

Does the proportion of Snow Geese using coastal marshes in southwest Louisiana vary in relation to light goose harvest or rice production?

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Introduction

In historical wintering areas along the Gulf of Mexico, Lesser Snow Geese *Chen caerulescens caerulescens* (hereafter Snow Geese) currently use two primary habitats, i.e., coastal marshes and adjacent agricultural lands north of the marshes. Snow Geese wintered only in coastal marshes until the 1940s; however, they began using agricultural lands, predominantly those planted with rice *Oryza sativa* (hereafter rice-prairies), within the last 80 years (BATEMAN et al. 1988). These two habitats differ in foraging conditions, which results in differing time budgets for Snow Geese (JÓNSSON & AFTON 2006). The relative costs and benefits in terms of food intake can vary annually for these two habitats in relation to weather or food availability (ALISAUSKAS 1998, ALISAUSKAS et al. 1988, 1998, JÓNSSON & AFTON 2006, JÓNSSON et al. 2014).



Snow Geese from coastal marsh habitats (both banded birds and collected specimens) have larger bills than do those from rice-prairies (ALISAUSKAS 1998, JÓNSSON 2005, JÓNSSON et al. 2014). ALISAUSKAS et al. (1998) suggested that the two morphs could represent separate populations, requiring separate management.

Prior to the application of the U.S. Conservation Order (ALISAUSKAS et al. 2011), there was some concern in Louisiana that the marsh Snow Geese would be particularly vulnerable to the increased harvest efforts expected from the Conservation Order.

Despite the morphological segregation, Snow Geese occasionally move between the two habitats, although movements generally are rare (ALISAUSKAS 1998, JÓNSSON et al. 2014). Movement decisions by Snow Geese may depend on which habitats offer greater safety from hunters or disturbance. We previously argued that Snow Geese are relatively safer from hunters in coastal marshes, wherein most Snow Geese are found within large waterfowl refuges (JÓNSSON et al. 2014). Furthermore, the habitat suitability of rice-prairies could be affected by annual variation in rice production, i.e., increased rice production probably increases food availability for Snow Geese in rice-prairies (JÓNSSON et al. 2014).

Although movements between habitats can be frequent for short time periods, the morphological segregation may persist for decades because exchange between the two habitats can be restricted over longer time-scales. Thus, annual changes in relative Snow Goose numbers between the two habitats can plausibly occur over a period of a decade or more. Here, our objective was to determine whether the annual proportion of Snow Geese using coastal marsh habitats in southwest Louisiana varied annually, as compared to rice-prairie habitats, possibly in relation to hunting pressure or rice production. We predicted that: 1) increased rice production would make rice-prairies more attractive for Snow Geese and thus, the proportion of Snow Geese using coastal marshes would be inversely correlated with rice acreage in Louisiana; and 2) increased light goose harvest and hunting pressure would favour an increased proportion of Snow Geese using coastal marshes.

Methods

In North America, both harvest and waterfowl winter survey estimates are combined for Snow Geese and the closely related Ross's Geese *C. rossii*, and the two species are jointly termed light geese by waterfowl managers (KRUSE & FRONCZAK 2014). We obtained light goose numbers from the annual mid-winter waterfowl survey (EGGEMAN & JOHNSON 1989; SHARP et al. 2002, U.S. FISH & WILDLIFE SERVICE 2015). In southwest Louisiana, the survey is carried out by staff of U.S. Fish and Wildlife Service (USFWS) and Louisiana Department of Wildlife and Fisheries (LDWF) in the first week of January.



The response variable

We used 14 years (2001-2014) of mid-winter waterfowl survey results and stratified data by winters for all analyses; winters were defined by January (the survey month) for the given calendar years representing the annual variation in this study. We stratified light goose numbers in southwest Louisiana (zone 3, see map below) from the mid-winter survey into the two habitats: rice-prairies (Survey units 1, 3, 6, 7, and 12 of Zone 3) or coastal marshes (Survey units 2, 4, and 5 of Zone 3; see Fig. 1 in JÓNSSON et al. 2014 and survey coverage maps in U.S. FISH & WILDLIFE SERVICE 2015).

