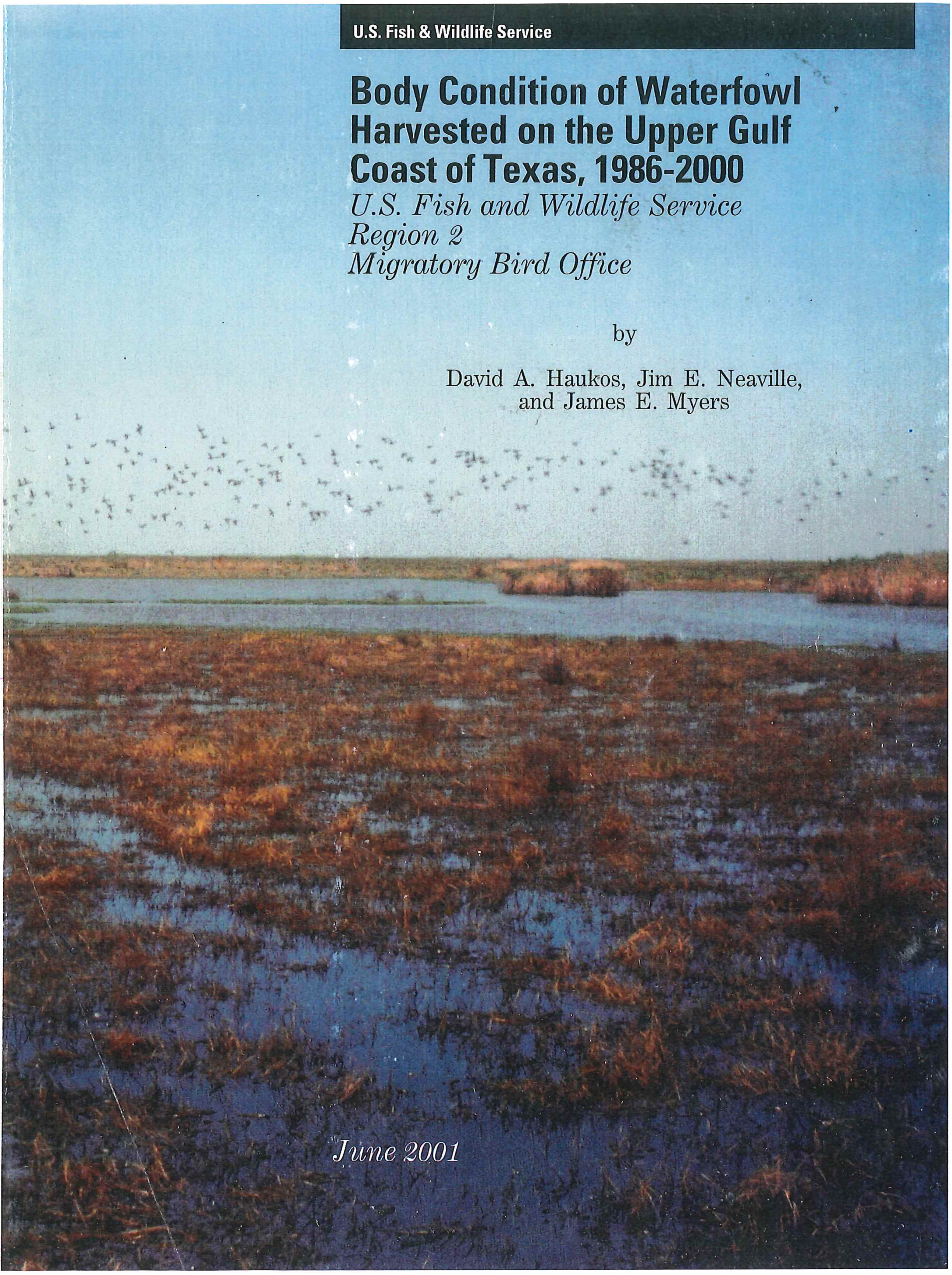

U.S. Fish & Wildlife Service

Body Condition of Waterfowl Harvested on the Upper Gulf Coast of Texas, 1986-2000

U.S. Fish and Wildlife Service
Region 2
Migratory Bird Office

by

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Abstract: Body condition is an indication of nutrient reserves (fat, protein) available to wintering waterfowl to meet current and future energy needs. There are numerous, interacting stress factors that may affect body condition of wintering waterfowl including food availability, habitat quality and quantity, weather, molt, courtship and pair formation, harvest, and disturbance. Body condition of wintering waterfowl influences overwinter survival and subsequent breeding activities. There is a lack of understanding of temporal and spatial variability in body condition within and among waterfowl populations during winter. From 1986-2000, 9,521 birds of 25 waterfowl species were measured (wing chord, body mass, body length, and wing span) at hunter-check stations on the upper Gulf Coast of Texas. A body condition index of body mass divided by wing chord was used to compare body condition of each species across months, hunting seasons, and between collection areas. Correlations between rainfall patterns and condition were examined. Percent composition of age-sex classes differed for harvested puddle and diving ducks, but not for geese. These results are likely the ability of hunters to differentiate among sexes for ducks. Monthly patterns of condition contrasted among species: mallards, mottled ducks, gadwalls, and ring-necked ducks increased in condition from November through January; American wigeon maintained condition throughout the winter; and most other species exhibited declines in condition during January, which may be a regulated loss as stress factors become alleviated. There were no common trends or patterns in condition of waterfowl among hunting seasons with some species such as mallard, male northern pintail, and ring-necked duck, to a finding of only two similar seasons for condition of green-winged teal. The only species to exhibit different seasonal patterns by sex was northern pintail. Condition of waterfowl tended to be better on the larger, unfragmented habitats that have relatively lower incidences of disturbance. Only condition of northern pintail and lesser scaup was correlated with six- and twelve-month precipitation levels indicating a greater affinity for certain wintering areas or habitats created by these rainfall patterns. Condition of migrating and wintering waterfowl remain a concern for wetland and waterfowl managers. The lack of similar condition patterns among species makes management more difficult because of the inability to assume that all species respond similarly to managed wetlands across months and seasons. Fragmentation and increasing disturbance of wintering areas will have detrimental effects on condition of waterfowl, which may lower future survival and reproductive success of these birds.

BODY CONDITION OF WATERFOWL HARVESTED ON THE UPPER GULF COAST OF TEXAS 1986-2000

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Nutrient reserves of waterfowl include the combination of available fat, protein, and other sources of energy stored in the body. Integrated measures of these reserves are collectively termed "condition" (Ringleman 1988). Owen and Cook (1977) defined condition as an individual's fitness to withstand present and future energy needs relative to its activity. Specifically, condition measures the probability of survival of a bird at a particular time of year and its potential for breeding successfully in the future (Ringleman and Szymczak 1985). Temporal changes in the relative magnitude of nutrient reserves as indexed by condition can be used as an indication of energy balance (Ringleman 1988).

Wintering waterfowl experience numerous, typically interacting, stress factors including but not limited to food availability, habitat quantity and quality, weather, molt, courtship, pair formation, recovering from or preparing for migration, disturbance, increasing densities over time, and harvest (e.g., Weller 1965, Bellrose 1980, Hepp and Hair 1983, Korschgen et al. 1985, Heitmeyer 1988, Gammonley and Heitmeyer 1990, Hohman et al. 1990, Smith and Sheeley 1993, Knapton et al. 2000). During winter, fat is the component of condition that is most labile and potentially limiting to waterfowl; that is, changes in body mass of wintering waterfowl usually reflect accumulation or depletion of lipids (Ringleman and Szymczak 1985, Moorman et al. 1992, Smith and Sheeley 1993). Stored lipids provide energy during periods of food shortage, severe weather, and other periods of physiological stress (Blem 1976).

Body condition of waterfowl during the wintering period may influence overwinter survival and reproductive success in the succeeding breeding season (e.g., Ankney and MacInnes 1978, Raveling 1979, Krapu 1981, Heitmeyer and Fredrickson 1981, Burnham and Nichols 1985, Nichols and Hines 1987, Pollock et al. 1989, Raveling and Heitmeyer 1989, Hohman et al. 1995). Hepp et al. (1986) and Blohm et al. (1987) documented a positive relationship between condition and winter survival in mallards (*Anas platyrhynchos*). Positive relationships between overwinter survival and body condition were also reported by Haramis et al. (1986) for canvasbacks (*Aythya valisineria*) and Conroy et al. (1989) for black ducks (*Anas rubripes*). Bergan and Smith (1993) found that poor body condition resulted in a relatively poorer ability by wintering female mallards to travel and avoid adverse weather or deteriorating habitat conditions, thus reducing their survival in playa wetlands of northwest Texas. Schmutz and Ely (1999) found that body condition was positively related to survival of adult female greater white-fronted geese (*Anser albifrons*) in fall and spring, but not for adult males or immature geese.

However, a few other studies of wintering waterfowl have shown conflicting results. For example, Cox et al. (1998) found that winter survival of female northern pintails (*Anas acuta*) in Louisiana was not related to body condition upon arrival on the wintering grounds. Similarly, winter survival of adult female pintails in California was not related to body mass at the time of capture (Miller et al. 1995). Migoya and Baldassarre (1995) found no relationship between body condition at time of capture and winter survival of northern pintails in Mexico. Jeske et al. (1994) also found no relationship between condition at banding and probability of dying from January through April for mallards. A possible conclusion from these studies is that condition of ducks upon arrival on the wintering grounds may not accurately reflect their condition status later in winter.

Little is known about the temporal and spatial variability in body condition within and among waterfowl populations during winter (Ringleman 1988). In addition, examination of changes in body condition among the majority of waterfowl species within and across wintering seasons has yet to be accomplished. Appraising variation of condition among many species wintering in the same area will provide insight into the responses by each species subjected to similar environmental stress factors.

Body condition of waterfowl on their wintering grounds is directly related to the quality and quantity of habitat (e.g., Miller 1986, Delnicki and Reinecke 1986, Heitmeyer 1988, Loesch and Kaminski 1989). Variation in condition among areas provides insight into habitat quality. Furthermore, the amount of precipitation on waterfowl wintering areas does influence age ratios of mallards the following breeding season (Heitmeyer and Fredrickson 1981), with increasing precipitation resulting in more production by mallards. Heitmeyer and Vohs (1984) found a positive correlation between precipitation and number of flooded wintering wetlands, hectares of surface water, wetland diversity, and emergent vegetation/open water interpersion during winter. Smith and Sheeley (1993) reported that northern pintails wintering in playa wetlands of northwest Texas were in better body condition during wet years (above-average rainfall) because more native foods were available (Haukos and Smith 1993, 1995). In addition, because of the improved condition related to availability of native forage, the birds molted and paired earlier (Smith and Sheeley 1993). Bergan and Smith (1993) reported that female mallards wintering in playas had higher survival in wet years. Therefore, examination of annual precipitation patterns could provide insight into causes of seasonal variation of wintering waterfowl condition.

Direct measurement of nutrient reserves or body condition through actual determination of fat and/or protein levels is difficult, time consuming, and expensive. Therefore, an index to condition would (1) allow for rapid assessment of bird condition, (2) permit evaluation of large numbers of birds, and (3) be cost-effective. There have been a considerable number of indices proposed to represent body condition in birds. Initially, body mass was most commonly used as the index. Several researchers have shown a high correlation between body mass and both fat (Owen and Cook 1977, Bailey 1979) and total nutrient (lipid and protein) reserves (Wishart 1979). However, despite a relatively close relationship between body mass and changes in lipid reserves, it was discovered that scaling body mass by a body structural measure reduced variability and improved correlations with lipid levels (Johnson et al. 1985, Harder and Kirkpatrick 1994).

Wing chord (wrist joint to tip of longest primary) is the most common scaler of structural size in condition indices (Owen and Cook 1977, Harder and Kirkpatrick 1994). This condition index was also suggested by Whyte and Bolen (1984) as the best predictor of body fat for wintering mallards, and for use to assess condition without sacrificing birds. Bergan and Smith (1993) used this index in evaluating survival of female mallards wintering in the playas. Hine et al. (1996) also adopted this index in evaluating condition of migrating ducks in Illinois. Ringleman and Szymczak (1985) reported that condition models using wing chord and body mass were best able to estimate total body fat. However, they developed a condition index that is the ratio of estimated fat (determined by mass and wing chord in a regression model) divided by fat-free dry mass (field mass - estimated fat); therefore, requiring development of fat predictive models specific to a distinct wintering area. Smith et al. (1992) recommended using log of body mass and wing chord in regression equations to predict the log of carcass fat for northern pintails wintering in playas.

Other condition indices have been used for wintering waterfowl. Rhodes and Smith (1993) found that an index of carcass mass divided by the sum of carcass length and wing length predicted fat levels in American wigeon (*Anas americana*) wintering in playa wetlands. Bennett and Bolen (1978) used body mass/(bill length*keel length) as a condition index to reflect stress in green-winged teal (*Anas crecca*) wintering in playas. Cox et al. (1998) adjusted body mass of female northern pintails for structural size with the use of principal components analyses. Wishart (1979) recommended use of the index body mass/(body length + wing length) as an index to lipid and protein reserves of American wigeon.

The upper Gulf Coast of Texas is one of the most important wintering areas for waterfowl of the Central Flyway (U.S. Fish and Wildlife Service 2000b). With the exception of mallards and Canada geese, Texas winters greater than 90% of waterfowl in the Central Flyway as indexed by the annual midwinter waterfowl inventory (U.S. Fish and Wildlife Service 2000a). The number of waterfowl counted during the annual midwinter inventory indicate the importance of the upper Gulf Coast of Texas to waterfowl of the Central Flyway (Table 1). Condition of these wintering birds and subsequent effects on survival and reproductive productivity will have direct impacts on waterfowl populations of the Central Flyway.

Objectives

(1) Examine the trends of body condition for waterfowl wintering on the upper Gulf Coast of Texas among seasons, within seasons, and across age/sex classes.

(2) Evaluate the potential impacts of timing and amounts of precipitation on body condition of waterfowl wintering on the upper Gulf Coast of Texas.

(3) Assess differences in body condition between habitats used by wintering waterfowl on the upper Gulf Coast of Texas

METHODS

Bird Collection and Measurement - From October 1986-February 2000, hunter-check stations were manned on public hunt units of Anahuac (Chambers County), McFaddin (Jefferson County), and San Bernard (Brazoria County) National Wildlife Refuges (NWRs). Over 95% of measured ducks were harvested on Anahuac and McFaddin NWRs. The East Hunt Unit of Anahuac NWR is 4,148 ha in size (N 29 59', W 94 27') and characterized by 1,936 ha (46.7%) of openland habitats, of which rice rotation is a major component (1986 1,336 ha, 2000 728 ha), 700 ha (11.7%) of brackish marsh, 1,066 ha (25.7%) of intermediate marsh, and 230 ha (5.2%) of fresh marsh. The Public Hunt Unit of McFaddin NWR represented by the check station data is 4,538 ha in size (N 29 42', W 94 7') and comprised of 4,121 ha (90.8%) of intermediate marsh and 417 ha (9.2%) of brackish marsh. Additional goose data were collected in conjunction with hunting guides operating in areas surrounding the cities of Katy (N 29 59', W 95 46') and Eagle Lake, Texas. Geese were principally harvested over rice and other crop fields in this area.

The range of marsh types found on the NWRs are represented by water salinity ranges (ppt, parts per thousand) and determine habitat type and quality. The greater the diversity in low and mid levels of plant succession, the greater amount of waterfowl use of manipulated habitat when adequate water levels are present.

The brackish marsh has the highest salinity (3.5-10 ppt, average is 8 ppt) of these marsh assemblages, resulting in lower plant diversity. As salinity decreases, plant diversity increases. Brackish marshes are transitional marshes occurring between the saline marsh (nearest to gulf water exposure) and the more inland intermediate marsh type. Dominant grasses include marshhay cordgrass (*Spartina patens*) and seashore saltgrass (*Distichlis spicata*). The dominant sedge is saltmarsh bulrush (*Scirpus robustus*) and forbs include cow pea (*Vigna luteola*) and saltmarsh aster (*Aster subulatus*). Aquatic species are dominated by dwarf spikerush (*Eleocharis parvula*) and widgeongrass (*Ruppia maritima*).

The intermediate marsh type (0.5-3.5 ppt, average is 3.5 ppt) occurs between brackish and fresh marsh or may occur as inclusions in the brackish marshes. The dominant grasses are marshhay cordgrass, seashore paspalum (*Paspalum vaginatum*, and common reed (*Phragmites australis*). Sedges include Olney bulrush (*Scirpus americanus*), sand spikerush (*Eleocharis montevidensis*), Gulfcoast spikerush (*E. cellulosa*), and California bulrush (*S. californicus*). Forbs are represented by cattail (*Typha* spp.), eclipta (*Eclipta prostrata*), Colorado-river hemp (*Sesbania macrocarpa*), coastal water hyssop (*Bacopa monnieri*), purple ammannia (*Ammannia coccinea*), with submergents such as sago pondweed (*Potamogeton pectinatus*), baby pondweed (*P. pusillus*), and banana water lily (*Nymphaea mexicana*).

The inland open fresh marshes (< 0.5 ppt) are dominated by a wide variety of plants. Major dominants include marshhay cordgrass, giant cutgrass (*Zizaniopsis miliacea*), maidencane (*Panicum hemitomon*), barnyard grass (*Echinochloa crusgalli*), and American cup scale (*Sacciolepis striata*). Other plants include cattails, alligatorweed (*Alternanthera philoxeroides*), smartweeds (*Polygonum* spp.), seedbox (*Ludwigia urguayensis*), delta duck potato (*Sagittaria platyphylla*), beggar's tick (*Bidens laevis*), American lotus (*Nelumbo lutea*), chicken spike (*Sphenoclea zeylanica)*, Florida crinum (*Crinum americanum*), powder thalia (*Thalia dealbata*), pickerelweed (*Pontederia cordata*), and burhead (*Echinodorus rostratus*). The long list of floating and submerged aquatics include white water lily (*Nymphaea odorata*), water shield (*Brasenia schreberi*), cabomba (*Cabomba caroliniana*), floating water primrose (*Ludwigia peploides*), water hyacinth (*Eichhornia crassipes*), frogbit (*Limnobium spongia*), lake acanthus (*Hygrophila lacustris*), common bladderwort (*Utricularia vulgaris*), and longleaf pondweed (*Potamogeton nodosus*).

It is important to note that some of the plants that occur in the fresh marsh also extend downstream into the intermediate marsh, with only a few species of the intermediate marsh extending into the brackish assemblage. The existence of these plants is due to their specific tolerances to salt concentrations and varying water depths. The extent of their distribution is dependent on individualistic plant tolerance across both wet and dry weather cycles.

Dates of refuge hunter-check stations establishment were based on annual hunting regulations (i.e., season opening and closing dates), with the intent of similar sampling effort of harvested birds among years. Check stations were manned each month of the hunting season, with three targeted periods: season opening weekend, any split-season opener, and the end of the hunting season. Each harvested bird was identified to species, sexed, and aged. Ducks were aged and sexed via tail- and wing-feather characteristics (Carney 1992, Dimmick and Pelton 1994). Geese were aged based on tail-feather characteristics and sexed using cloacal examination. Excess moisture was wiped from the birds prior to body measurements. Disfigured birds were excluded from the data set. Wing chord was measured in cm from the anterior edge of wrist joint to tip of longest primary. Body mass was measured with an electronic scale to the nearest gram. All birds were measured by Jim Neaville, refuge biologist, Anahuac National Wildlife Refuge. A body condition index (BCI) was calculated for each bird as body mass (g) divided by wing chord (cm). This index was used because (1) models to estimate fat of waterfowl wintering (*sensu* Ringleman and Szymczak 1985) on the Gulf Coast have not been established and (2) this ratio is the most common condition index reported for waterfowl.

