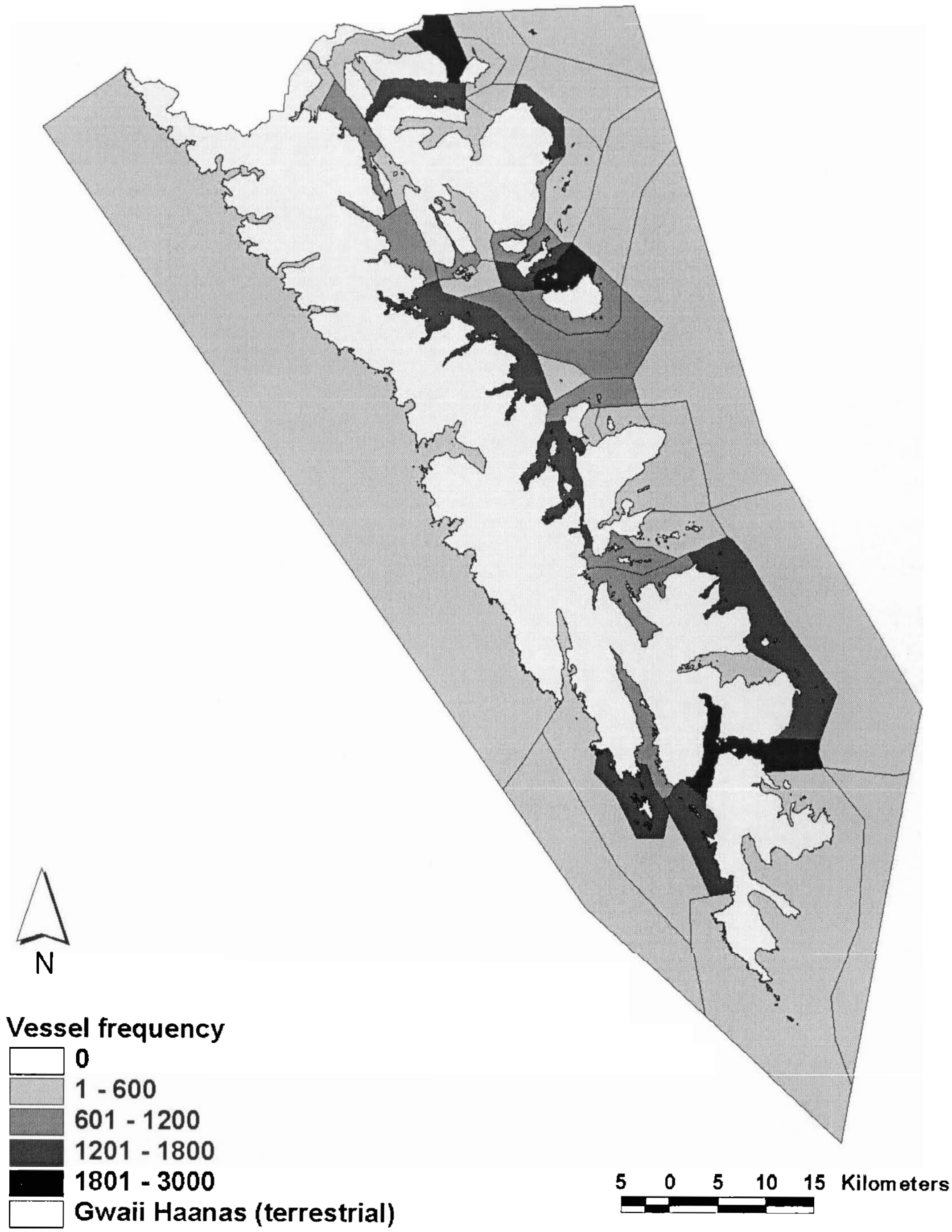

Figure 14. Frequency of vessel use along aquatic travel corridors by independent and commercial visitors combined during the 2001 season.

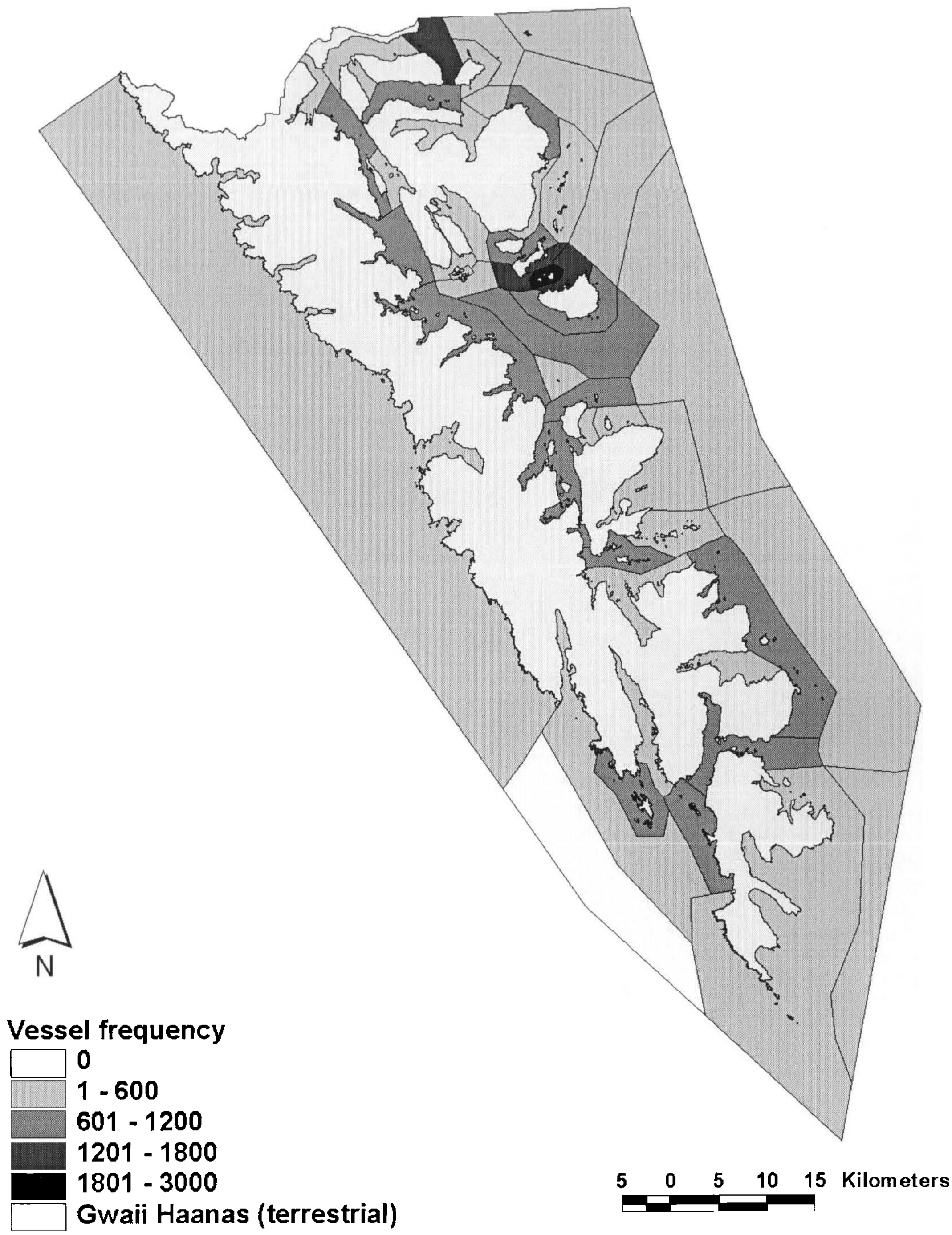

Figure 15. Frequency of vessel use along aquatic travel corridors by independent visitors during the 2001 season.