We then calculated the proportion of light geese using coastal marshes (PCM) from the mid-winter survey results and used this proportion to index annual Snow Goose use of coastal marsh habitat. Preliminary analysis showed that PCM was not correlated to light goose numbers in southwest Louisiana (survey numbers for zone 3 only), or to the state-wide total light goose numbers (survey numbers for zones 1, 2, 3 and 4 combined). Accordingly, we used PCM as the response variable in our analyses.

MIDWINTER WATERFOWL SURVEY BOUNDARIES OF THE CONTINENTAL U.S.



Explanatory variables and relevant assumptions

We included rice acreage and a hunting pressure index as explanatory variables in our analyses to examine our predictions. We examined annual variability in rice production using total rice acreage in Louisiana (Rice Online; United States Department of Agriculture 2014). We chose total light goose harvest in Louisiana (KRUSE & FRONCZAK 2014) as an index of hunting pressure in our analysis, which we examined previously in relation to total hunted days and hunter numbers, i.e. regular season harvest plus conservation order harvest within each winter (JÓNSSON & AFTON 2015). We initially considered the approach of PÖYSÄ et al. (2013): ranking the winters according to harvest rate (total light goose harvest / state-wide light goose numbers). However, both the harvest rate itself and ranking the winters by the harvest rate were correlated with total light goose harvest. We also considered the approach of SZYMANSKI et al. (2013), who used hunter numbers for grouping regions into low and high hunting pressure; however, hunter numbers consistently declined for Louisiana during 2001-2014 (KRUSE & FRONCZAK 2014). Thus, we chose to use total light goose harvest as our index (see also JÓNSSON & AFTON 2015).

For our analysis, we assumed that:

1. annual variation in rice production in all of Louisiana represented annual variation in rice production within our study area in southwest Louisiana (which also is the “heartland of Louisiana’s rice belt”; BABINEAUX 1967);
2. the January mid-winter survey for light geese in southwest Louisiana represented Snow Goose distribution between habitats; there are known limitations to the surveys which are discussed by EGGEMAN & JOHNSON (1989); and
3. that total light goose harvest was a reasonable index for hunting pressure (JÓNSSON & AFTON 2015).

For light goose harvest, annual state totals were the only available data; separate harvest estimates for southwest Louisiana were not available. Thus, we evaluated our second assumption by inspecting relationships between winter and light goose harvest with respect to: 1) state-wide totals (light goose numbers summed for waterfowl survey zones 1, 2, 3 and 4 in Louisiana); and 2) light goose numbers for zone 3 only, which corresponds to southwest Louisiana (U.S. FISH & WILDLIFE SERVICE 2015).

Relevant questions were: 1) whether light goose numbers in southwest Louisiana were correlated with the state-wide total; and 2) whether the state-wide total light goose numbers was related to winter or total light goose harvest in Louisiana. However, we found no relationships in any of the three cases (Appendix 1).

The observed annual trends in light goose numbers state-wide and specifically for southwest Louisiana were similar, suggesting that using state-wide total harvest vs. survey numbers specific to southwest Louisiana was reasonable for our analysis. Our second assumption appears justified after examining Snow Goose distribution among the four survey zones within Louisiana. Southwest Louisiana (zone 3) contained on average 49% of all Snow Geese in Louisiana during 2001-2010 (10 year average). By comparison, north Louisiana (zones 1 and 2) contained 46.4% of all Snow Geese in Louisiana but those zones are inland and have no adjacent coastal marshes. We surmise that similar events were occurring throughout the south coast of Louisiana because the state total was our hunting pressure index. The only other survey zone within Louisiana with coastal marshes is southeast Louisiana (zone 4) and on average 25-30 thousand Snow Geese (4.6% of state-wide total) were surveyed there annually from 2001-2010, or approximately ten times fewer than the number of Snow Geese using southwest Louisiana. Thus, Snow Geese in southeast Louisiana probably play a limited role in affecting state-wide PCM, relative to that of those in southwest Louisiana.



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Statistical analysis

We used a generalized mixed linear model to examine the effect of three explanatory variables on proportions of Snow Geese using coastal marsh habitats from 2001-2014. Specifically, our explanatory variables were total light goose harvest (our index of hunting pressure, thousands of birds) and rice acreage in Louisiana (thousands of acres/year) but we also included winter as a random effect, which accounted for annual variation:

1) The proportions of Snow Geese that used coastal marshes (PCM) = $\beta_0 + \beta_1(\text{total light goose harvest in Louisiana}) + \beta_2(\text{rice acreage in Louisiana}) + \text{winter (random effect)}$

Finally, we also ran a model where effects of rice acreage and light goose harvest in Louisiana on PCM were lagged by one year in case Snow Geese chose between coastal marshes and rice-prairies based on their experiences in the previous winter rather than the current winter.

