NOTTINGHAM TRENT UNIVERSITY

BROWN RAT (*RATTUS NORVEGICUS*) PRESENCE/ABSENCE SURVEYS ON ALDERNEY, CHANNEL ISLANDS AND SURROUNDING ISLETS: IMPLICATIONS FOR SEABIRD CONSERVATION.

By

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Abstract

Invasive Alien species (IAS) have been outlined to be one of the major drivers of biodiversity and ecosystem services changes behind habitat destruction and habitat change. Invasive Brown rats (*Rattus norvegicus*) are widely documented as one of the most successful invaders across the globe, colonising over 80% of the world's islands. Whilst only making up 3.5% of all bird species, research show that species such as colonial ground nesting seabirds are under the most threat from invasive species such as rats due to their lack of evolution in defence. In this study presence/absence surveys were carried out during the July 2014 in order to establish if invasive rats were present from vulnerable seabird colonies and if those levels were correlated to nest productivity. Results showed that invasive rats were detected at 42.8% of study sites with a significant difference being found between the sites (X^2 = 21.385, DF = 2, P < 0.001). However further analysis showed that there was a positive relationship between the total number of rats detected and nest productivity (rs = 0.535, n=7, P= 0.216). The low detection of rats throughout the study could be linked to successful past eradication attempts or the time at which they survey was carried out. Additionally the study saw a high detection rate of mice (*Mus musculus*) across all of the study sites which should also be further investigated to identify potential risk to ground nesting seabirds. Overall, continued surveys are needed around the known breeding colonies to see if the invasive rat and other small mammals, such as mice, will have a negative effect on the reproductive and nest success rates over the years.

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Chapter 1: Introduction, Literature Review and Aims

1.1. Introduction

Invasive Alien Species (henceforth referred to as IAS) have been outlined to be one of the main drivers of biodiversity and ecosystem services changes, along with habitat change, climate change, pollution and overexploitation (Millennium Ecosystem Assessment, 2005). Today, aided by the increase of trade and travel, the spread of IAS has been classed as an inevitable effect of globalisation. Environmental degradation, pollution, habitat loss and human-induced disturbance has led to the development of favourable conditions for IAS to thrive and consequentially IAS now pose a threat to conservation at a global, regional and local scale (Kettunen, 2009). The identification, prediction and development of management strategies for IAS has now become a large part of modern conservation science and efforts (Atkinson, 1996). IAS are also the focus of cooperative international efforts such as the Global Invasive Species Programme (GISP) (Lowe et al., 2000).

Rats (*Rattus* spp.) have now been estimated to be present on around 80% of the world's islands (Atkinson, 1985; Towns *et al*., 2006) and are listed in the top 100 world's worst invaders list produced by the Invasive Species Specialist Group (ISSG) (Lowe *et al*., 2000). Being omnivorous and opportunistic feeders, rats have been known to adapt their diet depending on the availability and abundance of prey species such as reptiles, birds, bird's eggs and intertidal species (Stapp, 2002; Caut *et al*., 2008; Jones *et al*., 2008).

In total, 236 bird species have been identified to be threatened by invasive rats (BirdLife International, 2013) and 67% of threatened birds on islands are under threat from IAS (Kettunen, 2009). Studies show that Seabirds, especially colonial ground nesting species such as the Atlantic Puffin (*Fratercula arctica*) and European Storm Petrel (*Hydrobates pelagicus*), have evolved characteristics that enable them to spend a large proportion of their life cycle at sea, resulting in them only coming to land to breed (Taylor *et al*., 2000). Unfortunately adaptations to this lifestyle, such as small legs and choosing to nest in burrows, have left them vulnerable to predation by invasive rats due to ineffective defence mechanisms (Le Corre, 2008).

Despite Seabirds only making up just 3.5% of all bird species, as a group they can be found in all the seas and oceans worldwide (Croxall *et al*., 2012). Studies as early as the early 1980's have broadly acknowledged the potential role seabirds have as indicators and monitors for the marine environment; particularly due to their sensitivity to changes in food supply, providing an insight to the health of fish stocks (Furness & Greenwood, 1993; Furness & Camphuysen, 1997; Parsons *et al*., 2008; Einoder, 2009). However, at both global and regional levels, the most important challenge is to ensure the existence and status of various seabird species that are already threatened (Croxall *et al*., 2012).

Recently, increased interest has been shown in combining current monitoring methods with both population trends and relevant behaviours (such as foraging rates) (Diamond & Devlin, 2003). These can reflect the demographic changes and highlight the health of the marine ecosystem (Diamond & Devlin, 2003). Information gathered about feeding habits, breeding success and threats can help develop policy framework in the UK and regional scales; such as Ramsar sites (Diamond & Devlin, 2003; Parsons *et al*., 2008).

When implementing and managing important marine areas a key step in their success is to obtain regular data on any key findings and fluctuations in the ecosystem (Piatt *et al*., 2007). As seabirds tend to be highly visible and easily enumerated, using their population trend and response to threats, such as invasive species, can help the ongoing management of protected areas such as Wetlands of International Importance (Ramsar sites). These sites ''*provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources*.'' (Ramsar, 2014).

The Ramsar site off the west coast of Alderney and encompassing the Burhou Islands was designated in August 2005 as it was highlighted to be an area home to multiple species of conservation concern, such as the Northern Gannet (*Morus bassanus*), Atlantic Puffin and the European Storm Petrel among others. To achieve the overall aims of the Ramsar Convention a work programme has been established to ensure all Ramsar obligations are fulfilled (Booker *et al*., 2007). The programme sets strategic goals including, 1) ''Maintaining and enhancing species populations and marine habitats of the Alderney West coast and Burhou Islands Ramsar site''; 2) ''Achieving the sustainable use of the Ramsar site and surrounding waters to protect the site for current and future generations'' and 3) ''Developing Environmental Legislation in the form of an Alderney Wildlife Act which will allow for the creation of marine and terrestrial protected areas'' (Booker *et al*., 2007).

1.2. Literature Review

1.2.1. *Invasive Alien Species*

Invasive Alien Species (hereafter referred to as IAS) have been defined as plants or animals that have been introduced to an area purposely or accidentally where they are not normally found (Kettunen *et al*., 2008). IAS can now be found in most major taxonomic groups, and known to have consequences upon the terrestrial, marine and freshwater environments. It has been estimated that around 480,000 IAS have been introduced globally (Pimentel *et al*., 2001).

IAS have been noted as one of the main threats to biodiversity at a global scale after habitat loss and destruction (Lowe *et al*., 2000). Being easier to travel between locations, the increase in human population has aided the rapid dispersal of invasive species across the planet, many beyond their natural biogeographic barriers. A review of the impact of IAS have found that invasions of non-native species cause an approx. of $1.4 trillion in damage per year, which represents nearly 5% of the world's GDP

(Pimentel *et al*., 2005). As a result it is not surprising that IAS have been identified as a major factor in the extinction of many native species, with 134 species extinctions since 1500 A.D. (Brooks, 2000). Nevertheless not all introduced species become a problem and Williamson (1993) came up with a statistical rule stating that from every 10 introductions only one of them goes on to become established in the environment, and then only one is every 10 established species become a problem/pest.

1.2.2. *Typical Characteristics of IAS*

Williamson & Fritter, 1996 investigated the characteristics between native and established flora species to investigate the 10-10 rule that was previously stated a few years previous. Results found that where significant differences in several of the factors that influenced results. Table 1.1 below outlines typical characteristics of a good invasive.

Table 1.1. List of typical Invasive Alien Species (IAS) characteristics. Originally outlined by Williamson (1993).

Factor influencing success	
Soil fertility	Dominance
Leaf Area	Spread (height/width)
Max. height	Age of first flowering

Pysek & Richardson (2007) later discussed that there is two different types of alien species: the K-strategists which are generally longer lived, taller and have bigger seeds than native species and the r-strategist alien species which are small, yet mature quickly allowing them to have a longer flowering season. This plasticity can allow the more generalist species, such as the Grey squirrel (*Sciurus carolinensis*) to take advantage of any niche, often in association with humans, overpowering the more vulnerable and endemic species, such as the endemic Red squirrel (*Sciurus vulgaris*). However a recent study by Sheehy & Lawson (2014) have shown that despite a generalist diet and habitat requirements, the introduced Grey squirrel has seen a regional population crash, suggesting that native species can have the ability to bounce back in numbers.

1.2.3. *Importance of Seabirds and their threats*

Data released by BirdLife International show that currently 466 bird species (34% of total) are threatened by invasive species (BirdLife International, 2013). Further studies show 67%- 75% of threatened birds on Islands are under threat from at least one invasive alien species, with the issue being more acute on smaller islands (Kettunen *et al*., 2009; Birdlife International, 2013).

