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BEHAVIOR OF PACIFIC BLACK BRANT AND OTHER GEESE IN RESPONSE TO AIRCRAFT DISTURBANCES AND OTHER DISTURBANCES AT IZEMBEK LAGOON, ALASKA

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ABSTRACT

From 18 September to 31 October 1986 studies of Pacific black brant (Branta bernicla nigricans), Canada (Branta canadensis), and emperor (Chen canagica) geese were conducted at Izembek Lagoon, Alaska. The distribution of brant, Canada and emperor geese overlapped, but each species had preferred habitats within the lagoon. Brant were found in areas with the largest eelgrass (Zostera marina) beds, Canada geese preferred areas near their alternative food source on tundra habitat, and emperor geese used areas with extensive mudflats. Tide and date had the greatest influence on the distribution of geese within specific study areas. At study areas of highest use, the number of brant increased and moved closer to shore during flooding tides, while Canada geese decreased in number due to use of tundra habitat. Seasonal shifts in the distribution of brant and Canada geese occurred in mid-October.

A total of 2027 potential disturbance events was recorded for all geese during the study period. Small helicopter and single-engine aircraft were the most numerous potential human-induced experimental and incidental disturbance events, respectively. Bald eagles (Haliaeetus leucocephalus) were the most frequent natural and potential disturbance cause for brant, Canada and emperor geese. Based on the proportion of brant flocks exhibiting disturbance-related behavior, small helicopters appeared to cause the greatest disturbance among the aircraft types tested. A decrease in altitude in all aircraft elicited a greater proportion of alert, mass or flight behaviors. The percentage of brant and Canada geese exhibiting flight in response to eagles was the highest among all disturbance causes. The behavioral response of geese to potential disturbance events appears to be independent of flock size and wind direction, although brant were more responsive to disturbance at high tides.

INTRODUCTION

Black brant stage in spring (April - May) and fall (September - November) at Izembek Lagoon near the western end of the Alaska Peninsula. Izembek contains the most extensive eelgrass beds in the world (McRoy 1970). This submergent marine seagrass provides brant nutritional and energetic food necessary for building fat reserves that will be depleted during nesting, incubation, brood rearing and migration (Fredrickson and Derksen unpubl. data).

Disturbance of brant, Canada geese and emperor geese by helicopter traffic associated with Outer Continental Shelf (OCS) petroleum exploration 'was observed at Izembek National Wildlife Refuge in fall 1984 (J. Sarvis and C. Dau pers. comm.). Petroleum exploration along the North Aleutian Shelf, St. George and Navarin basins is expected to occur and the existing 10,000 ft runway at Cold Bay may be used for industry support facilities. The behavior of geese in response to fixed-wing and helicopter aircraft must be quantified before the impact of these stimuli can be evaluated. We examined the response of geese to aircraft type (e.g. single vs multi-engine), altitude, and distance to determine if a sensitivity threshold exits and can be used for management recommendations (e.g. flight corridors, minimum altitude).

The objectives of this research are to: 1) determine the effect of aircraft overflights and other human activity on the behavior, distribution and habitat use of brant and other geese at Izembek Lagoon, and 2) evaluate the expected impact of disturbance on the energetic of migration and reproduction of geese.

Specific tasks to fulfill these objectives include: 1) quantify the behavioral response of geese to disturbance, 2) identify the spatial and temporal. distribution pattern of geese, 3) determine the daily time and activity budgets of undisturbed geese, 4) estimate quantity and quality of food resources, 5) develop a predictive model of energetic cost and potential habitat loss from disturbance.

Here we summarize a portion of the information collected in fall 1986. We discuss distribution of brant and other geese, behavioral responses to incidental and experimental aircraft overflights and weather data. Time and activity budgets for brant and habitat use of brant are summarized and will be examined in detail in Later reports.

METHODS

Study Area

The study was conducted at Izembek Lagoon, Alaska (163°00′ W, 55°15′ N) on the north side of the Alaska Peninsula (Figure 1). The lagoon has extensive areas of mud and sand exposed at low tide and barrier islands that partially protect the lagoon from the Bering Sea. Approximately 78% of its 218 km^2 area is intertidal, of which 68% is vegetated by eelgrass (Barsdate et al. 1974). The tides are both semidiurnal and mixed semidiurnal with a mean range of 0.98 m.

Geese were observed from 18 September to 31 October from seven permanent blinds (Figure 2) and four other unsheltered areas along the shoreline of Izembek Lagoon. Two of the permanent blinds, Halfway Point (HP) and Grant Point West (GW), were near locations used in 1985. The site within the instrument flight corridor was moved from the 1985 location at Outer Marker to Round Island: Round Island East (RE) and Round Island West (RW). Additional blinds were placed at South Applegate Cove (AC), Banding Island (BI), and Norma Bay (NB) (Figure 2). Observation points without blinds were at North Applegate Cove (NA), Outer Marker (OM), Quarter Point (QP), and Grant Point East (GE) (see Ward et al. 1986 for locations).

We made observations from the blinds 1-5 days per week for up to 12 hours per day. Time and date of occupancy varied for each blind site depending on weather, remoteness of blinds, use of the area by geese, and timing of experimental overflights. Five of the 7 blinds were constructed of camouflaged plywood with plexiglass windows on all sides and were large enough for two observers. The remaining two blinds were smaller and did not have plexiglass windows.

The field of view at each blind defined the study area. Each study area was further divided into subareas which usually represented homogeneous habitat types (e.g. bays, tidal channels, eelgrass beds, and mudflats). If a homogeneous habitat type extended beyond a distance of approximately 0.75 mi (distances varied and were influenced by the height of the blind and observers ability to see and accurately identify species, age and numbers of geese) or was too extensive to determine locations of flocks, it was divided into near and far subareas. The near subareas comprised the primary study area.

Subareas were delineated by bouys, natural landmarks, and channels. Latitude and longitude of the bouys were calculated by LORAN/GNS instruments operated from a fixed wing aircraft. The number of subareas varied at each site: 9 at BI and RW, 10 at AC, GW, and RE, 12 at NB, and 13 at HP.

Environmental Conditions

Temperature, precipitations wind speed and directions cloud cover, ceilings and barometric pressure were measured at the National Oceanic and Atmospheric Administration (NOAA) facility at Cold Bay approximately 7.5 km from Izembek Lagoon. Local environmental conditions (precipitation, wind speed and direction, cloud cover, visibility, and tide level) were recorded at each study site every hour during the observation period. Tide levels were measured at each study area with a PVC pipe marked in 0.5 ft increments. To compare the influence of tide among study areas, time lag of high and low water and water height differences at each study site were calculated from tide readings measured on calm days.

Distribution

Two methods were used to determine number and distribution of geese: aerial surveys of the entire lagoon and counts at each blind.

Aerial Surveys.- Personnel from the Office of Migratory Birds and Izembek National Wildlife Refuge (Izembek NWR) flew five aerial surveys during October to determine numbers and distribution of geese in Izembek Lagoon (Table 1). The altitude and course flown varied among surveys and pilots. The survey on 7 October was incomplete due to inclement weather and was continued on 8 October. Counts of flocks of geese were made in each of five zones within Izembek Lagoon (Figures 3-5). Zones were determined by their size and ease of positioning flocks of geese relative to landmarks and channels. Only surveys on 3 and 20 October are compared in this report, because they were completed in one day during high tide.

Ground Counts.- Techniques to count geese from blinds were similar to those used in 1985 (Ward et al. 1986). Geese were counted in all subareas upon the observers arrival at a blind and each hour during the observation period. Only counts of geese made in primary study areas were used to determine distribution patterns presented in this report. Counts outside the primary study areas were not as accurate and relatively less frequent. For each hourly count the following information was recorded: species, number of geese in each subarea, tide, time of day, and if a disturbance had occurred within the hour. Bouys which marked subarea boundaries enabled accurate location and positioning of flocks. Tide, date (early versus late in the study period), and time of day were analyzed by 1-way ANOVA and weather by T TEST to determine their- effect on distribution of geese ($SPSS^X$ 1986).

Response to Disturbance

Techniques for collecting data on incidental disturbance events were similar to those used in 1985 (Ward et al. 1986). Techniques during experimental overflights were modified to produce a higher degree of accuracy.

Categories of disturbance and behavioral -response in 1986 remained the same as in 1985 (see Ward et al. 1986). For each potential disturbance event the following information was recorded: 1) cause of disturbance, 2) distance of the flock to the stimulus when the flock first reacted, or if there was no reaction, then the distance of the closest approach, 3) altitude of aircraft, 4) social facilitation, 5) tide, 6) wind direction in relation to the flock and stimulus, 7) species, 8) flock size, 9) dominant behavior of the flock prior to the disturbance, 10) distance from the flock to the shore, 11) direction of the stimulus in relation to the flock (toward or lateral), 12) percent of the flock exhibiting each behavioral response category, 13) duration of' flight if it occurred, and 14) duration of the response. Flight duration was defined as the time required for 50% of the flock to land, and duration of the response was the time required for 90% of the birds to return to a normal (pre-disturbance) behavior. Cassette tape recorders enabled us to describe the behavioral response and duration for several flocks during a single disturbance event. VHF radios were used to monitor communications between incidental aircraft in the vicinity and Cold Bay flight service. 'Knowledge of approaching aircraft and information on altitude, direction of travel, and weather conditions were gathered from conversations between pilots and Cold Bay radio.

Six categories and 8 types of aircraft were used for experimental overflights: single engine (Arctic tern, Cessna 185 , and Cessna 206), light twin engine (Piper navaho), heavy twin (Hercules C-130), Grumman goose, De Haviland twin otter, small helicopter (Bell 206-B Jet Ranger), and large helicopter {Sikorsky HI-F-3). Experimental flights were conducted on 16 days from 26 September to 29 October. Each flight had established paths, altitudes and velocities. Most aircraft were flown along 10 standardized lines oriented to pass over all study sites and maximize efficient use of time (Figure 6). Other overflights did not follow the above lines but used other predetermined corridors (Figures 7-8). During a few cases unscheduled aircraft radioed their flight line to a blind prior to a pass and were not mapped. If multiple overflights for an aircraft were planned, altitude was gradually decreased for each successive pass. These flights were terminated when there was a substantial response by the geese.

Techniques were developed for experimental overflights to better estimate distances and chronology of response of geese. First, scale maps of each study site were drawn depicting all subareas, experimental flight lines, and way points of each flight line. To provide consistency of overflights latitude and longitude of each waypoint was previously calculated and relocated with LORAN/GNS instruments operated from an aircraft. Prior to an overflight, locations of flocks were marked on the map. During an overflight, the observer in the aircraft signaled the start, end, and each 0.1 mile increment of the line via VHF radio to the observer in the blind. Simultaneously, the observer on the ground recorded the response of the observed flocks on magnetic tape. This method enabled later reconstruction and mapping of aircraft position and flock behavior at any point along the flight path. The actual distance (aircraft to flock) as well as the lateral distance (perpendicular distance from the flock to the aircraft flight line) were measured directly from the map.

RESULTS AND DISCUSSION

Environmental Conditions

The fall of 1986 was considered one of the mildest in the past ten years (U.S. Department of Commerce 1986). Cyclonic storms and associated high winds typical of the Alaska Peninsula were at a minimum throughout the study period (18 September to 31 October). High winds hindered data collection on only two occasions. On 13, 14, and 17 October winds were from the NNE averaging 24.2, 26.2 and 23.9 mph, respectively. Only 3 blinds (AC, HP, and NB) were occupied on 13-14 October, because we were unable to access those requiring travel by boat. Observing geese during high winds was difficult and limited to within a short distance from the blind due to wave action. Mean wind speed during the study period was 15.6 mph. The dominant wind directions measured at the NOAA facility were from the north to northwest and south to southeast. Wind speed and direction varied at different study sites, but were generally consistent with the trends recorded by the NOAA.

Ambient temperatures were above average in 1986. From 18-30 September, mean daily temperatures fluctuated between 42° F and 55° F and between 40° F and 45° F from 1-5 October. Mean daily temperatures rose and reached a maximum of 520 F on 9 October, before returning to the low 40$s0 F and upper 30's° F on 14 October, where it remained, except for the low of 330 F on 18 October.

The frequency and amount of precipitation were below average during the study period. Measurable precipitation occurred on 1[illegible] of 44 days and totalled 8.23 in. During September measurable precipitation occurred on 13 days (7.37 in) compared to the mean of 20 days (3.8 in). During October measurable precipitation occurred on 19 days (15.1 in) versus a mean of 20 days (4.3 in). Although the amount of precipitation during September was twice the mean, 88% occurred before observations began. This frequent, sporadic, and light pattern of precipitation is normal for Cold Bay. It did not snow during the study period. Normally 3.3 in of snow falls during October.

Cloud cover, ceilings, and visibility were normal to above average. Average cloud cover from sunrise to sunset during the study period was 91% (approximately normal) and was less than 75% on only three occasions (26 September, 15 and 30 October). Ceilings throughout the study were usually between 2000-4000 ft and fell below 2000 ft on only four days. Visibility measured from the NOAA facility was consistently above 5 mi during daylight hours and often exceeded 15 mi. Fog was recorded on 14 of 44 days.

Population Assessment

Emperor and Canada"geese first arrived at Izembek Lagoon on 25 August, and brant were seen first on 30 August (Dau pers. comm.). By the second week of September, all three species were dispersed throughout the lagoon. On the first aerial survey (3 October), 93,200 brant, 18,850 Canada and 3,000 emperor geese were recorded (Figures 3-5). During the second survey (20 October), the number of brant (90,900) and emperor geese (2$800) remained about the same. However, numbers of Canada geese increased to 34,850 birds on 20 October. By 29 October, Canada geese had increased to 42,000 although brant and emperor geese decreased to 48,200 and 1,600, respectively. By 10 November all Canada and emperor geese had departed and only 5000-7000 brant remained.

Peak numbers of brant and emperor geese occurred between 3-20 October, and maximum numbers of Canada geese after 20 October. This pattern of asynchronous build-up between brant and Canada geese was also observed in 1985 (Ward et al. 1986). It should be noted that although Canada geese use both tidal and adjacent tundra areas, only those birds found intertidally were counted. Therefore, aerial. surveys probably underestimated the actual number of Canada geese. This was particularly true during high tides when Canada geese were most likely to use tundra habitats and early in the season when crowberry (Empetrum nigrum) and lingonberry (Vaccinium vitis-idea) was abundant (see tide section below).

Departure of brant from Izembek Lagoon in 1986 was early and asynchronous. Brant left in small flocks over several days unlike their normal exodus in very large groups over one or two days (Dau pers. comm.). Canada and emperor geese departed as in past years in small flocks over several days.

Distribution

Aerial surveys.- The pattern of use in the 5 zones of Izembek Lagoon was examined by calculating the proportion of geese observed in each zone during aerial surveys (Figures 3-5). To avoid potential biases from counts made at different tides only aerial surveys at high tides (3 and 20 October) are compared here. Several patterns are apparent: 1) not all zones are used equally by geese; 2) use of zones varied between species; 3) seasonal changes occurred for all three species.

Brant were found in all 5 zones with over half the population using zones 1 and 2 (Figure 3). Brant were least abundant in zone 5 (Moffet Lagoon). Brant showed some changes in distribution between surveys with an increase in zone 4 and a decrease in zone 3. This was also supported by observations made from study areas in the respective zones (Figure 9).

Canada geese were also found in all 5 zones but their pattern of use based on aerial surveys is not clear. Interpretation of counts within the zones was difficult because counts were ❑ade at high tide when more Canada geese were found on tundra habitat. In general, it appears that zone 5 was more important to Canada geese than brant (Figure 4). Canada geese were rarely found along barrier islands or spits, and t.ended to remain near the southern shoreline of Izembek Lagoon. A seasonal increase of Canada geese occurred in zone 1; however, data from ground observations at NB did not support as dramatic an Increase as was observed between surveys.

Emperors were least widespread of the geese. They concentrated primarily in zones 3 and 5 (Figure 5). Emperor geese tended to use barrier islands and spits more frequently than the other species.

Study area.- Brant were present at all seven study areas during 80% (n=618) of the hourly counts (Table 2). They occurred most frequently and in the greatest mean numbers at: NB, AC, and HP. The greatest mean densities were recorded at NB (732/mi^2) and AC (706/mi^2). Large numbers of brant were observed infrequently at GW. Distribution of brant was generally consistent between 1985 and 1986 field seasons. However, at RE (termed Outer Marker in 1985) fewer brant were observed in 1986 than in 1985 (Ward et al. 1986).

Canada geese occurred at 5 of 7 study areas, however their presence during hourly counts was less frequent than brant (52 vs. 80%) (Table 2). They were observed most frequently at: NB, 97% (n= 120), HP, 92.7% (n=96), and AC, 84% (n= 98). Canada geese were not present or occurred in low numbers at the remaining four study areas. The greatest number of Canada geese ocurred at HP (316/mi^2) and AC (305/mi^2).

Emperor geese were present in study areas only 21.6% (n=559) of the hourly counts and occurred in the lowest numbers of all species (Table 2). Though emperors were present at 5 of 7 areas, they were most often present at HP, 66.3% (n=95) and GW, 62.9% (n=62). Within these two study areas, emperor geese were consistently found in the same locations.

Tide.- Distribution of geese within specific study areas was directly influenced by changes in tide, date, and to a lesser degree by time of day and wind direction and speed. The number of geese within a study area was not affected by the presence or absence of a disturbance event prior to the last hourly count (brant: $P < 0.66$, $F=0.19$, df-1; Canada: $P < 0.11$, $F=2.5$, df-1; emperor: $P < 0.5$, $F=0.4$, df-1). Therefore all hourly counts were combined for analyses.

In 1986 tide gauges were used at 6 study areas to accurately measure tidal fluctuations. Tide influenced both species composition and number of geese at all study sites however, results were not consistent. At NB, AC, and HP brant increased with flooding tides, while at GW, brant were most abundant during high tides (>3.0 ft) (Figure 10). Conversely, brant at BI and RE occurred during low to medium tides (<3.0 ft). Within all study areas, as increasing tide submerged eelgrass beds, brant shifted to near-shore areas (Figures 11-13).

