Roseate Tern Recovery Project

New Approaches and Review of Island Management

Bluenose Coastal Action Foundation

Annual Report 2008 (Year 6)

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The aim of this document is to provide BCAF with a framework for future studies (i.e. what data could be collected and how to collect the data) that will provide valuable insight into some of the more obvious pressures and reasons why terns have preferentially selected some islands over others to nest, and to highlight some of the factors that have and may continue to limit their success. This document will facilitate data entry and detail those methods which could be used for the long-term collection of tern presence and abundance measures in Mahone Bay and provide the impetus for future areas of study. To facilitate understanding, methods, and results, recommendations have not been provided in a strictly scientific fashion, but rather provided in every-day language.

In 2008, tern presence (in transit, roosting and nesting) data was mapped using GPS waypoints uploaded onto a satellite image of Mahone Bay using ArcGIS (Version 9) editing tools. This is also the first year BCAF has collected data relating to: primary ocean productivity; mink populations (a highly effective predator); proximity of foraging areas to nesting areas; boat use and development pressures (from mooring data collected from local yatch clubs); historic trends in precipitation (that correlate the likelihood of abandonment with precipitation over an 8 year period); and nesting preferences with respect to local ecologic conditions. Research was directly related to CWS's Roseate tern Recovery Strategy (2006) and BCAF objectives as defined in their funding agreements.

1 Background

1.1 Introduction

The Mahone Bay Roseate Tern Recovery Project (RTRP) was initiated in April 2003 by the Bluenose Coastal Action Foundation (BCAF), a local non-profit conservation organization and member of the Atlantic Coastal Action Program (ACAP). The primary goal of this project is to aid in the recovery of the endangered Roseate tern (*Sterna dougallii)* by helping to monitor and manage tern populations within Mahone Bay and increase awareness of their presence and sensitivity to disturbance through public educational programs and advertisements. This project builds upon BCAF's Coastal Islands Project (2000-2003), where data had been collected for approximately 70 islands within the Bay specific to their ownership, state of development, and local ecologic conditions.

The Roseate tern is a migratory seabird protected under the Migratory Birds Convention Act 1994, and is under the management jurisdiction of the federal government. This species was listed as endangered within the Species at Risk Act (SARA) in June 2003. The Canadian Wildlife Service (CWS) – Atlantic Region, Environment Canada, has led in the development of a mandated recovery strategy for the Roseate tern and subsequently produced the *Recovery Strategy for the Roseate Tern (Sterna dougallii) in Canada* (http://www.sararegistry.gc.ca/virtual_sara/files/plans/rs_roseate_tern_1006_e.pdf), published in 2006 and herein referred to as the "Strategy 2006". The abovementioned document provides the guiding principles of how to manage and aid in the recovery of this species and BCAF is committed to working alongside CWS to support their recovery efforts.

The Roseate tern has also been listed in the Eastern United States as endangered, and Canada's new Strategy (2006) "sets goals and objectives that will contribute to the recovery of the Roseate tern on both sides of the border". In collaboration with biologists from CWS, BCAF has developed specific research and educational programs to assist Environment Canada in achieving both long-term and short-term objectives of the Strategy: to help restore a broader distribution of Roseate terns by establishing at least one more managed colony; to remove or reduce threats to Roseate terns and their habitat; and to have no fewer than 150 pairs of Roseate terns nesting in at least three colonies in Canada.

1.2 Threats to Roseate Terns

The primary threats to the reproductive success of terns, including Roseate terns, are predation (mainly by gulls, corvids, and mink) and habitat displacement (Strategy 2006). Where they occupy a limited breeding area, such as in Mahone Bay; human disturbance, habitat loss caused by development and rising sea levels, catastrophic weather events (likely to increase as a result of climate change), pollution, and disease further threaten their recovery.

1.3 Site Description

Mahone Bay (44°30'N, 64°15'W) is situated on the Eastern Atlantic coast of Nova Scotia. Lunenburg (pop. 2,600), Mahone Bay (pop. 1,015), and Chester (pop. 1,591) are the three most populated communities situated on its shores, with Halifax approximately 80 km to the Northeast. The area is a popular destination for boaters originating from within Nova Scotia and abroad. Within the Bay are numerous small to medium sized islands (200m^2 to 2400m^2) supporting a variety of habitats (rocky shores, cobble and sandy beaches, dunes, wetlands, and a variety of native vegetation such as beach pea, beach grass, rose, etc.) with local ecological conditions consistent to those preferred by nesting tern species.

Figure 1. Map of Mahone Bay

1.4 Roseate Terns and Mahone Bay – A Brief History

The coastal islands within Mahone Bay lie midway between Atlantic Canada's two officially "managed" tern colonies; Country Island and The Brother's Island. Grassy Island, within Mahone Bay, historically supported one-third of the breeding Roseate tern population in Canada. In the mid-1990's, terns abandoned Grassy Island having been displaced by predatory Herring gulls (*Larus argentatus*) and Great Black-backed gulls (*L. marinus*) which establish their nests three weeks to a month earlier than Common (*Sterna hirundo*), Arctic (*Sterna paradisaea*) and Roseate terns. According to local residents, Grassy Island has succumbed to significant erosion caused by rising sea levels, and in 2008, was a tiny (<350m^2) rocky outcrop, barren of shrubs and trees, and appeared susceptible to flooding given its low lying profile. Since the mid-1990's, and displacement from Grassy Island, terns collectively nested on Mash Island in 1995 (500 individuals including Roseate terns) and following abandonment of this colony (likely from mink predation), have not preferentially selected one island to nest, but rather have chosen to nest in smaller colonies on several other islands within the Bay (2000-2008). BCAF has reported that the breeding success of local tern populations since 2003 has been poor (caused predominately by flooding, mink predation, and anthropogenic disturbances), albeit accurate quantification of this measure has been difficult to determine as the project (2004-2007) had focused on "managing" Quaker Island (deterring predators, etc.) as opposed to quantifying productivity and stewardship bay wide.

1.5 2008 Funding Objectives

BCAF received funding from the Habitat Stewardship Program for Species at Risk, the Atlantic Coastal Action Program, and the Environmental Damages Fund to carry out the 2008 RTRP. Accordingly, effort was made to ensure research and education efforts satisfied the agreements made therein.

2 Logistics

2.1 Permits

Pearl Island is provincially designated as a Wildlife Management Area, and as such, activities within 1 nautical mile are prohibited without a permit (albeit fishing activities are not restricted within waters offshore of the island). Terns have nested on Pearl Island in past years; therefore, a Scientific Permit

from NS Department of Natural Resources (NS DNR) was sought and obtained allowing BCAF: (1) to conduct visual observations three times per week from a boat within the regulated abovementioned limit while accompanied by either CWS or DNR staff and (2) land on the island following colony abandonment (to identify possible causes of abandonment) while accompanied by either CWS or DNR staff to conduct an egg count and to count the number of chicks.

Grassy Island is also designated as a Wildlife Management Area; therefore, if gull nest and egg counts are to be conducted in future years, a permit to land and conduct the counts must first be obtained from NS DNR.

2.2 Transportation, Health and Safety

A 20' Boston whaler, generously donated by Rick and Barb Welsford, was used for monitoring purposes. BCAF ensured the boat and technicians were supplied with appropriate safety equipment including a marine radio, cellular telephone, flares, throw lines, a GPS unit, maps, etc. An equipment check-list was created and float plan completed prior to departure. A "boat-to-office" reporting procedure was initiated to ensure boaters were safe, at all times, while at sea. All field staff successfully completed a Small Craft Operators Course and Emergency First Aid Course. Kayaks were also used for monitoring purposes and, as noted above, staff were equipped with the appropriate safety gear and used similar reporting procedures.

3 Research and Monitoring Protocols

3.1 BCAF Roseate Tern Recovery Efforts 2003-2008

2003-2007

Efforts to measure abundance, distribution, and success of tern and predatory gull populations have been documented (to varying extents) by BCAF beginning in 2000, and from 2003 when Quaker Island was selected as the site for stewardship in Mahone Bay. This island was specifically chosen to act as the "managed site" based on site selection criteria developed by the US Roseate Tern Recovery Team and approved by CWS using two separate matrices, the Biological Suitability Criteria (BSC) and the Logistic Practicality Criteria (LPC). Generally speaking, information was gathered pertaining to site suitability by determining the ownership status of islands within Mahone Bay, determining the degree

to which islands are subject to human disturbance, and assessing islands in terms of size and accessibility to researchers. Tern and gull colonies were surveyed, tern foraging areas were documented, evaluation of land-based predators undertaken, productivity of gulls and terns were measured, flooding potential evaluated, and long-term island stability and habitat suitability surveys undertaken under the guidance of Andrew Boyne and Jason Beukens from the Canadian Wildlife Service. Given this study was undertaken solely during the summer of 2003, results of the abovementioned criteria are based on a limited amount of data (this study aims to provide insight into other areas where monitoring and research would provide more quantitative evidence to support selection of any one particular island for management as opposed to another island).

From 2004-2007, BCAF facilitated research and worked towards re-establishing a major tern colony on Quaker Island by using decoys, nesting boxes, a sound system playing tern calls, predator deterrence (human presence, pyrotechnics), and predator control measures (gull egg destruction and mink trapping). Using scopes and binoculars, observations of predatory behaviours and disturbances were monitored and local tern and gull abundance, distribution, and success on this and other islands within the Bay measured and documented.

The absence of tern breeding success from 2004-2007 on Quaker Island (caused by flooding, mink predation, and potentially anthropogenic disturbances), led BCAF, in consultation with CWS, to re-focus their efforts in 2008.

2008

This year, technicians were not stationed on Quaker Island, and alternatively, conducted broad-based surveys documenting tern abundance, distribution, success, and foraging habits throughout Mahone Bay. Primary gull colonies were also surveyed and predator watches were conducted to document conspicuous disturbances. In an attempt to better understand the potential factors influencing tern success, BCAF technicians investigated factors such as: primary ocean productivity; mink populations (a highly effective predator); proximity of foraging areas to nesting areas; boat use and development pressures (from mooring data collected from local yatch clubs); historic trends in precipitation (that correlate the likelihood of abandonment with precipitation over an 8 year period); and nesting preferences with respect to local ecologic conditions (from vegetation/substrate surveys), which may play a part in the breeding success of terns in Mahone Bay. Improvements to data collection methodologies, mapping, documentation, and continued public education and outreach efforts will

improve planning and decision making capacities. Notably, BCAF has remained committed to increasing public education and awareness of the inherent value of terns and their vulnerability to anthropogenic disturbances.

3.2 Marking and Mapping

Marking where terns are foraging, in transit, roosting, and nesting

Islands within Mahone Bay were observed using binoculars and/or a spotting scope (generously loaned from Paul MacDonald) from a boat (20' Boston Whaler generously loaned by the Welsfords), or from land (Westhaver and Gully Islands). The number of individual terns found roosting, within close proximity (in the water <100m), foraging, or nesting was recorded (Figure 2).

More specifically, foraging, flying (in transit), roosting, and nesting areas were identified in the field using GPS waypoints (+/-50m for those birds foraging and identified in transit since it was not always safe to veer from our pre-determined boating course due to time, weather, and sometimes navigational constraints, hence the large degree of error). These points were subsequently uploaded, using GPSBabelGUI, onto a spatially referenced satellite image of Mahone Bay (the base map), using ArcGIS, and provided excellent spatial representation of those areas utilized by tern species within the bay. The relative areas occupied by nesting terns on individual islands and the total area used by nesting terns were calculated using a statistical function within ArcGIS (refer to the attribute table for the "nesting area" shape file and also Table 2 below) following polygonization of colonies. This satellite image and base map could be used in future years if staff were to continue to mark all locations where terns are found foraging, nesting, etc. using BCAF's GPS unit, and could be used for inter-year comparisons of how terns use and occupy sites within the bay. Preferred nesting densities and nest site selection preferences in relation to local ecological conditions or anthropogenic disturbances could be evaluated based on the success or failure of a breeding colony (and many other possible research questions could be similarly answered) provided similar data is collected in future.

3.3 Productivity - Nest and Egg Counts

Gulls

A nest and egg count for all significant gull breeding colonies (>100 individuals) should be conducted in mid-late May (BCAF technicians should conduct visual surveys of these colonies to confirm the

presence/absence of birds incubating and contact the appropriate CWS staff member to discuss their findings and to confirm an appropriate date for the nest and egg count). Note: a permit from NS DNR is required to land on Grassy Island unless staff is accompanied by CWS (who have the required permits to conduct research within provincially designated Wildlife Areas).

Egg counts should be conducted prior to any significant number of hatchings to minimize undue stress to the chicks and ensure accuracy of the counts. If researchers cause the adults to flush from their nests, chicks are left particularly susceptible to weather conditions (heat, cold, wet). The chicks also tend to leave their nests shortly after hatching, and because they are camouflaged, the risk of stepping on one greatly increases. The four main islands with gull nesting in 2008 were Pearl, Grassy, Chockle Cap, and Star Islands. Unfortunately, nest and egg counts for gulls could not be completed in 2008. The boat was not safe for use until the end of May, and by the time technicians were made aware of other counts from CWS, many eggs had already hatched and chicks were freely roaming outside of their respective nests. Technicians did however conduct surveys from the boat and counted the individuals at each colony (Figure 3). Further insight into gull population dynamics in Mahone Bay would be available if monitoring practices remained consistent.

Terns

Consistent with data collected in 2003, a nest and egg count was conducted on June 16th, 2008, with CWS's Brad Toms (Species at Risk Technician) on Westhaver, Masons, Quaker, and Pearl Islands (Table 2 and Figure 3). Counts were conducted by a team of three people walking a path through the nesting colony, approximately 1m apart. The outside observer placed flags in the ground to mark the boundary where nests had been counted. When a nest was found, the number of eggs within was called out and CWS's Toms recorded the data. A small piece of Popsicle stick was placed beside the nest to avoid counting any one nest twice.

Ideally, nest, egg, and individual counts should be conducted on all islands during the same day to minimize the potential for error in estimation, especially considering terns can quickly and easily relocate and re-nest. If terns have re-laid, another count later in the season should be conducted, providing the risk of disturbance to earlier nesting birds and their eggs/chicks is minimal (see below).

An additional nest and egg survey was conducted with CWS's Toms on Crow and Quaker Islands on July 16th, 2008, (Table 2, Figure 4). Although terns were not observed on Crow Island earlier in the

nesting season, they appeared following abandonment of those nesting on Masons and Pearl Islands. Quaker Island was revisited because terns were found eliciting nesting behaviours in another area of the island from that which had originally been used by earlier nesting birds (an area approximately 50m NE from the original colony). Although it appeared that the Pearl Island colony had abandoned their three nests following routine monitoring, later surveys showed a marked increase in their numbers (n=31). An additional count was going to be conducted on July 16th, 2008, with Toms; however, ocean conditions prevented landing.