Due to their long evolution and their adaptations to life at sea, many seabirds lack the defence mechanisms to protect themselves from predators (BirdLife International, 2013) despite this compared to other marine species seabirds have been well studied (Vie *et* *al*., 2008). Sections 1.2.3.1 – 1.2.3.6 below reviews the impacts that the main introduced predators have upon seabird populations.

1.2.3.1. Hedgehogs

Studies have shown that the European Hedgehog (*Erinaceus europeaus*) has had detrimental effects upon ground nesting birds (Jackson *et al*., 2004). Research carried out by Jackson & Green, 2000 found that the high density of hedgehogs present on South Uist, Scotland was having a negative effect upon the internationally important bird populations present. Conversely, whilst Jackson & Green 2000 determine hedgehog as a factor in the wader's population decline, indirect measure were used such as latrines and feeding remains. Sanders & Maloney (2002) however carried out a five year study using video cameras to quantify the causes of nest mortality in ground nesting birds. Whilst they found that hedgehogs were a main predator on the nests (20% of nests), other predators such as the ferret (*Mustela furo*) and the cat were also found to be responsible, 18% and 43% respectively.

1.2.3.2. Cats

Records show that cats have accompanied humans for thousands of years to serve as pets, act as pest control or as a religious symbol (Serpell, 2000). With the rapid spread across the globe, cats have become a formidable predator, and probably had the most detrimental effect upon seabird populations (Moors & Atkinson, 1984). Cats have also been documented to be a major vector in the spread of diseases such as toxoplasmosis, yet the true impact of toxoplasmosis on native species (especially on islands) has not been classified (Duffy & Capece, 2012).

However, cats have been found to have detrimental effects upon vulnerable biodiversity, especially in island ecosystems. Many studies have confirmed that both domesticated and feral cats have had a detrimental impacts upon island biodiversity and in Hawai'i alone cats have contributed to 45 of the bird extinctions (Duffy & Capece, 2012). Other notable species have been driven to extinction are the Stephen Island Wren (*Xenicus lyalli*) and the Socorro Dove (*Zenaida graysoni*) (Jehl & Parkes, 1983; Fuller, 2000). Overall cats have contributed to at least 14% of the modern bird, mammal and reptile extinctions and alone pose a serious threat to 199 bird species (Medina *et al*., 2011; Birdlife International, 2013).

As opportunist hunters, studies have shown that feral cats had a tendency to shift their diet from typical diet of insects and rats/mice to the influx of the seabirds during the seabird nesting season (Matias & Catry, 2008; Peck *et al*., 2008; Bonnaud *et al*., 2009). This threat confirms that the diet of cats upon oceanic islands tends to be more restricted and influenced by the prey availability (Dickman, 1996).

While the control and eradication of cats on islands have seen numerous benefits for seabird recovery, especially ground nesting species (e.g. Cooper *et al*., 1995; Keitt *et al*., 2002, Keitt *et al*., 2003) it has been argued that the initial removal of cats can further seabirds through additional pressure from other invasive species, such as rats (Rayner *et al*., 2007). Gorman & Levy (2004) also argue that cats can often have a beneficial role within the ecosystem if they have been in an environment for a long period of time.

1.2.3.3. Avian predators

Whilst numerous studies have noted cats or rats as the main predator for seabirds, many have found that avian predators such as Corvids have also contributed to seabird declines (Shields and Parnell, 1986; Paine *et al*., 1990; Burrell & Colwell, 2012). Other avian predators such as Peregrine Falcons (*Falco peregrinus*) have been recorded to predominately predate small to medium birds which can be up to around 0.6kg in weight (Svensson, 2009). Above this size, success may be limited as a further study by Paine *et al*., 1990, states that Puffins (*Fratercula arctica*) (0.76kg) and oystercatchers (*Haematopus ostralegus*) were not predated on during the study despite their abundance.

1.2.3.4. Indirect methods

Documentation of invasive mammals, such as feral cats and rats to islands is often only noted regarding the direct impacts they have upon the biodiversity. However it has been suggested that introduced herbivores such as feral goats (*Capra aegagrus hircus*) and feral sheep (*Ovis aries*) can have an indirect effect on island bird species by altering the habitat structure. A study by Van Vuren (2013) found that bird species upon Santa Cruz Island, California responded accordingly after the feral sheep where removed from the island 24 years ago. While species that preferred undisturbed dense habitat thrived post feral sheep removal, species such as the Rufous-crowned Sparrow (*Aimophila ruficeps*) and the native island Scrub Jay (*Aphelocoma insularis*) had more of a mixed result suggesting presence of feral goats could help support the endemic species. Similar results show the endemic Palila (*Loxioides bailleui*), a highly specialised honeycreeper species which primarily feeds within māmane forest on the island of Hawai'i has only been sustained through the removal of 46,000 feral sheep, cattle and goats (Hess *et al*., 1999; Banko *et al*., 2002).

1.2.3.5. Rats

Listed as one of the world's 100 worst invasive species, Rats spp. are arguably one of the biggest threats to native flora and fauna (Lowe *et al*., 2000). Rats are now considered to be the most important invasive species to island avifauna and more than 80% now have rats present (Shrader-Frechette, 2001). Studies have reviewed that rats have driven at least 18 sub species to extinctions (Parker, 1999) though the overall impact from rats can depend on factors such as life history, climate and ecology of native predators on an island (Akinson, 1985). Evidence has also shown that rats have an indirect effect on both the above and below ground biota by interrupting sea-to-land nutrient transport by seabirds, thus acting as major ecosystem drivers (Fukami *et al*., 2006).

1.2.3.6. Other factors

Apart from introduced predators, it has been suggested that seabirds are reliable indicators for ecosystem change associated with climatic factors due to their sensitivity to climate variations (See review by Durrant *et al*., 2009) yet can affect the size and location of foraging territories and habits. Also natural disasters such as oil spills (e.g. Torrey Canyon, 1967 and Amoco Cadiz, 1978) has seen population declines in species such as the Atlantic puffin and European Shag (*Phalacrocorax aristotelis*) (Wanless *et al*., 1999).

1.2.4. Norway rat (Rattus norvegicus).

The Norway rat is a colonial, social and mostly nocturnal rodent (Olds and Olds 1979; MacDonald & Barrett, 2005). Adults can grow to an average of 275 mm in length (head body length) and have a mean weight of 275-520g (males heavier than females) (Cunningham & Moors, 1983; MacDonald & Barrett, 2005).

Often found in association with humans, *R. norvegicus* can be widely found in close proximity to grain stores, rubbish tips and sewage systems with generally only found away from humans in the absence of competition (MacDonald & Barrett, 2005). Studies have shown that *R. norvegicus* tends to be the better swimmer when compared to the black rat (*R. rattus*) and Kiore (*R. exulans*) and can regularly swim up to 1km dependant on the sea temperature (Russell *et al*., 2008).

Reports have shown that rats have the capability to breed throughout the year if there is an abundant food source, however Drever & Harestad (1998) suggested that Norway rats have been noted to exploit the best quality food available within their habitat. As omnivores, *R. norvegicus* often take protein and starch rich food such as bird eggs, frogs and young mammals (MacDonald & Barrett, 2005). Additionally, Caut *et al*., 2008 found that rats had the ability to change their diet, over different seasons depending on what was available.

1.2.5. Presence/absence surveys techniques

Sections 1.2.5.1 – 1.2.5.7 below outline some of the commonly used survey techniques for small mammals, in particular rodents such as the invasive rats.

1.2.5.1. Chew/gnaw sticks

A key feature of rodents is the presence of a large pair of incisor teeth. As these teeth will continue to grow throughout their life and have to be continually worn down by gnawing (Cunningham & Moors, 1983) chew sticks have been commonly used to establish the initial detection of invasive rats on islands (Thorsen *et al*., 2000; Russell *et al*., 2008). However using gnaw sticks to detect rats has been restricted by the presumed neophobic behaviour (avoidance of novel items) or where rats are known to be at a high density (Moors, 1985; Clapperton, 2006).

1.2.5.2. Tracking tunnels

Non-invasive methods such as tracking tunnels have been important in the survey of species found at low density or elusive species that are harder to detect via other standard methods (Watts *et al*., 2008). The footprints left behind by animals can give you a good indication of presence within an area at relatively cheap cost (Sutherland, 2006). Yet, efforts and success of identifying tracks are often limited to weather conditions and the skill level of the person identifying the tracks (Taylor & Raphael, 1988; Sutherland, 2006; Russell et al., 2009). Due to this, the development of new automatic track recognition methods have been put forward to aid the identification of cryptic small mammal species, such as the invasive rat. New methods can increase successful identification and give a better estimation of species presence and composition within an area and further aid the biosecurity of an area (Russell *et al*., 2009).

