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Determining the Breeding Phenology of Southern Giant Petrels on the Frazier Islands, East Antarctica, through Automatic Camera Monitoring in 2011-2015

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Determining the Breeding Phenology of Southern Giant Petrels on the Frazier Islands, East Antarctica, through Automatic Camera Monitoring in 2011-2015

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Abstract: The Southern Giant Petrel, *Macronectes giganteus*, is a sibling species with the Northern Giant Petrel, *Macronectes halli,* which were first separated and distinguished in 1966. Colonies are present on ten oceanic islands, six islands off South America, 4 locations in East Antarctica and numerous sites around the Antarctic Peninsula. Few studies have looked at the breeding phenology of Southern Giant Petrels on the Frazier Islands. Due to concerns relating to human disturbance, non-invasive monitoring using automated cameras was conducted from 2011-2015. This report is part of a preliminary study designed to monitor the ongoing population on the Frazier Islands and establish/understand key breeding parameters. The arrival of the first adults to the colony, incubation and brooding period were determined as well as estimates of hatching date, guard period and fledging time. With continued research, by the use of the automated cameras, further insights will be gained on the Southern Giant Petrel Colony not only on the Frazier Islands, but also at other locations.

Key Words: Breeding, camera monitoring, Frazier Islands, Southern Giant Petrel

Introduction

The order Procellariiformes consists of 4 families (Bretagnolle 1988). The marine petrels are found within the family Procillaridae consisting of five genera and seven species, all but one breeding in the southern Sub-Antarctic (Bretagnolle 1988). The two largest species within this family fall under the genus, *Macronectes* and are the Southern Giant Petrel *M. giganteus*, and the Northern Giant Petrel *M. halli* (Bretagnolle 1988). These sibling species have only recently been separated into distinct species by Bourne & Warham in 1966 based on differences in plumage colouration, behaviour and breeding biology (ACAP 2012).

Giant petrels have a circumpolar distribution throughout the Southern Hemisphere (Hunter 1984). Colonies are present on ten oceanic islands, six islands off South America, four locations in East Antarctica and numerous sites around the Antarctic Peninsula (ACAP 2012). The Southern Giant Petrel is more abundant in the higher latitudes. However, colonies do occur as far north as the Falkland Islands, Isla Noir, Chile and Chubut Province, Argentina (Patterson *et al.* 2008).

Approximately 1% of the global breeding population of Southern Giant Petrels is located along the Antarctic continental coast (Creuwels *et al.* 2005). This area is the southern limit of the species habitat and contains four known breeding locations in East Antarctica located near Mawson Station, Giganteus Island (67º35’S 62º30’E), near Davis Station, Hawker Island (68°38’S 77º51’E), near Casey Station, Frazier Islands (66°17’S 110°32’E) and near the French station Dumont d’Urville, Pointe Ge´ologie (66º20’S 140º01’E) (Creuwels *et al.* 2005). The Frazier Islands are all occupied by small colonies and are therefore probably extremely susceptible to major changes in the environment including from human disturbance (Creuwels *et al.* 2005).

The Frazier Islands **(Figure 1)** and their Southern Giant Petrel colonies were discovered in 1956 (Wienecke *et al.* 2009) and is the largest of the four continental colonies (Creuwels *et al.* 2005). They are located approximately 16km offshore from Australia's Casey station, in East Antarctica (ATCM 2013). The island group consists of 3 islands, Nelly, Dewart and Charlton Island, of which Nelly Island is the largest and Dewart supporting the largest colony. All 3 islands combined are designated as an Antarctic Specially Protected Area under Measure 2 (2003) as a sanctuary for the Southern Giant Petrels (ATCM 2013).