3.4 Predation Monitoring

Once terns were found breeding on an island, efforts to monitor for predators commenced using binoculars and/or a spotting scope from land and/or sea. Monitoring periods ranged from approximately 30 to 60 minutes and observations were conducted at a distance of between 50 and 800m. Observations such as the proximity of the predator (gull/corvid, etc.) to the breeding colony, behaviour of predator (in flight overhead colony/landed in the colony, etc.), and response from terns (colony flushed, individual tern chased gull, etc.) was recorded. Boat traffic near nesting colonies was also monitored and response by terns to such traffic documented. Monitoring results are presented in Table 3 and 3a, and additional details relating to the effect of predation and anthropogenic disturbance are presented in the Results and Discussion sections of this document. The methods used in 2008 were similar to those used in previous years and, as noted below, could be improved to better understand the impact predation and disturbance is having on the success of local tern populations.

3.5 Success – Fledgling Terns Counts

Although the method used to estimate fledgling success in 2008 was not ideal, it did provide a conservative measure of reproductive success on the two islands where terns successfully nested in 2008, which could be improved upon in future years. Briefly, 5 technicians approached Westhaver Island on July 29th, using 3 kayaks and the Boston Whaler, each individual positioned themselves so they could count (at the same time) the number of fledglings in sight, and within a specified quadrant (in this case, ¼ of the islands circumference). Following the survey, one person landed on Westhaver to check for any fledglings inside the lighthouse ring (none were found), but a thorough land survey was not conducted. At the end of the survey, the numbers were summed. A similar approach was used on Gully Island, but this time three persons landed on the island to check for chicks that could not yet

fly (none were found). A subsequent count was attempted on August 8th, 2008, at both islands to try and maximize the accuracy of the count; however, the vast majority of terns had already left the islands by this date.

3.6 Foraging Behaviours, Nest Site Selection, and Proximity to Quality Foraging Grounds

Published data (Rock 2007) suggests that Roseate terns prefer to consume sand lance and to forage within 7km of their nesting colony over shallow waters <5m in depth with sandy bottoms (where sand lance are most prevalent). Although it is possible that terns were using sand lance as a food source, it was found that they were definitely feeding on juvenile herring, which may have been more readily available. Nautical maps (electronic), provided by Rick Welsford, were uploaded as a layer onto the base map (using ArcGIS) and "marked" locations where terns were found foraging from 2008 bay wide surveys are shown in Figure 1.

In addition, the nautical maps were used to identify and quantify those potential forage areas where waters are <5m in depth (using the 5m contour lines from the nautical maps), within 1.3 km of the mainland, and within 0.3km from the closest point of land where Rock (2007) found the vast majority of Roseate terns were feeding (n=9) in a study of terns on Country Island (2003-2004). These forage areas were then quantified using Rock's preferential measures (i.e., distance to shorelines, <5m water depth) to present-day and past Roseate tern colonies where numbers exceed(ed) 50 breeding pairs. The islands found most favourable to support Roseate terns were not completed as the field crew ran out of time but those islands supporting suitable habitat seem to be those identified in BCAF's initial island study (RTRP 2003 Report). These also seem to be the islands which terns inhabit each year when returning from South America to breed.

3.7 Habitat Supportive of Breeding Terns

Dr. Jeremy Lundholm, plant biologist from Saint Mary's University, Halifax, helped quantify habitat and vegetation on islands supporting breeding tern colonies in 2008 on August 26th, 2008, at Westhaver, Gully, and Quaker Islands. A $1m^2$ sampling frame was constructed from PVC pipe and 2 rows and 2 columns of cord were attached at 33.3 cm intervals (equally spaced holes were drilled into the PVC pipe and the string attached) creating 9 squares. At the center of each of the 9 squares, a broom stick was positioned and the vegetation and underlying substrate was identified and categorized

respectively. The sampling frame was placed along a transect at specific intervals (i.e., 5m or 20m apart). Transects were placed within conspicuous vegetative zones. Surveys were conducted at the end of the reproductive cycle (late August) to ensure terns and their young were not subject to undue stress and chicks were post-fledging. In subsequent years, it would be advantageous to conduct sampling prior to when terns commence nesting, when vegetation is likely more representative of that when terns select their nest sites. It was found that terns preferred to nest on mostly cobble substrate with little to no vegetation. The majority of vegetation found when the surveys were conducted was invasive, often referred to as weeds, which would not have been present when the terns were selecting a nesting site earlier in the season. Since surveys did not seem to show results that differed from previous research by other groups, it is recommended that these surveys are not continued.

4 Results

4.1 Bay Wide Surveys

During the 2008 summer field season, BCAF technicians conducted surveys throughout Mahone Bay. Technicians visited those islands where terns and gulls had historically nested, along with the majority of islands throughout the bay, in search of any sites/islands being used for roosting and breeding. Surveying started on May 29th, and ended on August 7th, following completion of the breeding cycle. Table 1 shows those islands visited, the number of times each island was visited throughout the summer, and the maximum number of terns observed.

Table 1. Islands Surveyed, 2008.

Island	Number of Visits	Number of Terns Observed
Bachmans	2	1
Big	1	
Chockle Cap	6	
Coveys	2	1
Crow	18	43 (breeding)
Flat	1	
Frog	1	
Grassy	6	
Gully	9	75 (breeding)
Hobsons	3	25
Iron Bound	1	
Lloyds	1	
Long Island	1	
Lynch	2	1
Mash	8	20 (scrapes only)
Mason	13	61 (breeding)
Mountain	1	1
Pearl	7	75 (breeding)
Quaker	21	40 (breeding)
Rackets	2	
Rafuse	2	1
Saddle	9	25 (scrapes only)
Small	1	
Spectacle	2	
Star	3	
Westhaver	28	150 (breeding)

While conducting the surveys, technicians marked terns in transit, roosting, and foraging using a GPS unit and uploaded these waypoints onto a satellite image of the bay using ArcGIS (Figure 1). Areas used for nesting were subsequently drawn as polygons, and are shown in Figures 1a, 1b, 1c, and 1d below.

Figure 1. Tern (Common and Arctic) in transit, roosting, foraging, and nesting locations within Mahone Bay, 2008.

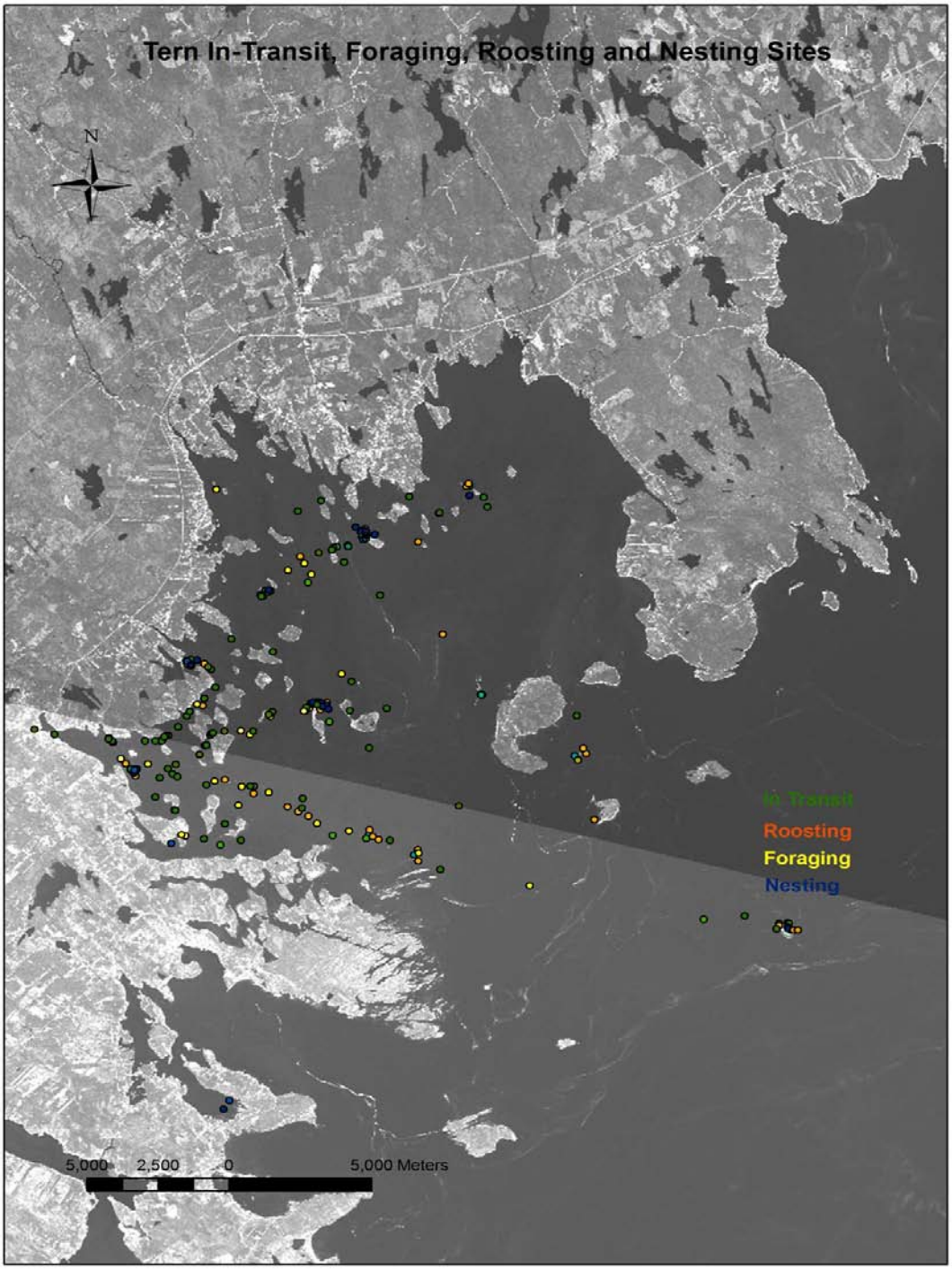


Figure 1a. Tern (Common and Arctic) nesting colonies/islands (Crow, Masons, and Westhaver Islands), 2008.

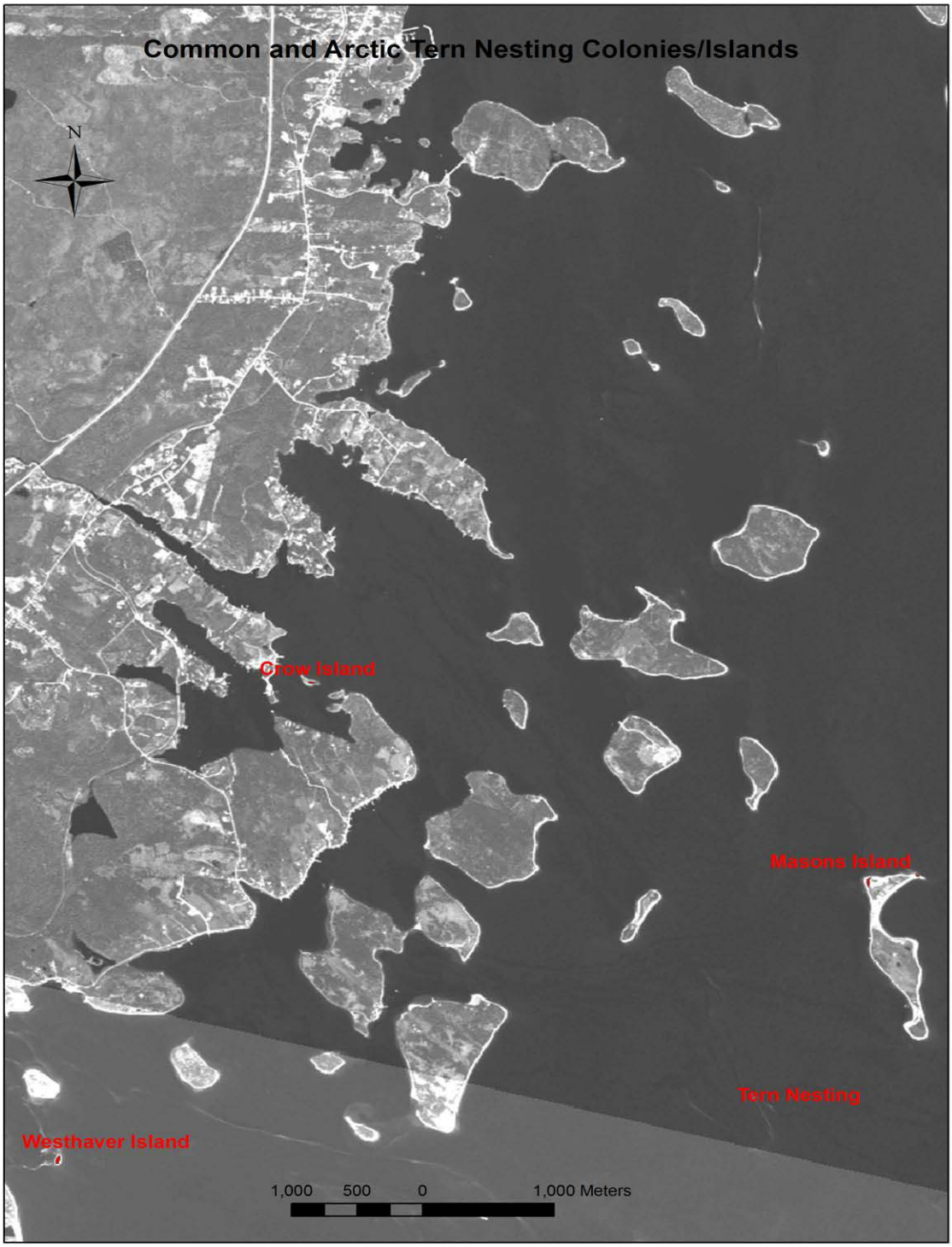


Figure 1b. Tern (Common and Arctic) nesting colonies/islands (Quaker Island), 2008.