Results

After accounting for winter as a random effect, we found that PCM was inversely related to total light goose harvest in Louisiana ($F^{1,11} = 9.60$, $P=0.01$), but was not related to rice acreage in Louisiana ($F^{1,11} = 0.10$, $P=0.76$).

The proportion of Snow Goose using coastal marshes increased during the study period (Fig 1) and was inversely related to total light goose harvest (Fig 2). We observed no 1-year lagged effect of rice acreage ($F^{1,10} = 0.29$, $P=0.60$) or total light goose harvest ($F^{1,10} = 3.31$, $P=0.10$) on PCM.

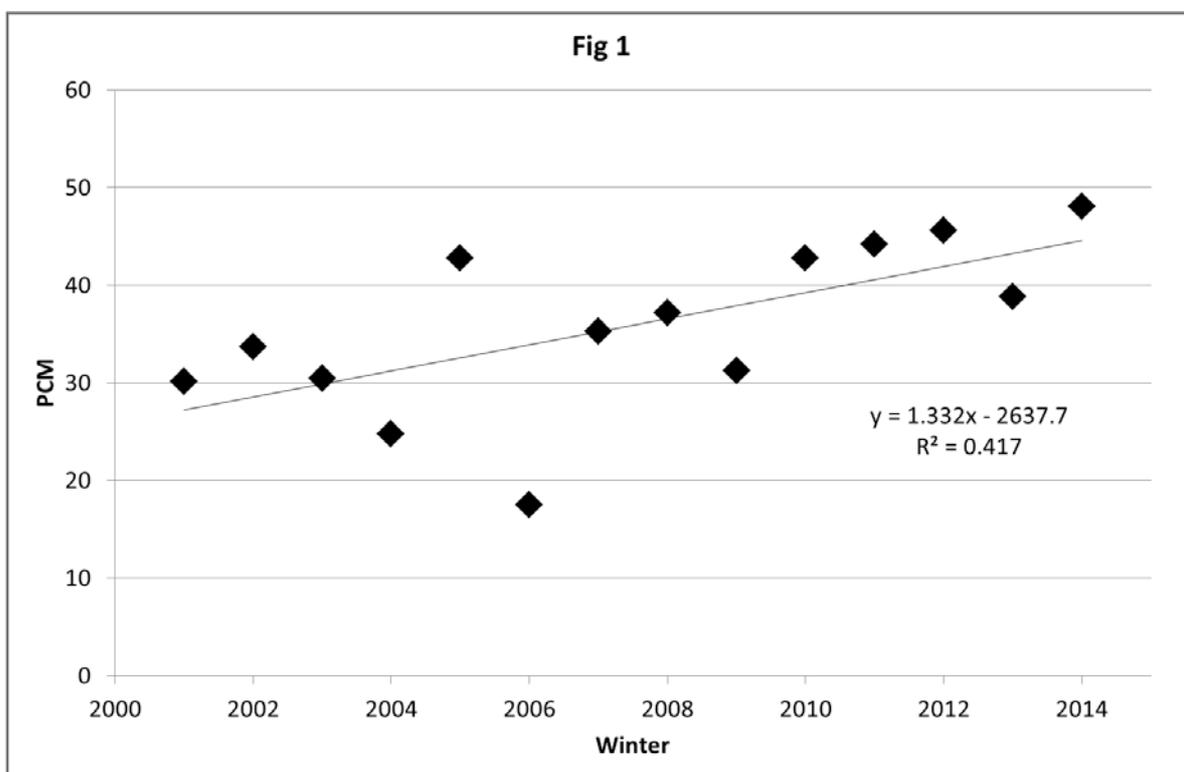


Fig. 1. The annual trend in proportion of Snow Geese in southwest Louisiana using coastal marsh habitat (PCM), calculated from midwinter waterfowl survey data from 2001-2014. The relationship shown is a simple linear regression of the two variables; the generalized linear model reported in the text included a winter effect as a random effect.