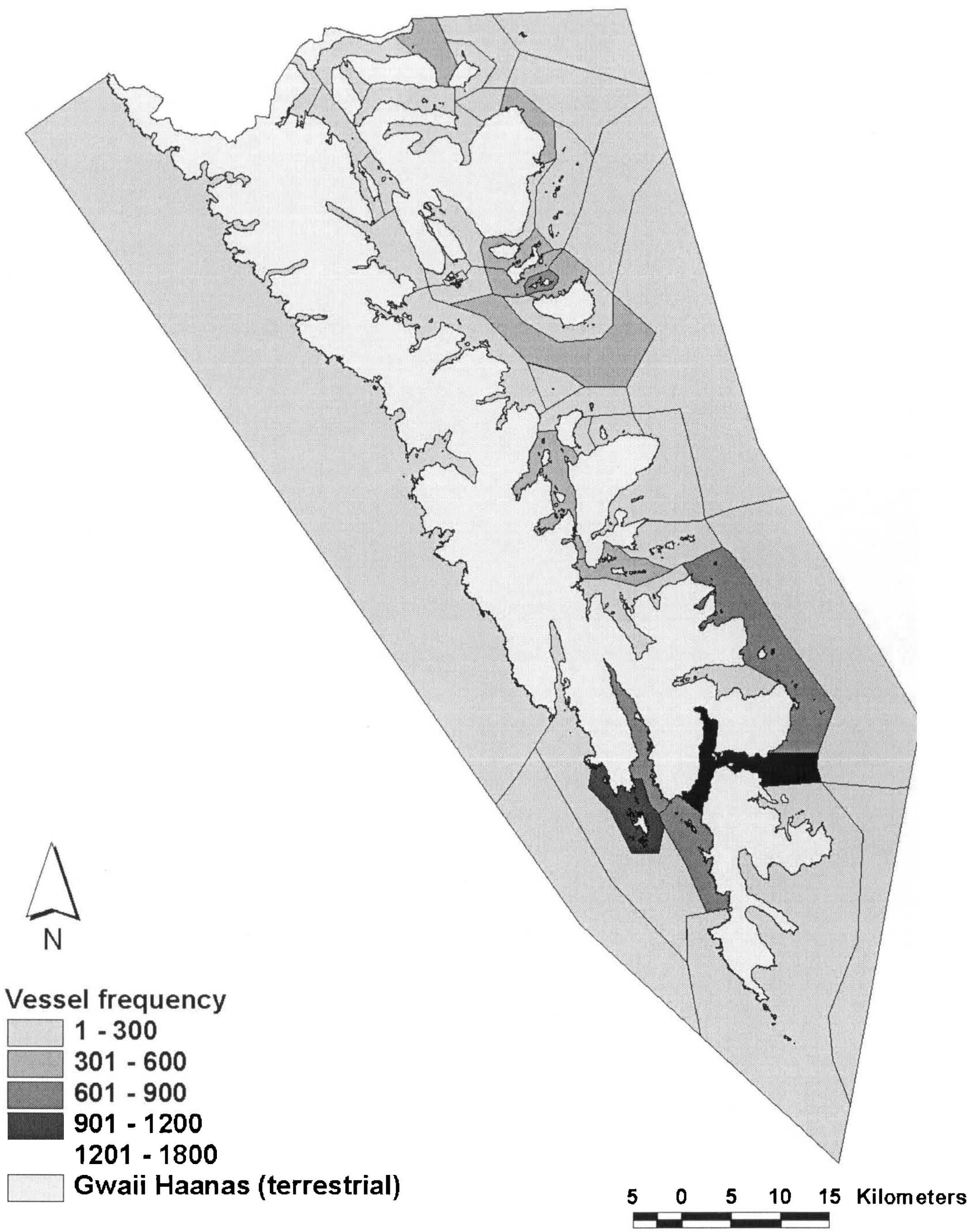

Figure 16. Frequency of vessel use along aquatic travel corridors by commercial visitors during the 2001 season.

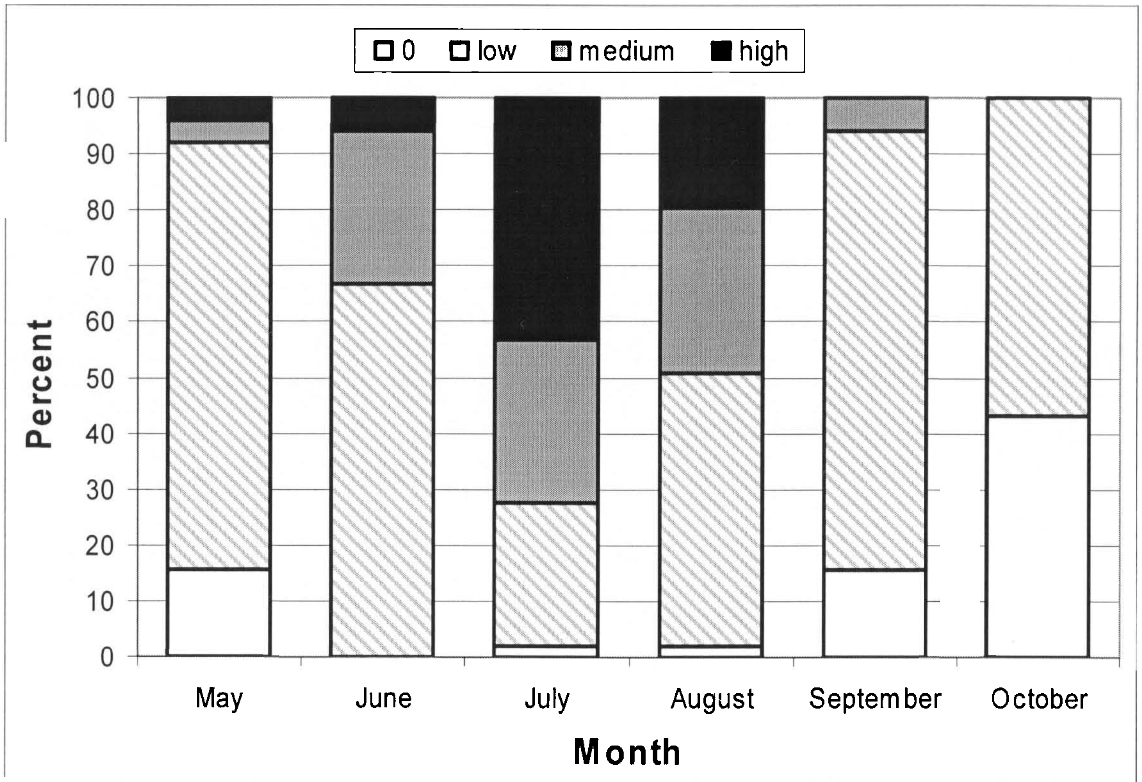

Figure 17. Monthly percentage of corridors grouped by vessel frequency categories for independent and commercial trips combined (number of corridors = 51).