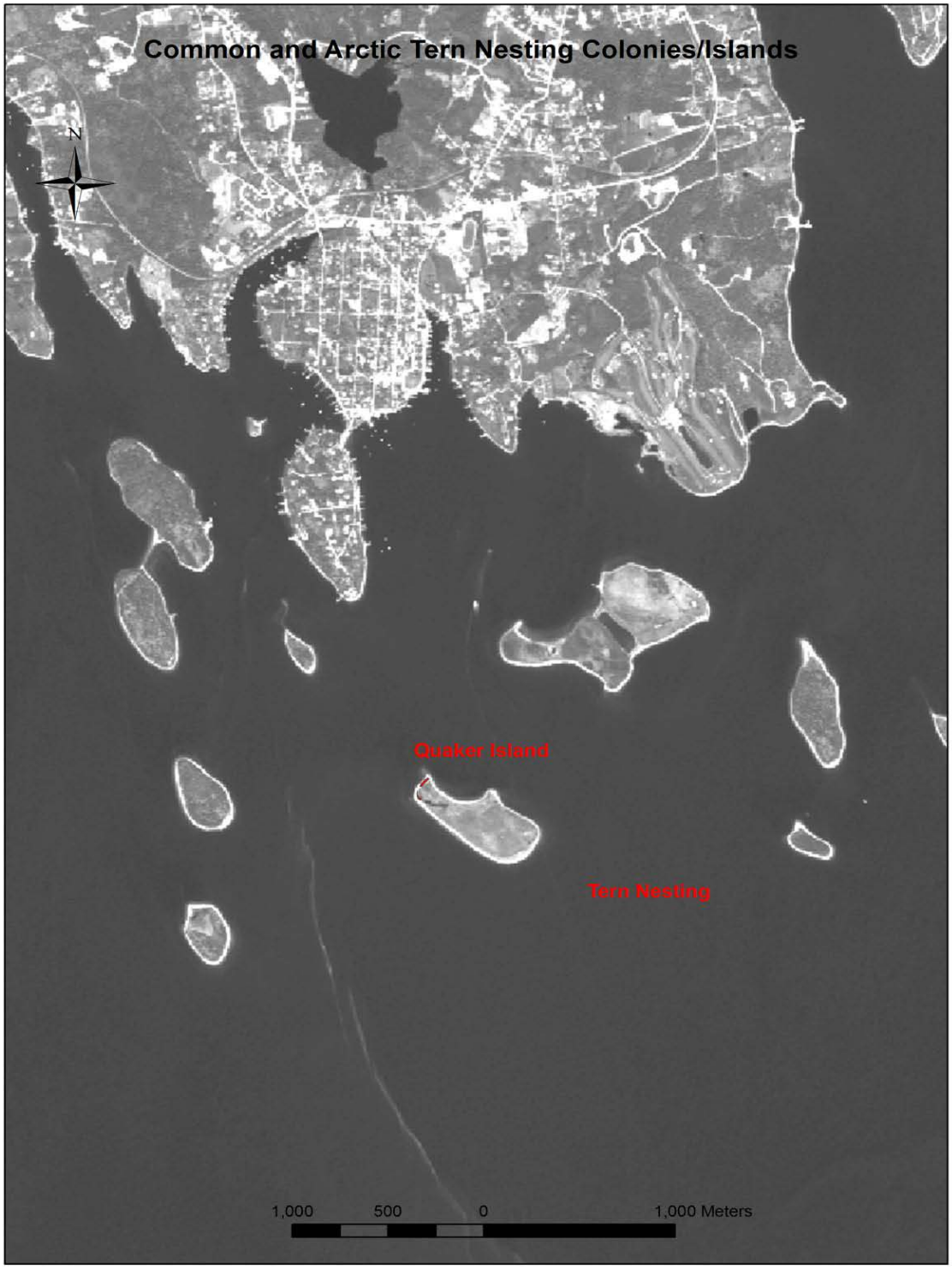


Figure 1c. Tern (Common and Arctic) nesting colonies/islands (Pearl Island), 2008.

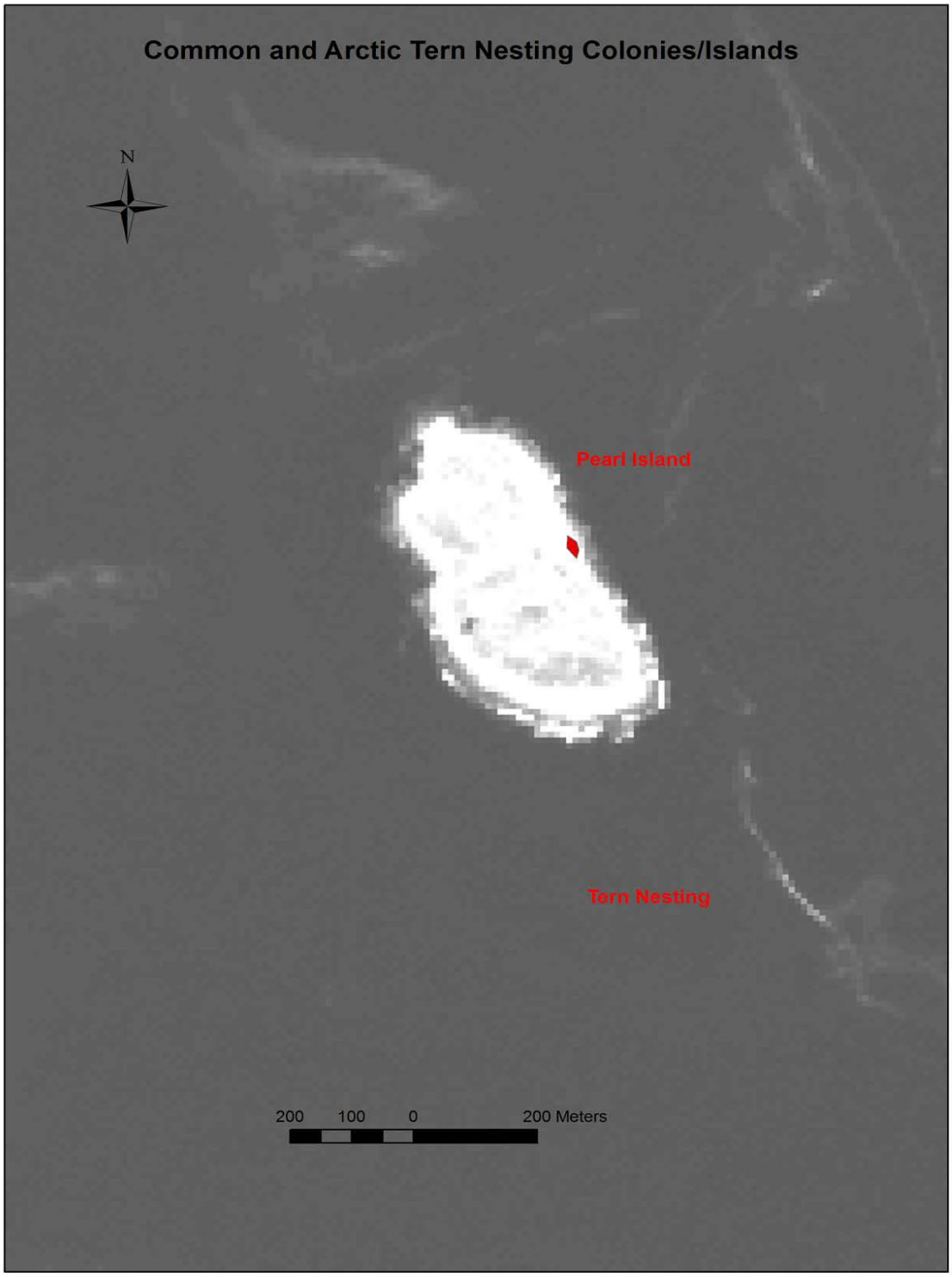


Figure 1d. Tern (Common and Arctic) nesting colonies/islands (Gully Island), 2008.

4.2 Nest and Egg Counts

Gulls

The four main islands gulls used for nesting in 2008 were Pearl, Grassy, Chockle Cap, and Star Islands. Nest and egg counts for gulls could not be completed in 2008. Technicians did, however, conduct observational surveys from the boat and counted the number of gulls in these breeding colonies. As presented in Figure 2 below, Pearl Island appears to have supported the largest breeding gull colony followed by Star, Chockle Cap, and Grassy Islands. Figures 3a and 3b present this data alongside that similarly collected in 2002 and 2003, and results indicate populations have not significantly changed (albeit further statistical analysis to show significance was not performed and could be in future).

Figure 2. Gull abundance, 2008.

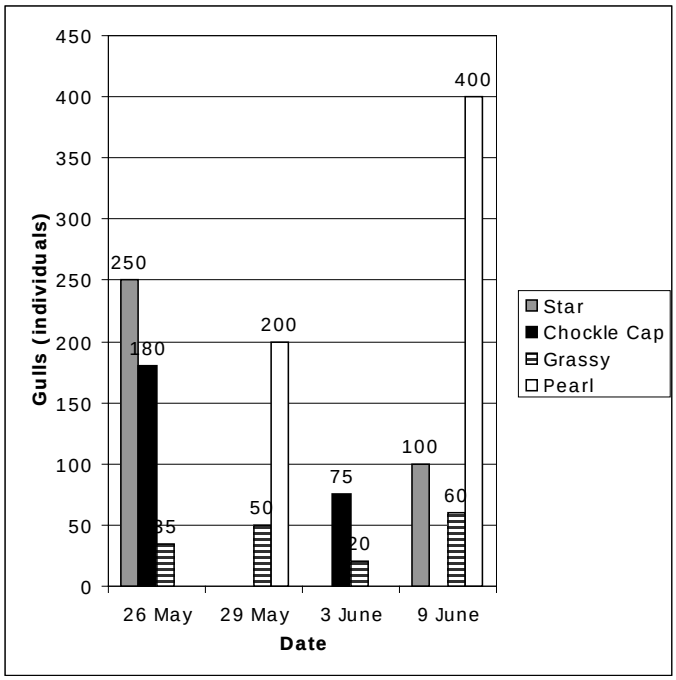


Figure 3a. Gull abundance on islands where significant numbers of gulls were found breeding (data was not available for 2004-2007).

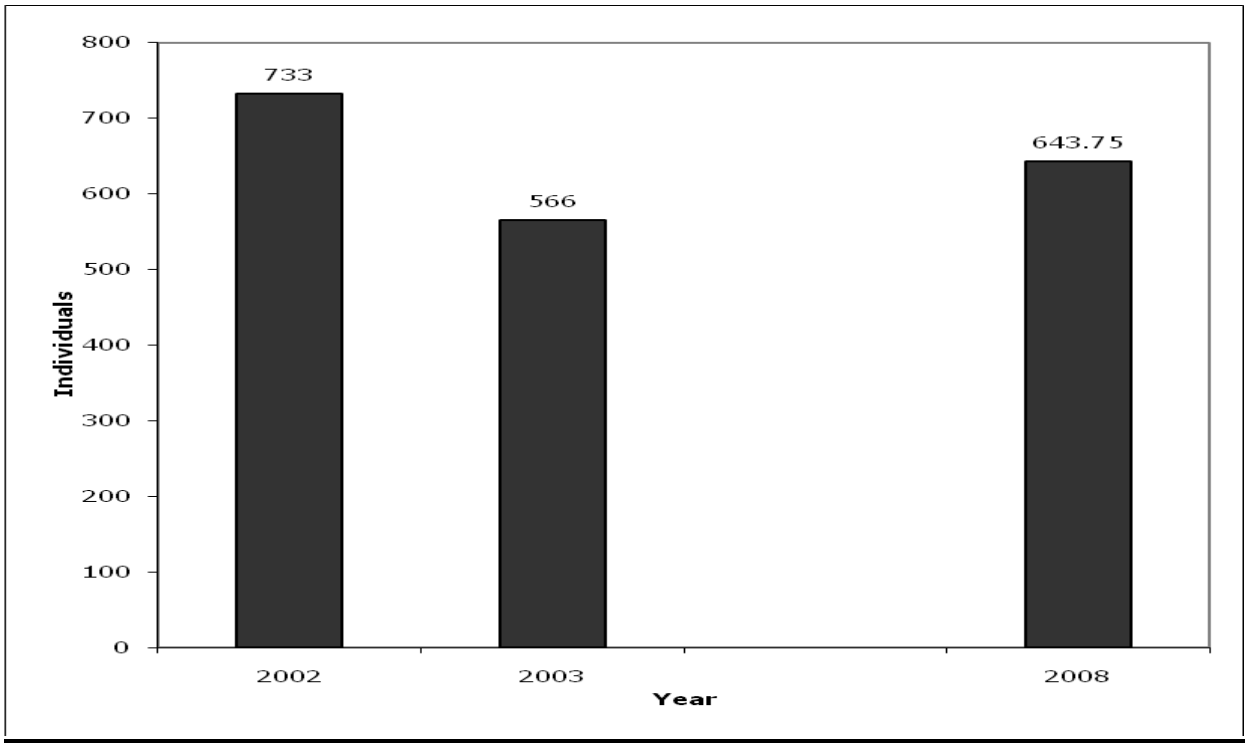
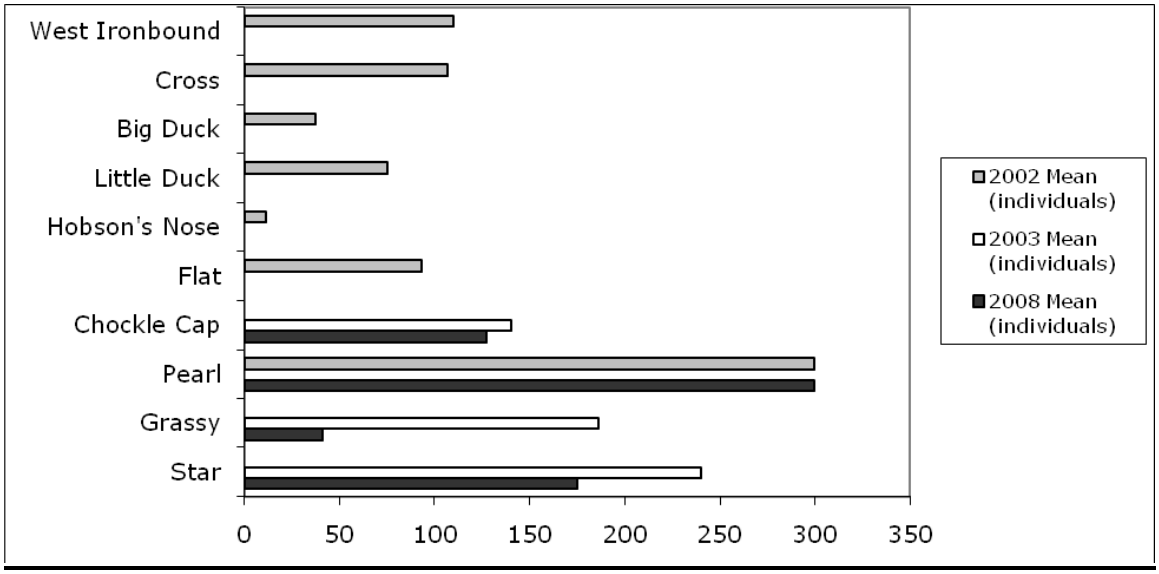


Figure 3. Mean number of individual gulls (data was not available for 2004-2007).



