Variation in Number of Ducks Harvested among Hunters in the Central Flyway

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Abstract: Knowledge of the relationship between waterfowl hunters and harvest levels may better inform harvest management decisions. We examined frequency of different sizes of daily harvests among duck hunters, and hunters' contributions to duck harvest in the Central Flyway from 1975–1984, 1988–1993, and 2002–2011 using the U.S. Fish and Wildlife Service's Parts Collection Survey. We stratified hunters sampled by the Parts Collection Survey into 10 equal hunter groups based on seasonal harvest. Hunter groups were ranked from 1 to 10, with hunter group 1 representing hunters with the lowest seasonal harvests, and hunter group 10 representing hunters with the highest seasonal harvests. Successful hunters attained the 5-duck (1975–1984), 3-duck (1988–1993), or 6-duck (2002–2011) daily limit in 8%, 28%, and 13%, respectively, of daily harvests. For all the time periods examined, hunter group 1 only contributed 0.98%–1.48% to the total duck harvest in the Central Flyway, whereas hunter group 10 contributed 31.26%–38.41% to the total duck harvest. We concluded that successful hunters were unlikely to achieve large daily limits, and that hunters disproportionately harvested ducks in the Central Flyway. Our data may assist in formulating duck harvest regulations.

Key words: Central Flyway, daily harvest, Parts Collection Survey, waterfowl hunting

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Unspecified or preconceived perceptions of waterfowl hunter-harvest relationships (e.g., "a small percentage of hunters harvest a large percentage of the ducks") may influence harvest management decisions. Because managers' perceptions of hunters may not always be accurate (Ringelman 1997, Miller and McGee 2001), empirically-based knowledge of duck hunter-harvest relationships is important in meeting duck harvest objectives. Knowledge of the distribution of number of ducks harvested among hunters and the attainment of different daily harvests and how those are affected by different regulations would be advantageous to managers as they propose hunting regulations and attempt to meet hunter expectations (Brunke and Hunt 2007). Such knowledge could also inform the development of regulations to help achieve a third goal as stated in the recently revised North American Waterfowl Management Plan (NAWMP 2012): increasing numbers of waterfowl hunters. Managers of waterfowl harvest often have limited options available to address the decline in waterfowl hunter numbers (NAWMP 2012, Vrtiska et al. 2013). However, harvest regulation development or modification may provide managers an avenue to improve conditions that are perceived to limit hunter numbers.

Our objective was to examine the variability of the number of ducks harvested daily among duck hunters and the relative contribution by successful and less successful hunters to duck harvest across different sets of seasonal regulations in the Central Flyway.

Methods

We obtained the Parts Collection Survey (PCS) data from the U.S. Fish and Wildlife Service (USFWS) Branch of Harvest Surveys to examine duck harvest in the Central Flyway which contains harvest data that is keyed to individual hunters. The PCS collects a wing from each duck harvested by hunters. Species of each wing is identified and assigned an age, sex and contains information on when and where it was harvested. Individual hunters participating in the PCS were assigned a unique hunter identification number for anonymity. The PCS has been collected annually since 1961 (Baldassarre and Bolen 2006, Raftovich and Wilkins 2013); thus, potential changes in harvest across time could be examined. Prior to 2002, hunters sampled by the PCS were randomly chosen from successful (i.e., hunters who harvested ≥1 duck per season) hunters who participated in the USFWS Mail Questionnaire Survey (MQS; Martin and Carney 1977, Baldassarre and Bolen 2006, Raftovich and Wilkins 2013). After 2002, hunters sampled by the PCS were randomly chosen from successful hunters in the USFWS Harvest Information Program (HIP) diary survey (Baldassarre and Bolen 2006, Raftovich and Wilkins 2013).

We edited the original PCS database to include only complete Central Flyway records on duck harvest during regular duck seasons (U.S. Department of Interior 2013). We removed harvested mergansers (*Mergus* spp. and *Lophodytes cucullatus*) from the data set be-

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cause daily limits for mergansers were treated differently by states in the Central Flyway. In Montana and New Mexico mergansers were included with ducks in the daily limit, whereas in all other states (Colorado, Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming) mergansers had a separate daily limit from ducks (U.S. Department of Interior 2013). The differential treatment confounds information across states, necessitating that we delete mergansers from consideration. Because mergansers contributed less than 1% of the total harvest for Montana and New Mexico (Kruse et al. 2002, Kruse 2013), we would anticipate any effect on the results would be insignificant relative to the scale of the study.

