

**THE STOPOVER ECOLOGY OF MIGRATORY
LANDBIRDS ON BON PORTAGE ISLAND,
NOVA SCOTIA**

By

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Thesis

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ABSTRACT

I mist-netted southbound migrating landbirds on Bon Portage Island, Nova Scotia, to determine the importance of the island in these birds' migration. I specifically asked: a) are the numbers of migrants that come to Bon Portage in the fall related to wind direction? b) can any species deposit fat on the island? and c) does wind direction influence either the abundance or fat loads of individual species in the fall?

I tested for a relationship between wind direction and the total capture rate of all migrants combined. The total capture rate was influenced by wind direction. However, contrary to expectation, headwinds did not result in large accumulations of birds on the island. Most birds were caught on Bon Portage when the winds were conducive to reoriented migration (from the northwest).

I next tested whether individual species can deposit fat on the island and found that Bon Portage can function as a fat-depositing site for Myrtle Warblers. I also found strong evidence that Blackpoll Warblers and White-throated Sparrows can deposit fat on Bon Portage. Evidence was not convincing for 14 other species for which sample sizes were adequate.

Finally, I tested if wind direction had an effect on either the capture rates or the fat reserves (determined by weights and fat scores) for species for which there were adequate data: Myrtle Warblers, Blackpoll Warblers, and Red-eyed Vireos. Wind direction had no significant effect on Myrtle Warbler capture rates; however, northwest winds resulted in the largest daily capture rates of Myrtle Warblers. Visible fat reserves of Myrtle Warblers were related to wind directions, but contrary to expectation, tailwinds did not result in birds with the lowest fat scores. Daily capture rates of Blackpolls were related to wind direction; however, contrary to expectation, headwinds did not result in the largest accumulations of Blackpolls. The highest capture rates of Blackpolls were on mornings after northwest and west winds. Wind direction influenced how heavy the Blackpolls that came to the island were, and as expected, there was a weak tendency to capture Blackpolls with lesser fat scores after favourable tailwinds. Wind direction influenced both the capture rates and fat reserves of Red-eyed Vireos. Contrary to expectation, direct opposing headwinds did not result in the largest accumulations of Red-eyed Vireos. The largest capture rates of Red-eyed

Vireos were associated with northwest winds. Wind direction also influenced the size of the fat reserves of Red-eyed Vireos that came to the island; however, contrary to expectation, tailwinds did not result in the most fat-depleted individuals.

I conclude that most birds initially come to Bon Portage Island simply because of its location on the southern end of the province; however once there, some species, such as Myrtle Warblers, are nonetheless able to stay and deposit small amounts of fat.

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" The mystery which surrounds the migratory flights of birds never fails to arouse wonder and speculation among those of us who hold a special interest in such matters..."

-Robie Tufts

GENERAL INTRODUCTION

STOPOVER RESEARCH

To put this thesis in context, I review literature concerning stopover ecology, as well as literature of the radar studies of landbird migration conducted in Atlantic Canada. Stopover ecology refers to the study of migrants while they are stopped at areas along their migration route, and has received much attention in the past 15 years. Since many species of landbirds may be experiencing population declines (Robbins et al. 1989, Terborgh 1992), some researchers have raised concerns about the loss of habitats and concomitant loss of food resources in critical stopover areas along their migration routes (Moore and Simons 1992). This loss may exacerbate the problem of losses of wintering and breeding habitats, which have long been suggested to be the cause of landbird population declines (Terborgh 1989).

Almost all species of landbirds, especially species that migrate long distances (e.g. Neotropical migrants that migrate from breeding areas in Canada or the United States to Central or South America), require frequent stops during their migrations to replenish depleted fat stores. The energy necessary for migration is derived from the fat reserves that they build up during these stops (Berthold 1975; Blem 1976, 1980).

Whether or not a particular migrant stays at a stopover site and what factors influence this decision have been the subjects of many

recent studies, including this thesis. Determining how and where birds replenish their fat stores will illuminate specific migration strategies and identify geographic areas where resources needed for migration are available (Winker et al. 1992a).

Although there is still much to be learned about the complex behaviour, physiology, and ecology of landbirds during migration, we have already learned a great deal about many aspects of stopover ecology. Perhaps the best documented pattern of stopover behaviour is that the probability of a migrant staying at a new site encountered during migration is related to the habitat at the site (Moore and Simons 1992). Furthermore the length of time a migrant stays at a stopover site (its stopover length) is also related to the habitat at the site (e.g. Biebach et al. 1986, Moore and Kerlinger 1987, Loria and Moore 1990). Species that find the habitat suitable for fat replenishment will stay, and stay longer, while those that cannot find food will move on quickly, presumably to find a better area. It has yet to be clarified, however, in which habitat(s) each species can deposit fat. Data from the breeding season may not apply, because birds are no longer feeding young, and may require food of different nutritional quality (Parrish 1997). Furthermore, although it is known (geographically) where many landbird species are able to deposit fat (e.g. Winker et al. 1992b, Winker 1995a, Morris et al. 1996), it is not known exactly where, on each species' migration route, individuals actually require sites for fat deposition to

continue migrating.

