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BEHAVIOR RESPONSE OF GREATER YELLOWLEGS, SNOWY EGRETS AND MALLARDS TO HUMAN
DISTURBANCE AT BACK BAY NATIONAL WILDLIFE REFUGE, VIRGINIA

HAROLD LASKOWSKI, U.S. Fish and Wildlife Service, 2145 Key Wallace Drive,
Cambridge, MD 21613.

TONY LEGER, U.S. Fish and Wildlife Service, Back Bay NWR, P.O. Box 6286.
Virginia Beach, VA 23456.

JOHN GALLEGOS, U.S. Fish and Wildlife Service, Back Bay NWR, P.O. Box 6286.
Virginia Beach, VA 23456.

FLORENCE JAMES, U.S. Fish and Wildlife Service, Back Bay NWR, P.O. Box 6286.
Virginia Beach, VA 23456

Conflicts arise when migratory birds and humans are present in the same areas (Boyle and Samson 1985). Response of wildlife to human activities includes: departure from the site (Owen 1973, Burger 1981, Kaiser and Fritzell 1984, Korschgen et al. 1985, Henson and Grant 1991, Kahl 1991, Klein 1993), use of sub-optimal habitat (Erwin 1980, Williams and Forbes 1980), altered behavior (Burger 1981, Korschgen et al. 1985, Morton et al. 1989, Ward and Stehn 1989, Havera et al. 1992, Klein 1993), and an increase in energy expenditure (Morton et al. 1989, Belanger and Bedard 1990). Altered behavior that increases energy expenditure, can cause a decline in body condition (Morton et al 1989, Belanger and Bedard 1990, Morton 1991). Waterfowl in poor condition experienced higher mortality rates (Haramis et al. 1986, Hepp et al. 1986). Bartelt (1987) found that human disturbance of family groups of Canada geese (Branta canadensis) resulted in increased hunting mortality. Body condition and lipid reserves during winter and spring migration can affect reproductive success of waterfowl (Ankney and MacInnes 1978, Raveling 1979, Krapu 1981).

The U.S. Fish and Wildlife Service administers a system of approximately 470 National Wildlife Refuges (NWR) that encompass over 36.4 million ha. of wildlife habitat throughout the U.S. Managers of NWRs expend considerable time and effort to improve habitat for wetland dependent migratory birds. At the same time, public lands are becoming increasingly important for public outdoor recreation including birdwatching, hiking, photography, and nature observation. Demand for nonconsumptive wildlife-oriented recreation increased by 10% from 1985-90 including an estimated 30 million people who traveled from their home to enjoy wildlife (U.S. Dept of Interior 1991). Public-use may be

authorized on a NWR if human activities are compatible with the refuge purpose (National Wildlife Refuge System Administration Act of 1966, 16 U.S.C. 668dd-668ee and Refuge Recreation Act, 16 U.S.C. 460k-460k-4). Back Bay NWR was established "... as a refuge and breeding ground for migratory birds and other wildlife." (Executive Order 7907, dated June 6, 1938). However, current and future public-use activities may be incompatible with migratory bird use of the Refuge. The expenditure of time and funds to improve habitat quality may be negated by human disturbance to birds. Managers are therefore faced with a dilemma of how much and what type of public recreation is compatible with refuge wildlife objectives. Our objective was to measure the effect of human disturbance on snowy egrets (Egretta thula), female mallards (Anas platyrhynchos), and greater yellowlegs (Tringa melanoleuca), at Back Bay NWR.

Most studies of human disturbance to wildlife, measured the response to disturbance as the frequency and duration of flight (Burger 1981, Korschgen et al. 1985, Burger et al. 1986, Bratton 1990, Kahl 1991, Havera et al. 1992). Erwin (1980) and Burger (1981) also measured the presence or absence of birds in habitats affected by disturbance. Frequency of flight or absence from habitat will only measure the most overt response of wildlife. Disturbance which results in subtle responses of birds may go undetected. Measurement of time activity budgets in the presence or absence of human disturbance will indicate the full range of response to disturbance. Only Morton et al. (1989) for black ducks (Anas rubripes), Ward and Stehn (1989) for brant (Branta bernicla), and Belanger and Bedard (1990) for greater snow geese (Chen caerulescens), measured the effects of human disturbance on time activity budgets of wetland birds.

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STUDY AREA

The study was conducted at Back Bay NWR, Virginia Beach, Virginia. The 2,935 ha Refuge is located on a barrier beach sand spit that separates the Atlantic Ocean from Back Bay. Habitat consists of 324 ha of oceanfront and dunes, 1154 ha of fresh-brackish marshes, 405 ha of freshwater impoundments, 800 ha of forest, and the remaining area is open water. Back Bay (which adjoins the Refuge) is approximately 10,300 ha. with an average depth of 1.3 m (Norman 1990).

Over 1.4 million people live in the Hampton Roads - Virginia Beach metropolitan area, within a 2-hour drive of the Refuge. About 100,000 visitors hike and bike along Refuge dikes or travel through the Refuge to False Cape State Park, which adjoins the Refuge's south boundary.

The Refuge is located within 30 miles of several military airports. This results in frequent aircraft overflights of Back Bay. Overflights are by jet fighters, helicopters and military transports. Most military flights are at an average altitude of approximately 450 m.

The Refuge manages 405 ha of impoundments to provide food for migratory birds, primarily during migration and winter. Much of the public use occurs along the dikes of this impoundment system.

METHODS

Behavior of snowy egrets, female mallards, and greater yellowlegs, was recorded within 91.4 m of impoundment dikes used by the general public. Egrets, mallards and yellowlegs were selected as representative migratory birds that commonly use the Refuge. Behavior of snowy egrets was recorded during August and September 1992 to represent post-breeding marsh and wading birds. Mallards were monitored during migration (November 1992) and during the winter (January 1993). Greater yellowlegs behavior was observed during the northward shorebird migration (May 1993).

Observations were made from stationary blinds located < 45.7 m from dikes. Each observation blind overlooked a 91.4 m x 91.4 m sample area. Fifteen sample areas were available during the study. Sample areas were subdivided with wooden stakes into 3 subplots, each 30.4 m x 91.4 m parallel to the dike. To reduce variability associated with time of day and wind speed (Paulus 1984), observations were made between 0900 and 1200 and data were not collected when wind was > 32 km/h or during precipitation. Observations were made with a 15-60x spotting scope or 7 x 50 binoculars, depending on proximity of the individual bird to the blind.

A bird was chosen for observation by counting the number of study birds on a site, a random number (n) selected between 1 and the number counted and the nth bird from the left was selected. On occasion, if a large group of study species were located on a site the flock was scanned with a spotting scope and the bird closest to the center of view was selected. A different bird was chosen for subsequent sampling. If no other birds were present on the site, 20 min was allowed before observing the same bird.

Activities were recorded using focal bird sampling procedures (Altmann, 1974). Continuous observation data were collected for 10 min periods, or until the bird departed the plot, to record infrequent activities and instantaneous responses to disturbance (Tacha et al. 1985). Observations were voice recorded on audio cassette tapes and behavior intervals were later determined by playing back the tapes and measuring intervals with a stop watch. Observations less than 2.5 min were excluded from analysis of time budgets.

Activities of birds were categorized as 1 of 9 behaviors (Table 1). The time of human presence on the dike also was recorded and categorized as 1 of 5 types of disturbance (Table 2). The general public was expected initially to

provide disturbance to birds. We soon found that visitors could not be depended upon to travel past an observation site when a bird was being observed. We therefore mimicked typical public use activities on days of data collection. Volunteers either walked, bicycled, or drove a vehicle past sample sites at random times.

Observations where any of the 5 human disturbances occurred were pooled into a category of Humans Present. Behavior of birds when humans were present was compared to behavior when humans were absent. Data were also analyzed separately for each disturbance type to determine if any one public use affected bird behavior. Observations with more than 1 type of public use were pooled into Combined Disturbance (Table 2). Wilcoxon rank sum and Kruskal-Wallis tests were used to test the null hypothesis that the average proportion of time expended in each activity was independent of human presence.

Analysis of time budget data only allows for testing the difference in proportion of time spent in each behavior when public use was present or absent. Therefore the overall effect of human presence on the birds ability to maintain fitness cannot be analyzed. Small differences in individual behaviors may not be significant, but the cumulative effect of difference among several behaviors may affect the birds energy expenditure. To test this question, feeding, resting and preening behaviors were combined into one category called Maintenance Behavior. These 3 activities have a positive effect on bird fitness, since they are associated with energy intake or body maintenance. Alert, swimming/walking, and flight were combined into one category called Escape Behavior. Although Escape behavior has a positive effect on immediate bird survival, the cumulative long term effect should decrease fitness because of disturbance. These categories are supported by Dahlgren and Korschgen (1992) who defined human disturbance as activities that elicit alertness, flight, swimming, or other displacement behaviors. Escape behaviors can be metabolically more expensive than Maintenance behaviors (Wooley and Owen 1978, Weathers et al. 1984). We used the Wilcoxon rank sum test to test the hypothesis that average proportion of time expended in Maintenance and Escape behavior were independent of human presence.

We calculated the proportion of birds that departed the site by flying, to detect if birds abandoned habitat in the presence of human disturbance. Chi-square contingency tables were used to test the null hypothesis that frequency of bird departure was independent of human presence. We used all observations regardless of the duration of time each bird was observed.