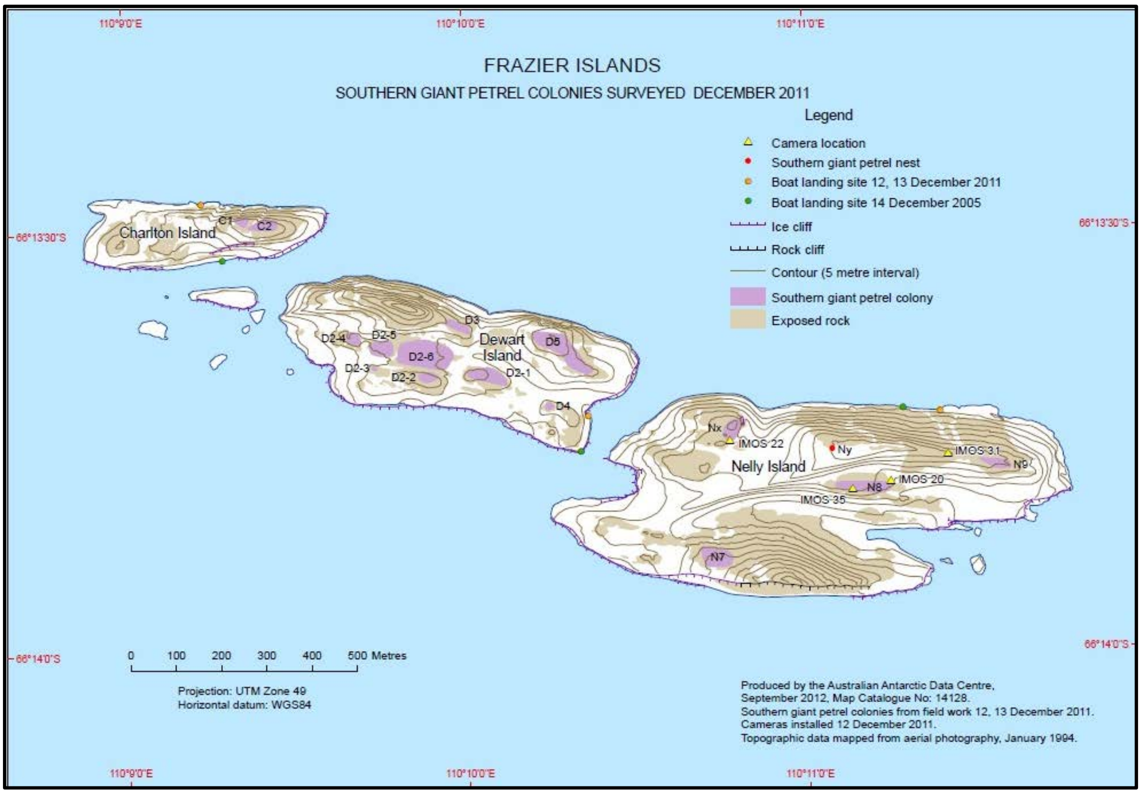

Figure 1. Location of the Frazier Islands with Southern Giant Petrel colony locations and camera locations.

The Southern Giant Petrel is listed within the Annex 1 of the Agreement on the Conservation of Albatrosses and Petrels (ACAP) which is a multilateral agreement designed to conserve albatrosses and petrels through international coordination in order to mitigate known threats to the populations (ATCM 2013) as well as in Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (ATCM 2013).

The International Union for the Conservation of Nature (IUCN) has currently down listed the Southern Giant Petrel from 'near threatened' to 'least concern' as a recent analysis of trend data (combined north and south of 60°S) for the global population covering the past three generations (64 years) gives a best case estimate of a 17% increase and a worst case scenario of a 7.2% decline (Birdlife International 2016). This estimate of a decline does not approach the threshold for classification as 'vulnerable' which has caused the species to be down listed (Birdlife International 2016).

However, the Australian Environmental Protection and Biodiversity Conservation Act 1999 (EPBC), lists the species as 'endangered' because when it was being listed, the Australian Antarctic Territory (AAT) populations were believed to have decreased since the 1950s and 1960s by between 30 and 92% (Stattersfield & Capper 2000).

The global breeding population of Southern Giant Petrels was estimated at 38,000 pairs in the late 1980s (Hunter 1985) declining by 18% to 31,000 pairs in the late 1990s (Rootes 1998). There is currently an estimated total of 46,000 breeding pairs and approaching 100,000 mature individuals (Birdlife International 2016). This consists of an estimated 19,500 pairs on the Falkland Islands (Islas Malvinas), 5,500 pairs on South Georgia (Georgias del Sur), 5,400 pairs on South Shetland Islands (Shetland del Sur), 3,350 pairs on South Orkney Island, 2,500 pairs on Heard and MacDonald Islands, 2,145 pairs on Macquarie Island, 2,300 pairs in South America, 2,300 pairs on the Tristan da Cunha Islands, 280 pairs on the Antarctic Continent (Birdlife International 2016). In has also been estimated that there is 1,190 pairs on the Antarctic Peninsula, 1,550 pairs on the South Sandwich Islands, 1,800 pairs on Prince Edward Islands, 1,060 pairs on Iles Crozet and four pairs in Iles Kerguelen (Birdlife International 2016).

In 2011, the most recent estimate of the population of the Frazier Islands was 237 breeding pairs with colonies located on all three islands (ATCM 2013). However, there may be other unknown colonies that have yet to be discovered due to incidental observations being recorded at the coast near Australia's Mawson Station (ATCM 2013).

Depending on the availability of building materials within the area of the colony, primarily small pebbles, the Southern Giant Petrel species build large, untidy nests measuring up to 1.5m in diameter (Hunter 1984). Giant Petrels lay one egg annually (Patterson *et al.* 2008) and failed breeders not laying a replacement egg. However, they often remain in the colony for up to nine days after the egg has been lost (ACAP 2012).

Southern Giant Petrels have a tendency to be highly susceptible to human disturbance (ATCM 2013). Recorded decreases in their populations have been well documented in relation to proximity to research stations, directly supporting the fact that this species is highly vulnerable to human disturbance (Patterson *et al.* 2008). Other interactions related to human presence causing decreases include commercial fisheries, habitat destruction, overflight activity and the effects of non-native species (Patterson *et al.* 2008). Overall, giant petrels are relatively shy birds in comparison to other petrel species and will not hesitate to leave the nest and abandon both the egg and/or a chick after any disturbance including severe weather, predator interaction or human presence (Chupin 1997).

The banding of Southern Giant Petrels in Antarctica was discontinued by Australia in 1986 due to disturbance concerns, but countries around the world continue to use this method. A study conducted during the 2009/10 summer on the South Shetland Islands looked at Southern Giant Petrel nest attendance patterns under extreme weather conditions where three birds abandoned their nests. Some 21% failed probably as a result of handling during the tagging procedure (Schulz *et al.* 2014). All other tagged individuals initially continued to breed but abandoned their nests later and no chicks hatched within nests where one or both adults were tagged (Schulz *et al.* 2014).

At the Frazier Islands, Southern Giant Petrel colonies occur across all three islands. Visits to the islands are infrequent and previously recorded data were collected at different times of the year. Also not all three islands were always visited at the same time. This inconsistency in the data complicates the pooling of all information per season and strongly influences previous trend analysis (Wienecke *et al.* 2009). It has been noted that the early counts conducted on the Frazier Islands were problematic, and it was concluded that some of the recorded trends were not in fact accurate but instead, were due to inconsistencies in the census methods (Creuwels *et al.* 2005).

Due to the lack of data and information on the breeding phenology of the Southern Giant Petrel, particularly on the Frazier Islands, and also the many concerns that have arisen over disturbance, particularly human disturbance, and breeding success in the species (Wienecke *et al.* 2009), the need to conduct ongoing censuses of all breeding populations is clearly apparent (Patterson *et al.* 2008). It is only through long-term monitoring and research that population trends and dynamics can be differentiated (Patterson *et al.* 2008).