Certain species are more behaviourally plastic during migration when faced with extreme ecological barriers (e.g. mountain ranges, deserts, or oceans). Loria and Moore (1990) found that lean migrant Red-eyed Vireos (all landbird species names used in this thesis are listed in Appendix A) displayed a greater foraging repertoire, made more frequent foraging maneuvers, and expanded their food resources more so than did fat individuals after they each had crossed the Gulf of Mexico, a water barrier of over 1000 km. Clearly, the ability to be flexible in foraging behaviour in new habitats during migration could be beneficial, especially after long flights. For example, Parrish (1997) found that certain species previously thought to be strictly insectivorous ate berries during migration. He also found that individuals of a species that shifted to berries gained significantly more mass than did those that remained insectivorous. Berries may offer an energetic advantage over protein-rich insects, as they may cost less energy to forage for, and are higher in carbohydrates, which can be more effectively used during migration than protein.

Despite its advantages, behavioural plasticity in migrants must be limited; birds are morphologically adapted to forage in only so many ways (Martin and Karr 1990, Moermond 1990, Winkler and Leisler 1992, Yong and Moore 1994). Martin and Karr (1990) found that most

Neotropical migrants are limited to only a few foraging maneuvers (e.g. flycatchers are limited to hawking). They are therefore also limited in prey types. Martin and Karr further suggested that the migration season may be exercising greater selection on landbirds' foraging strategies than do the breeding and wintering seasons, since food can be more limiting during migration. Hutto (1998) also argued that the migration season is perhaps of greater importance than the breeding season, since many species spend over one-third of their lives migrating, compared to only one-quarter breeding.

Another well-documented aspect of stopover ecology is that the fat load of a migrant upon arrival influences both the probability of stopover and the subsequent stopover length (Morris 1996, Moore and Kerlinger 1987). Red-eyed Vireos with small amounts of fat at arrival are more likely to stay at a stopover site and deposit fat (Loria and Moore 1992). Yong and Moore (1993) found that lean captive *Catharus* thrushes displayed less migratory restlessness (elevated activity associated with migration) than fat ones. Furthermore, captive lean birds were more active during the day, suggesting that lean birds forage more than fat birds at stopover sites. Similarly, the amount of fat deposited by migratory White-throated Sparrows was significantly related to the amount of fat the migrant had upon arrival (Cherry 1982). Cherry also concluded that a bird arriving at a stopover site with little or no fat reserves could not make another flight even if the weather were

favourable for migration. Morris (1996) compared the recapture rates of migrants that were held captive for 6 hours, and thus forced to lose weight, to those of controls, who were set free immediately after banding. In support of the hypothesis that fat loads of birds influenced stopover length, birds that were forced to lose weight were recaptured significantly more often than controls. It is clear then, that a migrant's energy reserves influence its stopover decisions.

Another factor that can influence stopover decisions is the number of conspecifics already at a site. Yong and Moore (1994) used enclosures of fruiting shrubs to show that during migration there is considerable interspecific and intraspecific competition for food resources at stopover sites. One outcome of such competition may be territoriality, which Rappole and Warner (1976) observed among migrating Northern Waterthrushes. When Northern Waterthrushes arrived at the site, they spent at least a day "floating" among the available habitats, after which they often settled in an area that they vigorously defended from conspecifics. Birds that did not find a territory within a day moved on, or became temporary floaters. Northern Waterthrushes with a territory gained significantly more weight than those that had no territory. Rappole and Warner (1976) also found that only a small percentage of the individuals actually remained at the stopover site, possibly because of this resource competition with conspecifics. Hence, they suggested that stopover sites may each have their own carrying capacity for

migrants, which is likely to be unique to each species.

A less studied factor influencing both a migrant's choice of stopover areas and the energetic condition of the migrant is weather, although certain relationships between weather and landbird migration have been well-studied with radar (see below). Northbound migrants that landed at a site on the northern coast of the Gulf of Mexico, after encountering opposing winds, were on average fatter than those that landed when the wind direction was favourable for migration (Moore and Kerlinger 1987). This suggests that migrants that land when the wind is favourable for migration do not have enough fat to continue migrating. However, few researchers have studied this aspect of stopover.