Total light goose harvest in Louisiana decreased through the study period and was particularly low (<65,000 birds) in 2010-2011 and 2013-2014 (Fig 3).

Rice acreage in Louisiana fluctuated over the study period but did not show a linear trend with winter (Fig 3); it was relatively high, 455-550,000 acres 2001-2005, decreased to 360,000 acres in 2006 but increased thereafter until 2010 towards a peak of 560,000 acres. From 2010 onwards, rice acreage in Louisiana ranged relatively low at 402,000-455,000 acres.

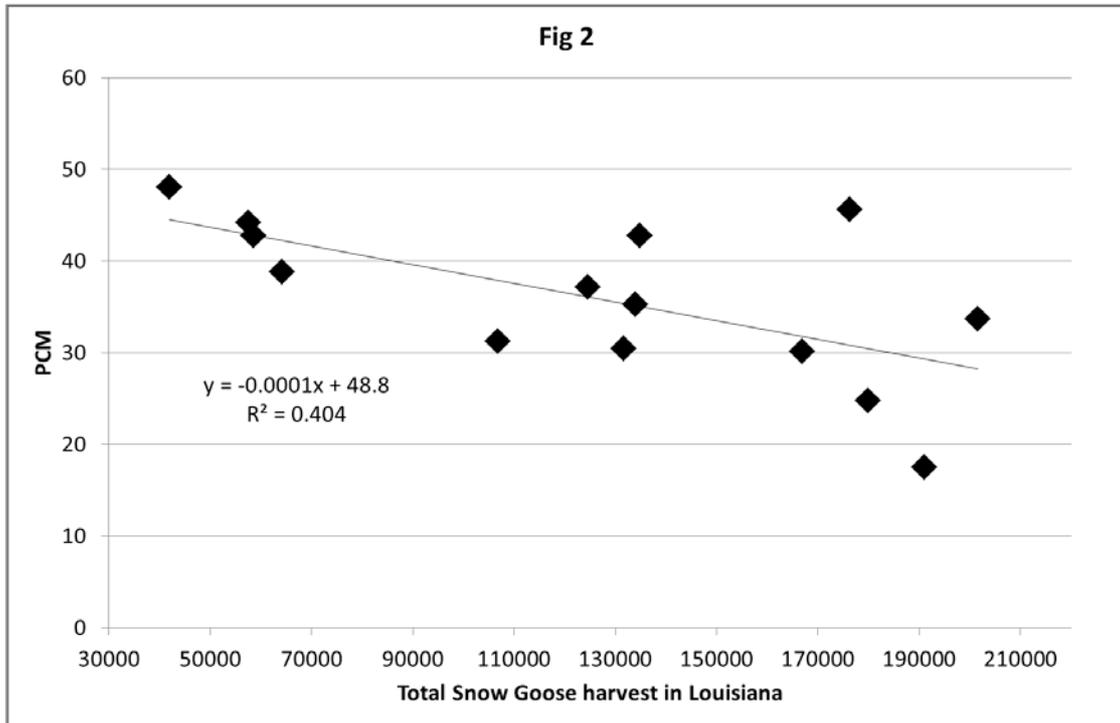


Fig. 2. The relationship between the proportion of Snow Geese in southwest Louisiana using coastal marsh habitat (PCM) and total light goose harvest, our index of hunting pressure. The relationship shown is a simple linear regression of the two variables; the generalized linear model reported in the text included this effect as a fixed effect which was significant after including the random winter effect shown in Fig. 1.