1.2.5.3. Remote cameras

Remote cameras have become a popular non-invasive and cost effective tool in the detection, identification and conservation of many species, in particular more cryptic and elusive species (Griffiths & Van Schaick, 1993; Karanth, 1995; Wallace *et al*., 2003). Large levels of data can be collected to determine population size, density and even differences between individuals (Griffiths & Van Schaick, 1993; Karanth, 1995; Kelly et al., 2008). Additionally compared to other non-invasive techniques, such as hair tunnels, camera trapping has been found to collect more in depth information (Paull *et al*., 2012)

Camera traps have also been used to establish the potential predators of seabird nests and their subsequent impacts (Major, 1991; Brown *et al*., 1998). A study carried out by Rendall *et al*., 2014, looked into the effectiveness of camera traps in detecting trap-adverse species such as the Black rat. They found that while black rats were detected at over 90% of the sites, detection rates of rat activity were not strongly influenced by the density of seabird burrows.

1.2.5.4. Hair tubes and catchers

Hair tubes and hair catchers are a cheap and require little man hours in the field. However this technique is often limited to the weather conditions and the identification confidence (Sutherland, 2006). The detection rates between different types of hairtube types has also been found, showing that traps should be adapted to the species being studied (Lindenmayer *et al*., 1999). Hair catchers have been used successfully to help early identification of non-indigenous rats (Jarrad *et al*., 2011). They state that as there is a difference in behaviour, detectability and preferred habitat for each of the rat species, the overall effort to detect individuals varies and methods should be adapted to fit.

1.2.5.5. Feeding remains

Remains left behind can provide clues to what species has been previously present in an area. Major (1991) found that rats and mice often leave behind predated egg shell fragments in or under the nest. Similar results were collected in a later study by Jackson & Green, 2000 on predation of wader nests by the European Hedgehog, where they found that as well as nest lining disturbance there were 17 and 19 egg shell fragments >2mm in diameter. They also state that egg shell fragments had crushed eggs and in one case teeth marks similar to captive hedgehogs.

1.2.5.6. Faeces

Finding and counting faeces has often been used to establish the presence/absence of more cryptic and elusive individuals without the need for physical capture (Sutherland, 2006). Additionally, dung counts can often be less time consuming if the species has characteristic faeces (Sutherland, 2006). Difficulties may however arise if trying to identify species down to sub species level. While rats have characteristic droppings; often torpedo in shape with tapering at one end, MacDonald & Barrett, (2005) states that droppings can vary in colour and size dependent upon the diet and between sub species. Studies have shown however that rat pellets can be used as an indicator for presence on islands to complement other survey techniques (Pierce, 2002).

1.2.5.7. Bait boxes

Bait boxes contain rodenticide and are one of the oldest methods of rat monitoring and data collected over a period of time can collect vital information about the uptake (Howald *et al*., 2007). Bait boxes can also be labour intensive and expensive when used on a large scale, especially when compared to methods (Howald *et al*., 2007). Frequent monitoring of bait stations is often needed to control an unwanted rat population, though could inadvertently increase the risk levels of sensitive species such as breeding birds. For example Taylor & Thomas, 1993, reported that South Island Robins in New Zealand have been seen to eat remains of a toxic bait designed for Norway rats and Eason & Spurr, 1995, reviewed that seabirds such as the Southern Black-backed gull (*Larus dominicanus*) could be at risk from secondary poisoning by scavenging on poisoned carcasses.

1.3 Aims and objectives

The main aim of this study is to detect whether Rats are present/absent from various notable seabird colonies on and around Alderney. If rats were detected, to see if there is any significant difference between the study locations. Data collected from this study feeds into the ongoing conservation work carried out by the Alderney Wildlife Trust and by the States of Alderney Team. The research will also tie into ongoing efforts of the largest Ramsar site situated in the Channel Islands.

Any key findings from this study can be used to direct the future efforts of the trust staff and volunteers in the management of the Ramsar site and the notable seabird colonies. Suggestions of areas to look into regarding the control of invasive species will be made.

Chapter 2: Materials and Methods

2.1. Study Area

Situated approximately eight miles off the coast of France, Alderney is the third largest island within the Channel Islands, measuring around 780ha in size. Alderney's west coast and the Burhou islands were designated as wetlands of worldwide importance and became the first Ramsar site in the Bailiwick of Guernsey. To date the Ramsar site covers approx. 1,500 hectares of land and sea and is the largest in the Channel Islands. In total there was seven study locations which are explained in more depth in sections 2.1.1-2.1.7.

2.1.1. Burhou

Burhou is a low-lying, uninhabited islet one and a quarter miles north west of Alderney that has had relatively little modification by man. Vegetation is dominated by Sea campion (*Silene uniflora*). The small island (approx. 800m in length) is home to a vast array of endangered seabird populations and falls within the Ramsar designation area. Burhou Island is home to the only Storm Petrel Colony in the Channel Islands.

Previous conservation efforts have detected the invasive brown rat upon the island and mitigation efforts were put in place to remove individuals. Records show that the last rat presence survey was carried out in 2008 and was suspected rat free.

2.1.2. Little Burhou

Located to the west of Burhou, Little Burhou is only accessible from Burhou at low tide, twice a day. Visits to the island were therefore restricted and completed when tides allowed. Vegetation upon the island is similar to that of Burhou.

2.1.3. Coque Lihou

Situated only 0.25 miles off the coast of Alderney, Coque Lihou is a rocky islet with areas of sparse vegetation at higher elevations. Due to its location, visits to the islet were timed around tides and weather conditions.

2.1.4. Hannaine

Connected at low tide, Hannaine is a rocky islet to the west of Alderney that is dominated by a thick blanket of Sea champion on the top. Previous studies recorded rat presence on the islet and subsequence two bait boxes were placed to trap any individuals (Soanes & Booker, 2008).

2.1.5. Houment des Pies

Again only connected at low tide, Houment des Pies is a rocky outcrop with patches of grass on the higher elevations. Surveys of this location was restricted by tides and staff availability (for health and safety), it was also restricted due the sensitivity of the breeding Common terns (Carney & Sydeman, 1999).

2.1.6. Trois Vaux Valley – Zig Zag

Unlike study locations explained in 2.2.1 – 2.2.5. Trois Vaux Valley – Zig Zag stretched a total 700m along the coastal path incorporating the boundary to the Ramsar site. Vegetation along transect consists of gorse with small breaks of heathland.

2.1.7. Clonque – Fort Doyle

Also following the coastal path/road, this transect stretched a total 2000m along the coastal path incorporating the boundary to the Ramsar site. The vegetation present was coastal grassland and scrubland.

2.2. Study Species

Despite its size, Alderney is home to an array of seabirds, some of which are of international, national and local importance (Table 2.1). For classification seabirds are considered internationally important species where over 1% of the population of the biogeographic region is present. Nationally important species are those where over 1% of the UK population is present and local importance is where over 25% of the Channel Islands population occurs. *All data discussed can be viewed in Appendix 1 for population and Appendix 2 for productivity.*

All species breeding upon Alderney or on its surrounding islets are ‘Amber’ listed under the UK’s Birds of Conservation Concern, in part due to the proportion of their global populations breeding in Britain (Gregory *et al*., 2002). The only exception is the herring gull (*Larus argentatus*) which was updated to ‘red’ in 2009 (Eaton *et al*., 2009).

Table 2.1: Outlining the notable species present on Alderney and its surrounding Islets, with regard to their population numbers and population trend.

Species	UK population (thousands)	Population trend
Gannet (*Morus bassanus*)	220	Increasing
Shag (*Phalacrocorax aristotelis*)	27	Decreasing
Atlantic puffin (*Fratercula arctica*)	580	Decreasing
Storm Petrel (*Hydrobates pelogicus*)	26	Decreasing
Fulmar (*Fulmarus glacialis*)	500	Increasing
Common Tern (*Sterna hirundo*)	10	Decreasing
Ringed Plover (*Charadrius hiaticula*)	5	Decreasing
Greater Black-backed Gull (*Larus marinus*)	17	Increasing
Lesser Black-backed Gull (*Larus fuscus*)	110	Increasing
Herring Gull (*Larus argentatus*)	130	n/a

All off shore locations were chosen for this research project on the basis of notable seabird populations being present or from anecdotal evidence suggesting that attempts have been made to colonise a location. The transects from Trois Vaux – ZigZag and Clonque - Fort Doyle were chosen on notable species being present as well as their location in relation to the edge of Alderney's Ramsar site. Location of the breeding colonies can be seen below in Figure 2.1. Species found at sites a- f can be seen in table 2.2.

