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HUMAN USE AND WILDLIFE DISTURBANCE - ESTABLISHING THE BASELINE FOR MANAGEMENT IN WESTERN PRINCE WILLIAM SOUND, ALASKA

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INTRODUCTION

Increasing human use of western Prince William Sound, Alaska, is anticipated as a result of the opening of a new access road to the community of Whittier in June 2000. The increased use, in combination with a steadily growing tourism industry, may affect the recovery of species injured by the *Exxon Valdez* oil spill of 1989. Ten years after the oil spill, only 2 injured species were considered to have recovered from the effects of the spill, while 12 species were believed to still be recovering (Exxon Valdez Oil Spill 1999). Populations of 8 species have shown little or no improvement and are listed as “not recovering," while an additional 4 species are in an unknown recovery status. Simple explanations for the different recovery responses shown by different species do not exist. The ability of a species to recover from the effects of an event like the spill depends on a multitude of factors, including breeding strategies, food availability, habitat quality, and other pressures that may exist on the population, in addition to any lingering effects of the spill. As human use in Prince William Sound (the Sound) increases, there is an increasing potential that human disturbance will play a major role in the distribution and population dynamics of many wildlife species. What effect this change may have on the recovery of species injured by the spill will depend on resource managers’ abilities to understand and mitigate the effects of human activity in areas important to the injured species.

Little information has been available to document and monitor the changing patterns of human use in the Sound. This project was designed as a tool to help resource managers of the western Sound understand the potential relationships between human activity and local wildlife populations. This information is particularly important because new access into the western Sound is expected to result in dramatic increases in recreation-based human activities (Alaska Department of Transportation 1995). Prior to the opening of the Whittier road, the only access to the community was via the Alaska railroad, float plane, or boat. Because Whittier is only 76 km from Anchorage, the new road will provide access to the Sound for the 73% of Alaska’s population within easy driving distance. This study was initiated in 1998 with the goal of establishing baseline information for future management of the Sound. Three objectives were identified: 1) provide a foundation for displaying and understanding existing human use patterns in the western Sound prior to the opening of the road; 2) review the literature to understand the potential disturbances these uses may have on injured resources; and, 3) make management recommendations to minimize adverse effects of increased human use on wildlife populations. This paper provides a summary of the methods and results of our project; detailed results were provided for resource managers (Murphy et al. 1999).

STUDY AREA

Prince William Sound is located in South-central Alaska. The Sound is sheltered from the Gulf of Alaska by Montague and Hinchinbrook islands, and is separated from interior Alaska by the Chugach and Kenai mountains. Our study area included the western half of the Sound. The line dividing the Sound for our study runs southwest from the southwestern edge of Valdez Arm through Montague Strait to the southwestern corner of Port Bainbridge (Fig. 1). The study area covers 9,700 km^2 (5,044 km^2 of saltwater) and includes 1,754 km of mainland shoreline and an additional 2,108 km of shoreline along 146 islands. Of the 5 human communities within the Sound, only Whittier and Chenega Bay are within the study area.

The Chugach National Forest manages the largest amount of upland areas within the study area (4,160 km^2); the State of Alaska manages additional public land (183 km^2), including the State Marine Park system. The Alaska Department of Natural Resources manages most of the submerged and tidal lands up to the mean high tide mark within the study area. Native Corporations manage approximately 265 km^2 of land primarily in the southwestern quarter of the study area. There is limited private ownership of lands outside of communities, but private parcels do exist (6 km^2).