It has been recommended that new and non-invasive technologies, again due to disturbance concerns, should be employed where possible (Wienecke *et al.* 2009). For example, a remote monitoring program has been used successfully in accessible Adelie Penguin colonies by the use of automated cameras (Wienecke *et al.* 2009). It has been shown that the use of the automated camera system for penguin assessment and monitoring, particularly for remote areas, is a significant advance (Southwell & Emmerson 2015) in population monitoring. The deployment of the cameras, and any equipment for monitoring purposes (ATCM 2013) should occur before breeding commences and the recovery of the equipment should occur after fledging has concluded (Wienecke *et al.* 2009). It was stated that the photos taken by the automated cameras have the potential to provide insights into the timing of some key events during the breeding season (Wienecke *et al.* 2009). Another advantage of using the automatic cameras is that the images can be stored for future use, and data can be verified (Wienecke *et al.* 2009).

This report is a preliminary study part of a larger project to establish and understand key breeding parameters of the Southern Giant Petrel on the Frazier Islands using automated cameras.

Method

Four automatic cameras (Canon 1000D) (Newbery & Southwell 2009) were temporally installed on Nelly Island on the 12/12/2011 **(Figure 2)** and ran over 4 seasons (S1, S2, S3, S4) until 2015. Photographs were taken at approximately 2hr intervals therefore approximately 7 photographs were taken daily **(Table 1)**.

	Start	Finish	Number of Photos
Season 1	12/12/2011	30/04/2012	1152
Season 2	01/09/2012	30/04/2013	1949
Season 3	01/09/2013	30/04/2014	1959
Season 4	01/09/2014	20/01/2015	1145

Table 1. Start and finishing dates of each season as well as the number of photos taken during that season.

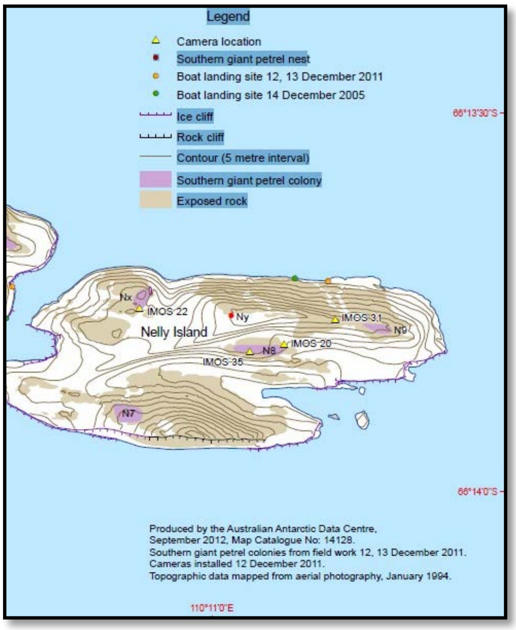

Figure 2. Location of the 4 cameras on Nelly Island, Frazier Islands.

As the data for Season 1 began later (December) as compared to all other seasons (September), the date that the first adult was sighted could not be recorded. Similarly, since the data in Season 4 stopped earlier (January when the cameras were removed from the island) as compared to all other seasons (April), the date the adults first left the chick unattended, the date the chick was last on the nest, the number of days the adult sat on the chick (brooding period) and also the date that the adult stopped sitting on the chick and sat next to it (beginning of the guard/non-brooding period) were not able to be recorded.

Photographs were uploaded and viewed using Picasa. Photos were deemed unusable if the whole image was black or no clear image could be viewed to determine presence or absence. A clear plastic film was placed over the computer screen and nests were marked with a circle to allow for an accurate comparison across seasons **(Figure 3)**. Four nests were located and marked (N1, N2, N3, N4) across all seasons with the presence and absence noted for adults and chicks for all four nests across all four seasons.

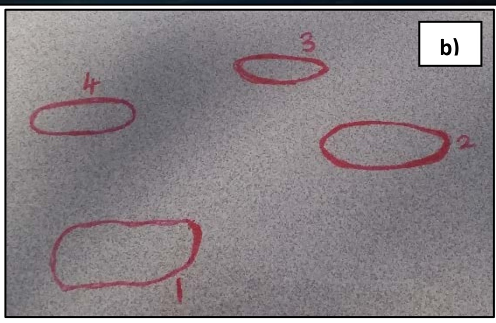

Figure 3. a) Image of photo taken from Nelly Island, Frazier Islands with clear plastic film placed over the computer screen with the 4 nests circled. Coloured circles indicate nests red: Nest 1, yellow: Nest 2, green: Nest 3 and blue: Nest 4 **b)** the clear plastic film circling the 4 numbered nests.

A nest was marked depending on its occupancy status as either 0 (nest unattended), AAC (2 adults, 1 chick), AC (1 adult, 1 chick), C (1 chick) or AA (2 adults). Data was then sorted by occupancy from time to date, with the highest occupancy overriding all other information for that day.

Data was graphed against month to reveal the breeding phenology from September to late March, with the exceptions of seasons 1 and 4 where cameras only captured December to late March and September to late January.

Incubation began when an adult was sighted on a nest and continuously remained on the nest until a chick was sighted.

The brooding period was calculated using the date the chick was first sighted to the date the adult stopped sitting on the chick and sat next to it.

The guard period was calculated using the date the adult stopped sitting on the chick and sat next to it to the date the adult first left the chick.

The projected number of days after hatching for fledging was calculated using the date the chick was first sighted to the date it was last on the nest for fledging.

Results

Out of all recorded nests across all seasons, there was a 35% success rate for possible breeding opportunities **(Table 1)**. Only 7 out of a possible 16 nests were successful in rearing a chick. Season 1 had a 75% success rate, Season 2 50% and Season 3 and 4 both had a 25% success rate. Nest 1 had a 100% success rate, Nest 2 25%, Nest 3 50% and Nest 4 a 0% success rate **(Table 1)**.