Statistical Analyses - Measured birds were separated into four age-sex classes: adult male, adult female, juvenile male, and juvenile female. If greater than 500 birds of a species were measured, a three-way factoral analysis of variance was used to compare the BCI among age-sex classes, months of collection, season (the wintering period of November - January), and respective interactions. Because of the variation in hunting seasons from 1986-2000, some months (i.e., September, October, and February) are poorly represented in the data and therefore, were only included in the analysis of variance models if more than 30 birds/species/month were measured during the study period; otherwise, these data are included in the summary statistics. The special early teal season allowed for the measurement of these species during September. If interactions occurred in the three-way model, the data were analyzed by one of the interacting factors, usually either by month or season. When fewer than 500 total birds/species were measured, separate two-way analyses of variance were conducted comparing the BCI among age-sex classes and months and among age-sex classes and seasons. Following any significant *F*-value ($P \leq 0.05$) in an analysis of variance and lacking significant interactions, factor levels were separated by the Least Significant Difference Test (LSD).

A two-way analysis of variance was used to compare BCI among age-sex classes and hunt units. Only ducks were evaluated in these analyses because of the uncertainty of where some geese were collected. Also, comparisons were limited to between Anahuac and McFaddin NWRs because of the lack of sufficient samples from other areas.

Rainfall was measured with several gauges on Anahuac NWR during the study period. These measurements were averaged and used in a correlation analysis with average seasonal (Nov. - Jan.) condition index for 12 species of waterfowl. The condition index for each species was tested for correlation with rain totals for the entire year (Jan. - Dec.), the last 6 months (July - Dec.), and the final 3 months (Oct. - Dec.).

RESULTS

During the 14 years of the study, 9,521 birds of 25 species of waterfowl were measured. In addition, 15 individuals were determined to be hybrids (10 mottled duck/mallard, 2 mallard/American wigeon, 1 gadwall/northern pintail, 1 gadwall/American wigeon, 1 Ross'/snow goose), but these birds were not included in any analyses. Percent composition of age and sex categories did not differ among species for geese ($\chi^2 = 10.6$, 9 df, $P = 0.30$; Fig. 1), but did so for puddle ($\chi^2 = 356.1$, 24 df, $P = <0.0001$; Fig. 2) and diving ducks ($\chi^2 = 58.1$, 12 df, $P = <0.0001$; Fig. 3).

Summary data for all species are presented for wing chord (Table 2), body mass (Table 3), condition index (Table 4), body length (Table 5), wing span (Table 6), and ranges associated with these measurements (Table 7). Too few Ross' goose (*Chen rossii*), cinnamon teal (*Anas cyanoptera*), fulvous whistling duck (*Dendrocygna bicolor*), black-bellied whistling duck (*D. autumnalis*), greater scaup (*Aythya marila*), common goldeneye (*Bucephala clangula*), bufflehead (*B. albeola*), hooded merganser (*Lophodytes cucullatus*), and ruddy duck (*Oxyura jamaicensis*) were collected to perform comparative tests; however, measurement data for these species are presented (Tables 2-7)

Canada Goose (*Branta canadensis*) - The BCI differed (3, 89 df, $F = 3.6$, $P = 0.02$) across age-sex classes (Table 4).

Greater White-Fronted Goose - During the analyses of the 237 measured greater white-fronted geese differences were found among age-sex classes for the BCI (3, 221 df, $F = 8.1$, $P = <0.0001$) (Table 4). The BCI did vary across months (2, 221 df, $F = 4.5$, $P = 0.01$) and seasons (12, 191 df, $F = 2.6$, $P = 0.004$) (Fig. 4).

Snow Goose (*Chen caerulescens*)- A total of 822 snow geese was measured. The 3-way analysis of variance resulted in a difference among age-sex classes for the BCI (3, 671 df, $F = 12.4$, $P = <0.0001$) (Table 4). In the 3-way analysis, a month by season interaction occurred (22, 671 df, $F = 1.7$, $P = 0.02$) that resulted in separate analyses by month and season. The BCI differed across months (3, 755 df, $F = 6.4$, $P = 0.0003$) and seasons (13, 718 df, $F = 2.5$, $P = 0.02$) (Fig. 5).

Mallard - In the 2-way analyses for the 341 measured mallards, the BCI differed (3, 328 df, $F = 33.9$, $P = <0.0001$) among age-sex classes (Table 4). The BCI did vary (2, 328 df, $F = 3.3$, $P = 0.04$) across months but not seasons (13, 288 df, $F = 1.3$, $P = 0.19$) (Fig. 6). There were no differences (1, 300 df, $F = 0.3$, $P = 0.62$) in BCI of mallards between Anahuac and McFaddin NWRs (Table 8).

Mottled Duck (*Anas fulvigula*) - Variation occurred among age-sex classes for the BCI (3, 537 df, $F = 14.8$, $P = <0.0001$) (Table 4). However, a month*season interaction was present (25, 537 df, $F = 2.8$, $P = <0.0001$), resulting in subsequent analyses of these variables by month and season. The BCI varied across both seasons (13, 630 df, $F = 2.5$, $P = 0.002$) and months (3, 660 df, $F = 10.9$, $P = <0.0001$) (Fig. 7). The BCI was greater (1, 653 df, $F = 10.7$, $P = 0.001$) for birds collected at McFaddin NWR than at Anahuac NWR (Table 8).

Northern Pintail - The BCI differed (3, 389 df, $F = 21.8$, $P = <0.0001$) among age-sex classes and months (2, 389 df, $F = 6.9$, $P = 0.001$) for the 410 measured northern pintails (Table 4, Fig. 8). The only sex-age class*season interactions for any species occurred (13, 368 df, $F = 2.0$, $P = 0.001$) in northern pintail. Therefore, subsequent analyses on the season effect were done by sex. The BCI did not vary across seasons for male (13, 292 df, $F = 1.1$, $P = 0.34$), but did so for female (12, 97 df, $F = 1.8$, $P = 0.05$) northern pintails (Fig. 8). Northern pintails collected at Anahuac and McFaddin NWRs did not differ (1, 362 df, $F = 0.01$, $P = 0.95$) in BCI between the two areas (Table 8).

Gadwall (*Anas strepera*)- An age-sex class*month*season interaction occurred in the 3-way analyses of 1,640 measured gadwalls (68, 1,448 df, $F = 1.4$, $P = 0.03$), resulting in continued analyses by month and season. The BCI varied among age-sex classes (3, 1,585 df, $F = 303.2$, $P = <0.0001$) across months (2, 1,625 df, $F = 49.1$, $P = <0.0001$), and among seasons (13, 1,585 df, $F = 11.3$, $P = <0.0001$) (Table 4, Fig. 9). There was an age-sex class by area interaction (3, 1621 df, $F = 2.9$, $P = 0.03$), so BCI was compared between areas by age-sex class. Adult females (1, 353 df, $F = 0.53$, $P = 0.47$), adult males (1, 546 df, $F = 0.61$, $P = 0.44$), and juvenile males (1, 394 df, $F = 1.5$, $P = 0.22$) had similar BCI values between the two areas (Table 8). However, condition index for juvenile females was greater at McFaddin NWR (1, 328 df, $F = 5.9$, $P = 0.02$) (Table 8).

American Wigeon - Results from the 3-way analyses of the 594 measured American wigeon indicated a difference among age-sex classes for the BCI (3, 457 df, $F = 16.5$, $P = <0.0001$) (Table 4). A month*season interaction (23, 457 df, $F = 1.8$, $P = 0.02$) was found, resulting in the need for a separate analyses by season and month. The BCI varied across seasons (13, 539 df, $F = 5.7$, $P = <0.0001$), but not months (2, 579 df, $F = 2.1$, $P = 0.13$) (Fig. 10). There were no differences (1, 578 df, $F = 1.5$, $P = 0.22$) in BCI of American wigeon between Anahuac and McFaddin NWRs (Table 8).

Blue-Winged Teal (*Anas discors*)- In the 3-way analysis for the 562 measured blue-winged teal, BCI was different among age-sex classes (3, 507 df, $F = 5.5$, $P = 0.001$) and across seasons (13, 419 df, $F = 3.7$, $P = <0.0001$) (Table 4, Fig. 11). However, an age-sex*month interaction was found (12, 419 df, $F = 2.3$, $P = 0.007$), resulting in subsequent analyses by age. For adult birds, BCI varied (4, 219 df, $F = 4.8$, $P = 0.0009$) across months (Fig. 11). A slightly different monthly pattern was found in juvenile birds (4, 333 df, $F = 15.9$, $P = <0.0001$) (Fig. 11). The BCI was greater (1, 520 df, $F = 13.4$, $P = 0.0003$) for birds harvested at McFaddin NWR than Anahuac NWR (Table 8).

Green-Winged Teal - The BCI differed (3, 1,979 df, $F = 85.6$, $P = <0.0001$) among age-sex classes (Table 4). A month*season interaction was found (25, 1,869 df, $F = 3.9$, $P = <0.0001$), resulting in subsequent analyses by month and season. The BCI varied across months (3, 2,019 df, $F = 6.57$, $P = 0.0002$) and among seasons (13, 1,979 df, $F = 3.3$, $P = <0.0001$) (Fig. 12). Green-winged teal harvested on Anahuac and McFaddin NWRs had similar BCIs (1, 1,979 df, $F = 2.2$, $P = 0.14$) (Tables 8).

Northern Shoveler (*Anas clypeata*)- There was an age-sex class*month*season interaction for the 680 measured northern shovelers (50, 530 df, $F = 1.8$, $P = 0.0009$), resulting in subsequent analyses by month and season. The BCI varied among age-sex classes (3, 617 df, $F = 10.7$, $P = <0.0001$) and seasons (13, 617 df, $F = 3.7$, $P = <0.0001$) (Table 4; Fig. 13). However, interactions were still evident for age-sex class and month (6, 634 df, $F = 3.1$, $P = 0.005$). Therefore, monthly analyses were separated by sex. For females, BCI differed (2, 317 df, $F = 6.7$, $P = 0.001$) among months (Fig. 13). Further interactions between age and month were found for males (2, 317 df, $F = 6.7$, $P = 0.001$). Separation of age within males revealed differences in BCI (2, 126 df, $F = 9.3$, $P = 0.0002$) among months for juveniles (Fig. 13). Although not as pronounced as for juveniles, BCI also varied among months (2, 191 df, $F = 3.7$, $P = 0.03$) for adults as well (Fig. 13). These complicating interactions were caused by the presence of numerous juvenile males weighing greater than 700 g harvested during December of 1993 and 1997. An age-sex class by area interaction was present (3, 646 df, $F = 8.7$, $P = 0.003$) in the between area analyses. Adult females (1, 96 df, $F = 8.6$, $P = 0.004$) and juvenile males (1, 128 df, $F = 4.8$, $P = 0.03$) had higher values from McFaddin NWR, while adult males (1, 190 df, $F = 0.18$, $P = 0.67$) and juvenile females (1, 232 df, $F = 1.6$, $P = 0.21$) had similar condition index values between the two areas (Table 8).

Wood Duck (*Aix sponsa*) - The BCI varied (3, 72 df, $F = 3.9$, $P = 0.01$) among age-sex classes for the 82 measured wood ducks (Table 4).

Redhead (*Aythya americana*) - Over the study period, 58 redheads were measured. The BCI differed (3, 50 df, $F = 3.3$, $P = 0.03$) among age-sex classes (Table 4).

Canvasback - Over the study period, 46 canvasbacks were measured. The BCI differed (3, 31 df, $F = 3.8$, $P = 0.005$) among age-sex classes (Table 4).

Ring-Necked Duck (*Aythya collaris*) - Because 334 ring-necked ducks were measured, the 3-way analysis was not conducted. The BCI differed among age-sex classes (3, 326 df, $F = 17.9$, $P = <0.0001$) and across months (2, 322 df, $F = 3.97$, $P = 0.02$) (Table 4, Fig. 14). Possibly due to small sample sizes, there were no differences in BCI (11, 290 df, $F = 1.6$, $P = 0.11$) among seasons (Fig. 14). The BCI analysis between areas was represented by an age-sex class*area interaction (3, 323 df, $F = 3.2$, $P = 0.02$), resulting in comparison of index values between areas by age-sex class. Adult males had greater BCI values on McFaddin NWR (1, 81 df, $F = 5.1$, $P = 0.03$), while adult females (1, 89 df, $F = 2.3$, $P = 0.13$), juvenile males (1, 65 df, $F = 0.51$, $P = 0.48$), and juvenile females (1, 88 df, $F = 1.8$, $P = 0.18$) had similar values between the areas (Table 8).

Lesser Scaup (*Aythya affinis*) - In the 3-way analyses for the 744 measured lesser scaup, a month*season interaction was significant (18, 638 df, $F = 2.6$, $P = 0.0003$). Therefore, all subsequent analyses were conducted by month and season. The BCI differed among age-sex classes (3, 731 df, $F = 8.9$, $P = <0.0001$), across months (3, 731 df, $F = 33.2$, $P = <0.0001$), and among seasons (13, 697 df, $F = 2.2$, $P = 0.008$) (Table 4, Fig. 15). Compared to Anahuac NWR, lesser scaup had greater (1, 733 df, $F = 13.6$, $P = 0.0002$) BCI values when collected on McFaddin NWR (Table 8).

Correlations Between Condition Index and Precipitation

For most species, there were no significant correlations ($P > 0.10$) between condition index and rainfall totals (Table 9). In general across species , the condition index was positively correlated with 12- and 6-month rainfall totals, but negatively correlated with the 3-month rainfall totals (Table 9). However, there are a few notable exceptions to this trend. Lesser scaup were significantly positively correlated to the 12- and 6-month rainfall totals (Table 9). A similar pattern was found for blue-winged teal (Table 9). Because of previously documented differences in condition trends by male and female northern pintail, correlation analyses were broken down by sex for this species. There were contrasting correlations between sexes of northern pintail as condition index of females was correlated with the 12-month precipitation total and male condition index correlated with the 6-month precipitation total (Table 9). Interesting were the negative correlations between rainfall and condition index of ring-necked duck and greater white-fronted goose for all precipitation totals (Table 9).

DISCUSSION

Variation in body condition within and among waterfowl species wintering on the upper Gulf Coast of Texas is a complex subject. Based on these data, it is evident that exogenous and endogenous factors affecting body condition of waterfowl vary considerably even among species on the same wintering grounds. Wintering waterfowl are typically subjected to stressful environmental and physiological conditions. Weather, molt, decreasing food availability, increasing bird densities, pair formation, disturbance and other conditions influence use of nutrient reserves (i.e., stored lipids) by wintering waterfowl. However, there are various strategies among and within waterfowl species for response to stressful environmental and physiological conditions. For example, male green-winged teal wintering in the Playa Lakes Region (PLR) of northwest Texas decreased in body condition under severe weather conditions such as freezing temperatures, precipitation events, and high wind chill; whereas females would leave the region, returning when severe conditions abated (Bennett and Bolen 1978). Therefore, it is unlikely that general patterns are possible for modeling changes in body condition across species of wintering waterfowl. It is much more important to recognize that body condition of most wintering waterfowl is a dynamic variable, fluctuating among age-sex classes, months, seasons, and habitat conditions.

This is the first long-term study of body condition of wintering waterfowl. Harvested birds from multiple species were sampled over a 14-year period, allowing for comparisons within species, among species and species groups, and across time both within and across seasons. There are conflicting views on the use of hunter-killed birds for making inferences on the condition status of a population of waterfowl. Evidence exists for a bias towards lower condition for hunter-killed birds compared to the population (Greenwood et al. 1986). Reinecke and Shaiffer (1988) found that hunter-shot mallards had lower condition indices than rocket-netted birds. McCracken et al. (2000) found that ring-necked ducks shot by hunters were in poorer condition than randomly collected birds, but there was a compounding variable of lead exposure in this study that may be confounding in other wintering areas as well. However, Bergan and Smith (1993) showed that bait-trapped wintering female mallards did not differ in body mass from birds randomly collected in playas. Additionally, Sheeley and Smith (1989) found no condition bias between northern pintails collected by hunters and those collected by researchers - that is, body condition did not differ between pintails shot over decoys and those shot in travel corridors or flushed from playa lakes. Morez et al. (2000) found no evidence that snow geese shot by hunters were biased toward poor condition.

Percent composition of age-sex classes differed for harvested puddle and diving ducks but not for geese. Apparently, this is the result of the ability of hunters to differentiate (consciously or not) among sexes (Metz and Ankney 1991). The lack of sexual dimorphism in geese resulted in the similar age-sex composition among species with adult males and females accounting for greater than 50% of harvested birds for all 4 species. There was much more variation in percent composition of age-sex classes for puddle ducks. In general, adult males were the highest ranked harvested age-sex class for most species with the most glaring exception of juvenile females being the highest taken age-sex class for northern shovelers. This may be due to a lack of distinguishing in-flight characteristics among females for species that most hunters are trying to avoid. Mottled ducks are likely an exception to this generalization despite our data showing adult males the highest ranked harvest sex-age class because they attain adult plumage and anatomical characteristics much earlier than other species (Stutzenbaker 1988). This results in frequent misclassification of juvenile birds as adults from midwinter on (Moorman et al. 1992). Indeed, results from banded birds indicates that hatch-year males make up more of the harvest than adults (B. Wilson pers. comm.). Therefore, it is probable that adult male mottled ducks were incorrectly aged late in the hunting season during this study. Such a pattern was not found in diving ducks, where the percent composition of age-sex classes showed less variation than that found in dabbling ducks. With the exception of lesser scaup, juvenile diving ducks dominated the harvest.

Differences in BCI among age-sex classes showed similar patterns within each waterfowl group. For snow and greater white-fronted geese, the rank order of age-sex classes for body measurements was adult male, adult female, juvenile male, and juvenile female. However, BCI values were similar between adult females and juvenile males for these species. Canada geese displayed fewer differences among age-sex classes, but these results may be related to sample size. With only a couple of exceptions, the rank order of values of BCI was adult male, juvenile male, adult female, and juvenile female for dabbling ducks. This pattern is consistent with other studies (e.g., Delnicki and Reinecke 1986, Ringleman 1988, Hier 1989, Krementz et al. 1989, Lokemoen et al. 1990, Hohman and Weller 1994, Hine et al. 1996). The notable exceptions to this pattern in our study include: (1) juvenile male blue-winged teal have larger average condition index value and similar body mass value as adults and (2) juvenile male mottled duck, northern pintail, American wigeon, and wood duck have similar condition index values as adult females. Compared to dabbling ducks, there were fewer differences BCI among age and sex classes in diving ducks.