Time of movement by the focal bird between subplots at each site was recorded and the bird assigned to either a movement or no movement category. Chi-square contingency analysis were used to test the null hypothesis that frequency of bird movement was independent of human presence.

Proportion of samples among sites, where human disturbance occurred or was absent was tested using chi-square contingency tables. If data were not equally distributed, Kruskal-Wallis test was performed on specific activities when no human use occurred, to determine if bird behavior was similar among sites.

RESULTS

Temperature ranged from 21° to 29° C when data was collected for snowy egrets between 5 August and 9 September 1992. Data for female mallards during migration were collected between 4 November and 9 December 1992, with a temperature range from -1° to 24° C. Data for female mallards in winter, were collected between 6 January and 10 February 1993 with a temperature range from -1° to 10.5° C. Data for greater yellowlegs were collected between 1 May and 6 June 1993. Temperature ranged from 15.5° to 29.5° C.

The proportion of observations among sample sites where human presence occurred was not equally distributed for snowy egrets ($X^2 = 34.61$, d.f. = 2, $P < 0.001$). Kruskal-Wallis test indicated there was a difference in use of sites by snowy egrets for maintenance ($P = 0.0004$), and feeding ($P = 0.0001$) behaviors. There was no difference in use of sites for resting ($P = 0.097$) and alert ($P = 0.061$) when no disturbance occurred. Disturbed and undisturbed observations of female mallards during migration also were not equally distributed among sample sites ($X^2 = 7.54$, df = 3, $P = 0.056$). Kruskal-Wallis tests indicated no difference in use of sites for maintenance ($P = 0.349$), feeding ($P = 0.093$), alert ($P = 0.599$), or preening ($P = 0.838$) behavior. Proportion of samples where humans were present for female mallards in January ($X^2 = 3.04$, df = 4, $P = 0.551$) and greater yellowlegs in May ($X^2 = 2.97$, df = 3, $P = 0.396$) were equally distributed among all sample sites.

Behavior Related to Human Presence or Absence

Snowy egret resting behavior decreased and alert behavior increased in the presence of humans. Preening decreased when humans were present, but this change was not significant (Table 3, Fig. 1). Feeding, walk/swim, and flight behaviors were not related to human presence.

Female mallards in November increased feeding, preening and alert behaviors in the presence of humans. Resting, walk/swim, and flight behavior were not influenced by human presence. In January, female mallard resting and preening behavior were not influenced by the presence of humans. However, feeding, alert, walk/swim, and flight behaviors were related to human presence (Table 3).

Greater yellowlegs increased alert behavior in the presence of humans. All other behaviors were not related to human presence.

Maintenance behavior decreased when humans were present for all study species. There was a concomitant increase in Escape behavior by each species (Table 4, Figs. 2a, 2b).

Behavior Related to Specific Human Actions

There were insufficient data to analyze for effects of specific public use activities on Maintenance or Escape behavior of snowy egrets.

Maintenance behavior of female mallards in November were not affected by individual public uses. However, Escape behavior was influenced by public activities. Comparing Escape behavior between presence and absence of specific human disturbances, aircraft and combined disturbance increased escape time (Table 7, Fig. 3a). Vehicles had a less conclusive effect on escape behavior of female mallards in November.

Maintenance behavior of mallards in January were related to the presence of vehicles and combined disturbance. Maintenance behavior decreased in the presence of vehicles and combined disturbance. Aircraft did not affect maintenance behavior. Escape behavior increased when vehicles were present and also for all combined disturbance. Aircraft did not affect escape behavior in winter (Table 7, Fig. 3b).

Greater yellowlegs maintenance and escape behavior were influenced by different human activities. Maintenance behavior declined when bicycles and vehicles were present, and for all combined disturbance (Table 8, Fig 4). The presence of aircraft or pedestrians did not influence yellowlegs maintenance behavior. Escape behavior increased when bicycles and vehicles were present and for combined disturbance.

Frequency of Flight and Movement Between Subplots

Snowy egrets did not respond to human presence by taking flight and departing the site (Table 5, Fig 5). They tended to fly with greater frequency when humans were absent, however this was not significant. Female mallards during both migration and winter, responded to human presence with flight departure from study sites. Mallard flight response to human presence in January was not different than in November ($X^2 = 1.65$, 1 df, $P = 0.199$). Yellowlegs did not fly from the study area in response to human presence (Table 5).

Snowy egrets and female mallards did not move about between subplots in response to human presence (Table 6, Fig 6). However, frequency of female mallard movement was greater in January than November ($X^2 = 11.19$, 3 df, $P = 0.01$). They tended to move toward subplots which were farther away from the dike. Yellowlegs increased their frequency of movement between subplots in the presence of humans. As with mallards, they also tended to move toward plots away from the dike.

DISCUSSION

The different measures of response to disturbance by species in our study, when analyzed separately, may not have shown a significant impact on bird behavior. However, by pooling data into categories of Maintenance and Escape behaviors, it was shown that human presence had an influence on the overall behavior of each species. We further show that each species responded to human disturbance differently. The response of snowy egrets and yellowlegs, may be associated with their respective feeding strategy. Both of these species were reluctant to depart a site in the presence of disturbance;

however yellowlegs did experience habitat loss by relocating to a different area of the site. Mallards responded to humans by altering behavior and taking flight, thus abandoning the habitat.

Snowy Egrets

Due to differences in use of sample sites by snowy egrets we are skeptical of results which indicate a change in maintenance behavior in the presence of humans. However, we do not believe that snowy egrets would seek a site for the purpose of increasing alert or other escape behaviors. We believe that increased snowy egret escape behavior in the presence of human disturbance in this study is real.

When considering only flight and other movement behavior, our results were similar to Klein (1993); snowy egrets did not overtly respond to nearby human disturbance by changing position or flying. However, unlike Klein (1993) who did not record other behaviors, our results indicate that snowy egrets increase escape behaviors when humans are present. Snowy egrets are reluctant to leave a foraging site when humans approach or are nearby. Their normal reaction was to become alert.

Wading birds frequently feed in ephemeral pools where potential prey may be concentrated (Kushlan 1981). Powell (1987) reported habitat use by snowy egrets was dependent on water depths. Water depths in Back Bay fluctuate as much as 1.0 m, depending on wind direction (Norman 1990). During summer, prevailing southerly winds increase water depths on Back Bay, which may influence Back Bay habitat suitability for wading birds.

Refuge impoundments are slowly drained during the summer, which concentrates food. Snowy egrets respond by increasing use of Refuge impoundments (Fig. 7). Therefore, when water levels are high within the bay, snowy egrets are more dependent upon Refuge impoundments for foraging; however at these times, human presence could lessen habitat suitability. Snowy egrets respond to human disturbance by increasing alert behavior, but may tolerate human presence if alternative or optimum feeding sites are not available elsewhere. Increasing escape behavior of recently fledged young could adversely affect growth and survival during this critical life stage.

Greater Yellowlegs

Unlike snowy egrets and mallards, yellowlegs only use the Refuge during spring and fall migrations (Fig. 8). Thus, they may be unfamiliar with optimum feeding locations and frequently move in search of such sites. This behavior is suggested by high rates of flight (Table 5), regardless of the presence or absence of humans.

Time budgets of yellowlegs (Table 3) showed an increase in movement behavior in the presence of disturbance, but this was not significant. Measurement of movement between subplots did show an increase in this behavior in the presence of human disturbance (Table 6). We feel that measurement of the physical relocation of birds was the more accurate measure of movement activity. Yellowlegs move constantly while feeding, thus their response to

human presence may be similar. They become alert and relocate on the occupied site. Therefore, they must spend more energy on escape behavior, which lessens the time available for maintenance behavior.

The duration of stay at migration stopover areas by semipalmated sandpipers is influenced by fat content of individual birds (Dunn et al. 1988). They do not continue migration until a threshold fat reserve is reached. If migration of yellowlegs is dependent on minimum fat reserves, the negative influence of human disturbance could delay their departure from the Refuge. This will cause delayed arrival and breeding at Arctic nesting grounds. For lesser snow geese (*Chen caerulescens*) in the Arctic, delayed breeding results in lower population recruitment (Cooke et al. 1984). Due to the shortness of the Arctic nesting season, yellowlegs may show a similar reduction in recruitment.

Female Mallards

Mallards arrive at Back Bay in early November and use the Refuge until mid-March (Fig 9). They are subjected to hunting pressure before and after their arrival at the Refuge, but were not hunted within Refuge impoundments included in this study. Hunting did occur around the Refuge boundary during this study. Mallard conditioning to hunting pressure may have influenced their frequent flight response when humans were present. This behavior may be detrimental to mallard populations because additional flight can increase hunting mortality and energy expenditure. Human disturbance increases hunting mortality of Canada geese (Bartelt 1987). Therefore, during the hunting season, frequent flights in response to human disturbance could increase the likelihood of encountering hunters around the perimeter of the Refuge.

Flight is the most metabolically expensive activity of birds (Wooley and Owen 1978, Prince 1979, Weathers et al. 1984). Frequent flight in response to human presence could cause mallards to expend large amounts of energy. To compensate for this, the bird must increase feeding behavior if body condition is to be maintained. Disturbance also may displace the bird into sub-optimal habitat. This may increase required feeding time to obtain an equivalent energy intake of food, while less time is available as a result of disturbance.

Both maintenance and escape activity budgets were influenced by human presence. The decline in maintenance behavior and increase in escape behavior that we observed could affect the condition of mallards during migration and winter, and affect survival (Haramis et al. 1986, Hepp et al. 1986, Morton et al. 1989), pairing (Hepp 1986) and reproductive success (Krapu 1981).