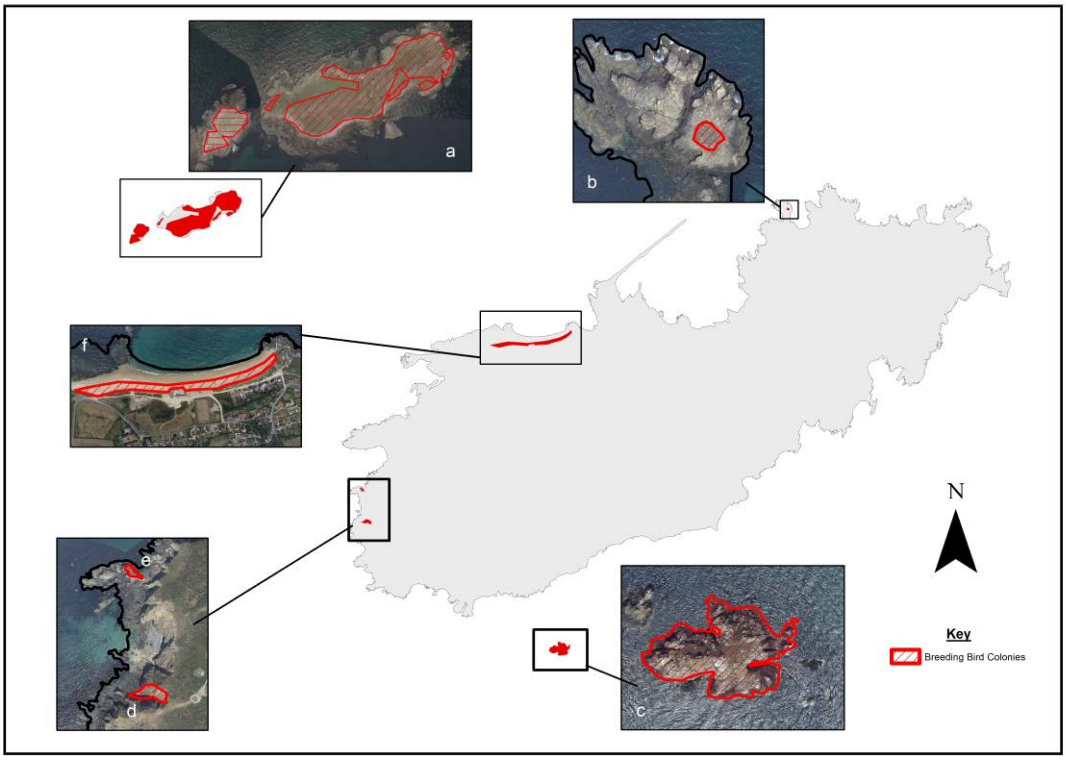

Figure 2.1. Sites of notable seabird colonies (clockwise): a =Burhou; and little Burhou (smaller island) b= Houment des Pies; c= Coque lihou; d= Tois Vaux bay; e = Hannaine and f = Platte Saline Beach.

Table 2.2: Outlining what species are present at each of the locations within the study

Study Location	Species										
	Puffin	Shag	Razorbill	Guillemot	Common Tern	Ringed Plover	Storm Petrel	Fulmar	Gulls (spp.)		
									Lesser Black backed	Great black backed	Herring
Burhou	x	x					x		x	X	X
Little Burhou		x							x	X	x
Coque Lihou		x	x	X				x		x	X
Hannaine	X*										
Haument des Pies					X					x	
Trois Vaux- Zig Zag						X					
Clonque – Fort Doyle						X					

* Anecdotal evidence suggesting attempts have been made in previous years to colonise/breed here

2.3. Data collection

Chew sticks were created from ½ inch wooden dowelling, cut up into equal lengths of approximately 10 inches in length. For ease of identification in the field, and to help reduce any public disturbance, red tape was placed around the top of the stick. Chew sticks were also numbered (on tape) to help survey efforts in case sticks were removed or lost.

2.3.1. Survey efforts

Overall chew sticks were *in situ* from the 25th June to the 31st July 2014 inclusive, totalling 36 days in total. The number of days for each of the sites varied due the staggered deployment of the sticks. Start and end dates for each of the sites can be seen in table 2.3 below. Chew sticks were used for this study as previous work by Alderney Wildlife Trust had success in the detection of invasive rats at several points on/around Alderney using chew stick methodology (Booker *et al*., 2007).

Table 2.3: Showing the survey periods for each of the study locations

Study Location	Number of sticks	Date		Number of days in field
		Put out	Collected in	
Trois Vaux – ZigZag	40	25/6/14	24/7/14	30
Clonque - Fort Doyle	24	26/6/14	24/7/14	29

Hannaine	17	3/7/14	27/7/14	24
Haument des Pies	9	7/7/14	31/7/14	24
Coque Lihou	32	3/7/14	16/7/14	13
Burhou	28	29/6/14	30/7/14	31
Little Burhou	16	29/6/14	29/7/14	30

The chew sticks upon Alderney were checked every two to three days when possible between the hours of 9.00am – 5pm. Chew sticks that were placed upon offshore stacks and islets were checked every 7-10 days when possible, fitted in between the surveys of the mainland transects. These sticks were timed around tides (accessibility), weather, boat availability, and staff to assist in surveys/fulfil health and safety procedures. Due to this time elapsed between some of the survey times was longer than planned, which may have affected the data gathered.

As the main aim of the study was to detect rat presence/absence, upon checking the chew sticks, any evidence of rat chew marks were recorded. Identification between rat and other small mammal marks was clear on most occasions, with there being a notable size difference in the width of each tooth mark (2-3mm vs 1mm). If no rat dentition marks were detected on the chew sticks, but smaller rodent teeth marks were seen, it was recorded as mice/shrew (mice and Greater toothed shrew (*Crocidura russula*) have been recorded on Alderney). If the chew stick was completely cleaned and the teeth marks were unable to make out to species level, it was also noted. This was then taken into account during analysing the data set. Any badly chewed or damaged sticks were replaced with a new stick.

2.3.2. Camera trap on Hannaine

During the survey period a remote camera trap (Bushnell Trophy camera) was donated to the Alderney Wildlife Trust. Due to the high level of interest surrounding the limited /failed colonisation of Atlantic Puffins on Hannaine (AWT, Pers. Comm.) the camera was placed opposite to one of the current chew sticks between 16^{th} -27^{th} July 2014, totalling 11 survey 'trap' nights. Due to the terrain and exposure upon the islet, the location in which the camera was placed was limited.

2.4. Statistical analysis

Data gathered from each of the survey days were entered into Microsoft Excel database where the different teeth marks were coded for statistical purposes (Table 2.4). Some of the data was then transferred to a statistical package (Minitab version 17) for analyses. The significance levels were set at 0.05.

Table 2.4: Codes used to categorise survey results prior statistical analysis

Species Detected/State of the stick	Code
Rat	1
Mouse/Shrew	2
Completely cleaned/Unable to distinguish teeth marks	0

Kolmogorov–Smirnov test was ran to see whether the data collected during the study was normally distributed. From this a Chi-Square Goodness-of-Fit Test carried out to see if there was a significant difference in the number of rats detected at each of the study locations. The same test was carried out on the mice/shrew data to see if there was a significant difference in the numbers found across the different sites. Also a spearmans correlation was carried out to see if there was a relationship between the average number of rats detected and some of the 2014 seabird's productivity counts.

2.5. Descriptive statistics

As each chew stick position was recorded, its co-ordinates were entered into a free software package (GPS UTILITY) and then exported into ArcMap (version 10.0) to achieve visual location of each of the sticks. Also from this it was possible were to see which ones has been chewed by rats in relation to the breeding bird colonies. Graphs also produced to show the proportion of sticks chewed across the different locations for both the invasive rats and mice/shrews.

Chapter 3: Results

Overall activity was found at 668 (89.42%) of chew sticks compared to 79 (10.58%) chew sticks being intact (Figure 3.1).

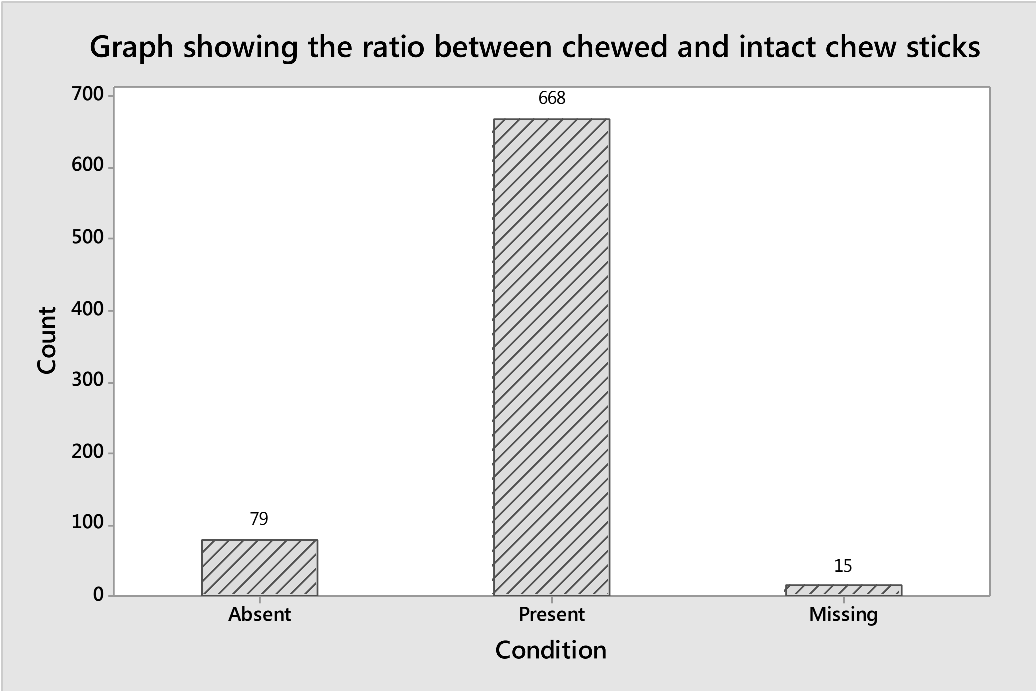

Figure 3.1. Graph showing the frequency sticks were chewed or not.