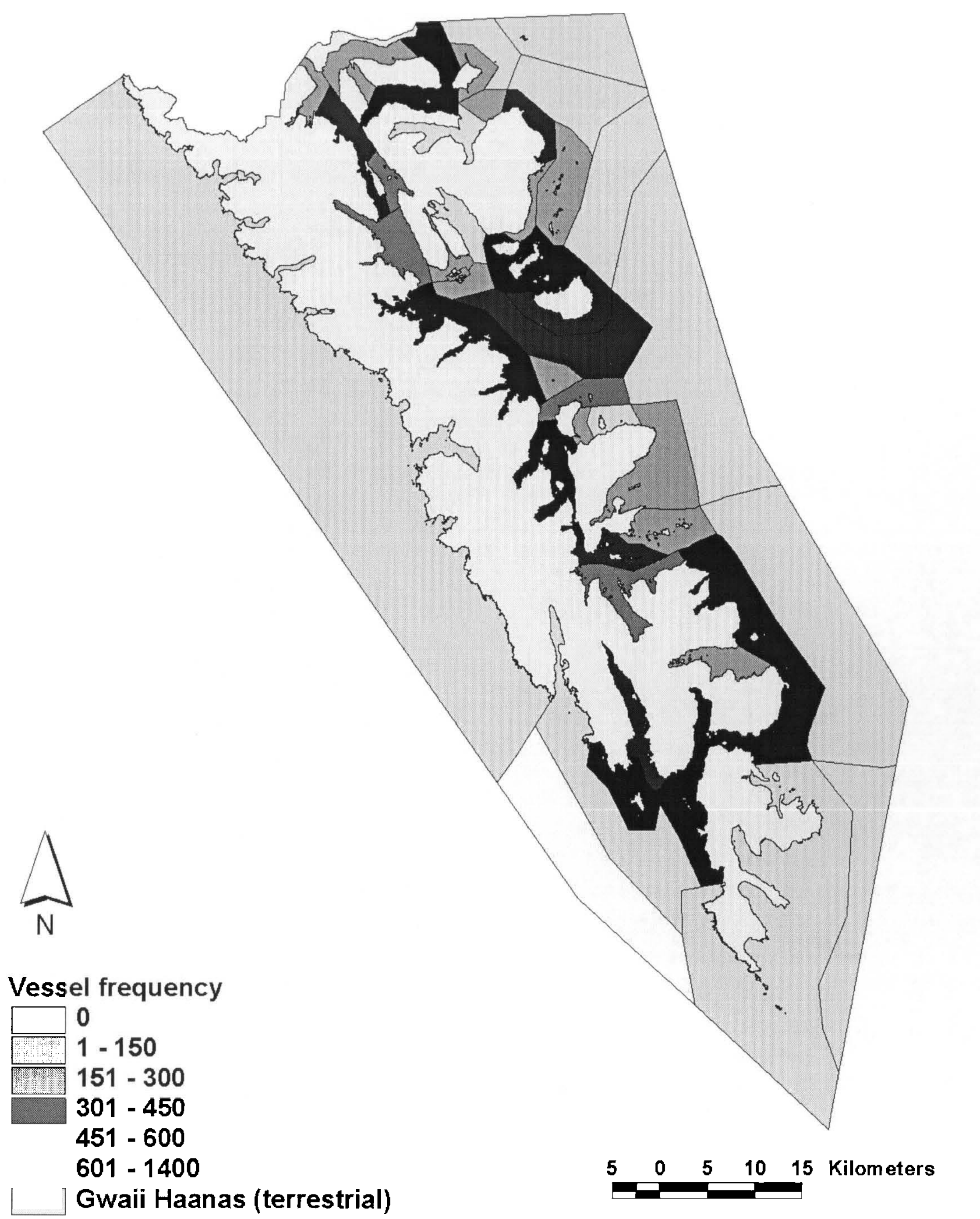

Figure 18. Frequency of vessel use along aquatic travel corridors during July 2001 for independent and commercial trips combined.

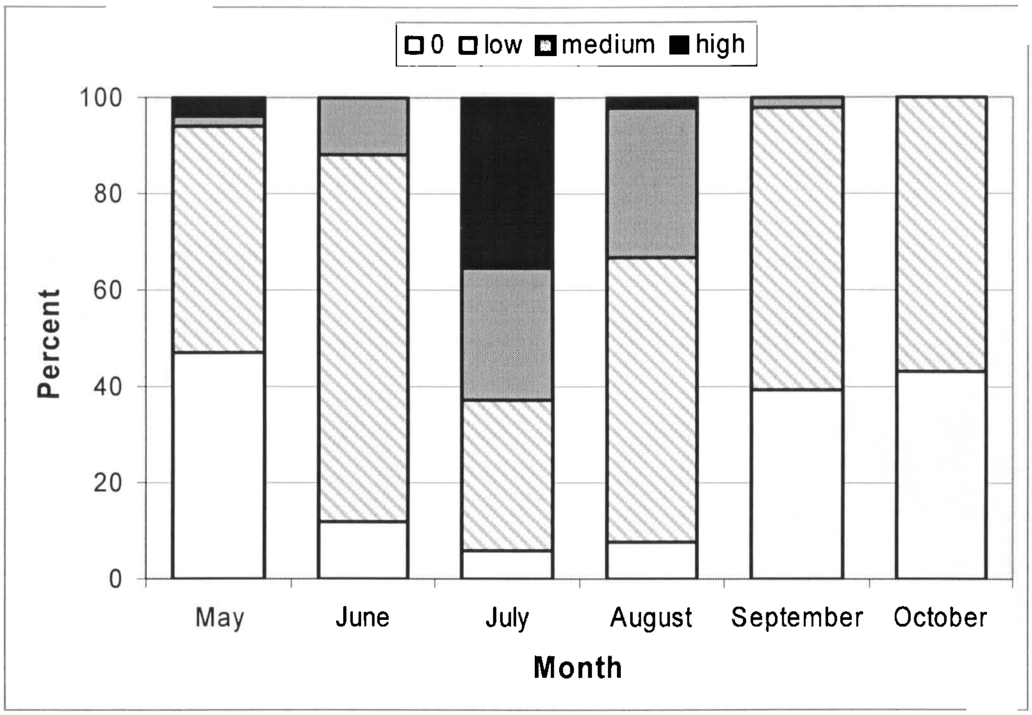

Figure 19. Monthly percentage of corridors grouped by vessel frequency categories for independent trips (n = 251) (number of corridors = 51).

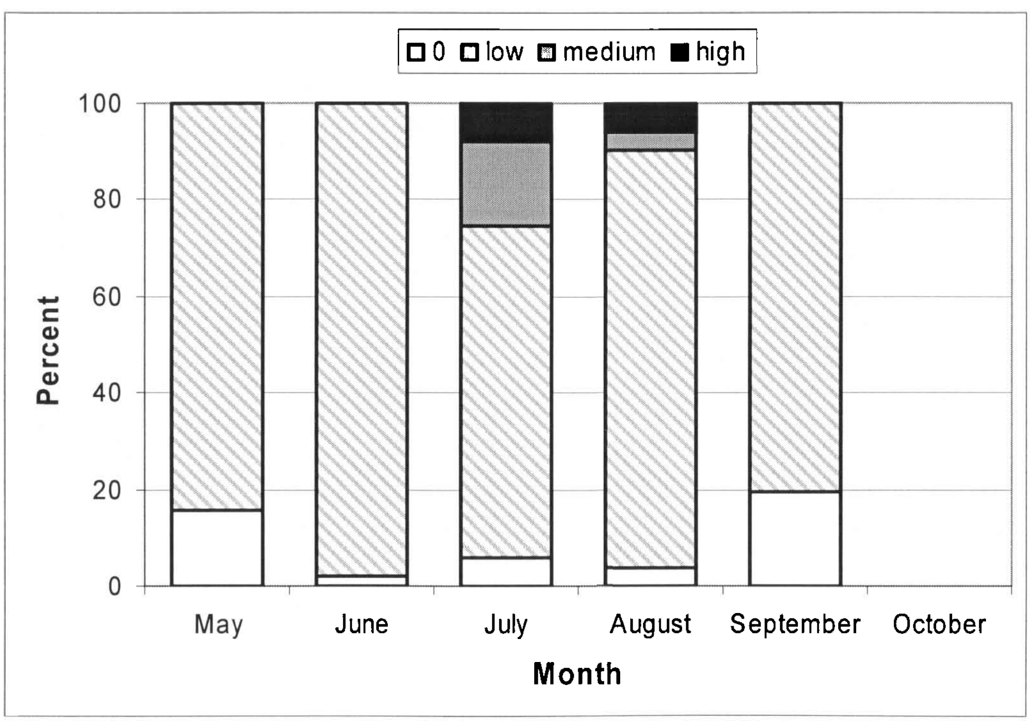

Figure 20. Monthly percentage of corridors grouped by vessel frequency categories for commercial trips (n = 137) (number of corridors = 51).