At all study areas Canada geese were most abundant during low tides, At high tide Canada geese left the lagoon for upland tundra areas and returned during ebbing tides. Flocks of Canada geese were frequently observed flying back and forth between tundra and tidal habitat. In previous years when crowberries and lingonberries were abundant, Canada geese were often observed flying 3-4 mi to graze (Jones in prep.). Although Canada geese were generally found in near-shore areas, birds were most abundant during flood tide (Figures 10-12).

Emperor geese were observed at HP and GW during low tides. They consistently used a near-shore foraging area at GW during low tides before shifting to the barrier islands during flooding tides. Generally, emperors used specific foraging areas during low tide and the barrier islands at high high tide.

Date.- Seasonal shifts in distribution of brant at RE, GW, and NB were recorded from counts of geese from blinds (Figure 9). At RE a significant increase ($P<0.02$, $F=5.5$, $df=1$) in the mean number of brant occurred between early ($\leq$13 October) and late (>13 October) sampling periods. This shift coincided with an increased number of brant observed in zone 4 between early (3 October) and late (20 October) acrid surveys (Figure 3). Concurrent observations from RE and HP recorded brant leaving RE and arriving at HP during high tides. Although this shift in distribution was also observed in fall 1985, we can only speculate on the reason. The mean number of brant at GW decreased ($P<0.0001$, $F=18.9$, $df=1$) between early and late sampling periods. During the late period brant rarely used GW below 4.0 ft. At NB study area the mean number of brant decreased ($P<0.05$, $F=4.0$, $df=1$) between early and late sampling periods. Although not significant, this trend was also observed between early and late aerial surveys in zone 1 (Figure 3). Observations of brant at NB indicated an increased amount of local movement out of the study area during the late period and on one occassion, 26 October, brant were observed departing Izembek Lagoon.

Canada geese exhibited shifts in distribution at AC and NB (Figure 9). At AC the mean numbers of Canada geese fluctuated during the early sampling period although significantly declined ($P<0.000$, $F=21.7$, $df=1$) during late. Conversely, Canada geese at NB study area increased ($P<0.000$, $F=38.0$, $df=1$) between early and late sampling periods. The fluctuation of Canada geese at AC and NB probably reflects changes in berry abundance. Canada geese declined in all three areas after 20 October (Figure 9).

Infrequent counts of emperor geese precluded analysis of seasonal shifts among study areas. The number of emperors at both HP and GW remained relatively stable during the early period (Figure 9). Emperors then declined at HP and increased at GW during the late period.

Time of day.- Early ($\leq$1200 h), mid-day (1200-1500 h), and evening ($\geq$1500 h) diurnal periods did not affect the distribution of brant or emperor geese within a study area (Table 3). However, the total number of Canada geese significantly increased ($P<0.02$, $F=7.8$, $df-1$) during early compared to mid-day and evening hourly counts at three study areas (NB, AC, and HP) combined. Within a study area this increase was significant ($P<0.000$, $F-15.9$, $df=2$) only at NB. Numbers of brant and emperor geese did not appear to be significantly influenced by diurnal periods.

Weather. - Wind direction, wind velocity, precipitation, temperature, and visibility were examined for their influence on distribution of brant. Only wind direction and velocity had an effect on t'ne number of brant. However, because of small sample sizes at NB and AC, tide and date may have influenced the results.

At NB the number ($\bar{x}$=5,402, SD=2,450, n=12) of brant observed on days with north winds was significantly higher (P<0.02, t=3.03, df=12) than brant ($\bar{x}$=10,984, SD=1,980, n=2) observed with south winds. However, the occurrence of south winds on 7 and 8 October coincided with maximum numbers of brant at NB (Figure 9) and may interact with wind direction to bias the results. The difference in mean number of brant between north and south winds was similar for low (≤2.6 ft), moderate (2.7-3.7 ft), and high (≥3.8 ft) tidal heights.

The number ($\bar{x}$=7,695, SD=2,499, n=14 days) of brant on days with calm to moderate winds at NB was greater (P<0.01, t=3.5, df=20) than brant ($\bar{x}$=4,148 SD= 1,826 n=8 days) on days with moderate to gale winds. The shoreline at NB " is oriented east-west and offers protection against south (offshore) winds but not from the generally stronger north (onshore) winds. Part of this difference may be attributed to decreased visibility due to wave action on days with strong winds.

Wind direction also had an effect on brant at AC. The number of brant ($\bar{x}$=3,130, SD=3, 30, n=10) on days with N-NE wind was less (P<0.05, t=2.4, df=13) than bra t ($\bar{x}$=5,859, SD=2610, n=5) on days with winds from the NW. In contrast to NB, winds may not have influenced the number of brant at AC because the sho:eline offers little protection from either wind direction.

Response to Dis urbance

Behavioral responses of geese to potential disturbance stimuli were monitored from 18 September through 31 October. Approximately 90% of the 798 total hours of observations were recorded at six study areas: Norma Bay (24.6%), Applegate Cove (18.9%), Halfway Point (14.2%), Round Island East (13.6%), Banding Island (10.8%) and Grant Point West (7.7%) (Table 4).

A total of 2027 potential disturbance (incidental + experimental) events (an event is defined as an observation of a behavioral response of a goose flock to a potential disturbance) was recorded for all geese during the study period. Small helicopter (19.9%), single-engine (16.9%), and twin-engine (13.3%) aircraft were the most important human-induced disturbance types, and bald eagles were the dominant natural cause (Table 4).

Although the total mean number of potential disturbance events and hours of observations were greater in 1986 than 1985 (see Ward et al. 1986) (2027 vs. 623 and 798.6 vs. 260.0, respectively), the mean number of disturbances per hour (2.5 in 1985 and 2.4 in 1986) were comparable. The highest rate of all types of potential disturbances per hour (excluding experimental overflights) was recorded at Norma Bay (1.8/h) and Halfway Point (1.6/h); however, the rate of incidental aircraft flights was highest at Halfway Point (1.0/h) because of its location along the Instrument Flight Rules (IFR) corridor. The relatively high rate of incidental aircraft disturbances at Norma Bay (0.85/h) is explained by the frequent commuter aircraft overflights between Cold Bay and False Pass.

Number and percent of potential disturbance events for brant (1359), Canada geese (529) and emperor geese (72) are listed in Figures 15-16 and Appendices A-C. Human-induced potential disturbances (incidental + experimental) accounted for 79.3, 70.7, and 83.3% of all events recorded while observing flocks of brant, Canada geese and emperor geese, respectively (Figure 15 and Appendices A-C). Single- and twin-engine aircraft were the most frequent human-induced potential disturbance events (excluding experimental overflights) for both brant and Canada geese. In 1985, jet and four-engine aircraft comprised the largest proportion of human-induced potential disturbance events (Ward et al. 1986). Small helicopters and single-engine aircraft comprised the majority of experimental disturbance events for all three species both in 1985 (see Ward et al. 1986) and in 1986.

Bald eagles were the most frequent natural cause and the most frequent incidental disturbance for brant, Canada geese and emperor geese. Additional natural disturbances included falcons (Falco spp.), northern harriers (Circus cyaneus), common ravens (Corvus corax) and a timber wolf (Canis lupus). Wintering brent geese (Branta bernicla bernicla) were also disturbed by a variety of natural causes: Greater black-backed gulls (Larus marinus), herons (Ardea cinerea), harriers, and carrion crows (Corvus corone) (Owens 1977).

Experimental overflights.- The total number of flocks of brant, Canada geese and emperor geese observed during experimental overflights were 689, 254, and 49, respectively (Table 5). Orientation of flight lines in relation to study areas are depicted in Figures 7. Experimental overflights with a Bell 206-B, single- and twin-engine fixed-wing aircraft accounted for a total of 40.2, 22.4 and 18,4% respectively, of all observations.

The behavioral responses of brant and Canada geese to 1000 Et experimental overflights by five aircraft are shown in Tables 6-7. Behavioral responses were grouped as **NC" (flocks which did not change their behavior in response to a potential disturbance), "ALM" (flocks which responded to a disturbance by becoming alert or massing together) and '*FLY" (birds which rose, circled or flew from the study area). Only flocks in which 80% or more of the birds exhibited a particular behavior were included in disturbance/response analyses. Although several trends are evident, variable environmental (wind direction and speed, tide) and biological (flock size, habitat quality) conditions and an insufficient number of replicates may have increased variance to the point of eliminating statistically significant differences. Based on the proportion of brant flocks exhibiting NC, ALM, and FLY behavioral categories small helicopters (HS) appeared to cause the greatest disturbance among the five aircraft types (Table 6). Simpson et al. (in prep.) also reported that helicopters compared to fixed-wing aircraft caused greater disturbance to brant based on the proportion of birds which showed no change behaviors (25.0 vs. 38.5%, respectively). The C-130 (AM) overflights at

1000 ft may have resulted in a similar degree of disturbance however, small sample size prohibited comparison. In contrast to brant, Canada geese were not disturbed by single-engine, twin-engine and Grumman goose aircraft at 1000 ft (Table 7). Only 5.6% (n=18) of the Canada flocks flew during 1000 ft small helicopter overflight.s, compared to 40.9% (n=44) of the brant.

Results of aptitudinal variation of experimental overflights of single-engine (Tables 8-9) and twin-engine (Tables 10-11) fixed-wing aircraft, and a small helicopter (Tables 12-13) indicate that aircraft at lower altitudes elicited a greater proportion of disturbance-related behaviors by brant and Canada geese. Only 10.0% of the brant flocks (n=10) located 0.0-0.24 mi from single-engine aircraft remained in a NC behavioral category during overflights at 150-500 ft; however, 90.9% of the flocks were not disturbed during overflights at 2000-2500 ft (Table 8). Canada geese were apparently less disturbed by single-engine planes as only 1 of 35 flocks showed any type of behavioral change with respect to overflights at 1000 or 2000-2500 ft (Table 9). Twin-engine aircraft overflights at 500 ft caused 32.1% (n=28) of the brant flocks located 0.0-0.24 mi from the aircraft to fly, and only 10.0% (n=20) of the flocks located the same distance flew at overflights of 1000 ft (Table 10). Twin-engine aircraft elicted less of a response from Canada geese as only 3 of 16 flocks exhibited any type of behavioral change at flights of 500-1000 ft (Table 11). Canada geese were less disturbed by small helicopters flown at higher altitudes (Table 12) however, brant did not follow a similar pattern (Table 13). A smaller proportion of brant flocks remained in the NC category during helicopter overflights at 3000 ft than at 300 ft at all distances-except 0.25-0.49 mi. Canada geese also appeared to be less sensitive than brant to large helicopters (1500 ft altitude) as only 7.1% (n=14) of the flocks located 0.50-0.99+ mi away flew as opposed to 24.3% (n=37) of the brant flocks (Table 14). The proportion of brant and Canada goose flocks exhibiting a particular behavioral response (NC, ALM, FLY) did not appear to be related to the distance between the flock and the aircraft (Tables 6-18). It was expected that as the distance between a flock and an aircraft increased, a higher proportion of birds would exhibit NC behavior and a lower proportion of ALM and FLY behaviors. This relationship was not found possibly because: 1) interacting biological or environmental factors (e.g. tide level, wind speed), and direction may have increased the variance associated with distance/behavioral measurements or 2) distance increments may be too close to detect differences in behavioral response proportions. Davis and Wisely (1974) found that 80.4% of the snow goose (*Chen caerulescens*) flocks (n=51) located within 2 mi of a Bell 206-B helicopter took flight (the flight behavioral response in this study required that only 10.0% of the flock to fly). However, the response was not statistically significant from the percentage of flocks (66.7% n=12) located 2-4 mi which flew.

Incidental overflights.- Results of observations of incidental single-engine (Table 15), twin-engine (Table 16), Grumman goose (Table 17), and jet aircraft (Table 18) are summarized for brant only because of insufficient sample numbers for Canada and emperor geese.. In general, results from incidental overflights followed those of experimental tests i.e., brant became less disturbed as altitude of an aircraft increased.

Eagle disturbances.- The rate of eagle disturbances during early (≤13 October) and late (>13 October) periods at Applegate Cove, Banding Island, and Norma Bay were compared because of an apparent influx of eagles into those areas in late October. The rate of eagle disturbances per hour decreased at Applegate Cove (0.7-0.5/h), increased slightly at Banding Island (0.2-0.3/h) and tripled at Norma Bay (0.4-1.2/h). An increased rate of disturbance was not recorded at Applegate Cove because of the high number of eagles and the frequency of flock disturbances. Up to 11 eagles were observed along shorelines or on exposed eelgrass beds at Applegate Cove. The frequency of brant and Canada geese taking flight and the mixing of flocks prevented an accurate recording of individual disturbance events.

Eagles caused the highest proportion of brant and Canada goose flocks to exhibit a flight response among both incidental and experimental disturbance types. They influenced an average of 80.6% of brant flocks located ≤0.99 mi to flush (average derived from 6 proportions given in Table 19). Only 56.9% of brant flocks located ≤0.99 mi flushed in response to 300 ft helicopter overflights (average derived from 3 proportions given in Table 13). An average of 60.3% of Canada goose flocks (average derived from 6 proportions listed in Table 20) flew when eagles were within 0.99 mi. vs 0.0% for flocks observed during 300 ft small helicopter overflights (average derived from values in Table 12).

Flock size.- The proportion of a brant flock exhibiting a particular behavioral response for an aircraft at a specific altitude and distance did not appear to be related to flock size (Table 21). Difficulties in delineating a loosely aggregated flock consisting of several hundreds or thousands of birds may have masked any possible relationships. Additional problems included the proximity of an overflight to a small portion of a flock and the possible influence of social facilitation. Often, only birds directly adjacent to a flight line would flush due to an approaching aircraft; however, other geese would then start to flush in a wave-like pattern. Owens (1977) stated that the disturbance behavior of brent flocks may be determined by the behavior of its most nervous members, since a few geese taking flight tended to cause the whole flock to flush. The actual proportion of the flock which took flight because of the overflight may have thus been overestimated.

Wind direction.- Wind direction was also not related to the proportion of brant exhibiting a particular behavioral response (Table 22). Although it was expected that a higher percentage of flocks would show alert, mass or flight behavior when an aircraft was upwind (due to the carrying of acoustical energy), no relationship was found. Difficulty in relating local wind direction to an approaching aircraft may in part explain inconsistent results

Tide.- The influence of tide on disturbance related behavior of geese under specific conditions (aircraft type, altitude and distance) is presented in Table 23. Brant appeared less likely to become alert, mass or take flight during low tides. At tides ≤ 2.4, ≤2.0 and ≤1.0 ft, the proportion of brant flocks exhibiting NC behavior was 50.0 (n=22), 58.3 (n=12) and 60.0% (n=5), respectively (Table 23). Similarly, the proportion of flocks exhibiting ALM behavior increased as tides increased. Tide did not however, appear to affect the proportion of brant which took flight. Tidal influence did not remain constant for brant flocks located greater than 0.49 mi from the aircraft (Table 24). In comparing single- and twin-engine fixed-wing aircraft and small helicopter observations, brant consistently exhibted a greater proportion of NC behavior at low tides vs. high tides (Table 25). During low tides, brant spent the greatest proportion of time feeding on available eelgrass (Ward unpubl. data), and thus may be less prone to a potential disturbance. At high tides, brant preen or rest and may be more susceptible to disturbance.

Flight duration.- Flight duration of Rise, Circle and Depart behavioral categories for brant and Canada geese was examined to determine differences between categories and species (Table 26). Insufficient sample size of flight durations for emperor geese precluded analysis. The mean duration of Rise, Circle and Depart behaviors differed significantly for both brant ($P<0.000$ $\chi=88.15$ $n=532$) and Canada geese ($P<0.000$ $\chi=45.92$ $n=127$) (Kruskall-Wallis, SPSS[x] 1986). Comparison of the duration of Rise, Circle and Depart behaviors between brant and Canada geese were not significant: Rise ($P<0.4$ $Z=-.83$ $n=53$), Circle ($P<0.3$ $Z=-1.12$ $n=346$) and Depart ($P<0.15$ $Z=-1.44$ $n=260$) (Mann-Whitney 2-tailed U, SPSS[x] 1986). Analysis of flight duration data with respect to disturbance cause has not been completed. Duration of flights and distances traveled by brant may differ as a result of different disturbance types. Although actual time in flight was not measured, snow geese did not fly a significantly greater distance in response to 500 ft overflights by a Bell 206 helicopter compared to identical overflights with a Cessna 185 fixed-wing aircraft (Davis and Wisely 1974).

ADDITIONAL RESEARCH

This section includes data currently being analyzed and therefore, results are not included in this report. These topics will be addressed in future reports.

Habitat Use

Distribution of habitat and its use by brant.- Habitat communities at Izembek Lagoon were classified using a 1978 LANDSAT image (exposed at -0.6 ft. mean lower low water). This image, containing habitat classes, is the most recent available of Izembek Lagoon. Intereptation of the LANDSAT image was provided by USGS/EROS Field Station, Anchorage, Alaska. Habitat complexes were superficially verified by comparing the LANDSAT map with notes recorded on habitat during ground surveys,

Three primary and 4 secondary habitat classes have been delimited from the image. Primary habitat classes included: eelgrass, mud flat, and water (Figure 2). Eelgrass habitat was further divided into: 1) long-length eelgrass (≥36 in) typical of deeper water, 2) medium-length eelgrass (12-36 in) typical of moderately deep water, 3) short-length eelgrass (≤12 in) typical of shallow water, and 4) detrital eelgrass, eelgrass detached from the sediment (Figure 16).

Verification of the habitat classes at Izembek lagoon is not possible with existing maps of the area. Plans are currently being made to secure photographic coverage of the lagoon in 1987. The large pixel size ($50m^2$) of the LANDSAT image combined with inaccurate maps of Izembek Lagoon preclude ground truthing of habitat classes. However, since primary habitat classes appeared to be representative from visual ground surveys, their amount and distribution have been determined for 5 zones (as used for counts of geese during aerial surveys; see Figure 3 for locations of zones) within Izembek Lagoon (Table 27).