Within Season Effects

Waterfowl commonly gain body mass during the fall (Sanderson and Anderson 1981, Austin and Fredrickson 1987, Serie and Sharp 1989, Hine et al. 1996), peak in mass as individuals arrive on wintering grounds (e.g., Takekawa 1987, Rhodes and Smith 1996), and then lose body mass during mid to late winter (Ryan 1972, Peterson and Ellarson 1979, Delnicki and Reinecke 1986, Miller 1986, Whyte et al. 1986, Heitmeyer 1988), which has been attributed to weather, courtship and pairing, molt, or diminished food resources for a negative energy balance and the need to catabolize stored reserves (Milne 1972, Owen and Cook 1977, Peterson and Ellarson 1979, Kaminsky and Ryan 1981, Joyner et al. 1984, Paulus 1984, Whyte and Bolen 1984, Smith and Sheeley 1993).

However, in response to lower maintenance costs (e.g., improving weather conditions, abundant food) decreasing nutrient reserves may be a regulated endogenous loss (Reinecke et al. 1982, Whyte and Bolen 1984, Hepp 1986, Loesch et al. 1992, Lima 1986, Smith and Sheeley 1993). Abundant food resources in the PLR during wet years allowed duck populations to maintain a relatively high level of condition without the need to store the food as fat or protein (Smith and Sheely 1993). It would be adaptive to increase body condition before stressful conditions occur thereby allowing use of these reserves during period of stress (weather, molting, courtship, increasing bird densities). In contrast, maintaining existing lipid levels through increased foraging time increases exposure to weather and predation as well as additional energy input to search for food. However, once the likelihood of stress is diminished, birds no longer need to endure the metabolic costs of maintaining extra mass and the flight costs associated with it. Therefore, birds may catabolize fat reserves, lose mass, and subsequently condition, because it is no longer needed.

On the upper Gulf Coast, wintering waterfowl are unlikely to experience extended periods of stressful weather. Therefore, any loss of condition (i.e., lipids) would either be a regulated loss or a response to physiological demands. Typically, increasing condition occurs just prior to spring migration. Our data do not provide a measure for this period.

There were considerable differences in patterns of condition index values among species wintering on the upper Gulf Coast of Texas. Greater white-fronted geese declined in condition from November through January, whereas snow geese decreased in condition from November to December, peaked in January, and declined again in February. Flickinger and Bolen (1979) during a study on the Gulf Coast of Texas from 1972-1976, found that snow geese lost mass from October through April, whereas harvested geese in this study had greater mass in January and February than November and December.

Among puddle ducks, mallards, mottled ducks, and gadwalls increased in condition from November through January in this study. Other studies have reported a mid to late winter loss in carcass mass or lipids for mallards. Rhodes (1991) and Rhodes et al. (1996) reported that body mass of adult mallards showed peaks upon arrival in playas and just prior to spring migration, while juveniles showed a steady body mass peaking just before migration back to the breeding grounds. Whyte and Bolen (1984) found no differences during winter in fat mass of juvenile mallards. However, they found that adults and juvenile females experienced a midwinter loss in fat.

Interestingly, despite being nearly non-migratory, mottled ducks in our study followed the same monthly pattern as mallards. Our results concur with those of Moorman et al. (1992) in Louisana, where mottled ducks gradually increased or maintained body mass and lipid reserves from fall through late winter. They believed that this overwinter increase was related to the potential of late winter and early spring breeding opportunities.

On the upper Texas Gulf Coast, American wigeons maintained their condition throughout the wintering period. Rhodes (1991) and Rhodes and Smith (1993) reported that body mass of wigeon peaked in early winter and then declined for birds wintering in playas.

Northern shovelers peaked in body condition during December and than decreased during January to values similar to November. This trend was also reported by Tietje and Teer (1988) for northern shovelers on the mid Texas Gulf Coast. They reported a body mass peak from mid-November to mid-December, with declining mass through the end of March.

Blue-winged teal exhibited a pattern of low condition values in September, increasing to a peak in October - November, then decreasing through January. This pattern was more drastic among juveniles than adults.

Green-winged teal had lowest condition values in October, increasing to a peak during December, and then decreasing into January. Green-winged teal wintering in playas increase body mass from October through December, decrease through February, and increase again in March (Baldassarre and Bolen 1986, Baldassarre et al. 1986).

Northern pintails maintained their condition through December but decreased in condition in January. Birds wintering in the playas decreased in fat from November to December, but did not vary from January to March in average precipitation years (Smith and Sheeley 1993). However, in a wet year, there was a decline in fat in February, which was attributed to a regulated loss to reduce energetic costs during periods of improving environmental conditions (Smith and Sheeley 1993). A similar midwinter decline in condition was also found in pintails wintering in California (Miller 1986).

In diving ducks ring-necked ducks increased in condition from November to December, and maintained these levels through January. In Florida, Hohman et al. (1988) found that immature ring-necked ducks were lower in mass than adults during fall migration but the two groups were equivalent in mass by late winter, and that both sexes showed a constant mass gain over winter. Lesser scaup had the lowest condition values in November, peaked in December, and showed a slight decrease in January.

The asynchrony in mass and condition fluctuations among species may reflect size difference, differences in selective pressures such as variation in chronology of pairing activities, or differential habitat use (i.e., niche). For example, pintails pair during December through January (earlier in wet years), but green-winged teal do not pair until February - March in the PLR (Baldassarre and Bolen 1986). Birds of larger size can store more lipids at the start of the wintering period, which is a metabolic advantage during periods of stress (Kendeigh 1969). Using principle components analyses on waterfowl populations wintering on the Gulf Coast of Texas just south of our study area, White and James (1978) convincingly showed little niche overlap among 13 species when considering 20 environmental and social factors; indicating notable resource partitioning that would lead to differential within season condition trends among species.

Among Season Effects

Many studies have documented changes in body condition associated with variability in climatic conditions from year to year (Bergan and Smith 1993, Rhodes and Smith 1993, Migoya and Baldassarre 1995, Cox et al. 1998). Baldassare et al. (1986) attributed these effects in the PLR to changes in annual values of snow cover, wind speed, wind chill, and temperature. Other factors potentially contributing to seasonal differences of condition within species are reproductive success, migratory and wintering habitat, and disturbance on the wintering grounds. Moorman et al. (1992) proposed that seasonal differences may be related to changes in gut morphology, which is possibly linked to diet diversity and habitat quality. Increasing diet diversity (i.e., improving habitat quality) decreases size and mass of digestive organs (Kehoe and Ankney 1985, Kehoe et al. 1988). Therefore, it may be possible that decreasing body mass or BCI among seasons may not be a reflection of declining habitat conditions but rather improving conditons.

For our data, BCI patterns across seasons mirrored changes in body mass. In general, there were considerable differences among seasons for BCI of waterfowl wintering on the upper Gulf Coast of Texas from 1986-2000. However, most patterns were unique for each species. For example, mallard, male northern pintail, and ring-necked duck exhibited no BCI differences among seasons, whereas other species only had a few seasons with similar measurements. Hypotheses for a lack of seasonal variation within a species include: (1) being a food and habitat generalist not influenced by seasonal changes in habitats or foods; (2) rapid adaptation to changing environmental conditions; and (3) ability to consistently outcompete other species.

There were contrasting seasonal BCI patterns for dabbling ducks, ranging from no differences among seasons for mallards and male northern pintails to a finding of only two similar seasons for the condition index of green-winged teal. Unlike the finding in our study, Jeske (1991) reported that body mass and condition of mallards wintering in the San Luis Valley of Colorado differed among a three year study period. Bergan (1990) also found annual differences in mallard body mass and condition index over a three-year period in for birds wintering in playas.

Northern pintails featured the only seasonal pattern that differed among sexes. In contrast to the lack of differences in males, female northern pintails appear to have the most dramatic seasonal fluctuations of any of the examined waterfowl species. For females, condition peaks occurred in 90-91 and 91-92, with a low in 92-93. This finding contrasts with the observation by Smith and Sheeley (1993) that carcass mass of male pintails differed between years, but not for females (a 2-year study). Cox et al. (1998) reported that condition of female northern pintails in Louisiana differed among winters from 1990-1993, with condition highest in 1990-1991, but in contrast to our findings, lowest in 1991-1992.

Mottled ducks are present on the upper Gulf Coast throughout the year. Unlike the other species, changes in condition of mottled ducks reflect only local environmental and habitat conditions. Therefore, seasonal patterns in body measurement and condition were not expected to be similar to the migratory species. Peaks in condition of mottled ducks occurred in 91-92 and 96-97, with lows found in 86-87, 87-88, 88-89, and 99-00.

Most blue-winged teal, the earliest migrating species, use the upper coast as a staging area in their migration to Central and South America. They exhibited their lowest condition values in 86-87 and 88-89. Since 94-95 the condition index has been relatively high and constant with the peak in 96-97 and only a slight dip in 97-98. As previously mentioned, green-winged teal displayed the most dramatic condition differences among seasons, with the peak in 96-97 and lows in 86-87, 87-88, 98-99. and 99-00.

Gadwall had the most distinctive seasonal pattern, with the peak in 89-90, and lows in 86-87, 87-88, 94-95, 97-98, and 99-00. Condition of American wigeon peaked in 89-90 and 90-91, with lows in 86-87, 87-88, 88-89, 97-98, and 98-99. Contrastingly, northern shoveler condition peaked in 92-93 and 98-99, with lows in 88-89, 90-91, and 91-92.

The contrast in seasonal patterns was drastic for the two diving ducks for which sufficient data existed for seasonal comparisons. Because of the within season variability, ring-necked ducks exhibited no differences in BCI among seasons. However, BCI differed among seasons for lesser scaup. Peaks in the condition of lesser scaup occurred during 87-88, 92-93, 95-96, and 98-99, with lows occurring in 88-89 and 93-94.

Other than smaller species exhibiting greater interseasonal variation than larger species, these results indicate that generalized statements on the condition of wintering waterfowl are not appropriate because of the seasonal differences among species. That is, for ducks, it was rare for a common pattern to occur across seasons among species; it was exceptional when peaks and lows corresponded among species. With the exception of numerous condition peaks in 97-98 and lows in 99-00, there was a lack of evident similarities in seasonal patterns among dabbling and diving ducks. From a management point-of -view, despite relatively consistent management practices on the National Wildlife Refuges throughout the study, it is apparent that not all species utilize available habitats similarly from one season to the next. However, greater white-fronted and snow geese featured comparable patterns for condition index across seasons with peaks during 87-88 and 99-00, and a low in 95-96.

Comparisons to Other Waterfowl Migrating and Wintering Areas

There have been several studies of body condition of migrating and wintering waterfowl. Most of the studies have concentrated on mallards or northern pintails. In addition, in a few studies different condition indices were used, resulting in the inability for direct comparison of our results in some instances. Furthermore, only a few studies have concentrated on wintering waterfowl of the Central Flyway, with the exception of the mallard and northern pintail studied in playas.

Northern Pintail - The BCI of northern pintails wintering on the upper Gulf Coast of Texas is lower than for those wintering in the PLR. Condition index of body mass/wing chord was an average of 3.7% lower for birds on the Gulf Coast compared to those collected in playas during 1984-1986 (Smith et al. 1992). Body mass was an average of 1.7% lower for birds on the Gulf Coast compared to those in playas (Smith et al. 1992). Interestingly, body mass of adult and juvenile female pintails wintering in Mexico (Migoya and Baldassarre 1995) was 8.4% lower than the values measured for birds wintering on the Gulf Coast. These differences may reflect the costs of migration distance or declining environmental stress factors reducing the need for endogenous lipid storage. Northern pintails were the only species that exhibited significantly different condition trends between sexes on the Gulf Coast of Texas. Smith and Sheeley (1993) found that females wintering in playas had higher percent of body fat than males. This aspect may be related to extensive amount of time pintails spend on the wintering grounds compared to other waterfowl species, with large portion of the population arriving in late August through mid-September.

Mallard - The mean condition index of body mass divided by wing chord was higher for female mallards wintering in playas 1986-1988 (Adult = 43.5, Juvenile = 41.8; Bergan and Smith 1993) than for birds on the upper Texas Gulf Coast (Adult = 40.3, Juvenile = 38.0). With the exception of juvenile females, average body condition of mallards on the upper Texas Gulf Coast (Male Adult = 43.7, Juvenile = 41.5; Female Adult = 40.3, Juvenile = 38.0) was similar to those recorded in fall migrating birds in Illinois (Male Adult = 43.1, Juvenile = 41.3; Female Adult = 40.2, Juvenile = 36.2) during 1985 and 1989-1991 (Hine et al. 1996).

Green-winged Teal - Compared to fall migrating green-winged teal in Illinois (Hine et al. 1996), adult males were in slightly poorer condition on the upper Texas Gulf Coast (Illinois = 20.5, Texas = 19.5). This relation was also found for adult females (Illinois = 19.8, Texas = 18.4); but not for juvenile males (Illinois = 18.4, Texas = 19.0).

Lesser Scaup - Condition of fall migrating lesser scaup in Illinois was substantially greater than those recorded in our study (Hine et al. 1996). Condition of male lesser scaup in the upper Texas Gulf Coast averaged 35.4 and 34.4, respectively for adults and juveniles, which are lower than averages for adults (43.6) and juveniles (39.9) in Illinois. The same pattern was found in females (Texas Adult = 33.6, Juvenile = 33.6; Illinois Adult = 42.5, Juvenile = 38.2). Our average January lesser scaup body mass measurements are less than those reported by Afton et al. (1989) for birds collected during January in Louisiana (Texas Male Adult = 710 g, Juvenile = 690 g; Female Adult = 650 g, Juvenile = 644 g; Louisiana Male Adult = 721 g, Juvenile = 726 g; Female Adult = 679 g, Juvenile = 668 g)

Ring-necked Ducks - There were few differences in condition of ring-necked ducks between those measured during fall migration in Illinois (Male Adult = 39.8, Juvenile = 38.0; Female Juvenile = 34.0; Hine et al. 1996) and those measured in the Upper Texas Gulf Coast (Male Adult = 39.4, Juvenile = 38.6; Female Juvenile = 36.3).

Snow Geese - Wintering snow geese in the upper Gulf Coast of Texas are from the mid-continent population. This population of geese has grown exponentially causing concern in regard to the degradation of their Arctic nesting grounds (Batt 1997). Although, the wintering population of these birds has been increasing along the Texas Gulf Coast (Anderson and Haukos 1999), the birds have shifted from their traditional wintering habitats of the coastal marshes (i.e., Anahuac, San Bernard, and Brazoria National Wildlife Refuges) inland to areas where coastal prairie have been converted to rice fields (Anderson and Haukos 1998). With the exception of adult males, body mass of remaining sex classes were an average of 3.1% greater for birds collected by Flickinger and Bolen (1979) than those measured in this study.

There are numerous potential reasons for the observation that most species on the Texas Gulf Coast were in apparently poorer condition than waterfowl in other migrating and wintering areas. First, there may not be the need to increase fat levels, and subsequent body mass and condition index, because the environment may not be as severe or food may not be limiting as in other areas. Second, extensive feeding flights may not be needed because of the proximity of forage, especially on the National Wildlife Refuges. Third, because of the isolated refugia available on National Wildlfie Refuges the birds may not be incurring energetic costs associated with disturbance. Conversely, however, habitat conditions associated with salt water intrusion may increase stress on birds wintering on the coast, resulting in lower body condition.

Differences in Body Condition between Anahuac and McFaddin NWRs

Several species of ducks had higher body condition on McFaddin NWR compared to Anahuac NWR. Species that demonstrated statistically higher values of condition on McFaddin NWR include mottled duck, juvenile female gadwall, blue-winged teal, adult female and juvenile male shoveler, adult male ring-necked duck, and lesser scaup. Even for nonstatistically significant findings, the trends were for higher values on McFaddin.

These hunt areas are essentially adjacent and both contain coastal marsh. However, McFaddin NWR is approximately 98% coastal marsh compared to the nearly 35% found at Anahuac NWR. Furthermore, much of McFaddin is nearly inaccessible by hunters compared to the almost total access that occurs at Anahuac because of the extensive fragmentation of the hunt area via levees, canals, drainage ditches, reservoirs, cattle management areas, oil and gas exploration and drilling, and rice-field construction. In addition, based on check-station interviews, hunters at McFaddin are more experienced and selective in their waterfowl harvest. Therefore, birds at Anahuac may experience more disturbance and higher stress that has resulted in lowered body condition.

An additional factor is the consideration of lead exposure. Despite the lead shot ban in these hunt areas since 1980-1981, there is still a high prevalence of lead shot in gizzards of harvested waterfowl. For example, from 1987-1988 through 1999-2000, 24.7% of 991 sampled mottled ducks (a nonmigratory species) on Anahuac NWR had lead pellets in their gizzards (J. Neaville, unpublished data). Historically, birds at Anahuac NWR were subjected to higher hunting pressure, which may have resulted in higher depositions of spent lead shot compared to

McFaddin NMR. Biologists remain concerned about the continued occurrence of spent lead shot on wintering waterfowl populations.

Effects of Precipitation on Condition

The general paucity of significant correlations between rainfall and seasonal condition were not surprising because of the movement ability of waterfowl. That is, if suitable habitat conditions were not present in a specific wintering area, then the birds will move to another area. However, condition of lesser scaup and northern pintail was highly correlated with the various rainfall totals, which could indicate a greater affiliation to certain wintering areas for these species. Northern pintail and lesser scaup remain well below their long-term population average, while other waterfowl species are at or near record high levels (U.S. Fish and Wildlife Service 2000a). Further complicating the analyses, seasonal condition of male and female pintails correlated to different precipitation totals. The condition of birds in the wintering populations of these two species apparently is tied to habitat conditions created by annual precipitation. A possible reason for the correlations found in lesser scaup is the need for the extended existence of wetlands for establishment of their preferred coastal mollusk food base (Harmon 1962). Another explanation could be the nearly complete niche overlap of northern pintails and lesser scaup based on ordination of 20 environmental and social factors measured along the Texas Gulf Coast by White and James (1978). That is, these two species are subjected to similar environmental and physiological stresses when wintering on the Gulf Coast.

With very few exceptions, seasonal condition of wintering waterfowl was positively correlated with twelve- and six-month precipitation levels, and negatively correlated with the three-month levels. This emphasizes the importance of establishment and maintenance of wetlands early in the growing season to allow the wetland to be fully functional (i.e., produce food and develop cover) by the time wintering birds arrive. Indeed, any lack of freshwater along the Gulf Coast of Texas creates a response of increasing use of saline habitats, which stresses the birds and results in decreasing body condition (Tietje and Teer 1988). Dabbling ducks wintering in Oklahoma preferred natural wetlands, especially smaller wetlands used for feeding (Heitmeyer and Vohs 1984). The negative correlations for the three-month rainfall totals likely result in marsh depths exceeding ideal conditions for dabbling ducks. Also, tropical storm events probably generate these data, and bring saline tides rapidly changing water levels and quality in the coastal marshes, which are not beneficial for foraging waterfowl.

The two obvious exceptions to this generalization were the ring-necked duck and greater white-fronted goose that were negatively correlated with all precipitation levels. Greater white-fronted geese rely more on dryland conditions for feeding compared to other species, using wetlands only for roosting.

Condition of migrating and wintering waterfowl remain a concern for wetland and waterfowl managers. Greater body mass and subsequent condition have been documented as associated with the quality of wetland habitat, with other factors interacting to contribute to condition status.