Terns

There were 6 islands that supported breeding tern populations in Mahone Bay in 2008: Quaker, Pearl, Westhaver, Crow, Gully, and Mason Islands. Egg and nest counts were conducted on Mason, Pearl, Quaker, and Westhaver Islands on June 16th, with help from Brad Toms, Canadian Wildlife Service. A second nest and egg count was conducted on July 16th, on Quaker and Crow Islands as these islands supported terns that nested later in the season. Nest and egg counts were not conducted on Gully Island because BCAF technicians were unaware of their presence until after the vast majority of eggs had hatched (it would have caused too much disturbance to chicks and counts would not have been accurate). A local resident, Frank McAulay, informed BCAF of this particular colony, which is located in Bayport, NS approximately a 20 minute drive from Mahone Bay.

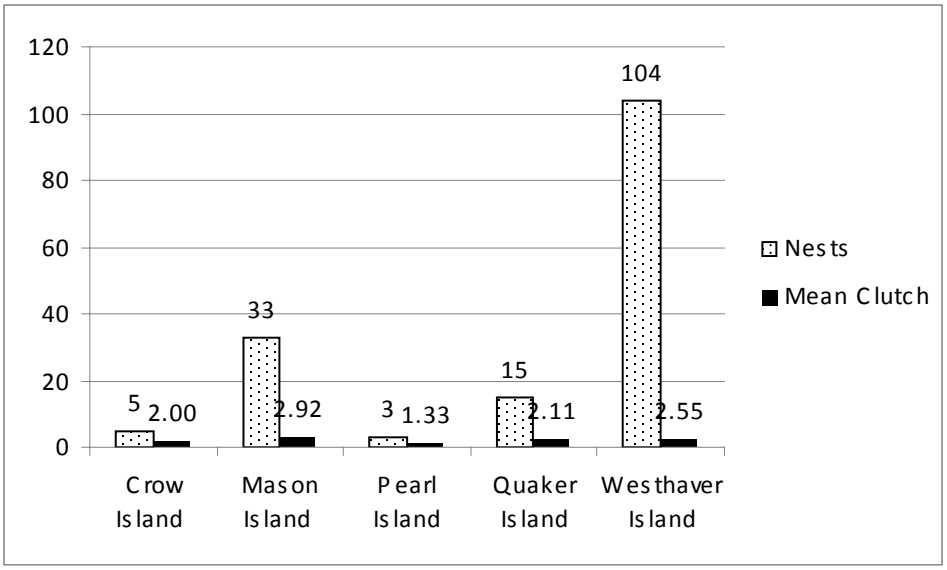
The areas occupied by nesting terns were calculated from polygons drawn in ArcGIS and using the "calculate geometry" function in the associated "attribute table". Table 2 displays the results of both the June and July counts along with nesting areas and densities. Mean clutch size was also calculated and presented in Figure 4.

Table 2. Islands where terns (Common and Arctic) were nesting, the number of nests, eggs, fledglings, and the relative size of those nesting areas.

Island	16 June 2008		16 July 2008		Nesting Area	Density of Nests
	Nests	Eggs	Nest	Eggs	(m2)	(nests/m2)
Crow	0	0	5	10	669	223
Gully	unknown	unknown	unknown	unknown	unknown	unknown
Mason	33	89	0	0	1877	56.9
Pearl	3	4	unknown	unknown	454	151.3
Quaker	15	33	3	5	1126	62.6
Westhaver	104	265	unknown	unknown	1745	16.8
Total	**155**	**391**	**6**	**8**		

* Note: Nest and egg count could not be conducted on Pearl on 16 July as sea conditions were too rough to permit landing. There were 31 terns exhibiting nesting behaviours on this occasion. Westhaver Island was not re-visited on 16 July to minimize disturbance considering 100 terns remained active at this site along with significant numbers of chicks.

Figure 4. The number of nests counted and the mean clutch size of all islands where terns were found breeding in 2008.



4.3 Predator Watches

Once tern nesting locations were confirmed, BCAF technicians began conducting predator watches. Table 3 documents those islands where watches were conducted, the duration of watches, as well as the main causes of disturbance. Considering Westhaver Island supported the largest breeding colony of terns in 2008, and can easily be observed from Westhaver Beach, more predator watches were conducted here than elsewhere (783 minutes). The main cause of disturbance at Westhaver Island was by gulls. Using this method to observe predators, as opposed to using more effective VHS/digital 24hr infra-red cameras, will only allow identification of conspicuous disturbances (mainly avian) and only in the short time when watches are actually conducted.

Table 3. Main disturbances from predator watches, 2008.

Island	Start Date	End Date	Total Predator Watch (min)	Main Threats (# of incidents) / (total threats)	All Predators/ Causes of Disturbance
Crow	7-Jul	29-Jul	218	*Larus spp.* (6) and *Corvus brachyrhynchos* (6) / (19) *32% gull disturbance* 1 gull disturbance/36 minutes	*Corvus brachyrhynchos* *Haliaeetus leucocephalus* *Larus argentatus* *Larus marinus* *Pandion haliaetus* *Phalacrocorax auritus*
Gully	8-Jul	25-Jul	115	*Larus spp.* (4) / (6) *67% gull disturbance* 1 gull disturbance/28 minutes	*Larus argentatus* *Larus marinus*
Mason	12-Jun	2-Jul	201	*Larus spp.*(40) / (69) *60% gull disturbance* 1 gull disturbance/5 minutes	Anthropogenic (footprints/boats moored) *Corvus brachyrhynchos* *Larus argentatus* *Larus marinus* *Phalacrocorax auritus*
Quaker	12-Jun	23-Jul	253	*Larus spp.* (27) / (38) *71% gull disturbance* 1 gull disturbance/9 minutes	*Corvus brachyrhynchos* *Haliaeetus leucocephalus* *Larus argentatus* *Larus marinus*
Saddle	12-Jun	12-Jun	29	*Larus spp.* (5) / (8) *63% gull disturbance* 1 gull disturbance/6 minutes	*Larus argentatus* *Larus marinus* *Phalacrocorax auritus*
Westhaver	12-Jun	25-Jul	786	*Larus spp.* (65) / (88) 74% gull disturbance 1 gull disturbance/12 minutes	*Ardea Herodias* *Haliaeetus leucocephalus* *Larus argentatus* *Larus marinus* *Pandion haliaetus* *Phalacrocorax auritus*
		Total	**1602**		

Table 3a. Disturbance, predator watches, 2008.

Island	Total Predator Watch (min)	Total Disturbance Events	Disturbance Events Per Minute	Gull Disturbance Events	Gull Disturbance Events Per Minute
Crow	218	19	11	6	36
Gully	115	6	19	4	29
Masons	201	69	3	40	5
Quaker	253	38	7	27	9
Saddle	29	8	4	5	6
Westhaver	786	88	9	65	12

4.4 Abandonment of Colonies

Terns abandoned colonies on four of the six islands in 2008 including, Crow, Mason, Pearl, and Quaker. Notably, these were the smallest nesting colonies. The suspected reasons for abandonment are detailed in Table 4. Predation was likely the cause of abandonment on Pearl Island (significant numbers of gulls were nesting on Pearl). Both Mason and Quaker Islands are prone to anthropogenic influences (footprints and several boats were moored during predator watches at both); however, direct evidence for abandonments were not documented. Using offshore observational methods can only provide evidence of larger, mostly avian predation, and anthropogenic impacts during times when watches are being conducted (which is a very limited amount of time). The cause of abandonment for the tern colonies on Crow and Quaker Islands remain a mystery; however, Island Watchers reported that Crow Island experiences flooding almost every high tide period now, which would explain the abandonment. Quaker Island is also very close in proximity to the mainland, with the Chester Yacht Club only 2km away, so predictions for abandonment there would be human disturbance and high boating traffic. Since these events were not directly observed, they were not recorded in Table 4. Improved observational methods should be sought to better understand the limiting factors to tern success in Mahone Bay (predation by snakes, fire ants, mink, and anthropogenic disturbances are unlikely to be observed using this method of predator watches).

Table 4. Abandonment of tern colonies, 2008.

Island	Date Abandoned	Reason for Abandonment	Individuals
Crow	between July 25 and 30	Unknown	43 (5 nests)
Mason	between June 26 and 30	Anthropogenic, predators (gulls, crows)	66 (33 nests)
Pearl	between June 17 and 25	Likely predation (large gull colony)	6 (3 nests)
Quaker		Unknown	36 (18 nests)

To provide greater insight into past causes of abandonment from the various islands terns have nested was summarized and is presented in Table 5 below. Notably, the influence of large numbers of nesting gulls seems to be the significant limiting factor preventing terns from breeding on Pearl Island. In the past, severe weather has also significantly reduced the success of terns in Mahone Bay. In 2007, BCAF research suggests that terns abandoned from all seven islands where they were breeding following a precipitation event (>24mm of rain). Climate change may result in more severe storm events which may influence the success of tern colonies in the future and be further compounded by rising sea levels.

Table 5. Documentation of abandonment of tern colonies in past breeding season.

Island	Date Abandoned	Reason for Abandonment	Individuals (terns)
Quaker	July 20 2004	Severe thunderstorm	
Quaker	June 11 2005	Mink	46 (23 pairs)
Westhaver	2006	Unknown	
Saddle	2006	Unknown	
Westhaver	2007-June (first week)	Storm event	50
Grassy	2007-June (first week)	Storm event	30
Saddle	2007-June (first week)	Storm event	6
Mash	2007-June (first week)	Storm event	70
Crow	2007-June (first week)	Storm event	40
Hell	2007-June (first week)	Storm event	20
Hobson's	2007-June (first week)	Storm event	12
Pearl	between July 5 and 24 2007	Likely gull predation	500

4.5 Fledgling Counts

Gulls

Fledgling counts for gulls were not conducted this year; however, subsequent visits to the islands indicated that significant numbers of chicks had survived. Fledgling gulls could easily be observed on the beaches, in the waters adjacent to islands, and in flight.

Terns

Fledgling counts were conducted on those islands where terns were successful; notably Westhaver and Gully Islands. Counts for these islands were conducted on July29th, and the results are presented in Table 6. As earlier explained, the other colonies abandoned prior to the fledging of chicks, and the method used likely underestimates the actual number of fledglings. Use of enclosures would be required to more accurately assess reproductive success.

Table 6. The total number of nests, eggs, and fledglings on Gully and Westhaver Islands, 2008.

Island	Nests (16 June)	Eggs (16 June)	Fledglings (29 July)	Notes
Gully	Unknown (estimated between 38 and 50 due due to observations of 76-100 terns)	Unknown	**16**	12 nests with a total of 17 un-hatched eggs were found.
Westhaver	104	265	**50**	Upon brief inspection of the island on 29 July, chicks less than one week old were discovered. Chicks this young would not have been observed on the beach thereby providing evidence this count method underestimated fledgling numbers. A complete search was not conducted to minimize disturbance.

*Note: Refer to the discussion section below for further information on the fledgling count results.

5 Discussion

5.1 Bay Wide Surveys

In a departure from previous seasons where BCAF technicians were stationed on Quaker Island, bay wide surveys were conducted to document how and where terns were using the bay and its islands. Table 1 provides evidence that terns preferentially nested on several islands in 2008, as opposed to just one or two islands (including Crow, Gully, Mason, Pearl, Quaker, and Westhaver). Other areas frequented by the terns (roosting) included Hobson's, Mash, and Saddle Islands. Generally speaking, these islands, and those home to the larger gull colonies, were most frequented by BCAF technicians. Figure 2 presents those locations (as waypoints uploaded from the GPS) where terns preferred to nest, roost, and forage. Results from this year's surveys provide valuable insight on where to concentrate search efforts in the future. Organization and preparation of required equipment in late April and early May would help to facilitate an earlier start of surveying (specifically to ensure gull nest and egg

counts are conducted). Digital still photographs should be taken on islands with nesting terns and gulls to better document numbers and to help technicians accurately estimate numbers in future counts.

5.2 Nest and Egg Counts

Nest and egg counts were conducted on June16th, 2008. With continued observations throughout the entire breeding season, terns were found nesting on Westhaver, Gully, Quaker, Pearl, Crow, and Mason Islands. It is important to ensure that counts are conducted once the vast majority of terns have finished laying eggs, but not too late in the season when significant numbers of terns would have hatched. Close attention to the behaviour of terns to identify when birds begin to incubate will allow an approximation of when the breeding cycle begins, and counts should commence no later than 16 days past this time.

Westhaver

Westhaver Island likely supported the largest breeding colony of terns in 2008 (a nest and egg count was not conducted on Gully; however, the number of individuals on Gully was just 75, compared to over 200 on Westhaver; refer to Table 2 and Figure 4). Significant numbers of terns have nested here in the past (the colony abandoned in 2007 following a severe storm). One gull nest was found during our nest and egg count this year, and this pair caused significant disturbance to the colony. Latterly, a gull fledgling was observed on the island. CWS chose not to destroy this clutch (a permit would have been required), and in future, it is suggested that gull nests are destroyed within close proximity to any significant tern nesting colony to minimize the potential for abandonment.

Quaker

Quaker Island did not support nesting terns in 2006 or 2007, following predation by mink in 2005. In 2008, 15 tern nests were found (Table 2 and Figure 4). On July16th, a second egg count was conducted on Quaker as terns appeared to have re-nested in a new location to the east (3 new nests were found; Table 2 and Figure 4). It is suspected that these birds may have been members of the Mason Island colony that abandoned earlier in July.

Gulls did not nest on Quaker Island in 2008. Deterrence measures used by BCAF while stationed on Quaker from 2004-2007 (pyrotechnics, egg destruction, presence of technicians, etc.) appear to have successfully limited use of this island by nesting gulls (historically this island supported large colonies

of breeding gulls). It is difficult to conclusively provide evidence to link lack of breeding success with any predator(s) or anthropogenic/other influences using predator watches alone. Use of 24 hour surveillance cameras would significantly improve our understanding of the dynamics of future breeding colonies. During a survey of the island, a rock foundation was discovered, which could be home to garter snakes, an effective predator of tern eggs (comm. AOU conference, Portland, OR). It is important to note, however, that snakes were never identified on the island by previous crews living out on the island.