Rat teeth marks were detected at 39 of 762 occurrences equating to 5.12% of the total. Rat chew marks were only detected at three of the study locations; Trios Vaux- ZigZag, Clonque- Fort Doyle and Hannaine. Of these 39 positive rat detections, 26 (66.67%) were found between Clonque causeway and Fort Doyle, 10 (25.64%) on Hannaine and three (7.69%) on transect from Trois Vaux – ZigZag (Figure 3.2). Results found that there was a significant difference in the number of rats detected at each of the study sites (X^2 = 21.385, DF = 2, P= < 0.001).

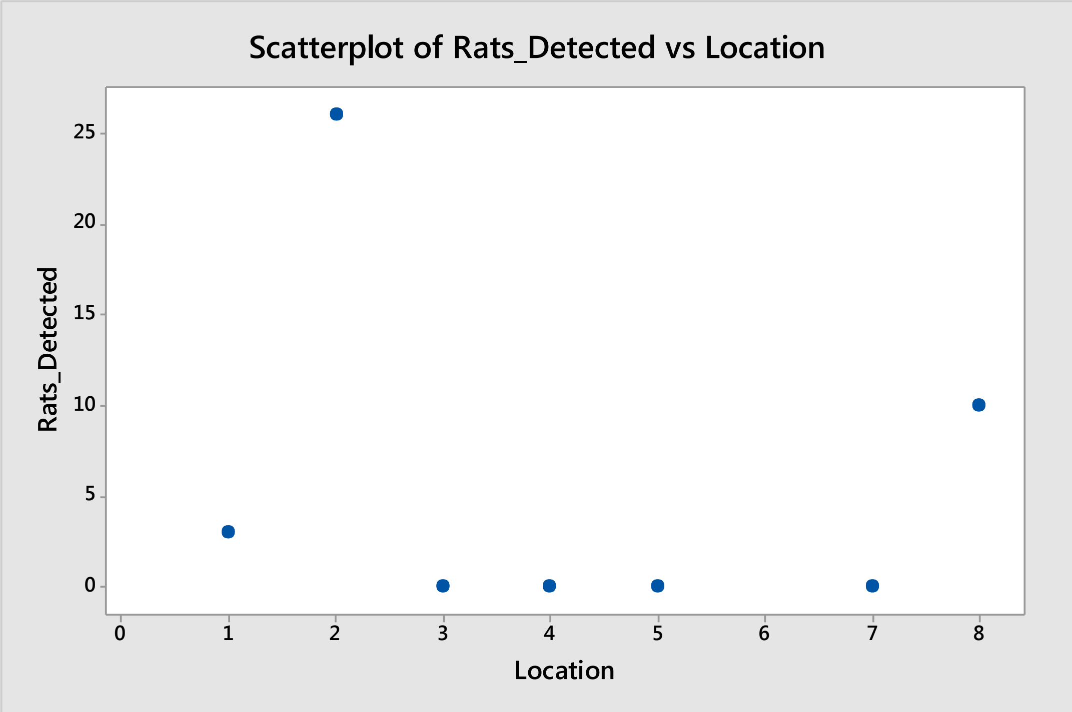

Figure 2.2: Scatterplot showing the number of rats detected at each of the study locations. Location 1= Trois Vaux-ZigZag; 2= Clonque-Fort Doyle; 3 = Houment des Pies; 4= Burhou; 5= Little Burhou; 7= Coque Lihou; 8= Hannaine

Further analysis found the rats detected within the Trois Vaux – ZigZag transect were on average 115 metres away from the Fulmar colony. The rats upon Hannaine were all within the possible breeding area. For the transect from Clonque- Fort Doyle, 7 of the 26 detections (26.92%) were found within 60 metres of the Ringed plover colony on Platte Saline beach.

Mice/shews however were found at 100% of study sites. The highest detection rates in proportion to the number of sticks was found at Houment des Pies (92%). The lowest detection rate was transect from Clonque- Fort Doyle (71%) despite this transect detecting the most mice (Figure 3.3 & 3.4). Results show there was a significant difference in the number of mice/shrews between the study locations (X^2 =240.191, DF= 6, P= <0.001)

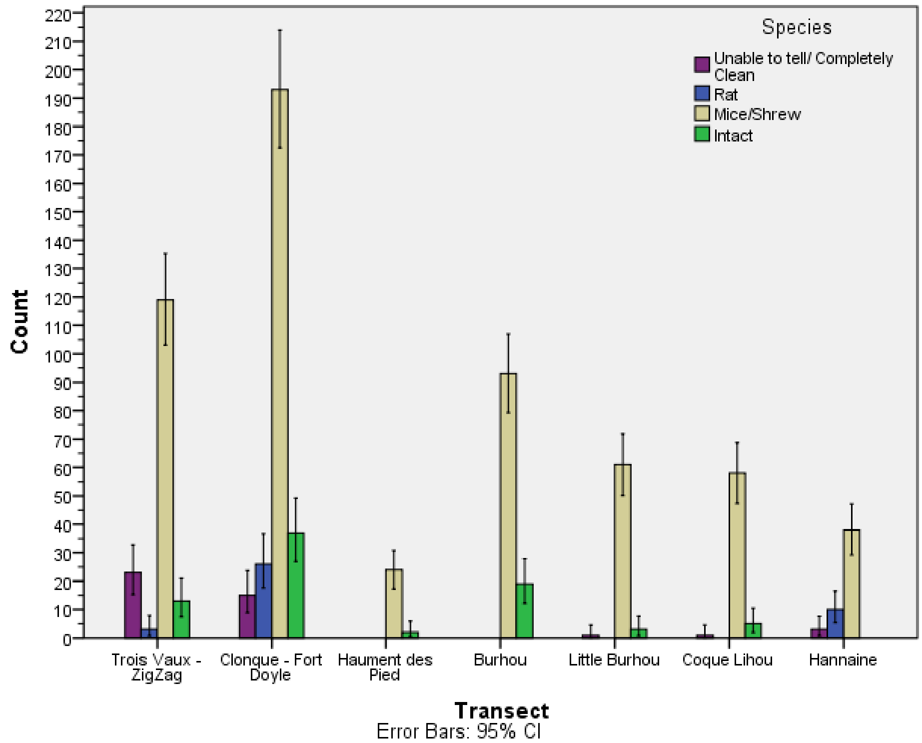

Figure 3.3: Showing the proportion of each species found at each of the study locations with 95% CI bars.

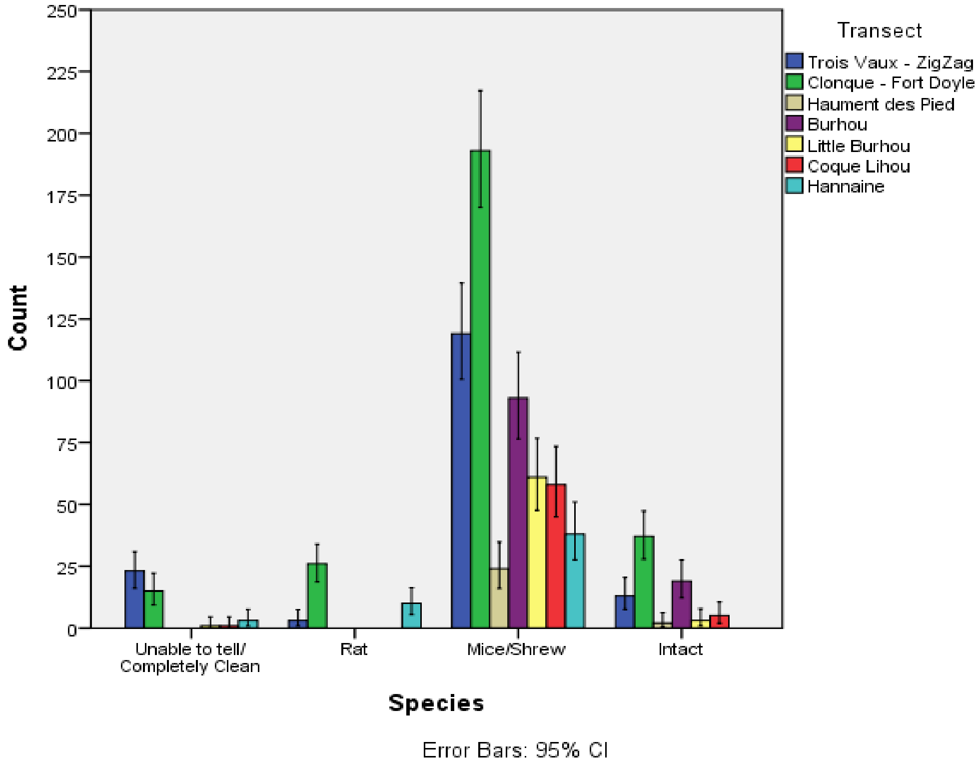

Figure 3.4: Showing the detection amounts for each species, broken down for each study location. Error bars: 95% CI.