Maintaining quantity and quality habitat throughout the entire wintering period on the upper Texas Gulf Coast is very important because waterfowl species show differing condition situations throughout the winter. Although this study did not show a decreasing trend of condition since 1986, a comparison by Hine et al. (1996) between waterfowl measured in the 1930s and 1980s in Illinois indicated a significant decline in condition of waterfowl since the 1930s. This trend was also reported by Hier (1989) for ring-necked ducks in Minnesota and Afton et al. (1989) for lesser scaup in Louisiana. They attributed these declines to several factors including weather, deteriorating habitat conditions, increased disturbance, and food availability. The upper Gulf Coast of Texas is being continually impacted resulting in degradation of waterfowl habitat through urbanization, continued conversion to cropland, improper grazing and wetland management, salt water intrusion, and invasive exotic species among other factors. Although our data indicate that condition trends vary among wintering waterfowl species, further degradation of wetland habitats in this region will eventually negatively affect all species with direct impact on future production of waterfowl in the Central Flyway.

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Table 1. Percentage of total waterfowl counted during the midwinter inventory found on the upper Gulf Coast of Texas in 1999, which was the last year that midwinter counts were tabulated by upper and lower coasts.

Species	Percent of Texas Inventory	Percent of Central Flyway Inventory
Mallard	1.8	0.6
Mottled Duck	88.5	88.5
Northern Pintail	82.5	81.4
Gadwall	19.7	19.0
Green-winged Teal	59.9	57.4
American Wigeon	31.9	29.7
Northern Shoveler	58.2	54.6
Canvasback	63.3	62.4
Redhead[a]	85.1	84.8
Lesser Scaup	67.8	67.1

[a] The Midwinter Inventory does not include the Laguna Madre of Texas, where the majority of redheads winter. Birds wintering in the Laguna Madre are counted during a separate, special survey.

Table 2. Average wing-chord measurement (cm) for each age and sex class of 25 waterfowl species harvested on the upper Gulf Coast of Texas from 1986-1987 through 1999-2000 hunting seasons.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Canada Goose	28	39.6	0.39	17	37.4	0.49	35	37.3	0.38	13	35.2	0.52
Greater White-Fronted Goose	57	42.2	0.14	56	39.5	0.18	72	40.4	0.13	52	38.6	0.17
Snow Goose	219	42.4	0.09	147	39.6	0.17	248	40.9	0.07	174	38.4	0.11
Ross' Goose	11	37.7	0.42	4	35.6	0.59	9	37.2	0.71	3	34.5	0.99
Mallard	118	28.6	0.08	86	27.9	0.07	77	26.8	0.08	60	26.2	0.09
Mottled Duck	304	25.6	0.03	128	24.9	0.06	109	24.1	0.06	143	23.8	0.05
Northern Pintail	216	27.2	0.04	93	26.3	0.07	72	25.3	0.07	38	24.5	0.12
Gadwall	553	27.0	0.02	397	26.3	0.03	357	25.1	0.03	334	24.8	0.04
American Wigeon	199	26.1	0.04	165	25.3	0.05	60	24.5	0.08	170	24.1	0.04
Blue-winged Teal	130	18.9	0.04	160	18.5	0.04	94	18.0	0.05	178	17.7	0.03

Table 2. Continued.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Cinnamon Teal	3	19.1	0.07	2	19.1	0.15						
Green-winged Teal	771	18.4	0.01	511	18.1	0.02	454	17.5	0.02	299	17.4	0.02
Northern Shoveler	202	24.4	0.04	133	23.6	0.05	101	22.8	0.05	238	22.6	0.05
Wood Duck	39	22.2	0.09	15	21.8	0.11	6	21.4	0.18	21	21.5	0.11
Fulvous Whistling-Duck	4	21.2	0.12	4	20.2	0.11	7	20.3	0.32	3	20.0	0.12
Black-bellied Whistling-Duck	4	24.8	0.28	3	23.9	0.18	2	23.7	0.10	4	23.6	0.23
Redhead	3	23.3	0.12	25	22.7	0.10	6	22.0	0.14	23	21.7	0.10
Canvasback	7	23.3	0.19	12	23.3	0.14	8	22.5	0.15	12	23.3	0.14
Ring-necked Duck	83	19.7	0.05	90	19.4	0.04	92	18.7	0.04	69	18.5	0.05
Greater Scaup	1	22.1		11	20.8	0.38	2	21.3	0.25	6	20.9	0.21

Table 2. Continued.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Lesser Scaup	241	20.2	0.03	179	19.9	0.03	138	19.5	0.03	187	19.3	0.04
Common Goldeneye	1	23.0		1	21.0		1	20.0		2	20.4	0.75
Bufflehead	1	17.3		1	16.7		5	16.1	0.22	5	15.1	0.11
Hooded Merganser	1	18.7		1	18.2		8	18.2	0.22	8	18.2	0.16
Ruddy Duck	1	14.6		12	14.4	0.11	4	13.9	0.23	16	14.6	0.33

Table 3. Average body-mass measurement (g) for each age and sex class of 25 waterfowl species harvested on the upper Gulf Coast of Texas from 1986-1987 through 1999-2000 hunting seasons.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	x̄	SE	n	x̄	SE	n	x̄	SE	n	x̄	SE
Canada Goose	28	1922.9	59.3	17	1725.9	59.4	34	1677.6	76.2	14	1484.7	66.2
Greater White-Fronted Goose	57	2408.1	29.4	56	2139.5	28.0	72	2161.2	23.0	52	1966.1	26.0
Snow Goose	227	2206.1	14.7	143	1928.4	19.0	259	1984.3	13.1	174	1789.0	15.4
Ross' Goose	11	1516.0	62.3	4	1306.0	120.6	9	1492.2	100.4	3	1223.0	116.5
Mallard	118	1249.3	9.8	86	1156.9	11.1	77	1180.9	12.5	60	995.7	12.6
Mottled Duck	303	1063.6	5.0	128	987.1	8.1	109	960.0	8.5	142	909.9	6.1
Northern Pintail	216	953.5	6.2	93	892.4	10.3	72	831.0	10.3	38	762.3	17.5
Gadwall	553	917.9	3.3	397	851.6	3.6	357	793.1	3.5	334	761.0	3.9
American Wigeon	199	783.5	5.3	165	720.7	5.1	60	704.2	7.8	170	667.4	4.7
Blue-winged Teal	130	414.5	3.5	160	414.0	3.2	94	390.1	4.1	178	378.4	3.1

Table 3. Continued.

Species	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Cinnamon Teal	5	416.0	18.5	2	425.0	13.0						
Green-winged Teal	765	360.9	1.1	511	344.4	1.3	454	321.8	1.3	297	311.9	1.7
Northern Shoveler	203	597.0	3.2	133	575.3	4.9	103	544.2	5.1	241	527.1	3.2
Wood Duck	40	648.6	7.8	15	609.5	15.7	6	606.0	11.2	21	575.6	9.4
Fulvous Whistling-Duck	4	835.8	21.1	4	682.5	24.3	7	735.1	49.0	3	704.0	16.8
Black-bellied Whistling-Duck	4	864.8	20.9	3	790.3	42.4	2	829.0	15.0	4	778.5	30.3
Redhead	4	1042.8	62.0	25	923.9	11.1	6	906.3	14.7	23	823.4	18.3
Canvasback	11	1247.5	46.5	13	1259.2	23.1	9	1127.7	48.3	13	1065.1	37.0
Ring-necked Duck	83	776.8	6.2	91	748.9	5.7	92	705.0	5.3	68	673.0	6.7
Greater Scaup	1	1196.0		13	733.8	37.9	2	893.5	26.5	6	823.7	32.9

Table 3. Continued.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Lesser Scaup	241	716.0	4.3	179	683.6	5.0	138	662.4	5.4	187	648.1	4.8
Common Goldeneye	1	922.0		2	895.0	16.0	1	622.0		2	628.0	31.0
Bufflehead	1	382.0		1	367.0		6	343.5	19.0	5	275.0	6.3
Hooded Merganser	1	735.0		1	507.0		8	526.0	22.9	8	511.6	12.8
Ruddy Duck	1	558.0		13	529.3	19.0	4	500.0	17.4	16	499.3	8.1

Table 4. Average condition index value (body mass [g]/wing chord [cm]) for each age and sex class of 25 waterfowl species harvested on the upper Gulf Coast of Texas from 1986-1987 through 1999-2000 hunting seasons.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Canada Goose	27	48.4	1.1 A	17	46.0	1.2 A	34	44.8	1.5 AB	13	41.2	1.3 B
Greater White-Fronted Goose	57	57.0	0.7 A	56	54.1	0.7 B	72	53.5	0.5 B	52	50.9	0.6 C
Snow Goose	217	51.9	0.3 A	142	48.3	0.5 B	245	48.3	0.3 B	167	46.4	0.3 C
Ross' Goose	11	40.1	1.4	4	36.7	3.4	9	39.8	2.0	3	35.3	2.7
Mallard	118	43.7	0.3 A	86	41.5	0.4 B	77	40.3	0.4 C	60	38.0	0.5 D
Mottled Duck	299	41.5	0.2 A	127	39.6	0.3 B	109	39.8	0.3 B	144	38.2	0.2 C
Northern Pintail	216	35.0	0.2 A	93	33.9	0.4 B	72	32.8	0.4 B	38	31.1	0.7 C
Gadwall	553	34.0	0.1 A	397	32.4	0.1 B	357	31.6	0.1 C	334	30.7	0.1 D
American Wigeon	199	30.0	0.2 A	165	28.4	0.2 B	60	28.8	0.3 B	170	27.7	0.2 C
Blue-winged Teal	130	22.0	0.2 AB	160	22.4	0.2 A	94	21.7	0.2 BC	178	21.4	0.2 C

Table 4. Continued.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Cinnamon Teal	3	22.7	0.4	2	22.3	0.8						
Green-winged Teal	766	19.5	0.1 A	511	19.0	0.1 B	454	18.4	0.1 C	297	17.9	0.1 D
Northern Shoveler	201	24.5	0.1 A	133	24.4	0.2 A	101	23.9	0.2 B	238	23.4	0.1 C
Wood Duck	39	29.2	0.3 A	15	28.0	0.7 AB	6	28.3	0.5 B	21	26.7	0.4 B
Fulvous Whistling-Duck	4	39.4	1.2	4	33.8	1.1	7	36.2	2.2	3	35.1	0.8
Black-bellied Whistling-Duck	4	34.9	0.5	3	33.0	1.6	2	35.0	0.8	4	33.0	1.1
Redhead	3	42.8	2.4 A	25	40.7	0.4 AB	6	41.1	0.8 AB	23	38.4	0.8 B
Canvasback	7	53.9	2.9 A	13	53.7	1.1 A	8	49.5	2.4 AB	11	47.9	1.6 B
Ring-necked Duck	83	39.4	0.3 A	90	38.6	0.3 A	92	37.7	0.3 B	68	36.3	0.3 C
Greater Scaup	1	54.1		11	35.6	1.7	2	42.0	0.8	6	39.3	1.3

Table 4. Continued.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Lesser Scaup	241	35.4	0.2 A	179	34.4	0.2 B	138	33.9	0.3 BC	187	33.6	0.2 C
Common Goldeneye	1	40.1		1	43.4		1	31.1		2	30.7	0.4
Bufflehead	1	22.1		1	22.0		5	21.8	1.3	5	18.2	0.5
Hooded Merganser	1	39.3		1	27.8		8	28.9	1.1	8	28.2	0.7
Ruddy Duck	1	38.2		12	36.1	1.2	4	35.9	0.8	16	34.3	0.6

[A,B,C,D] Means followed by the same letter are not different ($P \leq 0.05$) within species.

Species that have means not followed by a letter were not tested for differences between sex and age classes due to inadequate sample size for one or more classes.

Table 5. Average body-length measurements (cm) for each age and sex class of 13 waterfowl species harvested on the upper Gulf Coast of Texas from 1986-1987 through 1999-2000 hunting seasons.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Canada Goose	5	69.6	4.0	6	65.5	1.5	3	68.7	10.7	3	59.1	2.7
Greater White-Fronted Goose	6	74.3	1.1	6	70.3	1.3	7	70.0	0.4	6	66.5	1.0
Snow Goose	32	72.5	0.3	8	67.9	1.5	30	69.4	0.5	12	66.1	0.6
Mallard	28	59.7	0.4	12	59.5	0.4	5	54.8	0.3	7	54.4	0.5
Mottled Duck	32	57.5	0.3	12	56.4	0.5	9	53.3	0.3	7	52.8	0.3
Northern Pintail	22	66.8	0.8	7	59.5	1.2	3	54.1	0.9	1	53.7	
Gadwall	28	53.8	0.2	18	53.4	0.3	13	49.4	0.2	22	48.9	0.3
American Wigeon	14	51.1	0.4	7	49.1	0.7	1	48.0		10	45.8	0.3
Blue-winged Teal	25	40.3	0.2	16	39.8	0.2	7	38.3	0.4	13	37.9	0.5
Green-winged Teal	47	37.9	0.1	27	37.6	0.1	21	35.3	0.2	22	35.8	0.4

Table 5. Continued.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Northern Shoveler	20	49.7	0.3	13	48.8	0.4	12	46.8	0.2	10	47.5	0.6
Ring-necked Duck	13	43.0	0.3	3	43.1	0.6	7	41.3	0.3	4	41.4	0.8
Lesser Scaup	48	42.7	0.1	10	42.0	0.2	21	40.8	0.1	9	41.0	0.3

Table 6. Average wing-span measurements (cm) for each age and sex class of 13 waterfowl species harvested on the upper Gulf Coast of Texas from 1986-1987 through 1999-2000 hunting seasons.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Canada Goose	5	139.3	3.7	4	136.5	4.2	3	131.9	2.1	1	114.3	
Greater White-Fronted Goose	2	148.0	6.3	2	144.0	3.0	6	141.6	1.2	3	137.4	1.6
Snow Goose	18	149.3	0.7	6	137.9	1.9	13	140.3	1.0	5	137.9	1.8
Mallard	14	95.6	0.7	11	94.4	0.8	6	91.4	0.5	7	89.2	0.7
Mottled Duck	27	88.2	0.4	13	85.4	0.7	8	83.7	0.6	7	83.1	0.4
Northern Pintail	15	92.1	0.5	7	88.8	0.7	2	87.1	0.6	1	83.7	
Gadwall	15	90.0	0.5	11	88.9	0.5	9	84.3	0.7	18	84.8	0.5
American Wigeon	11	85.9	0.6	7	84.8	0.4	1	81.4		7	80.6	0.7
Blue-winged Teal	14	63.7	0.3	11	62.9	0.4	8	61.4	0.4	7	61.6	0.8
Green-winged Teal	33	61.0	0.2	19	60.7	0.3	20	58.4	0.4	8	58.4	0.2

Table 6. Continued.

	Male						Female					
	Adult			Juvenile			Adult			Juvenile		
Species	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Northern Shoveler	13	80.4	0.4	10	78.1	0.7	8	76.2	0.5	9	76.7	0.8
Ring-necked Duck	11	72.0	0.7	4	71.2	0.7	7	68.5	0.6	2	68.7	2.6
Lesser Scaup	41	73.6	0.2	7	71.9	0.9	11	71.4	0.3	7	70.4	0.7

Table 7. Range of values for body mass (g), body length (cm), wing chord (cm), and wing span (cm) for each age and sex class of 13 waterfowl species harvested on the upper Gulf Coast of Texas from 1986-1987 through 1999-2000 hunting seasons.

Species Age/Sex[a]	Body Mass	Body Length	Wing Chord	Wing Span
Canada Goose				
AF	1336-3973	58.0-90.2	34.2-44.8	127.8-134.9
AM	1449-2937	64.0-85.5	36.9-45.5	131.4-150.0
IF	962-1923	55.0-64.1	32.6-39.2	
IM	1377-2196	60.3-70.5	34.6-40.7	123.9-141.7
Greater White-Fronted Goose				
AF	1753-2738	68.5-71.0	37.8-42.7	136.8-145.1
AM	1678-2807	71.3-79.1	39.1-44.2	141.8-154.3
IF	1570-2378	63.1-69.7	35.8-41.2	134.6-140.3
IM	1571-2532	65.5-74.2	35.7-42.5	141.0-147.0
Snow Goose				
AF	1363-2545	66.2-79.7	37.8-44.7	135.6-148.4
AM	1565-2732	69.3-77.5	38.2-45.9	144.0-153.3
IF	1290-2462	62.5-70.5	35.6-43.0	131.4-142.1
IM	1105-2618	58.6-72.6	35.4-42.7	129.3-142.9
Mallard				
AF	767-1404	53.7-55.6	25.2-28.4	89.2-93.0
AM	1004-1574	55.0-63.3	26.0-30.7	90.0-99.0
IF	811-1223	51.8-56.3	24.4-27.8	86.8-92.7
IM	948-1562	56.5-62.3	26.0-29.1	89.5-98.7
Mottled Duck				
AF	733-1227	52.0-54.9	22.5-25.5	80.3-85.3
AM	751-1275	54.5-60.7	23.9-27.2	82.1-92.0
IF	706-1157	51.7-54.0	22.1-25.2	82.1-85.1
IM	716-1159	53.0-58.7	23.1-26.7	79.1-88.4
Northern Pintail				
AF	640-1070	52.5-55.8	24.0-26.5	86.5-87.7
AM	594-1182	59.0-71.6	25.6-29.0	87.1-94.6
IF	523-997		22.0-25.8	
IM	673-1119	55.7-64.1	24.3-27.8	86.1-92.0

Table 7. Continued.

Species Age/Sex[a]	Body Mass	Body Length	Wing Chord	Wing Span
Gadwall				
AF	585-1042	48.0-50.9	23.0-27.2	80.3-86.7
AM	693-1150	51.7-56.2	24.2-28.5	87.0-93.0
IF	565-1000	46.8-53.3	22.6-27.8	81.6-91.0
IM	648-1034	51.3-55.6	24.4-28.3	85.8-91.1
American Wigeon				
AF	606-866		23.1-25.8	
AM	549-992	49.2-54.5	24.2-27.8	83.4-89.1
IF	501-860	44.3-47.0	21.5-25.9	77.8-83.2
IM	542-978	46.0-51.0	23.1-27.0	82.5-86.4
Blue-winged Teal				
AF	317-494	37.6-40.4	17.1-19.3	59.6-63.6
AM	314-517	38.5-42.6	18.0-20.0	61.9-65.0
IF	276-484	35.7-42.5	16.2-18.8	59.6-65.9
IM	301-530	38.2-41.0	17.1-19.6	60.8-65.1
Green-winged Teal				
AF	254-417	33.8-37.1	15.7-18.7	54.1-60.6
AM	276-467	35.9-40.1	17.1-19.8	57.5-64.1
IF	235-396	33.2-42.1	16.1-18.9	57.5-59.3
IM	221-431	35.8-39.1	16.2-19.3	57.0-62.7
Northern Shoveler				
AF	379-689	45.4-48.2	21.0-24.5	74.3-79.2
AM	476-711	47.4-53.2	22.6-25.8	78.0-82.7
IF	408-709	45.6-51.3	20.0-29.1	72.8-81.5
IM	439-811	45.2-50.8	20.0-24.8	74.6-81.3
Ring-necked Duck				
AF	565-817	40.0-42.1	17.8-19.8	66.4-70.4
AM	603-889	41.4-44.7	18.5-20.6	69.4-78.0
IF	532-776	40.1-43.4	17.6-19.6	66.1-71.3
IM	569-901	42.1-44.1	18.5-20.2	69.4-72.6

Table 7. Continued

Species Age/Sex[a]	Body Mass	Body Length	Wing Chord	Wing Span
Lesser Scaup				
AF	482-783	39.8-42.1	18.5-20.8	70.1-72.9
AM	547-921	40.0-45.1	19.0-22.3	70.2-75.7
IF	453-874	39.2-42.4	17.8-20.9	68.1-73.0
IM	471-887	41.3-43.3	18.7-21.1	67.5-74.8

[a] AF=adult female, AM=adult male, IF=juvenile female, IM=juvenile male.