Masons

Mason Island is a new nesting area for terns (however, it is possible that BCAF was unaware of previous nesting attempts because, apart from 2003, thorough bay wide surveys had not been consistently conducted). A total of 33 nests were found in two separate locations along its northern shores (Table 2 and Figure 4). Terns were found foraging immediately adjacent to this island, where surrounding waters are shallow and sandy-bottomed (suitable substrate for sand-lance, the primary food source for Roseate terns). Vegetation and beach structure appears appropriate; however, future analysis of vegetation and substrate survey data collected at the end of this field season will be required to better identify its potential to support Roseate terns alongside significant numbers of Common and Arctic terns. Evidence of footprints through the nesting colony, a number of boats moored off-island, and local knowledge suggests this island is prone to greater anthropogenic disturbance than Westhaver, Gully, and Mash Islands. More favourably, this peninsula was recently acquired by the Mahone Islands Conservation Association (MICA) to encourage ecological protection of this area. This island may be suitable for future management.

Pearl

Although Pearl Island may historically have been home to a significant number of nesting terns, the presence of a large gull colony (herring and great black-backed) is preventing their present-day success (Table 2 and Figure 4). Future management of this gull colony would be challenging considering other seabirds are nesting here (refer to Island Stewardship Feasibility Study 2003 – A Review of Findings below for further discussion). Although Pearl Island would be the most suitable location for tern stewardship, the gull presence on the island will forever cause the failure of terns unless the gull population was managed. Since Pearl Island is a Wildlife Management Area, NS DNR would need to approve any type of gull deterrence or management. Pearl Island was ranked number 1 in the 2003

island selection but was not selected due to the large gull population and difficulty in transporting staff and supplies on and off the island.

Crow

On July 16th, a nest and egg count was conducted on Crow Island. A total of 5 nests and ten eggs were found (oftentimes second clutches are smaller; Table 2 and Figure 4). Since no terns were observed on, or around this island in the earlier part of the season, these late nesters may also have been re-nesters from the colony that abandoned from Mason Island in early July (see Quaker Island above). The terns did not successfully hatch chicks on Crow Island. Island Watchers suggest this is due to constant flooding of Crow Island during high tide periods.

Gully

Nest and egg counts were not conducted on Gully Island this season as technicians were unaware of their presence until they were informed by a local resident (Frank MacAulay) past the time when counts can feasibly be conducted (most eggs would have already hatched). An early visit indicates that as many as 100 terns may have been nesting here. James Hirtle, a local bird enthusiast, indicated that 6 Roseate terns may be present; however, Roseate terns were not observed by either BCAF technicians or CWS on subsequent visits. According to Mr McAulay, terns have been nesting here for about 50 years. BCAF were informed by CWS that they had conducted counts of terns in past years, the results of which are presented in Table 7 below.

Table 7. CWS Gully Island Tern Counts

Year	Aerial Estimate	Ground Estimate	Total # Nests
1995	10	20	10
1999	80	150	88
2003	0	not surveyed	not surveyed
2007	300	196	194

5.3 Predator Watches

Predator watches were conducted using similar methods to those employed while staff were stationed on Quaker Island, but were undertaken on all islands where terns were found breeding in 2008. The information gathered using this method does not provide an accurate account of all predation events, but rather provides a limited snapshot of predation events that are easily observed using binoculars during the limited time when watches are conducted. It is strongly suggested that future predator watch methods be updated and adapted to ensure better understanding of the potential threats to tern success. If, in future, any one island is selected for management, and if predator enclosures are being considered, intimate knowledge of all potential predators is required to ensure such enclosures are appropriately constructed. This is especially significant considering the great expense management of any one island entails.

Westhaver

Despite continued disturbance from a pair of Great black-backed gulls on Westhaver Island, terns successfully fledged chicks from this large colony. Of the 88 disturbances recorded (786 minutes), 66 were by gulls. At least one gull chick successfully fledged from this island.

Masons

On Masons Island, just 201 minutes of predator watches were conducted; however, 40 incidents of disturbance were caused by gulls. Compared with Westhaver Island, this island was subject to significantly greater disturbance from gulls, and coupled with documented anthropogenic disturbances, these two factors may together have caused this colony to abandon. In addition, several egg shells were found with small holes that appeared consistent with those caused from predation by insects (comm. AOU conference, Portland, OR). However, this type of predation may have occurred following the abandonment of the colony, as opposed to having caused the actual abandonment.

Quaker

Only 38 disturbances from gulls were documented on Quaker Island in 253 minutes of monitoring. Methods to identify predators and disturbances should be adapted to better quantify the types of predators and other influencing factors limiting tern reproductive success as they are likely unique to each island. Investigation into the use of surveillance cameras and enclosures is suggested.

5.4 Abandonment of Colonies

Only two of the six islands successfully fledged chicks. These two islands, Westhaver and Gully, supported the vast majority of breeding terns (the actual proportion could not be calculated because an egg count was not conducted on Gully Island). It has been well documented that terns are more successful when nesting in larger colonies (a larger number of co-nesting terns can better ward off potential predators). In addition, anthropogenic disturbances may be less influential where larger numbers of terns are defending their territories (terns can "dive bomb" intruders in defence of their nests/chicks). The factors that may have attributed to abandonments in 2008 are documented in Table 3.

The causes of abandonment from Quaker Island in 2008 are unknown. During 253 minutes of predator watches, only 38 threatening events were recorded (27 by gulls). Mink had predated eggs in earlier years (technicians stationed on the island witnessed the predation) and garter snakes may now inhabit this island. Quaker Island is also situated close to Chester and is a favoured location for boaters. Considering this island had previously been selected for management and, in future, may be selected for management again, improvements to better quantify predatory influences and disturbances is required to ensure appropriate deterrence measures are selected.

Abandonment of colonies has been a common occurrence in Mahone Bay in previous years, and the causes vary from storm events, predation (especially likely at smaller colonies), to the unknown (Table 4). Efforts to better monitor predation and disturbance should be undertaken to better understand and consequently reduce the factors that are causing abandonments.

5.5 Fledgling Counts

Following the advice of Brad Toms (CWS), fledgling counts were conducted on July 29th, in accordance with the methods outlined above (Research and Monitoring Protocols 3.5). As noted, counts are conservative with 50 fledglings found on/near Westhaver and 16 on/near Gully Island. A subsequent count was attempted the following week for comparative purposes, but the majority of terns and fledglings had already left the islands.

In future, if terns nest on Westhaver Island within the lighthouse's circular base, a count of those nests and eggs found within should be specified. This would allow a later count of fledglings (just prior to flight and when it would be unlikely any chicks would have had the ability to escape from the base) and provide some measure of success/productivity for this island (which has been home to >100 nesting terns in recent years).

Gully Island is also small enough to be thoroughly searched to gain a valuable approximation of fledglings. Since Gully Island has been used by breeding terns for more than 50 years, establishing a repeatable method to estimate productivity and success would allow longer-term evaluation of any upward or downward trends. Using enclosures of known size and documenting the number of nests, eggs, hatchings, and fledglings from this area is another strategy which has been used to monitor success of tern colonies, but has not been adopted by BCAF (or CWS) for use in Mahone Bay.

5.6 Vegetation Surveys

Surveys were conducted in late August to determine vegetation and substrate present in tern nesting colonies. Ideally, the surveys should be conducted in late April or early May prior to the arrival of the terns, but before the late summer plant material starts to grow. The vegetation present on the islands is significantly different in the late summer when compared to vegetation present when the terns arrive and begin choosing sites to nest. It was determined that if surveys are continued, they would need to be done in early May as stated above; however, since many researchers have already provided answers to the substrate terns prefer, it was suggested by CWS that BCAF not focus any effort in this area.

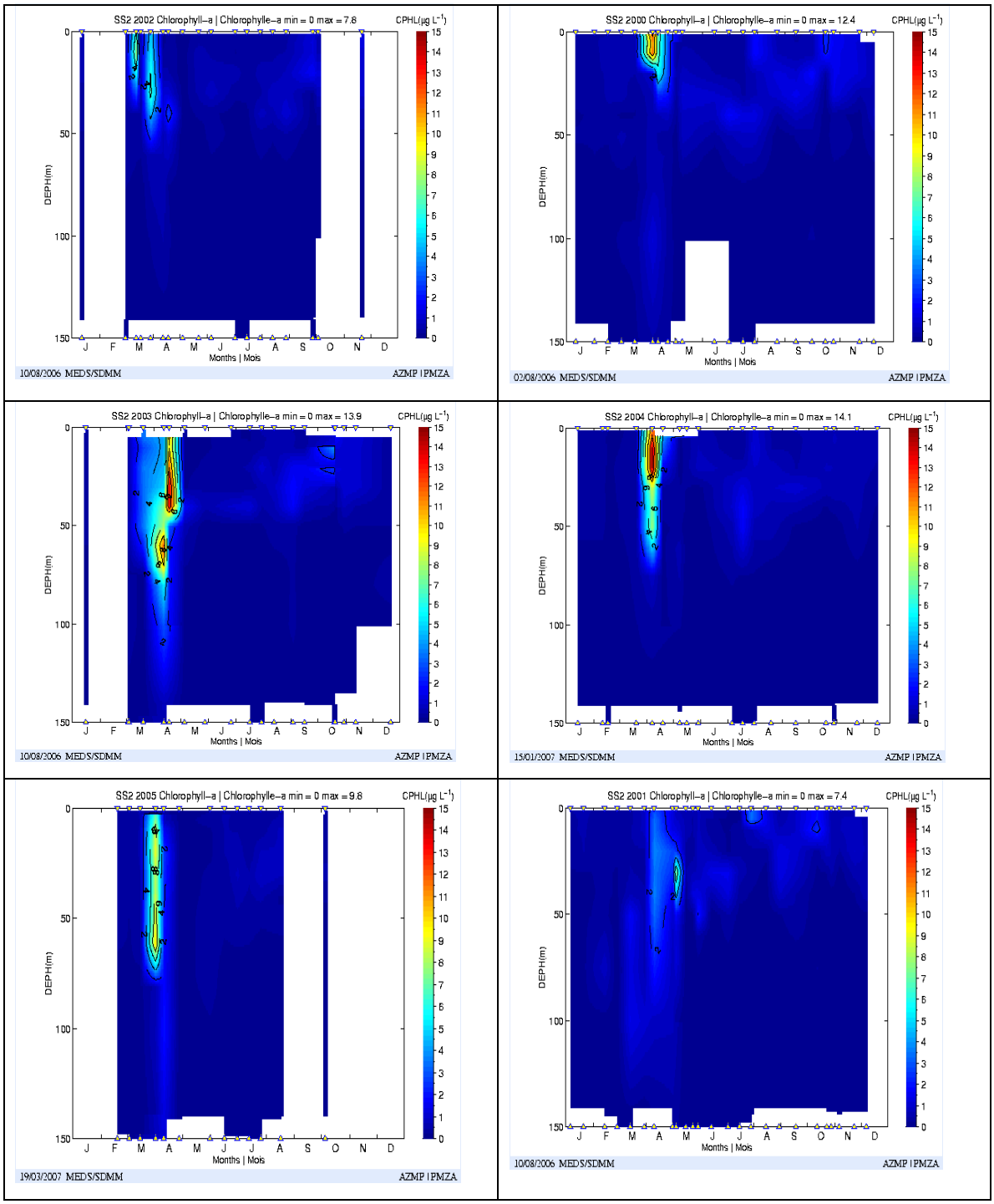
The following section details some other factors which may limit tern success and could be continued in the future.

5.7 Primary Ocean Productivity (ChlA) and Prey Availability to Terns

Food availability may be one of the limiting factors to the prevalence and success of tern populations in the bay in recent years. Primary ocean productivity can influence the timing and availability of prey species (abundance and distribution). Information was gathered from the Bedford Institute of Oceanography which presents trends in concentration of Chlorphyll A from 2000 to 2005 (Figures 5). Examination of the graphs shows spikes of production around March and April. These spikes are

shown in the graphs of Figure 5. by brighter colours to indicate the densities of Chlorophyll A, with red indicative of more dense concentrations and blue representing less dense concentrations. The spikes result from a couple of different factors. Similar to land-based plants, phytoplankton require light, nutrients, and water to photosynthesize. Considering phytoplankton live in water, light and nutrients limit their growth and productivity. Prevalence of both nutrients and light in spring (March and April) from increases in daylight and upwelling of nutrients, result in a spike in production of Chlorophyll A and a resultant spike in the charts. The spike (Chlorophyll A) quickly levels off because the nutrients that were required (and were limiting growth) are quickly used up by increasing populations of phytoplankton. Although the production of Chlorophyll A slows thereafter, its production does not stop entirely.

Figure 5. Chlorophyll A 2000-2005, Station 2 Buoy, St. Margaret's Bay, NS



Zooplankton feed on phytoplankton. Small fish such as juvenile Hake, Herring, and Sand Lance prey on zooplankton. These juvenile fish are the primary food source of predatory birds such as the tern (Roseate terns primarily feed on Sand Lance). Theoretically, if the production of phytoplankton significantly drops or increases, this would correspondingly affect other species relying on

phytoplankton as their primary food source. The higher an animal is within this food chain, and the more dependent this animal is on one particular food source (such as ROST's preference for Sand Lance), the more likely their population is to be affected by such changes.

In speaking with Glen Harrison, Head of the Ocean Research & Monitoring Section at the Bedford Institute of Oceanography, he indicated that it is very likely that spikes in Chlorophyll can more closely be related to growing anthropogenic inputs associated with increases in baywide development (nutrient loading from fertilizer and septic runoff and even boating can increase nutrient levels) and not necessarily lead to increases in food availability for terns.

5.8 Anthropogenic Pressures – Bay wide Development

In future, BCAF could collect data to monitor bay wide development from the number of building permits granted, planning applications submitted, and the overall increase in the number of year-round and seasonal homes. These results could be evaluated in relation to increases with Chlorophyll A concentrations, total number of breeding terns, and even the availability of prey species if Fisheries and Oceans Canada (or some other organization) have historically collected this information.

5.9 Anthropogenic Pressures – Boating

Local yacht clubs and the harbourmaster were contacted in attempts to identify if boat use in the bay has increased in recent years based on the number of moorings rented. Although the exact numbers were not made available to BCAF, communication with managers suggests that the number of rented moorings is increasing. Collection of more concrete evidence would be helpful to better understand the trend in boat use in the bay.

5.10 Precipitation – Flood Events Causing Abandonment

Precipitation data from a gauge in Westernhead near Liverpool, NS was gathered between 2000 through 2008 from "Weather Underground" (http://www.wunderground.com/global/stations/71411.html) (Figure 5, Appendix). By collecting weather information from an online historical almanac, efforts to quantify how weather, specifically storm/rainfall events, affects tern populations from year to year, providing tern abundance and breeding data has been collected, could be considered.

