ASSESSING SURVIVAL OF POST FLEDGING MALLARDS ON THE EAST COAST OF THE CENTRAL NORTH ISLAND OF NEW ZEALAND.

A joint study between the Auckland/Waikato and Eastern Region Fish and Game Councils.

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Introduction

Using radio telemetry to monitor waterfowl is a common technique internationally but has largely been used on relatively sedentary indigenous waterfowl species in New Zealand (e.g. Whitehead et al. 2010). Waterfowl managers rely upon estimates of survival to aid in assessing waterfowl population status and guide management decisions (Johnson et al., 1987). Little is known about the movements, non-harvest mortality and habitat use of grey and mallard duck species in the study area and quantitative data on these parameters is required to make effective management decisions in regards to habitat creation/restoration and the timing and duration of the dabbling duck hunting season.

When using telemetry, two main objectives must be realised 1) the transmitter must be attached securely for the intended length of the study and 2) the transmitter attachment must not affect the animal in ways which would bias the study. A popular method of attachment for adult dabbling ducks involves a double loop harness for mounting backpack type models. These have provided satisfactory retention times, however, some studies have reported affects to behaviour, condition and reproductive success (Pietz et.al 1993, Devries et al. (1997). Tail mount transmitters attached with glue or a combination of glue and sutures do not appear to adversely affect mallards in the same manner, but retention time has often been a problem (Rotella et al., 1993). Conversely, Giroux et al. (1990), reported excellent results with a modified glue and cable-tie tail mount attachment method, tracking for up to 135 days with no discernable effect on the movement and activity of marked and control specimens. This research concluded that using tail mount transmitters could overcome some of the problems associated with harnesses.

Banding models provide us with good estimates of survival for the different cohorts, but it is difficult to differentiate causal factors and evaluate non-harvest and harvest mortality. Currently it is assumed that non-harvest mortality, between post-fledging (January) and the start of the hunting season (May) is low and does not have a large impact on structuring the population. Anecdotally, factors such as botulism outbreaks during this time have led to large, localised non-harvest mortality events and this needs to be explored. Identifying cause specific mortality parameters during hunting and non-hunting periods is crucial to gaining a better understanding of total survival estimates.

Internationally, a number of studies have shown a lower survival during hunting periods compared to non-hunting periods, with survival rates being particularly low at the onset of the hunting season (Fleskes et al., 2007). Other studies, however have found that mortality from hunting to be lower, or similar, to other causes of mortality (Bielefeld and Cox Jr, 2006) and in some instances (e.g. (Davis, 2007) lower survival rates have been recorded during non-hunting periods.

Survival can further be influenced by environmental factors (McDougall, 2012) and body condition (Pollock et al., 1989b, Bergan and Smith, 1993) which can affect both harvest and non-harvest mortality. High survival has been recorded during favourable climatic conditions including high temperatures and improved habitat conditions (Fleskes et al., 2007) and lower survival during repetitive exposure to extreme cold (Bergan and Smith, 1993).
The relationship between body condition and survival has been less conclusive. It is thought that individuals with lower body condition are more likely to be unpaired and more susceptible to being decoyed and harvested (Hepp et al., 1986). They are also at greater risk to contract disease and less able to exhibit predator and hunter avoidance measures since more time must be spent foraging (Fleskes et al., 2002). Dufour et al. (1993) concluded that increases in survival through both lower natural mortality and hunting susceptibility could be attributed to individuals with higher body condition while other studies have found no correlation between these parameters (Lee et al., 2007).

Distribution and movements of waterfowl are often influenced by a combination of sanctuary and hunted lands. Understanding this relationship is instrumental to managing habitats, especially in areas where hunting pressures are high(Link, 2007). Since circa 87% of banded birds get harvested within 50km of their banding site (McDougall, 2012) it is assumed that they exhibit a high degree of site fidelity and low survival could therefore negatively impact regional populations (Link, 2007, Klee, 2010). Using telemetry to estimate survival rates of Juvenile (hatch year) and adult (after hatch year) birds as measured at the time of banding in will help Fish and Game to better understand the dynamics governing mallard and grey duck population changes and allow managers to make more informed and accurate decisions.
Adult mallards on average have a higher survival rate than juveniles in the study area (McDougall, 2010). Juvenile birds also have a consistently higher direct recovery rate than adults indicating a greater susceptibility to be harvested (Nichols et al., 1990, Caithness et al., 1991). Adult mallards wintering in Arkansas had a higher survival rate than juveniles

(Reinecke et al., 1987), whereas no significant differences were observed between cohorts in Texas (Bergan and Smith, 1993)and Louisiana (Link, 2007).