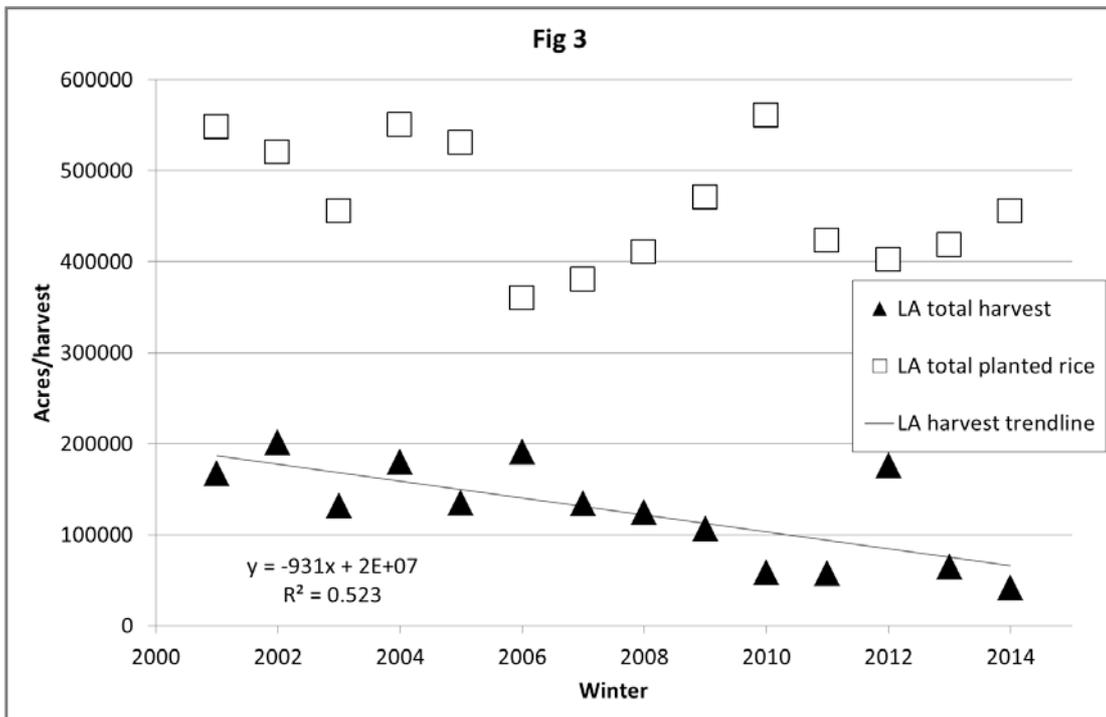


Fig. 3. Planted rice (acres) in Louisiana (open symbols) and total light goose harvest (solid symbols) from 2001-2014. Both variables use the same y-axis. There was no linear trend in rice acreage, whereas light goose harvest declined during the study period.

Discussion

Contrary to our prediction, we observed an inverse correlation between PCM and light goose harvest in Louisiana. A possible explanation for this finding is that the high observed use of marsh by the Snow Geese 2010-2014 (see Fig. 1) could have contributed towards a lower light goose harvest, rather than hunting pressure in the rice-prairies favouring high use of coastal marshes. Notably, there was no decline in state-wide total harvest in Arkansas, Missouri, Nebraska, South Dakota or North Dakota in 2001-2013 (JÓNSSON & AFTON 2015). Thus, our hunting pressure index showed no trend in the other major Snow Goose hunting states in the flyway, whereas in Louisiana, Snow Geese have been under decreased hunting pressure, while simultaneously showing no trend in state-wide Snow Goose numbers.

Our prediction about the effects of rice acreage also was not supported, neither for direct effects (lag=0), nor did Snow Geese seem to use the experience from the previous winter to choose between habitats (lag=1). Although there was no relationship between rice acreage and the proportion of Snow Geese using coastal marshes, we note that the largest annual changes in total light goose harvest and PCM occurred during a low rice acreage period during 2010-2014. Rice acreage has increased in the states north of Louisiana since 2000, which probably attracts Snow Geese to areas such as the Mississippi Alluvial Valley (MAV). However, there was no trend in the numbers of wintering Snow Geese in Louisiana during this study, while the total continental Snow Goose population increased 2001-2014 (ALISAUSKAS et al. 2011). We previously argued that northwards expansion of wintering Snow Geese was explained by an exploratory, younger segment of the population (JÓNSSON & AFTON 2015), which probably would be the bulk of the Snow Geese expanding the wintering range northwards.

Marsh burns attract Snow Geese to coastal marshes to feed (JÓNSSON et al. 2014). Coastal marsh refuges generally are burned according to a 3-year rotating program, with one-third of refuge areas burned during a single fall/winter (October–February) season (GABREY & AFTON 2000). Unfortunately, we have no data on coastal marsh burns during our study period but we suspect that PCM would be positively correlated to frequency or extent of marsh burns.