Breeding Success of all Nests					
Nest	**1**	**2**	**3**	**4**	**Success (%)**
Season					
S1	X	X	X		75
S2	X		X		50
S3	X				25
S4	X				25
Success (%)	100	25	50	0	

Table 1. The breeding success of all nests recorded across all 4 seasons. X marks a successful nest (a chick was recorded). Nest 1 was successful in all 4 Seasons, Nest 2 was successful in Season 1 and unsuccessful in Seasons 2, 3 and 4, Nest 3 was successful in Seasons 1 and 2 and unsuccessful in Seasons 3 and 4 and Nest 4 was unsuccessful across all 4 seasons. Therefore, 7 out of the 16 possible breeding opportunities were successful (35%).

Adults appeared to arrive at the colony from early September **(Table 2)**.

The incubation period began in early November and continued from mid-November to late January lasting for 65, 65, and 67 days (S2:N1, S3:N1, S4:N1), 80 days (S2:N3) and 82 days (S2:N2) with the egg hatching some time December and January.

Date First Adult Sighted				
Nest	**1**	**2**	**3**	**4**
Season				
S1*	ND	ND	ND	ND
S2	17/09/13	06/09/12	13/09/12	02/09/12
S3	01/09/13	01/09/13	02/09/13	01/09/13
S4	05/09/14	02/09/14	04/09/14	26/11/14

Table 2. The date that an adult was first recorded at a nest across all 4 seasons. S1* not recorded as data for Season 1 began later in the season in January where adults were already present. All adults arrived in September with the exception on S4, N4 with a later arrival in November. ND=No data.

Brooding began from early January to mid-February, when the chick was first sighted **(Table 3)** to the start of the guard period **(Table 4)**, this marked the onset of the chick provisioning and began in early February to mid-March. The guard period ended when the adult was deemed to have first left the chick alone when it was not sighted within or near the nest, this occurred in mid-January **(Table 4)**.

Date Chick Sighted				
Nest	**1**	**2**	**3**	**4**
Season				
S1	30/12/11	02/01/12	05/01/12	ND
S2	04/01/13	ND	12/01/13	ND
S3	06/01/14	ND	ND	ND
S4	10/01/15	ND	ND	ND

Table 3. The date that a chick was first recorded at a nest across all 4 seasons. Across all successful nests, a chick was first recorded in early January with the exception of S1, N1 where a chick was first recoded in late December. ND= No data.

The brooding period lasted for 17 (S1:N1), 13(S2:N1), 12 (S3:N1), 10 (S1:N2), 10 (S1:N3), and 4 days (S2:N3).

Start and End of Guard Period								
Nest	**1**		**2**		**3**		**4**	
	Start	End	Start	End	Start	End	Start	End
Season								
S1	15/01/2012	15/01/2012	12/01/2012	18/01/2012	15/01/2012	14/01/2012	ND	ND
S2	17/01/2013	20/01/2013	ND	ND	16/01/2013	19/01/2013	ND	ND
S3	22/01/2014	26/01/2014	ND	ND	ND	ND	ND	ND
S4	ND	ND	ND	ND	ND	ND	ND	ND

Table 4. The start and end of the guard period. Across all successful nests, the adult first stopped brooding the chick and began to guard it in early to mid-January.*Season 4 dates was not recorded as the data concluded on the 20/01/2015 and the adult was still sitting (brooding) on the chick. ND= No data.

The guard period lasted for 1 (S1:N1), 3 (S2:N1), 4 (S3:N1), 6 (S1:N2), 1 (S1:N3) and 3 days (S2:N3).

The combined brooding and guarding time for the chick was 18 (S1:N1), 16 (S2:N1), 16 (S3:N1), 16 (S1:N2), 11 (S1:N3), and 7 days (S2:N3).

The projected number of days after hatching **(Table 3, Table 5)** for fledging was 109 (S1:N1, S1:N2), 107 (S2:N1), 110 (S3:N1), 100 (S1:N3) and 97 days (S2:N3).

	Chick last on Nest			
Nest	**1**	**2**	**3**	**4**
Season				
S1	17/04/12	20/04/12	14/04/2012	ND
S2	20/04/13	ND	18/04/2013	ND
S3	25/04/14	ND	ND	ND
S4*	ND	ND	ND	ND

Table 5. The date that the chick was last recorded on the nest all 4 seasons. Across all successful nests, the chick first left the nest in late April. *Season 4 dates was not recorded as the data concluded on the 20/01/2015 and the chick was still present up to this date. ND= No data.

The adult completely left the chick and did not return in mid-March to late April **(Figure 4)**. An estimated fledging time was given between late April and early May **(Figure 4)** but could not be clarified as the data set concluded on the 30th of April for Seasons 1, 2 and 3 and the 20th of January for Season 4.

Courtship begins from late September through to late October **(Figure 4)**. The egg laying period was projected to occur also from early October through to early November **(Figure 4)**.