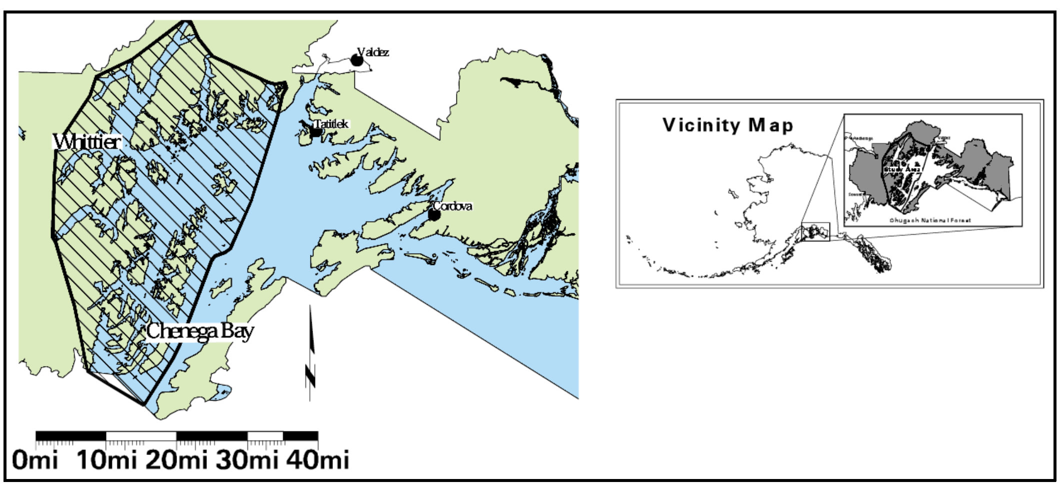

Fig. 1. ***Location of study area in Prince William Sound, Alaska.***

METHODS

Human activity in the western Sound is strongly water based. People participating in upland activities generally access upland sites via the water. The greatest potential for disturbance to injured species is also most likely to be from water-based activities. For these reasons, our project focused entirely on water-based human uses. We divided water-based activities into 5 user groups: kayaks, charter boats, cruise ships and Alaska State ferries, commercial fishing, and (other) recreational motor boats. Because the activities and movements of these different user groups are distinct, and would presumably have different potentials to disturb wildlife, distribution use patterns were developed independently for each group. To establish existing use patterns of different user groups in the western Sound, we collected the most recent data available for analysis. Because this project was initiated in January, 1998, the largest segments of our data are based on use levels in 1997 and 1996. Some additional data were collected in 1998, primarily for the cruise ship and Alaska State ferry user group. Only data for the months of May through September were considered, because most user groups were generally inactive in the western Sound during the remaining months.

Whittier Harbor. Daily records from the Whittier Harbor were used to determine the number and type of boats and their temporal use patterns for recreation, commercial fishing, and some charter boats. In 1997, the harbor staff kept records of individual boats docked in the harbor at 0600 every day. A record of every boat present in the harbor was entered into a computerized system by vessel registration number, name, and slip number. The harbor staff, and other local experts, identified the primary use and class of each vessel. Some vessels, such as commercial fishing vessels, were also classified by their US Coast Guard number. These data were entered into a Microsoft™ Access database.

By searching the Access database for missing dates for individual vessels, we determined which boats were out of the harbor for each day. Boats that were out of the harbor for up to 14 days were assumed to be on a trip in the western Sound. Boats absent longer than 14 days were assumed to have been pulled from the water or to have left for another harbor destination (e.g., Seward, Valdez, Cordova). To determine the number of boats making day trips from the harbor, these data were examined for changes in slip numbers that did not correspond to gaps in the sequence of dates. This process for determining day trips worked for those boats that were assigned a different slip each time they entered the harbor. These harbor users represent slightly less than 50% of the records from the Whittier Harbor data. We applied the frequency and timing of day trips calculated for the transient slip holders to harbor users who have permanent slips to describe the frequency of day trips for these users.

Kayaks. Kayak data were compiled primarily from daily records of 2 of the 3 water taxi operators who transported kayakers to destinations at the beginning and/or end of their trips in 1997. These data described the number of kayakers in each group, the date, whether the kayakers were picked-up or dropped off, and the location. From these data we determined the number of kayakers in a group, point of origination, destination, and length of trip. Kayakers who only used a water taxi for 1 direction of their trip were assumed to have come directly from, or returned to, Whittier to complete their trip. To estimate the number of kayakers who did not use a water taxi service for any portion of their trip, we sampled the number of kayaks transported into Whittier on the Whittier-Portage train, and identified which groups were being met by charter operators. During the months of June, July, and August, 1998, a stratified, observer-selected sample was taken of the number of kayaks carried on trains arriving in Whittier. Each scheduled train, according to its arrival time and day of the week, was met once a month.

Once these data were summarized to show destination and pickup points for kayak groups around the western Sound, we consulted with local experts to develop trip routes for the individual groups (e.g., P. Twardock, Alaska Pacific University, personal communication). Based on these recommendations and on the assumption that kayakers generally paddle an average of 16 km/day, probable trip routes were developed for every group of kayakers in the database. A total of 146 unique trips were developed. Trip routes for 192 kayaks that did not use guide or charter services were assumed to be roundtrips from Whittier. Because the average duration of all trips was 5.5 days, we allocated the majority of these trips to areas within a 3-day paddle from Whittier (i.e., 50 km).

Charter Boats. The charter boat user group included water taxi operators, sport fishing charters, and small overnight charter boats. The same data used to determine origins and destinations for kayakers were used to establish trips for water taxi operators. Each drop off or pick up point identified in the records became the destination for a trip from Whittier. Descriptions of use patterns of other kinds of charter boats in the western Sound were based on information from charter operators in combination with data from the Whittier Harbor records. Sport fishing locations in the western Sound used during each summer month were also identified. The number of trips made by sport fishing charter boats out of the harbor were used to establish the frequency of use of each fishing location for each month. Because distribution and frequency of trips for this user group were based on trips from Whittier to specific destinations, each destination was recorded separately as though it was a specific trip from Whittier. This overestimated the total number of trips for the vessels considered because more than 1 destination may have actually been visited on a specific trip. This overestimation was assumed to compensate for the fact that only 2 of several sightseeing charter vessels were used in the calculations.

The use of each route between Whittier and the destination point was doubled to represent that a charter boat was assumed to return to Whittier once it reached its destination.