Table 8. Average condition index (body mass [g]/wing chord [cm]) of 10 duck species harvested on Anahuac and McFaddin National Wildlife Refuges on the upper Gulf Coast of Texas from 1986-1987 through 1999-2000 hunting seasons.

	Location					
	Anahuac			McFaddin		
Species Age/Sex*	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Mallard	121	41.1 A	0.4	187	41.5 A	0.3
Mottled Duck	338	39.6 A	0.2	323	40.7 B	0.2
Northern Pintail	102	33.7 A	0.4	268	34.1 A	0.2
Gadwall						
AF	106	31.8 A	0.3	249	31.6 A	0.1
AM	165	34.2 A	0.2	383	34.0 A	0.1
IF	128	30.2 A	0.2	202	31.0 B	0.2
IM	161	32.6 A	0.2	235	32.3 A	0.1
American Wigeon	118	28.9 A	0.2	468	28.8 A	0.1
Blue-winged Teal	186	21.5 A	0.2	342	22.3 B	0.1
Green-winged Teal	802	18.8 A	0.1	1185	19.0 A	0.1
Northern Shoveler						
AF	58	23.3 A	0.3	40	24.6 B	0.3
AM	112	24.5 A	0.2	80	24.6 A	0.2
IF	131	23.5 A	0.2	103	23.2 A	0.2
IM	79	24.0 A	0.2	51	25.0 B	0.4
Ring-necked Duck						
AF	45	38.1 A	0.3	46	37.3 A	0.4
AM	17	38.1 A	0.8	66	39.8 B	0.3
IF	33	36.6 A	0.4	34	36.1 A	0.5
IM	36	38.2 A	0.5	54	39.0 A	0.4

Table 8. Continued

Species Age/Sex*	Anahuac n	Anahuac $\bar{x}$	Anahuac SE	McFadding n	McFaddin $\bar{x}$	McFaddin SE
Lesser Scaup	228	33.8 A	0.2	513	34.8 B	0.1

* Data are presented by age/sex class within species when a age/sex class by location interaction ($P < 0.05$) occurred. AF=Adult Female, AM=Adult Male, IF=Juvenile Female, IM=Juvenile Male.

[A,B] Means followed by the same letter within species between locations are not different ($P>0.05$).

Table 9. Pearson's Correlation Coefficient between an average October-January Condition index (body mass[g]/wing chord[cm]) of waterfowl harvested on the Upper Gulf Coast of Texas from 1986-2000 and average 12 month (Jan.-Dec.), 6 month (July-Dec.), and 3 month (Oct.-Dec.) rainfall totals measured at Anahuac National Wildlife Refuge.

Waterfowl Group/Species	Twelve Month Rainfall Average		Six Month Rainfall Average		Three Month Rainfall Average	
	r	*P*	*r*	*P*	*r*	*P*
Puddle Ducks						
Green-winged Teal	0.03	0.91	0.14	0.62	-0.12	0.68
Gadwall	0.02	0.93	-0.12	0.67	-0.24	0.41
Mottled Duck	0.43	0.12	0.44	0.11	-0.18	0.53
American Wigeon	0.03	0.91	-0.20	0.49	-0.29	0.32
Blue-winged Teal	0.56	0.04	0.49	0.07	-0.17	0.55
Northern Pintail						
Female	0.49	0.09	0.46	0.11	-0.18	0.53
Male	0.27	0.35	0.54	0.04	-0.08	0.79
Mallard	0.22	0.44	0.11	0.69	0.11	0.72
Northern Shoveler	0.35	0.21	0.32	0.27	0.20	0.49
Diving Ducks						
Lesser Scaup	0.67	0.008	0.69	0.006	0.41	0.15
Ring-Necked Duck	-0.06	0.85	-0.44	0.18	-0.17	0.62
Geese						
Snow Goose	0.01	0.96	0.07	0.82	0.57	0.04
Greater White-fronted Goose	-0.53	0.06	-0.22	0.48	-0.51	0.07

Figure 1. Percent composition of age and sex categories for 4 species of geese harvested from 1986-2000 on the upper Gulf Coast of Texas.

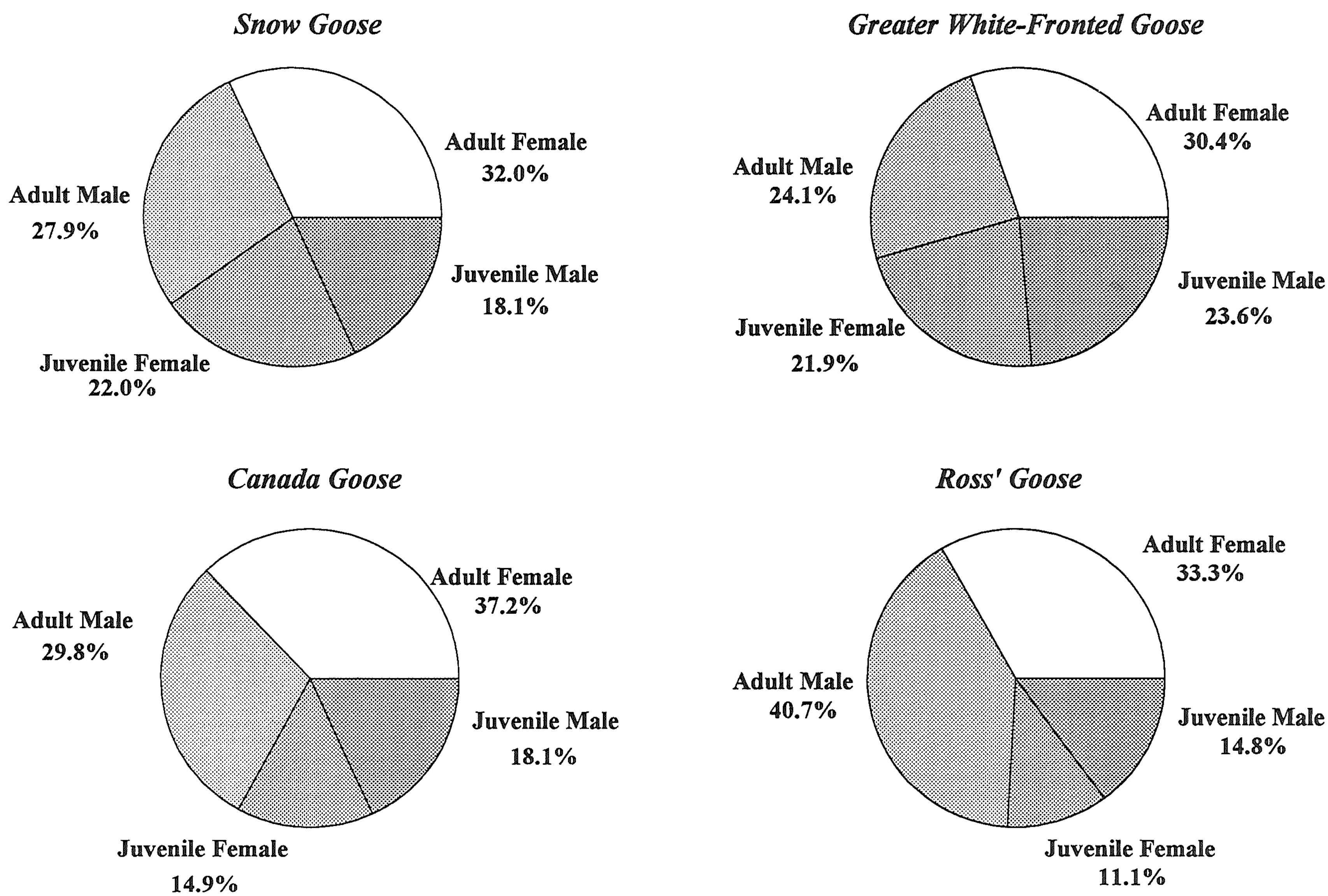


Figure 2. Percent composition of age and sex categories for 9 species of puddle ducks harvested from November 1986-January 2000 on the upper Gulf Coast of Texas

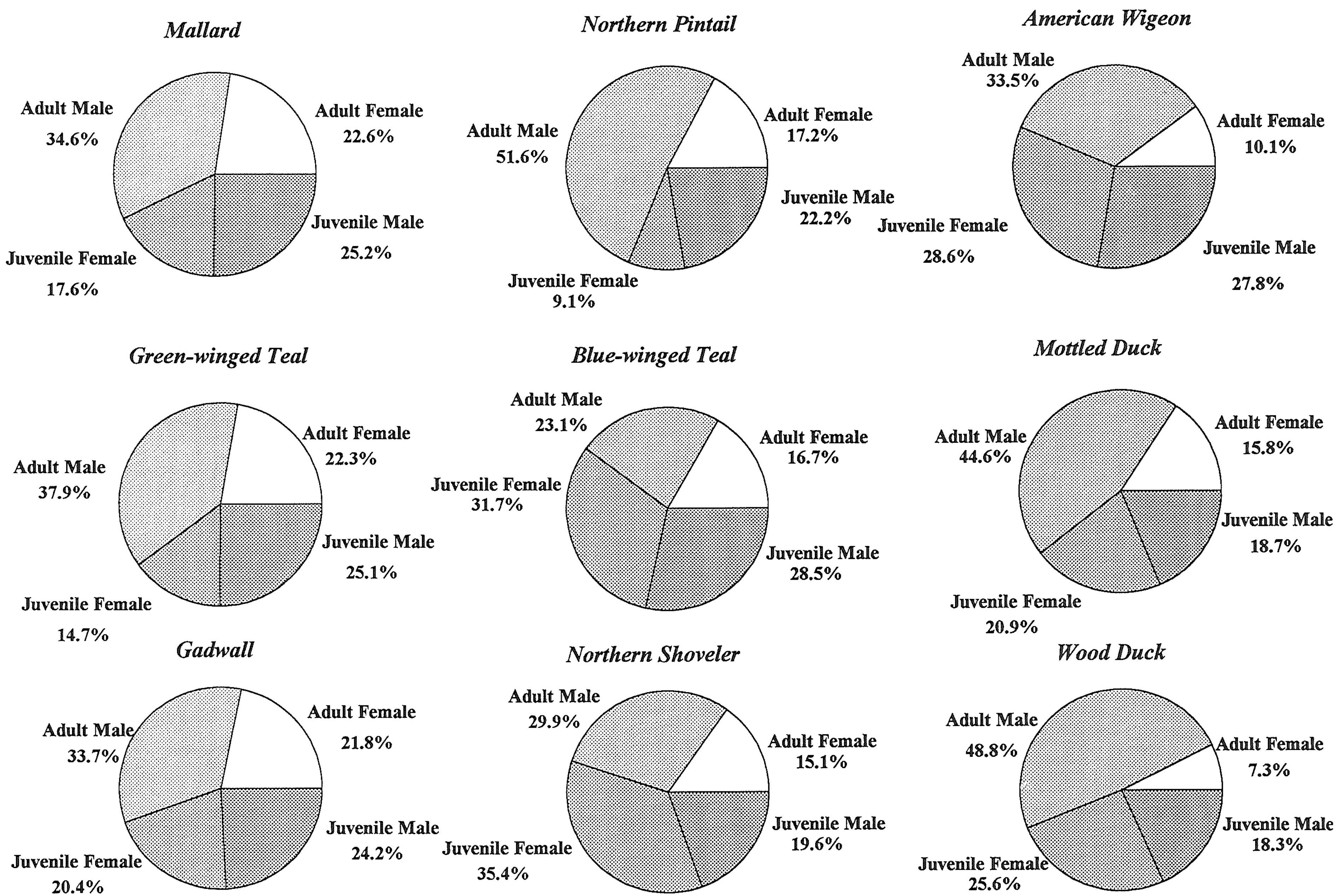


Figure 3. Percent composition of age and sex categories for 5 species of diving ducks harvested from November 1986-January 2000 on the upper Gulf Coast of Texas.

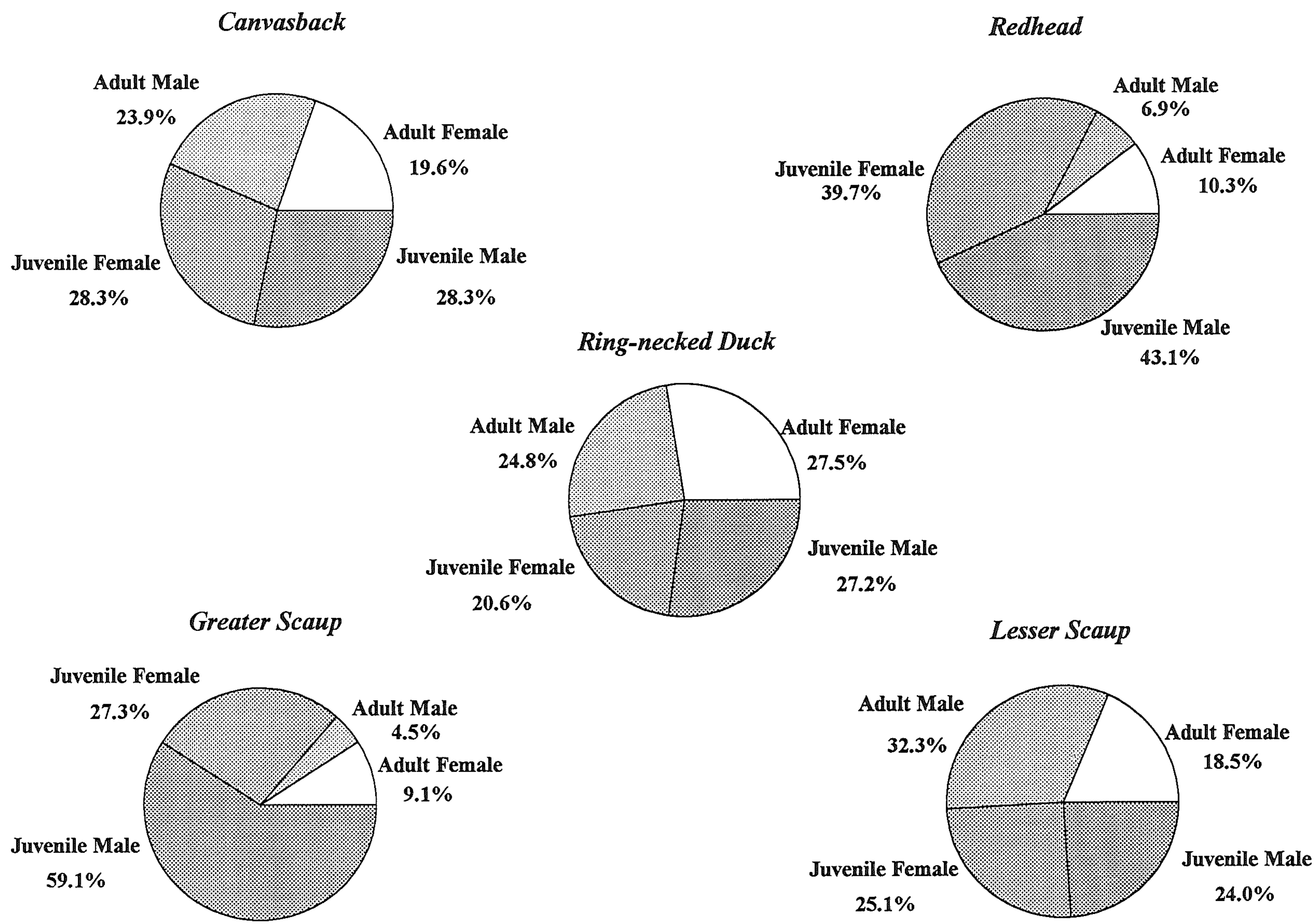
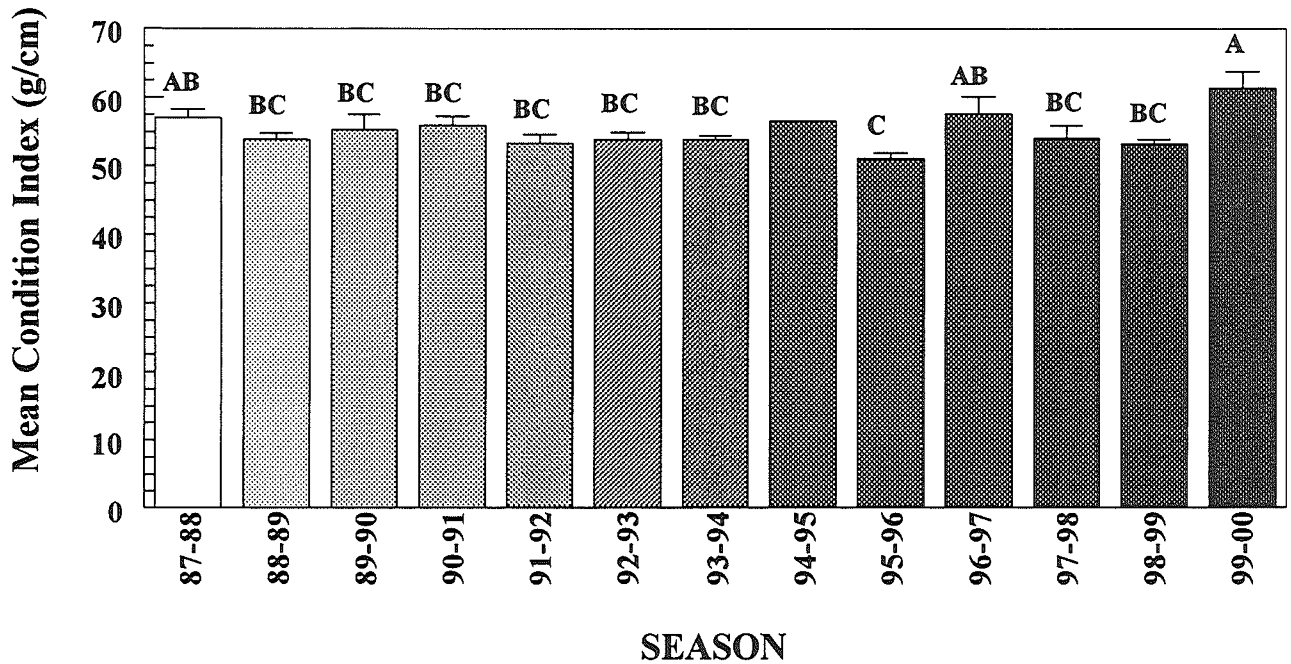
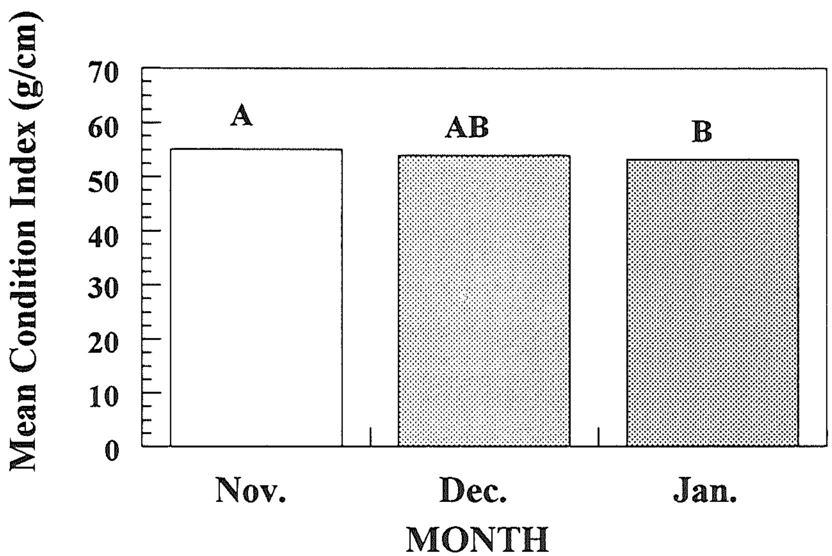


Figure 4. Comparisons of mean condition index values of greater white-fronted geese harvested on the upper Gulf Coast of Texas among November (n=74), December (n=43), and January (n=116) and hunting seasons from November 1986 - January 2000. Means represented by the same letter are not different (P > 0.05).