The general. pattern of use by brant (determined from aerial surveys) was compared with the amount and distribution of the primary habitat classes within the five zones (Figures 3-5 and Table 27). It appeared that brant, Canada and emperor geese had distinct areas of use. There was overlap between species but generally brant occurred. in zones containing the greatest amounts of eelgrass, Canada geese tended to use near-shore areas and not necessarily zones with the greatest amounts of eelgrass and emperor geese appeared to use areas with extensive mud flats.

Foods and nutritional quality of foods.- To understand types and nutritional value of foods eaten by brant, we intensified our sampling effort in 1986 to secure information on the relationship between forage quality and use by brant. Brant were collected to determine the part (leaves, shoot or root and rhizomes) and type (e.g. long or short bladed eelgrass or epiphyte covered vs. epiphytes) of eelgrass preferred. Birds were collected whenever possible, preferably after having been observed feeding in a known location. If brant were observed feeding prior to collection, a sample of plants from the foraging area was collected for nutritent analysis. Only 27 brant were collected, of which 13 were collected from known feeding locations. This information has not been analyzed. Nutrient content of plants collected in 1985 (Table 28) showed two trends: 1) nitrogen content of eelgrass varied ($P<0.05$, $F=39.6$, $df=4$) between study sites (AC, GE, QP, HP, and RE; see Ward et al. 1986 for locations), and 2) higher intertidal plants, which are typically short and thin leafed were greater ($P<0.01$, $F=93.4$, $df=1$) in nitrogen content than low intertidal plants, which were long and wide leafed at QP. To better understand the relationship of nutrient content between study sites and intertidal height, a more intensive systematic sampling plan was initiated in fall 1986. Samples of eelgrass were taken at 5 different study areas (NB, BI, GW, GE and RE). At each sampling site measurements of leaf length and width, density and intertidal height were recorded.

Collected brant were also used to determine body weight and composition (fat, water, crude protein and ash) as a function of season. This information is needed to gauge the required weight gain necessary for a transoceanic migration to wintering areas.These data and nutrient content of foods and time budgets will be used to examine the costs of disturbance (extra flight and time away from foraging).

Time and activity budgets

Time budget data was collected for approximately 2000 birds sampled from flocks near blinds. Continuous records of duration and sequence of feeding, swimming, alert, resting, flying, walking, and maintenance behaviors were entered by keystroke on a handheld HP71B field computer. Data analysis has not been initiated. This data set, along with 1985 data, will allow us to determine the pattern of foraging activity as function of time of day, season, tidal height, weather conditions, flock size and age of bird. The feeding rate may also relate to quality or accessibility of eelgrass plants or specific beds.

PLANS FOR 1987 FIELD SEASON

Disturbance.- Plans for the 1987 field season include a continuation of the basic designs used in 1986. In addition we will: 1) integrate data on behavior, distribution, flight time, time and activity budgets, and response to aircraft disturbances in a predictive model, 2) formulate a more rigorous statistical analysis of data, 3) initiate collection of acoustic information to quantify the intensity and quality of aircraft sounds as they relate to behavioral response of the flock, 4) increase overflights with larger helicopters as well as repeat measures with fixed-wing aircraft, 5) evaluate the use of radio-tagged birds to establish 24 h patterns of movement and 'behavior, and 6) determine a more workable and valid design to assess the proportion of time brant spend in flight.

Distribution.- Basic design of data collection will be the same in 1987 as was used in 1986. Additional effort will emphasize: 1) securing aerial photographs of the lagoon showing eelgrass beds at low tide, 2) data collection at one study area to understand the pattern of flock foraging behavior as it relates to variations in eelgrass quality and tidal height, and 3) collecting brant to determine foraging preference for specific eelgrass phenotypes.

ACKNOWLEDGEMENTS

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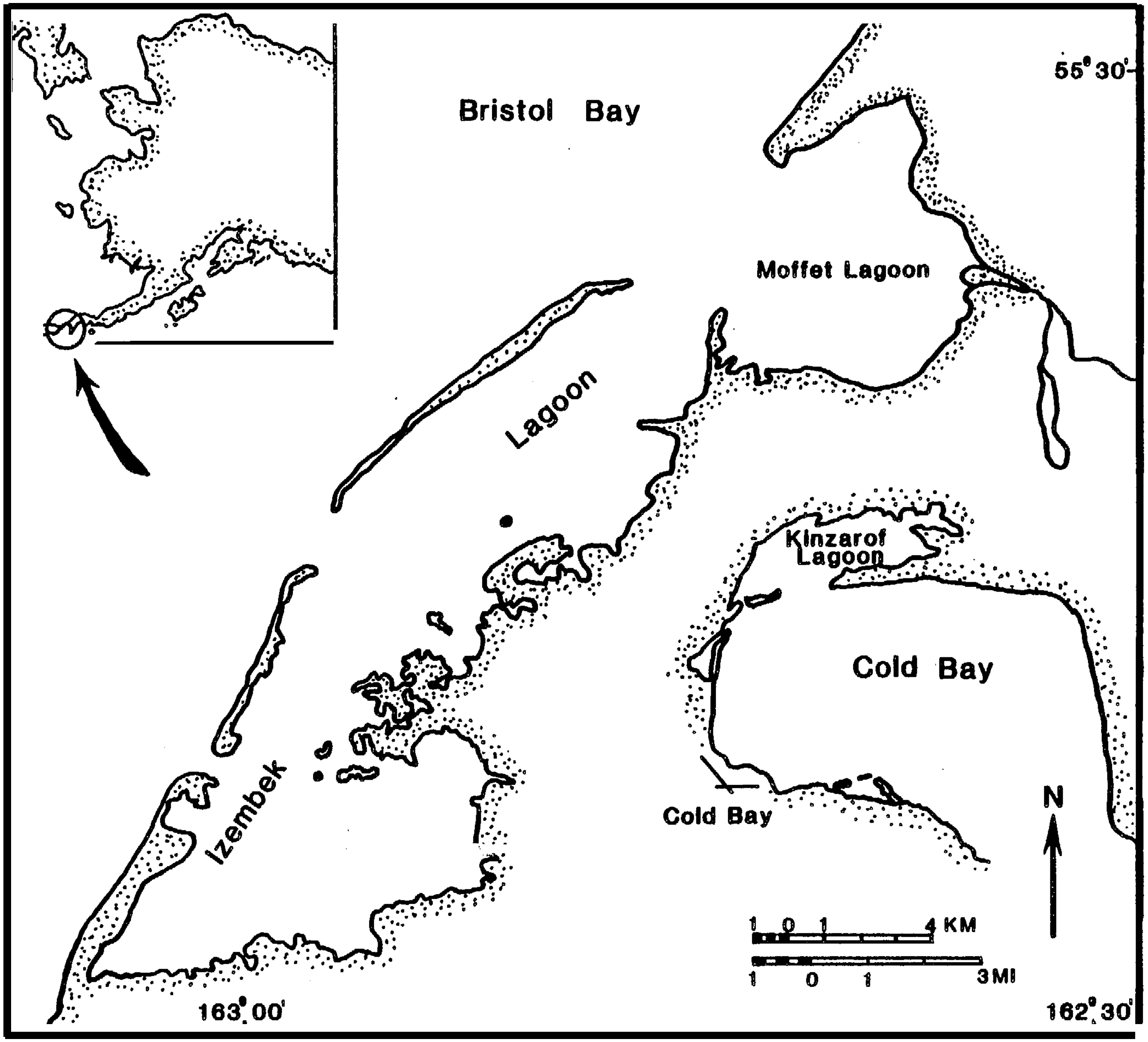

Figure 1. Izembek Lagoon, Alaska.

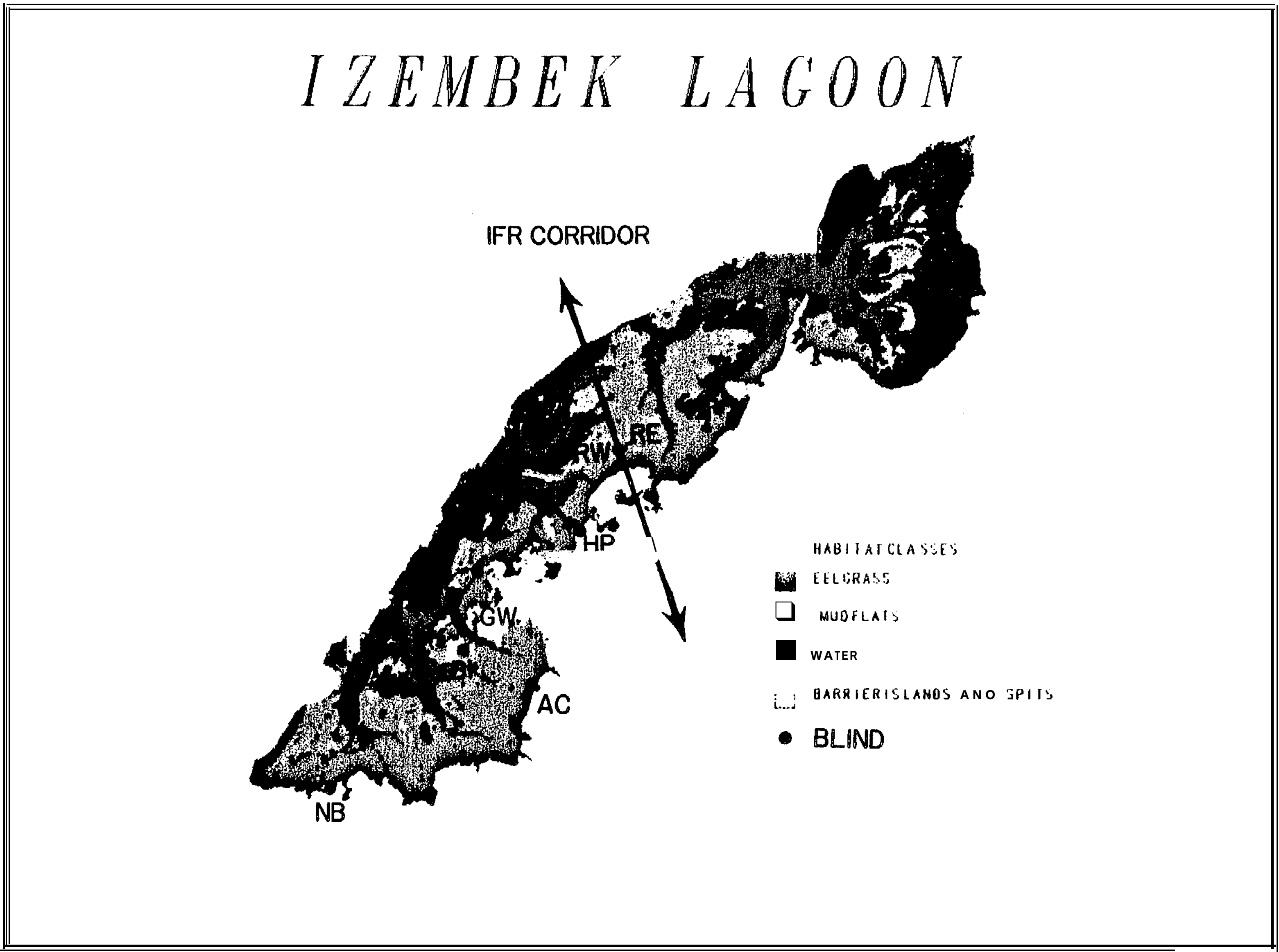

Figure 2. Locations of study areas, Instrument Flight Rules (IFR) corridor, and primary habitat classes (as interpreted from 1978 LANDSAT image) at Izembek Lagoon, Alaska. Study areas include: Norma Bay (NB), Applegate Cove (AC), Banding Island (BI), Grant Point West (GW), Halfway Point (HP), Round Island West (RW) and Round Island East (RE).

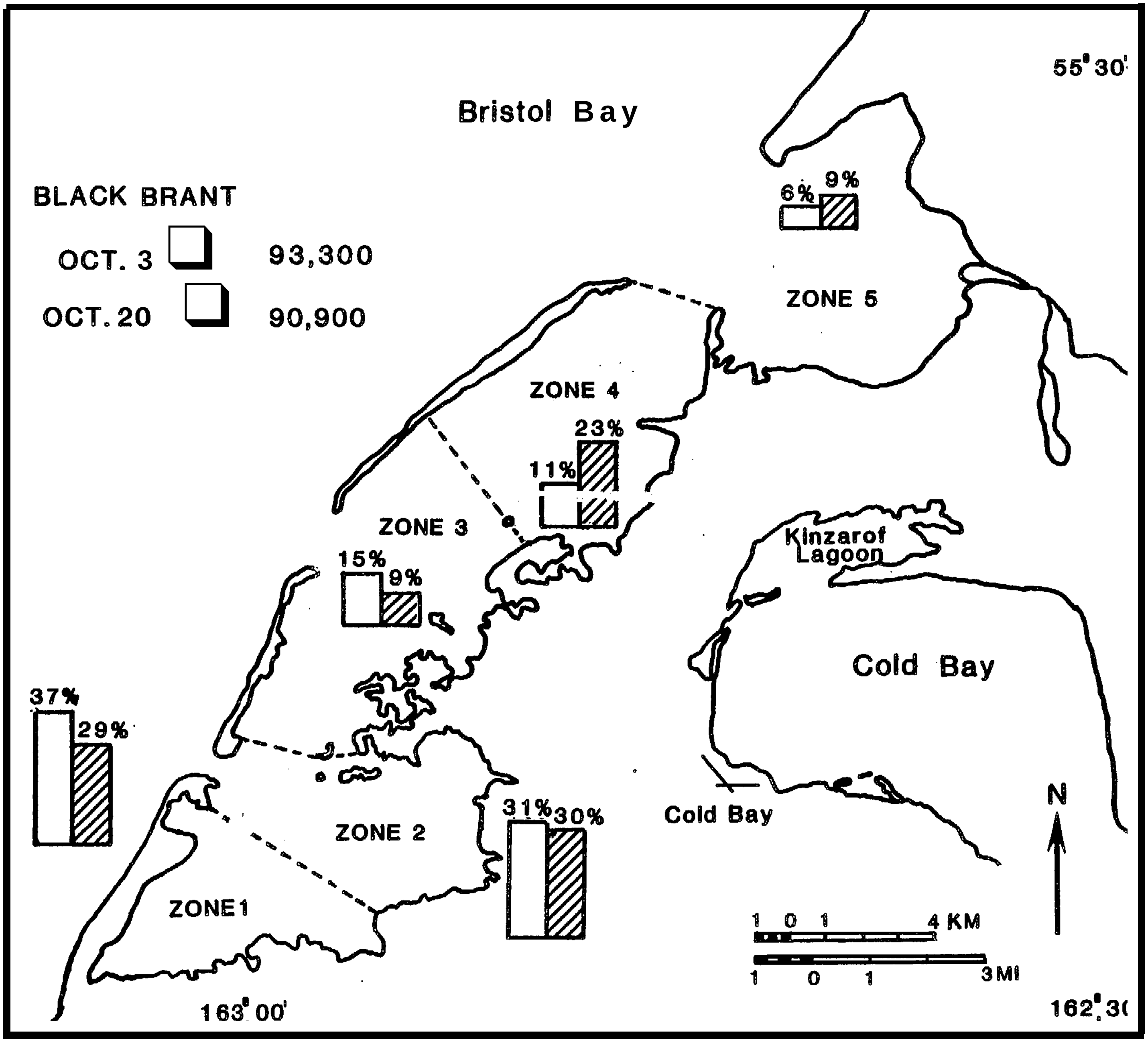

Figure 3. Percent of brant present in five zones of Izembek Lagoon, Alaska during 3 and 20 October 1986 aerial surveys.

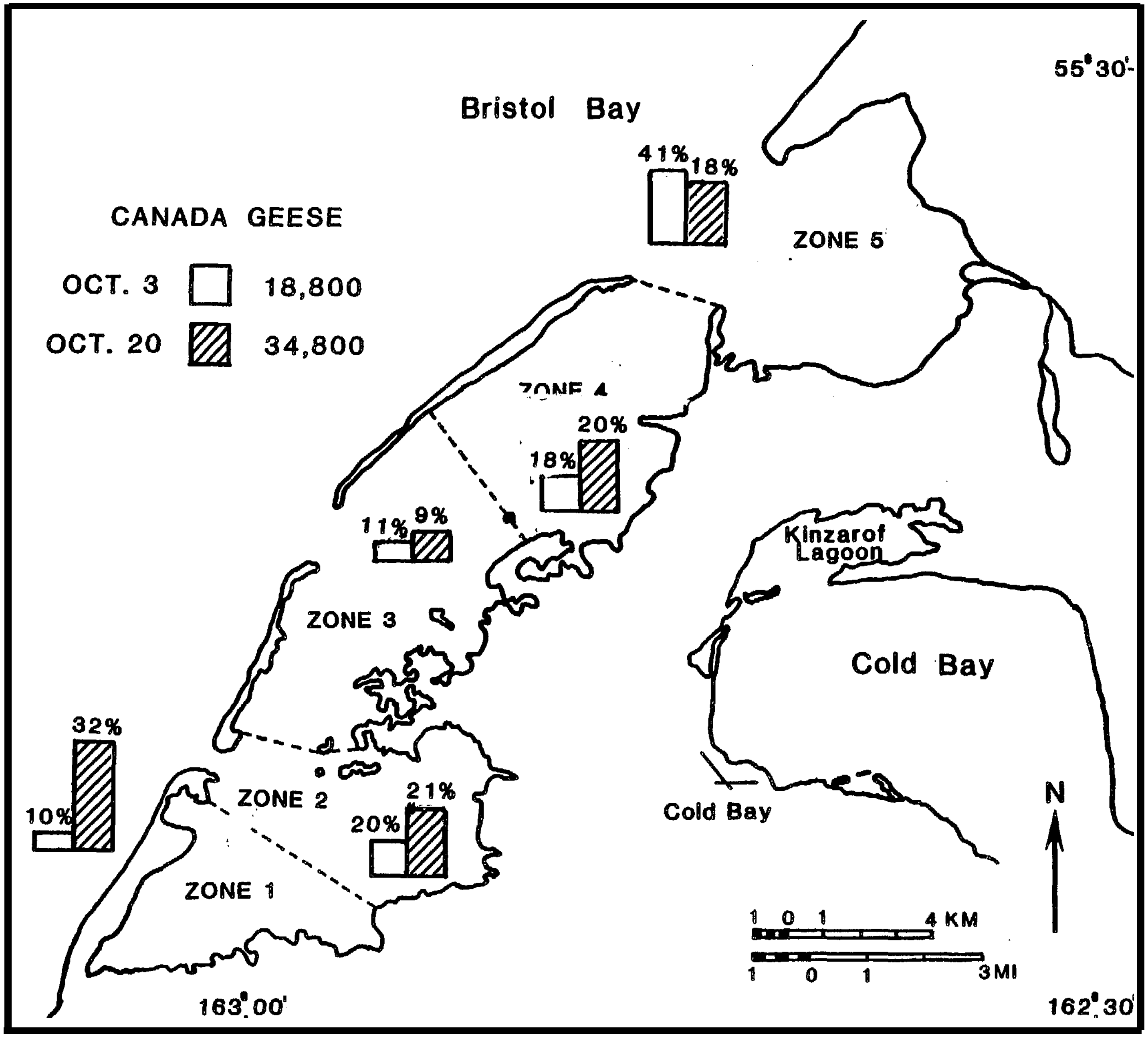

Figure 4. Percent of Canada geese present in five zones of Izembek Lagoon, Alaska during 3 and 20 October 1986 aerial surveys.