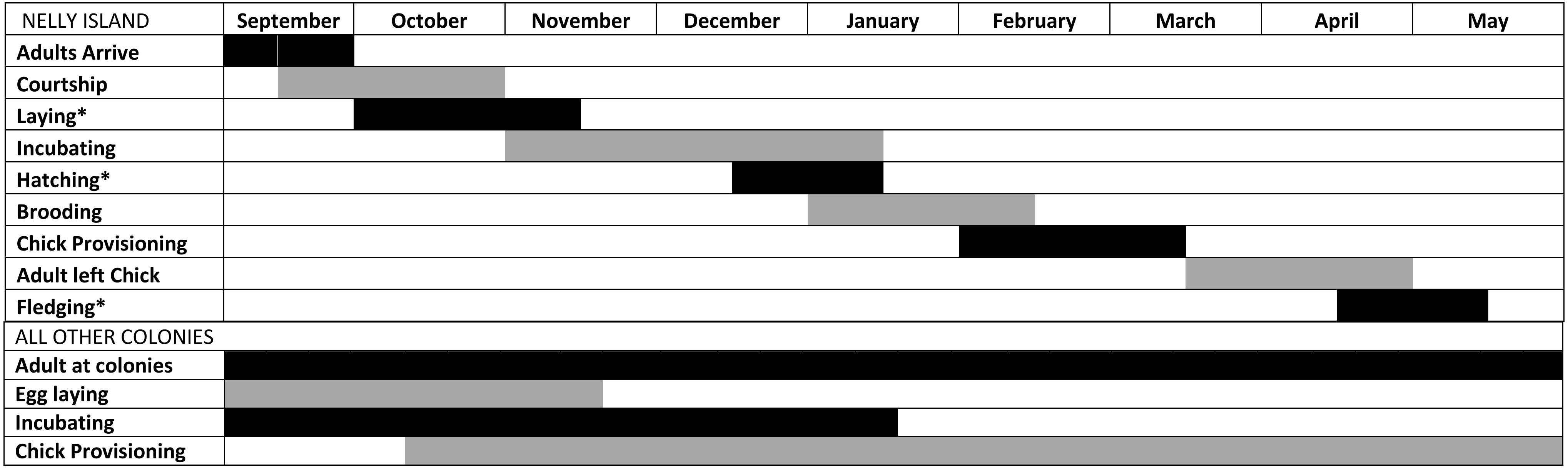

Figure 4. The projected breeding phenology of the Southern Giant Petrel colony located on Nelly Island, Frazier Islands and breeding phenology across all sites (ACAP) where birds tend to be present year round at colonies but numbers are lowest around mid-winter. *projections based on available data.

Discussion

Comparison with other Sites

Only 7 out of a possible 16 breeding opportunities were successful on Nelly Island during this study. All nests were used throughout all seasons however only Nest 1 was successful in all seasons, Nest 2 in Season 1 and Nest 3 in Seasons 1 and 2. On South Georgia, both species of giant petrel usually breed annually. However, in the 1978/79 breeding season 26.9 to 57.5% of previously breeding birds did not breed (paired or otherwise) in the following two seasons (Hunter 1984).

At Nelly Island, the egg laying period was projected to occur also from early October through to early November. A census on South Georgia during the 1978-81 and 1981-82 summer seasons was carried out; laying dates among *M. giganteus* ranged from 30 October - 14 November on Bird Island (1978-79), 5 November-20 November at Dartmouth Point (1979-80) and 3 November - 24 November again on Bird Island (1980-81) (Hunter 1984).

At Nelly Island, the incubation period began in early November and continued from mid-November to late January lasting for 65-82 days; eggs hatch some time in December and January. The incubation for both species of giant petrels has been recorded at 60 days (Hunter 1984). In comparison to Giant Petrels (not separated) at Macquarie Island, having the shortest recorded incubation period lasting 57-62 days (Warham 1962). On Heard Island, the incubation was recorded as 70 days (Downes *et al.* 1959) and for a single bird located at Terre Adelie, 60 days (Prevost 1953). This in comparison to other fulmars, such as the Northern Fulmar *Fulmarus glacialis* which has an incubation period of 40-57 days (Fisher 1952), the Southern Fulmar *Fulmarus glacialoides* 43-44 days (Prevost 1958) and approximately 45 days for the Cape Petrel (Downes *et al.* 1959), the Southern Giant Petrel on Nelly Island has a relatively longer incubation period.

The start of incubation for S1 could not be recorded as data began only on the 12th of January. An egg shell appeared to have been kicked out of Nest 1 during Season 3 on 03/01/201 4 and also during Season 4 on the same nest on 04/01/2015. During this same time, in Season 2 early January, again on Nest 1, a large amount of down feathers were recorded possibly indicating an egg had hatched. Sub-Antarctic skuas *Stercorarius maccormicki* were recorded in 4 incidences in Season 3 on Nest 3 from late November until early January possibly indicating an egg had been abandoned after which the adult remained at the colony. This phenomenon was also recorded in South Georgia whereby any eggs that were left uncovered were soon predated by sub-Antarctic skuas *Catharacta lonnbergi* (Hunter 1984).

Adult attendance with the chick can be divided into two stages, the brooding stage when both adults continuously sit on top of the chick, alternating throughout the period, and the guard or non-brooding period when the adult/s is still at the nest but instead frequently sat next to or near the chick rather than on top of it (Rice & Kenyon 1962). The guard period officially ceases when the chick was first observed without either adult present (Hunter 1984).

At Nelly Island, the brooding period was calculated to be 11±4 (range 4-17) days. At South Georgia, the brooding period was recorded as 18.4±2.2 days (Hunter 1984) similar to the Frazier Island, but compared to Macquarie Island, based upon 8 records, the chick was brooded for approximately 15-24 days (Warham 1962) which is shorter than on the Frazier Islands.

The data for Season 4 concluded on the 20th of January therefore the date the adult first left the chick could not be determined and, hence, neither could the brood and guard (non-brooding) period for this season within all nests. For those that could be determined, the period was 3±1 days (range

1-6). This guard period was similar to that recorded on South Georgia which was 2.4±2.2 days (Hunter 1984).

The combined brood and guard period calculated was 14±4 days (range 7-18). It has been stated that young chicks (in general, across all locations) have a combined brooding and guarding period of 24-26 days and has been attributed to when they attain thermal independence (ACAP 2012). This period appears to be a lot longer than what has been observed on the Frazier Islands. However, the current data was not calculated using the exact date of hatching making it difficult to determine when the brooding period began.