It is hypothesised that (1) Non-harvest mortality post fledging will be low (2) individuals in poor condition at the time of banding will have a higher mortality rates (3) Survival during non harvest periods will be higher than during harvest periods and that this will differ between Juveniles and Adults (4) Freshwater wetlands will receive the highest proportional use (5) Habitat utilisation will change between hunting and non hunting periods.

Objectives

PRIMARY OBJECTIVE

-The primary objective of the study is to determine non-harvest mortality of mallard duck post-fledging through to the start of the hunting season.

SECONDARY OBJECTIVES

-Evaluate the effectiveness of using radio telemetry for monitoring waterfowl in the central North Island of New Zealand by utilising differing transmitters and methods of attachment.

-Assess possible mortality factors such as disease, predation and hunting.

- Use transmitter returns to confirm estimates of reporting rate evaluated from annual harvest survey results.

-Movement patterns and distribution prior to and during the hunting season may help reveal the relative importance of different habitat types at these times.

-If transmitter battery life permits and birds stay in the study area there will also be an attempt to monitor the birds post-hunting and during the start of the breeding season to measure factors such as nest success and brood survival.

Methods

Mallard and grey duck were captured with maize baited walk-in funnel cage traps (McDougall, 2012). Birds were aged and sexed using cloacal features (Ward and Middleton, 1971, Baldassarre and Bolen, 2006).

Individually numbered stainless steel leg bands were attached and VHF transmitters fixed either as a harness backpack or tail mount to 16 juvenile female, 10 juvenile male, 8 adult female, and 12 adult male mallard randomly selected from the trap sample. Transmitter attachment and release occurred on 4 days between January 14 and February 3, 2011.

Transmitters were of two types: 16 gm Sirtrack two-stage transmitters (10 month life) and 6 gram Sirtrack single-stage tail mount transmitters (5 month life). The 16 gram two-stage transmitter was attached as a harnesses around the body (Appendix 2; Figure 3,Figure 4,Figure 5) with the aerial down the back (Figure 2), while the 6 gm single-stage transmitter was attached using glue and cable ties (Appendix 2; Figure 6, Figure 7) based on protocols outlined in Giroux et al. (1990), or as a harness similar to the technique used for the 16gm transmitter. We altered the attachment method of the single-stage transmitter from tail to harness after observing that once the aerial was submerged reception greatly reduced. The better performing two-stage transmitters were attached to juvenile females as their survival over the study period was of predominant interest. The two-stage transmitters have a mortality switch that allows time since death to be calculated.

A three element handheld Yagi receiving antenna and automatic scanning receiver (Samuel and Fuller, 1996) were used from a vehicle or by foot. Two aerial surveys were conducted prior to and post the dabbling duck hunting season. Parallel flight transects were established at conservative 500m intervals (Gilmer et al., 1981) at an average height of 300m (Range 250 -1500m) such that all radio marked birds present in the extended study area could be located.

Study Area

The core study site is on the east coast of the North Island of New Zealand 26 km south east of Tauranga . This area was chosen for its habitat diversity, proximity to both the Auckland/Waikato and Eastern regions, and accessibility to potential sites where dabbling ducks are likely to congregate.

The area encapsulates the estuarine environments around Maketu, a large farm drainage area to the west and the Kaituna Wildlife Management Reserve (Figure 1. Study area in which radio marked female grey and mallard ducks will be monitored. The primary study area is denoted by solid line and red fill and the extended aerial search area by dashed lines and yellow fill (Figure 1). The capture site was located at the Waewaetutuki wetland, which adjoins the little Waihi Estuary. Trapping was conducted in conjunction with the current banding programme run in the Eastern Region. The extended aerial search encompassed areas inland 7km to Te Puke to the outskirts of Tauranga to the North and Pukehina to the South.