Our estimate of PCM is derived from a single waterfowl survey each January, whereas Snow Geese generally arrive in southwest Louisiana in November (JÓNSSON 2005). Thus, events in early winter (November and December) could have affected distributions of Snow Geese in January, when surveys were conducted. For example, hunting disturbance or food depletion during early winter in the rice-prairies (ALISAUSKAS et al. 1988) could favour high marsh use in January. Specifically, direct mortality from hunting, frequent disturbance, and food depletion in the rice-prairies could have forced movements into the coastal marshes by the time Snow Geese are surveyed in January. A more rigorous study with estimates of PCM throughout winter is required to determine relationships between events within each habitat and their role in determining PCM.

Disturbance (FOX & MADSEN 1997, NEWTON 1998, SZYMANSKI et al. 2013), as defined by FOX & MADSEN 1997: is “any human activity that constitutes a stimulus (equivalent to a predation threat) sufficient to disrupt normal activities and/or distribution of waterbirds relative to the situation in the absence of that activity”.

Snow Geese are more accessible from roads in the rice-prairies than in coastal marshes (JÓNSSON et al. 2014), which results in relatively higher disturbance in rice-prairies. Disturbance includes hunting activities, but also other human activities that flush geese, such as human presence, hazing, noise, traffic, aircraft, boats, etc. (FOX & MADSEN 1997, NEWTON 1998). Furthermore, there is a temporal component, i.e., hunted species are more sensitive during hunting seasons than during non-hunting seasons and a spatial component, i.e., disturbance causes birds to avoid certain areas and seek other areas where they are less likely to be disturbed (NEWTON 1998). Total harvest, harvest rates or hunter numbers do not quantify or incorporate the disturbance elements of hunting pressure, i.e. effects of hunter traffic, flushing or the noise from the shooting. We suspect that these phenomena generally are more common in the rice-prairies than the coastal marshes.

Excessive hunter disturbance causes Snow Geese to form larger flocks and the associated increased flock vigilance makes Snow Geese less vulnerable to hunters (ALAN AFTON and PAT KEHOE, pers. obs). Such disturbance of Snow Geese probably declines initially as number of hunters decline. With fewer hunters in an area, Snow Geese are flushed and spooked less often and stay in smaller flocks. Smaller flocks are more easily lured into decoy sets and approach decoy sets faster, closer and at lower altitudes (ALAN AFTON and PAT KEHOE, pers. obs); thus, decreasing number of hunters could increase harvest rather than decreasing it in the long term. For example, the year 2012 had similar light goose harvest as 2001-2008 with less than half the hunters present (Appendix 2). Hunters can vary how often they hunt and how long they hunt. We suspect that with fewer hunters present, those remaining are either better or more experienced hunters, who go hunting more often when Snow Geese are in smaller flocks. Thus, Snow Geese could become vulnerable with reduced hunter numbers, if the effect of fewer hunters results in smaller and more dispersed Snow Goose flocks.

By definition, both light goose harvest and midwinter waterfowl surveys provide estimates that are combined totals for Snow Geese and Ross's Geese. In southwest Louisiana, Ross's Geese are not found in the coastal marshes but frequently flock with Snow Geese in the rice-prairies (JÓNSSON & AFTON 2009). Snow and Ross's Goose populations increased in tandem, continent-wide during the study period (ALISAUSKAS et al. 2011) and thus, we surmise that number of Ross's Geese in our study area would not greatly affect the comparisons presented here. Ross's Geese were 4-10% of all light geese in Louisiana 2001-2002 i.e. 24,000-48,000 individuals (HELM 2003); this proportion probably is higher in the rice-prairies in winters of high use of coastal marshes by Snow Geese.

So why have marshes become more important recently for Snow Geese, as indicated by midwinter waterfowl surveys? ALISAUSKAS et al. (1998) argued that coastal marshes could be important in some years for Snow Geese that ordinarily would not winter there. The high use of coastal marshes in 2010-2014 could be the beginning of changed habitat use for Snow Geese in southwest Louisiana. This period also was characterized by low light goose harvest and low rice acreages, both of which could increase marsh use by Snow Geese. After an all-time low in 2006, PCM increased from 35% in 2007 to 48% in 2014, during a period where light goose numbers in southwest Louisiana and state-wide remained stable. Thus, changes in bird numbers did not push Snow Geese into the marshes. The increasing use of marsh habitats by Snow Geese warrants further attention, especially in relation to light goose harvest in Louisiana.