Cruise Ships and Alaska State Ferries. This user group included vessels in the Alaska Marine Highway ferry system (ferries), 3 companies that operated day-cruises out of Whittier, large cruise ships (e.g., Princess and Holland lines), and smaller overnight cruises that followed consistent routes and schedules in the western Sound. Routes, number of vessels, and schedules for day-cruises and ferries were based on information from 1998. Trip frequencies and routes for the overnight cruise ships, both large and small, were based on information from 1997. Trip routes were based largely on information provided by members of the Alaska Visitors Association (AVA) (P. McNees, AVA, personal communication). AVA members drew their vessel routes for day cruises and small overnight cruise ships on maps of the study area. The 3 day-cruise companies provided information on the number of days per week that the vessels operated and the length of season. Schedules for the large cruise ships were based on docking records for Valdez and Seward in 1997. Adjustments were not made for cancellations that may have been caused by inclement weather or mechanical problems. The frequency of occurrence of an individual vessel was doubled along any portion of a route that required a vessel to return on the same route. For example, a day cruise ship that made daily round trips between Valdez and Whittier was assumed to travel along the route twice to represent each leg of the round trip.

Commercial Fishing. The Alaska Department of Fish and Game (ADF&G) commercial fishing districts and permit records for 1996 were used to determine the frequency and extent of commercial fishing use in the study area (Johnson and Merritt 1996). Permit records for 1996 were used because we felt that the 1996 records would be more representative of the 1998 pink salmon fishery (the 2 year life cycle of pink salmon make data from even-year fisheries more similar than comparing even to odd-year data.). Only commercial salmon fisheries were considered in our analysis of distribution. Most other major fisheries in the western Sound occurred outside of our May–September study period. Permit records were used to establish the number of boats fishing in each subdistrict for each opening. These data were then compiled for each month. Travel routes and frequency of use along the routes were developed based on harbor data. We assumed that most fishing vessels would travel a direct route between the harbor and the fishing location. Vessel traffic along the routes was doubled to account for round trip traffic. Similarly, the Chenega IRA Council provided records of the number of fishing vessels docked or moored near the village. These vessels were assumed to travel to and from the subdistricts near Chenega Bay at a frequency similar to the trips out of Whittier Harbor. We placed less emphasis on the commercial fishing activities in the study area because we assumed that the industry is unlikely to change as a result of the Whittier Road opening. Unlike the majority of other users in the Sound, ADF&G regulates this industry so there is an avenue to address potential indirect effects.

Recreational Motor Boats. This user group included all motorized recreational boats and sailboats. The Whittier Harbor data were used to calculate the number of vessels out of the harbor and the duration of trips taken by individual boats. However, we did not have a direct method for determining where the boats traveled once they left Whittier. To characterize the destinations of this user group, a questionnaire was sent in February, 1998 to 350 slip holders at the Whittier Harbor. The questionnaire requested information about personal recreation use patterns in 1997. Information received included types of recreation vessels used, number of trips made in the Sound, destinations and trip purpose, numbers of other boats seen, and number of boats respondents were willing to see. We assumed that these responses were representative of all Whittier Harbor recreational boaters and extrapolated the frequency of use to correspond to the number of boat trips known to have occurred in each month based on the harbor data. Rather than extrapolate trips to specific sites, we used the user responses to determine what percentage of the Whittier Harbor data should be assigned to a particular region of the western Sound. For example, in July the user survey data showed that 27 of 279 trips occurred around Knight Island, and the harbor data analysis indicated that 675 multi-day trips occurred in July, so we assigned approximately 67 trips (10%) to the Knight Island area.

To estimate recreational boat use associated with Chenega Bay and the nearby hatchery, the Chenega Bay IRA Council recorded visitor use by recreational boaters to the village harbor for July–September, 1998. The Armin F. Koernig (AFK) Fish hatchery staff also provided records of their recreational use for June–September, 1998. For safety, hatchery managers required their staff to record the destination, boat, and the expected return time for any trip out of the hatchery. These data were then used to estimate recreational boat use associated with the other 3 hatcheries in the study area.

Developing Current Use Patterns. The extent of human use in the western Sound was described through a geographic information system (GIS)-based analysis of the distribution of water craft in association with 435 preferred destinations (e.g., recreational and commercial fishing areas, mooring buoys, camping sites, recreation cabins). Cell-based modeling using the GRID feature of the Arc/Info GIS formed the basis of our approach to evaluate human-use patterns in the western Sound (Environmental Systems Research Institute, Inc.1994). All processes used a 60 m cell size. Weighted distance functions were used to describe areas that were available to and used by vessel operators. Separate grids of the water portion of the western Sound were created for the analysis of dispersion of vessels in each class. For each vessel class a source grid was created which represented trip initiation points or sources (i.e. Whittier or Chenega). The COSTDISTANCE function was used to determine the minimum accumulative-travel cost from the source through each cell on the grid to a specific destination on the grid. This function allowed for the control of factors that influenced movement of water vessels. Finally, the least-accumulative cost to each of the neighbors of the cell just removed was determined. This process was repeated until all cells on the grid were assigned an accumulative cost to reach a specific destination.