Mallard escape behavior during November increased in response to aircraft and combined human disturbance. Vehicles increased escape behavior, but not significantly. In January, maintenance behavior decreased and escape behavior increased in response to vehicles and combined disturbance. Although many managers believe that vehicles cause relatively little disturbance to wildlife, when compared to other human activities, our results indicate that this human disturbance should not be ignored. Although not measured, we believe that vehicle speed is a contributing factor to increased mallard escape behavior.

Various wildlife species react differently to the same disturbance (Gwyn and Forbes 1980, Burger 1981, Bratton 1990, and Klein 1993). Results from our study also show differences by species in responses to various disturbances. Aircraft were found to affect mallards during the winter period, while eliciting very little response from greater yellowlegs during spring migration. Our results are similar to Owens (1977), Ward and Stehn (1989), and Belanger and Bedard (1989), who found aircraft to be particularly disturbing to some species of waterfowl.

Human disturbance impacts on specific activities of studied birds generally followed an expected pattern. Decreases were noted in maintenance behaviors such as feeding or resting; while increases were noted in alert or locomotion when humans were present. A notable exception was an increase in mallard preening behavior during November in the presence of humans. Mallards at these times may have been trying to maximize their energy efficiency. Some preening may be conducted while the bird is also monitoring potential threats. This type of behavior could be considered a nervous energy expenditure that also increases the birds comfort level during the disturbance. With yellowlegs a short period of preening frequently followed a flight. Morton (pers. communication) identified an increase in comfort movements of sanderlings prior to and after flight, as humans approached along a beachfront. Thus increased preening may be associated with flight activity. We believe there are probably two levels of preening, one associated with necessary feather maintenance, and another associated with arranging feathers following flight activity. Increased preening activity associated with flight as a result of disturbance would take time away from other maintenance behaviors. We could not measure the difference in preening types in this study.

Habituation is a response by wildlife to ignore non-harmful disturbances that occur frequently. The response of mallards to disturbance was not different between November and January, which indicates that habituation did not occur. For example, mallards were as likely to flush during January as during November and both maintenance and escape behaviors were also similar. The waterfowl hunting season was taking place outside the Refuge between the 2 data collection periods. Hunting activity may have resulted in a continued high level of response by mallards to humans within the Refuge. Thus, during the fall hunting season waterfowl may be particularly susceptible to human disturbance.

The proportion of time spent in flight could not be accurately measured in this study. Mallard response to human disturbance with flight behavior was not quantified by measurement of time-activity budgets. However, measuring the frequency of flight did show a significant increase in this behavior when humans were present. Flight was normally observed for a short time and then the bird was lost from view. This resulted in a premature ending of the 10 min sample period. Flight bias in time activity budgets has been identified by Paulus (1988) and Morton et al. (1989). Therefore, the reaction of mallards to human presence in this study, as measured by time-activity budgets, is underestimated.

We believe the results of this study minimally reflect the effects of human disturbance on behavior of sampled species. Birds sampled with no disturbance may have been subjected to previous disturbance. These birds may have maintained a heightened state of awareness. If it were feasible to obtain true control data where no previous human disturbance had occurred, greater difference in response of disturbed birds may have been detected.

MANAGEMENT IMPLICATIONS

Because wetland habitat is decreasing and human recreational demands are increasing, human disturbance is an increasingly important issue faced by managers of National Wildlife Refuges. Managers cannot assume that human presence is not a problem simply because birds were not observed to fly away. Subtle responses to disturbance such as those exhibited by snowy egrets and greater yellowlegs may occur. These responses may be as detrimental to the birds fitness as the overt response of habitat departure.

Currently, publicly managed lands provide only a small portion of migratory bird habitat needs. However, the importance of these lands for migratory bird populations will increase as privately owned lands are developed. Dahl and Johnson (1991) documented 1.05 million ha of wetlands lost in the conterminous United States between the mid 1970's to the mid 1980's. Although the rate of wetland loss is declining, the net result will be an overall decreased carrying capacity for migratory bird populations, and an increased dependency on remaining wetlands. To compensate for wetland loss, federal, state and private landowners need to manage wetlands specifically for wildlife dependent upon wetland habitats. Human recreation on these lands will have an influence on their use by wildlife populations.

Managers cannot measure response to human disturbance for every wildlife species using a NWR. The response of wildlife to human disturbance varies from tolerance to habitat abandonment. Of 13 wetland bird species studied, Klein (1993) found snowy egrets to be one of the least affected by human disturbance. Bratton (1990) found snowy egrets least likely to flush in the presence of boating disturbance, of eight marsh and wading bird species. Parr (1974), Batten (1977), and Tuite et al. (1984), found that mallards were more tolerant of human presence than other species of waterfowl. This study shows that human presence can have a significant effect on the behavior of these tolerant species. Therefore, human disturbance would have a significant impact on other migratory bird species, than those reported in this study, at Back Bay NWR.

Where possible, public uses that adversely affect wildlife should be identified. A particular use may have no effect on 1 species while having a very detrimental effect on another species. This was shown for yellowlegs and mallard response to aircraft. Information such as this, along with chronology of species use, and where important habitat is located would aid in selectively controlling disturbance.

We support Morton (in press) who recommends that human disturbance be explicitly recognized by land managers and be incorporated into the decision-

making and management planning process. Human disturbance management to wildlife warrants the attention provided to more traditional wildlife management programs such as, forest, wetland, cropland and population management techniques. Korschgen et al. (1985), Kahl (1991), Havera et al. (1992), Klein (1993), and Morton (in press), proposed management actions that could reduce the frequency or effects of disturbance: 1) eliminate public use from the area, 2) restrict public access to specific times of day or periods of the year, 3) develop education programs for the public, 4) provision of buffer zones or screens between public use areas and wildlife, 5) increase food resources to offset effects of disturbance, 6) restrict certain human activities, 7) restrict public-use activities to specific areas, 8) provide blinds for viewing wildlife, and 9) speed restriction on certain vehicle uses. Some of these actions can be readily implemented by managers. Other actions may be extremely controversial. Unfortunately the benefits of many identified actions have not yet been tested. Managers need to experiment with innovative methods to control or eliminate the effects of human disturbance on wildlife. The effectiveness of these control methods at reducing disturbance should also be measured.

Wildlife management must have public support to succeed. To achieve public acceptance, restrictions cannot be applied thoughtlessly. Managers must identify important wildlife populations that are at risk on their areas, important habitat, and critical use periods. Management actions should be applied which will show positive benefits to the population. When management actions are taken to reduce or eliminate human recreation, then alternative opportunities should be provided for the public to view, better understand and appreciate wildlife.

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Table 1. Description of activities used to record the response of snowy egrets, yellowlegs and mallards at Back Bay National Wildlife Refuge during August 1992 to June 1993.

Behavior	Description
Feeding	Any activity associated with feeding, including short periods of locomotion while feeding and stationary posture while waiting for prey.
Resting	Motionless behavior including head tucked under a wing or the bird standing on one leg.
Preening	Preening, oiling or bathing associated with feather maintenance.
Alert	Identified by bird's appearance and intent observation toward a single direction where a potential threat may be perceived. Frequently the bird may have its head up to observe better, or it may crouch to avoid detection.
Walk/Swim	Locomotion other than flight or associated with active feeding.
Flight	Include birds which have flushed and fly for any length of time.
Other	Any activity not specifically defined.
Lost View	Recorded when a bird was temporarily lost from view behind an obstruction.
Departed	An end of observation code, where bird departed by flight.

Table 2. Categories used to measure human use at Back Bay National Wildlife Refuge during August 1992 to June 1993.

Category	Description
Pedestrian	One or more people walking along the dike system adjacent to study sites.
Bicycle	Biking activity along the dike system.
Vehicle	Motor vehicles on the dike system. Includes Government and public vehicles.
Aircraft	Aircraft operating below an altitude of 450m.
Combined Disturbance	Category established during data analysis when two or more disturbance types occurred during the same observation period.

Table 3. Time activity budgets for snowy egrets, female mallards and greater yellowlegs during the Presence and Absence of public use on Back Bay NWR, August 1992 to June 1993.

Behavior	Snowy Egret		p	Mallard - Nov.		p	Mallard - Jan.		p	Greater Yellowlegs		p
	Absent n=25	Present n=38		Absent n=43	Present n=73		Absent n=51	Present n=82		Absent n=44	Present n=137	
Feeding	0.5595	0.5901	0.648	0.6588 *	0.5692	0.033	0.6760	0.6655	0.058	0.6335	0.5628	0.152
Resting	0.0967 *	0.0383	0.040	0.1129	0.1097	0.759	0.0397	0.0314	0.331	0.1167	0.1067	0.550
Preening	0.1525	0.0277	0.103	0.0315 *	0.0685	0.008	0.0935	0.0510	0.462	0.1008	0.1173	0.403
Alert	0.0873 *	0.1940	0.006	0.0045 *	0.0422	0.0001	0.0122 *	0.0790	0.0001	0.0333 *	0.0864	0.0001
Walk/Swim	0.0537	0.0808	0.261	0.1280	0.1773	0.087	0.1394 *	0.1486	0.017	0.0592	0.0804	0.053
Flight	0.0184	0.0271	0.086	0.0065	0.0020	0.287	0.0006 *	0.0069	0.0036	0.0160	0.0224	0.460
Other	0.0019	0.0172		0.0058	0.0084		0.0005	0.0028		0.0028	0.0036	
Lost Visual	0.0290	0.0246		0.0422	0.0228		0.0367	0.0146		0.0378	0.0203	

* Denotes significant difference $p = 0.05$ in proportion of time spent in activity when humans are present or absent.