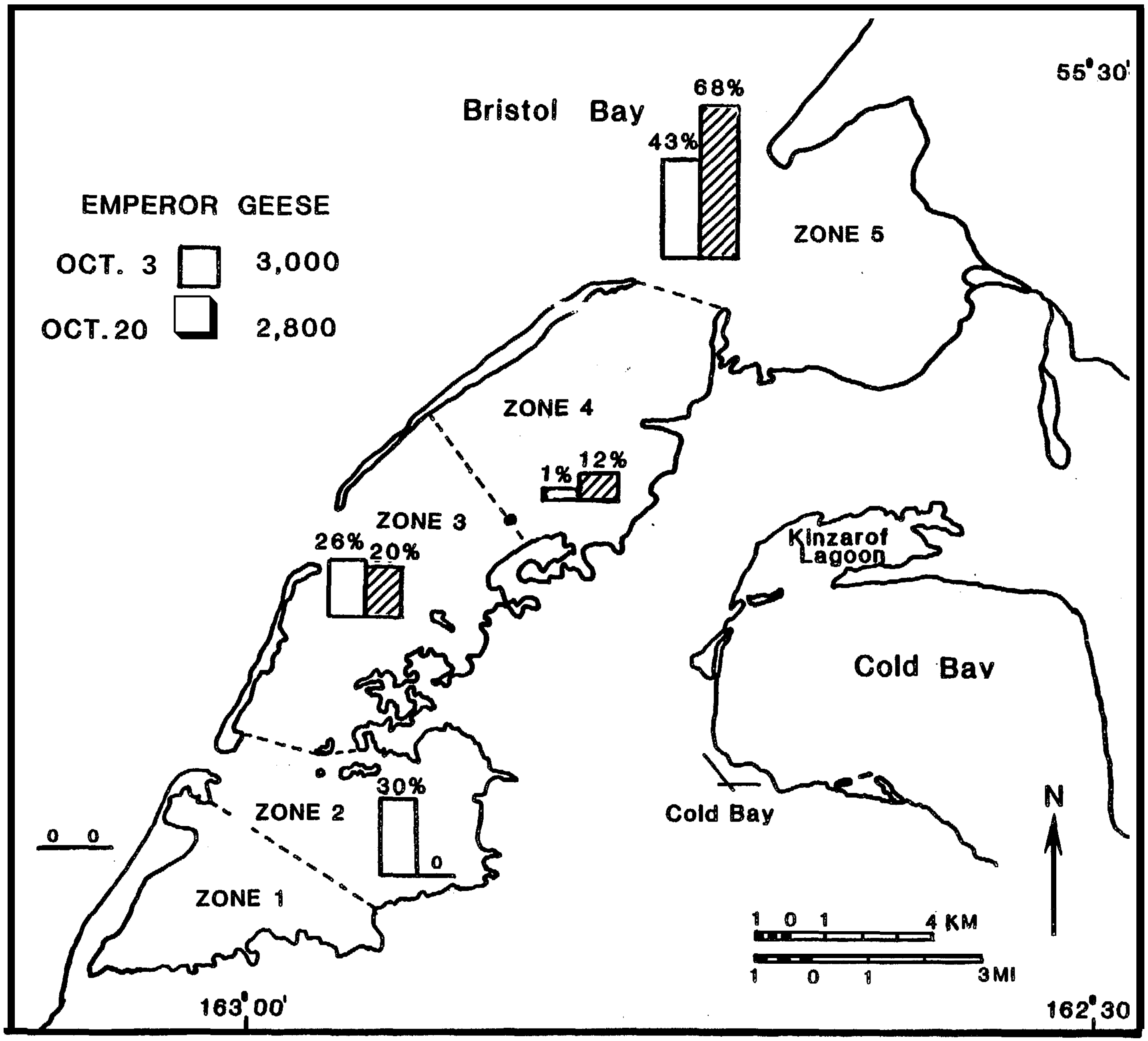

Figure 5. Percent of Emperor geese present in five zones of Izembek Lagoon, Alaska during 3 and 20 October 1986 aerial surveys.

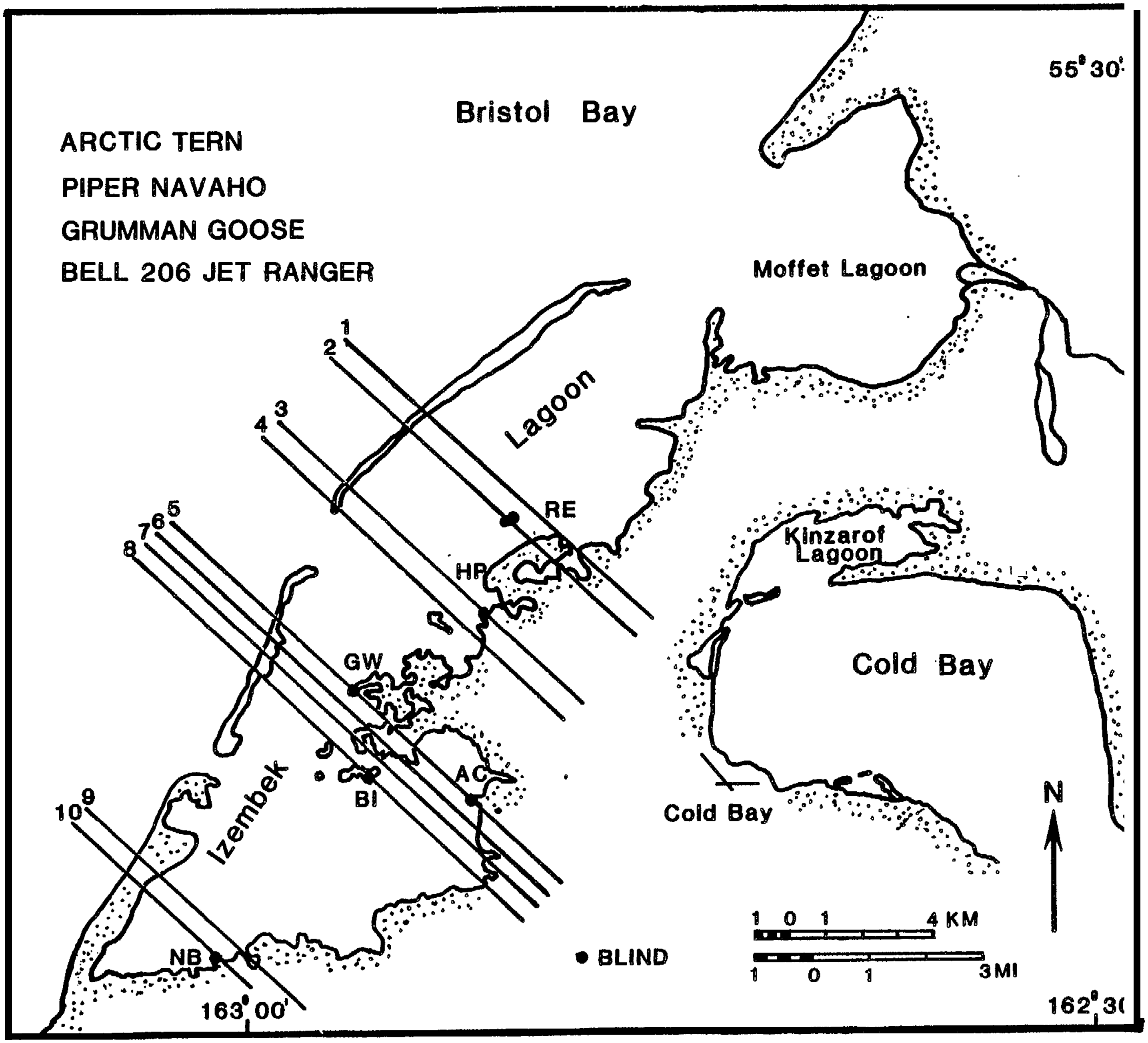

Figure 6. Number, position and orientation of experimental fixed-wing and helicopter overflights at Izembek Lagoon, Alaska from 18 September to 31 October 1986.

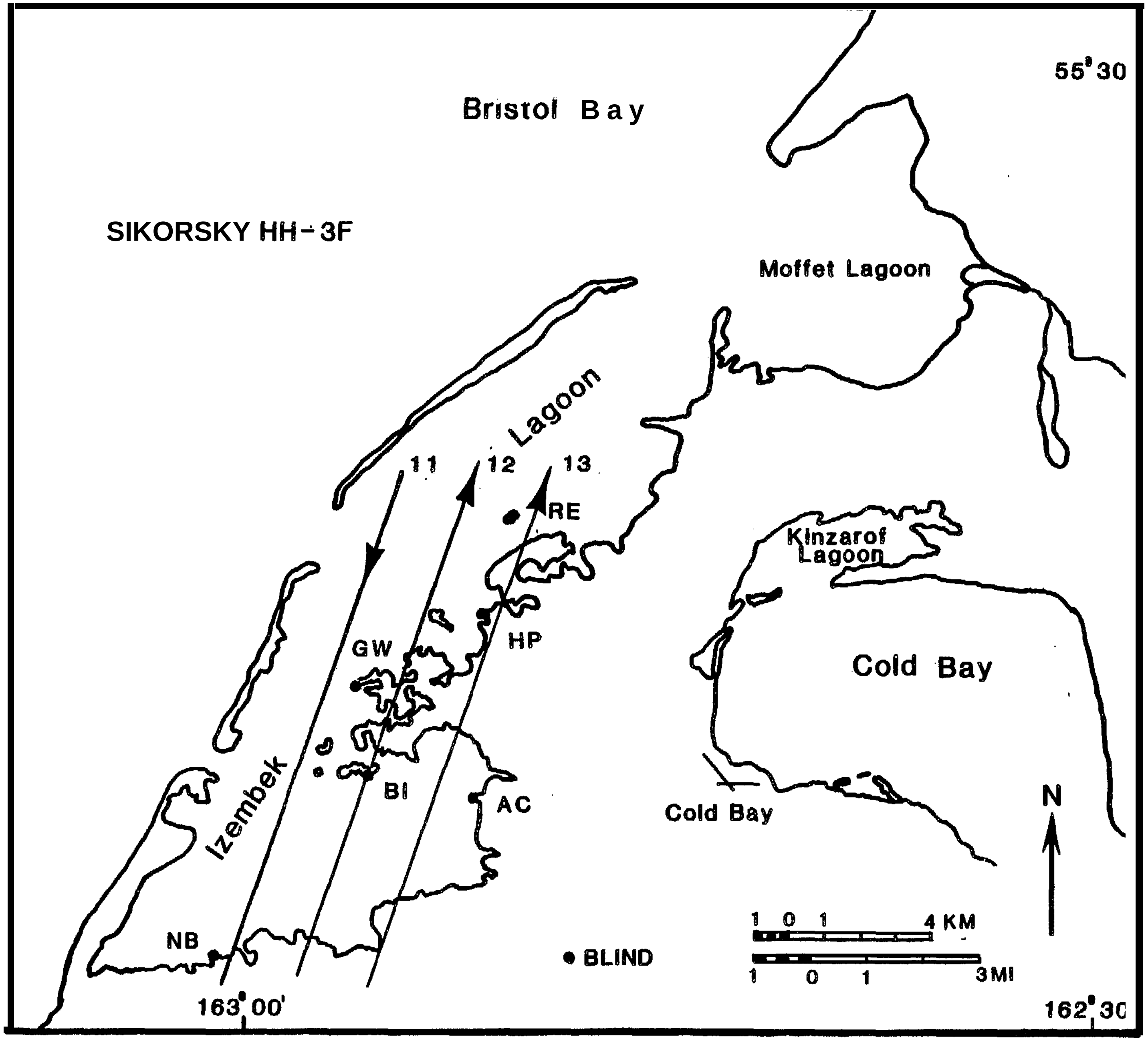

Figure 7. Number, position and orientation of experimental helicopter overflights at Izembek Lagoon, Alaska from 18 September to 31 October 1986.

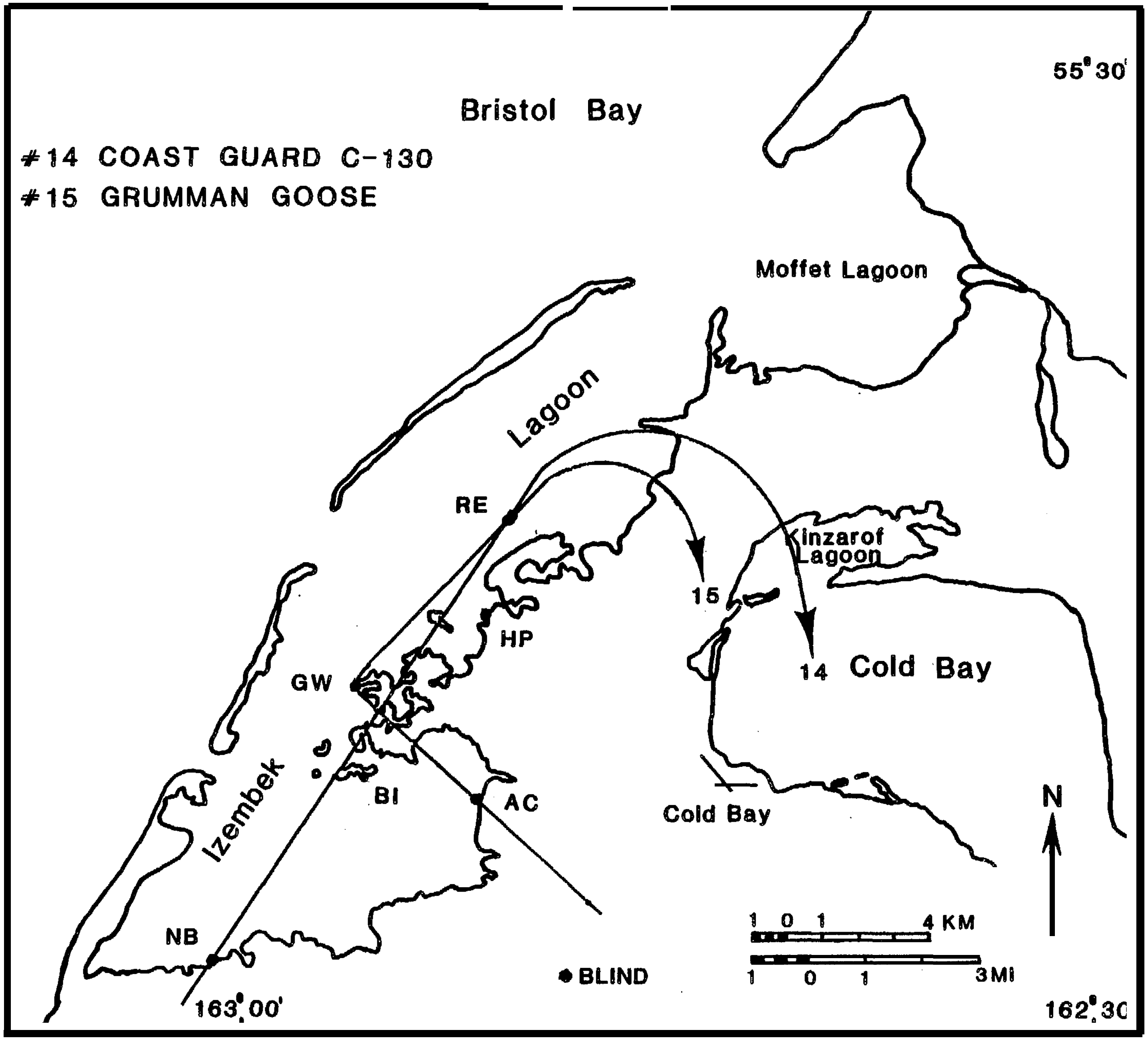

Figure 8. Number, position and orientation of experimental fixed-wing overflights at Izembek Lagoon, Alaska from 18 September to 31 October 1986.