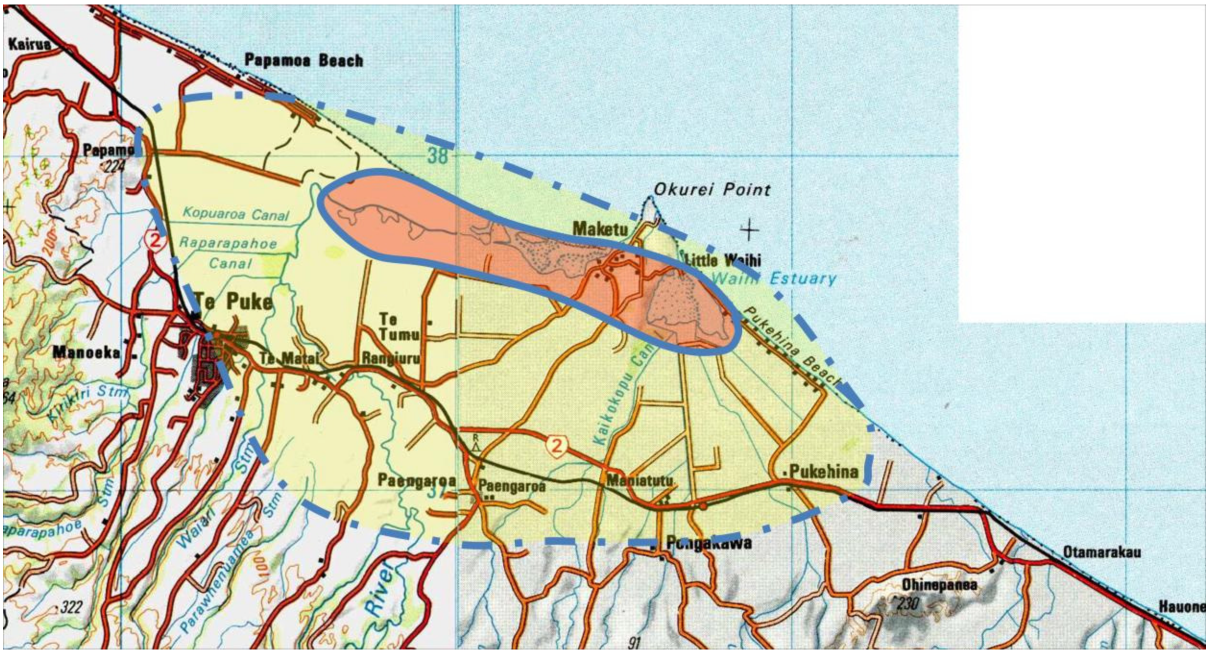

Figure 1. Study area in which radio marked female grey and mallard ducks will be monitored. The primary study area is denoted by solid line and red fill and the extended aerial search area by dashed lines and yellow fill

Statistical Analysis

Survival over the study period was evaluated using Known Fate procedure (Cooch and White, 2009) based on Kaplan-Meier methodology (Kaplan and Meier, 1958) and stagger entry design (Pollock et al., 1989a) in Program MARK (White and Burham, 1999). Model covariates were age, weight, and transmitter type (single-stage tail mount, single-stage backpack and, two-stage backpack). Survival periods were monthly intervals January 2011-October 2011.

Burnham Live Dead format based on combined ring recovery and recapture data (Burnham, 1993) was used in Program MARK (White and Burham, 1999) to compare survival rates of banded mallard without transmitters with estimates of survival for those with. Average survival rates were calculated using random effects models (Burnham, 2001, Burnham and White, 2002).

The probabilities of encountering a bird with either a two-stage back pack, single-stage backpack or, a single-stage tail mount were compared (Kruskal-Wallis test (Zar, 1996) in Program R (R Development Core Team, 2005).

Figure 2. Mallard hen showing transmitter aerial.

Results

Mortality

Prior to the opening of the duck shooting season (7 May 2011) only one bird, a juvenile female, was determined to have died. The bones were found underwater in a drain next to a dairy shed 3km from the banding site. The mortality switch indicated that it died 31 days after attachment (outside of the 48 hour adjustment period suggested by Williams et al. (2002) or 1 week suggested by Pollock et al. (1989a).

Of the four other transmitters birds that were recovered during the hunting season 1 tail mounted transmitter was not detected (the band only was reported, the hunter had not noticed a transmitter). Tracking in the vicinity of the pond where this bird was shot did not reveal a signal. One other bird was found dead on the road 61 km (outside the study area) from the release site on the 19th of October 2011. This bird had previously been recorded in the immediate study area on all occasions up until 3 May 2011.

Censored

12 of the transmitter birds were recaptured in the cage traps at 19 and 20 days after initial attachment. During these recapture occasions it was established that one sirtrack two-stage backpack transmitter had failed sometime prior to the 19th day of the study. The transmitter was removed and the bird released.

10 birds were censored (not seen again) from the beginning of the study (Table 1).Recovered transmitters (from birds that had been shot and the transmitter returned to Fish & Game) were either not working or very faint by 11th of November 2011.

One tail mounted functioning single-stage transmitter was recovered (shot 7 May 2011) from the original release site but had not been detected up until this time.

Table 1. Tracking array presenting the number of birds alive at the beginning of each month, how many die, the number censored (not seen again), and the number alive at the end of the month.

	Survived to occasion									
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Number Alive at Start	34	36	24	21	18	14	12	8	7	7
Number Dying	0	1	0	0	4	1	0	0	0	1
Number Alive at end	24	24	21	18	14	12	8	7	7	3
Number Censored	10	11	3	3	0	1	4	1	0	3

Survival Estimation

The *Time* dependant model received the greatest support (AICc=49.81; *wi*=0.47; Table 2) with some support for the *Age + Time* (AICc=51.802; *wi*=0.173) and *Weight + Time* (AICc=51.93; *wi*=0.163) models. In both of these later models however, the confidence intervals for the Beta estimates of the covariates (Age & Weight) span zero.