Table. 4 Average proportion of time^a spent in Maintenance and Escape behavior by snowy egrets, female mallards and yellowlegs when human disturbance was present and absent at Back Bay NWR .

Species		Human Presence	Maintenance			Escape		
			Ave.	(SE)	P	Ave	(SE)	P
Snowy Egret	Aug 1992	Absent	0.811	(0.234)	0.035 ^b	0.160	(0.211)	0.029
		Present	0.673	(0.267)		0.302	(0.257)	
Mallard	Nov 1992	Absent	0.809	(0.244)	0.019	0.139	(0.179)	0.002
		Present	0.756	(0.219)		0.221	(0.207)	
Mallard	Jan 1993	Absent	0.809	(0.279)	0.001	0.152	(0.249)	0.0001
		Present	0.751	(0.203)		0.235	(0.203)	
Yellowlegs	May 1993	Absent	0.854	(0.177)	0.005	0.108	(0.146)	0.0008
		Present	0.790	(0.172)		0.189	(0.173)	

^a Proportion of Time Expended in Maintenance and Escape Behavior does not sum to 1.0, since time spent in 'Other' and 'Lost Visual Contact' categories was not included in analysis.

^b Result of Wilcoxon Rank Sum test to determine if human presence has an influence on behavior. P values < 0.05 are considered significant.

Table. 5 Flight response by Yellowlegs, Snowy Egrets and Female Mallards to human disturbance at Back Bay NWR.

Species	Disturbance		Remain		Take Flight		<u>P</u>
			<u>n</u>	(%)	<u>n</u>	(%)	
Snowy Egret	Aug 1992	Absent	21	(75.0)	7	(25.0)	0.421
		Present	34	(82.9)	7	(17.1)	
Mallard	Nov 1992	Absent	44	(95.7)	2	(4.3)	0.050
		Present	68	(83.9)	13	(16.1)	
Mallard	Jan 1993	Absent	54	(98.2)	1	(1.8)	0.001
		Present	70	(76.1)	22	(23.9)	
Yellowlegs	May 1993	Absent	37	(71.1)	15	(28.9)	0.537
		Present	108	(75.5)	35	(24.5)	

Table. 6 Frequency of movement between subplots by yellowlegs, snowy egrets and female mallards as affected by human disturbance at Back Bay NWR.

Species	Disturbance		Remain in 1 Subplot		Move between Multiple Subplots		<u>P</u>
			<u>n</u>	(%)	<u>n</u>	(%)	
Snowy Egret	Aug 1992	Absent	21	(75.0)	7	(25.0)	0.225
		Present	25	(61.0)	16	(39.0)	
Mallard	Nov 1992	Absent	40	(87.0)	6	(13.0)	0.783
		Present	69	(85.2)	12	(14.8)	
Mallard	Jan 1993	Absent	43	(78.2)	12	(21.8)	0.055
		Present	58	(63.0)	34	(37.0)	
Yellowlegs	May 1993	Absent	36	(69.2)	16	(30.8)	0.015
		Present	71	(49.7)	72	(50.3)	

Table 7. Effect of specific types of human disturbance on Maintenance and Escape behavior of Female Mallards at Back Bay NWR during November 1992 and January, 1993.

Human Disturbance	n	Maintenance			Escape		
		Ave	(SE)	P	Ave	(SE)	P
Female Mallards - November							
None	44	0.809	(0.243)		0.139	(0.179)	
Vehicle	14	0.761	(0.233)	0.156 ^a	0.199	(0.193)	0.082
Aircraft	30	0.809	(0.140)	0.182	* 0.183	(0.137)	0.035
Combined	47	0.760	(0.218)	0.109	* 0.229	(0.217)	0.022
		0.267 ^b			0.044		
Female Mallards - January							
None	51	0.810	(0.280)		0.152	(0.249)	
Vehicle	30	* 0.772	(0.191)	0.012	* 0.216	(0.196)	0.003
Aircraft	19	0.798	(0.213)	0.247	0.1925	(0.199)	0.069
Combined	21	* 0.733	(0.178)	0.005	* 0.259	(0.175)	0.001
		0.009			0.001		

^a Results of Wilcoxon Rank Sum test comparing proportion of time in maintenance or escape behavior during each type of human presence with proportion of time when no human use was present.

^b Results of Kruskal-Wallis test to determine if different human use had an effect on behavior.

* Denotes significant ($P < 0.05$) difference between behavior when no humans were present and behavior during occurrence of the human activity.

Table 8 Effect of specific types of human disturbance on Maintenance and Escape behavior of Greater Yellowlegs at Back Bay NWR during May, 1993.

Human Disturbance	n	Maintenance			Escape		
		Ave	(SE)	P	Ave	(SE)	P
None	44	0.854	(0.177)		0.109	(0.146)	
Pedestrian	10	0.801	(0.250)	0.532 ^a	0.183	(0.258)	0.623
Bicycle	36	* 0.766	(0.187)	0.013	* 0.202	(0.193)	0.004
Vehicle	14	* 0.778	(0.171)	0.024	* 0.214	(0.172)	0.003
Aircraft	30	0.879	(0.118)	0.974	0.079	(0.089)	0.619
Combined	47	* 0.755	(0.148)	0.001	* 0.244	(0.149)	0.000
		0.0006 ^b			0.0001		

^a Results of Wilcoxon Rank Sum test comparing proportion of time in maintenance or escape behavior during each type of human presence with proportion of time when no human use was occurred.

^b Results of Kruskal-Wallis test to determine if effect of human use on behavior.

* Denotes significant ($P < 0.05$) difference between behavior when no humans were present and behavior during occurrence of each human activity.

Fig. 1

Proportion of Time expended by Snowy Egrets, Female Mallards and Greater Yellowlegs in various activities at Back Bay NWR.