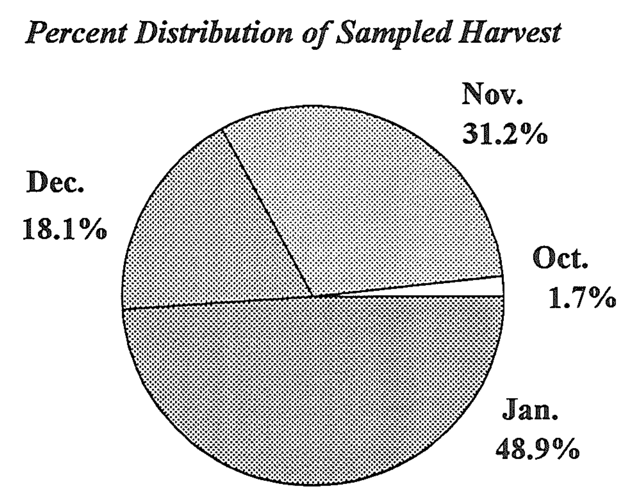
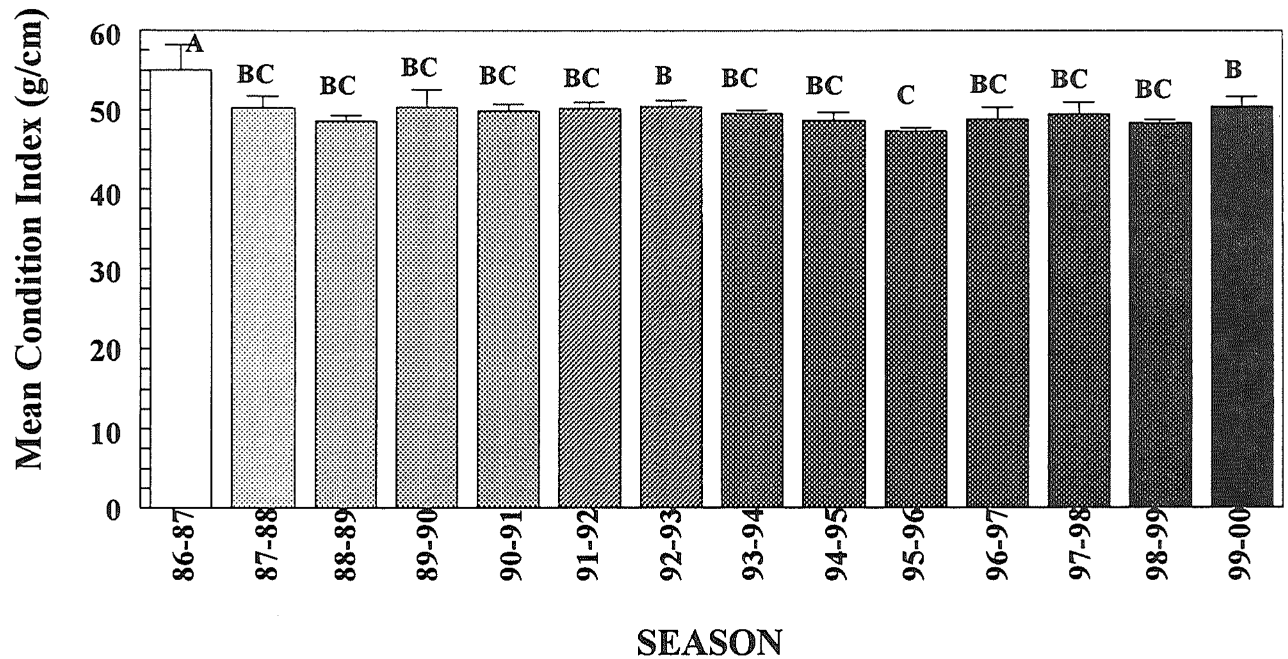
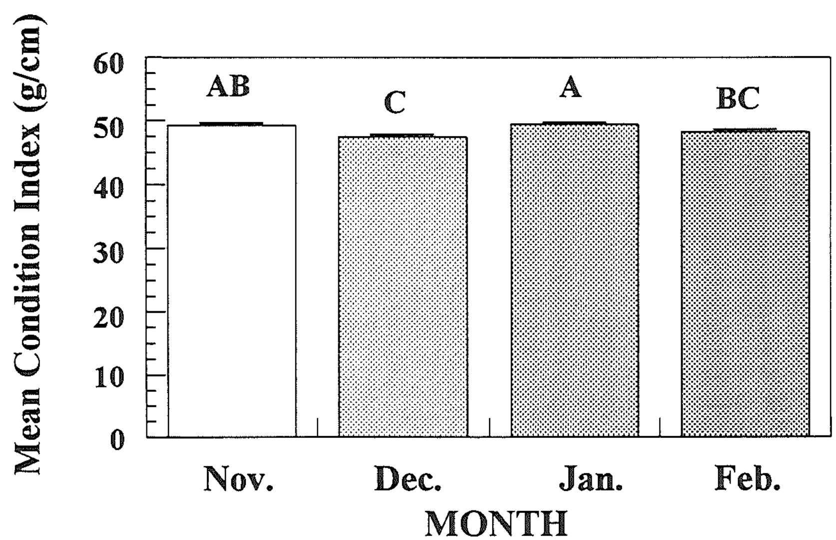


Figure 5. Comparisons of mean condition index values of snow geese harvested on the upper Gulf Coast of Texas among November (n=215), December (n=128), January (n=372), and February (n=78) and hunting seasons from November 1986-January 2000. Means represented by the same letter are not different (P > 0.05).





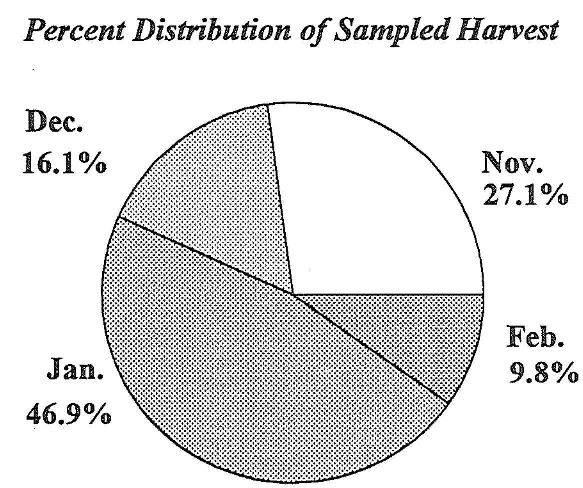
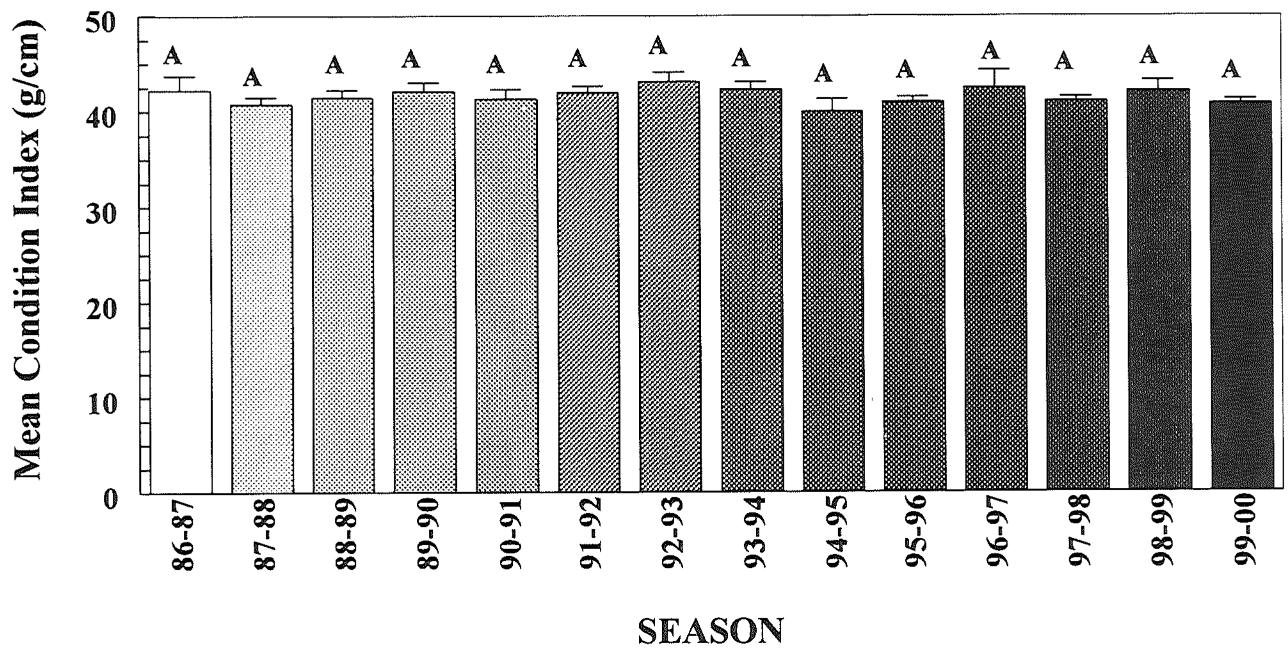
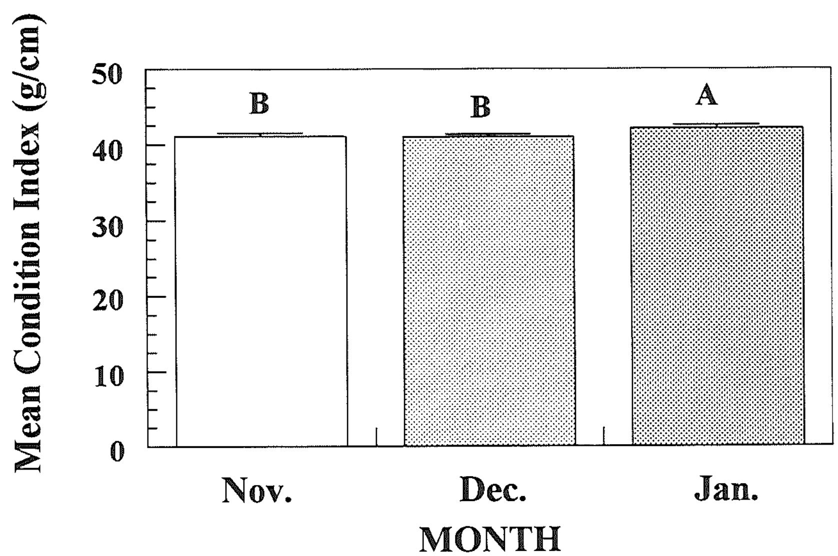


Figure 6. Comparisons of mean condition index values of mallards harvested on the upper Gulf Coast of Texas among November (n=101), December (n=118), and January (n=121) and hunting seasonsfrom November 1986-January 2000. Means represented by the same letter are not different (P > 0.05).





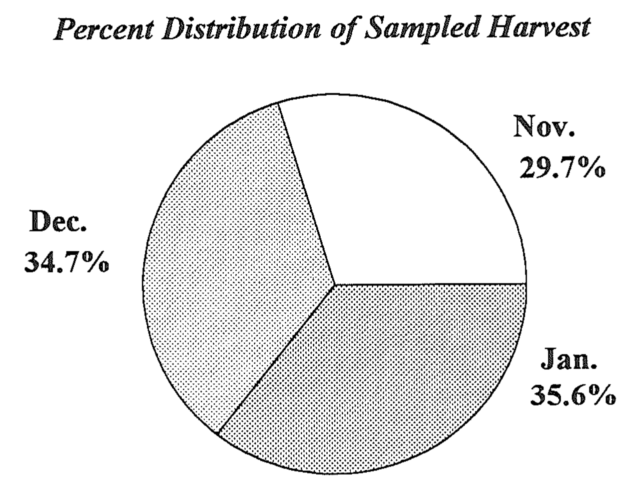
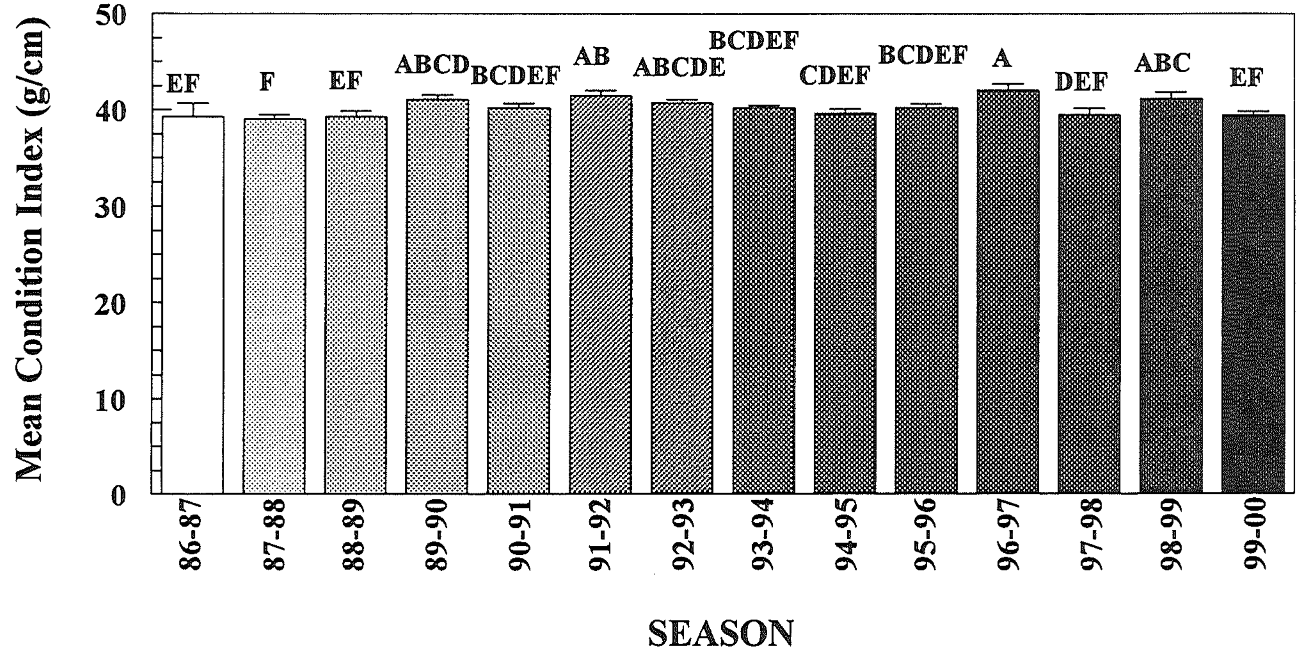
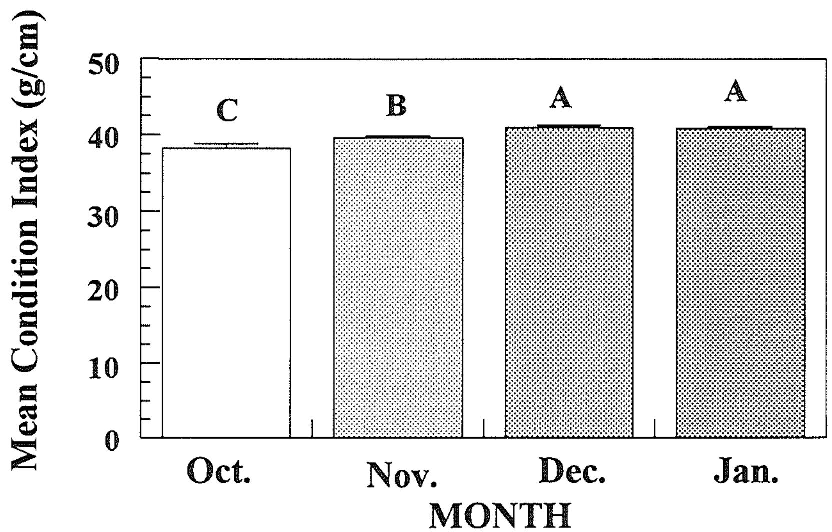


Figure 7. Comparisons of mean condition index values of mottled ducks harvested on the upper Gulf Coast of Texas among October (n=28), November (n=322), December (n=170), and January (n=166) and hunting seasons from November 1986-January 2000. Means represented by the same letter are not different (P > 0.05).