We then divided the PCS sample into three time periods that represented different federal harvest frameworks in the Central Flyway: (1) 1975–1984, with a 5-duck daily limit and 60-day season; (2) 1988–1993, with a 3-duck daily limit and 39-day season; and (3) 2002–2011, with a 6-duck daily limit and 74-day season (Kruse et al. 2002, Kruse 2013). Daily limits and season length were the same during 1997–2011, but allowable start and end dates for duck hunting seasons were not the same during 1997–2001. Thus, we used only 2002–2011 for the third time period in our analyses. Additional season days for High Plains Management Units (Kruse et al. 2002, Kruse 2013) were included in our analyses. We then summarized the frequency of occurrence for daily harvests of a given size. We removed samples with daily harvests greater than those legally allowed during the representative time period, as they may represent party harvests, multiple daily harvests, or illegal daily harvests. Specifically, we removed daily harvests greater than five ducks from 1975–1984 (daily harvests removed = 4,424), greater than three ducks from 1988–1993 (daily harvests removed = 1,074), and greater than six ducks from 2002–2011 (daily harvests removed = 487). We also examined HIP diary survey database from 2002–2011 to obtain an estimate of the number of daily bags that contained zero because the HIP diary data contains daily bags of zero, whereas the PCS does not. The HIP diary is an annual survey in which hunters voluntarily report daily harvest totals, or seasonal totals of days hunted and ducks harvested.

We stratified hunters into 10 equal groups similar to Haugen (2013). For each time period independently, we ranked all hunters in the PCS sample in ascending order by seasonal harvest, and then split the ranking into 10 groups of hunters with a roughly equivalent sample size in each (~10% of total sample). The use of deciles for stratification allows comparisons to be made among the same relative group (by seasonal harvest) of successful hunters across all time periods. For example, the 10th hunter group represented the top-ranked 10% of successful hunters (by seasonal harvest) for each time period, whereas the 1st hunter group represented the bottom-ranked 10% of successful hunters for each time period (Haugen 2013).

The PCS data contained a weight variable for each individual duck sampled. The weights were an estimate of how many ducks in the total harvest were represented by the corresponding duck collected for the PCS (Raftovich and Wilkins 2013). Weights varied on an annual basis. We used PCS-derived weights to estimate duck harvest for each hunter group and time period. We calculated hunter contribution by dividing a hunter group's duck harvest by the total number of ducks harvested for each time period. We also calculated 95% confidence intervals using normal approximation of a binomial distribution for each estimate of contribution to duck harvest for each time period (Dowdy et al. 2004).

We used SAS software (SAS Institute 2009) to conduct a chi-square goodness-of-fit test to describe the level of variation in the contribution to duck harvest from each hunter group during each time period. The proportion of hunters in each of the 10 hunter groups (roughly 10%) was used as that hunter group's expected contribution to Central Flyway harvest for the chi-square analyses. Lastly, we used a chi-square test to compare the contributions of hunter groups among the different regulation periods; the null hypothesis was that relative patterns in contribution from the 10 hunter groups remained similar in proportion across the regulation periods.

Results

The PCS data provided 53,414 daily harvests from successful Central Flyway hunters from 1975–1984, 42,023 daily harvests from 1988–1993, and 51,136 daily harvests from 2002–2011. A daily limit of five ducks was attained in 8% of daily harvests for hunters during 1975–1984 (Table 1). A three-duck daily limit during 1988–1993

Table 1. Percent (%) and frequency (Freq) of occurrence of different daily harvest sizes in Central Flyway states from three time periods. Data from U.S. Fish and Wildlife Service Parts Collection Survey sampled hunters.

	Time period					
	1975–1984[a]		1988–1993[b]		2002–2011[c]	
Daily harvest	%	Freq	%	Freq	%	Freq
1	35.70	19,069	35.47	14,907	23.50	12,019
2	28.34	15,136	36.65	15,401	20.24	10,350
3	17.57	9,383	27.88	11,715	15.72	8,038
4	10.72	5,727	–	–	12.25	6,264
5	7.67	4,099	–	–	15.02	7,681
6	–	–	–	–	13.27	6,784
Total	100.00	53,414	100.00	42,023	100.00	51,136

a. Daily limit = 5; season length = 60 days.
b. Daily limit = 3; season length = 39 days.
c. Daily limit = 6; season length = 74 days.

Table 2. Hunter groups' (stratified hunters ranked based on their seasonal harvest) contribution to duck harvest (and 95% confidence intervals) in the Central Flyway relative to their proportion of the sampled hunters for three time periods, derived from U.S. Fish and Wildlife Service Parts Collection Survey data.