For the full study period survival was estimated at 0.24 (SE=0.14; Table 3). Survival for all cohorts prior to the beginning of the hunting season was estimated at 0.95 (SE=0.07).

Table 2. Model Ranking on their AICc value. Individual covariates include weight of the bird at release, age (adult of juvenile), and transmitter type.

Model	AICc	Δ AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
{S(t)}	49.8121	0	0.46792	1	10	27.544
{S(Age+t)}	51.8023	1.9902	0.17298	0.3697	11	27.0523
{S(Weight+t)}	51.9258	2.1137	0.16263	0.3476	11	27.1757
{S(.)}	53.881	4.0689	0.06118	0.1307	1	51.8433
{S(Weight+Age+t)}	54.2191	4.407	0.05167	0.1104	12	26.9349
{S(Weight)}	55.5075	5.6954	0.02713	0.058	2	51.3932
{S(Age)}	55.7192	5.9071	0.0244	0.0521	2	51.6049
{S(TranType)}	55.8746	6.0625	0.02258	0.0483	2	51.7603
{S(Weight+Age)}	57.6044	7.7923	0.00951	0.0203	3	51.3736

Average annual survival for banded mallard & grey duck in the A1 area over the last 16 years is 0.56 (SE=0.056). This is not significantly higher than 0.24 (SE=0.14) over the 10 month study.

Table 3. Survival Estimate for each monthly period

Month	S	SE	95% Confidence Interval	
			Lower	Upper
Jan	1.0000	0.0000	1.0000	1.0000
Feb	0.9545	0.0444	0.7385	0.9936
Mar	1.0000	0.0000	1.0000	1.0000
Apr	1.0000	0.0000	1.0000	1.0000
May	0.5000	0.1768	0.2001	0.7999
Jun	0.6667	0.2722	0.1535	0.9566
Jul	1.0000	0.0000	1.0000	1.0000
Aug	1.0000	0.0000	1.0000	1.0000
Sep	1.0000	0.0000	1.0000	1.0000
Oct	0.7500	0.2165	0.2378	0.9665

Reporting Rate

From 2009 to 2011 1155 mallard and grey duck have been banded in Waewaetutuki, of these 59 were recovered (shot, retrieved, and reported), in the year of banding (5.1%). Assuming a reporting rate of 0.62 (0.572 - 0.674; 95% CI) (McDougall, 2012) then harvest rate (shot and retrieved) in the year of banding equates to 8.2%. Five of the 46 transmitter birds were recovered (10.9%) during the hunting season. It is presumed that reporting rate of the transmitter birds is 1 (following an extensive advertising campaign and telemetry results at known hunting sites). Harvest rate of the transmitter birds given a reporting rate of 1 is 10.9%. For the harvest rate of the band only birds to equate to 10.9% reporting rate is 0.47 (assuming the transmitter birds are as likely to be shot and recovered as the banded birds). 0.47 is well below the average annual phone survey estimate of 0.62. This warrants further study.

Transmitter Efficacy

Transmitter type was not randomly allocated between cohorts therefore it was not possible to ascertained if encounter rate was a function of transmitter type and mounting method or was a function of different cohorts having different site fidelity.

Nevertheless on average the backpack two stage transmitters were encountered more frequently on a monthly basis than the single stage (Kruskal-Wallis $\chi^2 = 10.3784_{(2)}$, , $P = 0.0056$).

Table 4. Average monthly encounters as a function of transmitter type and mounting style.

Backpack; Mean(±SD)	Tail Mount	Tail mount -as backpack
3.5 (2.068)	1.375 (1.26)	0.75 (0.75)

Observation suggested that the single-stage tail mounts performed poorly when the bids were sitting on the water (the aerial was under the water), and that the single stage transmitters had a very poor range sometimes as little as 200m.

Post Season Monitoring

Only three of the ten of juvenile hens fitted with long life backpack transmitters were detected in the study area post the hunting season. These birds exhibited very little movement <500m from their locations at the start of June and through to the end of the study in October. All of the observed locations were non-hunted wetlands. Two of these individuals were found to be nesting during the September and October monitoring periods.

Discussion

Back pack two-stage transmitters had a greater encounter probability than Tail mount transmitters irrespective of attachment method. It was unclear if this was due to transmitter type as two-stage models were attached only to the juvenile female cohort. Tail mount transmitters are lost with the rectrice moult and can only be used on birds with strong rectrices (Giroux et al., 1990). It was often difficult to find appropriate post-moult specimens fitting these criteria at the time of attachment in mid January and assigning transmitters to specimens in a truly random fashion is therefore compromised. One harvested bird recovered outside the extended study area on 7 May 2011 had only the leg band reported. Further phone interviews confirmed that it was unlikely that the transmitter was still attached upon retrieval. Aerial tracking in the vicinity of the pond where the bird was shot did not reveal a signal. In this instance it is possible that detachment occurred prior to harvest or that the transmitter was damaged and lost during the act of harvesting and retrieving the bird.