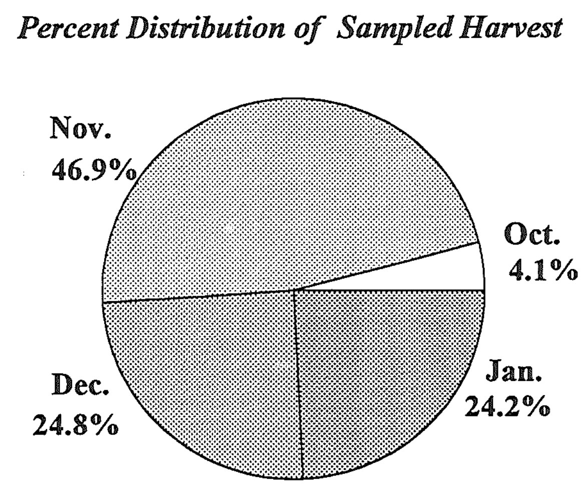
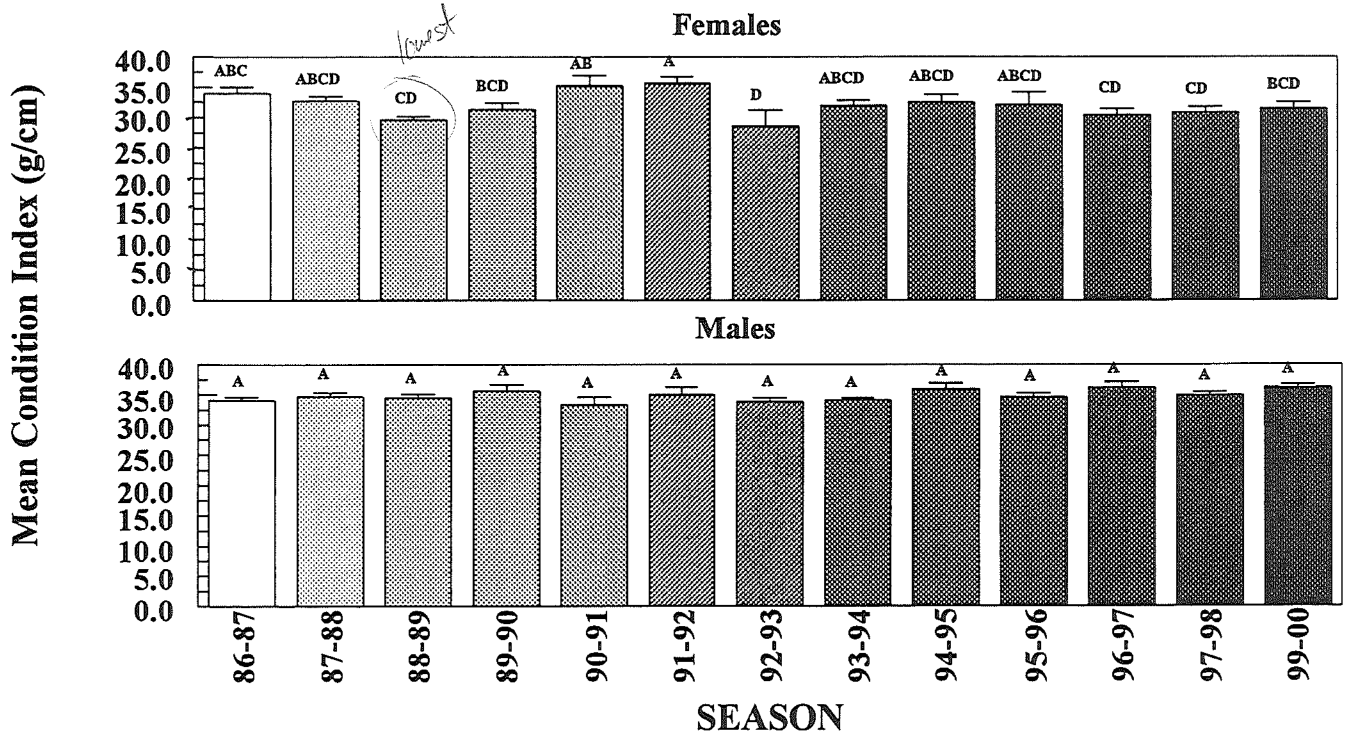
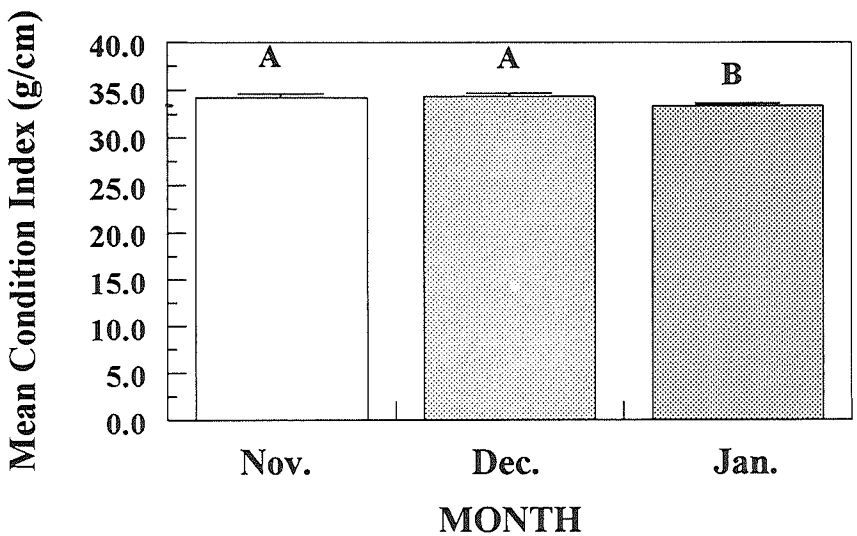


Figure 8. Comparisons of mean condition index values of northern pintails harvested on the upper Gulf Coast of Texas among November (n=110), December (n=132), and January (n=159) and hunting seasons from November 1986-January 2000. Means represented by the same letter are not different (P > 0.05).





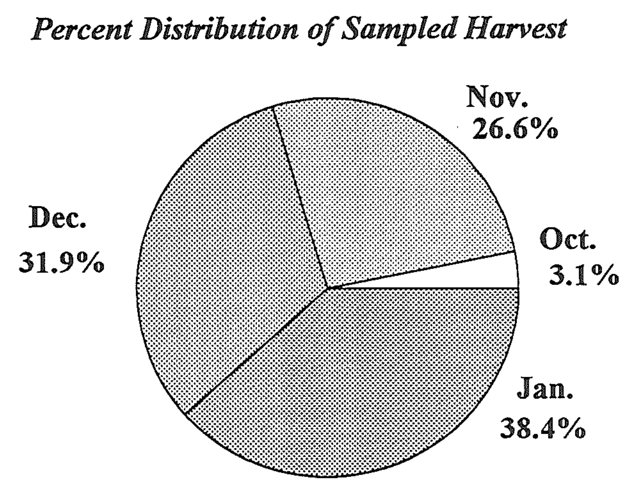
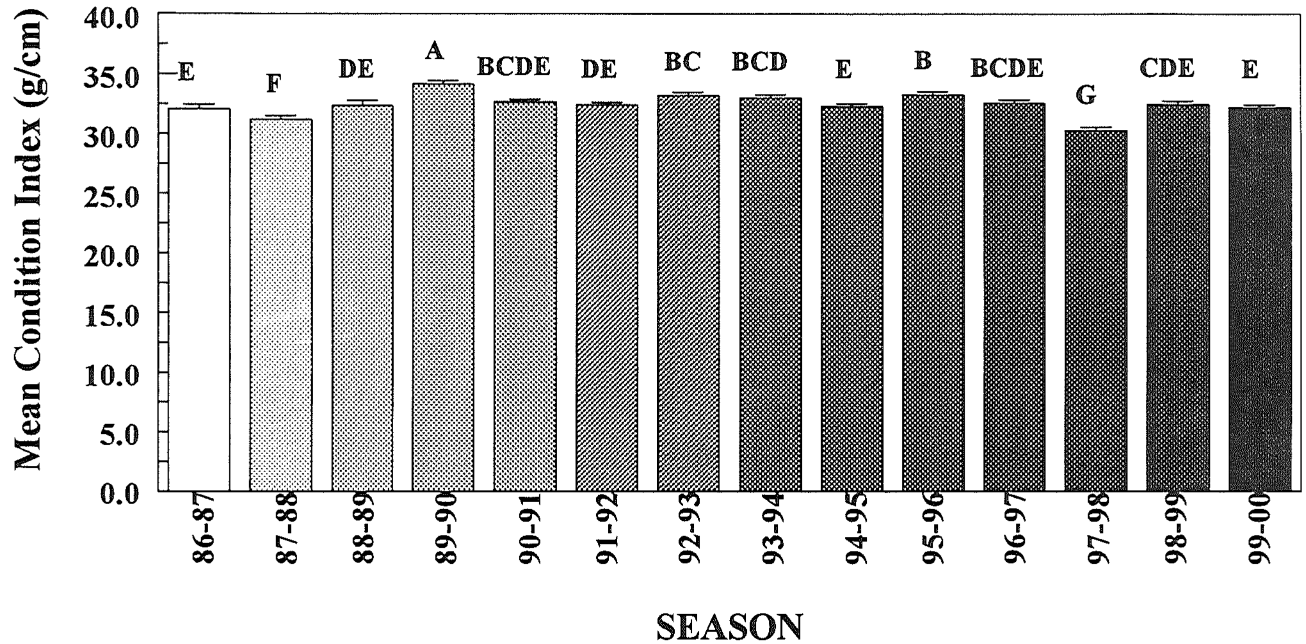
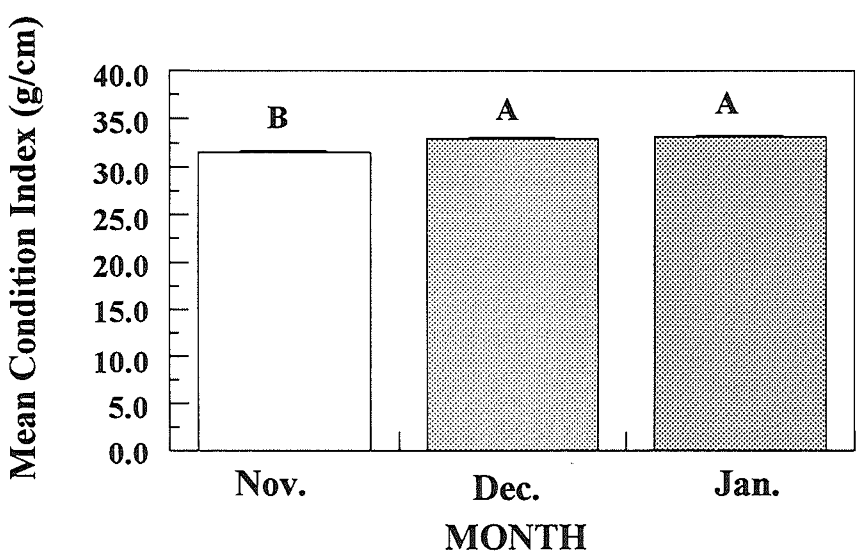


Figure 9. Comparisons of mean condition index values of gadwall harvested on the upper Gulf Coast of Texas among November (n=631), December (n=480), and January (n=493) and hunting seasons from November 1986 - January 2000. Means represented by the same letter are not different (P > 0.05).





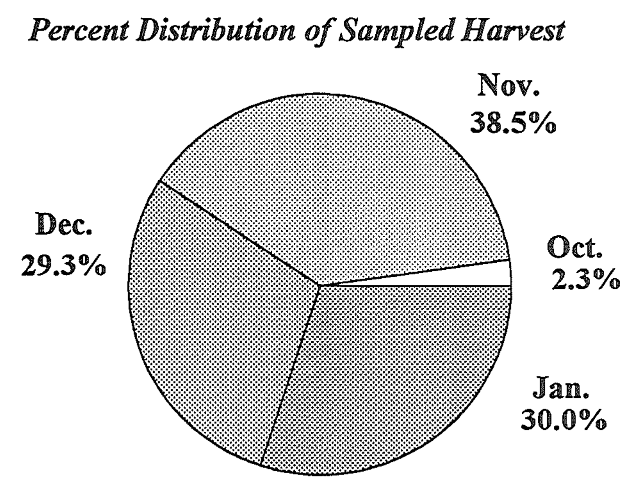


Figure 10. Comparisons of mean condition index values of American wigeon harvested on the upper Gulf Coast of Texas among November (n=179), December (n=218), and January (n=194) and hunting seasons from November 1986-January 2000. Means represented by the same letter are not different (P > 0.05).

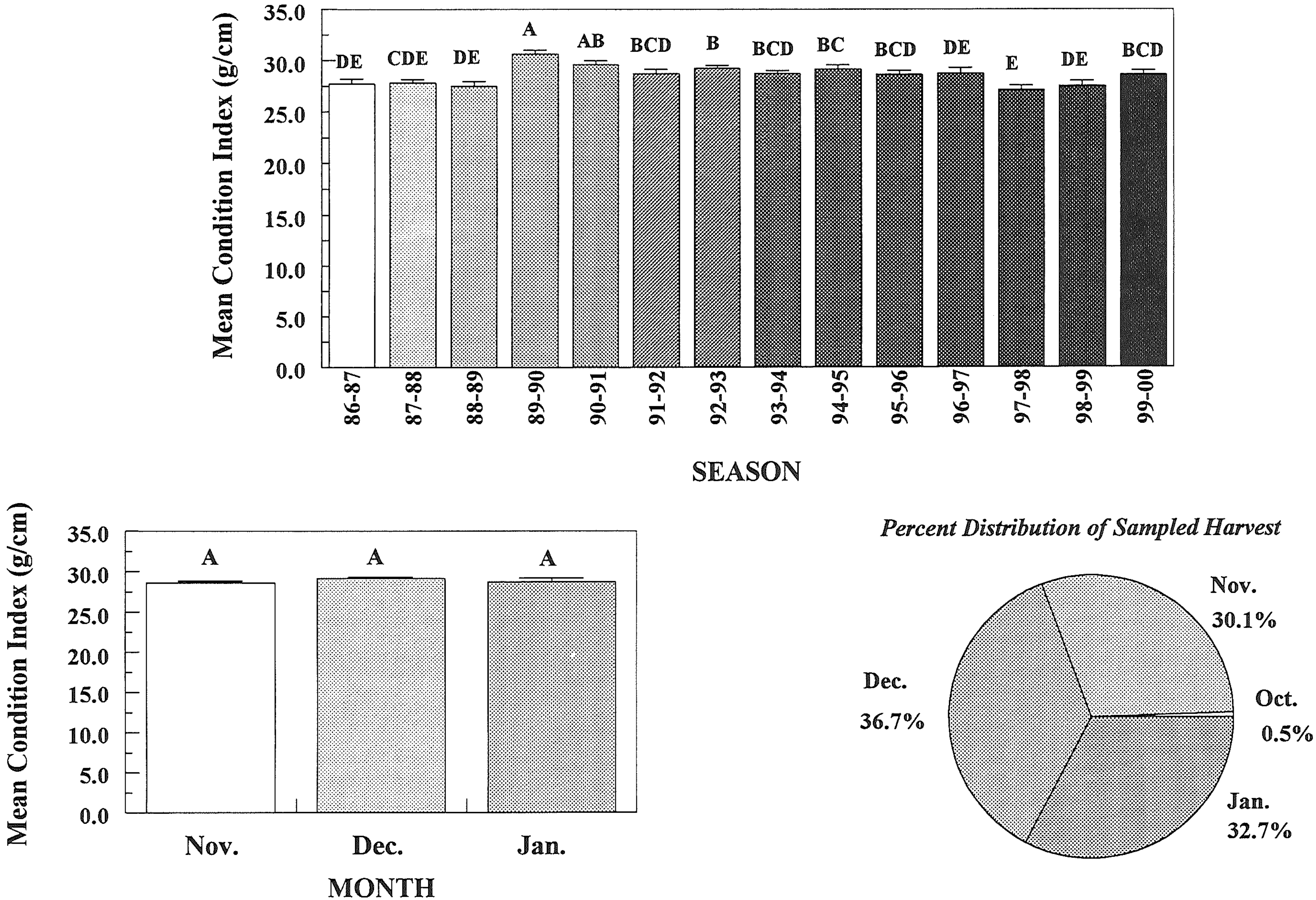
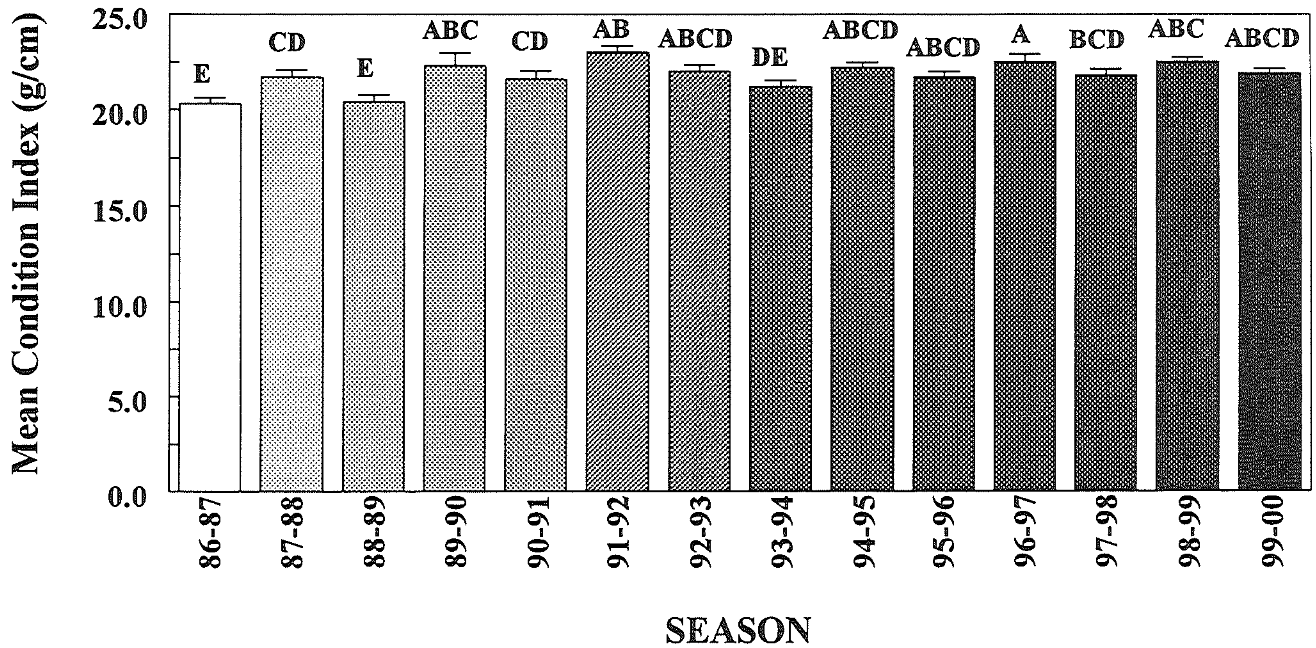
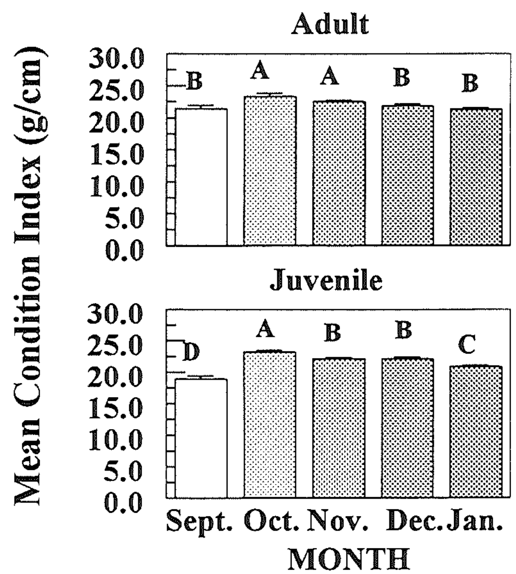


Figure 11. Comparisons of mean condition index values of blue-winged teal harvested on the upper Gulf Coast of Texas among September (n=19), October (n=53), November (n=198), December (n=120), and January (n=166) and hunting seasons from November 1986-January 2000. Means represented by the same letter are not different (P > 0.05).