The projected number of days after hatching for fledging was 105.3±5.4 days (range 97-110). Generally, across all areas including Marion Island, fledging generally occurred 100-130 days after hatching which is concurrent with the data as hatching date was unknown. Therefore it is more likely to be longer than projected. This period is also similar for fledging on Macquarie Island, with 7 recorded determinations being 102, 103, 106, 108, 110, 113, and 117 days (Warham 1962). The fledging period recorded in Patagonia for Southern Giant Petrels lasted from late March to late April after only 86-125 days on the nest (Quintana *et al.* 2005).

At South Georgia, males fledged after 117±4.96 days and females, 123±5.61 days with male chicks recorded as having a longer mean fledging period than female chicks (Hunter 1984).

Data Caveats

I attempted to determine whether or not the same birds were using the same nests over the four consecutive seasons. However, this proved unsuccessful due to fluctuating lighting conditions that obscured any noticeable differences in the colouration of the partner birds.

In the sub-Antarctic, Southern Giant Petrels at Iles Crozet (Voisin 1988), Macquarie and South Georgia (Warham 1962, Hunter 1984), tend to not breed within the same nest as in previous years (Voisin 1988). In particular, at Iles Crozet, the same nest is rarely used two years in a row (Voisin 1988). Three birds, two breeding and one nonbreeding, that were observed for several seasons, had moved to other locations after being ringed (Voisin 1988). In comparison to Southern Giant Petrels at the South Orkneys and in Terre Adélie, Antarctica, appear to breed in much more stable colonies in old nests, or nest sites are largely reused (Voisin 1988). It is believed that this may be an adaption to cold climates as energy expenditure is higher and food harder to come by (Voisin 1988). By reusing the nests, there is a reduction in the cost of energy as they will not have to search for a new location (Voisin 1988). However, this explanation does not hold for the Southern Giant Petrel, *M. g. solanderi,* at the Falkland Islands, which is a sub-Antarctic environment, as they breed in permanent colonies (Voisin 1988).

The problem of lighting fluctuations was also encountered when trying to determine adult change overs at the nest. This determination was made for alternating incubation shifts between adults at South Georgia where on average, males undertook a significantly higher proportion (54.2%) of incubation than females (Hunter 1984).

For the best possible evaluation of the breeding behaviour of the birds, it would be ideal to have a complete data set. As the data for Season 1 began later (December) compared to all other seasons (September), and also the data in Season 4 concluded earlier (January) compared to all other seasons (April), some parameters for comparison could not be recorded. Therefore, vital information could have been missed. Having data for complete seasons would also provide higher validation of the results.

The comparison to Macquarie Island data was difficult as much information dated back to 1959-61 i.e. before the genus was separated into two species. However, the incubation and brooding periods recorded here were shorter than those observed at the Frazier Islands.

Due to the behaviour of the giant petrels, precise laying dates could not be determined. Southern Giant Petrels sit tightly on their eggs rendering them invisible. Also the frequency at which images were taken was too coarse for detailed observations.

Recommendations

Based on this report, the deployment of further automatic cameras and any such equipment used for monitoring purposes should be conducted in August as the first arrivals of adults and courtship has been observed to occur in early September. The recovery of such equipment should occur in June although cannot be relied upon as data was only recorded up until late April however fledging was projected to occur in late April, early May.

Conclusion

This study has used a non-invasive monitoring program through automatic cameras to observe the breeding phenology of a Southern Giant Petrel colony on Nelly Island. Since Southern Giant Petrels are extremely susceptible to any sort of disturbance, the continued use of the automated cameras should be supported and continued for the upcoming seasons to further identify and verify key events during breeding season. It is expected that by collecting data from the continued use of multiple cameras, will facilitate the identification of ecological drivers, allow practical, early detection of climate change or fisheries related impacts, and contribute to reliable bio-regional scale estimation for Antarctic populations (Southwell & Emmerson 2015). As banding of the species has been discontinued in Australia due to mortality, the same should be done for the rest of the world to protect the species, especially now that this method provides so much information on the breeding phenology of the bird. The need to construct an organized and long-term monitoring program for this species and long-lived species in general, has become more important than ever with climate change which continues to add to previous challenges faced by policy makers and wildlife managers (Wienecke *et al.* 2009). This report presents initial data from the Nelly Island automated camera monitoring system and lays down the foundation for continued monitoring within the Frazier Islands and it is hoped that through this ongoing research, Southern Giant Petrel colonies will continue to be conserved and protected.

Acknowledgements

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References

Agreement on the Conservation of Albatrosses and Petrels. 2010. ACAP Species Assessment: Southern Giant Petrel *Macronectes giganteus.*

Birdlife International 2016. Species factsheet: *Macronectes giganteus.* Downloaded from http://birdlife.org on 24/02/2016.

Bretagnolle, V. 1988. Social Behaviour of the Southern Giant Petrel. *Ostrich*, 59, 116-125, 10.1080/00306525.1988.9633712.

Chupin, I. 1997. Human Impact and Breeding Success in Southern Giant Petrel *Macronectes* *giganteus* on King George Island (South Shetland Islands). *Korean Journal of Polar Biology*, 8, 113-116.

Conroy, J.W.H. 1972. Ecological aspects of the biology of the Giant Petrel, *Macronectes giganteus* (Gmelin), in the maritime Antarctic*. British Antarctic Survey Scientific Reports*, 75, 1-74.

Creuwels, J., Stark, J., Woehler, E., Franeker, J. & Ribic, C. 2005. Monitoring of a Southern Giant Petrel *Macronectes giganteus* population on the Frazier Islands, Wilkes Land, Antarctica. *Polar Biology*, 28, 483-493, 10.1007/s00300-004-0663-8.