As many coastal areas are currently being developed for human use, there is an immediate need to identify critical stopover areas (e.g. Winker et al. 1992a, Parrish 1997), and within these areas, habitats that are important to migrants (e.g. Moore and Kerlinger 1987, Moore and Simons 1992). Furthermore, by determining the energy status and requirements of different migrants across a broad geographic range, we can more completely understand the various migration strategies of each species.

RADAR STUDIES OF MIGRATION IN ATLANTIC CANADA:

Migration of landbirds over the western Atlantic Ocean has been studied in great detail using weather radar (e.g. Able 1974; Drury and Nisbet 1964; Richardson 1972, 1976, 1978a, 1978b, 1980; Williams et al. 1977; Williams and Williams 1990). The effects of wind on landbird migrants in flight have been particularly well-studied (see Richardson 1991 for a review). Thus, it is known which wind directions are the most favourable (i.e. which directions result in the most birds flying at one time) for both spring and fall migrations on the Atlantic coast.

Few areas on the east coast of North America have hosted as many radar migration studies as has Atlantic Canada (Richardson 1972, 1976, 1978a, 1978b, 1980). Richardson conducted many observational studies using surveillance radar in Barrington, Halifax, and Sydney, Nova Scotia, as well as St. Margarets, New Brunswick (e.g. Richardson 1972, 1976). Richardson thus documented the large-scale, general patterns of migration for this area. He found that the majority of fall migrants over Atlantic Canada fly southwest, approximately parallel to the northeast-southwest axis of eastern North America (Richardson 1972, 1976, 1980, see Fig. 1). Similar orientation has also been observed in migrants over northern New England (Drury and Keith 1962).

When the wind direction was favourable for southwestward migration, large numbers of passerines took off 30 to 45 minutes after sunset. After midnight, the rate gradually decreased. These nocturnal

migrants flew southwest in a broad front over Nova Scotia, without appearing to turn or follow coastlines. However, during the day, Richardson often observed (with radar) large concentrations of passerines above coastlines, especially near the southern end of the province (Richardson 1972, 1976).

Richardson found that the number of landbirds migrating over Atlantic Canada during a given night was significantly related to wind direction. Wind speed, temperature, barometric pressure, and precipitation had comparatively little effect on the numbers of migrating landbirds (Richardson 1976). Southwest-migrating landbirds over Nova Scotia appeared to require tailwinds for southwest flight. Furthermore, most birds migrated southwest over Nova Scotia when the wind direction was from the northeast or north (Richardson 1972, 1976). Hence in this thesis I assumed that north and northeast wind directions were the most favourable wind directions for birds migrating southwest over Nova Scotia.

Richardson also found that when there were tailwinds at dawn (i.e. from the north or northeast), nocturnal migrants that found themselves at the southern end of the province continued flying southwest during the day across the Gulf of Maine, a flight of approximately 4-5 hours for a typical landbird (Richardson 1976). In contrast, if there were headwinds at dawn (i.e. from the south or southwest), Richardson (1972,

1976 1978a, 1978b) showed that many nocturnal migrants which were already over water returned to mainland Nova Scotia by changing direction and flying either north or northwest. This phenomenon has been termed reoriented migration. Most authors agree that reoriented migration represents nocturnal migrants either compensating for lateral wind drift incurred during the previous night's migration, or birds simply returning to land via the most direct route to seek food and shelter for the day (Murray 1976, Alerstam 1978, Richardson 1978b).

Richardson (1978b) examined reoriented migration in detail using surveillance radar at Barrington and Sydney, Nova Scotia. He found that reoriented migration among landbirds over Nova Scotia was significantly related to wind conditions. Reoriented migration was unrelated to cloudiness, visibility, or magnetic disturbance. Specifically, birds undertaking reoriented migration were usually seen on mornings when the wind direction was from the northwest.

Richardson also observed a small group of landbird migrants that flew in a mainly south-southeast direction from Nova Scotia and New England (Richardson 1972, 1976, 1978a, 1978b, 1980; Williams et al. 1977; Williams and Williams 1978). These migrants' direction implies that they make a non-stop flight over the Atlantic Ocean (trans-oceanic flight) to wintering grounds in South America. Richardson (1972, 1976, 1978b) found that in Nova Scotia, none of these trans-oceanic migrants

underwent reoriented migration, and they usually initiated migration with north or northwest winds. Trans-oceanic migrants usually departed 20-30 minutes after sunset over all land areas of Nova Scotia, not just from coastal areas. Some birds initiated the flight from as far north as New Brunswick and continued flying past the southern tip of Nova Scotia. However, few birds began the flight from more than 150 km inland from the coast of New Brunswick or Maine.