Fig 1a Snowy Egrets - August 1992

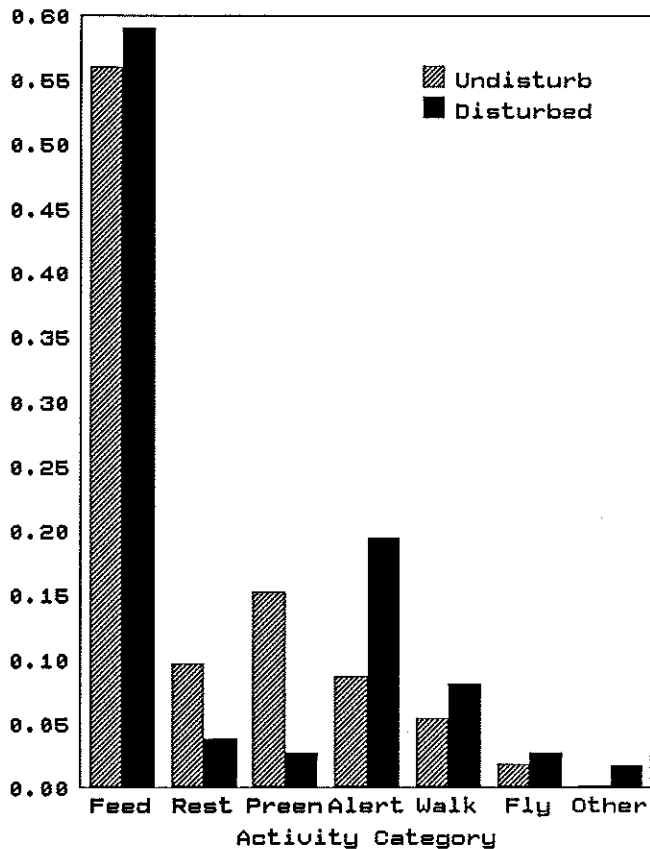


Fig 1b Female Mallards - November 1992

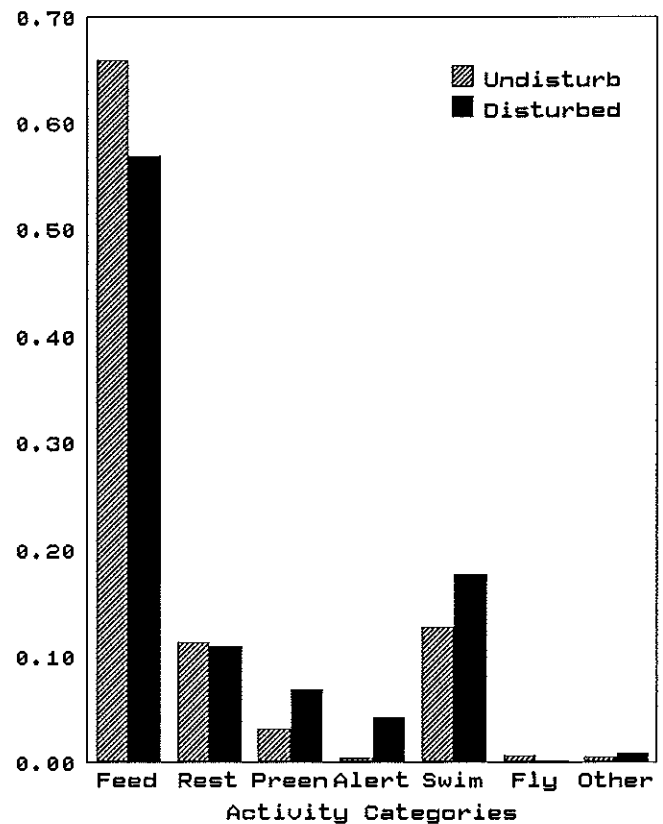


Fig 1c Female Mallards - January 1993

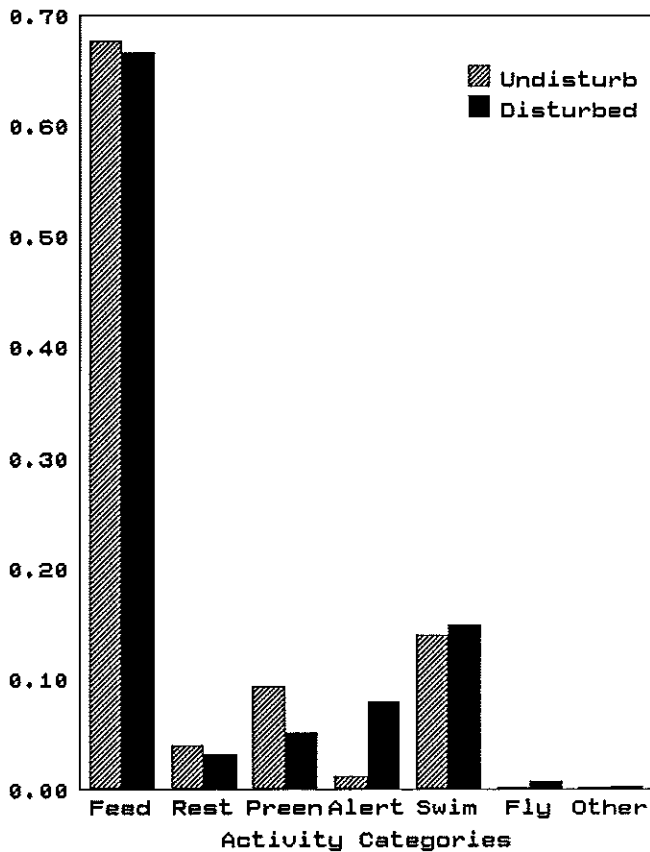


Fig 1d Greater Yellowlegs - May 1993

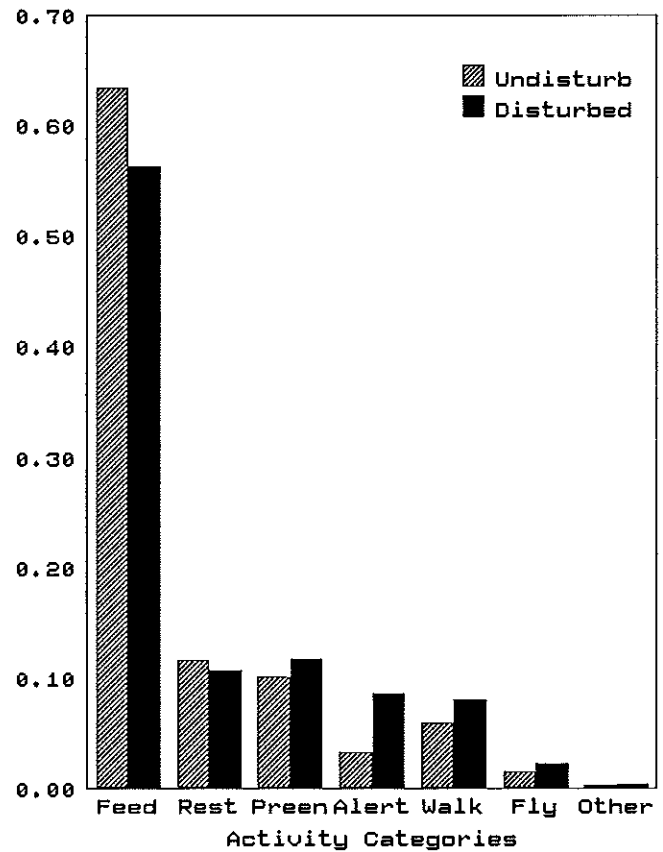


Fig 2a Proportion of time expended in Maintenance Behavior when Human use was present or absent.

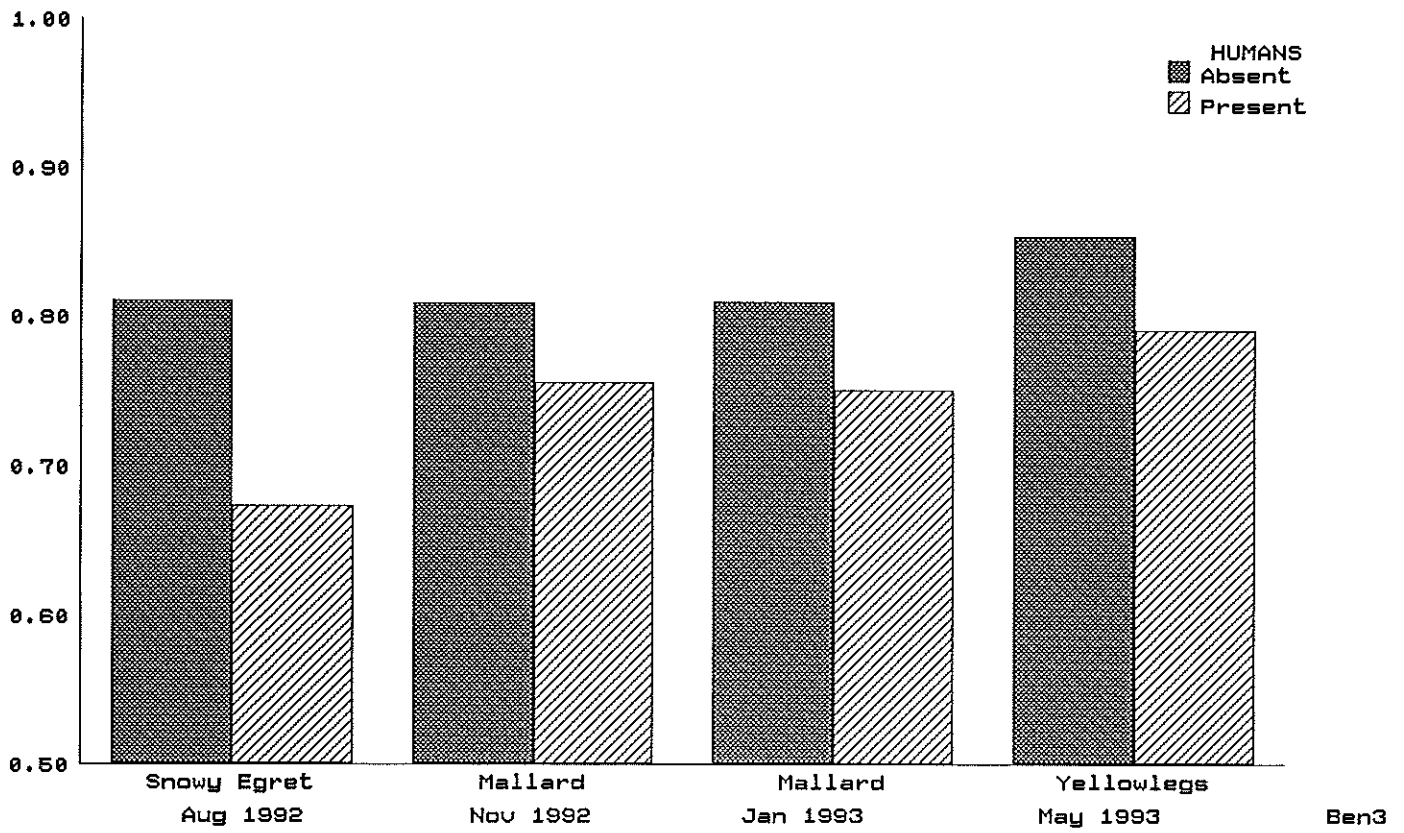
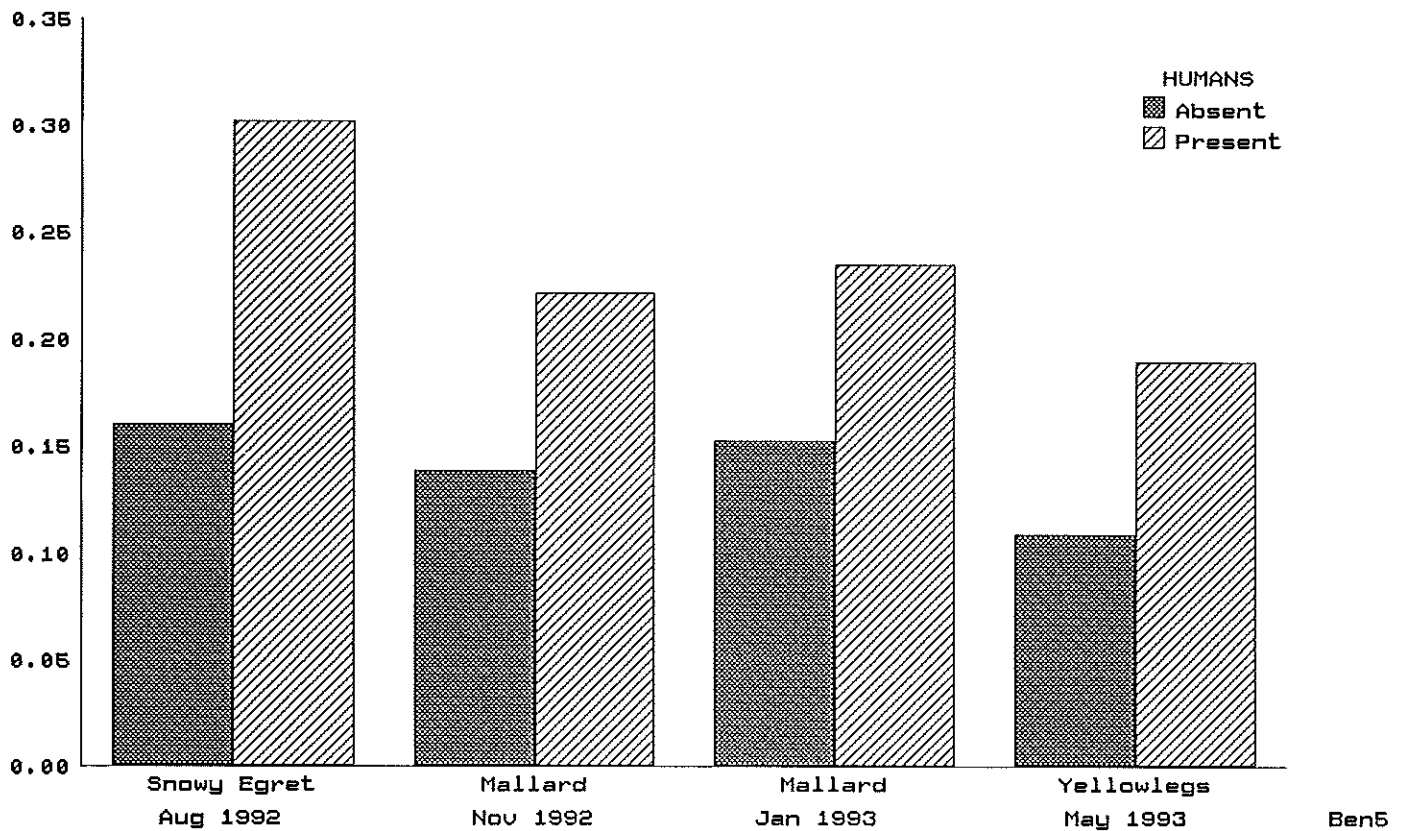