Downes, M. C., Ealey, E. H. M., Gwynn, A.M. and Young, P.S. 1959. The birds of Heard Island. ANARE Rep. Ser. B. 1. 135pp.

Fisher, J. 1952. The Fulmer. Collins, London 496pp.

Hunter, S. 1984. Breeding biology and population dynamics of giant petrels Macronectes at South Georgia (Aves: Procellariiformes). *Journal of Zoology*, 203, 441-460, 10.1111/j.1469-7998.1984.tb02343.x.

Hunter, S. 1985. The Role of Giant Petrels in the Southern Ocean Ecosystem. *In* Seifried, W. & Condy, P., *ed.*. *Antarctic Nutrient Cycles and Food Webs*. Berlin Heidelberg: Springer, 534-542.

Management Plan for Antarctic Specially Protected Area No 160: Frazier Islands, Windmill Islands, Wilkes Land, East Antarctica Measure 14 (2013) Annex ATCM XXXVI Final Report

Newbery, K.B. and Southwell, C., 2009. An automated camera system for remote monitoring in polar environments. *Cold Regions Science and Technology*, *55*, 47-51.

Patterson, D., Woehler, E., Croxall, J., Cooper, J., Poncet, S., Peter, H., Hunter, S. & Fraser, W. 2008. Breeding Distribution and Population Status of the Northern Giant Petrel *Macronectes Halli* and the Southern Giant Petrel *M. Giganteus*. *Marine Ornithology*, 36, 115-124.

Prevost, J. 1953. Notes sur l'ecologie des petrels de Terre Adelie. Alauda, 21, 205 -222.

Prevost, J. 1958. Note complementaire sur l'ecologie de petrels de Terre Adelie. Alauda, 26, 125-130.

Quintana, F., Schiavini, A. & Copello, S. 2005. Estado poblacional, ecología y conservación del Petrel Gigante del Sur (*Macronectes giganteus*) en Argentina. *El Hornero*, 20, 25-34.

Rice, D. & Kenyon, K. 1962. Breeding Cycles and Behavior of Laysan and Black-Footed Albatrosses. *The Auk*, 79, 517-567, 10.2307/4082639.

Rootes, D. M. 1988. The status of birds at Signy Island, South Orkney Islands. *British Antarctic Survey Bulletin,* 80, 87-119.

Schulz, U., Krüger, L. & Petry, M. 2014. Southern Giant Petrel Macronectes giganteus Nest Attendance Patterns under Extreme Weather Conditions. *Zoological Science*, 31, 501-506, 10.2108/zs130135.

Southwell, C. & Emmerson, L. 2015. Remotely-operating camera network expands Antarctic seabird observations of key breeding parameters for ecosystem monitoring and management. *Journal for Nature Conservation*, 23, 1-8.

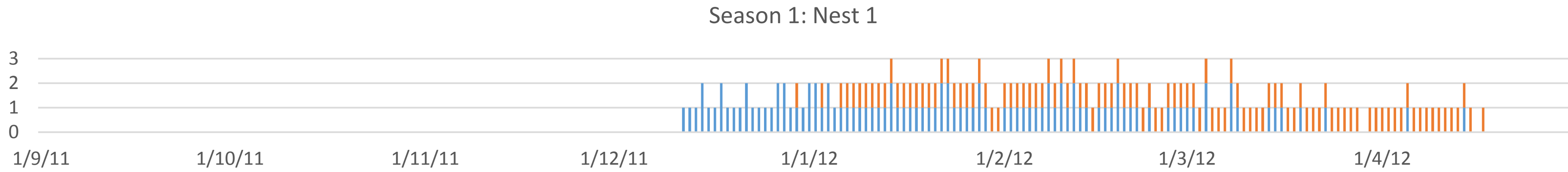
Stattersfield A.J., Capper D.R. (2000) Threatened birds of the world. Lynx Ediciones, Barcelona, and BirdLife International, Cambridge.

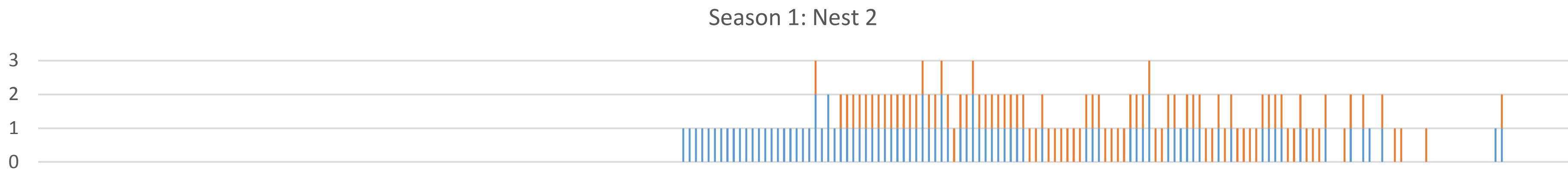
Voisin, J. 1988. Breeding Biology of the Northern Macronectes Halli and the Southern Giant Petrel M. Giganteus at Ile De La Possession, Iles Crozet, 1966-1980. *Cormorant*, 16, 1988.

Warham, J. 1962. The Biology of the Giant Petrel Macronectes giganteus. *The Auk*, 79, 139-160, 10.2307/4082519.

Wienecke, B., Leaper, R., Hay, I. & van den Hoff, J. 2009. Retrofitting historical data in population studies: southern giant petrels in the Australian Antarctic Territory. *Endangered Species Research*, 8, 157-164, 10.3354/esr00201.