Corresponding cost grids were established for each vessel class. The cost grids assigned an impedance value to each cell that reflected choices involved in moving through any particular cell (e.g., avoidance of open water, avoidance of navigation risks). The value of each cell in the cost grid represented the ease of a particular vessel type passing through the cell (Environmental Systems Research Institute, Inc 1994:253). Each cell location was given a weight proportional to the relative cost incurred by a vessel passing through a cell. Arc/Info GRID functions were then used to create grids that represented the most efficient dispersion of water craft by vessel class the western Sound. These dispersion grids for each vessel class were combined through map algebra to describe density of use in the western Sound, by use class. The dispersion and density grids were then combined with grids of sensitive areas for injured species to identify those areas where conflict may occur. These methods were used for all groups except the cruise ship and ferries user group. These vessels largely follow a predetermined route that could be assigned a numerical count of vessels.

<u>Calculation of the Mean Level of Occurrence</u>. With the exception of the cruise ships and State ferry user group, all analysis area maps of the mean occurrence of human use were generated in the same fashion. Analysis areas were geographically defined bays, or a collection of small adjacent bays. The Arc/Info CORRIDOR function defined the "most efficient" travel corridor from a source to a specific destination. The numbers of vessels projected to use a specific corridor during a specific month were entered into each cell within that corridor. All of the corridors used during a specific month were combined through map algebra to represent the seasonal cumulative use pattern for that user group. The resulting "raw" data number in each cell represented the number of times a vessel in a particular use class occurred in that cell during the period of interest. This process was not designed to present information at the resolution of individual cells. Rather, it was more appropriate to calculate the mean value of all of the cells in an analysis area for analysis and presentation. For the cruises and ferries group, a total occurrence number for vessels was calculated for each analysis area by month and assigned to all cells in the analysis area.

Evaluation of Use Patterns. To evaluate the projected distribution of vessels in each user group throughout the western Sound, aerial surveys were conducted during summer months in 1998 to record the density of water vessel use on weekends and weekdays. A stratified random sample of the 40 analysis areas in the study area resulted in 13 analysis areas selected for aerial surveys. Our goal was to conduct a survey during 1 weekday and 1 weekend in each area during each month. Random pairs of dates were selected for the surveys from the first 3 weeks of each summer month, leaving the last week and weekend of each month as back-up survey dates. Aerial surveys were flown at 150 meter elevation in either a Cessna 180 or 206. We completely surveyed each sample area. The location and type of vessel observed in each analysis area were recorded. All aerial survey data were compared to projected densities of user groups through regression analyses to determine if predicted densities compared to observed number of vessels from the aerial surveys. To test the ability of an observer in an airplane to see and identify kayaks on the water, 3 flights were coordinated with boat-based surveys. The boat-based observers began surveying the sample area by paralleling the shoreline and recording all kayaks and motorized vessels observed. The corresponding aerial survey was conducted in the same fashion as other surveys.

Resource Distribution. To compare human use levels near concentrations of injured species, distribution maps of concentration areas were created for 3 species. The 3 injured resources were used as examples to demonstrate how information on distribution of human use was relevant to the recovery of different species. Harbor seals (*Phoca vitulina)*, pigeon guillemots (*Cepphus columba*), and cutthroat trout (*Oncorhynchus clarki*) were selected to represent 3 classes of animal species injured as a result of the spill. To understand how human activities may affect injured species and other wildlife populations in the western Sound, we examined studies published in the scientific literature pertaining to human disturbance of wildlife. Our specific goal for this literature review was to summarize information that could be used by managers to understand the effects of human activity near wildlife populations. Information that identified distances at which disturbance occurred and that identified the consequences of the disturbance was of particular interest. We focused our search on taxa and forms of disturbance that may be relevant to current or future conditions in the western Sound.

RESULTS

There were 727 individual vessels that docked in the Whittier Harbor during the summer months of 1997. Nearly 6800 trips were estimated to have originated from the harbor. The description of current use patterns for kayaks was based on 1368 occurrences of kayaks over 146 routes. Sixty-nine (69) percent of the kayaks used charter services 1 way on their trip, while 15% were dropped off and picked up by a charter service, and 16%

paddled their entire trip. Charter boat operators based in Whittier commonly used 76 destinations. Most of these destinations were used by water taxi charter services that transported kayakers to or from different parts of the study area. The distribution of existing use for charter boats was based on 692 individual trips; 447 of these were for water taxi operators, 245 were for other charter operations – primarily sport fishing or sightseeing. Three companies operated day cruises out of Whittier in 1997 and 1998. Large cruise ships (e.g., Princess and Holland lines) made trips through the western Sound 112 times during the summer of 1997. Voyages of the Alaska State ferries were also incorporated into this user group. During 1996, 19 commercial fishing subdivisions were fished in the western Sound. Nine hundred (900) trips by commercial fishing vessels were estimated to have originated from the Whittier Harbor to these fishing areas; 50 originated from the Chenega Bay Harbor. There were 341 recreational motorboats and sailboats that docked in the Whittier harbor in 1997. These boats made 1145 multi-day trips from the harbor, with an additional 1612 trips that were estimated at less than 24 hrs. During June, July, and August, 1998, 36 recreation boats used the Chenega Bay village harbor.