Fig 2b Proportion of time expended in Escape Behavior when Human use was present or absent.



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Fig 3a Proportion of time F. Mallards spend in Maintenance and Escape Behavior in the presence or absence of humans.

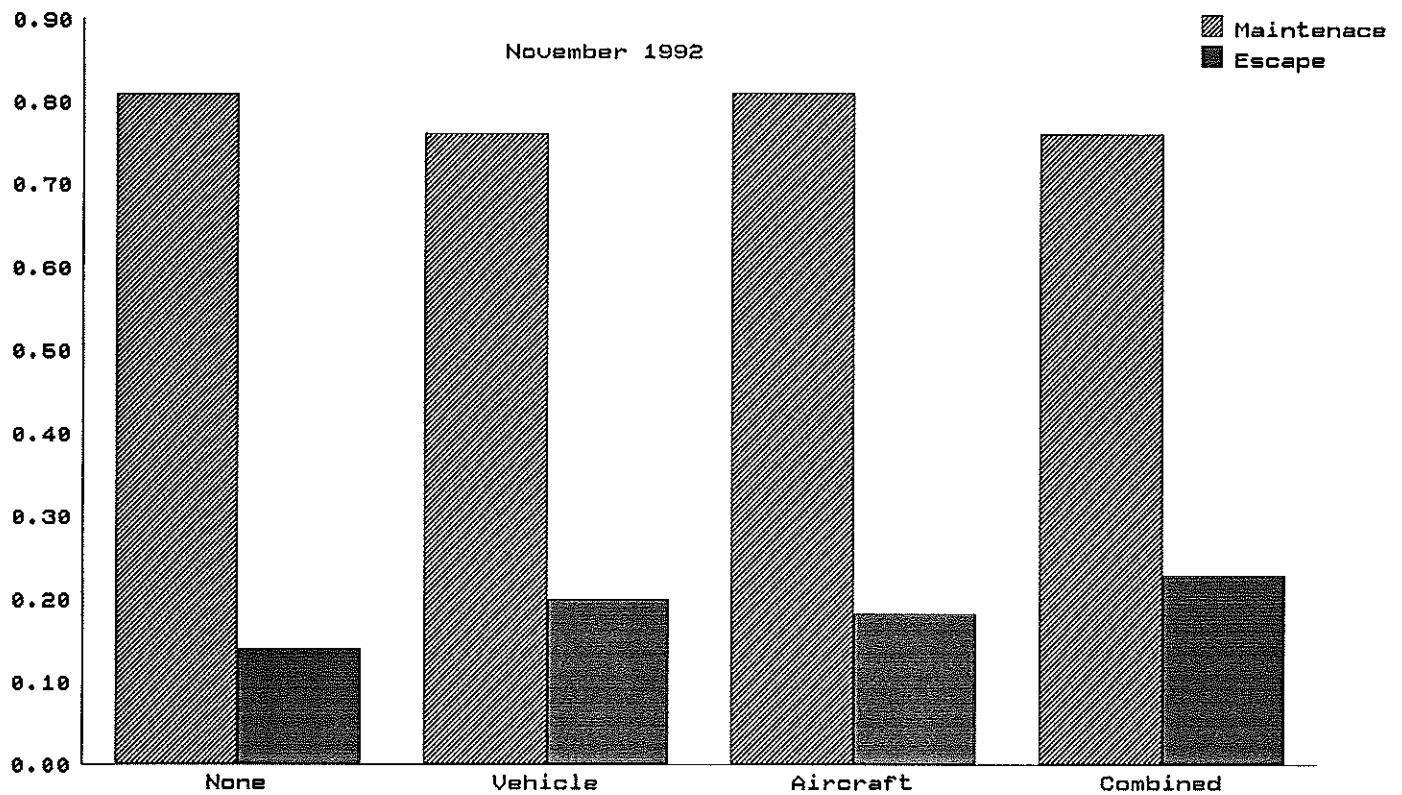


Fig 3b Proportion of time F. Mallards spend in Maintenance and Escape Behavior in the presence or absence of humans.

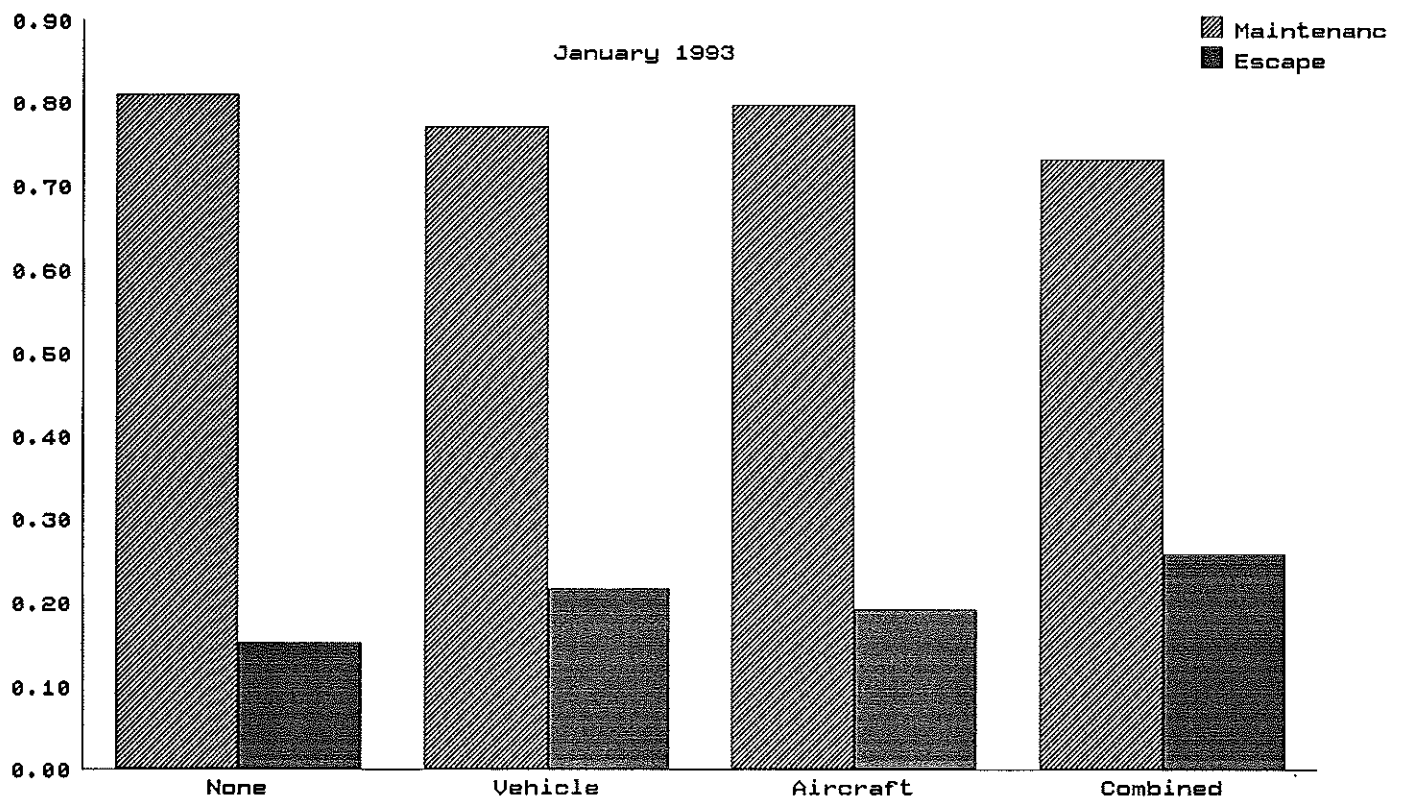


Fig 4 Proportion of time yellowlegs spend in Maintenance and Escape Behavior under different human uses.