Appendix


Season 1: Nest 1
3
2
1
0
1/9/11
1/10/11
1/11/11
1/12/11
1/1/12
1/2/12
1/3/12
1/4/12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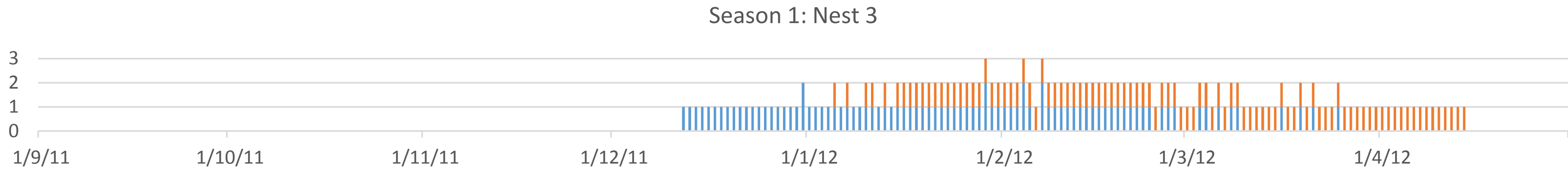
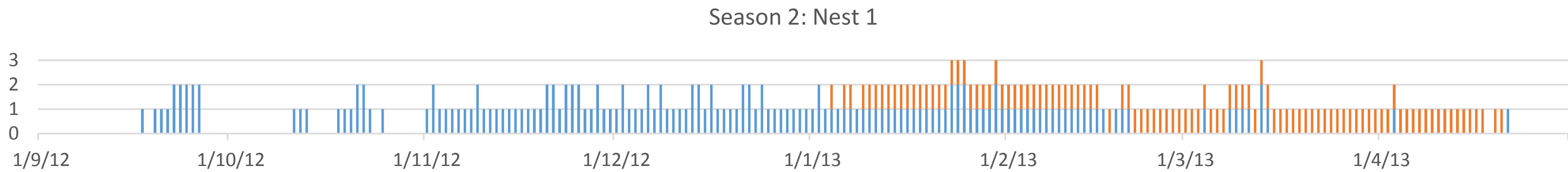
3
2
1
0


Season 1: Nest 3
3
2
1
0
1/9/11
1/10/11
1/11/11
1/12/11
1/1/12
1/2/12
1/3/12
1/4/12


Season 2: Nest 1
3
2
1
0
1/9/12
1/10/12
1/11/12
1/12/12
1/1/13
1/2/13
1/3/13
1/4/13

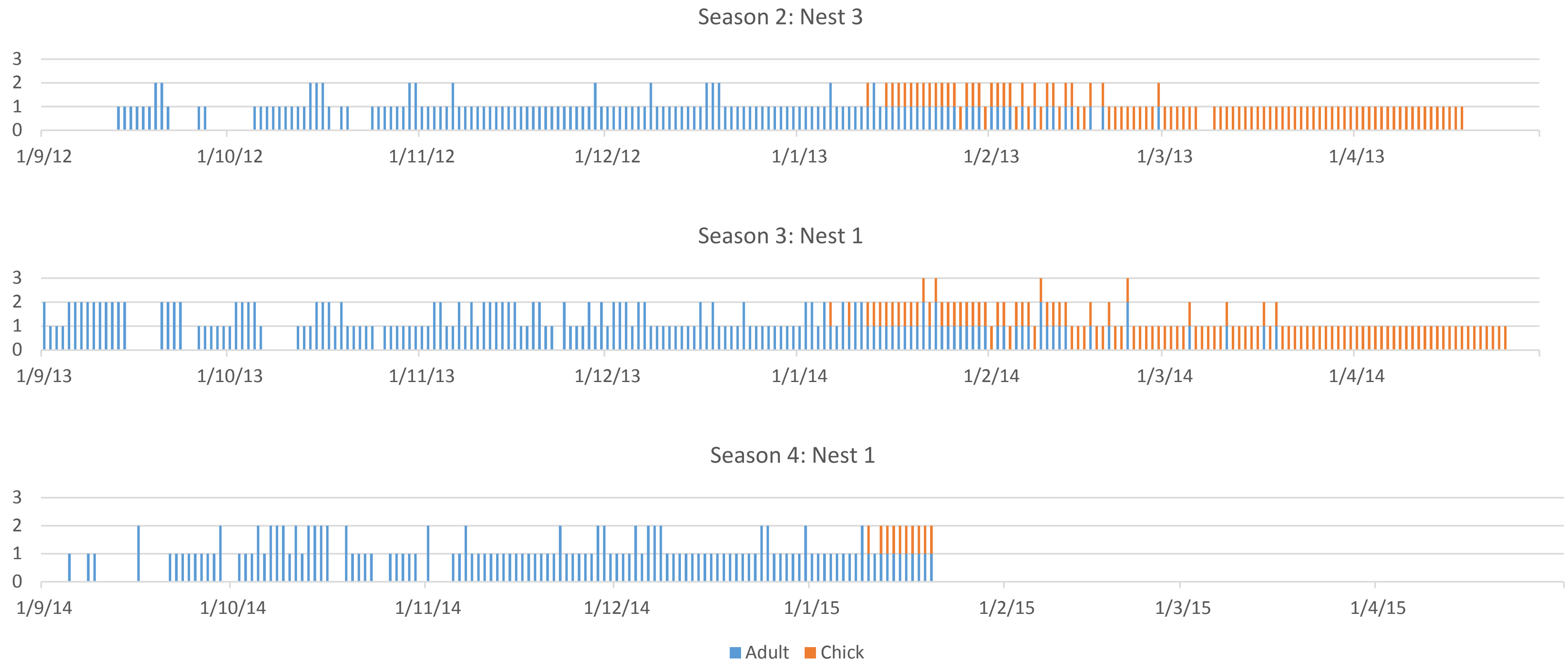


Figure 5. Plots displaying all successful nests. Nest 1 was successful in all 4 Seasons, Nest 2 was successful only in Season 1, Nest 3 was successful only in Seasons 1 and 2 and Nest 4 was not successful in any season.