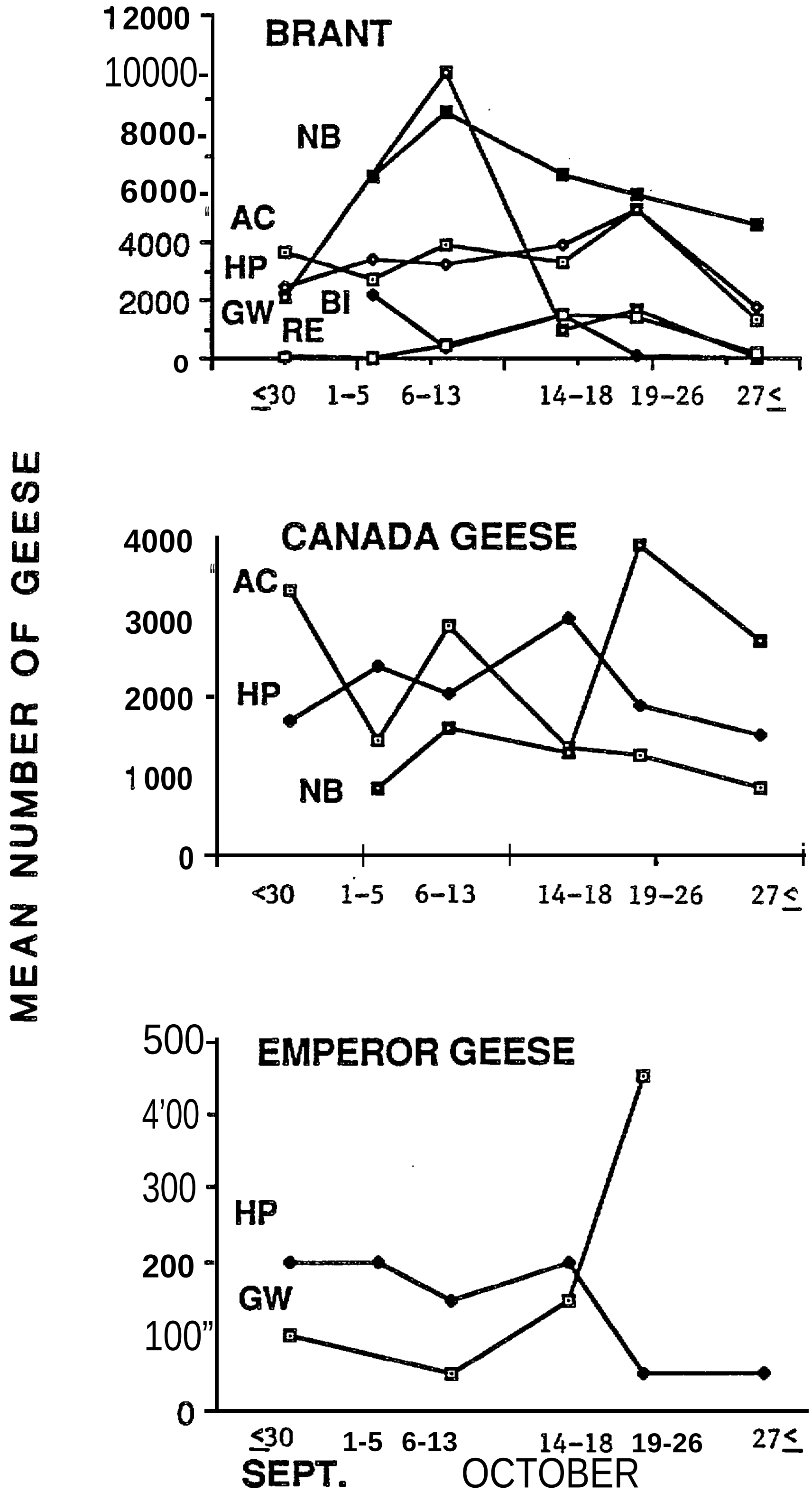

Figure 9. Mean number of geese at Norma Bay (NE), Applegate Cove (AC), Banding Island (BI), Grant Point West (GW), Halfway Point (HP) and Round Island East (RE) study areas at Izembek Lagoon, Alaska from 18 September to 31 October 1986.

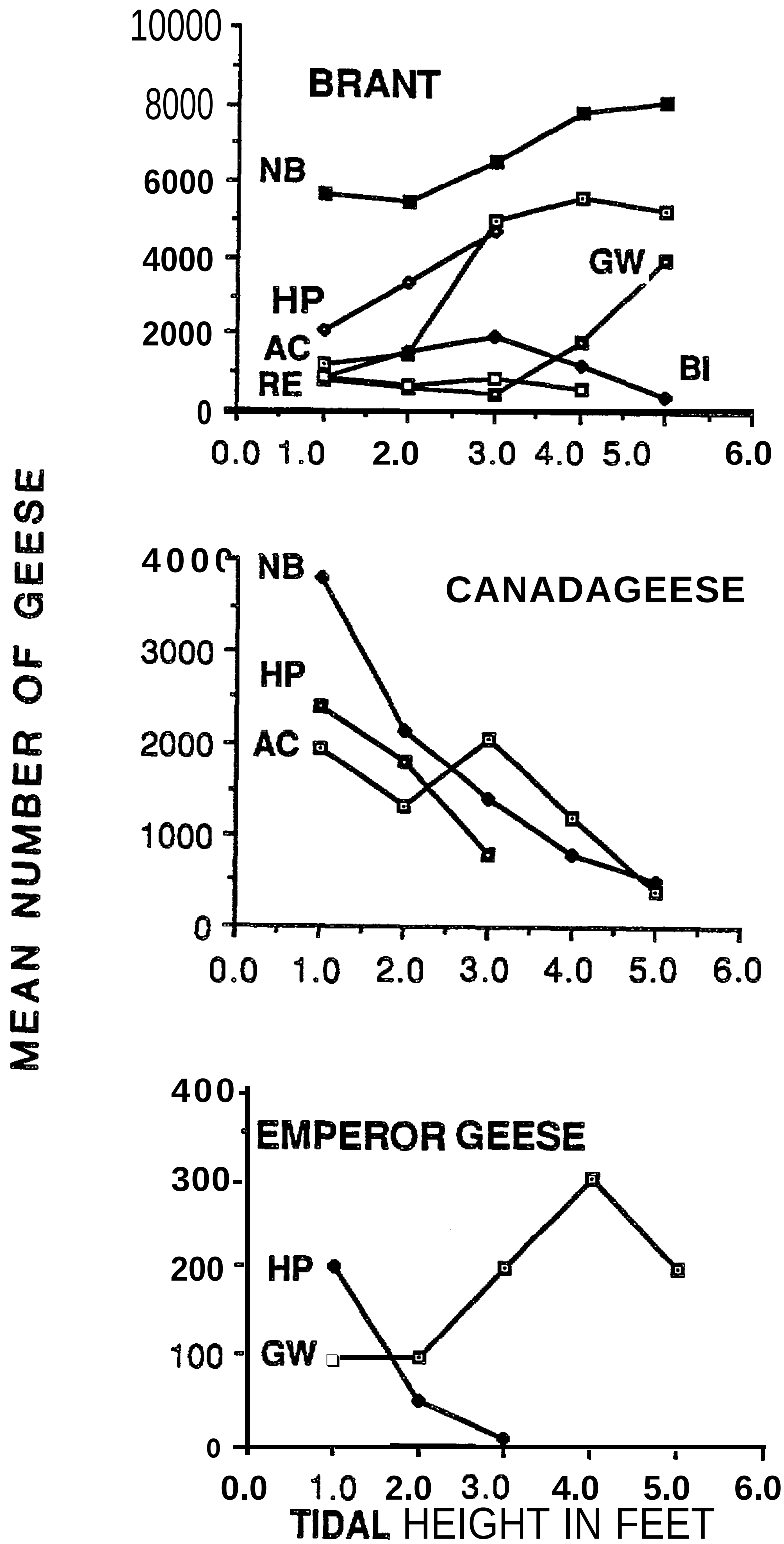

Figure 10. Mean number of geese at Norma Bay (NB), Applegate Cove (AC), Banding Island (BI), Grant Point West (GW), Halfway Point (HP), and Round Island East (RE). Means are calculated from tidal heights grouped into 1.0 ft. increments.

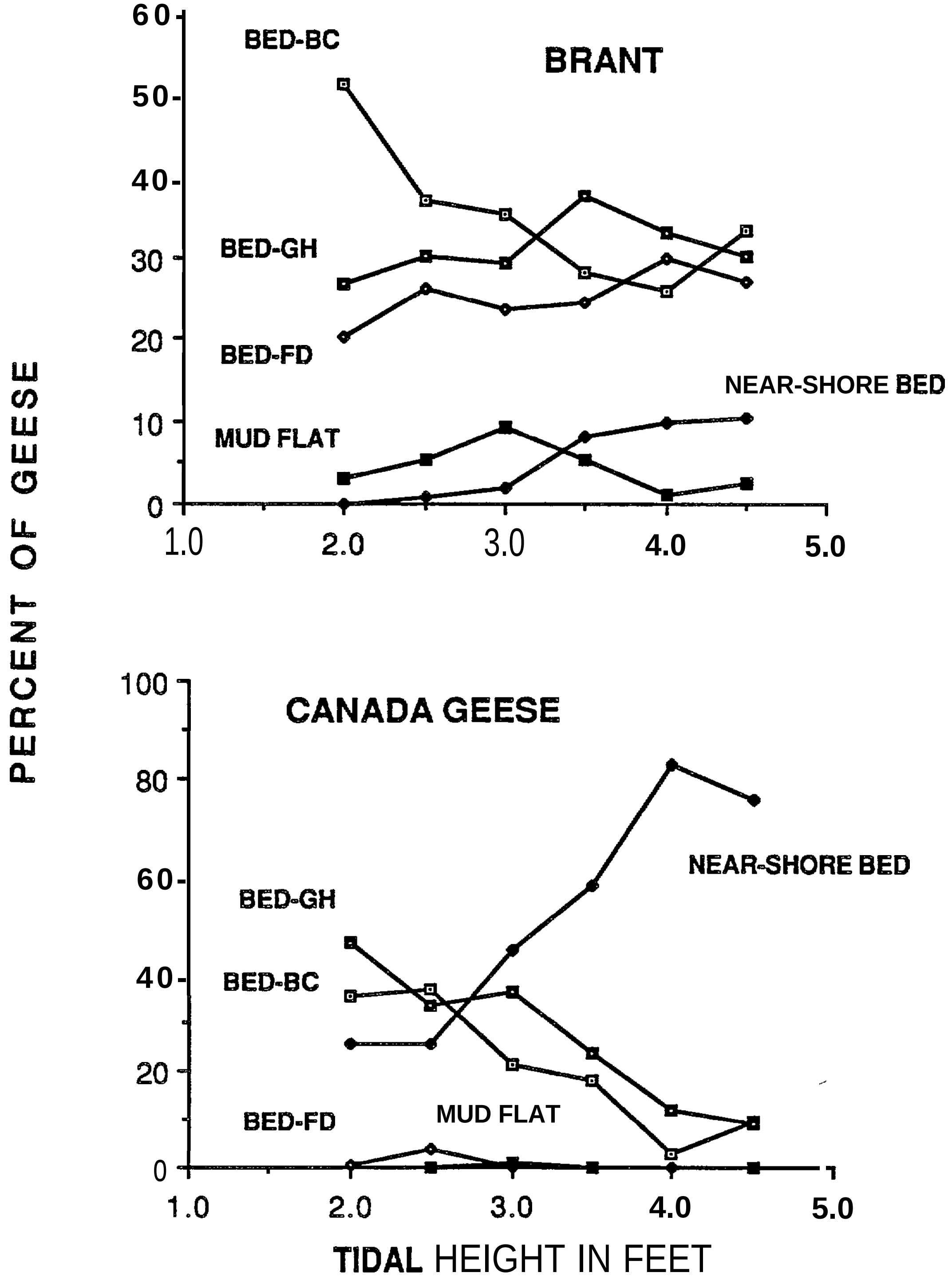

Figure 11. Proportion of brant and Canada geese within subareas (representing eelgrass beds and mud flats) of Norma Bay study area at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Means are calculated for tidal heights grouped into 0.5 ft. increments.

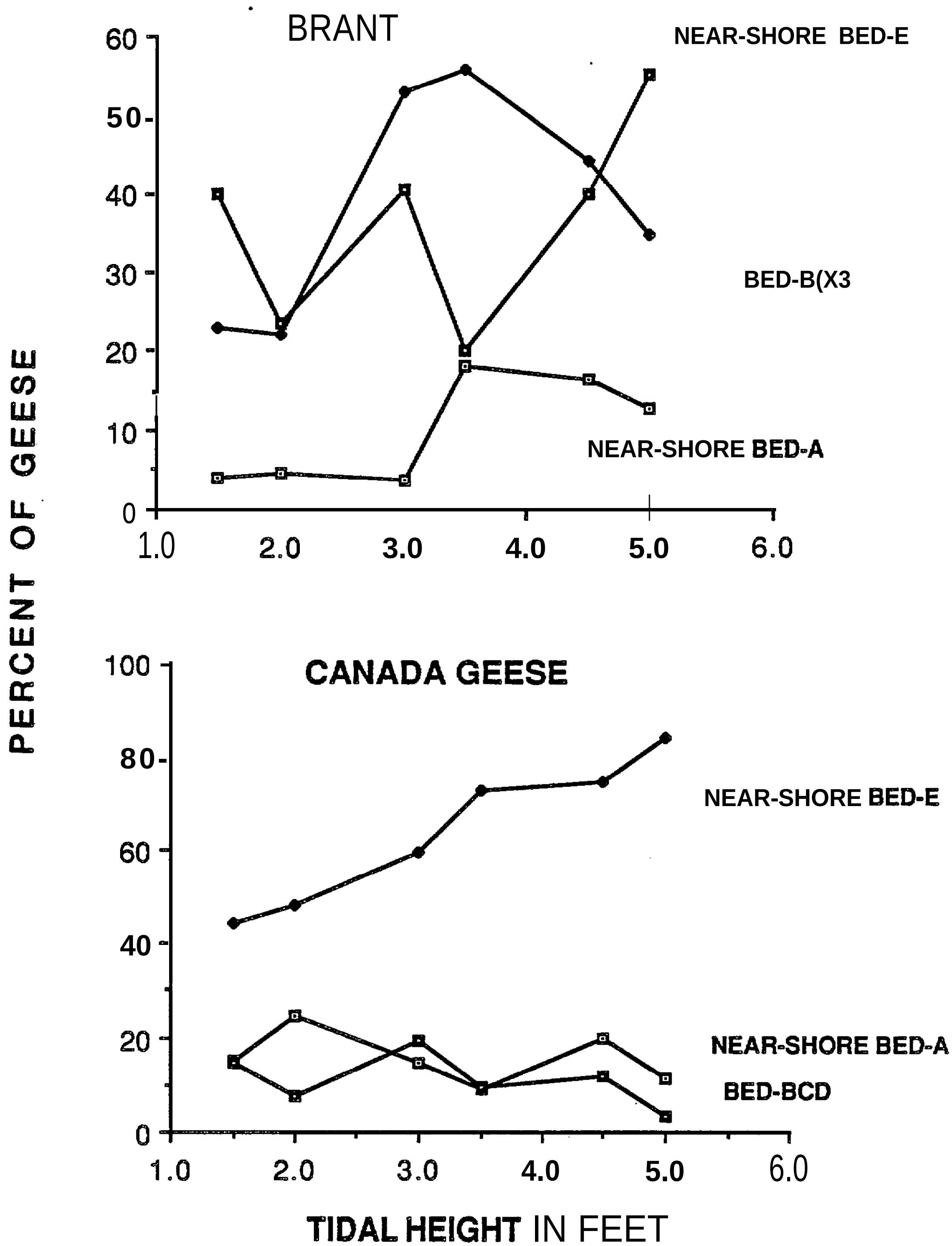

Figure 12. Proportion of brant and Canada geese within subareas (representing eelgrass beds and mud flats) of Applegate Cove study area at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Means are calculated for tidal heights grouped into 0.5 ft. increments.

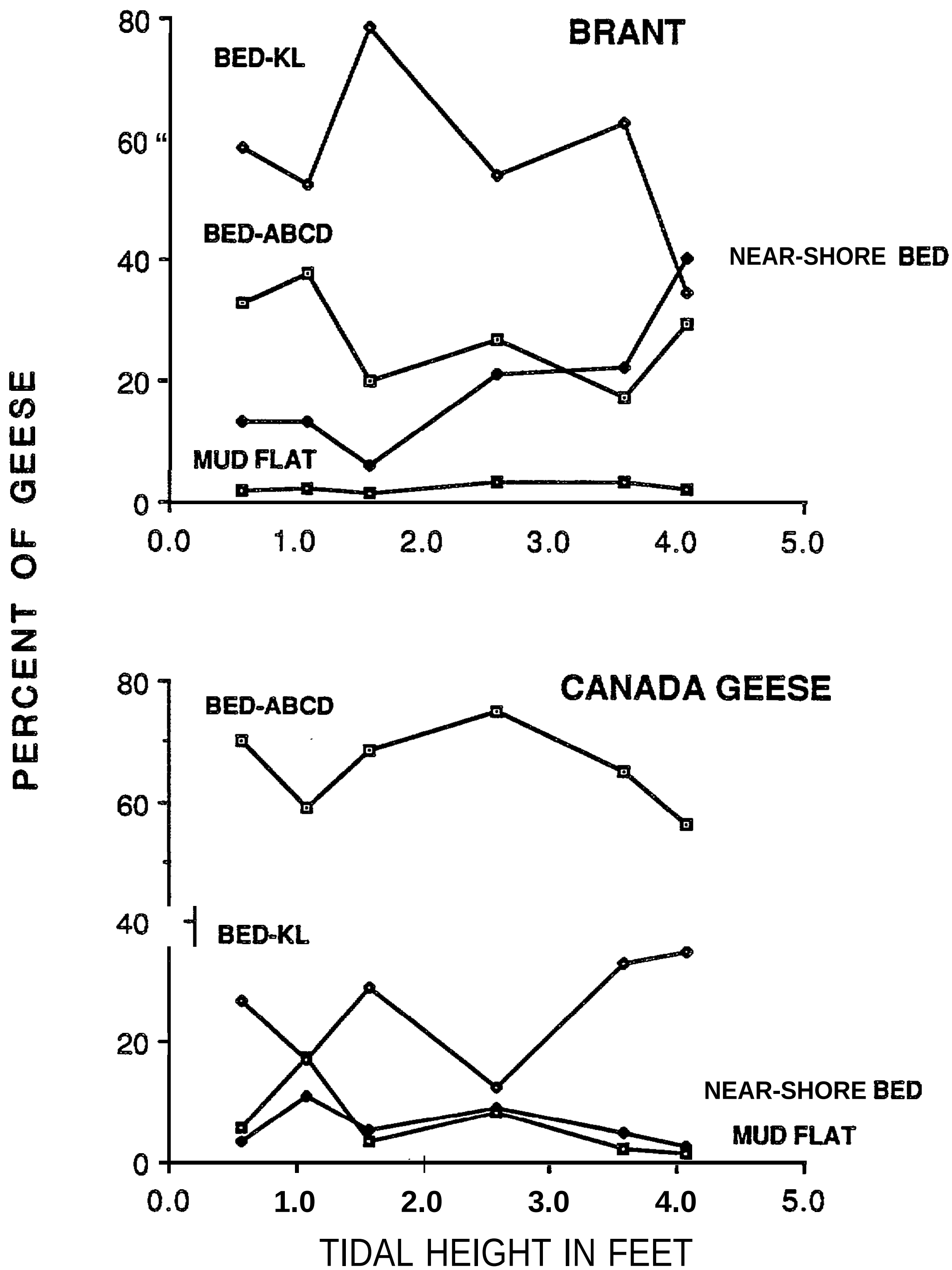

Figure 13. Proportion of brant and Canada geese within subareas (representing eelgrass beds and mud flats) of Halfway Point study area at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Means are calculated for tidal heights grouped into 0.5 ft. increments.