Retention time was better than in a number of other studies. For example, Rotella et al. (1993) reported that 31 of 49 transmitters fell off adult Mallards within 2 months using a glue and suture method. We did not find any detached transmitters in the core study area during the course of our study and movement parameters of birds with tail mount transmitters indicated that many of these stayed attached for 5 months or more.

Detection range of the 6 g tail mount transmitters was poorer than expected when conducting ground monitoring and less than the 1km suggested by the manufacturer and found in similar studies (Giroux et al., 1990). When monitoring from ground level in areas of thick vegetation a range of only circa 200m was common, however aerial tests using fixed transmitter locations had a detection range of up to 1.5km. Tail mounted transmitters had a lower range than when the same transmitters were mounted via harness, however, overall detection of the single-stage transmitter using a harness mounting method was the lowest of the three methods trialled during the study itself. Our experiment indicates that tail mount transmitters are not appropriate from monitoring post fledging mallards in N.Z. unless signal strength and detection range are significantly increased.

Backpack transmitters using harness attachments have been implicated in low survival rates for female mallards (Jeske, 1991). We believe this was not a major influence as survival leading up to hunting season was close to 1. We have also had five transmitter returns from hunters in the 2012 game bird season. None of these birds exhibited any negative signs (lesions, rubbing, feather loss) and were considered to be in good condition by the hunters who harvested them. Breeding behaviour and success are particularly susceptible to negative effects associated with transmitter attachment. Radio marked mallard hens have been found to feed less, rest and preen more, initiate nests later and lay smaller clutches (Pietz et al., 1993). The three hens with long life transmitters that remained in the core study area for its duration all formed pair bonds and two laid clutches. We could not determine clutch size and brood survival as part of this study, however, the effects of transmitter attachment should be considered for any future projects focused on mallard reproductive ecology.

This study suggests there is no basis to move the opening of the mallard season to earlier in the year to increase the number of birds available to hunters. Non-harvest mortality between the time of banding and the onset of the hunting season was low, with a 95% survival rate over this period. The one confirmed mortality event was determined during an aerial survey and necropsy results were inconclusive due to the amount of time between death and recovery. The transmitter and remnant bones were discovered directly adjacent to a farm effluent pond but interviews with the manager revealed nothing out of the ordinary. He had not noticed any signs of sick or dying birds during summer months which would indicate a botulism outbreak on the pond.

Hunting (71%) was the primary cause of radio marked mallard mortality and the time dependant model received the highest level of support. We found no evidence of crippling loss in the core study area and all returned transmitters still functioned despite some receiving pellet damage. Hunting mortality is the primary cause of mortality for overwintering mallards in Colorado (67%) (Dooley et al., 2010) and California (91%) (Fleskes et al., 2007) . Estimates of survival during the hunting season were susceptible to both positive and negative bias. Some marked birds may have been killed or crippled by hunters either damaging the radio tracker or being retrieved and not reported. Conversely, radio transmitters may have predisposed some birds to hunting mortality (Reinecke et al., 1992). Survival rates were derived from increasingly smaller sample sizes towards the end of our study due to mortality and censorship, thus mortality events towards the end of our tracking season had a larger impact on survival estimates than mortalities near the beginning of our tracking period. Survival of radio marked mallards (24%) is lower than the average (56%) in the Eastern region over the past 16 years as estimated from banding, however, this difference is not statistically significant. Failure to establish a difference is probably a function of the large variance associated with the small sample size of the transmitter birds. Heavy hunting pressure may have caused the departure of many transmitter birds outside of the core study area, leading to a high level of censorship. If these birds remained outside the core study area subsequently, it is unlikely that we would have located them using ground based tracking techniques, however, dead recoveries outside of this area were included in our survival analysis. Survival was lower during the first month of the hunting season and this is likely related to mallard naivety and increased hunter participation, particularly on opening weekend. Other studies have similarly found lower survival at the beginning of hunting periods (Longcore et al., 2000, Davis, 2007).

If natural mortality of post-fledging mallards was significant between the time of banding and the start of the hunting season, management interventions such as predator control targeting this life stage or shifting the hunting season forward to maximise harvest opportunities could be considered. It appears that attempts to reduce natural mortality of fledged mallards are unlikely to succeed. Hoekman et al. (2002) concluded that 43% of population change could be attributed to nest success, 19% for survival of adult females during the breeding season and 14% for duckling survival compared with only 9% for adult female survival outside the breeding season. Management strategies that increase nest success, increased brood survival, or decrease hunting mortality are more likely to produce meaningful gains in recruitment and are worthy subjects for continuing study.