The Blackpoll is to date, the only species that is considered to be a trans-oceanic migrant (Nisbet et al. 1995, but see Murray 1989). The evidence for this is mostly indirect, but substantial (summarized by Nisbet et al. 1995). The first evidence is the radar observation of large groups of passerines moving south-southeast from not only Nova Scotia (Richardson 1972, 1976, 1980), but from the coast of New England as well (Williams and Williams 1978). Observations of grounded migrants suggest that Blackpolls are concentrated from Virginia to Nova Scotia during the fall, but are scarce in the southern Atlantic states, unlike other species, which are common throughout the migration route. There are also numerous banding records of Blackpolls grounded in Bermuda, Puerto Rico and the Lesser Antilles, as well as visual observations of Blackpolls flying over these areas without landing (Nisbet et al. 1995).

In this thesis I test the hypothesis that all species except Blackpoll Warblers encountered on Bon Portage are southwest-migrating species.

Under this hypothesis, I assume that north and northeast winds are favourable tailwinds, while southwest winds are unfavourable headwinds for these species. In contrast, the hypothesis predicts that north and northwest winds are favourable tailwinds for Blackpoll Warblers, because empirically the largest numbers of (presumably) Blackpolls were observed migrating during these wind directions (Richardson 1972, 1976, 1978b). Conversely, I assume that south and southeast winds are unfavourable headwinds for Blackpoll Warblers.

INTRODUCTION

Most migratory species, especially neotropical migrants, must make frequent stopovers during their migrations to deposit fat stores for the next flight (Blem 1980, Biebach et al. 1986). Little is known of the stopover ecology and behaviour of migrants at stopover sites along their migration route (Moore et al. 1995). The stopover ecology of landbirds on the Atlantic Coast of North America (the “Atlantic Flyway”), especially in northern areas, has only been studied by a few researchers (Murray 1979; Morris et al. 1994, 1996; Parrish 1997). Consequently, little is known of fat deposition requirements, stopover lengths, or even timing of migration for many species in Atlantic Canada.

Bon Portage Island, located approximately 3 km off the southwestern shore of Nova Scotia (Fig. 1), is an ideal site to study landbird stopover ecology. Numerous radar studies conducted in this area (e.g. Richardson 1972, 1976, 1978b) provide important baseline information on large-scale patterns of migration around Bon Portage. These data allow for explorations into little-known relationships such as those between wind direction and stopover, which this thesis will address. However, this is the first study of landbird stopover ecology on Bon Portage. Thus, it is not known if migrants use the island as a final stopover for fat deposition before they cross the Gulf of Maine, if the island is merely a resting area for migrants during daylight hours, or if it

is a place where migrants seek refuge from unfavourable wind conditions. Therefore, the overall objective of this thesis is to determine the importance of Bon Portage to migrating landbirds.

There are probably a variety of reasons why each migratory species initially comes to Bon Portage. Some, for example, may need to deposit fat for their next flight (across the Gulf of Maine for most species), while others may have to interrupt their migration because of unfavourable environmental conditions. Wind direction affects migrating landbirds in Atlantic Canada more than any other aspect of weather (Richardson 1972, 1976, 1978). Thus, on Bon Portage, wind direction may have an influence on the numbers of migrants that initially come to the island. Furthermore, since direct headwinds (from the southwest) are counterproductive to forward (southwest) migration, more birds may settle at ground sites during this wind direction than any other. Therefore, I predicted the largest overall numbers of birds would come to Bon Portage when the wind was from the southwest.

Once on Bon Portage, all species may not be able to deposit fat, because of the island's small size, limited habitats and resources. If so, species that are unable to deposit fat while on the island should not remain long on Bon Portage after arrival. Recapture rates, stopover lengths, and fat reserves can be used to determine whether a species is capable of depositing fat on the island.

Wind direction may have a species-specific effect on the numbers of birds that come to Bon Portage. A species that migrates in a southwestward direction in the fall may come to the island in the greatest numbers when it encounters direct headwinds (i.e. from the southwest). Similarly, Blackpoll Warblers, which migrate in south-southeast directions, may be most abundant on the island during direct headwinds from the south or southeast.

Finally, fat reserves of migrants on Bon Portage may be related to wind direction. For example, headwinds may force migrating birds to land when fat deposition is not necessary, while tailwinds may allow these "fully-fueled" birds to continue. Furthermore, birds that land on Bon Portage during tailwinds may not have enough fat to continue their migration. Thus, for a southwest-migrating species, I predicted that the individuals captured on the island during north and northeast tailwinds would be carrying the least amount of fat. Similarly, I predicted that Blackpoll Warblers captured during favourable tailwinds (northwest for this species) would be carrying the least amount of fat.

To address these hypotheses, this thesis has three specific objectives:

1. To test if the overall numbers of southwestward migrating landbirds that are present on Bon Portage in the fall are related to wind directions.