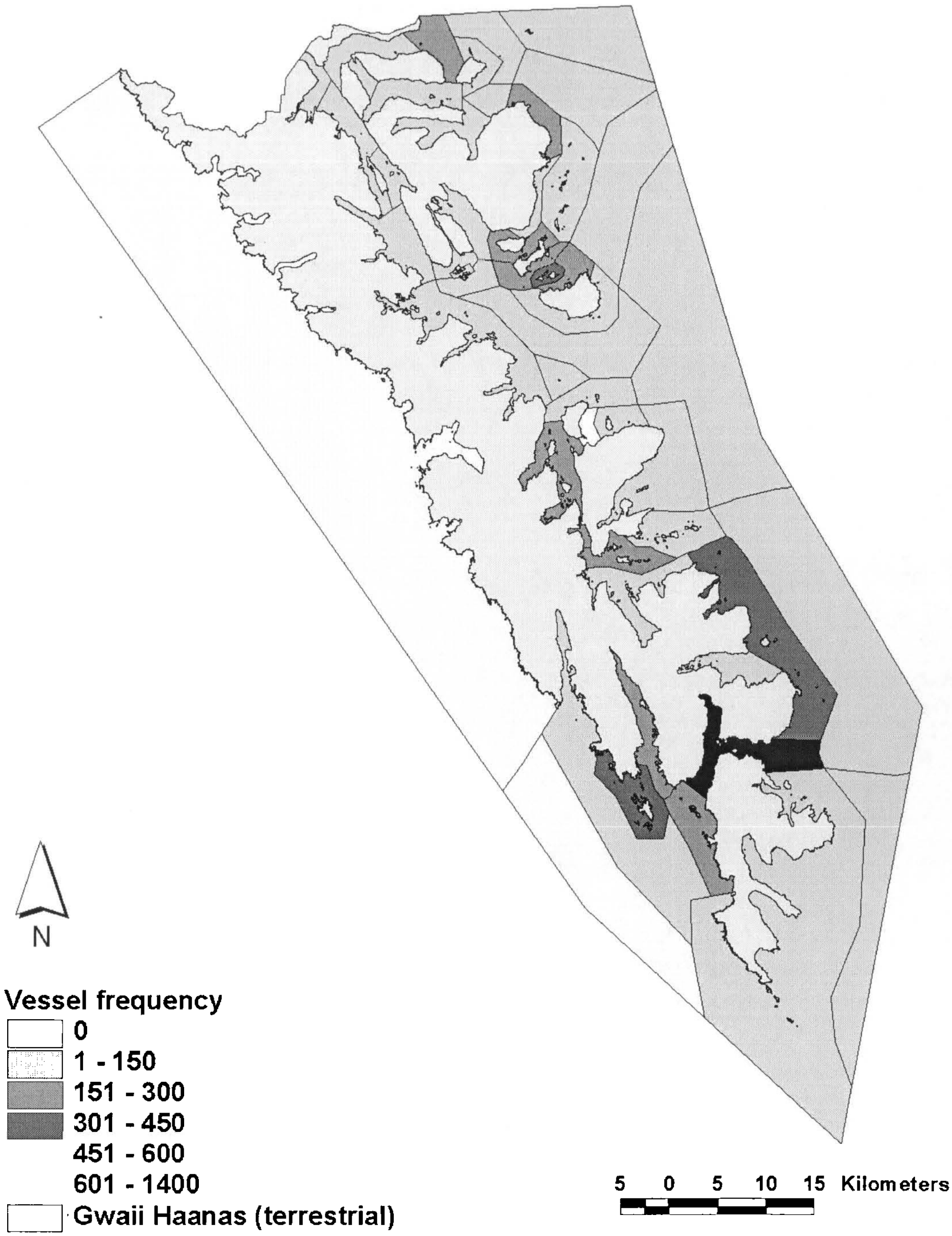

Figure 21. Frequency of vessel use along aquatic travel corridors during July 2001 for commercial trips.

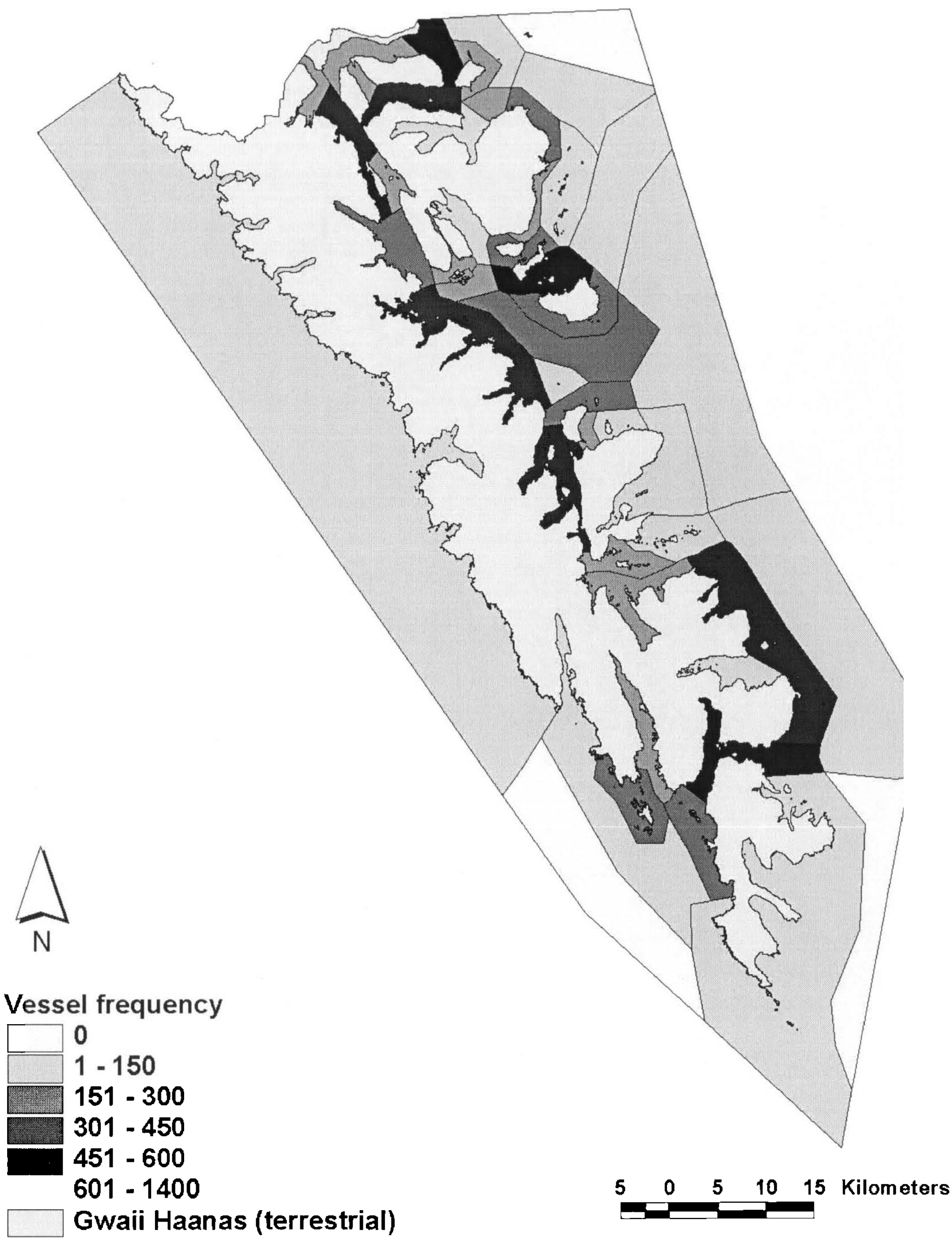

Figure 22. Frequency of vessel use along aquatic travel corridors during July 2001 for independent trips.