3.1. Analysis of remote camera trap images from Hannaine

The remote camera was placed out for a total of 11 trap nights collecting a total of 105 images, of which Rattus (spp.) were detected in seven of the photos (Figure 3.5 & 3.6). Identification between *R.rattus* and *R. novegicus* was not possible. However suggestions could be important for future management by the Alderney Wildlife Trust.

Figure 3.5: Orange box outlines a *Rattus* spp.

Figure 3.6: Orange box outlines *Rattus* spp. individual. Note that a thick tail can be seen (left of picture)

3.2. Burhou and little Burhou

No rats were detected upon the island of Burhou or neighbouring Little Burhou. However there was evidence of small mammals (mice/shrews) upon the island as they were found at 83.04% (n=93) and 95.38% (n=62) of total chew sticks respectively.

During an Apparent Occupied Burrow (AOB) count for the Puffins on Burhou, a failed egg was discovered. Upon inspection less than 1mm teeth marks were observed (Figure 3.7). Teeth marks were clear (see both teeth marks) but were not deeply engraved into the egg shell.

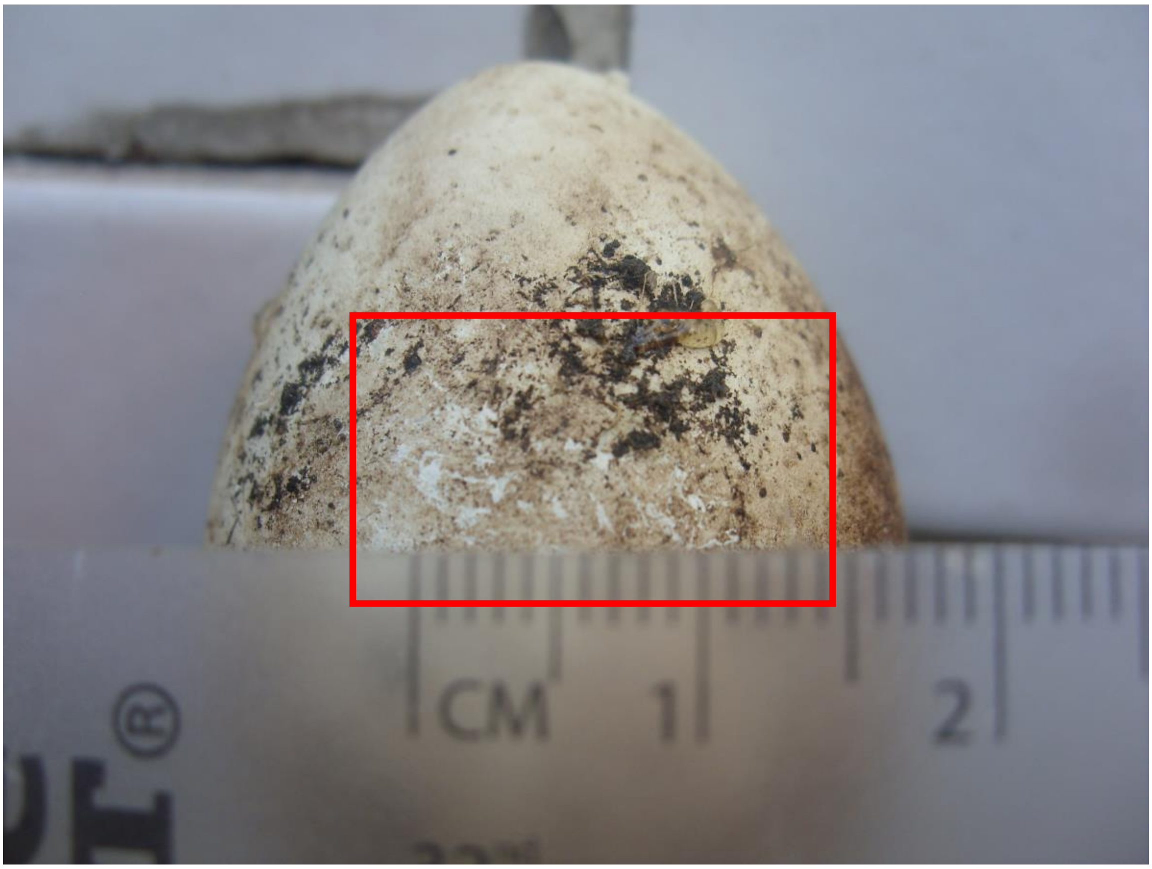

Figure 3.7: Red box outlines the area that has been attempted to gnaw.

3.3. Evidence of nest predation

During the survey of the chew sticks on Houment des Pies, evidence was found of nest predation upon some of the addled common tern eggs. Egg shell remains were found in and around the nest site as seen in Figure 3.8.

Figure 3.8: Evidence of Common Tern (*Sterna hirundo*) egg predation.

3.4. Does the number of rats detected affect seabird productivity?

Seabird productivity scores included within the study can be seen in Table 3.1 along with the overall number of rat detections. A spearmans correlation carried out found a positive relationship between the number of rats detected and the impact on nest productivity (rs = 0.535, n=7, P= 0.216) (Figure 3.9).

Table 3.1: Notable Seabird colonies within the study and the corresponding number of rats detected

Species	Productivity	Number of Rats Detected
Shag (Coque Lihou)	0.62	0
Shag (Little Burhou)	0.61	0
Shag (Burhou)	0.21	0
Puffin	0.36	0
Fulmar	**0.55**	3
Ringed Plover (Platte Saline)	1	26
Common Tern	0.44	0

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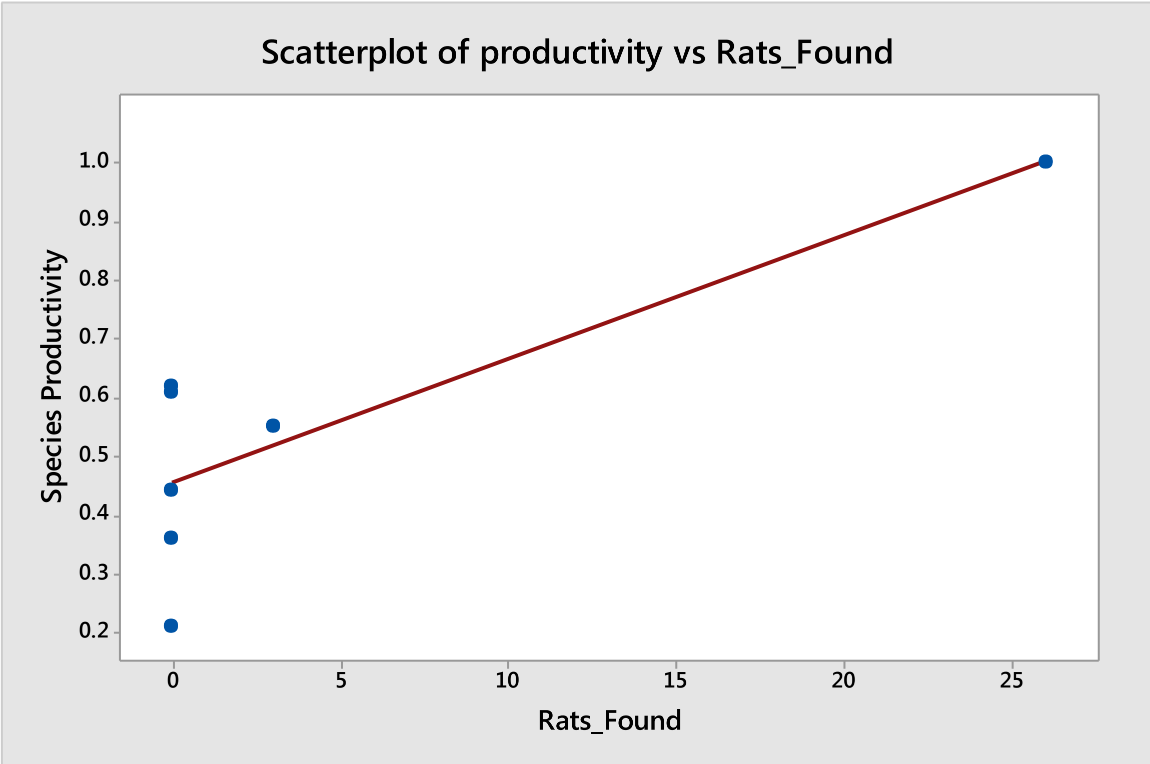

Figure 3.9.: Scatter graph showing the number of rats detected against the seabird productivity counts.