2. To test whether any species can build up fat on the island, and
3. To test if wind direction affects either the abundance or fat reserves of individual species on Bon Portage in the fall. For this objective, Myrtle (Yellow-rumped) Warblers (hereafter Myrtle Warblers), Blackpoll Warblers, and Red-eyed Vireos will be tested, as these were the only species with adequate sample sizes.

The results of these tests were used in combination to address my overall objective of determining the importance of Bon Portage to migrating landbirds.

With the recent establishment of long-term banding stations on Bon Portage and Seal Islands (as part of the Atlantic Bird Observatory), the potential for future research on the stopover ecology of landbirds in southwestern Nova Scotia is great. Following this thesis I have presented some suggestions for future work that could follow the present project (Appendix B). In addition, I have made recommendations to banders and volunteers at each Atlantic Bird Observatory site so that the (primarily) migration monitoring data that are collected can also be used in future studies of the stopover ecology of landbirds (Appendix C).

STUDY SITE

Bon Portage Island (43°28'N 65°45'W), is a 150 ha island situated approximately 3 km off the southwestern tip of Nova Scotia (Figure 1). It is elongated, being 600m wide and 3 km long, with an overall north-south orientation (Johnson 1984; Figure 2). The island has two forested sections separated by a floating bog. Bon Portage is forested with white spruce (*Picea glauca*), black spruce (*P. mariana*), and balsam fir (*Abies balsamea*), with some mountain ash (*Sorbus americana*) and white birch (*Betula papyrifera*). Along the edge of the forest on the eastern side of the island are small stands of speckled alder (*Alnus rugosa*). A fire burned across a section on the southern end where there is now new vegetation with wild raisin (*Viburnum cassinoides*) and various other small shrubs.

In the early 1980s, there was an infestation of hemlock looper (Order Lepidoptera, *Lambdina fiscellaria*), which caused a dramatic change in the vegetation of certain areas of the island (Randy Milton, pers. comm.). In these areas, most of the forest softwood is now dead, creating openings in the once-dense evergreen canopy. The early successional forest floor in these areas is composed of small hardwood saplings such as white birch and mountain ash, mixed in with dense patches of Canada yew (*Taxus canadensis*), and raspberry (*Rubus* sp.).

Together with the spring and fall landbird migrants, Bon Portage has large breeding populations of Leach's Storm Petrels (*Leucorhoa*

oceanodroma), Herring Gulls (*Larus argentatus*), Great Black-backed Gulls (*Larus marinus*), as well as a number of American Crows (*Corvus brachyrhynchos*) (MacKinnon 1988). Native to the island are Masked Shrew (*Sorex cinereus*) and Meadow Vole (*Microtus pennsylvanicus*). White-tailed Deer (*Odocoileus virginianus*) are sometimes seen on the island as well. Snowshoe Hare (*Lepus americanus*) and Muskrat (*Ondatra zibethicus*) were introduced by people (MacKinnon 1988).

The area of Bon Portage sampled in this thesis (indicated in figure 2) is centered around the Cyril Coldwell Laboratory, located on the eastern side on the southern end of the island. This area consists of four main habitat types. The old growth, spruce/fir, undamaged forest; the burned area now consisting of wild raisin; the hemlock looper damaged forest, now in early stages of succession; and the primarily alder-dominated shore habitat.

METHODS

GENERAL METHODS:

From 12 August to 2 November in 1995, and from 12 August to 20 October in 1996, standard 12 m x 2.5 m, 30 mm mesh, nylon mist nets were operated on Bon Portage in each of the four main habitat types in the sample area around the Cyril Coldwell Laboratory. These mist nets were as high as the surrounding vegetation in each of the shore, burn, and early successional habitats. However, the vegetation around the old growth, spruce/fir nets exceeded the height of the nets, so that some species that frequent this habitat may not have been adequately sampled (Remsen and Good 1996).

The number of nets operated each day varied with the weather conditions (i.e. exposed nets were not opened on days with high winds, and none were opened during rain). However, on most days, at least three nets were operated in each of the four habitats. When weather and personnel allowed, the total 21 nets were opened. Nets were opened by 20 minutes after sunrise, and operated continuously for 5 hours in 1995 and 6 hours in 1996. To account for the varying numbers of mist nets used per day, captures were standardized to number per 100 net-hours (#/100NH) where 1 net hour is one 12 meter, 30mm net, operating for 1 hour (Ralph 1976). In the fall of 1995, I conducted all of the banding myself, but was helped by two field assistants in 1996. All original

banding data and accompanying wind data are now located at the Biology Department at Acadia University.