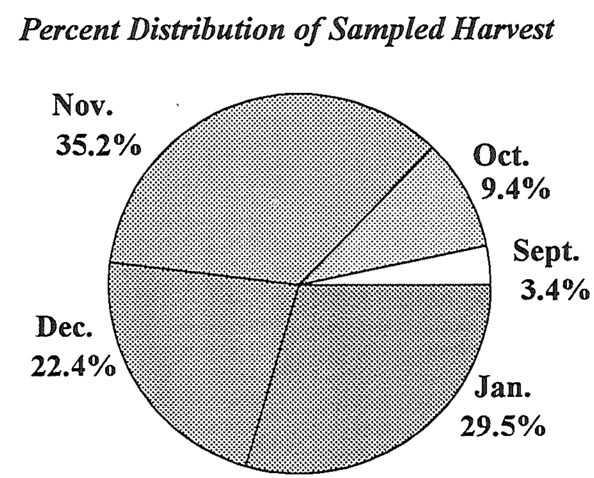
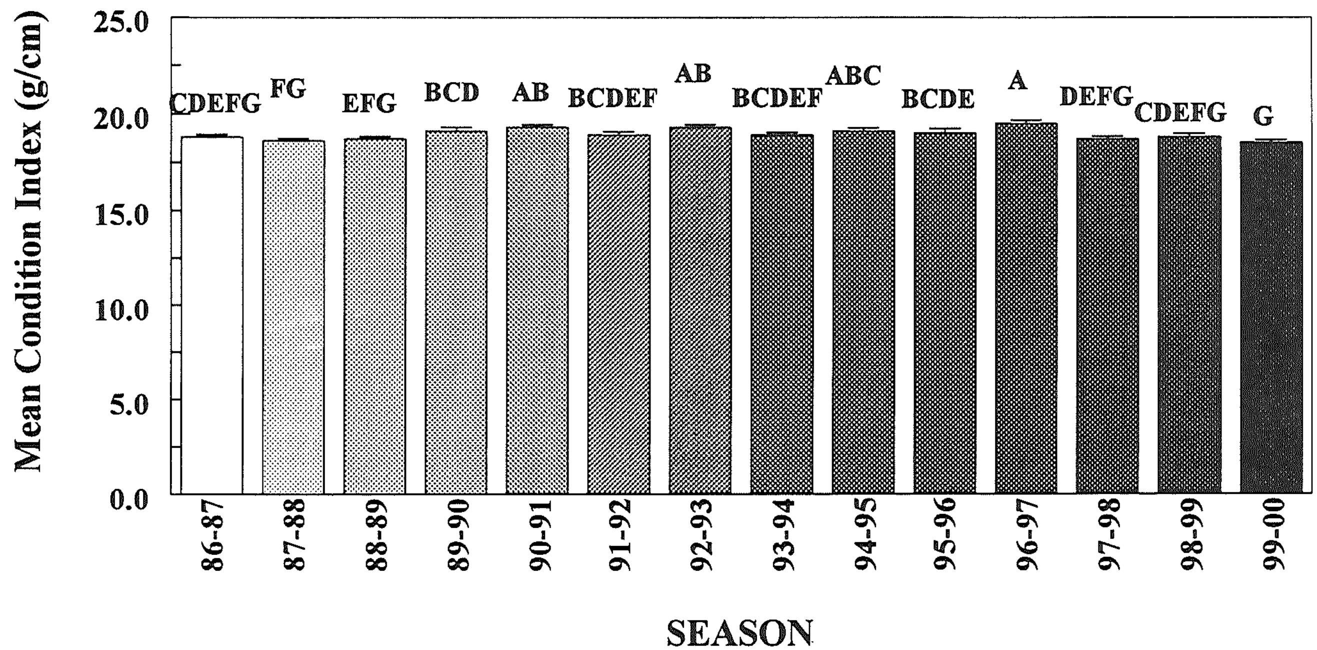
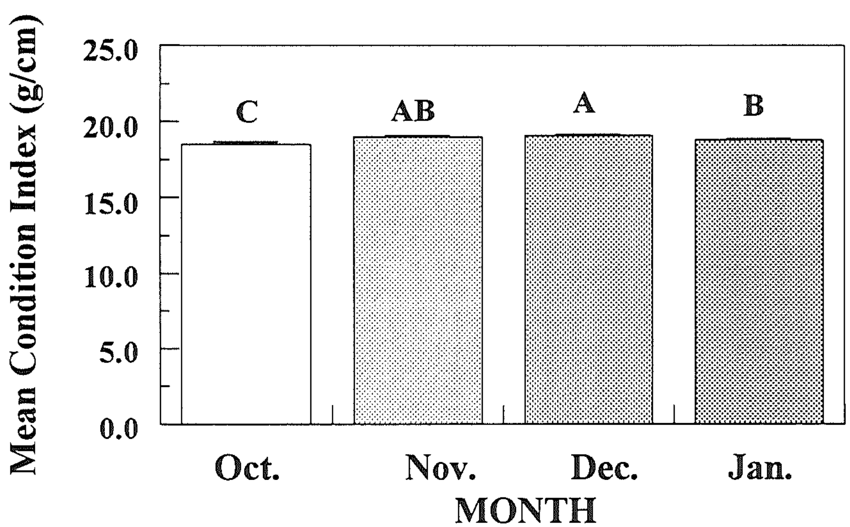


Figure 12. Comparisons of mean condition index values of green-winged teal harvested on the upper Gulf Coast of Texas among October (n=106) November (n=578), December (n=575), and January (n=775) and hunting seasons from November 1986 - January 2000 . Means represented by the same letter are not different (P > 0.05).





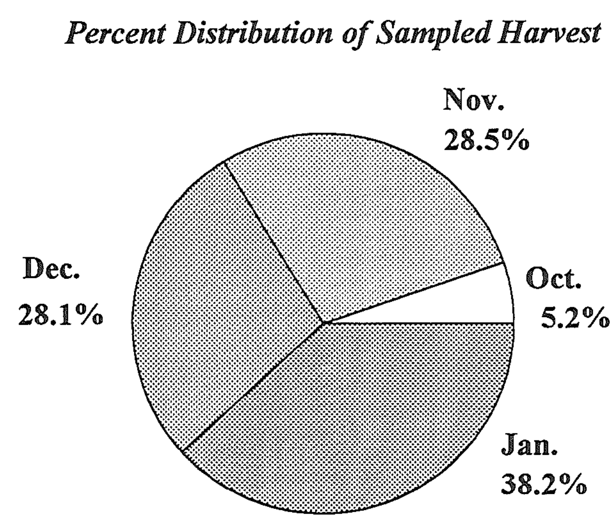


Figure 13. Comparisons of mean condition index values of northern shovelers harvested on the upper Gulf Coast of Texas among November (n=241), December (n=191), and January (n=215) and hunting seasons from November 1986-January 2000. Means represented by the same letter are not different (P > 0.05).

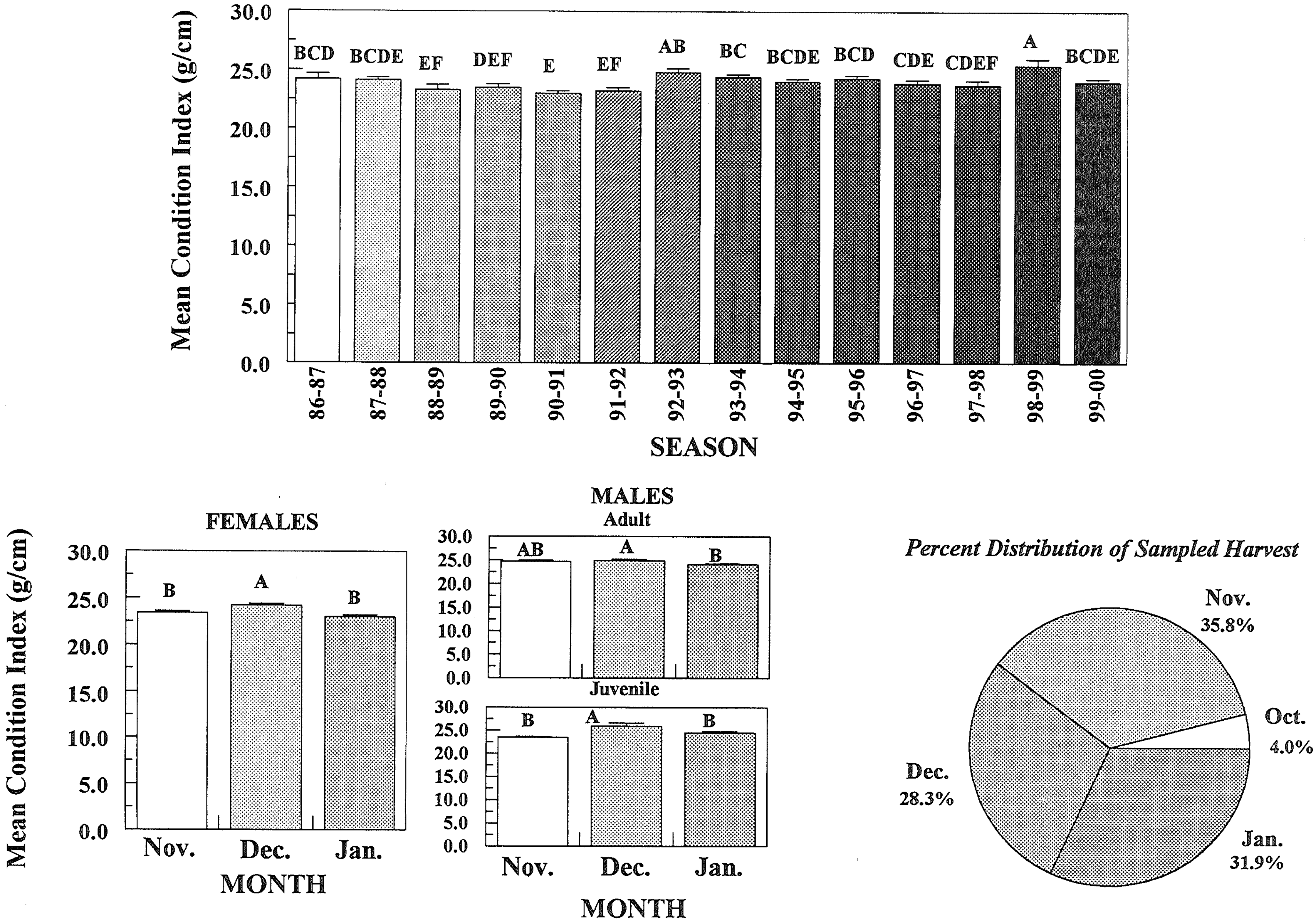


Figure 14. Comparisons of mean condition index values of ring-necked ducks harvested on the upper Gulf Coast of Texas among November (n=115), December (n=93), and January (n=127) and hunting seasons from November 1986 - January 2000. Means represented by the same letter are not different (P > 0.05).

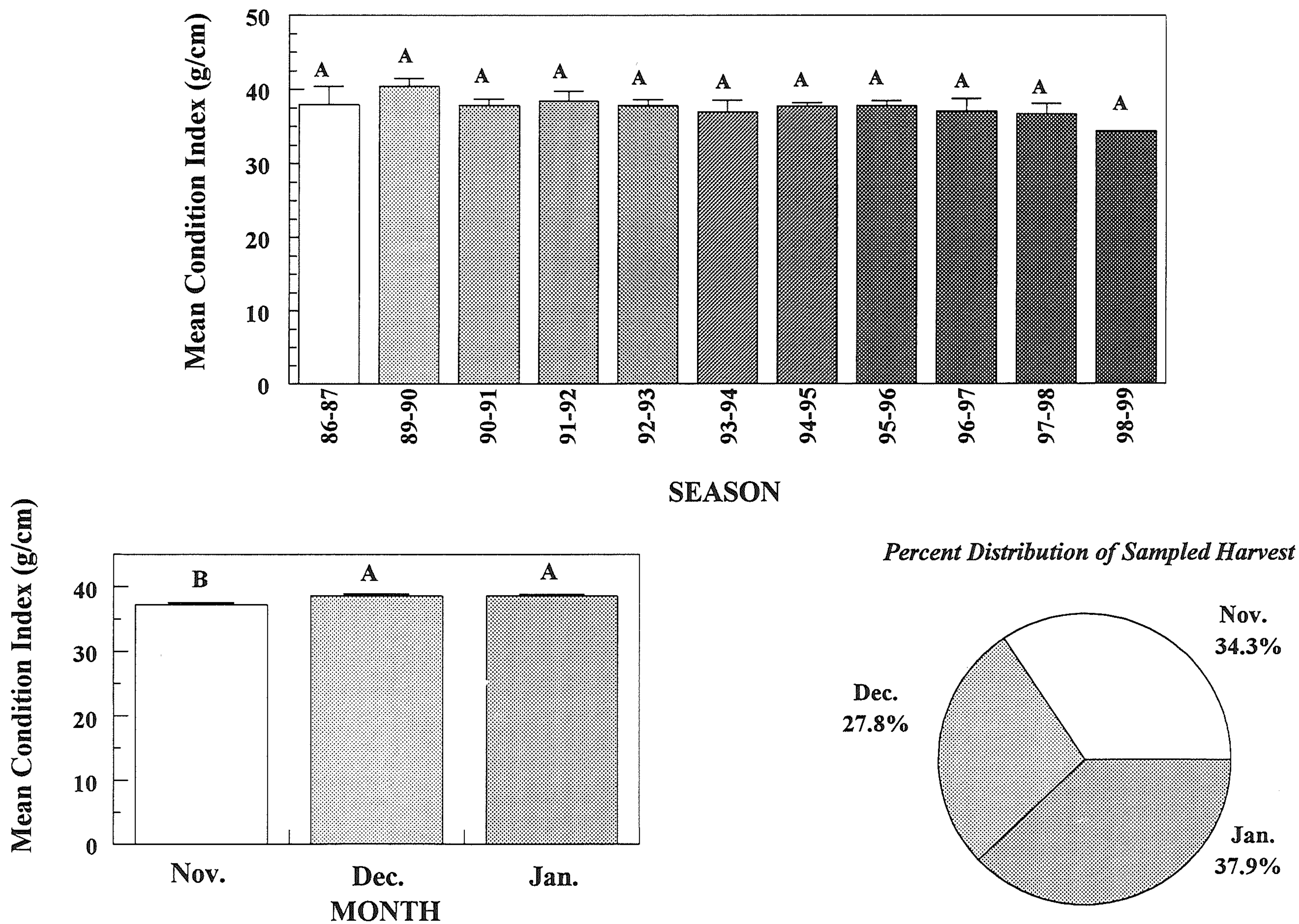
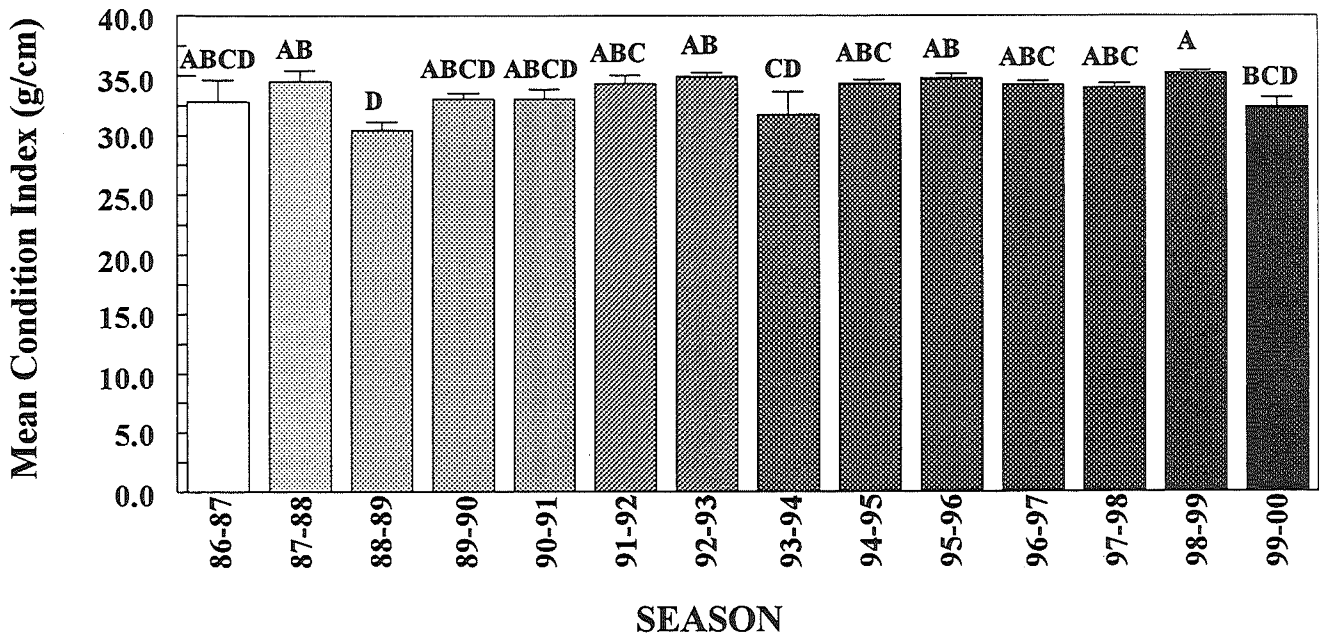
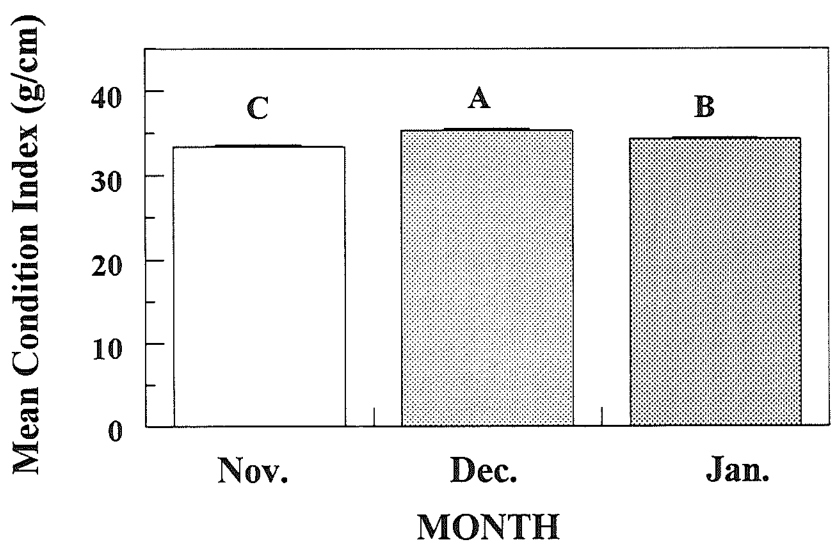
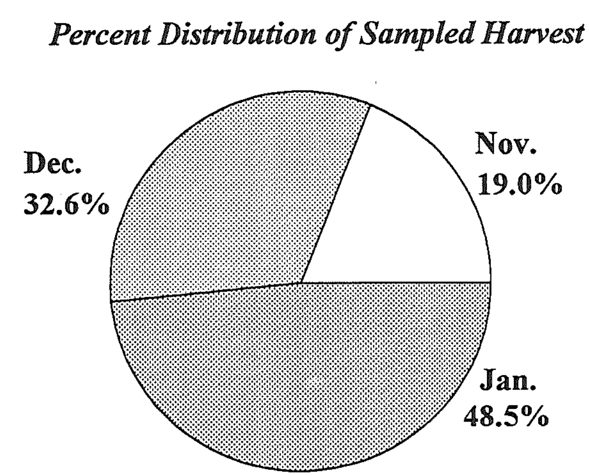


Figure 15. Comparisons of mean condition index values of lesser scaup harvested on the upper Gulf Coast of Texas among November (n=141), December (n=242), and January (n=360) and hunting seasons from November 1986 - January 2000. Means represented by the same letter are not different ($P > 0.05$).







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Cover photograph of Texas coastal marsh habitat
Photograph by Jim Neville