Two forms of distribution maps were developed based on the user group data. grid-based distribution maps generated directly from the raw data were developed for each user group for each of the 5 months. The focus of these human use distribution maps was to represent where people were going in the study area, and to represent how the levels of use compared among areas (Fig. 2). Although these raw distribution maps are useful, they imply more specificity than is warranted because they were tied to the 435 shoreline destinations. To reduce the perception of shoreline specificity, distribution maps were created based on the mean occurrence of use for each group across analysis areas (Fig. 3).

The distribution maps for the kayak and recreational boats user groups were evaluated using aerial and boat-based surveys. Seventeen (17) aerial surveys were flown from June through September to provide information necessary to evaluate patterns of use developed for water vessels in the western Sound. Two hundred (200) recreational motor boats and 228 kayaks were observed during the surveys. Comparisons of the relative number of kayaks and recreational motor boats estimated to occur in the western Sound through our GIS analyses with the results of the aerial surveys revealed strong correlations ($R^2 = 0.71$ for kayaks, and $R^2 = 0.80$ for recreational motor boats).

Locations were obtained for 36 harbor seal haulout sites, 131 pigeon guillemot nesting areas, and 6 watersheds having cutthroat trout populations. To understand the relationship of population distributions of resources relative to estimated levels of human use, the mean level of human use by analysis area was compared to the population distribution. One advantage of developing distribution data for each user group individually is the ability to consider a specific user group that may have more relevance to a particular species. For example, the kayak user group probably presents little risk of sport fishing disturbance to cutthroat trout populations, but perhaps are the greatest concern for nesting pigeon guillemots which often have nests near campsites used by kayakers. To identify how existing human use of the Sound relates to each of the 3 species, we plotted the mean occurrence of use for the user group(s) most likely to affect the species with the species' concentration areas during their most vulnerable period (e.g., nesting for pigeon guillemots) (Fig. 4).