Each open net was checked at intervals of no longer than 30 minutes. Birds were removed from the nets, placed in cloth bags, transported to the Cyril Coldwell Laboratory, processed and released. Processing entailed the following: each bird was banded with an aluminum USFWS leg band, aged, sexed (according to Pyle et al. (1987)), weighed, had its unflattened wing chord measured, and was assigned a fat score. I used a fat scoring method following Helms and Drury (1960), where 0 = no trace of fat in furculum, 1 = trace of fat, 2 = fat filling but not level with sides of furculum, 3 = fat level with furculum sides, 4 = fat overflowing from furculum, and 5 = fat overflowing furculum and continuous with abdominal fat. For all birds, the interval between net extraction and release was approximately 40 minutes. Because fat scoring is partly a subjective measurement, in all analyses of migrants' fat reserves in this thesis, I conducted separate tests on both the fat scores and weights of the migrants. So as not to bias observations, all recaptured birds were processed exactly the same as initially captured birds without referring to the original capture data.

In 1995, birds were weighed using a 50 g Pesola spring scale (with 0.5 g graduations) and their weight was estimated to the nearest 0.25 g. In 1996, an Acculab V-333 electronic balance was used and all weights

were recorded to the nearest 0.1 g. Since two methods were used to measure the weights of birds, I tested for differences between these two methods *a posteriori* by weighing 35 objects, of weights varying between 5 g and 50 g, with both scales. A paired t-test revealed a significant difference between the two methods of measurement ($t=2.14$, $df=34$, $p=0.03$). Thus, in all analyses of weights in this thesis where the data from both years was pooled, I included a dichotomous dummy variable to account for this difference. Unfortunately, using a different weighing method each year means that I can not control for possible effects of annual variation on the weights of migrants. However, this variation is believed to be negligible, as there was no significant (at 0.05 level) difference in the fat scores that I assigned to Myrtle Warblers between 1995 and 1996 (two-sample t-test, $df=457$, $p=0.085$). This suggests that annual variation in weights of species is also either small, or nonexistent. Furthermore, I can think of no previous study which documented annual variation in weight or size of a species at a stopover site. Moreover, combining consecutive years of data to increase sample sizes is a frequent practice (e.g. Morris et al. 1996, Parrish 1997, Winker et al. 1992a).

Similar to other coastal banding stations, hatch-year birds predominated in the banding captures on Bon Portage (over 90% for most species). Since recent evidence shows that certain species can display age-related differences in stopover ecology (Woodrey and

Chandler 1997, Woodrey and Moore 1997, Yong et al. 1998), I removed after-hatch-year birds from all analyses with little loss of data. All results and subsequent conclusions are based on hatch-year birds.

There is also evidence that some species display sex-related differences in stopover ecology (e.g. Morris et al. 1996, Yong et al. 1998). Unfortunately, it was rarely possible to sex hatch-year birds in the hand on Bon Portage. Thus, examination of sex-specific differences in stopover ecology on Bon Portage was not possible with these data.

A problem that is often encountered at migration monitoring stations in the fall is the presence of individuals that were hatched at the site during the summer (e.g. Winker et al. 1992a, Morris et al. 1994). For instance, on Bon Portage, Fox Sparrows breed on the island, but also migrate. Thus, if a Fox Sparrow is captured on Bon Portage after the regular breeding season, it can not be determined if that individual has just completed a migratory flight, or if it came from the island in the first place. To address this, in the summer of 1996, I attempted to band all of the breeding birds and their young in the vicinity of the mist net sample area by operating the same mist nets once every ten days. I followed the same protocol as was used during the migration season. I found large breeding populations of Swainson's Thrushes, Golden-crowned Kinglets, American Redstarts, Yellow Warblers, Common Yellowthroats, Fox Sparrows, Song Sparrows and Winter Wrens in 1996 (Appendix D). These

species were not included in the analyses of migrants. In contrast, less than five females in breeding condition were banded for Blackpoll Warblers, Black-throated Green Warblers, Gray Catbirds, Northern Parulas, Savannah Sparrows, and Ruby-crowned Kinglets (Appendix D). Since these species' breeding populations were less than 5 % of their respective numbers of migrants of these species, and the small numbers of residents was unlikely to substantially affect analyses, I have included these species as migrants.

In 1995, Environment Canada provided local daily wind directions, in the form of marine forecasts for the Lurcher area. The Lurcher area encompasses Shelbourne County, in which Bon Portage lies. For the 1995 season the dawn (0530) and evening (2030) Lurcher marine forecast wind direction were used in all analyses concerning wind direction. Wind direction data in 1996 was recorded on the island throughout the banding period. I recorded the local wind direction in the morning and evening on Bon Portage using a hand-made fixed weather vane located on the eastern shore of the island, approximately 200 m from the central banding station. The weather vane was placed in a completely open area so that trees and structures would not obscure the actual wind direction. The vane was placed on a pole approximately 20 feet tall. Each day the wind direction on Bon Portage was recorded with this vane within 20 minutes before and after dawn and between 2000 and 2200 in the evening. In each year, wind directions either from the

Environment Canada data or at the site were recorded as from the north, northeast, east, southeast, south, southwest, west, northwest, or calm (no wind direction was discernable).