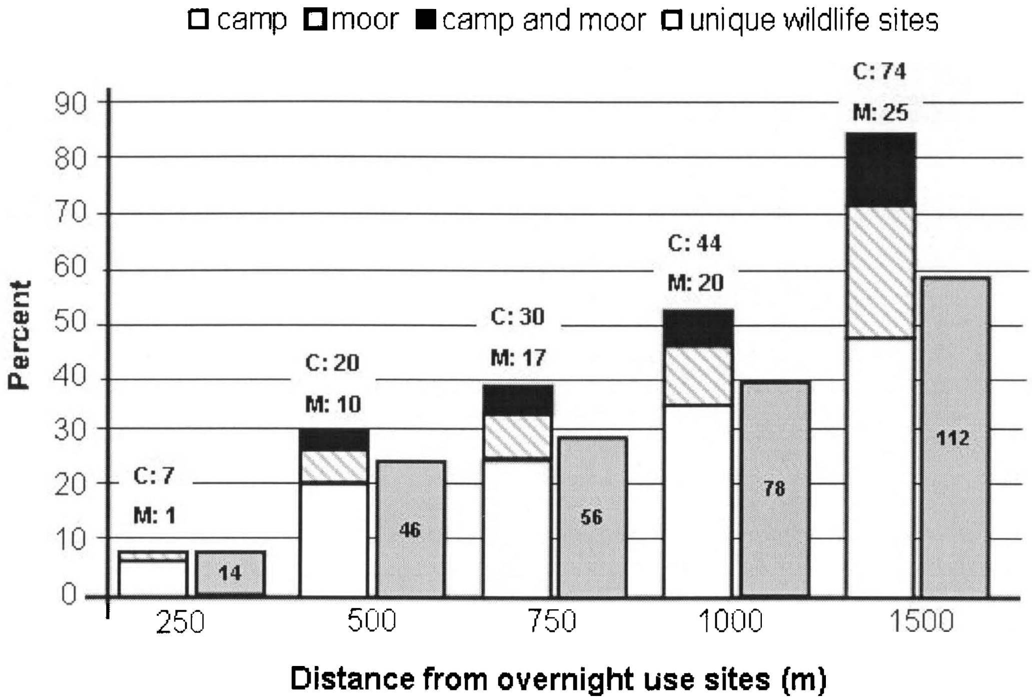

Figure 23. Percentage of seabird colonies within various distances to camp sites (C, n_{Camp} = 204), moor sites (M, n_{Moor} = 85) and both camp and moor sites. The values above the stacked bars indicate the number of corresponding overnight use sites within the distance category. The value embedded within the "unique wildlife sites" bar indicates the total number of seabird colonies within that distance ($n_{colonies}$ = 193). Visitor types are combined, which represents the aggregation of all independent and commercial use areas into sites. All values reflect total seasonal use. The interval between 1000 and 1500 distance categories is 500 m compared to the 250 m interval between the other distance categories.

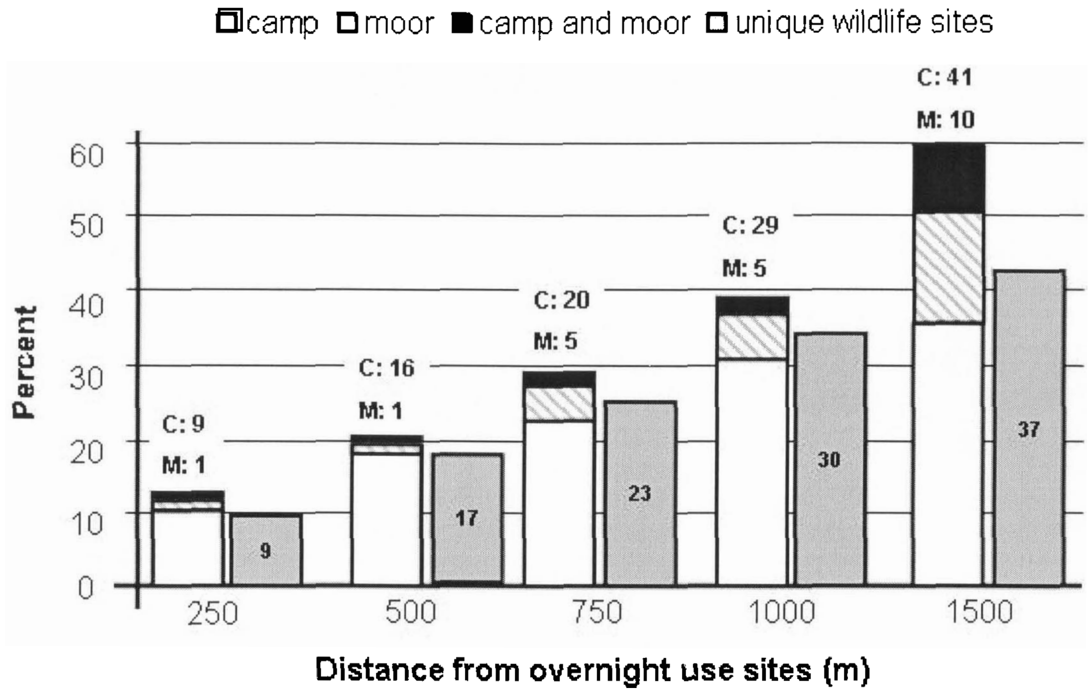

Figure 24. Percentage of Peregrine Falcon eyries within various distances to camp sites (C, n_{Camp} = 204), moor sites (M, n_{Moor} = 85) and both camp and moor sites. The values above the stacked bars indicate the number of corresponding overnight use sites within the distance category. The value embedded within the "unique wildlife sites" bar indicates the total number of eyries within that distance (n_{eyries} = 88). Visitor types are combined, which represents the aggregation of all independent and commercial use areas into sites. All values reflect total seasonal use. The interval between 1000 and 1500 distance categories is 500 m compared to the 250 m interval between the other distance categories.

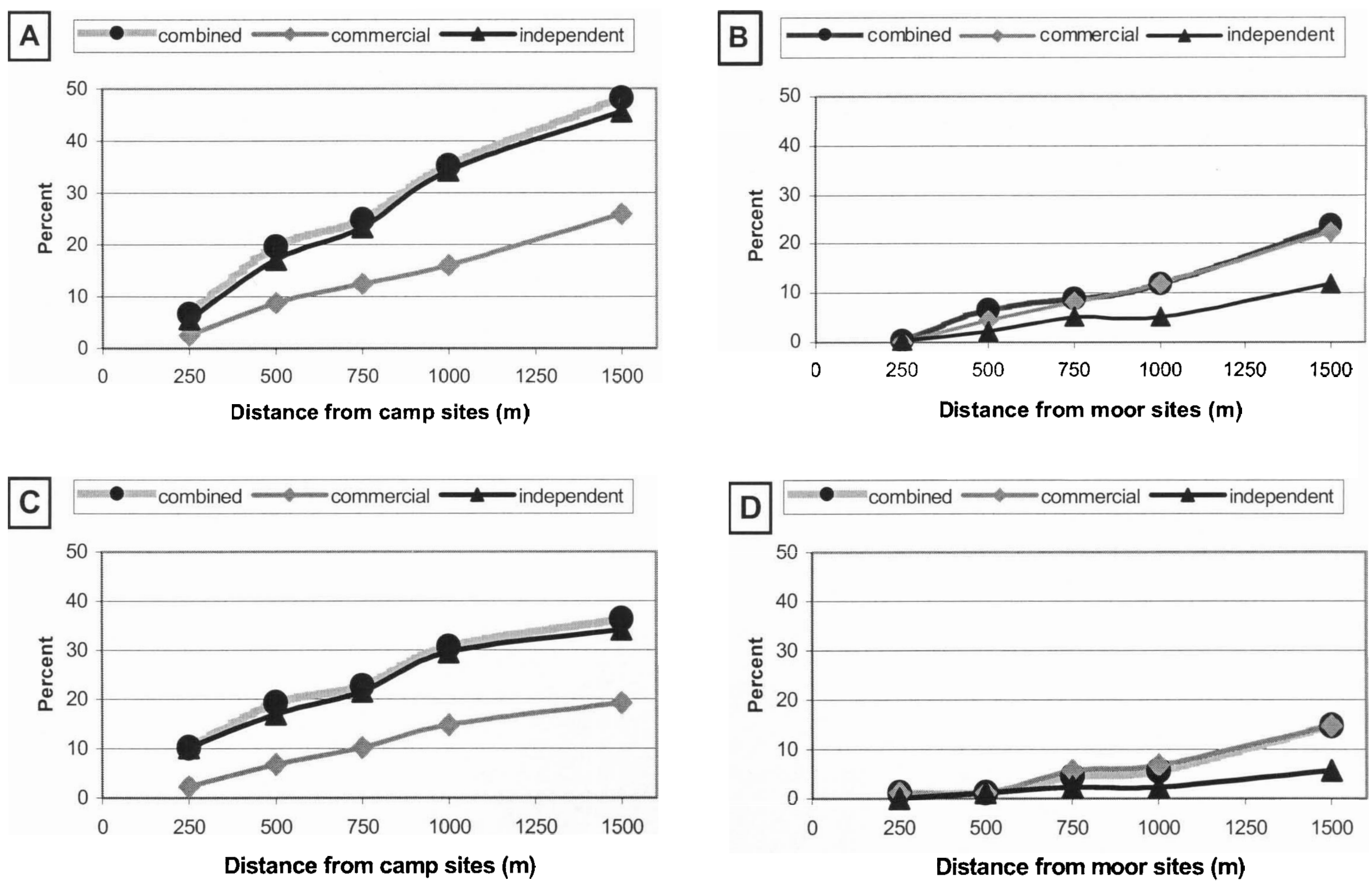

Figure 25. Percentage of wildlife sites within incremental distances from overnight use sites between visitor types. A) Percentage of seabird colonies within distances from camp sites, B) Percentage of seabird colonies within distances from moor sites, C) Percentage of falcon eyries within distances from camp sites, and D) Percentage of falcon eyries within distances from moor sites. "Combined" category represents the aggregation of all independent and commercial use areas into sites.