The few juvenile hens that were not harvested and remained in the study area exhibited a high degree of site fidelity between the start of June and the end of the study. This indicates that important biological phases related to reproduction such as prospecting nest sites and pair bond formation, are occurring during the end of the hunting season. Moreover, hens appeared to seek out non-hunted refuge sites during June and remained in close proximity to nest. Mate loss during the breeding season can lead to a reduction in reproductive performance (Lercel et al., 1999) and disturbance can lead to decreased nesting in areas that would otherwise be suitable (Korschgen and Dalgren, 1992). The effects of extended hunting season lengths and relative importance of refuge sites on the reproductive ecology of mallards in New Zealand warrants further study and should be incorporated into the new design for a nationwide telemetry project.

The *Age + Time* and *Weight + Time* models received limited support, however the confidence intervals for the Beta estimates for the respective covariates (age and weight) span zero. Body condition has been linked to survival in a number of oversees studies. Mallards in lower body condition are relatively more vulnerable to both hunting (Hepp et al., 1986) and non-hunting mortality than those in higher condition (Link, 2007). Dooley et al. (2010) found that body condition received the second highest level of support behind harvest and was particularly important in years where weather was severe. Because many of the adult females were in the moult at the time of first capture we used weight instead of body condition indices.

Annual survival of juvenile mallards is consistently lower than that of adult mallards in the Eastern Fish and Game Region (McDougall, 2010, McDougall, 2012) and other mallard studies in New Zealand (Nichols et al., 1990, Caithness et al., 1991). Direct recovery rates of banded juveniles are also consistently higher (Nichols et al., 1990, Caithness et al., 1991), indicating a greater susceptibility of this cohort to be harvested (Klee, 2010). Age specific models did not receive a high level of support for radio tagged birds, but this may be due to the relatively small number of hunter returns. We expect that with a larger sample size, juvenile mallards would exhibit a higher harvest mortality rate than adults, especially at the onset of the hunting season.

Estimates of annual kill and harvest rates are confounded by reporting and retrieval rate estimates. Assuming that the reporting rate of a bird shot and retrieved with a transmitter is 1 (given the novelty of the occurrence, extensive advertising, and telemetry monitoring over the hunting season) then harvest rates are either, (1) higher for the transmitter birds than the band only birds or; (2) reporting rate, estimates from the phone survey of 0.62 (average annual) are higher than the Waewaetutuki band birds (0.47).

Management Implications

Moving the hunting season forward as a management action to try and increase hunter opportunity (more birds in the air) is unlikely to increase harvest.

Survival of radio marked mallards was low and hunting was the primary source of mortality. Given the high degree of site fidelity this species exhibits in New Zealand, low survival rates could be of concern with regard to managing localised populations, especially in areas receiving high hunting pressure.

Pre-season survival rates were high and attempting to reduce non-harvest mortality post-fledging, between the time of banding and the beginning of the hunting season is not likely to be an effective tool to increase overall survival in the study area.

Management strategies that increase nest success and brood survival, or decrease hunting mortality are more likely to produce meaningful gains in recruitment.

The telemetry study throws some doubt on telephone survey band reporting rate estimates, indicating that they may too high. A reliable estimate of reporting rate is imperative to determining kill and harvest rates. Phone survey estimates of reporting rate should be accredited with either additional telemetry work or reward bands.

6 gram tail mount transmitters were ineffective due to poor detection range and should not be used for this type of study, especially where heavy vegetative cover predominates and a ground based technique is the primary form of monitoring.

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Appendix 1

Table 5. Release details Age sex and morphological characteristics

ID	Prefix	Band No	Species No	Age	Sex	Locality released	Date Released	Date Attached	Trans type	Attach Site	Initial capture Weight	Tarsus Length	Total Head Length
1	27	106858	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Backpack	Waewaetutuki	0.96	54	110
2	27	106874	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Backpack	Waewaetutuki	1.08	58	104
3	27	108302	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Backpack	Waewaetutuki	1.09	56	113
4	27	108334	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Backpack	Waewaetutuki	1.04	57	112
5	27	106862	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Backpack	Waewaetutuki	0.92	52	101
6	27	108370	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Backpack	Waewaetutuki	1.03	56	105
7	27	108388	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Backpack	Waewaetutuki	0.92	59	112
8	27	108410	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Backpack	Waewaetutuki	0.91	55	108
9	27	108464	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Backpack	Waewaetutuki	0.95	50	101
10	27	106873	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Backpack	Waewaetutuki	0.94	55	112
11	27	106852	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.17	40	110
12	27	106883	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.28	41	111
13	27	108285	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.39	54	106
14	27	108281	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.11	57	114
15	27	108305	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.21	51	104
16	27	108331	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.1	51	107
17	27	108353	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.3	57	112