Differences in these two methods of recording wind detection are believed to be minimal, as Environment Canada's marine forecast is based partly on data obtained from a weather station on Clarke's Harbour, approximately 10 km southeast of Bon Portage (Bowyer and Gray 1989). Moreover, on the occasions when the marine forecasts were consulted in 1996, I detected no discrepancies between the two methods (i.e. both methods were in agreement). Furthermore, since the wind directions were measured in 45-degree increments, any small differences due to local geography were probably negligible. Moreover, in many analyses in this study, adjacent wind directions had to be combined to meet sample size requirements for statistical tests (see below). This further reduces the effects of small differences in the two methods.

DATA ANALYSIS

EFFECT OF WIND DIRECTION ON TOTAL CAPTURE RATE:

All analyses in this thesis were performed using SPSS (SPSS 1996). To test for a relationship between wind directions and the total numbers of migrants on the island, I compared the total capture rate relative to the corresponding wind directions at dawn. For this, I performed a Kruskal-Wallis 1-way ANOVA on the total capture rates of all SW-migrating species (i.e. all except Blackpoll Warblers) in each dawn wind

direction. For this test, days with northeast winds at dawn were combined with north winds since on only 4 days out of the banding periods of both years was the wind direction at dawn from the northeast. A non-parametric ANOVA was used here because the wind direction sample sizes were uneven and parametric ANOVAs are sensitive to unequal sample sizes. I further compared, using a Mann-Whitney test, the overall numbers of migrants during southwest headwinds to the numbers during all other wind directions combined.

FAT DEPOSITION:

To determine if a species can deposit fat while on the island, I used common methods from the literature, (e.g. Rogers 1991, Winker et al. 1992a, Morris et al. 1996) to develop a set of four criteria to apply to all commonly encountered species. The four criteria for assessing the ability to deposit fat during stopover are:

1. The species should have recaptured individuals;
2. Recaptured individuals should remain on the island for more than 1 day, on average;
3. There should be a positive relationship between the weights of all individuals of the species and the time of capture, and/or between the fat scores of the individuals and the time of capture; (i.e. captured birds should be heavier/fatter as the day progresses) and

4. Recaptured individuals should increase in weight and/or fat score between first and last capture.

If a single criterion is met this will provide weak evidence that the species can deposit fat while on Bon Portage. However, if any species meets all the criteria, it will be interpreted as strong evidence that the species is able to use the island for building fat stores.

Criterion 1. If no individuals of a species were recaptured, it is commonly assumed that these birds departed from the site soon after initial capture (e.g. Moore and Kerlinger 1987, Moore and Simons 1992, Morris et al. 1996). Thus my first criterion was if individuals of the species were recaptured.

Criterion 2. A species' recaptured individuals should have an average stopover length of more than 1 day. If individuals were present on Bon Portage for two or more consecutive days, it implies that they could at least maintain themselves on the island's resources. For this criterion, a minimum estimate of the length of stopover was calculated for all recaptured individuals by subtracting the initial day of capture from the final, and adding 1 day (following Lavee et al. 1991). Thus, a stopover of two days with this calculation means that the bird was present on the island for at least two consecutive days. The addition of one day is necessary since a bird recaptured later the same day would have a stopover length of zero. It can not be assumed that the bird was

captured on the day of its arrival or departure. However, as this limitation is true for all individuals, an average of all such stopover calculations should provide a conservative estimate of the true stopover lengths for each species.

Criterion 3. If a species was depositing fat on the island, individuals of that species should become progressively heavier or fatter as each day progresses. In other words, there should be a positive relationship between time of capture and weight, fat score, or both for all new individuals (non-recaptured birds and first captures of birds that were later recaptured) (Winker et al. 1992a).

Using only the recaptured birds for analyses of weight and fat changes has one major disadvantage, recaptured birds on Bon Portage represent less than 5% of individuals. Winker et al. (1992a) addressed this limitation by using linear regression to determine the relationship between fat score, or weight, and time of day for all newly captured birds. They proposed that a bird that gains weight at a site should show a positive relationship between either fat score or weight and time of capture. This method allows all birds to be analyzed, no matter how many were recaptured. However, Winker (1995a) also found that there were significant positive relationships between body size (indicated by wing and tail measurements) and time of day. This was a bias that Winker et al. (1992a) did not consider. Nor did Winker et al. (1992a)

account for the effects of seasonal variability in the weights of migrants.