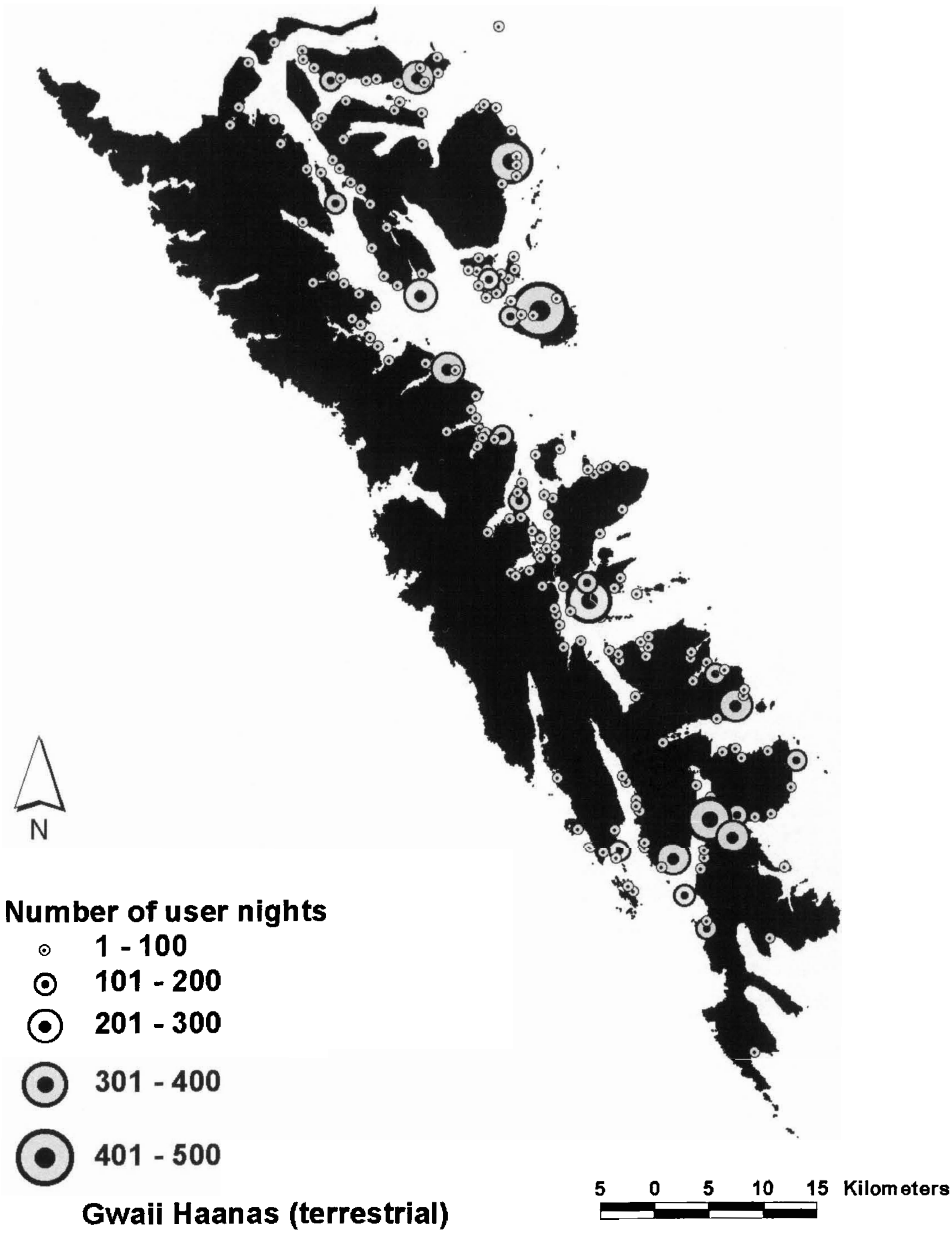

Figure 26. Location of camp sites (commercial and independent visitors combined) and intensity of visitor use. Camp sites within 500 m of seabird colonies and/or Peregrine Falcon eyries are in yellow. "Visitors combined" represents the aggregation of all independent and commercial camp use areas into camp sites.

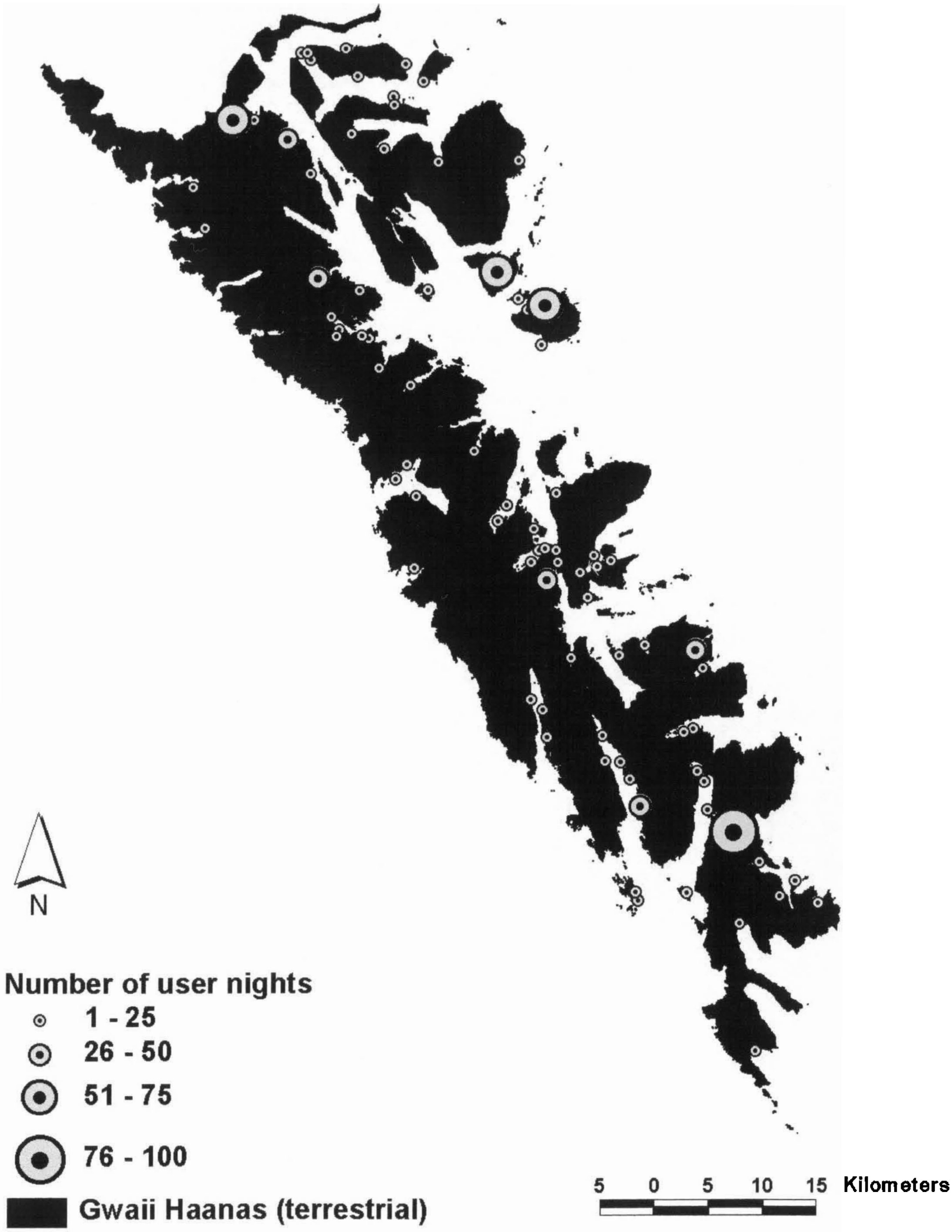

Figure 27. Location of moor sites (commercial and independent visitors combined) and intensity of visitor use. Moor sites within 500 m of seabird colonies and/or Peregrine Falcon eyries are in yellow. "Visitors combined" represents the aggregation of all independent and commercial moor use areas into moor sites.