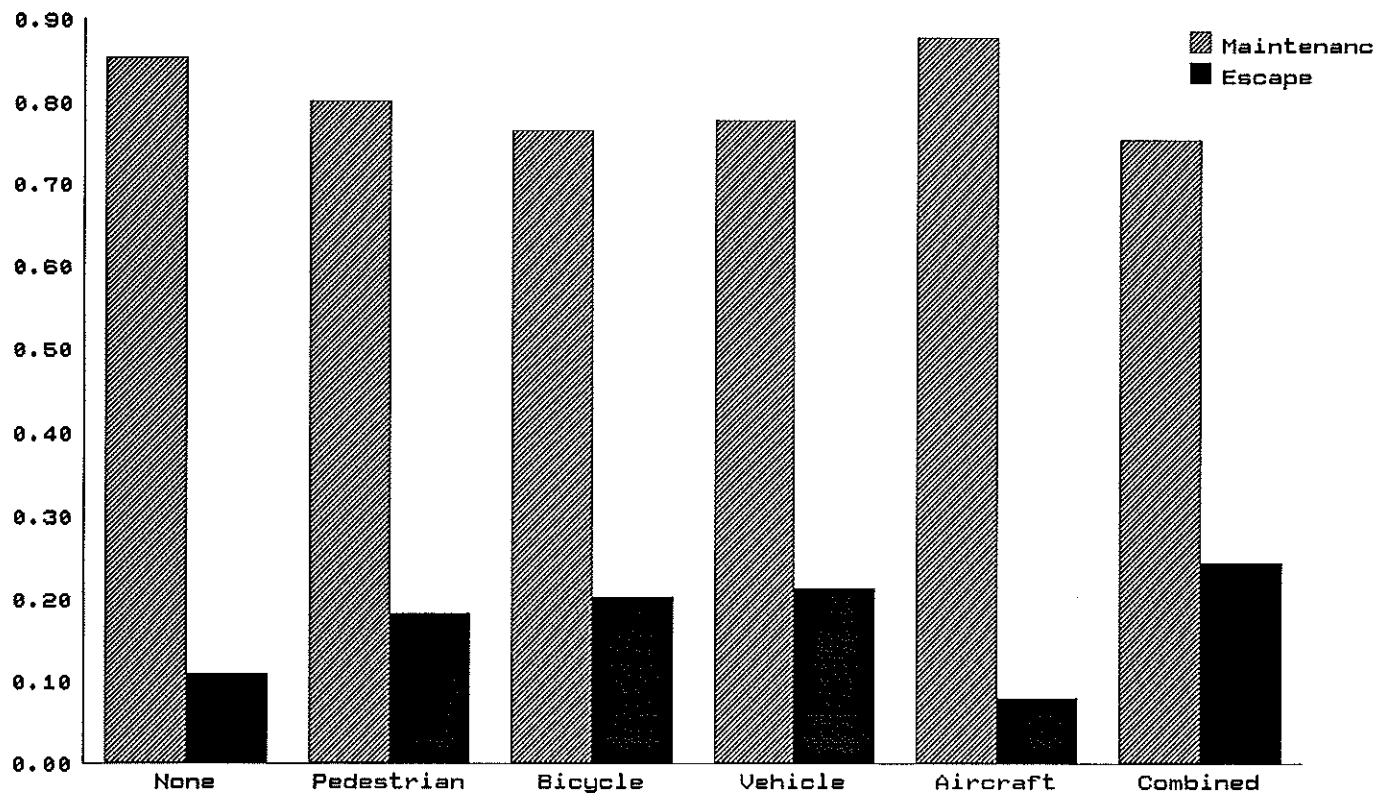


Fig 5 Freq of flight by snowy egrets, mallards and yellowlegs in the presence/absence of human use.

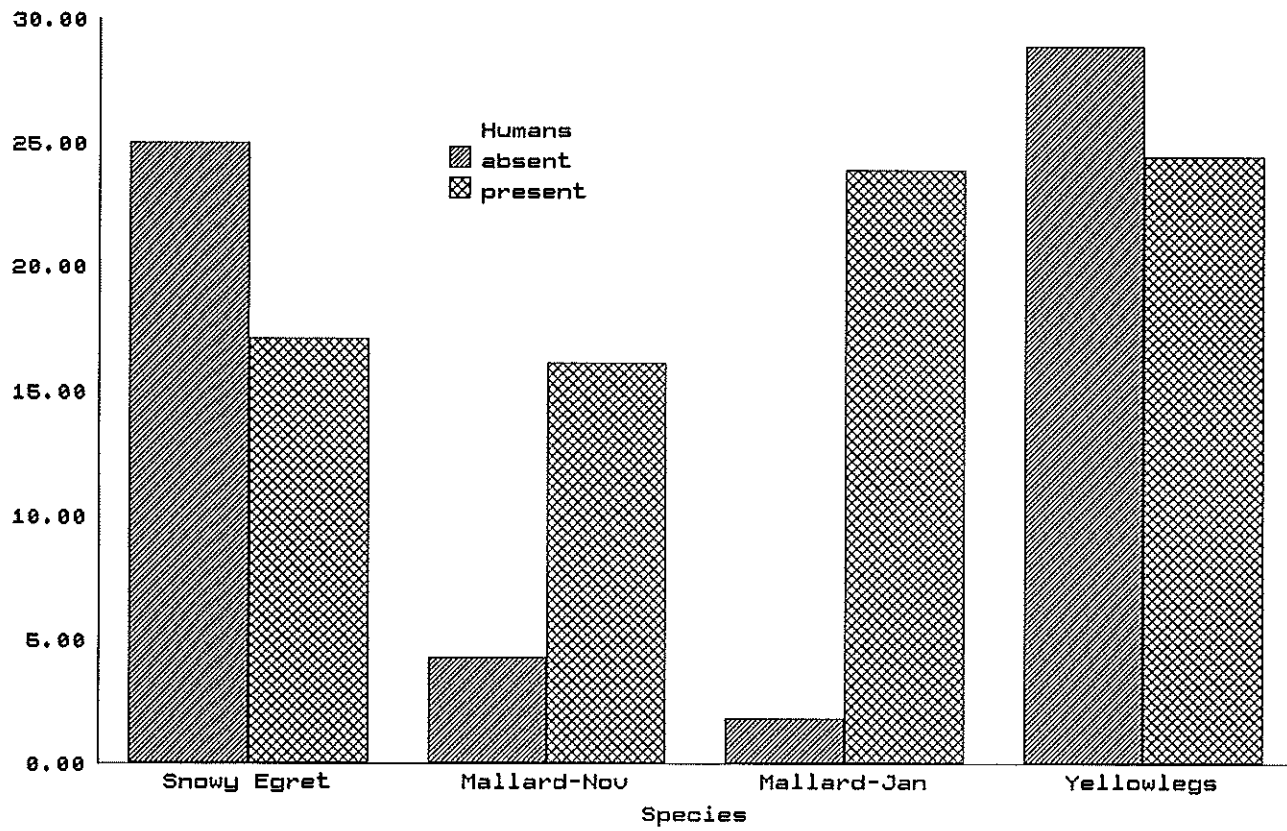


Fig 6 Freq of movement between subplots by egrets, mallards and yellowlegs in the presence/absence of human use.