On July 19th, 2004, BCAF reported that approximately 25 active nests (with chicks) on Quaker Island were abandoned following a storm with 44km/hr winds and rainfall of 21mm. On June 21st, 2007, 24mm of rain caused complete abandonment of all islands used by nesting terns (Westhaver, Grassy, Hell, Saddle, Mash, Crow, and Hobson's Islands). The aim in collecting precipitation data in 2008 was to identify the potential threat to the reproductive success of terns nesting on Quaker Island and others based on those years (within an 8-year period where data was available) where precipitation exceeded 21mm during the known tern reproductive cycle (May 1st – August 15th) within Mahone Bay (albeit this may be slightly conservative).

From 2000-2008, precipitation (from May 1st – August 15th) exceeded 21mm on 33 separate days. A summary of the number of days in each season where precipitation exceeded 21mm and the total precipitation (from May 1st – August 15th) for each of these years is presented in Figure 6. In the year 2000, there were only two days that resulted in excess of 21mm and they occurred early in the season; however, there is no data on tern nesting to associate this event with abandonment or success as in 2001 and 2002. In 2003, there were 12 days during the breeding season where precipitation exceeded 21mm and where nests/eggs (had they been laid) on Quaker potentially could have flooded causing the colony to abandon. Terns were found nesting on 5 islands in 2003 (Westhaver, Crow, Mash, Spectacle, and one near Corkum Islands) and those that abandoned (Spectacle, Mash, and one near Corkum Islands) were not clearly linked to any cause (i.e., storm event). In 2004, three days exceeded 21mm and the nesting terns on Quaker abandoned. In 2005, there were 11 days where precipitation was in excess of 21mm. A colony was established on Quaker in 2005, where they survived heavy precipitation events early in the season, but the colony was completely wiped out by mink on June 11th, so no link to severe weather could be quantified. In 2006, there were no precipitation events over 21mm and in 2007, 24mm caused complete abandonment of all terns nesting on the seven islands they were nesting (refer to Table 5).

In 2008, we experienced an excess of 21mm of precipitation on 4 separate days. Pearl was the first colony to abandon between the dates June 17th to 30th, where there were no precipitation events of over 21mm showing that the colony may have abandoned for some other reason. Observations indicated that Masons Island abandon between June 25th to 30th, while Quaker Island abandoned between July 23rd and 30th. Between both of these time periods, there were no significant amounts of precipitation, which again indicates that weather may not have been the cause of the abandonments. On July 21st and

22nd, (35mm and 51mm respectively), precipitation amounts were in excess of 21mm. Following these events, between the days of the July 25th to 30th, the colony established on Crow had abandoned. Given the time gap between the precipitation and abandonment, there may not be any correlation between these precipitation events and weather.

Generally speaking, precipitation events greater than 21mm are experienced in most years during the breeding cycle. Precipitation events exceeding 24mm caused complete abandonment of all nesting colonies in 2007. Since 2000, there have been 28 days where precipitation has exceeded 24mm, and apart from 2002 and 2006, all other years between 2000-2008 have experienced this heavy rainfall. It is possible that climate change and the severity of rainfall events may be impacting tern success in Mahone Bay. Rising sea levels may also compound the influence of precipitation events as nesting areas may be closer to high tide marks than historically. Further attempts to collect historic data would shed light on the significance and impact of severe precipitation provided tern abundance and success data where available.

Figure 6. Precipitation (cm) 2000-2008

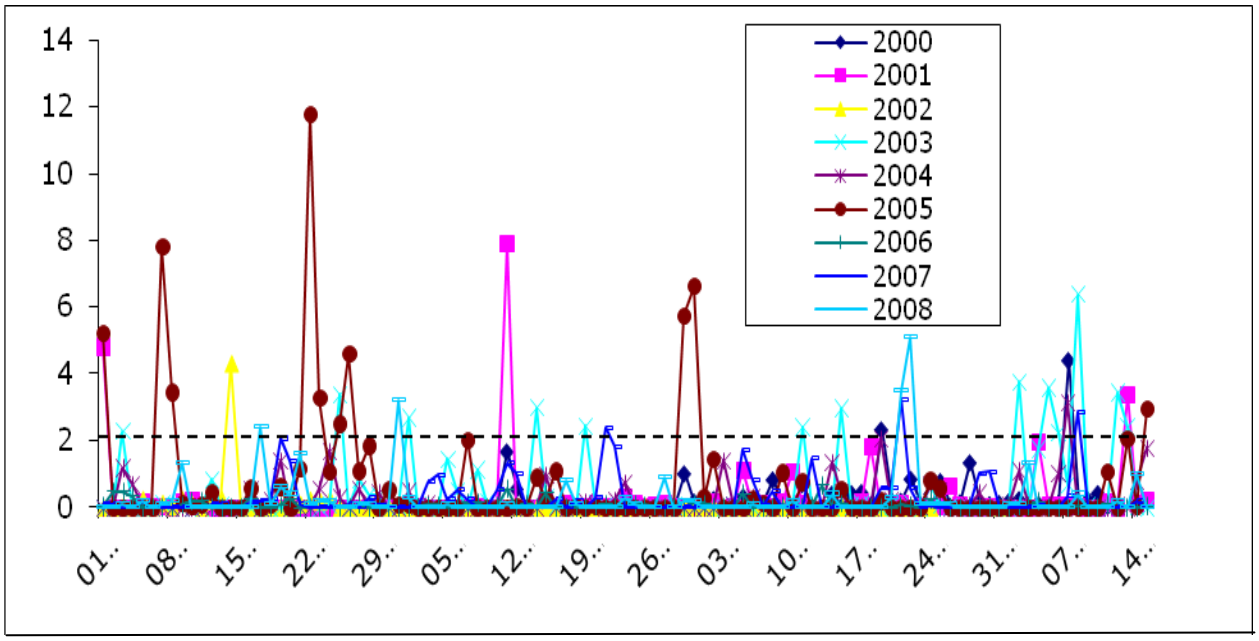
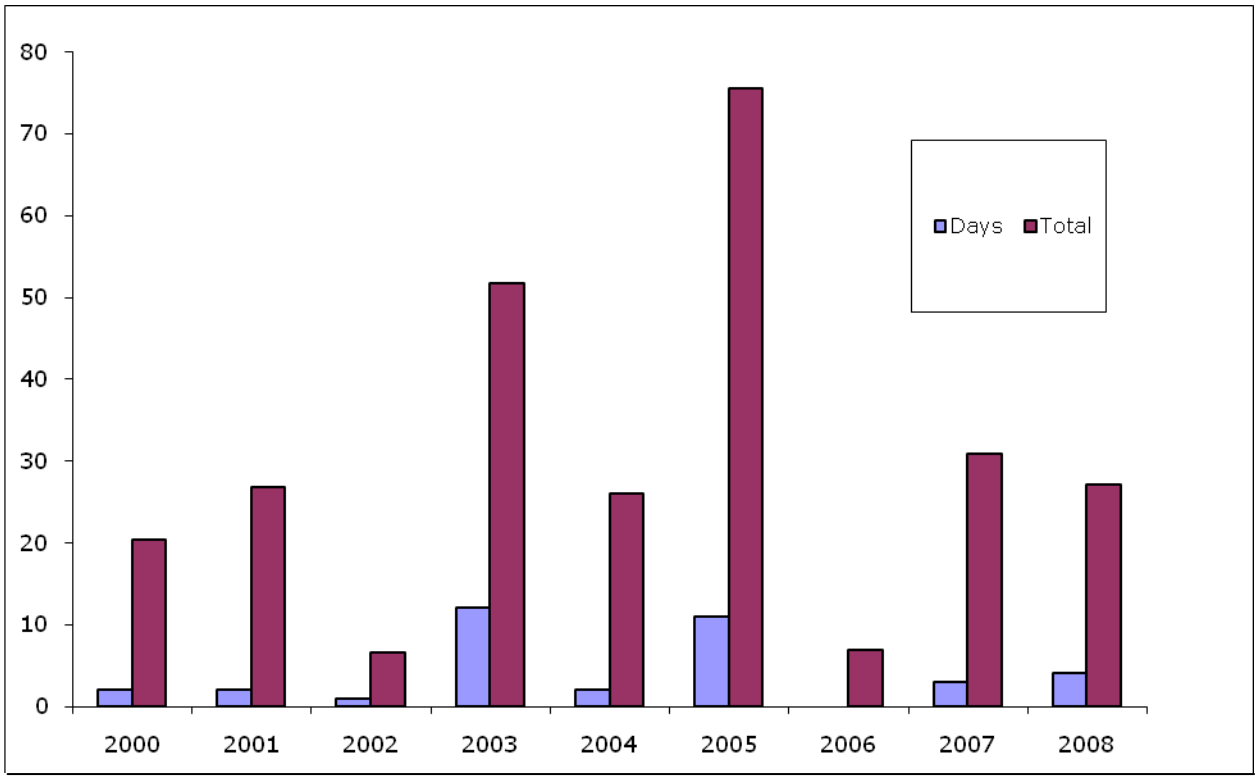


Figure 7. Total Precipitation and Days Exceeding 2.1cm of Rainfall



5.11 Predation – Mink

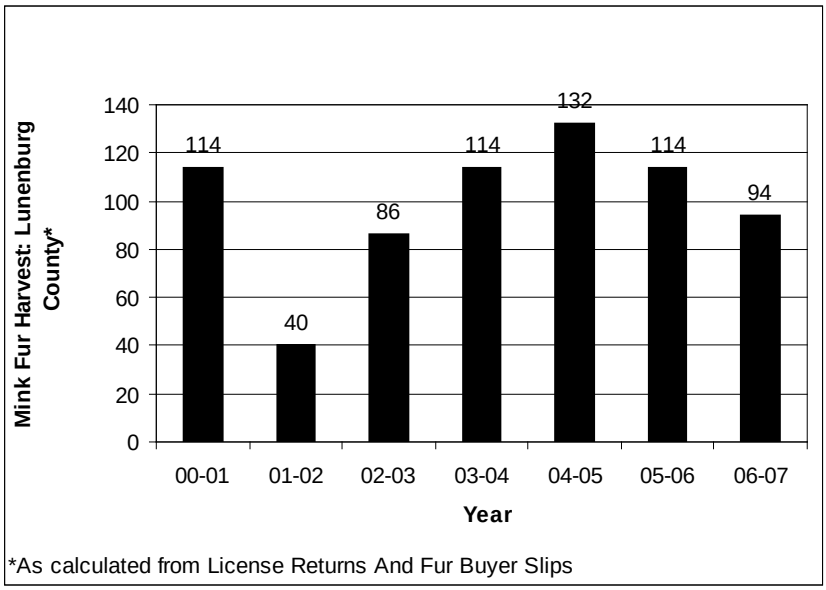
Mink are semi aquatic and can easily travel from the mainland to many of the islands in Mahone Bay. A significant quantity of published data exists providing evidence that mink are highly effective predators of tern eggs. In addition, published data indicates that following predation, as opposed to flooding, some species of birds, including terns, are less likely to nest the following year.

In BCAF's 2003 RTRP Report, mink reportedly caused the complete abandonment of approximately 250 pairs from Mash Island in 1995. This report further suggests that terns have not preferentially selected one island to nest, but rather have broken up into several smaller groups breeding on different islands following this predation event. In 2005, mink predated and caused the abandonment of the entire breeding colony on Quaker Island (nests~23).

To identify trends in mink populations, data pertaining to the local mink fur harvest was obtained from the Nova Scotia Department of Natural Resources for Lunenburg County (Figure 8). While the information gathered from trapper results does not provide accurate abundance data (total population) for mink, it does provide information on presence and absence in particular areas. In consultation with

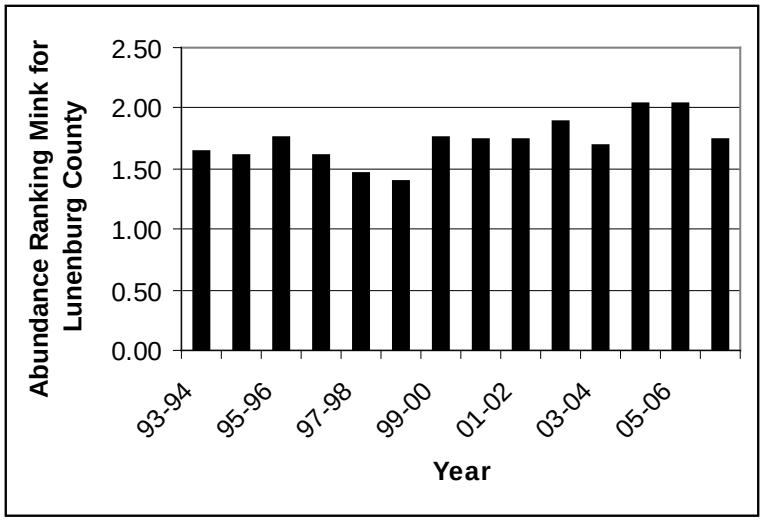
Mike O'Brien, Wildlife Manager, Fur and Upland Game Program, NS DNR, he indicated that the results from mink numbers attained through Licence Returns and Fur Buyers slips tend to be skewed to areas where it is easiest to trap the mink; generally this tends to be near coastal areas. In essence, this data could simply be used to gain some understanding of the presence or absence of mink in a particular area.

Figure 8. Mink Fur Harvest for Lunenburg County as calculated from License Returns and Fur Buyer Slips.



Abundance ranking data for mink was also obtained from NS DNR. This information is obtained annually from hunters and trappers and provides yearly abundance scores for mink specific to different counties in NS. Hunters and trappers are asked to indicate how plentiful they feel a particular species is based on their first hand observations and local knowledge. The specified range is from 0-5, with 0 indicative of none, 1 for low, 2 for medium, 3 for high, and 4 for very high. Figure 9 presents the abundance scores for Lunenburg County. In future, this information should continue to be collected to better understand trends in local mink populations (and potentially other species that pose a threat to the success of terns).

Figure 9. Abundance Ranking of Mink, Lunenburg County.



Occupancy modelling (by the experts) is one method of better understanding the population dynamics of similar fur bearing species (and other potential predators) over extended periods of time, but is unlikely to be available at present.