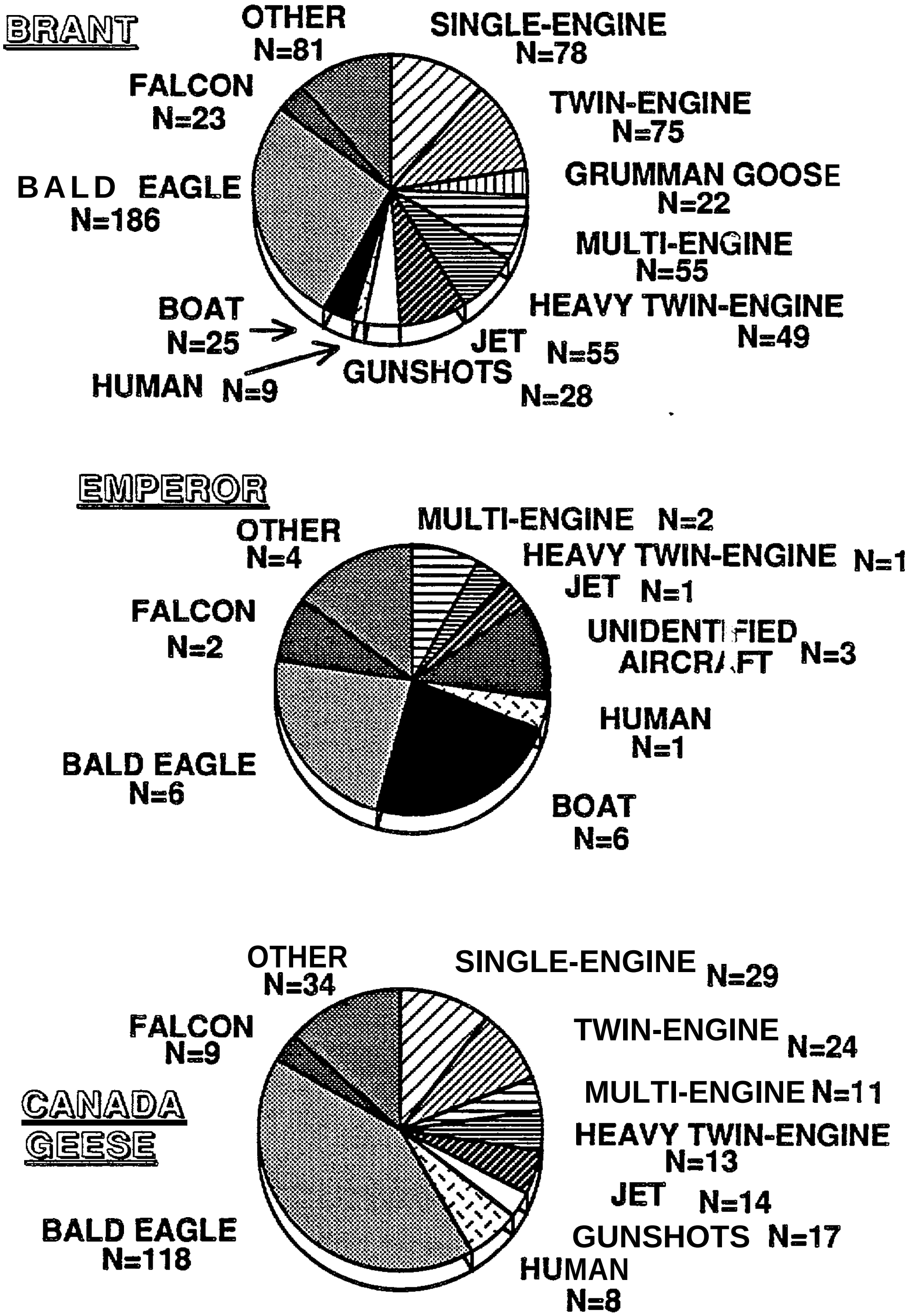

Figure 14. Frequency of potential disturbance events to goose flocks during 798 hours of observations at Izembek Lagoon, Alaska from 18 September to 31 October 1986.

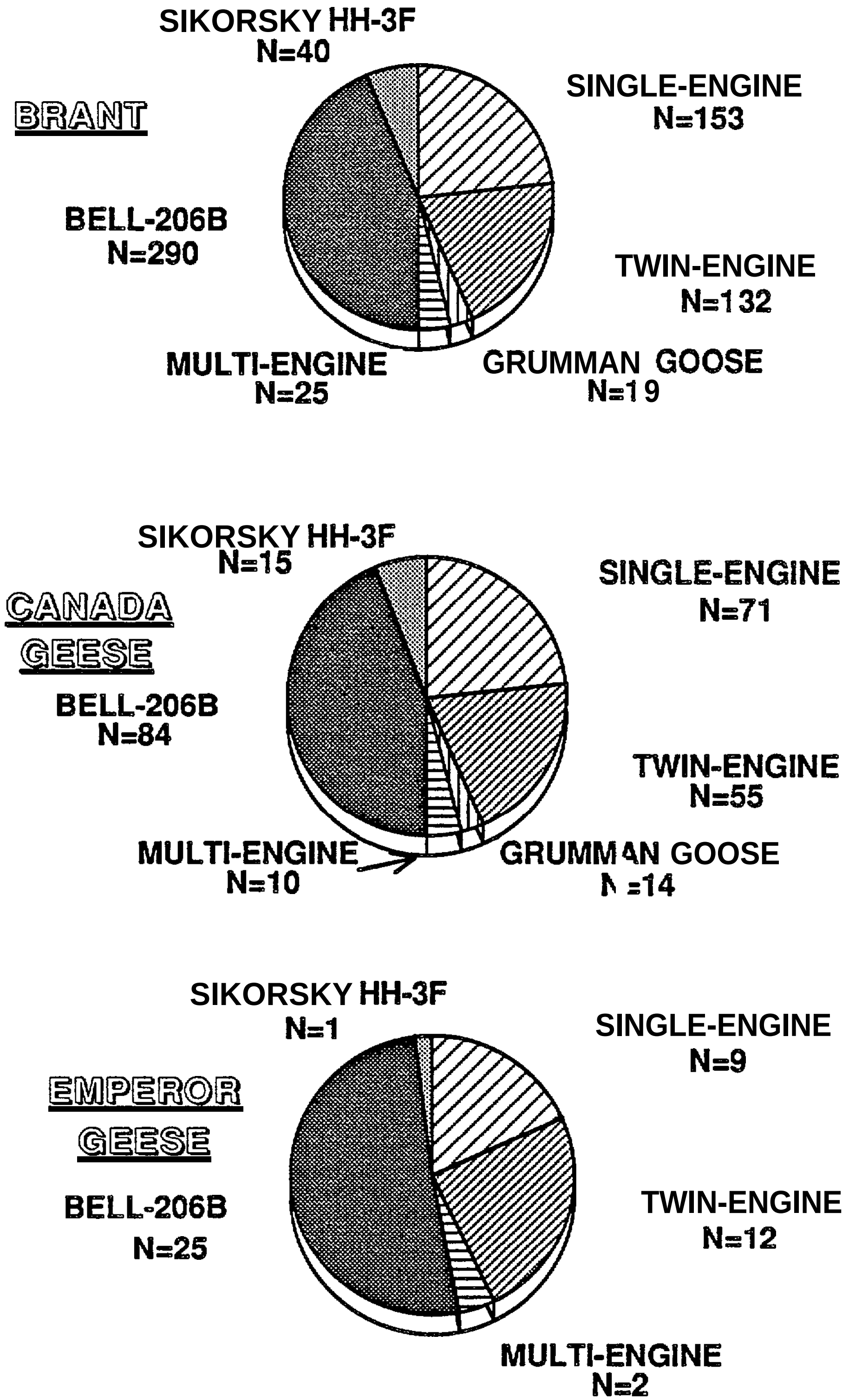

Figure 15. Frequency of potential disturbance events from experimental overflights to goose flocks at Izembek Lagoon, Alaska from 18 September to 31 October 1986.

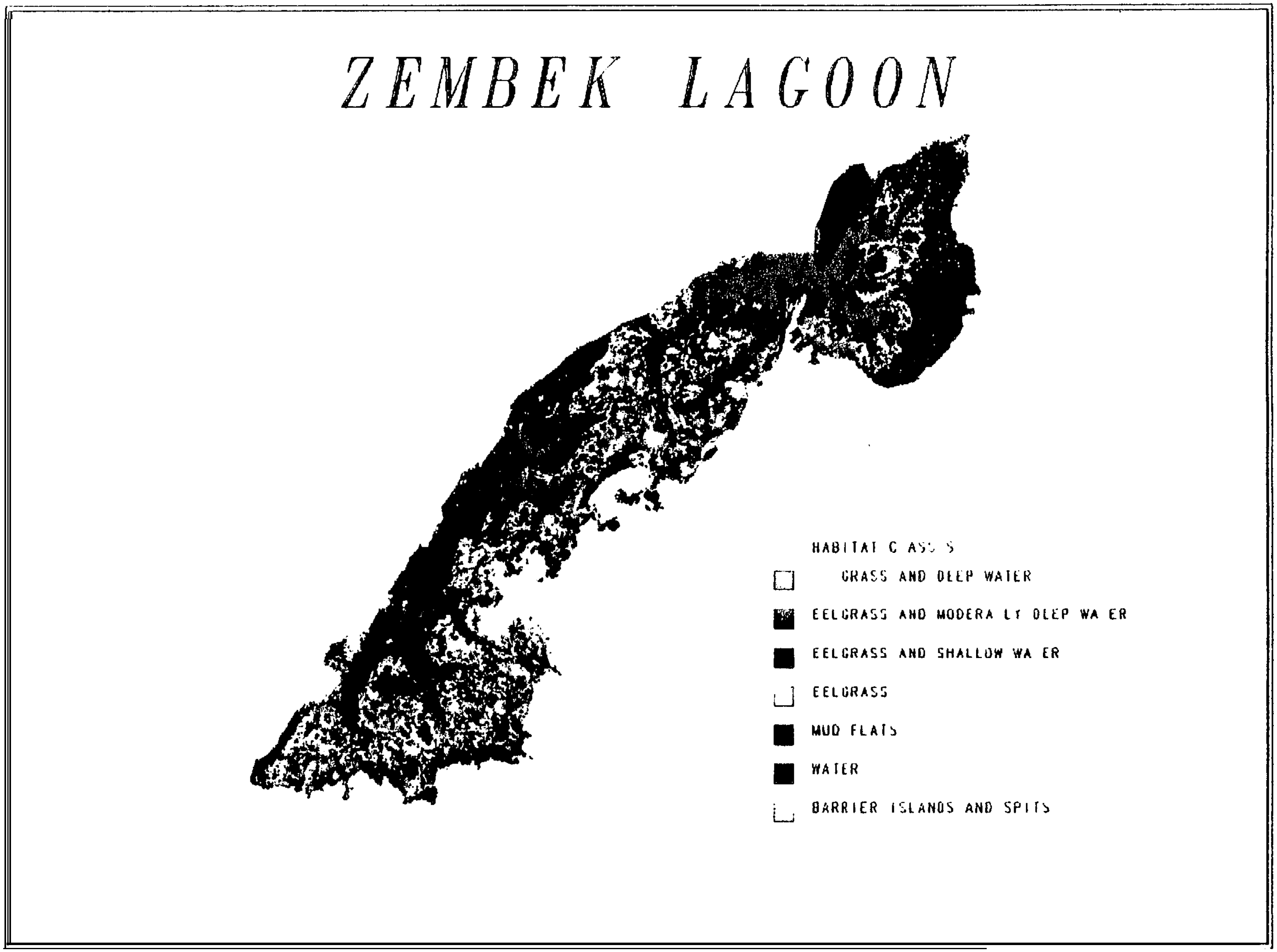

Figure 16. Habitat classes within Izembek Lagoon, Alaska as interpreted from a 1978 LANDSAT image.

Table 1. Schedule of five aerial surveys at Izembek Lagoon, Alaska from 18 September to 31 October 1986. The survey on 7 October was incomplete and continued on 8 October.

Date	Time	Pilot	Observer	Aircraft	Tide
3 October	1120-1237	B. Butler	C. Dau	Cessna 206	High
7 October	1530-1620	R. King	B. Eldridge	Cessna 185	High
8 October	1916-1945	R. King	D. Derksen	Cessna 185	Moderate
20 October	1020-1155	J. Sarvis	C. Dau	Arctic Tern	High
29 October	1105-1230	J. Sarvis	C. Dau	Arctic Tern	Low

le 2. Frequency and mean number of black brant (B), Canada geese (C), and emperor geese (E) at seven study areas at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of hourly counts is in parentheses.

dy a	Size (mi^2)	Species	Days with counts	Days with geese	Total counts	Counts with geese	Mean # geese/ mi^2	No. of geese present Mean	SD	Range
ma	4.2	B	22	22	121	121	732	'6,819	3,488	600-19,050
,		C	22	21	120	116	148	1,378	1,145	0-4,975
		E	22	2	121	3	0	0	1	0-5
legate	2.1	B	26	26	110	97	706	3,339	3,021	0-14,650
re		C	25	25	98	83	305	1,441	1,343	0-6,350
		E	22	0	93	0	0	0	0	0-o
fway	2.7	B	21	21	95	90	528	3,129	2,648	0-11,800
int		C	21	21	96	89	316	1,876	1,204	0-5,625
		E	21	20	95	63	37	146	180	0-1,025
und	0.8	B	17	13	103	57	415	774	1,530	0-11,100
Land		C	14	2	79	4	4	8	36	0-200
st		E	14	8	80	15	5	9	28	0-160
riding	0.7	B	12	11	77	51	627	945	1,279	0-5,800
land		C	12	0	77	0	0	0	0	0-o
		E	12	0	"77	0	0	0	0	0-o
ant	9.0	B	14	12	69	60	222	4,446	8,200	0-40,000
int		C	14	2	71	3	0	2	12	0-1oo
St		E	12	9	62	39	9	181	223	0-856
und	0.7	B	10	7	43	19	100	161	510	0-3,200
land		C	7	0	30	0	0	0	0	0-o
?St		E	8	1	31	1	0	0	2	0-9
otals	20.2	B	122	112	618	495	71	3,165	4,251	0-40,000
		C	115	71	571	295	19	854	1,201	0-6,350
		E	111	40	559	121	1	46	127	0-1,025

Table 3. Mean number of brant (B) Canada (C) and emperor geese (E) at Norma Bay, Applegate Cove and Halfway Point, during morning (<1200 h), mid-day (1200-1500 h) and evening (>1500 h) diurnal periods at Izembek Lagoon, Alaska. Canada geese were sampled at 3.0 ft tide. Number of hourly counts is given in parentheses.

Study area	Species	Mean number of geese			
		Early	Mid-day	Evening	F-Test[a]
Noms Bay	B	6503 (55)	7108 (24)	6792 (38)	NS
	C	2487 (37)	1109 (16)	1149 (16)	**
Applegate Cove	B	2820 (26)	3197 (28)	3489 (37)	NS
	C	1702 (20)	1302 (19)	1488 (21)	NS
Halfway Point	B	2853 (15)	2334 (27)	3873 (13)	NS
	C	2048 (15)	1967 (22)	2197 (9)	NS
	E	131 (15)	145 (26)	93 (13)	NS
Combined	B	3925 (96)	3756 (79)	3663 (88)	NS
	C	2178 (72)	1504 (57)	1509 (46)	*
	E	135 (15)	141 (26)	124 (13)	NS

a * denotes P< 0.0S, ** denotes P< 0.001 and NS= not significant.

Table 4. Frequency of potential disturbance events for all geese at Izembek Lagoon from 18 September to 31 October 1986.