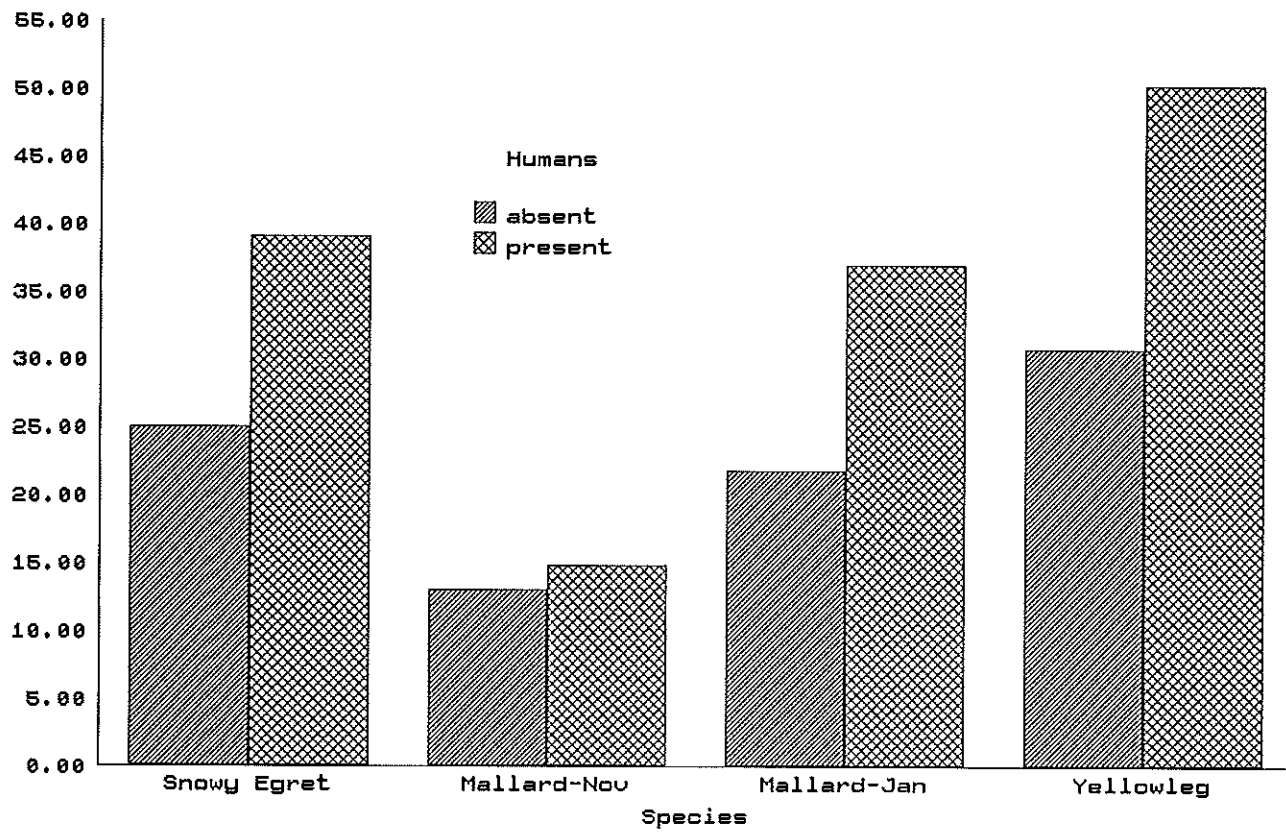


Fig 7 Chronology of Snowy Egret use at Back Bay NWR (1992).

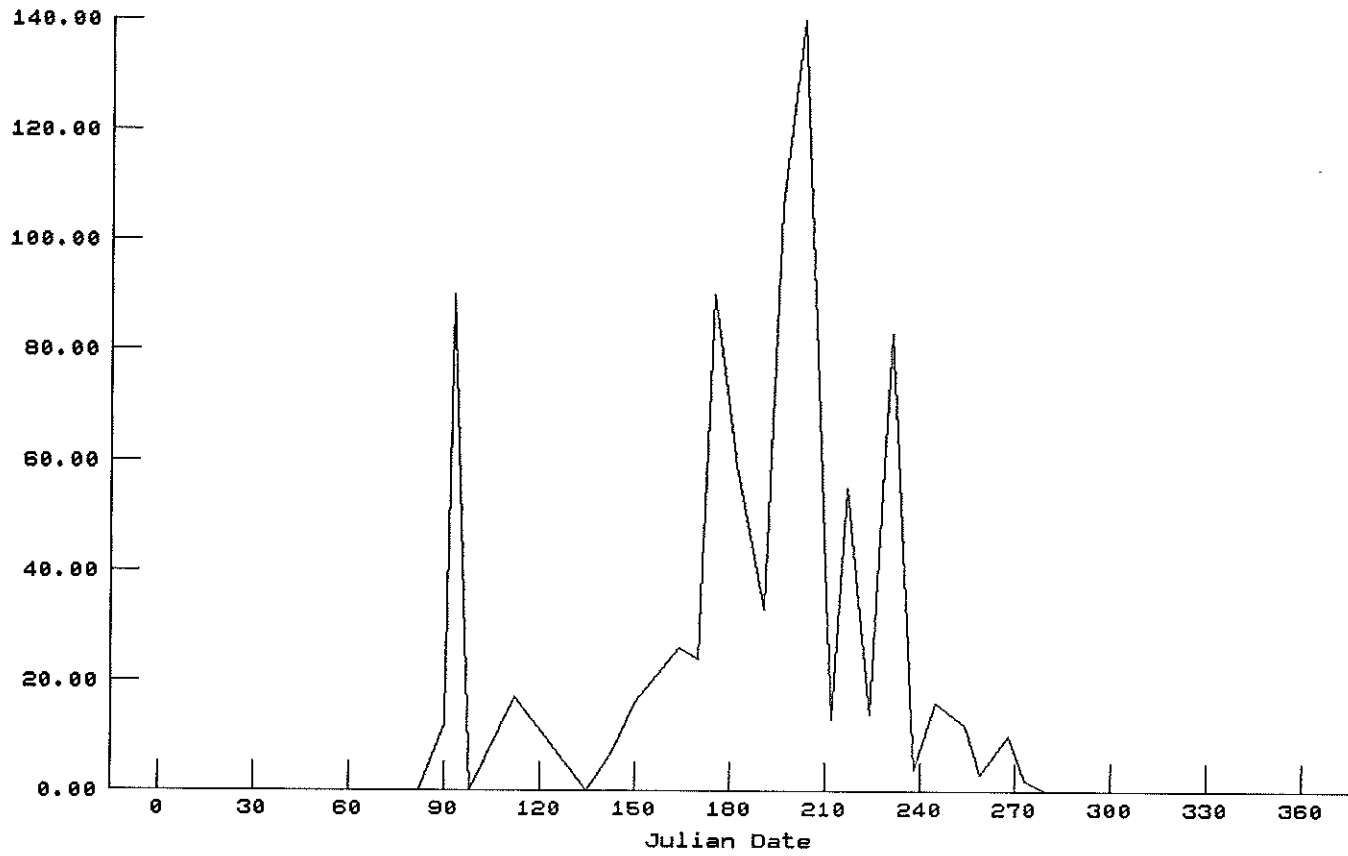


Fig 8 Chronology of Greater Yellowlegs use at Back Bay NWR
(1992).

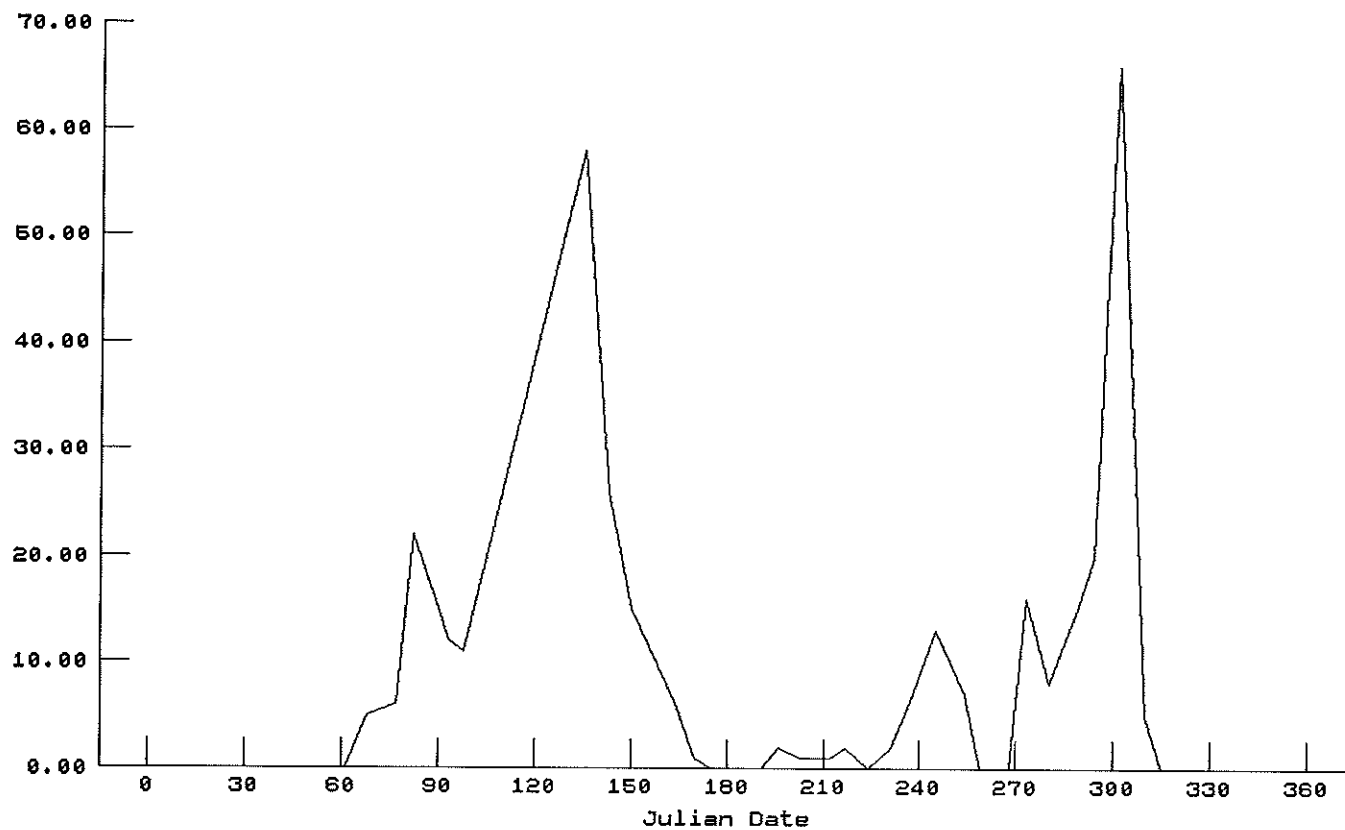


Fig. 9 Chronology of Mallard and Combined Waterfowl use
at Back Bay NWR (1992-1993).