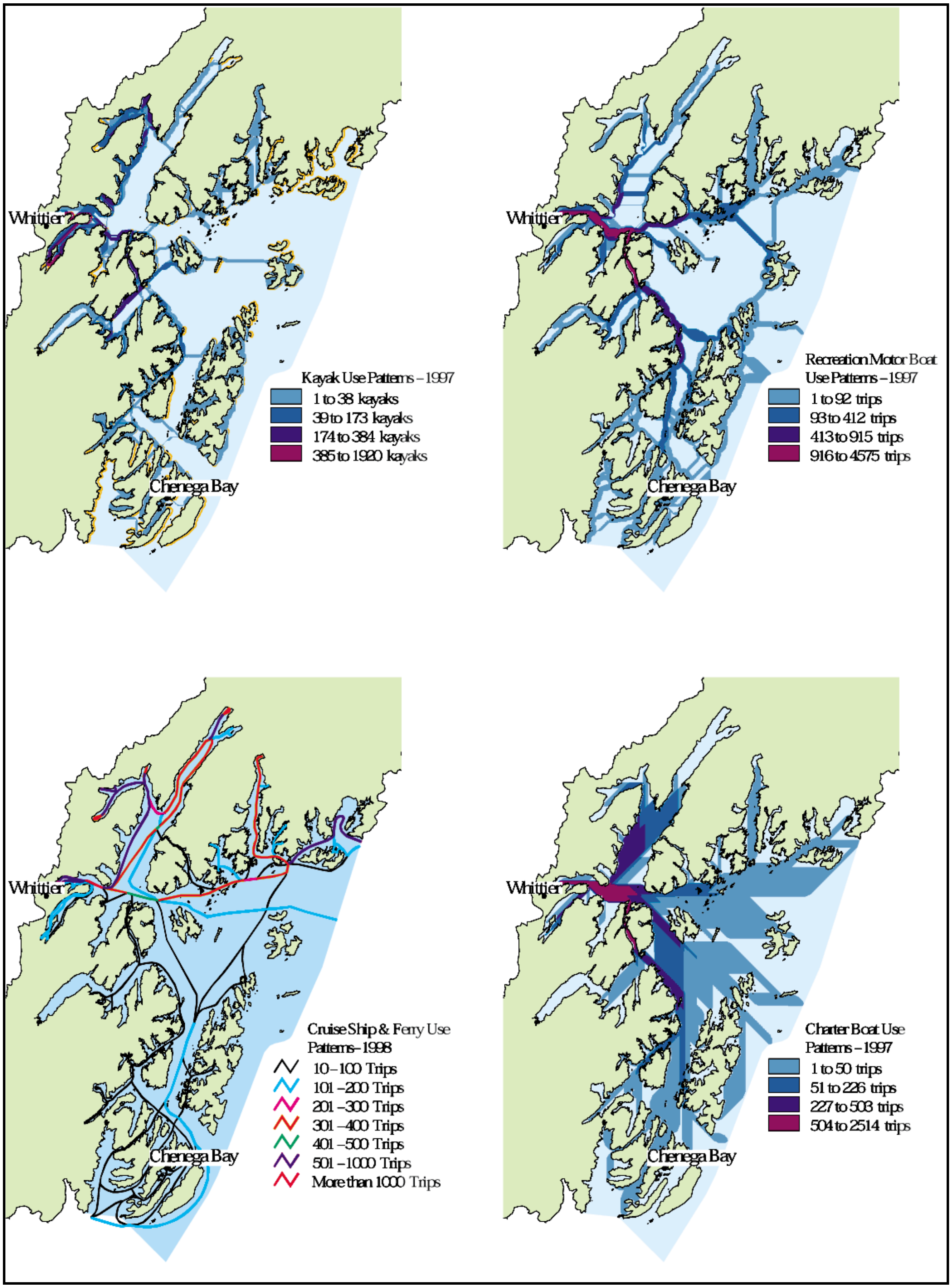

Fig. 2. Baseline use patterns for water vessels in western Prince William Sound, Alaska, May-September.

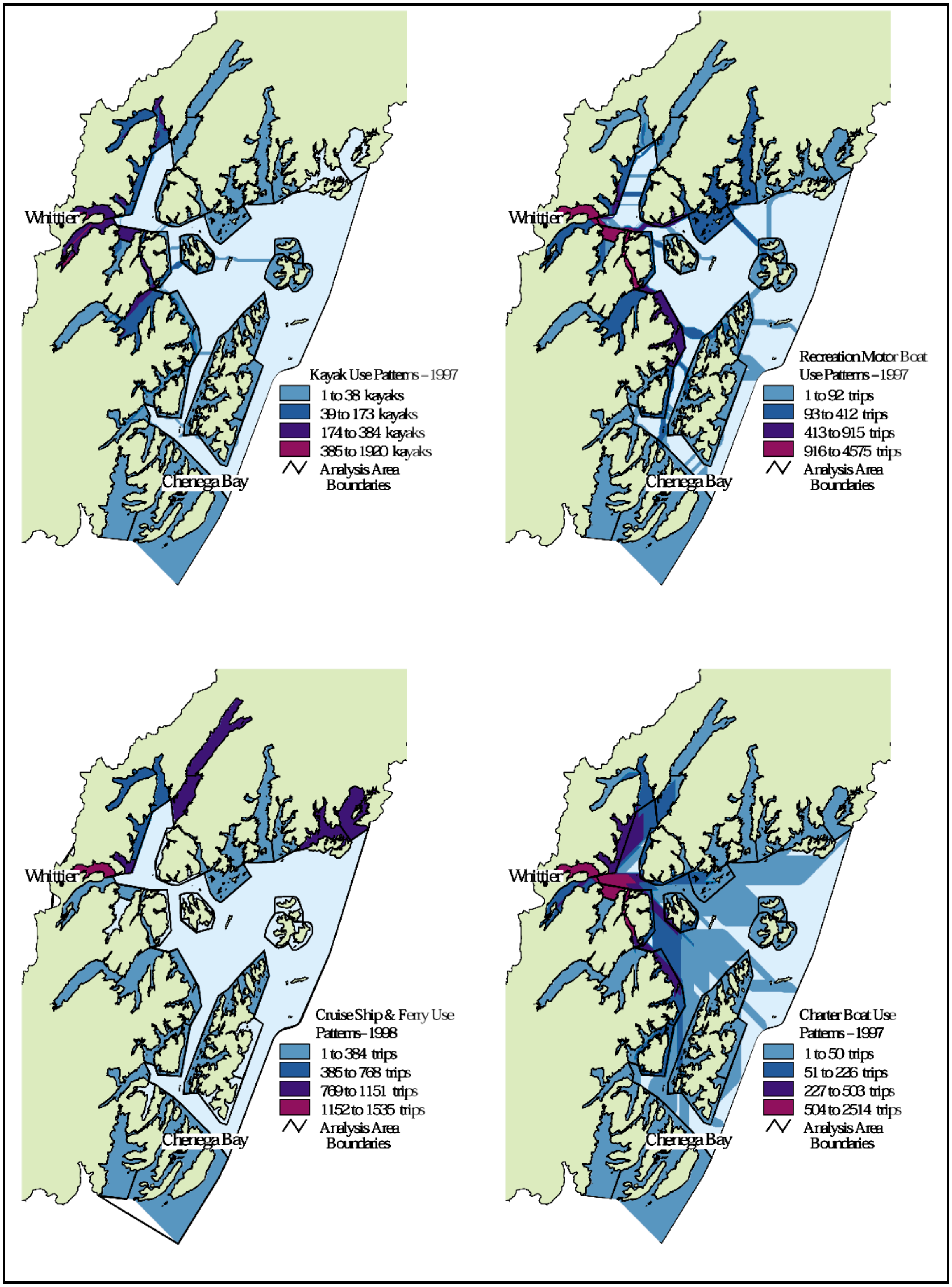

Fig. 3. ***Mean number of water vessels present by analysis area in western Prince William Sound, Alaska, May-September.***