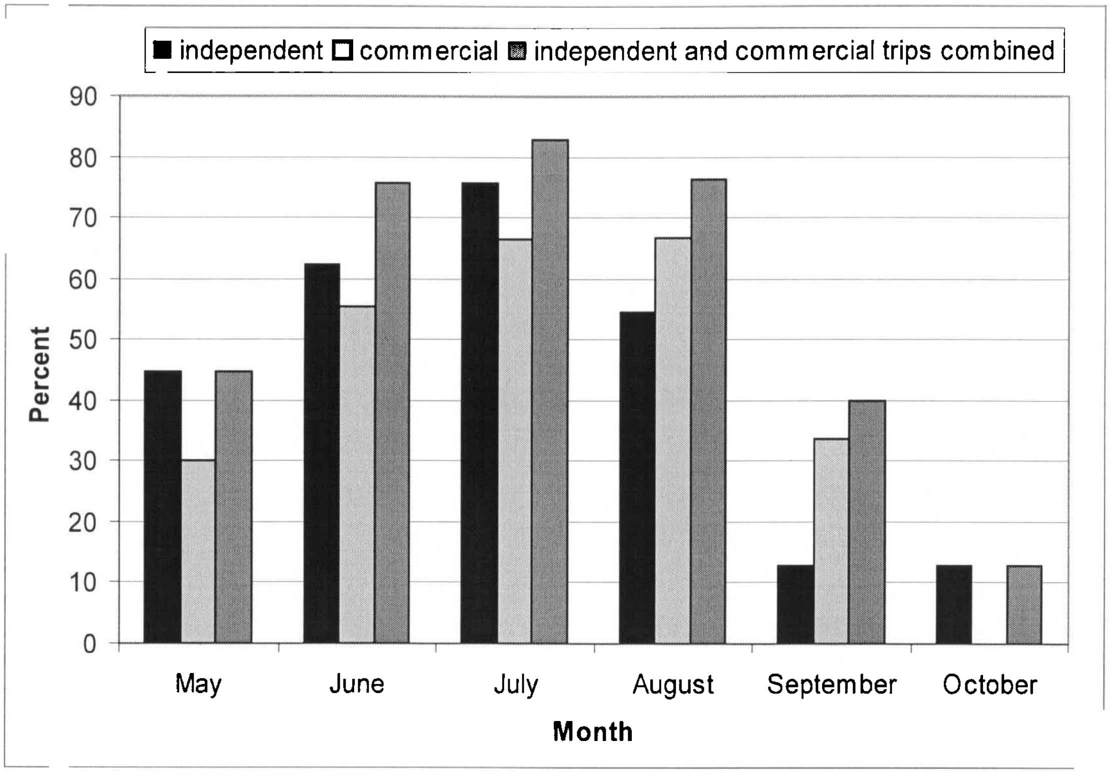

Figure 28. Monthly percentage of seabird colonies intersected by visitor trips based on a 500-m zone during 2001 (n = 193).

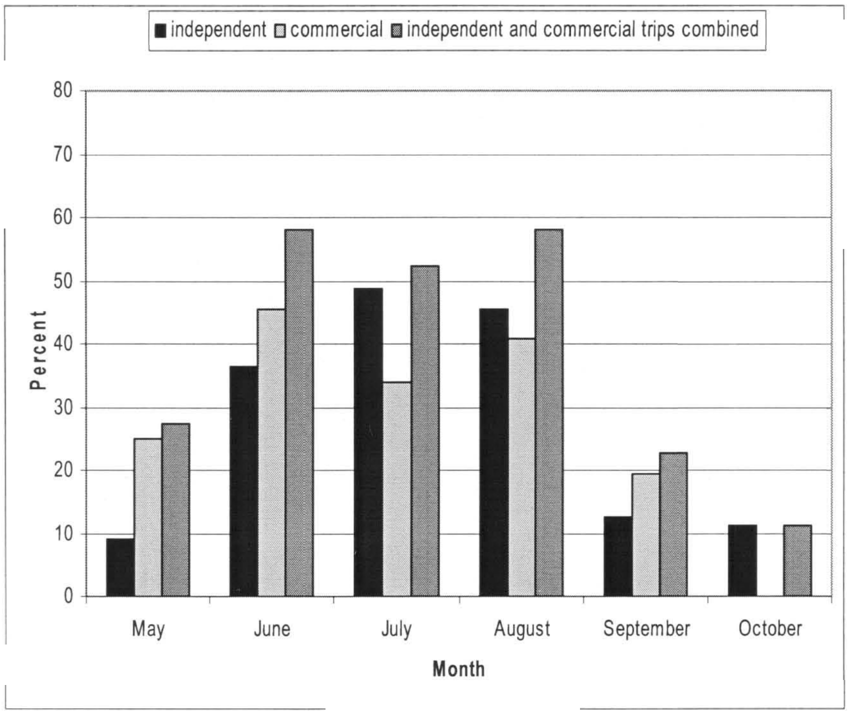

Figure 29. Monthly percentage of Peregrine Falcon eyries intersected by visitor trips within a 500-m buffer.

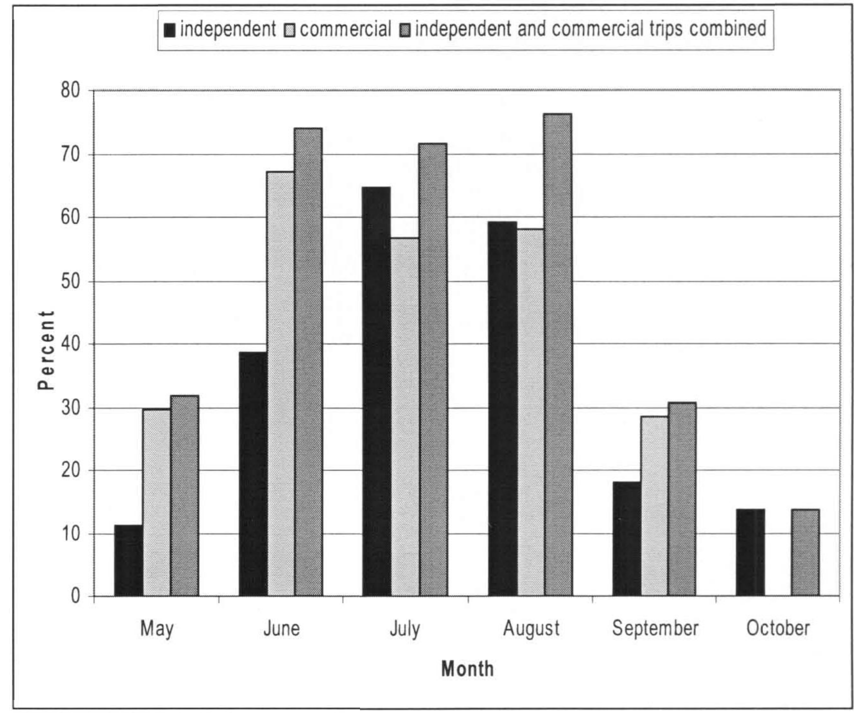

Figure 30. Monthly percentage of Peregrine Falcon eyries intersected by visitor trips within an 800-m buffer.

TABLES

Table 1. Breeding seabirds of Gwaii Haanas National Park Reserve –Common and scientific names, species status and preferred nesting habitat.