6 Island Stewardship Feasibility Study of 2003 – A Review of Its Recommendations

Having the ability to control predators such as mink and gulls is critical to aid in Roseate tern recovery and encourage the re-establishment of larger mixed tern colonies. The most obvious reason terns have not preferentially chosen to nest on any one particular island/location is linked to the presence of large numbers of nesting gulls in close proximity to suitable tern nesting habitat. Mink, and possibly flooding, have been immediate and catastrophic causes of nest failure in previous years. Scientific evidence also exists that snakes and ants can be the cause of significant losses of bird eggs (comm. AOU Conference, Portland, OR 2008). Predators are more likely to cause terns to choose not to nest on any one particular island the following year in comparison to flooding (The Birders Handbook 1988). Flood events every 10 years or more are apparently less likely to cause permanent shifts in nesting patterns (The Birders Handbook 1988). However, heavy precipitation events (24mm) caused complete breeding failures on all islands terns were found nesting in 2007 (n=7), and just 21mm caused a colony to abandon on Quaker Island in 2004. Research suggests that more severe precipitation events/storms may result from climate change. Coupled with conspicuous rising sea levels in Mahone

Bay, these seemingly climate related factors may significantly impact tern success in the future, and need to be considered when selecting any island for future management.

Based on historic evidence, large colonies of breeding terns (~100 pairs or more) have been identified on Quaker (1970's and 1987, BCAF RTRP Report 2003), Mash (1997, BCAF RTRP Report 2003), Grassy (1992, 1993, and possibly other years, BCAF RTRP Report 2003), Crow (2003 and nesting was documented in 2000, 2001, and 2002, BCAF RTRP Report 2003), Westhaver (2000, 2003, 2007, and 2008, BCAF RTRP Reports) and Gully (1999, 2007, CWS survey results provided by NS DNR, August 2008, and 2008: comm. with Frank McAuley suggests terns have nested here for >50 years). Apart from Grassy, a review of the suitability for future management of the abovementioned islands is provided below. Likely due to rising sea levels, a significant proportion of the centre of Grassy Island is waterlogged, and accordingly, it is unlikely this island could support significant numbers of nesting terns so further review of this island has not been included in this report. Review of some of the other islands detailed in BCAF's 2003 suitability report, which are also not suitable for longer-term management (insufficient habitat, have not been used by nesting terns, land-use conflicts, etc.), have also been excluded from this report.

6.1 Quaker Island

In 2008, two nesting attempts (active nests=18) along the N and NW peninsula failed with complete abandonment (unknown causes). The second nesting attempt may have been those terns which had earlier abandoned from two small colonies on Masons Island (unknown causes). This was the smallest breeding colony of terns in 2008.

While stationed on Quaker Island, BCAF technicians "managed" predators from 2004-2007, primarily focusing on gull deterrence. In 2004, a storm event (21mm of precipitation) caused the small colony of breeding terns to abandon. In 2005, mink caused abandonment of 23+ nests (the entire colony), and in 2006, a mink was spotted early in the season and trapped. Another mink was observed on the island later in the season (August) and may have been the reason terns chose not to nest here in 2006 (albeit predation the previous year may also have been a contributing factor). Although snakes have not been reported on Quaker Island, an abandoned rock foundation at the base of the lighthouse was identified in 2008, which provides excellent snake habitat (comm. American Ornithological Conference, Portland, OR).

Taking a more pro-active approach to controlling predators on islands which have, and could support large numbers of breeding terns, would appear the most reasonable approach to minimizing future losses and encourage long-term nesting of terns. While gull deterrence and increased mink trapping efforts would be desirable, efforts to identify any other predators should be undertaken to maximize the success of any future management efforts. For example, even if mink trapping were consistently undertaken, snakes or even fire ants may be contributing to recent abandonments on Quaker Island. Surveillance cameras should be used to better quantify predation events and other disturbances if this island is to be considered for future management.

Approximately 21mm of precipitation caused the colony to abandon in 2004, somewhat less than the amount of precipitation that caused abandonments of all colonies (from 7 other islands within the bay) in 2007 (24mm). Also, given this island's close proximity to Chester, anthropogenic disturbances will likely increase as development and boating pressures continue to increase. Trails within the vegetation were conspicuous this year.

Investigation into local ecological conditions (from vegetation and substrate randomized plot sampling within known breeding areas) should be evaluated in comparison to conditions existing on other islands where large tern colonies have successfully bred. Surveys were undertaken in 2008 on Quaker, Westhaver, and Gully Islands and raw data can be accessed at the BCAF office in Mahone Bay.

Although it would seem appropriate to conduct habitat/vegetation sampling on islands where larger colonies of terns (including those with Roseate terns) have historically been successful, it is possible that their compositions have changed due to development, storm events, and rising sea levels. In this sense, it may be difficult to infer that results from sampling in areas where terns have historically bred are indicative of good-quality habitat, unless conditions have not significantly changed. As earlier noted, vegetative/substrate surveys should be conducted prior to breeding, when conditions are more representative of those when terns are selecting nest sites. Particular attention to quantifying the underlying substrate is necessary.

6.2 Pearl Island

Although it is possible that a significant number of terns had historically nested on Pearl Island, there is no evidence to suggest any recent fledgling successes (2003-2008). Although as many as 500 individual terns were observed on July 5th, 2007, there is no evidence that terns successfully fledged from this island. Such large numbers of terns documented on this day likely arose from terns choosing to re-nest there after abandoning other colonies in the bay. Upon revisiting the colony late July, there were only 20 terns counted. Abandonment and lack of success was attributed to the gulls, as gull chicks were found throughout the area that had previously hosted tern chicks.

In 2008, 75 individuals were counted on May 29th, (including 3 Roseate terns), but just three nests were found on June 6th, during productivity surveys. It appeared that these nests were abandoned when terns were not present during a later survey on June 25th. On July 16th, 24 terns were observed approximately 20-30m SE of their former nesting site exhibiting defensive behaviours towards gulls, but terns were absent by mid-August (sea survey August 11th, 2008). It is unlikely that any terns successfully fledged from Pearl Island this year. In addition, significant numbers of gulls (HERG and GBBG) were nesting on Pearl Island in 2008, and this island has historically maintained high populations of gulls (>200 pairs, comm. CWS and ROST co-ordinator Wendy Rodenhizer). Furthermore, large (> 1m) garter snakes were observed June 16th, 2008, and their presence was earlier identified in a National Audubon Society Survey, which had been prepared for NS DNR (National Audubon Society 1992). Published data offers documented evidence that garter snakes prey on tern eggs (comm. AOU Conference, Portland, OR. 2008).

The presence of significant numbers of nesting gulls (+200 pairs) alongside significant populations of other seabirds, including puffins, guillemots, and razorbills, would inherently make the task of preventing predation and disturbance from gulls very difficult without significantly disturbing these other breeding seabirds. In addition, the presence of garter snakes would create further difficulty in managing a tern colony here, and would likely require either its complete extirpation and continued monitoring for its presence or use of enclosures specifically designed to prevent snake predation. Although use of enclosures around tern breeding colonies has been successful in other areas at minimizing predation (comm. AOU Conference, Portland, OR. 2008), the actual location where terns prefer to nest would need to be better understood, as such structures should be established prior to nesting to prevent disturbance and early abandonment.

Pearl Island has been legally designated as a provincial Wildlife Management Area and does not allow people to land or to boat within 1 nautical mile without a permit, albeit commercial fishing is permitted without such offshore restrictions. However, given the abundance of gulls, presence of snakes, and other nesting seabirds, managing this island in attempts to attract terns to nest would be challenging. This island is also the most challenging from a logistics perspective (refer to BCAF's RTRP Report 2003).

6.3 Westhaver Island

In 2008, 104 active tern nests were identified and terns successfully fledged from this island (fledglings=~50, albeit the method to quantify fledglings undoubtedly underestimated the actual number). Over 200 active nests were identified in 2007, albeit the colony abandoned likely following a storm event in June.

Westhaver Island is subject to offshore anthropogenic stresses given its close proximity to the Town of Mahone Bay and its boating community. However, given its small size, it was not subject to onshore anthropogenic stresses comparative to that witnessed on Quaker and Masons Islands (there is no conspicuous landing area or beach at Westhaver Island) this year.

In 2008, predator surveys clearly and quantitatively provide evidence that one pair of GBBGs created significant, on-going disturbance to this colony (refer to Table 3 above). During nest surveys in June 2008, a gull nest with 2 eggs was found on the top of the island; albeit CWS staff did not destroy it (a permit would have been required). A later survey (August 7th) confirmed the presence of a gull chick. In future, a permit should be sought that would allow nest/egg destruction of gulls breeding within close proximity (<100m) to significant tern breeding colonies. In this sense, BCAF would be working to help re-establish colonies by minimizing a significant threat to their success in more than one area, which may provide the impetus for the re-establishment of one larger tern colony, which in turn could be managed similarly to Country Island.

6.4 Mash Island

In 2008, a small number of terns were observed using this island (roosting) and there was some evidence of nest scrapes (<10). No complete nests with eggs were found. Some evidence of anthropogenic activity was noted (footprints were identified along its sandy beaches). This island is likely of sufficient size to support a larger colony of terns. It is not subject to the same (higher) anthropogenic disturbances as Quaker and Masons Islands, but does have poison ivy.

In BCAF's 2003 Suitability Report, this island was home to 500 breeding individuals in 1997 (comm. DNR biologist John Mills), including ROST, and was likely the first island used after Grassy Island had been completely abandoned by terns after displacement by a large breeding gull colony. Mink were reported as the likely cause of complete abandonment of this tern colony, and following this event terns have not preferentially selected one site to nest, but rather several smaller sites. Since this time, it is unlikely ROSTs have successfully bred within Mahone Bay.

A quantifiable vegetative and habitat survey should be undertaken to better identify if this island supports suitable habitat or could support suitable habitat (if the decision was made to change the vegetative structure to one more favourable to terns to reduce quantities of poison ivy). Improvement to predator watch systems would help to identify potential threats (i.e., surveillance cameras).

6.5 Masons Island

There were two small breeding colonies of terns located on the NW and NE peninsula. These lands are now owned by the Mahone Islands Conservation Association (MICA signs were posted on the peninsula, July 2008). Both colonies abandoned (unknown causes) and these birds likely re-nested on both Quaker and Crow Islands (both of these later breeding attempts failed). Anthropogenic disturbance was observed with both adult and children's footprints within a breeding colony. Several boats were observed moored at the NE bay, albeit no human disturbance was more directly observed during our predator watches. Local knowledge suggests this island is subject to anthropogenic disturbances (it is a popular boating destination), and furthermore, the island has a large sheltered beach in close proximity to where terns nested in 2008.

This island was not ranked in 2003, but does possess significant quantity of what appears suitable habitat, does not presently support breeding gulls, and is now owned by a conservation group which likely would support management efforts. Vegetative and habitat surveys should be conducted to identify if this island supports ample habitat for a large colony of terns. Improvement to predator watch systems would help to identify potential threats (i.e., surveillance cameras).

6.6 Crow Island

Just 3 active nests were found on July 16th, 2008, and were likely from breeders that earlier abandoned from Masons Island. A later survey on August 8th, confirmed no terns had successfully fledged from this island. BCAF has reported terns nesting on this island from 2000-2003 (81 nests were counted in 2003).

The island is owned by NS DNR, but is prone to flooding and situated close to the mainland (<50m) and hence there is the increased likelihood of predation by mink, snakes, and human disturbance. This island would not likely be able to support any large numbers of breeding terns, as nests would be consistently flooded and/or easily predated.

6.7 Gully 16

According to local resident Frank McAuley, terns have historically bred on Gully Island for over 50 years. In 2008, a nest/egg count was not conducted, as BCAF was unaware of this breeding colony until June 30th, (when chicks would have already hatched). Approximately 75-100 individuals were subsequently identified during surveys by BCAF and CWS. A local birder reported seeing ROST (6), albeit ROST were not observed during any of BCAF's surveys, including one conducted with CWS's technician Brad Toms. Sixteen fledglings were counted during our survey (as noted above, this is likely an underestimate).

Gully Island, owned by the Nova Scotia Department of Natural Resources, is located in the mouth of Bayport, approximately 320m from the nearest point of mainland and about 840m from the nearest point of mainland with a sparse number of seasonal/year-round houses. It is situated in a sheltered shallow bay (<5m) that inherently restricts use by motorized boats. The island itself is somewhat elevated (>1.5m) with vegetation that apparently supports breeding terns; the approximate area of the

island is 1300m^2. Given that ample foraging habitat exists in close proximity to the island (terns were consistently observed foraging immediately offshore), its ability to support breeding terns, the relative absence of potential anthropogenic disturbance, limited disturbance from gulls and other birds, and the fact a local resident traps mink (and has trapped mink for about 15 years, comm. Frank McAuley), this island would potentially serve as an ideal management candidate. The island's size may be the limiting element in its ability to support any significant colony. Investigation into ROST preferences and whether Gully would be an island conducive to Roseate tern nesting would better evaluate this island's potential for future management.

7 Public Outreach and Awareness

In 2008, to increase public awareness of nesting terns, BCAF focused on distributing information to the boating community, youth, and the general public. Methods of outreach included: posting seabird nesting signs on wharfs and islands where terns were found nesting; development and distribution of tern identification cards to a kayak outfitter and tour group; improvements to the Island Watchers Program; distribution of placemats to local restaurants and information posters to local businesses; newsletters; creation of public service announcement for broadcast on a local radio station; presentations to youth at yacht clubs and schools; and involvement at local festivals.

To engage the boating community and to increase awareness of tern nesting areas, BCAF posted new seabird nesting signs acquired from CWS. These new signs displayed a seabird logo developed in the United States. Signs were posted on wharves including: Mahone Bay, Chester, Indian Point, Western Shore, and Lunenburg government wharves; Lunenburg and Chester Yacht Clubs; Oak Island Resort; Fisheries Museum of the Atlantic wharf; and Westhaver Beach. Signs were also posted where terns were nesting (or thought to be nesting) including Masons, Quaker, Crow, Mash, Saddle, Gully, and Westhaver Islands. The island signs were anchored in wooden crates that were subsequently filled with local stones and placed within close proximity to the nesting area as well as in areas readily visible to boaters.

Local residents have continued to act as voluntary stewards to provide valuable information with respect to tern abundance and disturbance via the Island Watchers Program. Created in 2004, the program has experienced varying degrees of success in collecting accurate and relevant data on tern populations. This year, improvements were made to the reporting forms and email contacts were

acquired for all participants that had access to the internet. Switching from regular post to email for submission of information will facilitate reporting and decrease response time. The new form provides specific examples and definitions of terms in hopes of acquiring more accurate and useful data.

The tern identification cards were provided to East Coast Outfitters, a kayaking outfitter and tour group based in Mahone Bay, to pass out to their patrons. The cards were created to increase knowledge about the three different tern species that can breed in Mahone Bay and included photographs, details of their distinguishing features, and brief descriptions of their physical features and calls. The card also provides information about the status of the Roseate tern and that reporting any Roseate tern sightings would be helpful in the recovery of the species. Contact information and links to BCAF's website were included.