Time period	Ranked hunter group	Individual hunter's seasonal duck harvest	Sampled hunters in the hunter group (%)[a]	Central Flyway duck harvest contribution (%)[b]	Cumulative harvest contribution (%)
1975–1984[c]	10	21+	9.34	34.00 [33.98, 34.02]	34.00
	9	15–20	10.53	19.15 [19.13, 19.17]	53.15
	8	11–14	8.6	11.30 [11.29, 11.31]	64.45
	7	9–10	10.05	10.34 [10.33, 10.35]	74.79
	6	7–8	9.95	7.57 [7.56, 7.58]	82.36
	5	5–6	12.88	7.63 [7.62, 7.64]	89.99
	4	4	7.92	3.51 [3.50, 3.52]	93.50
	3	3	9.56	3.08 [3.07, 3.09]	96.58
	2	2	10.12	2.21 [2.20, 2.22]	98.79
	1	1	11.08	1.21 [1.21, 1.21]	100.00
1988–1993[d]	10	19+	9.61	31.26 [31.22, 31.30]	31.26
	9	12–18	11.9	21.82 [21.78, 21.86]	53.08
	8	9–11	11.55	13.61 [13.58, 13.64]	66.69
	7	7–8	9.55	8.92 [8.90, 8.94]	75.61
	6	6	7.73	6.09 [6.07, 6.11]	81.70
	5	5	7.43	4.89 [4.87, 4.91]	86.59
	4	4	8.28	4.28 [4.26, 4.30]	90.87
	3	3	11.07	4.46 [4.44, 4.48]	95.33
	2	2	12.01	3.19 [3.17, 3.21]	98.52
	1	1	10.93	1.48 [1.47, 1.49]	100.00
2002–2011[e]	10	35+	10.11	38.41 [38.39, 38.43]	38.41
	9	24–34	10.25	18.40 [18.38, 18.42]	56.81
	8	18–23	10.18	12.46 [12.45, 12.47]	69.27
	7	14–17	8.62	8.13 [8.12, 8.14]	77.40
	6	11–13	8.71	6.05 [6.04, 6.06]	83.45
	5	9–10	9.3	5.36 [5.35, 5.37]	88.81
	4	7–8	8.75	3.94 [3.93, 3.95]	92.75
	3	5–6	11.97	3.96 [3.95, 3.97]	96.71
	2	3–4	10.98	2.30 [2.29, 2.31]	99.01
	1	1–2	11.22	0.98 [0.98, 0.98]	99.99

a. Expected contribution to Central Flyway duck harvest used in the chi-square analyses.
b. Calculations incorporate weights derived by the Parts Collection Survey.
c. Daily limit = 5; season length = 60 days.
d. Daily limit = 3; season length = 39 days.
e. Daily limit = 6; season length = 74 days.

was attained in 28% of daily harvests reported by successful Central Flyway hunters (Table 1). A daily limit of six ducks was attained in 13% of daily harvests for successful Central Flyway hunters during 2002–2011 (Table 1). From 2002–2011, 22.55% ($n = 123{,}930$) of the daily bags in the HIP diary data set contained zero ducks.

The PCS data provided a sample of 15,819 hunters from 1975–1984, 8,629 hunters from 1988–1993, and 5,952 hunters from 2002–2011. As expected, hunters did not equally contribute to duck harvest for all time periods; 1975–1984 ($\chi^2 = 2.25 \times 10^7$, df = 9, $P < 0.001$), 1988–1993 ($\chi^2 = 3.97 \times 10^6$, df = 9, $P < 0.001$), and 2002–2011 ($\chi^2 = 2.62 \times 10^8$, df = 9, $P < 0.001$). The lowest-ranked hunter group (hunter group 1) harvested between 1% and 2% of the harvested ducks in the Central Flyway across all time periods (Table 2). The top-ranked hunter group (hunter group 10) harvested between 31% and 38% of the ducks in the Central Flyway during the time periods we considered (Table 2). Only hunter groups 7 (1975–1984 only), 8, 9, and 10 contributed to duck harvest more than their predicted contribution (i.e., their proportion to the sampled hunters; Table 2). As expected, we also found the ranked hunter groups' contribution to the total duck harvest differed over the three time periods ($P < 0.001$, df = 18). The highest-ranked hunter group exhibited the maximum difference among time periods (31% of harvest during 1988–1993 and 38% during 2002–2011; Table 2). The lowest-ranked hunter group's contribution changed by less than 1% across the three time periods (Table 2). However, the patterns of hunter group's contribution to the total harvest were relatively similar to one another across time periods (Table 2).