Family	Common Name	Scientific Name	CDC[1] Rank	COSEWIC[2] Rank	Nesting Behaviour and Habitat[3]	Data Source
Hydrobatidae	Fork-tailed Storm-petrel	*Oceanodroma furcata*	N/A	N/A	Burrows, small forested islands	(Hatter 1977; Rodway 1988; Rodway et al. 1988, 1990, 1994; Summers 1974)
	Leach's Storm-petrel	*Oceanodroma leucorhoa*	N/A	N/A	Burrows, small forested islands	(Hatter 1977; Rodway 1988; Rodway et al. 1988, 1990, 1994; Summers 1974)
Phalacrcoracidae	Pelagic Cormorant	*Phalacrocorax pelagicus pelagicus*	Red	N/A	Cliff ledges or crevices, forested islands	(Hatter 1977; Rodway 1988; Rodway et al. 1988, 1990, 1994; Summers 1974)
Laridae	Mew Gull	*Larus canus*	N/A	N/A	Surface nester, sites in proximity to freshwater, some in trees	(Rodway et al. 1992)
	Glaucous-winged Gull	*Larus glaucescens*	N/A	N/A	Treeless, small, low, offshore islands, rocky headlands	(Campbell 1975; Gaston 1992; Hatter 1977; Rodway 1988; Rodway et al. 1988, 1990, 1994; Summers 1974; Vermeer et al. 1991b)
Alcidae	Rhinoceros Auklet	*Cerorhinca monocerata*	N/A	N/A	Burrows, grass hummocks, moss, bare soil	(Gaston & Jones 1991; Harfenist 1994; Rodway 1988; Rodway et al. 1988, 1990, 1994; Vermeer et al. 1991a)
	Cassin's Auklet	*Ptychoramphus aleuticus*	Blue	N/A	Burrows, forested or grassy islands	(Harfenist 1994; Rodway 1988; Rodway et al. 1988, 1990, 1994)
	Horned Puffin	*Fratercula corniculata*	Red	N/A	Burrows on slopes with grass hummocks or crevices	(Butler 2000; Rodway et al. 1990, 1994)
	Tufted Puffin	*Fratercula cirrhata*	Blue	N/A	Burrows on slopes with grass hummocks or crevices	(Rodway et al. 1988, 1990, 1994)
	Common Murre	*Uria aalge inornata*	Red	Candidate list	Cliff ledges, surfaces of rocky islands	(Carter et al. 2001)
	Ancient Murrelet	*Synthlibormaphus antiquus*	Blue	Special Concern	Burrows, forested islands	(Harfenist 1994; Rodway 1988; Rodway et al. 1988, 1990, 1994)
	Marbled Murrelet*	*Brachyramphus marmoratus*	Red	Threatened	Solitary nesters on branches of old growth trees	N/A
	Pigeon Guillemot*	*Cepphus columba*	N/A	N/A	Burrows in crevices among large boulders; solitary or colonial nesters	N/A

[1] Conservation Data Centre, refers to provincial listing status (British Columbia)
[2] Committee on the Status of Endangered Wildlife in Canada
[3] Synthesised from Harfenist et al. 2002
* Not included in the analyses

Table 2. Monthly number of trip intersections within 500 m of seabird colonies for visitor and vessel type.

	Independent Trips				Commercial Trips				Total
	Canoe	Kayak	Powerboat	Sailboat	Canoe	Kayak	Powerboat	Sailboat	
May	46	181	0	0	0	21	15	243	506
June	0	754	0	726	0	117	42	469	2108
July	11	2348	503	591	0	420	291	628	4791
August	0	1409	223	106	0	462	220	597	3016
September	0	156	18	7	0	61	39	285	565
October	0	96	0	0	0	0	0	0	96
All months	57	4944	744	1431	0	1080	605	2222	11082

Table 3. Monthly percentages of seabird colonies (n=193) intersected within a 500-m buffer zone relative to number of vessels (vessel type and visitor type combined).

	Number of vessels					
	0	>0 and <31	>30 and <151	>150 and <301	>300 and <601	>600
May	55	34	10	0	1	0
June	24	48	25	2	1	0
July	17	29	41	7	5	1
August	24	35	35	4	2	0
September	60	31	8	1	0	0
October	87	13	0	0	0	0
All months	10	14	45	16	11	5

Table 4. Monthly number of trip intersections within a 500-m zone around Peregrine Falcon eyries for visitor and vessel type.

	Independent Trips				Commercial Trips				Total
	Canoe	Kayak	Powerboat	Sailboat	Canoe	Kayak	Powerboat	Sailboat	
May	0	35	0	0	0	10	3	65	114
June	0	255	0	181	0	15	6	117	574
July	4	765	113	64	0	76	24	132	1177
August	0	517	53	14	0	68	53	99	805
September	0	74	25	0	0	10	9	64	182
October	0	53	0	0	0	0	0	0	53
All months	4	1700	191	259	0	180	95	478	2905

Table 5. **Monthly number of trip intersections within an 800-m zone around Peregrine Falcon eyries for visitor and vessel type.**

	Independent Trips				Commercial Trips				Total
	Canoe	Kayak	Powerboat	Sailboat	Canoe	Kayak	Powerboat	Sailboat	
May	0	50	0	0	0	22	7	107	186
June	0	315	0	322	0	27	13	258	936
July	4	1140	230	110	0	128	56	337	2005
August	0	701	103	21	0	98	74	242	1239
September	0	124	42	0	0	13	22	148	350
October	0	64	0	0	0	0	0	0	64
All months	4	2394	375	453	0	288	174	1092	4780

Table 6. **Monthly percentages of Peregrine Falcon eyries (n = 88) intersected within a 500-m zone relative to number of vessels (vessel type and visitor types combined).**

	Number of vessels					
	0	>0 and <31	>30 and <151	>150 and <301	>300 and <601	>600
May	73	24	3	0	0	0
June	42	38	20	0	0	0
July	48	23	16	12	1	0
August	42	33	25	0	0	0
September	77	15	8	0	0	0
October	89	11	0	0	0	0
All months	24	35	20	5	15	1

Table 7. **Monthly percentages of Peregrine Falcon eyries (n = 88) intersected within an 800-m zone relative to number of vessels (vessel type and visitor type combined).**

	Number of vessels					
	0	>0 and <31	>30 and <151	>150 and <301	>300 and <601	>600
May	68	24	8	0	0	0
June	26	48	26	0	0	0
July	28	25	26	13	8	0
August	24	44	26	6	0	0
September	69	19	12	0	0	0
October	86	14	0	0	0	0
All months	7	39	28	8	10	8

Table 8. Monthly percentages of seabird colonies located within corridors ranked according to use. The number of corridors are indicated in parentheses.

	Corridor use-level			
	None	Low	Medium	High
May	20 (2)	77 (26)	1 (2)	2 (2)
June	0	58 (18)	21 (11)	21 (3)
July	0	22 (5)	25 (9)	53 (18)
August	0	45 (12)	12 (11)	43 (9)
September	11 (6)	85 (24)	4 (3)	0
October	59 (19)	41 (19)	0	0
All months	0	47 (15)	14 (6)	39 (11)

Table 9. Monthly percentages of Peregrine Falcon eyries located within corridors ranked according to use. The number of corridors are indicated in parentheses.

	Corridor use-level			
	None	Low	Medium	High
May	49 (2)	48 (14)	1 (1)	2 (1)
June	0	58 (8)	39 (9)	3 (1)
July	0	51 (4)	7 (4)	42 (10)
August	0	21 (5)	56 (7)	23 (8)
September	25 (3)	73 (14)	2 (1)	0
October	67 (8)	33 (10)	0	0
All months	0	58 (8)	14 (3)	28 (7)

Table 10. Vessel frequency of use categories on a monthly basis and for the 2001 season.

	Monthly periods	All months combined
None	0	0
Low	1-150	1-600
Medium	151-300	601-1200
High	>300	>1200

Table 11. Attributes of spatial visitor management strategies with specific reference to Gwaii Haanas. Adapted and used by permission ©J. Marion.

	Spatial Management Strategy		
	Spatial segregation	**Spatial containment**	**Spatial dispersal**
Goal	Minimise resource use conflicts by separating uses based on resource capabilities Minimise visitor pressure from sensitive areas	Concentrate visitor use to environmentally resistant or a limited number of sites	Diffuse visitation over a larger area to maintain a low frequency of use
Forms of implementation	Zoning Closures Buffer restrictions	Designated areas Designated sites	Linear dispersal Total dispersal
Tools of implementation	Regulations Park planning and management frameworks	Regulations Provision of facilities	Regulations Education/information
Temporal component	Yes	Yes	Yes
Current strategy employed by Gwaii Haanas	Closures	Designated sites	Total dispersal
Gwaii Haanas example	Permanent camping closure in Burnaby Narrows	Installation of mooring buoys, but these are not enforced	Random camping policy