Study area	Total time in blind (hours)	Oeya in blind	Mean hours/ day in blind	Nean number of disturbances par hour		Number and percent of potential disturbance eventa: Fixed-wing aircraft AC	AH	AJ	AN	AS	AO	AT	A	Helicopter SS	HL	Other B	P	G[d]	E	F	M	U	TOTALS
Grant Point (West)	61.5	14	4.4	2.5 (1.2)[a]	n	1	7	7	11	9	7	23	0	34	14	20	0	3	7	2	0	8	153
					%	1*3	10.5	9.1	9.2	2.6	25.9	8.5	0	8.4	20.6	64.5	0	11.5	2.2	5.6	0	8.3	7.5
Round Island (Seat)	108.6	14	7.8	1.5 (0.7)	n	4	12	11[b]	12	34		12	2	3	6	3	0 4	9	6	3	0	14	166
					x	51	17.9	14.3	10.1	9.9	14.8	4.4	8.3	8.9′	4.4	0	, 12.9	34.6	1.9	8.3	0	14.4	8.2
Half way Point	113.6	21	5.4	3.5 (1.6)	n	19	10	37′	49	55	1	53	0	91	6	0	21	6	18	14	1	20	401
					%	24.1	14.9	48.0	41.2	16.0	3.8	19.6	0	22.5	8*8	o	67.7	23.1	5.6	38.9	8.3	20.6	19.8
Applegate Cove	151.1	23	6.6	2.3 (1.1)	n	9	12	6	5	53	“4	59	0	92	17	0	0	1	84	2	3	1	348
					%	11.4	17.9	7.8	4.2	15.5	14.8	21.9	0	22.8	25.0	0	0	3*9	26.3	5.6	25.0	1.0	17.2
Bending Island	86.1	12	6.6	2.6 (1.1)	n	2	9	4	12	36	4	44	5	55	0	2	2	3	21	4	0	17	22U
					%	2.5	13.4	5.2	10.1	10.5	14. s	16.3	20.8	13.6	0	6.5	6.5	11.S	6.6	11.1	0	18.6	10.8
Norma Bay	196. b	22	8.9	2.9 (1.8)	n	32	12	2b	16	122	7	78	13	73	0	3	0	0	164	10	8	31	571
					%	40.5	17.9	2.6	13.4	35.6	25.9	28.9	54.2	18.1	0	9.7	0	0	51.4	27.8	b6.7	34.0	28.2
Other[c]	81.1	23	3.5	2.1 (1.1)	n	12	5	10[b]	14	34	0	1	4	23	28	6	4	4	19	1	0	3	168
					x	15.1	7.5	13.0	11.8	9*9	0	0.4	16.7	5.7	41.2	19.3	12.9	15.4	6.0	2.8	0	3.1	8.3
TOTALS	798.6	32			n	79	67	77	119	343	27	270	24	404	68	31	31	26	319	36	12	94	2027
					X	3.9	3.3	3.8	5.9	16.9	1.3	13.3	1.2	19*9	3.4	1.5	1.5	1*3	15.7	1.8	1).6	4.7	

Fixed-wing aircraft: AC - Grumman Goose; AH - Heavy twin-engine (e.g. YS-11); AJ - Jet (e.g. Boeing 727); AN - Heavy multi-engine (e.g.′ Lockheed C-130, Electra); AS - Single-engine propeller (e.g. Arctic Tern); AT - Small twin-engine propeller (e.g. Piper Navajo); AO Twin Otter; A - Unidentified aircraft

Helicopter: HS - Small (e.g. Bell 206); HL - Large (e.g. Sikorsky HH-3F)

B - Boats; P - Person\ G - Gunshots; E - Eagle; F - Falcon; M - Miscellaneous (Northern Harrier, Raven, Wolf); U - Unidentified Cause

[a] ( ) = mean number of potential disturbances per hour excluding experimental overflight.

[b] Includes one or sore disturbances caused by small jet aircraft (e.g. Rockwell Sabreliner).

[c] Includes Grant Point Seat, Round Island West, Applegate Cove North, Quarter Point, and Outer Marker study areaa.

[d] Includes six combined gunshot and person disturbances.

Table 5. Summary of experimental aircraft overflights at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Flight paths are shown in Figure 6 unless noted.

Aircraft. type	Altitude (ft)	No. of flight lines	No. flocks observed		
			Brant	Canada	Emperor
Fixed wing aircraft					
Single-engine	150	2a	7	1	0
	200	4a	10	1	0
	300	7a	14	0	0
	500	12[a]	25	15	1
	800	1[a]	4	2	0
	1000	16	49	32	2
	1200	1[a]	1	0	0
	1500	3a	3	3	0
	2000	5a	13	12	6
	2500	9[a]	21	5	0
	Subtotals	60	147	71	9
Twin-engine	500	19	77	32	7
	1000	10	54	12	1
	Subtotals	29	131	44	8
Grumman goose	500	1[b]	4	3	1
	1000	4	7	8	1
	2000	4	8	8	1
	3000	4	6	10	1
	subtotals	13	25	29	4
Twin otter	300	6[e]	18	1	0
	1000	1	3	0	0
	Subtotals	7	21	1	0
Multi-engine	1000	1[b]	14	6	2
	1700	1[b]	6	3	0
	2000	3a	5	1	0
	Subtotals	5	25	10	2
	Totals	114	354	155	23

Table 5. Continued.

Aircraft type	Altitude (ft)	No. of flight lines	No. flocks observed		
			Brant	Canada	Emperor
Helicopters					
Bell 206-B	300	13	84	15	3
	700	2[a]	3	3	0
	850	1[d]	0	1	0
	900	1[d]	4	0	0
	1000	30	139	48	15
	1500	1	3	3	0
	3000	11	57	14	7
	Subtotals	59	290	84	25
Sikorsky HH-3F	1500	3[c]	45	15	1
	Subtotals	62	335	99	26
All aircraft	Grand totals	176	689	254	49

[a] Some overflights did not follow the standardized flight lines depicted in Figure 3. One single-engine overflight at 300, "1500 and 2000 ft, one Bell 206B helicopter overflight at 700 ft, and five single-engine overflights at 500 ft were flown along different flight paths.
[b] Flight paths are shown in Figure 7.
[c] Flight paths are shown in Figure 8.
[d] One overflight - aircraft was ascending when flocks were being observed.
[e] Flight. paths were oriented north/south at 2.0 mile intervals across the . entire lagoon.

Table 6. proportion of brant flocks exhibiting a >80% No Change (NC), Alert+Mass (ALM) or Rise+Circle+Depart (FLY) behavioral response to single-engine, twin-engine, Grumman Goose, multi-engine or small helicopter (Bell 206B) 1000 ft experimental overflights at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Aircraft	Actual distance (mi)	Behavioral response category		
		NC	ALM	FLY
Single-engine				
	0.0 - 0.24	75.0 (8)	25.0 (8)	0.0 (9)
	0.25 - 0.49	41.7 (12)	0.0 (12)	33.3 (12)
	0.50 - 0.99	37.5 (8)	25.0 (8)	30.3 (lo)
	>0.99	11.8 (17)	64.7 (17)	11.1 (18)
	Totals	45	45	49
Twin-engine				
	0.0 - 0.24	20.0 (20)	36.8 (19)	10.0 (20)
	0.25 - 0.49	71.4 (7)	14.3 (7)	0.0 (7)
	0.50 - 0.99	42.9 (7)	14.3 (7)	0.0 (8)
	>0.99	90.0 (lo)	0.0 (lo)	9.1 (11)
	Totals	44	43	46
Grumman goose				
	0.0 - 0.24	33.3 (3)	66.7 (3)	0.0 (3)
	0.25 - 0.49	100.0 (1)	0.0 (1)	0.0 (1)
	0.50 - 0.99	0.0 (1)	0.0 (1)	0.0 (1)
	>0.99	50.0 (2)	50.0 (2)	0.0 (2)
	Totals	7	7	7
Multi-engine				
	0.0 - 0.24	0.0 (3)	33.3 (3)	66.7 (3)
	0.25 - 0.49			
	0.50 -.0.99	25.0 (4)	25.0 (4)	50.0 (4)
	>0.99	50.0 (2)	0.0 (2)	50.0 (2)
	Totals	9	9	9
Small helicopter				
	0.0 - 0.24	37.0 (27)	37.0 (27)	21.4 (28)
	0.25 - 0.49	16.7 (12)	41.7 (12)	38.5 (13)
	0.50 - 0.99	29.3 (41)	15.0 (40)	40.9 (44)
	70.99	60.0 (30)	10.0 (30)	15.6 (32)
	Totals	110	109	117

Table 7. Proportion of Canada goose flocks exhibiting a >80% No Change (NC), Alert+Mass (ALM) or Rise+Circle+Depart (FLY) behavioral response to single-engine, twin-engine, Grumman Goose, multi-engine or small helicopter (Bell 206B) 1000 ft experimental overflights at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Aircraft	Actual distance (mi)	Behavioral response category		
		NC	ALM	FLY
Single-engine				
	0.0 - 0.24	100.0 (lo)	0.0 (lo)	0.0 (13)
	0.25 - 0.49	100.0 (4)	0.0 (4)	0.0 (4)
	0.50 - 0.99	100.0 (8)	0.0 (6)	0.0 (9)
	‘0.99	100.0 (2)	O*O (2)	0.0 (2)
	Totals	22	22	28
Twin-engine				
	0.0 - 0.24	60.0 (5)	20.0 (5)	0.0 (5)
	0.25 - 0.49	100.0 (1)	0.0 (1)	0.0 (1)
	0.50 - 0.99	100.0 (1)	0.0 (1)	0.0 (1)
	>0.99	100.0 (1)	O*O (1)	0.0 (1)
	Totals	8	8	8
Grumman goose				
	0.0 - 0.24	100.0 (6)	0.0 (6)	0.0 (6)
	0.25 - 0.49	100.0 (1)	0.0 (1)	O*O (1)
	0.50 - 0099			
	>0.99	100.0 (1)	0.0 (1)	0.0 (1)
	Totals	8	8	8
Multi-engine				
	0.0 - 0.24			
	0.25 - 0.49			
	0.50 -..0.99	0.0 (1)	100.0 (1)	0.0 (1)
	>0.99	0.0 (1)	0.0 (1)	100.0 { 1)
	Totals	2	2	2
Small helicopter				
	0.0 - 0.24	66.7 (6)	33.3 (6)	0.0 (6)
	0.25 - 0.49	50.0 (2)	0.0 (2)	0.0 (3)
	0.50 - 0.99	94.1 (17)	0.0 (17)	5.6 (18)
	>0.99	87.5 (8)	12.5 (8)	0.0 (9)
	Totals	33	33	36

Table 8. Proportion of brant flocks exhibiting a ≥80% No Change (NC), Alert-l-Mass (ALM) or Rise+Circle+Depart (FLY) behavioral response to single-engine experimental overflights at three altitudes at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category		
		NC	ALM	FLY
≥150 ≤500				
	0.0 - 0.24	10.0 (lo)	40.0 (lo)	50.0 (lo)
	0.25 - 0.49	0.0 (11)	0.0 (11)	90.9 (11)
	0.50 - 0.99	23.5 (17)	5.9 (17)	66.7 (18)
	>0.99	18.2 (11)	0.0 (11)	75.0 (12)
	Totals	49	49	51
1,000				
	0.0 - 0.24	75.0 (8)	25.0 (8)	0.0 (9)
	0.25 - 0.49	41.7 (12)	0.0 (12)	33.3 (12)
	0.50 -0.99	37.5 (8)	25.0 (8)	30.0 (lo)
	>0.99	18.2 (17)	64.7 (17)	11.1 (18)
	Totals	45	45	49
≥2,000 ≤2,500				
	0.0 - 0.24	90.9 (11)	0.0 (11)	7.7 (13)
	0.25 - 0.49	50.0 (6)	0.0 (6)	50.0 (6)
	0.50 - 0.99	62.5 (8)	37.5 (8)	0.0 (8)
	>0.99	50.0 (6)	16.7 (6)	33.3 (6)
	Totals	31	31	33

Table 9. Proportion of Canada goose flocks exhibiting a >80% No Change (NC), Alert+Mass (ALM) or Rise+Circle+Depart (FLY) behavioral response to single engine experimental overflights at three altitudes at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category NC	ALM	FLY
>150 <500				
	O*O - 0.24	80.0 (5)	0.0 (5)	0.0 (5)
	0.25 - 0.49	0.0 (1)	100.0 (1)	0.0 (1)
	0.50 - 0.99	75.0 (4)	O*O (4)	25.0 (4)
	>0.99	66.7 (3)	0.0 (3)	33.3 (3)
	Totals	13	13	13
1,000				
	0.0 - 0.24	100.0 (lo)	0.0 (lo)	0.0 (lo)
	0.25 - 0.49	100.0 (4)	O*O (4)	0.0 (4)
	0.50 - 0.99	100.0 (6)	0.0 (6)	0.0 (6)
	>0.99	100.0 (2)	0.0 (2)	0.0 (2)
	Totals	22	22	22
>2,000 <2,500				
	0.0 - 0.24	100.0 (6)	0.0 (6)	0.0 (6)
	0.25 -0.49	100.0 (1)	0.0 (1)	0.0 (1)
	0.50 - 0.99	100.0 (4)	0.0 (4)	0.0 (4)
	>().99	50.0 (2)	50.0 (2)	0.0 (2)
	Totals	13	13	13

Table 10. Proportion of brant flocks exhibiting a ≥80% No Change (NC), Alert+Mass (ALM) or Rise+Circle+Depart (FLY) behavioral response to twin-engine experimental overflights at 500 and 1,000 ft at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category NC	ALM	FLY
500				
	0.0 - 0.24	14.3 (28)	17.9 (28)	32.1 (28)
	0.25 - 0.49	88.9 (9)	0.0 (9)	0.0 (9)
	0.50 - 0.99	62.5 (16)	0.0 (16)	5.9 (17)
	>0.99	100.0 (7)	0.0 (7)	0.0 (7)
	Totals	60	60	61
1,000				
	0.0 - 0.24	20.0 (20)	36.8 (19)	10*O (20)
	0.25 - 0.49	71.4 (7)	14.3 (7)	0.0 (7)
	0.50 - 0.99	42.9 (7)	14.3 (7)	0.0 (8)
	>0.99	90.0 (10)	0.0 (lo)	9.1 (11)
	Totals	44	43	46

Table 11. Proportion of Canada goose flocks exhibiting a ≥80% No Change (NC), Alert+Mass (ALM) or Rise+Circle+Depart (FLY) behavioral response to twin-engine experimental overflights at 500 and 1,000 ft at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocksis in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category NC	ALM	FLY
500				
	0.0 - 0.24	66.7 (6)	16.7 (6)	0.0 (6)
	0.25 - 0.49	100.0 (3)	0.0 (3)	0.0 (3)
	0.50 - 0.99	100.0 (5)	0.0 (5)	0.0 (5)
	>0.99	66.7 (3)	0.0 (3)	0.0 (3)
		17	17	17
1,000				
	0.0 - 0.24	60.0 (5)	20.0 (5)	0.0 (5)
	0.25 - 0.49	100.0 (1)	0.0 (1)	0.0 (1)
	0.50 - 0.99	100.0 (1)	0.0 (1)	0.0 (1)
	>0.99	100.0 (1)	0.0 (1)	0.0 (1)
	Totals	8	8	8

Table 12. Proportion of Canada goose flocks exhibiting a $\geq$80% No Change (NC), Alert+Mass (ALM) or Rise+Circle+Depart (FLY) behavioral response to small helicopter (Bell 206B) experimental overflights at 300, 900-1,000 and 3,000 ft at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category		
		NC	ALM	FLY
300				
	0.0 - 0.24	0.0 (2)	100.0 (2)	0.0 (2)
	0.25 - 0.49			. -
	0.50 - 0.99	100.0 (4)	0.0 (4)	0.0 (4)
	>0.99	100.0 (7)	0.0 (7)	0.0 (7)
	Totals	13	13	13
$\geq$900 $\leq$1,000				
	0.0 - 0.24	66.7 (6)	33.3 (6)	0.0 (6)
	0.25 - 0.49	50.0 (2)	0.0 (2)	0.0 (3)
	0.50 - 0.99	94.1 (17)	0.0 (17)	5.5 (18)
	>0.99	87.5 (8)	12.5 (8)	0.0 (9)
	Totals	33	33	36
3,000				
	0.0 - 0.24	100.0 (1)	0.0 (1)	0.0 (1)
	0.25 -0.49	100.0 (3)	0.0 (3)	0.0 (3)
	0.50 - 0.99	100.0 (5)	0.0 (5)	0.0 (5)
	>0.99	100.0 (4)	0.0 (4)	0.0 (4)
	Totals	13	13	13

Table 13. Proportion of brant flocks exhibiting a ≥80% No Change (NC), Alert+Mass (ALM) or Rise+Circle+Depart (FLY) behavioral response to small helicopter (Bell 206B) experimental overflights at 300, 900-1,000 and 3,000 ft at Izembek Lagoon, Alaska from 18 September to 31 October. Total number of observed flocks is in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category NC	ALM	FLY
300				
	0.0 - 0.24	46.7 (15)	0.0 (15)	40.0 (15)
	0.25 - 0.49	7.7 (13)	0.0 (13)	78.6 (14)
	0.50 - 0.99	27.8 (18)	0.0 (18)	52.2 (23)
	>0.99	58.8 (17)	11.8 (17)	18.2 (22)
	Totals	63	63	74
>900 ≤1,000				
	0.0 - 0.24	37.0 (27)	37.0 (27)	21.4 (28)
	0.25 - 0.49	16.7 (12)	41.7 (12)	38.5 (13)
	0.50 - 0.99	29.3 (41)	15.0 (40)	40.9 (44)
	>0.99	60.0 (30)	6.7 (30)	15.6 (32)
	Totals	110	109	117
3,000				
	0.0 - 0.24	25.0 (8)	28.6 (7)	25.0 (8)
	0.25 - 0.49	0.0 (2)	0.0 (2)	66.7 (3)
	0.50 - 0.99	57.1 (21)	4.8 (21)	27.3 (22)
	>0.99	20.0 (15)	13.3 (15)	52.9 (17)
	Totals	46	45	50

Table 14. Proportion of brant and Canada goose flocks exhibiting a $\geq$80% No Change (NC), Alert+Mass (ALM) or Rise+Circle+Depart (FLY) behavioral response to large helicopter (Sikorsky HH-3F) experimental overflights at 1,500 ft at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Species	Actual distance (mi)	Behavioral response category NC	ALM	FLY
Brant				
	0.0 - 0.24	0.0 (4)	0.0 (4)	100.0 (4)
	0.25 - 0.49			
	0.50 - 0.99	0.0 (6)	50.0 (6)	16.7 (6)
	>0.99	60.0 (30)	6.7 (30)	25.8 (31)
	Totals	40	40	41
Canada geese				
	0.0 - 0.24			
	0.25 - 0.49			-
	0.50 - 0.99	33.3 (3)	0.0 (3)	33.3 (3)
	>0.99	63.6 (11)	18.2 (11)	0.0 (11)
	Totals	14	14	14