Chapter 4: Discussion

The main aim of the study was to carry out invasive rat presence / absence surveys across multiple locations across Alderney and its islets. Results show that chew sticks were a suitable method in detecting rat presence, but also highlighted that other small mammals like mice and shrews also had a tendency to nibble on the sticks.

4.1 Feasibility of the methodology

The materials used to make the chew sticks were cheap and all available from the local DIY store on the island. Chew sticks were designed to be quick and easy to create, as if rat presence was high, sticks would need to be changed on a frequent basis. This proved to be valuable in some of the offshore islets such as Little Burhou where survey effort was limited by the times of the low tides.

However through the study it became apparent that while it was clear to differentiate between teeth marks of adult rats and other small mammals, it was harder to tell the difference between small mammals such as mice/shrews and potential young rats. Due to this, chew marks that were not large enough to be rats, were classed as mice/shrew. As a consequence by grouping the results in this manner, some rat individuals may have missed out /classed as the wrong species, further altering the data set gathered. The relative experience of the surveyor likely had a bias in the data collection and subsequent data analysis. Unfortunately there seems to be no literature on the width and shape of the small mammal dentition, with just common information on how many teeth and the dentition formula (Cunningham & Moors, 1983), and as a result the results were gathered with caution.

Due to the ease of access to the two study sites upon Alderney, it was possible to check the sticks every 2-3 days for the duration of the study period. However due the location of the remaining study sites, it was not possible to survey at the same frequency. This limited the level of data that could be collected.

4.2 Level of rat detection

Rats were detected throughout the study period, yet the overall detection level remained low (39 positive detections from a possible total of 668). In total rats were only detected at three of the seven study locations, the two transects on Alderney (n= 26 and 3) and on Hannaine (n=10). Whilst the low detection rate across the study could question the validity of the chew stick method, previous studies by the Alderney Wildlife Trust showed that rats were detected on islands such as Burhou and Houment des Pies using this methodology (Broadhurst & Skene, 2008). Positive rat detections on Burhou in 2008 were later eradicated in order to protect seabird colonies. Therefore the absence of rats from these locations can be viewed as a positive for the conservation of the seabirds.

Results found that the most rats were found upon the transect going from Clonque causeway to Fort Doyle (n=26). Here, a higher level of detection may be due to the increased human population numbers in the immediate area. Towards the end of the Clonque –Fort Doyle transect, there is a group of houses and sewage plant facility. This could prove to be a stable food source for the rats meaning they can remain in higher numbers throughout the year. Thorsen *et al*., 2000 goes on to state that if there is a natural food source standard techniques such as 'gnaw sticks' are deemed ineffective.

However, through the use of Arc Map analysis results showed that rats were on average 60-115m away from a breeding colony (Ringed Plovers and Fulmars respectively). Rats can travel up to 3-4km in a single night (MacDonald & Barrett, 2005). The results gathered from this study suggest that while chew sticks can positively identify rat presence it does not take into account the whole area that an individual rat could travel in one night. Studies show rats on farms (where food is often readily available) only travel a mean distance of 65m (MacDonald & Barrett, 2005). This falls within the average distance found for the rats detected on the Clonque-Fort Doyle transect, and could be related to the increased human settlement.

It has been widely documented that rats and other rodents have the need to gnaw on items such as wood to keep their continually growing incisors trimmed (Cunningham & Moors, 1983; Salmon *et al*., 2003). Yet the level of success of the chews sticks within this study could have been down to the method of presentation/ 'flavour' chosen. Other studies have used chocolate wax blocks, soap candles to detect rats with positive results (Appleton *et al*., 2006). Unfortunately there is limited research in the development a 'perfect' attractant for rodents such as rats due to the difficulties with the *in situ* field survey efforts (Clapperton, 2006).

The additional use of a remote camera trap on Hannaine meant that additional evidence of rats could be gathered, confirming the presence of rats. Multiple rats were captured using this method though the terrain and ecology of the study site meant the placement of the remote camera was limited to one area, limiting the data gathered. Furthermore, evidence shows that ground nesting birds such as Puffins are affected by rat predation, and their absence from an area (which may be otherwise classed as suitable) can be related to the presence of rats (Stoneman & Zonfrillo, 2005). Though due to the lack of data, other factors such as gull predation (Soanes *et al*., 2010) and weather, it was not possible to test whether rats are a factor in the low breeding and/or colonisation attempts made in previous years.

4.3 Level of mice/shrew detection

Whilst the main aim of the study was to look into the presence/ absence of rats, it was rapidly found that there was a high detection rate for mice/shrew marks. This could highlight the use of chew sticks as a good indicator for small mammal presence. The success of the chew sticks for smaller mammal detection could be due to them being present at a higher density compared to the invasive rat. The rat population upon Alderney is controlled through poison bait boxes, maintaining a steady population, this may allow the mice to persist at higher densities and in higher numbers. A study carried out by Innes *et al*., 1995 similarly found that the removal of the black rat allowed mice to increase in numbers.

A review by Angel *et al*., 2009 found that small mammals such as mice have also been note to have an impact upon ground nesting seabirds, through the predation of eggs. Wanless *et al*., 2007 also found that despite their size mice have been known to group together and prey upon larger seabird chicks such as a the Tristan Albatross (*Diomedea dabbenena*). The analysis for this study found there was a significant difference in the number of mice/shrews detected across the study sites (X^2 =240.191, DF= 6, P= <0.001) with the highest proportion of mice found in relation the total number of chew stick was Houment des Pies (92%), the colony of Common Terns.

Outside the presence/absence study, evidence of small mammal predation was seen on an unhatched Puffin egg recovered from a nest on Burhou. However, the teeth marks did not break through the egg shell suggesting that the egg shell thickness could be too thick for one lone mouse/shrew to get through. The time at which this attempt of predation on the egg happened is unclear. MacDonald & Barrett, 2005 showed that mice/shrews mainly feed upon grains and insects, therefore it could be suggested that the marks upon the puffin egg may have occurred after the egg became addled, and was an opportunistic investigation towards the egg. Yet, it should be questioned whether the high levels and variation of mice/shrews upon Alderney and its islets, will or are having an impact on the success of the nesting seabirds.

Additionally while the chew sticks detected no rats upon Coque Lihou, research found a strong presence of mice/shrews. As there had been no previous terrestrial surveys upon

Coque Lihou, this result is a significant factor in the future management of the islands seabirds. Similar results were found on Burhou and little Burhou.

4.4 Correlation between invasive rats and nest productivity

Analysis found that there was a positive relationship between the seabird productivity and the number of rats detected ($r_s = 0.535$, $n=7$, $P= 0.216$). Unfortunately productivity counts were not available for all species studied within the research project, this meant that there was a small sample size, limiting the results and the conclusions that could be made from the study. Additionally, some of the productivity scores used within the study were only preliminary as the breeding season (for species such as Fulmars) had not finished by the end of the study.

An interesting result was the correlation between the 2014 productivity of the Ringed plover and the number of rats detected on the subsequent transect. Many studies show that with the increase in rats in an area often relates to a lower productivity count (Towns *et al*., 2006). However 2014 saw an increase in the public awareness and care for the ringed plover nest sites. As a consequence, the ringed plovers were able to spend more time on the nest, protecting the eggs from potential predators such invasive rats. As a result they were successfully able to hatch and raise multiple broods over the summer period (AWT, pers com.). By spending more time on the nest, opportunist predators have a reduced incentive and increased risk to predate the nest, making it more cost effective to source food elsewhere. Igual *et al*., 2006 found that the breeding success of the Cory's shearwater (*Calonectris diomedea*) increased when rats were removed from an area in regards to the level of predation on young chicks, but egg loss remained the same throughout the study. This could mean the control of the rat population by the States of Alderney team is benefiting the Ringed plover individuals.

4.5 Limitations

Even though rats were detected using the chew stick methodology, it was clear that there were a few limitations. One main limitation was the ability to tell between the different small mammals and young rats' teeth marks. The lack of experience and knowledge in the identification of chew marks meant longer time was spent per stick in order to make a judgement. A study by Jarrad *et al*., 2010 found when compared to other detection techniques chew sticks took longer to analyse than methods such as remote camera traps.