ID	Prefix	Band No	Species No	Age	Sex	Locality released	Date Released	Date Attached	Trans type	Attach Site	Initial capture Weight	Tarsus Length	Total Head Length
18	27	108423	251	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.03	52	106
19	27	108430	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.18	53	110
20	27	108434	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.22	51	105
21	27	106861	252	J	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.26	56	107
22	27	108405	252	J	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.29	55	110
23	27	108287	252	J	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	0.93	51	105
24	27	106853	252	A	F	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.01	51	102
25	27	108300	252	J	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.16	53	111
26	27	108326	252	J	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.24	55	114
27	27	106864	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.03	53	107
28	27	106888	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	0.94	56	109
29	27	108324	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	0.96	57	106
30	27	106889	252	A	F	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.01	58	111
31	27	106876	252	A	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.17	62	115
32	27	106855	252	J	M	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	1.11	56	115
33	27	106886	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	0.89	57	104
34	27	108306	252	J	F	Waewaetutuki	14-Jan-11	14/01/2011	Tail Mount	Waewaetutuki	0.92	55	107
35	27	108759	252	J	M	Waewaetutuki	02-Feb-11	2/02/2011	Tail Mount	Waewaetutuki	1.04	58	114
36	27	108987	252	A	F	Waewaetutuki	03-Feb-11	3/02/2011	Tail mount -as backpack	Waewaetutuki	1.2	57	108

ID	Prefix	Band No	Species No	Age	Sex	Locality released	Date Released	Date Attached	Trans type	Attach Site	Weight capture Initial	Length Tarsus	Total Head Length
37	27	108374	252	J	M	Waewaetutuki	14-Jan-11	2/02/2011	Tail Mount	Waewaetutuki	1.23	58	113
38	27	81007	252	J	F	Kaituna Wildlife Management Reserve	02-Feb-05	2/02/2011	Tail Mount	Waewaetutuki	1.22	54	104
39	27	108789	252	A	F	Waewaetutuki	02-Feb-11	2/02/2011	Tail Mount	Waewaetutuki	1.25	58	107
40	27	107529	252	J	M	Waewaetutuki	03-Feb-11	3/02/2011	Tail mount -as backpack	Waewaetutuki	1.17	59	109
41	27	107541	252	A	F	Waewaetutuki	03-Feb-11	3/02/2011	Tail mount -as backpack	Waewaetutuki	1.3	57	109
42	27	108790	252	A	F	Waewaetutuki	02-Feb-11	2/02/2011	Tail Mount	Waewaetutuki	1.18	57	108
43	27	108414	252	A	F	Waewaetutuki	14-Jan-11	2/02/2011	Tail Mount	Waewaetutuki	1.35	58	107
44	27	108364	252	A	F	Waewaetutuki	14-Jan-11	2/02/2011	Tail Mount	Waewaetutuki	1.18	54	103
45	27	105633	252	J	F	Waewaetutuki	30-Jan-09	2/02/2011	Tail Mount	Waewaetutuki	1.2	52	103
46	27	107514	252	J	M	Waewaetutuki	03-Feb-11	3/02/2011	Tail mount -as backpack	Waewaetutuki	1.14	54	111

Appendix 2

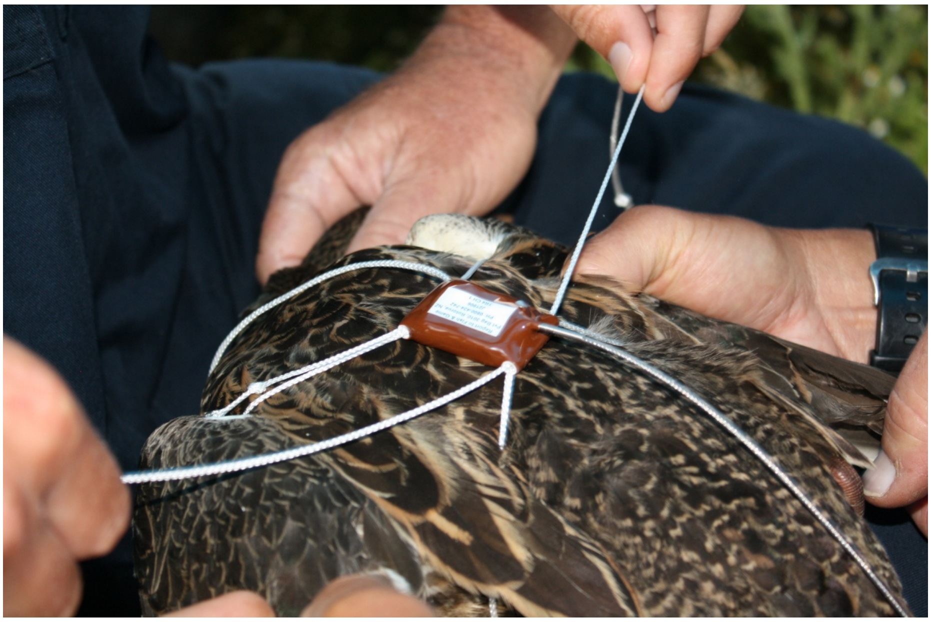

Figure 3. The backpack transmitters were attached such that two straps (nylon cord) made a separate loop around each wing and joined (reef knot) over the breast bone sheathed in electrical heat shrink tubing.