Table 15. Proportion of brant flocks exhibiting a ≥90% No Change (NC), Alert+Mass (ALM), or Rise+Circle+Depart (FLY) behavioral response to single-engine incidental aircraft overflights at 200, 500, and 1000 ft at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category NC	ALM	FLY
200				
	0.0 - 0.24	0.0 (1)	0.0 (1)	100.0 (1)
	0.25 - 0.49	0.0 (4)	0.0 (4)	100.0 (4)
	0.50 - 0.99	50.0 (2)	50.0 (2)	50.0 (2)
	>0.99	50.0 (2)	0.0 (2)	50.0 (2)
	Totals	9	9	9
500				
	0.0 - 0.24	75.0 (4)	0.0 (4)	25.0 (4)
	0.25 - 0.49	0.0 (1)	0.0 (1)	0.0 (“1)
	0.50 - 0.99	40.0 (5)	20.0 (5)	40.0 (5)
	>0.99	71.4 (7)	14.3 (7)	14.3 (7)
		17	17	17
1000				
	0.0 - 0.24	- -	- -	- -
	0.25 - 0.49	- (1)	- (1)	- (1)
	0.50 - 0.99			
	>0.99	92.3 (13)	0.0 (13)	7.7 (13)
	Totals	14	14	14

Table 16. Proportion of brant flocks exhibiting a ≥80% No Change (NC), Alert+Mass (ALM), or Rise+Circle+Depart (FLY) response to twin-engine incidental aircraft overflights at 500, 1500, and 2000 ft at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category		
		NC	ALM	FLY
500				
	0.0 - 0.24			
	0.25 - 0.49	0.0 (3)	66.7 (3)	33.3 (3)
	0.50 - 0.99	14.3 (7)	42.9 (7)	42.9 (7)
	>0.99	100.0 (1)	0.0 (1)	0.0 (1)
	Totals	11	11	11
1500				
	0.0 - 0.24	100.0 (1)	0.0 (1)	0.0 (1)
	0.25 - 0.49			
	0.50 - 0.99	100.0 (1)	0.0 (1)	0.0 (1)
	>0.99	63.6 (11)	18.2 (11)	18.2 (11)
	Totals	13	13	13
2000				
	0.0 - 0.24	100.0 (2)	0.0 (2)	0.0 (2)
	0.25 - 0.49			
	0.50 - 0.99			–
	>0.99	100.0 (5)	0.0 (5)	0.0 (5)
	Totals	7	7	7

Table 17. Proportion of brant flocks exhibiting a >80% No Change (NC), Alert+Mass (ALM), or Rise+Circle+Depart (FLY) behavioral response to Grumman Goose incidental aircraft overflights at 1000 ft at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category NC	ALM	FLY
1000				
	0.0 - 0.24			
	0.25 - 0.49			
	0.50 - 0.99	50.0 (2)	0.0 (2)	O*O (2)
	>0.99	20.0 (5)	0.0 (5)	80.0 (5)
	Totals	7	7	7

Table 18. Proportion of brant flocks exhibiting a ≥80% No Change (NC), Alert+Mass (AIM), or Rise+Circle+Depart (FLY) behavioral response to jet aircraft (AJ) incidental overflights at 1500 and 5000 ft at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category NC	ALM	FLY
1500				
	0.0 - 0.24	0.0 (1)	0.0 (1)	100.0 (1)
	0.25 - 0.49			
	0.50 - 0.99			–
	>0.99	42.9 (7)	i4.3 (7)	14.3 (7)
	Totals	8	8	8
5000				
	0.0- - 0.24	0.0 (1)	0.0 (1)	100.0 (1)
	0.25 -0.49			
	0.50 -0.99			
	>0.99	93.3 (14)	0.0 (14)	0.0 (14)
	Totals	15	15	15

Table 19. Proportion of brant flocks exhibiting a_s30% No Change (NC), Alert+Mass (ALM), or Rise+Circle+Depart (FLY) behavioral response to eagles at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Altitude (mi)	Actual distance (mi)	Behavioral response category ALM	FLY	
0-100				
	0.0 - 0.24	2.4 (41)	0.0 (41)	95.2 (42)
	0.25 - 0.49	4.3 (23)	4.3 (23)	65.2 (23)
	0.50 - 0.99	7.7 (26)	3.8 (26)	85.2 (27)
	>0.99			
	Totals	90	90	92
101-300				
	0.0 - 0.24	0.0 (16)	0.0 (16)	87.5 (16)
	0.25 - 0.49	0.0 (9)	22.2 (9)	77.8 (9)
	0.50 - 0.99	9.1 (11)	18.2 (11)	72.7 (11)
	>0.99			
	Totals	36	36	36

Table 20. Proportion of Canada goose flocks exhibiting a >80% No Change (NC), Alert+Mass (ALM), or Rise+Circle+Depart (FLY) behavioral response to eagles at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Total number of observed flocks is in parentheses.

Altitude (ft)	Actual distance (mi)	Behavioral response category NC	ALM	FLY
0-100				
	0.0 - 0.24	0.0 (34)	11.8 (34)	73.5 (34)
	0.25 - 0.49	0.0 (10)	40.0 (10)	60.0 (10)
	0.50 - 0.99	28.6 (7)	28.6 (7)	42.9 (7)
	>0.99			
	Totals	51	51	51
101-300				
	0.0 - 0.24	0.0 (16)	12.5 (16)	68.7 (16)
	0.25 - 0.49	16.7 (6)	0.0 (6)	66.7 (6)
	0.50 - 0.99	33.3 (3)	0.0 (3)	50.0 (4)
	>0.99	0.0 (1)	0.0 (1)	100.0 (1)
	Totals	26	26	27

Table 24. Proportion of brant flocks exhibiting a ≥80% behavioral response (NC = No Change, ALM = Alert+Mass, FLY = Rise+Circle+Depart) to experimental overflights (single-engine+twin-engine+small helicopter) at low (≤2.4 ft) and high (>2.4 ft) tide levels with respect to flock distance to aircraft at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Aircraft altitude = 1000 ft.

Distance (mi)	Tidal height (ft)	N	Percent of flocks responding NC	ALM	FLY
0.0-0.49					
	≤2.4	59	50.0	13.6	16.7
	> 2.4	204	32.4	35.8	20.3
0.50-0.99					
	≤ 2.4	45	33*3	20.0	33.3
	> 2.4	117	34.2	18.9	28.6
>0.99					
	≤2.4	75	37.5	48.8	7.4
	>2 .4	109	61.1	8.3	16.2

Table 25. Proportion of brant flocks exhibiting a >80% behavioral response (NC = No Change, ALM = Alert+Mass, FLY = Rise+Circle+Depart) to experimental overflights (single-engine, twin-engine, small helicopter) at low (≤2.4 ft) and high (>2.4 ft) tide levels at Izembek Lagoon, Alaska from 18 September to 31 October 1986. Aircraft altitude ≈1000 ft. All brant flocks were 0.5 mi from the aircraft.

Aircraft	Tidal Height (ft)	N	Percent of flocks responding		
			NC	ALM	FLY
Single-engine					
	≤2.4	25	75.0	12.5	11.1
	>2.4	27	55.5	11.1	0.0
Twin-engine					
	≤2.4	24	37.5	12.5	0.0
	>2.4	46	31.6	38.9	10.5
Small helicopter					
	≤2.4	13	50,0	25.0	20.0
	>2.4	106	28.6	40.0	27.8
All aircraft					
	≤2.4	68	50.0	13.6	16.7
	>2.4	204	32.3	35.8	20.3

Table 26. Flight duration (seconds) of Rise, Circle, and Depart behavioral response categories for geese at Izembek Lagoon, Alaska from 18 September to 31 October 1986.

Species		Flight duration in seconds		
		Rise	Circle	Depart
Brant	$\bar{X}$ + S.E.	33.18 ± 4.71	96.3123.37	129.26 ± 5.20
	range	5 -110	10 - 418	25 - 642
	n	27	291	214
Canada geese	$\bar{X}$ + S.E.	25.77 ± 3.01	93.5829.23	115.59 + 11.13
	range	5 - 65	15 -419	16 - 360
	n	26	55	46
Canada and emperor geese	$\bar{X}$ ± S.E.	25.77 ± 3.01	90.41 ± 8.77	115.86 ± 10.55
	range	5 - 65	15 -419	16 - 360
	n	26	59	49
All geese	$\bar{X}$ ± S.E.	29.55 ± 2.84	95.31 ± 3.16	126.76 ± 4.67
	range	5 - 110	10 - 419	16 - 642
	n	53	350	263

Table 27. Percent cover estimates of three primary habitat classes (as interpreted from 1978 LANDSAT Imagery of Izembek Lagoon) in five zones of Izembek Lagoon, Alaska. See Figure 3 for location of zones.

Habitat	Percent cover estimates in zones					
	1	2	3	4	5	Totals
Eelgrass	10.8	8.4	8.1	13.0	5.5	45.8.
Mud Flat	3*3	1.2	11.5	5.0	16.0	37.0
Water	2.3	2.3	3.4	5.8	3.4	17.1
Totals	16.4	11.8	23.0	23.9	24.9	100

Table 28. Nutrient content of eelgrass at low (L) and high (H) tidal heights from Applegate Cove (AC), Grant Point East (GE), Quarter Point (QP), Halfway Point (HP), and Round Island East (RE) at Izembek Lagoon, Alaska fall 1985. For locations of samples aee Ward et al. (1986).

Study area	Date	Plant part	Intertidal position	%N	%P	%K	%Ca	%Mg	% N on NDF	% Fat	z TNC	% Dry matter	% NDF	% Ash	G. wet wt.
Quarter Point	09-27-85	Sheath	L	1.59	.50	3.24	0.40	.55	2.07	n/e	n/e	16.0	33.9	n/e	6..0
Quarter Point	09-27-85	Sheath	H	2.42	.82	5.16	0.?4	.74	0.98	n/e	m/e	12.2	37.1	n/e	5.4
Quarter Point	10-08-85	Sheath	L	1.88	.67	3.42	0.48	.67	2.20	n/e	n/e	16.8	34.2	n/ e	3.6
Quarter Point	10-08-85	Shea th	H	3.07	.83	4.47	0.81	.95	2.24	n/e	n/e	13.1	34.4	n/e	4.2
Quarter Point	10-20-85	Sheath	L	2.03	.59	3.19	0.,40	.59	2.57	n/e	n/e	16.6	31.6	n/e	5.9
Quarter Point	10-20-85	Sheath	H	3.54	.69	4.08	0.48	.76	2.44	n/e	8.7	12.4	40.5	n/e	11.6
Quarter Point	09-27-85	Leaves	L	1.60	.49	2.45	0.97	.53	2.50	0.64	22.5	20.8	49.1	12.4	19.7
Quarter Point	09-27-85	Leaves	H	3.14	.81	4.52	1.38	.61	3.83	0.1	2.1	17.0	57.1	19.5	25.3
Quarter Point	10-08-85	Leaves	L	1.83	.58	2.32	1.22	.51	2.64	n/e	15.8	21.6	56.5	13.0	9.3
Quarter Point	10-08-85	Leaves	H	3.58	.84	4.45	1.28	.74	4.39	n/e	1.3	16.6	49.0	19.4	11.2
Quarter Point	10-20-85	Leaves	L	1.87	.51	2.18	1.07	.52	2.79	[illegible]	20.4	19.7	48.0	12.7	17.0
Quarter Point	10-20-85	Leaves	H	3.38	.80	3.88	1.15	.61	3.80	0.86	4.8	16.4	56.8	17.6	37.2
Quarter Point	09-27-85	Root & Rhizome	L	0.92	.37	1.70	1.21	.79	0.83	1.26	17.1	7.7	50.3	24.3	107.9
Quarter Point	09-27-85	Root & Rhizome	H	1.37	.51	2.47	1.40	.93	1.11	1.48	1.2	7.4	56.1	32.3	68.5
Quarter Point	10-08-85	Root & Rhizome	L	0.81	.39	1.49	1.06	.72	0.73	0.86	15.0	8.1	54.9	32.4	103.8
Quarter Point	10-08-85	Root & Rhizome	H	1.22	.43	2.18	1.06	.88	0.68	0.72	0.9	9.0	64.2	46.3	43.1
Quarter Point	10-20-85	Root & Rhizome	L	0.88	.31	1.61	1.20	.78	0.72	0.90	13.8	8.3	49.4	27.9	85.4
Quarter Point	10-20-85	Root & Rhizome	H	1.40	.51	2.50	0.91	.83	0.99	0.94	13.3	9.4	45.1	26.5	71.0
Halfway Point	10-10-85	Whole	L	0---	[illegible]	[illegible]	[illegible]	.50	0.70	0.44	4.7	15.1	69.4	64.2	119.6
Halfway Point	10-10-85	Whole	H	1.44	.24	1.92	0.92	.61	2.26	0.76	20.6	15.0	44.2	17.4	58.8
Applegate Cove-Mid	10-19-85	Whole	L	1.53	.36	2.66	0.72	.69	1.96	0.86	19.5	13.0	45.5	20.5	59.5
Applegate Cove-Mid	10-19-85	Whole	H	1.68	.40	3.20	0.72	.64	2.39	0.60	20.2	14.5	45.0	17.0	56.2
Round Island East	10-10-85	Whole	L	1.42	.37	2.18	.80	.61	1.79	.66	20.3	15.7	45.8	18.8	58.3
Round Island Eaat	10-10-85	Whole	H	1.87	.44	3.17	1.00	.94	2.12	.88	2.0	10.1	58.7	24.2	52.1
Grant Point Eaat	10-10-85	Whole	L	1.39	.26	2.54	1.04	.65	1.82	.62	20.2	16.4	46.4	21.5	52.2
Grant Point East	10-10-85	Whole	H	1.57	.31	2.71	1.52	080	1.88	1.26	3.1	13.5	54.3	30.2	53.3
Grant Point Eaat	10-19-8.3	Whole	LL	1.54	.25	2.52	1.44	.70	1.98	.66	19.1	16.4	44.5	18.4	44.1
Grant Point Eaat	10-19-85	Whole	L	1.55	.28	2.15	1.43	.67	2.20	.78	20.2	14.9	45.3	17.8	43.3
Grant Point Eaat	10-19-85	Whole	H	1.70	.29	2.69	1.13	.66	2.21	.s4	20.1	15.5	43.7	17.4	51.4

Appendix A. Frequency of brant flocks responding to potential disturbance events during 798 hours of observations at Izembek Lagoon, Alaska from 18 September to 31 October 1986.

	Total events	
	n	Percent
Human-induced		
Fixed-wing aircraft		
Single-engine propeller		
incidental	80	5.9
experimental	147	10.8
Twin-engine propeller		
incidental	58	4.3
experimental	131	9.6
Twin-Otter		
incidental	2	0.2
experimental	21	1.6
Grumman goose		
incidental	18	1.3
experimental	25	1.8
Multi-engine propeller		
incidental	55	4.1
experimental	25	1.8
Heavy twin-engine	49	3.6
Jet	55	4.0
Unidentified aircraft	18	1*3
Subtotals	684	50.3
Helicopters		
Bell 206-B, experimental	290	21.3
Sikorsky HH-3F		
incidental	4	0.3
experimental	45	3.3
Subtotals	339	24.9
Gunshots	21	1.6
Human	9	0.7
Boat	25	1.8
Subtotals	55	4.1
Totals	1078	79.3

Appendix A. Continued.

		Total events	
		n	Percent
Natural			
Bald eagle		189	13.9
Falcon[a]		23	1.7
Northern harrier		2	0.2
Common raven		8	0.6
Other		59	4.3
	subtotals	281	20.7
All events	Grand totals	1359	100.0

[a] Either peregrine or gyrfalcon.

Appendix B. Frequency of Canada goose flocks responding to potential disturbance events during 798 hours of observations at Izembek Lagoon, Alaska from 18 September to 31 October 1986.

		Total events	
		n	Percent
Human-induced			
Fixed-wing aircraft			
Single-engine propeller			
incidental		29	5.5
experimental		71	13.4
Twin-engine propeller			
incidental		24	4.5
experimental		44	8.3
Twin-Otter			
experimental		1	0.2
Grumman goose			
incidental		3	0.6
experimental		29	5.5
Multi-engine propeller			
incidental		11	2.1
experimental		10	1.9
Heavy twin-engine		13	2.4
Jet		14	2.6
Unidentified aircraft		3	0.6
	Subtotals	252	47.6
Helicopters			
Bell 206-B			
experimental		84	15.9
Sikorsky HH-3F			
incidental		3	0.6
experimental		15	2.8
	Subtotals	102	19.3
Gunshots		3	0.6
Human		17	3.2
	Subtotals	20	3.8
	Totals	374	70.7

Appendix B. Continued.

		Total events	
		n	Percent
Natural			
Bald eagle		120	22.7
Falcon[a]		9	1.7
Common raven		1	0.2
Other		25	4.7
	Totals	155	29.3
All events	Grand totals	529	100.0

[a] Either peregrine or gyrfalcon.

Appendix C. Frequency of emperor goose flocks responding to potential disturbance events during 798 hours of observations at Izembek Lagoon, Alaska from 18 September to 31 October 1986.

		Total events	
		n	Percent
Human-induced			
Fixed-wing aircraft			
Single-engine propeller			
experimental		9	12.5
Twin-engine propeller			
experimental		8	11.1
Grumman goose			
experimental		4	5.5
Multi-engine propeller			
incidental		2	2.8
experimental		2	2.8
Heavy twin-engine		1	1.4
Jet		1	1.4
	Subtotals	27	37.5
Helicopters			
Bell 206-B			
experimental		25	34.7
Sikorsky HH-3F			
experimental		1	1.4
	Subtotals	26	36.1
Human		1	1.4
Boat		6	8.3
	Subtotals	7	9.7
	Totals	60	83.3

Appendix C. Continued.

		Total events	
		n	Percent
Natural			
Bald eagle		6	8.3
Falcon[a]		2	2.8
Wolf		1	1.4
Other		3	4.2
	Totals	12	16.7
All events	Grand totals	72	100.0

[a] Either Peregrine or Gyrfalcon.