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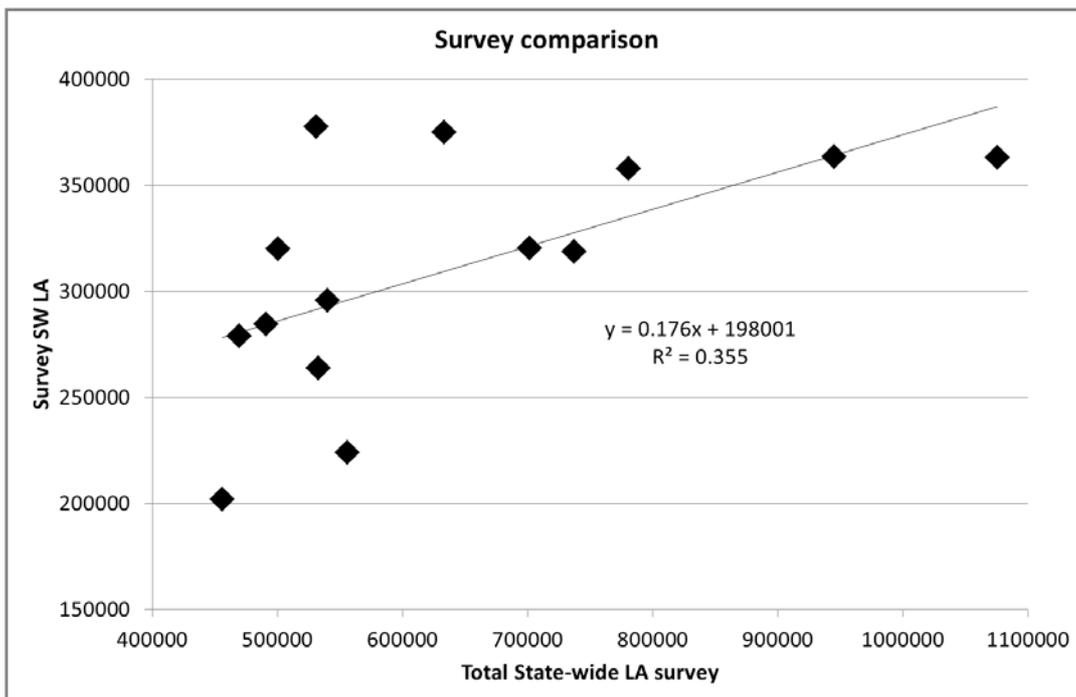
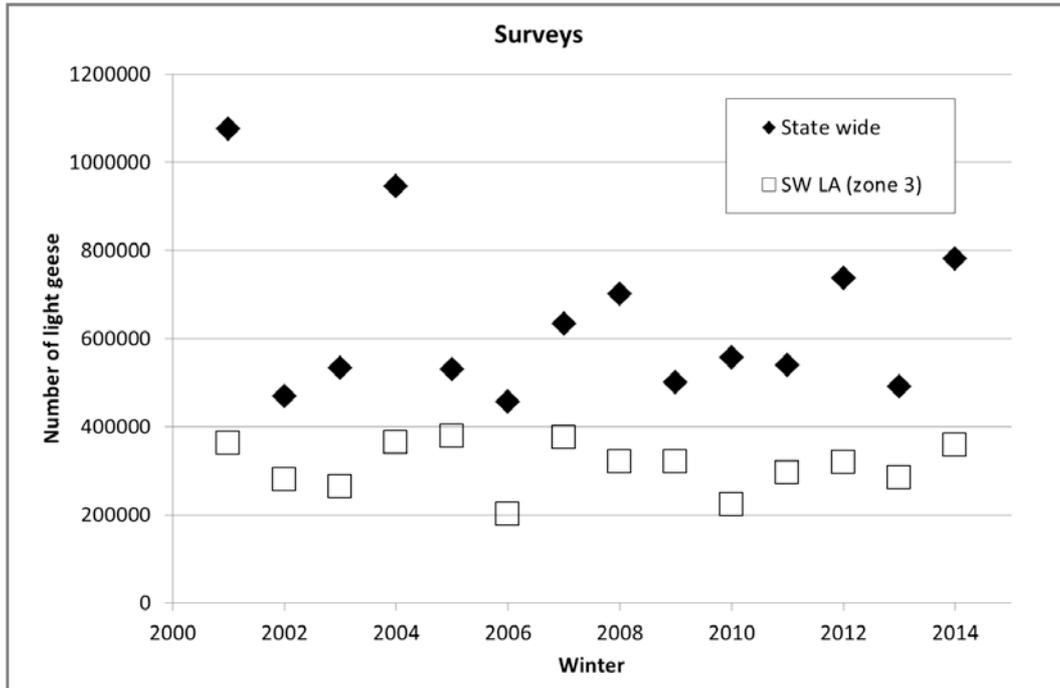
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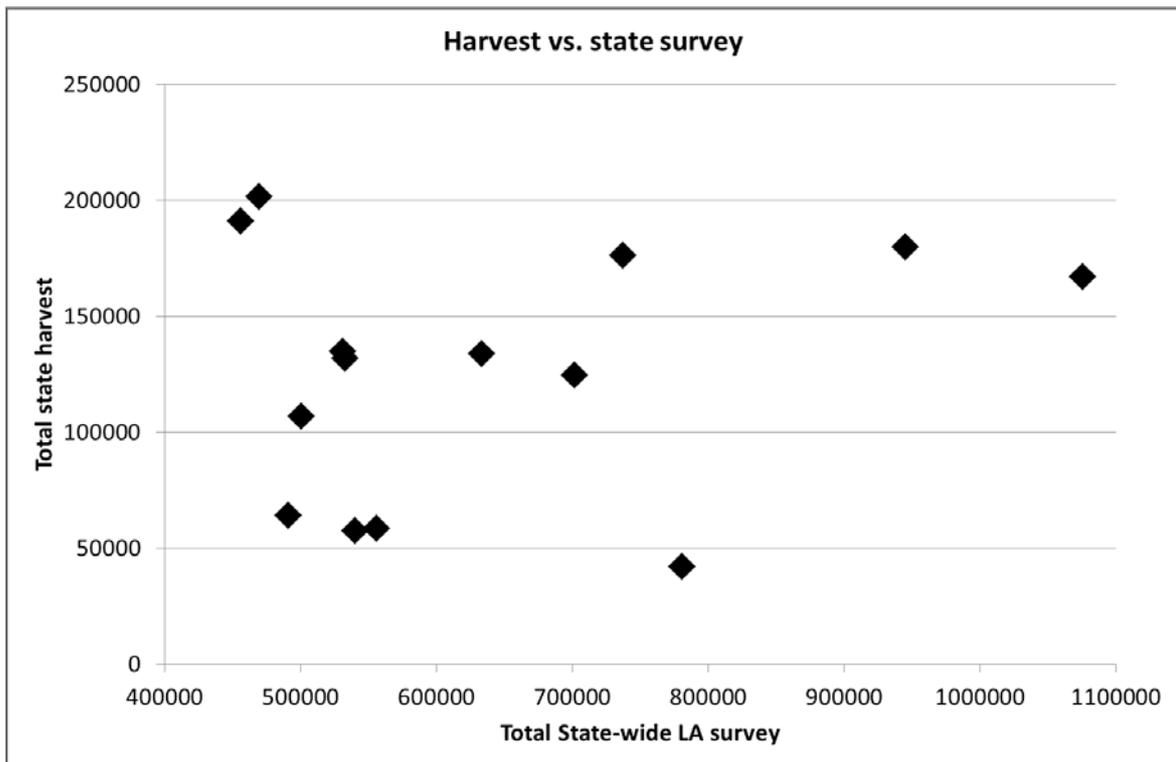
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Snowgoose (Alpheraky 1904)

Appendix 1. Examination of state-wide and southwest zone Snow Goose numbers from the midwinter waterfowl survey for Louisiana from 2001-2014, in relation to winter (top panel), survey numbers in southwest Louisiana (middle panel) and total light goose harvest (bottom panel). There was no year trend in state-wide Snow Goose numbers or survey numbers for southwest Louisiana (top panel), a weak positive correlation between state-wide light goose numbers and light goose numbers for southwest Louisiana ($R^2=0.355$, middle panel) and no relationship between state-wide light goose numbers and state-wide light goose harvest (bottom panel).





Appendix 2. Interrelationships of total light goose harvest, with total days hunted (top panel) and hunter numbers (bottom panel) for Louisiana 2001-2012 (data from Kruse & Fronczak 2014). Total light goose harvest has no relationship to total days hunted or hunter numbers. All three parameters were low in 2009-2012 (these years are labeled).