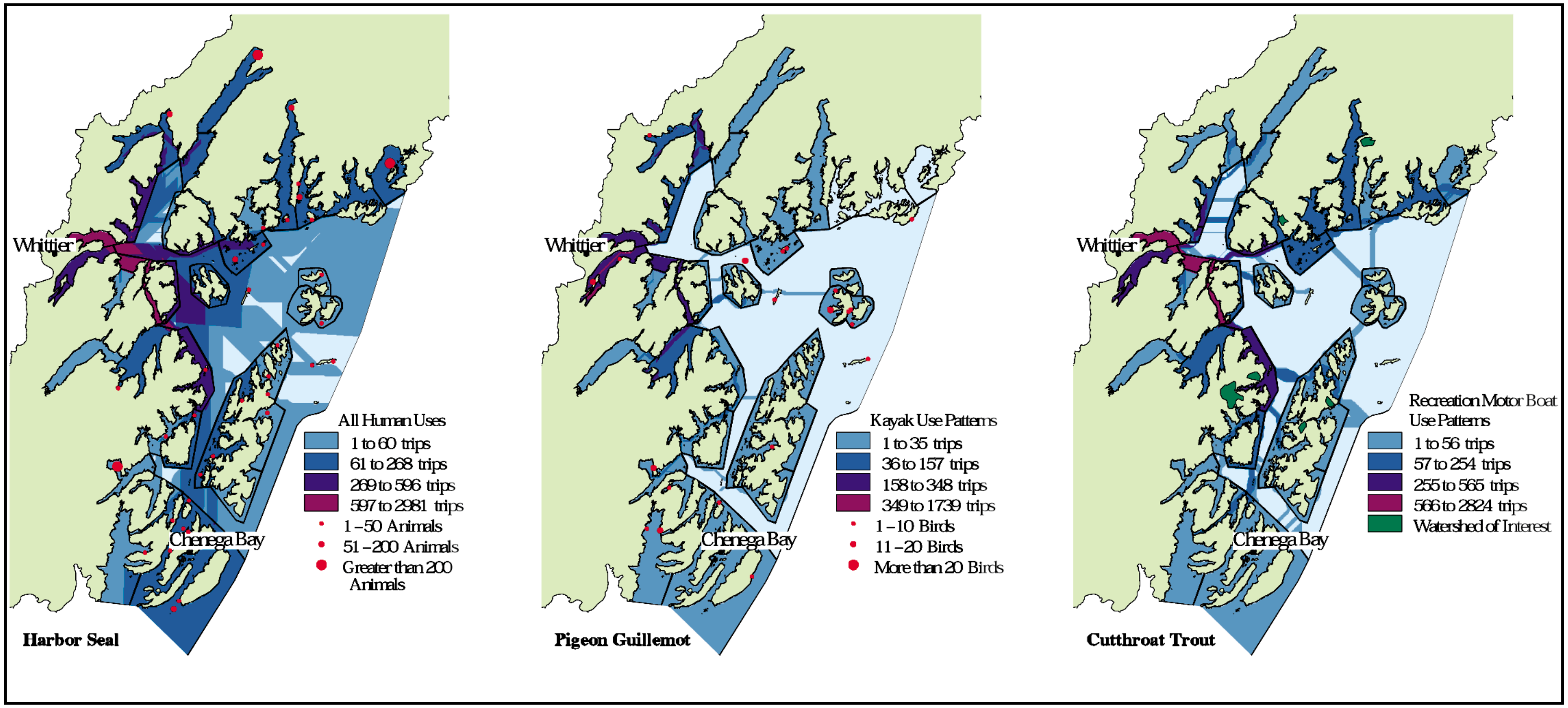

Fig. 4. ***Relationship of human use patterns with distribution of species of interest in western Prince William Sound, Alaska.***

DISCUSSION

Natural resource management has become increasingly multi-jurisdictional and interdisciplinary over the last quarter century, and, as a result, is extremely complex. Diverse groups, representing a wide spectrum of interests are becoming increasingly involved in influencing State and Federal agencies' management of the natural lands, oceans, and resources. Through the 1990s out-of-state tourism in Alaska increased approximately 87% for the summer months (Alaska Visitors Association 1999). Many businesses market Alaska's scenery and wildlife to their customers. The challenge for managers in the Sound is to provide opportunities for both commercial and recreational use of the environment, without causing irreparable harm to wildlife resources. This is particularly important for resources, such as those injured by the spill, that may not be resilient to changes in their environment.

With changes in human use expected as a result of the opening of the road to Whittier, it is important to have some understanding of use patterns prior to these changes. Ideally an on-site assessment of both human and biological activity would be completed around each bay or island in the Sound. The Sound's vast size makes that task impossible. Our approach was to gather data on existing use and to graphically represent the information. The GIS aspect of this project provides a tool that may be used to create a variety of images to convey information, and is dependent upon the question that is asked. For this compilation of information to be a useful tool, managers need to understand its capabilities and limitations. We asked resource managers for questions that they would like to have answered about the baseline use level of human activities in the Sound, and queried our data to determine if we could provide insight.