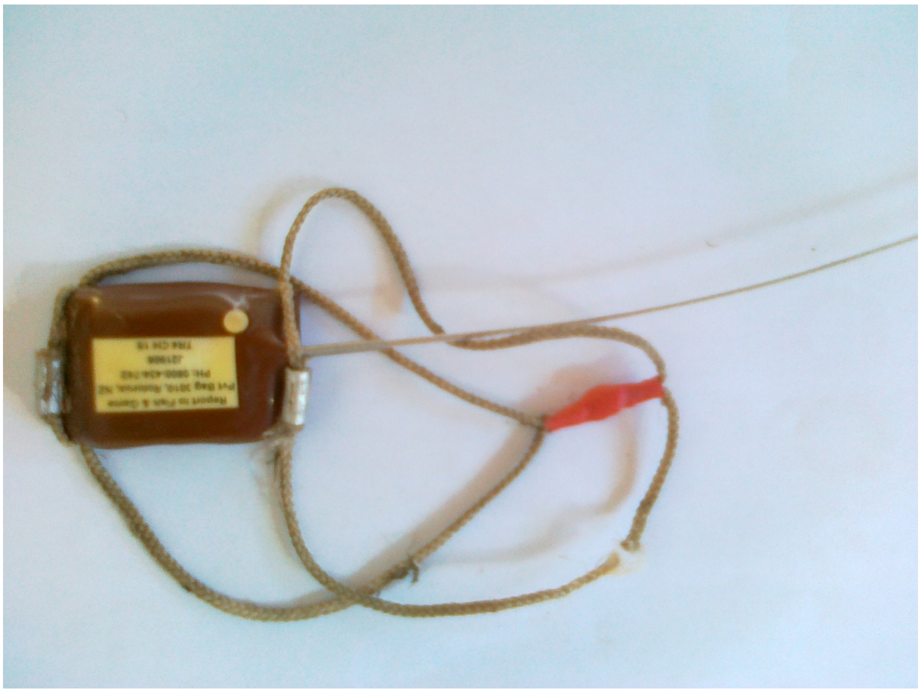

Figure 4. Backpack harness showing breastbone reef knot sheathed in red electrical heat shrink tubing

Figure 5. The nylon cord was crimped at both ends of the transmitter to complete the loop.

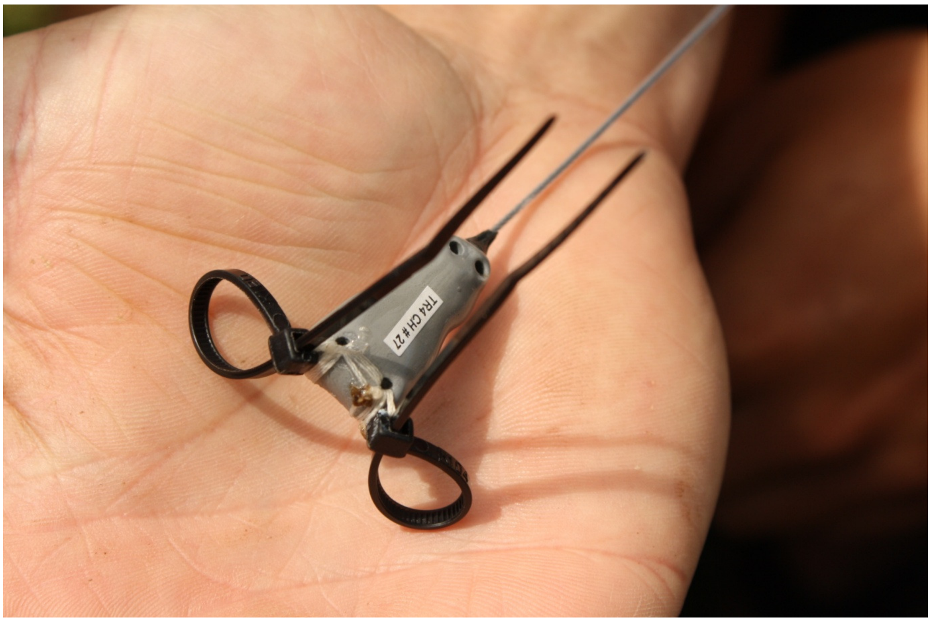

Figure 6. Tail mount transmitter ready for deployment using modified glue and cable tie method.

Figure 7. Transmitter is glued to the tail feathers.