As this study was carried out during the summer months it meant that only small picture of the true impact of the invasive rats could be gathered. Also it has been documented that small mammal populations fluctuate throughout the year (Monadjem & Perrin, 2003). Within this study, surveys were carried out at a time where there was an increase in the amount and availability of alternative food sources across Alderney (summer tourist season). This consequentially meant that rats will no longer be restricted by food supply and may not need to chew the sticks (Dilks & Towns, 2002).

A main limitation to the study was the restricted access to some of the study sites. Surveys had to be planned around tides/ boat availability/ weather, meaning that less data could be collected for analyses. During the last week of the study, the main transport became unavailable due to unforeseen circumstances. Overall, as there was a low sample size the analysis gathered was restricted. In addition to the restricted access of the study sites, the difficult terrain often limited the positioning of the sticks. As a consequence in some cases, sticks were placed closer together than initially planned or less sticks could be used. Clapperton *et al*., 2006 found however that the positioning of the detection technique did not affect the level of detection or the behaviour of the rodent.

4.6 Recommendations

While the main aim of carrying out rat presence/absence surveys was achieved, the study was carried out in a short amount of time meaning that identifying trends and patterns rat presence proved difficult. Recommendations would be to carry out the study for a longer period of time or across multiple seasons/years to establish the true impact that the invasive rats are having upon the vulnerable seabirds within the Alderney. Increasing the survey efforts across the whole of the Channel Islands could also highlight any areas/ threats that might not be necessarily, be seen at first glance, particularly at a local scale. Additionally as it has been found small mammal populations vary across the year, often in relation to availability of food within a habitat, so it is not surprising that the most invasive rat detections are in late summer and early summer which overlaps with a peak in post breeding numbers and winter detects the hungry individuals (Møller, 1983; Innes *et al*., 2001). These subsequent population numbers can then be made to see if there is a significant difference in the number of rats found in the same areas outside the seabird breeding season.

Furthermore, if more information was gathered alongside the rat/presence data, such as individual nest productivity (different areas in each colony – edge vs. centre), it would be possible to establish to what extent invasive rats have an effect on the colonies.

The chew sticks were shown to be effective in detecting rat presence. Collection of additional information such as density and spread of the rats (in regards to home ranges) could help further invasive rat control by the States of Alderney and focus conservation work carried out by Alderney Wildlife Trust in regards to the management of the seabirds within the Ramsar site. Additional methods of detection (camera traps, tracking tunnels) could also be trialled to see if there is a difference in success rate between different sites/Detection methods. Different presentation methods (chocolate wax blocks/ candles) may also increase positive identification between rats and other small mammals.

High number of mice/shrews were detected upon Burhou, Little Burhou, Houment des Pies and Coque Lihou. With the added knowledge that there are no rats present, effort should be undertaken to try and establish whether mice are currently or will be a limiting factor in the success of the present vulnerable ground nesting seabirds such as the Puffin and Storm petrel. These surveys could be carried out at regular intervals to monitor the rat presence/absence.

Chapter 5: Conclusion

It has been widely recognised that it is important to know what is in an environment before you can successfully manage it. Therefore through presence/absence surveys using wooden chew sticks this study highlighted that it was possible to detect invasive rats, as well as other small mammals such as mice and shrews. Analysis suggests that there was a difference in the number of rats detected between the study sites as well as a difference in the number of mice. Through the use of chew sticks no invasive rats were detected upon Burhou and Houment des Pies where they were previously detected and eradicated in previous years. However areas of no rat signs does not necessarily mean that rats are not present in the area. To therefore establish whether rats were successfully eradicated from Burhou in 2008, further surveys need to be carried out at different times of the year to take into account fluctuations in population numbers.

Analysis showed that chew sticks were successful at detecting high levels of mice compared to rats. This, however, may be a result of the species density on Alderney and its surrounding islets. Surprisingly, analysis found that there was a positive relationship between the seabird productivity scores and the number of rats found on the related transect. However most studies within the literature usually find that the increase in invasive rats tends to reduce the success of the seabird in question. However as scores were not available for all the species additional surveys need to be carried out in future years to get a clearer image of trends.

Rats can have devastating effects on many seabird species. This study, in addition to current work carried out by the Alderney Wildlife Trust will be able to help build an image of the areas in which rats are found in highest numbers and where efforts need to be focussed in the conservation of vulnerable seabirds, such as the Atlantic puffin and the European storm petrel.

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Appendix 1-Population Information for Seabirds

			SCR	Seabird 2000			-	Burhou Project		Ramsar ARS1					Ramsar ARS2				
Location	**Species**	**Method**	**1987**	**1999**	**2000**	**2002**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Les Etacs	**Gannet**	AON	2391	3450	-	-	-	4862	-	-	-	-	-	5765	-	-	-		
Ortac	(*Morus bassanus*)		1985	2500	-	-	-	2547	-	-	-	-	-	2120	-	-	-		
Coque Lihou	**Shag**	AON	80	-		-	-	-	-	-	-	-	-	-	-	77	66		
Little Burhou	(*Phalacrocorax*		8	-		-	-	-	-	-	-	-	-	-	-	35	36		
Burhou	*aristotelis*)		6[1]	47		-	-	-	-	19	21	19	24	23	20	21	14		
Alderney			31	160		-	-	-	-	-	-	-	-	-	-	18[2]	51		
Burhou	**Puffin**	AOB	210[3]	180[3]		-	-	120	127	114	132	-	153	160	176	168	143		
	(*Fratercula arctica*)	(Raft)	-	-		-	-	(139)	(92)	(127)	(134)	(131)	(157)	(174)	(175)	(96)	(58)		
Burhou	**Storm Petrel**	AON	-	-	-	60	-	-	90	-	40	-	-	28	-	-	**2,500**		
	(*Hydrobates*	(Rung)	(35)	-	-	-	(300)	-	(215)	-	(420)	-	-	-	-	-	(**500**)		
	pelagicus)																		
Burhou	**Herring Gull**	AON	70	125[4]		-	-	202	110	148	164	52[2]	85	73	5	18	32		
	(*Larus argentatus*)	(Chicks)	-	-		-	(16)	-	(3)	-	(1)	(8)	(17)	(6)	(4)	(12)	(18)[5]		
Alderney			96	285[4]		-	-	-	-	-	-	-	-	-	-	-	315[6]		
Burhou	**Lesser BBG**	AON	105	313[4]		-	-	1103	936	994	1001	640[2]	1074	1236	991[4]	-	1392		
	(*Larus fuscus*)	(Chicks)	-		| (232)	-	(308)	(386)	(140)	-	(3)	(281)	(335)	(11)	(202)	(28)	(276)		
Alderney			13	70[4]		-	-	-	-	-	-	-	-	-	-	-	315[6]		
Burhou	**Great BBG**	AON	22	27[4]		-	-	18	18	16	17	-	23	23	4	1	6		
	(*Larus marinus*)	(Chicks)	-	-		-	-	-	-	-	(0)	(5)	(0)	(1)	(4)	(1)	(2)[5]		
Alderney			5	21[4]		-	-	-	-	-	-	-	-	-	-	-	315[6]		
Alderney	**Fulmar**	AOS	53	50		-	-	-	-	26	20[2]	38	34	16[2]	34	29	29		
	(*Fulmarus glacialis*)																		
Platte Saline	**Ringed Plover**	AOS	-	-		-	-	-	-	-	1	3	5	3	2 (8)	2 (8)	4 (4)		
Clonque	(*Charadrius*	(Ind.)	-	-		-	-	-	-	-	-	-	-	-	-	-	2[2]		
	hiaticula)																(4)		
Houmet des	**Common Tern**	AON	18	20[4]		-	-	15	-	11	-	-	-	-	5	14	25		
Pies	(*Sterna hirundo*)	(Ind.)	-	-		-	-	-	-	(64)	-	-	-	-	(24)	(43)	(28)		

[1]Counted in 1988; [2]Partial colony count only; [3]Individuals on land; [4]AOS not AON; [5]Inc. Little Burhou; [6]All gull spp. together

Productivity Information for Seabirds - Values given relate to number of successfully fledged chicks per nesting site

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Gannet	-	-	0.80	0.88	-	0.62	-	-	0.52	**0.65**		
Shag (Coque Lihou)	-	-	-	-	-	-	-	-	0.69	0.62		
Shag (Little Burhou)	-	-	-	-	-	-	-	-	0.74	0.61		
Shag (Burhou)	-	-	-	0.14	0.21	-	-	1.24	0.57	0.21		
Shag (Alderney)	-	-	-	-	-	-	-	-	1.00	0.41		
Puffin	0.64	0.61	0.63	0.65	-	0.66	0.66	-	-	0.36 – 0.60		
Fulmar	-	-	-	-	0.47	0.53	-	0.56	0.52	**0.55**		
Ringed Plover (Platte Saline)	-	-	-	-	0.66	0.20	0.00	0.00	1.50	1.00		
Common Tern	-	-	-	-	-	-	-	-	0.57	0.44		