<u>Potential Products</u>. The following represent questions asked by resource managers for the Sound: "what is the cumulative human use level in the Sound?", "*how does use vary over time?*",*"which areas are subject to competition/conflict between user groups?"* and finally, *"how can these data be used to protect injured resources?*". The GIS capabilities of our project would allow a manager to look at any combination of the 5 user groups to understand the cumulative human use of an area relative to the rest of the western Sound. To understand how use varies over time, the GIS data can be compiled monthly for May through September by analysis areas or for the entire study area. A daily record of use could be extracted for boats in the Whittier harbor and for kayakers based on the water taxi data. A quick analysis of the harbor data indicated that the peak use for recreational motor boats in 1997 occurred on 16 July with approximately 240 boats out in the Sound, and that use levels were significantly higher on weekends than on weekdays. Our compilation of data were less effective at answering the questions on the competition between user groups in the Sound. Although it is possible to use these data to show the

level of use of each user group in a particular analysis area, comparisons between user groups are complicated by the independent methods used to create each user group's distribution. For example, consider human use of the tidewater glacier bay nearest to Whittier, which is popular for kayakers, recreation motor boat use and is visited by day cruise and small overnight cruise ships. The predictable schedules and routes of the cruise ship user group provide more accurate estimates than techniques for the other user groups. The data for origin and destinations of kayakers are also strong; however, we had to make assumptions about where kayakers went during their trips. For the recreational motor boats, we were unable to estimate the number of boats that would have made a side trip into the bay. Therefore, we feel that this user group is probably under-represented in many of the analysis areas close to Whittier. Similarly, we could not estimate how commercial fishing vessels may be used outside of their fishing periods.

To answer the last question *"how can these data be used to protect injured resources?"* will depend on the problem to be addressed by the resource manager. The combination of user group patterns, overlaid with species distribution, should provide valuable information in designing research or monitoring programs which take human activities into account (Fig. 4). A more direct application could be through the consideration of human use patterns in making resource use decisions that could direct activities away from important wildlife areas. Although understanding the consequences of disturbance is difficult, and depends on a variety of factors specific to the situation, management decisions can be made to protect species by understanding the human use of the area, and the potential consequences of that use.

A review of the literature on the effects of the types of human activities likely to occur in the Sound clearly established that many activities near wildlife cause disturbance to individual animals (Murphy et al. 1999). However, understanding the effects of human-caused disturbance to wildlife is challenging. Activities without immediate effects may cause cumulative impacts that are not apparent until long after the disturbance, or until the disturbance has continued for some time. Conversely, disturbances that cause immediate effects may not necessarily result in cumulative effects over time (Riffel et al. 1996). Unlike activities that physically alter a species' habitat, disturbance allows the habitat to remain physically intact, but reduces its ability to support wildlife (Goss-Custard and Durell 1990). Whether or not disturbance will cause a change in the population of a particular species depends on a variety of factors that are specific to each situation. Factors that influence the vulnerability of a species to disturbance include seasonal factors and the biological activity occurring at that time, group size, species size, feeding location, and the general behavior of the species, such as its intrinsic wariness and flight response (Burger et al. 1995). Similarly, the frequency and form of activity will influence the potential for disturbance.

For resource managers interested in understanding the potential effects of human activity on wildlife in Prince William Sound, it may be useful to ask the question, "who is most disturbed, by whom, where and when?" (Davidson and Rothwell 1993). In reviewing the literature on human disturbance to marine mammals and birds, it is apparent that there are inter- and intra-specific variations in how animals respond to human activity. Because there is so much variation in the response of different species, and individuals, to different forms of human activities, managers must carefully consider the specific situation being addressed. While it is inappropriate to make generalizations about how a particular activity will affect wildlife, there are some disturbance patterns that warrant consideration. For instance, fast-moving and erratic motion tends to be consistently more disturbing to a wide range of wildlife species than slow, steady motion (e.g., Burger 1981, Smit and Visser 1993). Aircraft activity is often very disturbing to many species of wildlife, and helicopters elicit an even greater response than fixed-winged aircraft (e.g., Mehlum and Bakken 1994, Smit and Visser 1993). Juvenile animals are often more vulnerable to disturbance than are adults (e.g., Goss-Custard and Durell 1990).

Many activities occurring in the Sound today, and probably for the foreseeable future, may not show immediate impacts to wildlife. Many people may think that the disturbance they cause is inconsequential and will not directly harm the animals. While they may be correct, the combined effects of disturbance may often be significant or they may be disturbing an animal at a crucial time period, which could lead to the eventual loss of their offspring or other serious consequences (e.g., Belanger and Bedard 1990). In spite of the complexities of establishing cause and effect relationships, managers can take steps to reduce potential effects by understanding how both people, and wildlife, use an area. Many articles that presented approaches for managing people to reduce the effects of disturbance on wildlife identified the same range of protective measures. Potential protective measures included: (1) public education, (2) enforcement of existing laws and regulations, (3) exclusion of specific forms of transportation (ranging from cars to jet skis), (4) exclusion of dogs and the removal of other introduced predators, (5) excluding people from large or small areas, (6) redirecting public access, and (7) habitat manipulation (e.g., Pienkowski 1993, Velarde and Anderson 1994). Because land management jurisdiction in the Sound is so complex, public education may be one of the strongest tools available to managers.

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