A presentation about the Roseate tern was given to children participating in the Learn to Sail Program at the Lunenburg Yatch Club. The presentation was about 20 minutes long with 10 minutes at the end for questions; approximately 50 children were in attendance. A presentation was also given at Lunenburg Academy, a local elementary school, to a group of Grade Primary students. Presentations will continue in the fall when school is back in session. An "activity page" for children has been created and will likely be available for next year's students. Other schools that were visited to educate students with regards to the Roseate tern were Lunenburg Junior Senior High, Gold River Elementary, and Aspotogan Elementary.

Informational posters were put up at 3 local businesses (LaHave Bakery, Joann's Bakery, and Mahone Bay Save Easy); ten posters were provided to Tucans and East Coast Outfitters; and two restaurants, Duke Street Eatery (Chester) and Island View Restaurant (Western Shore) accepted informational Roseate tern placemats to use in their restaurants (both accepted approximately 5800 placemats total).

In addition to print information, BCAF developed a public service announcement that was broadcast on the local radio station, CKBW (98.1 Bridgewater). There was an immediate response to the broadcast (a call was received from a local resident informing technicians that he had heard the radio announcement and was calling to inform BCAF of terns feeding off of Whynots Cove at Indian Point). He also expressed interest in becoming a member of the Island Watcher Program and the appropriate information was forwarded to him.

BCAF provided project information at a booth in the Mahone Bay Classic Boat Festival on the weekend of July 31st – August 3rd. At the booth, a poster provided updated information about the Roseate Tern Recovery Program. Also, decoys of the Roseate and Common terns were available for public viewing, as were the new seabird nesting signs. Handouts were provided including the Summer Roseate Tern Recovery Newsletter and a Maritime Clean Boating Guide.

8 Recommendations

8.1 Study Design

1. Maintain consistent methods to quantify tern abundance, distribution, and productivity through bay wide observational and quantitative surveys similar to the methods used in this study (bay wide surveys).

   Digital (still) photographs should be taken of terns following a flush event from each island where they are found roosting/nesting. These in-field individual estimates should subsequently be compared with the actual numbers from the photographs. This would improve BCAF's ability to accurately estimate abundance as the season progressed, and could provide some quantified measure of accuracy of in-field estimation methods.

   Nest and egg counts on all islands where terns are breeding should be completed throughout the nesting season similar to the methods used in this study.

2. Fledgling success should be measured inside the lighthouse ring on Westhaver Island each year terns are nesting here. A record of the number of nests and eggs should be kept separate from those counted outside the ring. A later count of chicks that successfully hatched and were almost at the developmental stage where they can fly, would provide a measure of reproductive success that could be assumed equal to, and extrapolated for the entire island. If hatching is asynchronous inside the ring, additional counts may be required.

   Serious effort to consistently measure reproductive success on Gully Island should be undertaken as this island should be considered for future management.

3. Further investigation into alternative fledgling count methods should be undertaken. At the very least, an off-shore count of fledglings on the beach, and a subsequent count of those chicks still remaining on the island (possibly because they cannot fly because of later laying/hatching) should be undertaken similar to the methods used in this study.

4. Once the vast majority of terns have fledged, an island-wide survey for nests with un-hatched eggs should be completed. This would provide some measure of productivity (and could be compared with the results from the fledgling count).

5. Vegetation and habitat classification surveys should continue to statistically quantify preferred local ecological conditions and should be correlated with productivity and breeding success. This would allow more informed decision making when selecting which islands are most suitable for future management. Studies should be undertaken prior to the nesting season (early

May) to ensure results are representative of conditions when terns are initially selecting sites to nest. Dr. Lundholm from SMU assisted in 2008, and kindly offered to assist BCAF in subsequent years (either by himself or potentially one of his graduate students).

6. Precipitation data should consistently be collected, presented, and evaluated to better understand how local precipitation patterns and storm events could be influencing productivity and success. From earlier data, precipitation events exceeding 24mm cause complete abandonment of nesting colonies (2007). Climate change may be influencing the number and severity of precipitation events, which could be significantly impacting tern success. Rising sea levels may also play a role in how these precipitation events influence abandonments.

7. The relative abundance (m^2) of preferred foraging habitat (i.e., <5m deep with sandy substrate and within 7km of nesting) should be quantified with respect to those islands being considered for future management and added as an Appendix to this report. As above, this would provide additional (quantified) data which would help BCAF/CWS make more informed decisions of what island(s) to manage in future. This could be done out-with the field season.

8. Further investigation (data collection) of bay wide development could be included with this report and consistently updated in future years. The number of building permits could be obtained, mapped, and correlated with nesting success. This data could be collected during winter months.

9. Collection of chlorophyll A data should continue and investigation into whether DFO and/or another organization have data pertaining to juvenile herring, hake, and sand lance populations undertaken. This information would improve our understanding of some limiting factors to tern reproductive success and may permit evaluation of any longer-term trends in success and nesting patterns. This data could be collected during winter months.

10. Consistently seining for fish along Westhaver Beach and in close proximity to Gully Island in future years may also provide evidence of longer-term trends in prey availability.

11. Use of surveillance video equipment (digital with >4 frames per second using solar power to continuously charge batteries) is strongly suggested on any island being considered for future management to accurately quantify predation events. The predator surveillance methods used in this study cannot provide enough evidence to accurately identify the causes of abandonment, but rather provide limited evidence of conspicuously obvious disturbances from gulls/corvids/people. Investigation into their use could be initiated during the winter.

12. Following identification of the predators on any island(s) selected for management, predator enclosures should be considered to maximize the likelihood of successful breeding. Government (United States Fish and Wildlife and Geological Survey) and non-government (Audubon) organizations in Maine should be consulted, as this is where the concept and use of such enclosures originated (comm. Nanette Seto, wildlife biologist, Portland, OR). Protection groups in New Zealand have also been using similar enclosures and, according to Seto, was where the enclosures adopted in Maine originated.

13. If coastal erosion structures are to be constructed in Mahone Bay, efforts to encourage the funders/contractors, etc. to use substrate and vegetation suitable for nesting terns (based on the results from this year's and future studies) should be undertaken. Investigation into predator

enclosures may be worthwhile, as these could be built into the actual erosion structures which would likely maximize their effectiveness.

14. A meeting should be held with CWS and the advisory committee to ensure future research efforts meet expectations of all parties and, most importantly, will help aid in the recovery of Roseate terns through the selection of the most appropriate island based on additional evidence than previously collected

8.2 Communication

1. Meetings with CWS endangered species management and technicians, alongside a meeting with BCAF's ROST advisory committee, should be held during the winter (2009). Monitoring protocols and methodologies should be agreed upon and formalized prior to the commencement of any future study.

   A subsequent meeting with CWS/BCAF's advisory committee (or a representative of the committee) should be held with all BCAF technicians working on the project to ensure the required data is collected.

2. Considering time constraints for technicians, the final reporting document introduction and methods sections should be completed by BCAF's ROST coordinator.

3. Considering primarily university (co-op) students are hired to work on the ROST project, efforts to formalize communication with experts would both maximize the potential that future studies provide the most relevant data possible and provide students with valuable research/work experience.

4. Weekly meetings with BCAF field staff and the co-ordinator should be held to ensure research meets CWS and funding objectives and the final report is being prepared to accurately articulate findings.

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	2000	2001	2002	2003	2004	2005	2006	2007	2008
01-May		4.83	0	0	0	5.23	0.05	0.08	
02-May		0	0	0	0	0	0.48	0.1	
03-May		0	0.03	2.29	1.19	0	0.48	0	
04-May		0	0.03	0	0.69	0	0.33	0	
05-May		0.18	0.25	0	0.03	0	0	0.2	
06-May		0.03	0.03	0	0	0	0.03	0	
07-May		0.03	0.13	0.13	0	7.8	0	0	
08-May		0	0.03	0	0	3.45	0	0	
09-May		0.18	0.25	0	0	0.13	0.08	0	
10-May		0.2	0.1	0	0	0.05	0.18	0	
11-May		0	0	0	0.03	0.08	0.2	0	
12-May		0	0.2	0.84	0	0.46	0	0.08	
13-May		0	0.25	0.05	0	0	0	0.08	
14-May		0	4.29	0	0	0	0	0	
15-May	0	0	0	0	0	0	0	0	
16-May	0.2	0	0	0	0.53	0.58	0.28	0.15	
17-May		0	0	0	0	0	0	0.2	
18-May		0	0	0	0.2	0.08	0	0.25	
19-May		0	0	0	1.4	0.63	0.08	2.08	
20-May		0	0.23	0	0	0	0.28	1.4	
21-May		0	0.1	0	0	1.17	0	0.08	
22-May		0	0.23	0	0	11.76	0	0	
23-May		0	0.18	0	0.56	3.28	0	0	
24-May		0	0.25	0.08	1.68	1.07	0	0	
25-May		0	0	3.38	0.3	2.51	0	0	
26-May		0	0	0	0	4.6	0	0.1	
27-May		0	0	0.86	0.56	1.09	0.08	0	
28-May		0	0	0.38	0.03	1.85	0	0.3	
29-May	0	0	0	0.36	0.43	0	0	0.05	
30-May	0	0	0	0	0	0.53	0	0	
31-May		0.03	0	0.05	0	0.08	0	0	
01-Jun		0	0	2.69	0.48	0.08	0	0	
02-Jun		0.03	0	0.05	0.03	0	0.03	0	
03-Jun		0	0	0	0.13	0	0.08	0.76	
04-Jun		0	0	0	0	0	0.08	0.97	
05-Jun		0	0	1.45	0	0	0	0.25	
06-Jun		0	0	0.48	0	0	0	0.53	
07-Jun		0	0	0	0	2.01	0.15	0.25	
08-Jun		0.03	0	1.14	0	0	0.15	0	
09-Jun	0	0	0	0.15	0	0	0	0	
10-Jun	0	0	0	0.05	0	0	0.05	0.53	
11-Jun	1.68	7.92	0	0	0	0	0.56	1.32	
12-Jun	0.56	0	0	0	0	0.05	0	1.02	
13-Jun	0	0	0	0	0	0	0.1	0	
14-Jun	0	0	0	3	0	0.91	0	0	
15-Jun	0	0.05	0	0.33	0.97	0.23	0.43	0	
16-Jun	0	0.03	0	0.05	0	1.09	0	0.25	
17-Jun	0	0.1	0	0	0	0	0	0	
18-Jun	0	0.03	0	0	0	0.05	0	0.2	

19-Jun	0	0.03	0	2.44	0.15	0	0	0
20-Jun	0	0.13	0	0.1	0.08	0.05	0.03	0.3
21-Jun	0	0.05	0	0.08	0	0	0.1	2.39
22-Jun	0	0.05	0	0	0.23	0	0	1.83
23-Jun	0.08	0.33	0	0.08	0.74	0	0.03	0
24-Jun	0	0.1	0	0	0	0	0.1	0
25-Jun	0	0.03	0.03	0	0	0	0.08	0
26-Jun	0	0.08	0	0	0	0	0.03	0
27-Jun	0	0.1	0	0	0	0	0	0
28-Jun	0.03	0.03	0	0.05	0	0	0	0
29-Jun	1.02	0	0	0	0	5.74	0	0
30-Jun	0.18	0	0	0	0	6.63	0.13	0
01-Jul	0.3	0	0	0	0	0.3	0.13	0
02-Jul	0.25	0.18	0	0	0	1.45	0	0
03-Jul	0	0	0	0	1.4	0	0	0
04-Jul	0.05	0.05	0	0.08	0.05	0	0	0
05-Jul	0.33	1.12	0	0	0	0	0.41	1.73
06-Jul	0	0.05	0	0	0.3	0.25	0	0.81
07-Jul	0.13	0.13	0	0	0	0.13	0	0.05
08-Jul	0.84	0.03	0	0	0	0	0	0.48
09-Jul	0	0.15	0	0.08	0.05	1.04	0	0
10-Jul	0	1.09	0	0.05	0	0	0	0
11-Jul	0.71	0.13	0	2.41	0	0.76	0	0
12-Jul	0		0	0.1	0	0	0.05	1.47
13-Jul	0		0	0	0	0	0.66	0
14-Jul	0.41		0	0	1.35	0	0.05	0
15-Jul	0.05		0	2.97	0.43	0.56	0.13	0
16-Jul	0.43		0	0.05	0	0	0	0
17-Jul	0.46	0.15	0	0.1	0	0	0	0
18-Jul	0.1	1.83	0	0.08	0	0	0	0
19-Jul	2.34	0.05	0	0	2.06	0.2	0	0.58
20-Jul	0.23	0.05	0	0.05	0.2	0	0	0.56
21-Jul	0.2	0.1	0	0	0	0	0.08	3.25
22-Jul	0.86	0	0	0.1	0.05	0	0.05	0.56
23-Jul	0.1	0.03	0	0	0.05	0	0	0
24-Jul	0	0.03	0	0.66	0.66	0.81	0.25	0.05
25-Jul	0.79	0.03		0.08	0.48	0.58	0	0
26-Jul	0.05	0.66		0.03	0	0	0	0
27-Jul	0.15	0.08		0	0	0	0	0
28-Jul	1.35	0		0	0.05	0	0	0
29-Jul	0.13	0		0	0.43	0	0	1.02
30-Jul	0.1	0.05		0	0	0	0	1.07
31-Jul	0.13	0	0	0	0	0	0	0
01-Aug	0.2	0		0	0.05	0	0	0
02-Aug	0.25	0		3.76	1.09	0	0.05	0
03-Aug	0.1	0		0	0.05	0	0.03	0
04-Aug	0.1	1.98		1.75	0	0	0.18	0.05
05-Aug	0.08	0.08		3.58	0	0	0	0
06-Aug	0.13	0.08		2.24	1.02	0	0	0
07-Aug	4.42	0.05		0.69	3.12	0	0	0.33
08-Aug	0.08	0.05		6.38	0	0	0.05	2.87
09-Aug	0.23	0		0.05	0	0	0	0
10-Aug	0.43	0		0	0	0	0	0

11-Aug	0.05	0.15		0	0	1.07	0.1	0
12-Aug		0		3.45	0.05	0	0	0
13-Aug		3.4		2.41	0	2.06	0	0
14-Aug		0.13		0.03	0.79	0.05	0	0.2
15-Aug		0.23		0	1.78	2.95	0.05	0
Totals	20.31	26.74	6.61	51.74	25.95	75.48	6.95	30.83