Discussion

If hunter satisfaction is motivated by harvest and is an explicit goal of managers, then it is important hunter expectations match plausible achievement with regard to daily harvests (Brunke and Hunt 2007). We speculate that a hunter's perception of success, and subsequently satisfaction, could be influenced by daily limits (Snow 1982, Cook et al. 2001, Schroeder et al. 2014). Schroeder et al. (2014) suggested daily limits could represent a legal norm for waterfowl hunters, and legal norms may define social norms over time. Thus, hunters may perceive daily limits as a prescriptive behavior for what ought to be achieved (Morris 1956). For example, hunters believe a current limit of 6 ducks is "about right" according to the National Flyway Council and Wildlife Management Institute (2006). However, our analyses show that even the most successful hunters do not often obtain the daily limit. The vast majority of daily harvests observed were under the daily limit regardless of the period examined (Table 1). If daily limits are considered a prescriptive behavior, hunter expectations of harvest success may not match reality. We suspect that duck hunters may be more satisfied harvesting fewer ducks but attaining a daily limit than having a higher bag limit and not achieving it (see Nieman et al. 1986), similar to anglers who have reported more satisfaction with their fishing trip as their daily harvest approached the daily limit (Cook et al. 2001). We found that successful hunters in the PCS sample were less likely to attain a daily limit when daily limits were higher (i.e., five or six ducks) than when daily limits were set at three. However, the PCS may be biased high for measures related to daily harvest attainment because the PCS only contains hunters who harvested at least one

duck per season. If the PCS contained data on hunters who failed to harvest even one duck during the season, then the daily harvest attainment estimates will be lower due to zeroes in the data set. Indeed, according the HIP diary data, 22.55% of daily bags from 2002–2011 contained zero ducks. Thus, a logical assumption is that even a lower proportion of hunters than we estimated from the PCS data attained a daily limit. Managers should conduct investigations to assess the relationship between duck hunter expectations and satisfaction related to daily bag limits and possibly adjust daily bag limits accordingly.

The data show that harvest contribution is disproportional among successful hunters in the Central Flyway among the three different regulation periods investigated. Similarly, our results indicate individual hunters contributed disproportionally to the total duck harvest across time periods as well. However, across time periods, hunter groups contributed to the total harvest in a relatively similar pattern. Our data provide managers with an empirical link between proportions of duck hunters and proportions of duck harvest. In the Central Flyway for the periods we reviewed, the top 20% of successful hunters (hunter groups 9–10) were responsible for 52%–56% of the total harvest. The desired effect of a regulatory decision on duck harvest is influenced by the regulation's effect on hunters. Our data provide some insight into the relationship between a proportion of hunters and their contribution to duck harvest. As such, managers may be able to better predict how a regulatory decision may affect duck harvest if they can anticipate how many hunters will be affected by the regulatory change.

The number of participants in the PCS has recently declined. Our sample was 46% smaller for the 1988–1993 period relative to the 1975–1984 period. That decrease in sample size was roughly proportional to the number of years in the time periods. However, we found a decrease in PCS participants of 62% from the 1975–1984 period to the 2002–2011 period when the time periods contained the same number of years. Participation of duck hunters has declined in recent years (Enck et al. 2000, Vrtiska et al. 2013), but not at the same magnitude as participation in the PCS. Our analyses assumed changes in hunter samples in the PCS resulted from changes in how PCS participant samples were drawn from HIP diary participants (2002-current, derived from HIP registered hunters) compared to MQS participants (1961–2001, derived from duck stamp purchasers; K. Wilkins, USFWS, personal communication; Martin and Carney 1977; Raftovich and Wilkins 2013). Even with these changes, we believe our samples are of sufficient size and representation to provide useful information to waterfowl managers.

Our study showed that larger daily limits were not attained by the majority of successful hunters, and harvest occurred disproportionately among successful Central Flyway hunters. Managers should consider treating hunters as a community with multiple, distinct typologies rather than a singular typology. Such consideration also may lead to differential hunting regulations among typologies that increase satisfaction or participation within each one.

Although our data suggest a relationship exists between harvest, hunters, and regulatory periods, it is uncertain as to whether underlying mechanisms are driving the patterns we observed. Specifically, changes in duck abundance, hunter effort, or other mechanisms could all contribute to the observed patterns. It was not our intention to determine the driving mechanism, but rather report the observed trends. Nonetheless, our data on daily harvest attainment and hunter harvest contributions provide managers with information that could aid in harvest management and human dimension decisions. For example, knowing the patterns and estimates of daily harvest attainment may help managers adjust daily harvest limits, balancing the potential need to limit harvest on duck species with the potential impact on hunters and perhaps their satisfaction. Our examination of one facet of the linkage between hunters and harvest, used in combination with other information, should help inform regulatory decisions.

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