To determine the relationship between weight and time of capture, I used a modification of the method of Winker et al. (1992a). I performed a forward stepwise linear regression where I first had as explanatory variables wing length (to account for effects of body size on weight), date of capture (to account for any variation in the weights of migrants within a season; in number of days since Jan. 1) and a dichotomous dummy variable to account for the differences in weighing methods. I then forced time of capture into the model. In 1995, individuals that did not have their wing chords measured were excluded.

Krementz and Pendleton (1990) reported that fat scoring is a reliable method of indexing the amount of fat carried by a bird, but inter-observer variation may be substantial. I found no significant variation in fat scoring (of Myrtle Warblers) between my two assistants in 1996, (two tailed t-test, $df=87$, $t=-1.16$, $p=0.25$). I therefore pooled the data sets of these two observers in all fat score analyses. There was a significant difference in fat scoring (of Myrtle Warblers) between myself and my two assistants combined (two-tailed t-test, $df=471$, $t=-4.84$, $p<0.01$).

Therefore, to examine the relationship between time of capture and the fat scores of each species, I first fitted a dichotomous observer variable to the model. For this variable, I used myself as the primary observer, and both of my assistants as the secondary observer. I then fitted a date

variable to account for any seasonal variability (in number of days since Jan. 1), and finally, time of capture. In all of these regressions of weight and of fat scores, only species with 20 or more individuals were tested.

Criterion 4 If there were weight gains between first and last captures (Moore and Kerlinger 1987, Winker et al. 1992c, Morris et al. 1996), and/or gains in fat scores (e.g. Biebach et al. 1986), this was taken as definitive evidence of fat deposition on Bon Portage.

To test whether recaptured birds were gaining weight I compared the weights of recaptured individuals between first and last capture using one-tailed paired t-tests following Morris et al. (1994). Only species with ten or more recaptured (hatch-year) individuals were tested.

Rogers (1991), using a fat scoring system nearly identical to the Helms and Drury (1960) system I used in this study, found his fat scoring method to be linearly related to the lipid indices (actual fat contents) of birds. He therefore treated the scores as continuous, numeric variables. I therefore also treated my fat scores as continuous numeric variables, using paired t-tests (one-tailed) to test for differences between fat scores of first and last captures of recaptured (hatch-year) individuals.

EFFECT OF WIND DIRECTION ON MYWA, REVI, and BLPW:

Because of the nature of this analysis (where data for each species was subdivided into 9 wind categories), only the sample sizes for three

species, Myrtle Warblers, Blackpoll Warblers and Red-eyed Vireos, were large enough for this analysis.

Richardson (1972, 1976, 1978b) showed that southwest (SW)-migrating birds at dawn, either reoriented to the coast or continued migrating, depending on the wind direction. Thus, I assumed that SW-migrating species assess dawn wind direction in their decision to either continue migrating or land. Wind direction at dawn was therefore used in the analyses for Myrtle Warblers and Red-eyed Vireos (both SW-migrating species).

Richardson (1972, 1976) showed that trans-oceanic migrants always initiated their trans-oceanic flight from Nova Scotia just after sunset. He also showed that these birds never reoriented to the coast at dawn. I assumed, then, that Blackpoll Warblers use the evening wind direction to decide whether to initiate their trans-oceanic flight. Thus the wind direction that should be related to the abundance and fat reserves of Blackpolls on Bon Portage in the mornings would be the wind direction during the previous evening. For analyses with Blackpoll Warblers, I therefore used the wind direction recorded during the previous evening.

Myrtle Warblers did not start to arrive on Bon Portage in any appreciable numbers until the middle of September in both years. I therefore chose a migration start date each year based on the first day in

which the cumulative number of individuals captured for the season exceeded 5% of the total number captured that year. Thus only the data from September 29 to the last day of banding in 1995 and that from October 1 to the last day of banding in 1996 were used for all analyses concerning wind direction and Myrtle Warblers. The bulk of the migration of both the Blackpoll Warbler and Red-eyed Vireo was covered by the banding periods in both years. Wind data from the entire period were used for all analyses of these species.

Certain wind directions were recorded on less than 5 days over both seasons for the migratory peaks of each species. Therefore, some wind directions had to be combined with adjacent directions to make statistically meaningful sample sizes. In these cases, the wind directions were combined so that each new wind direction(s) was still biologically meaningful. For example, for all analyses of Myrtle Warblers, days with north and northeast winds were combined, as were southeast and south, and west and northwest. The north/northeast combination represents favourable tailwinds for this species' migration.

To test whether dawn wind direction affected abundance of Myrtle Warblers and Red-eyed Vireos, I performed a Kruskal-Wallis 1-way ANOVA on the daily capture rates of each of these species in each dawn wind direction. Similarly, I tested whether the previous evening's wind direction affected the number of Blackpoll Warblers on the island the

next morning.

To test whether the weights and fat scores were associated with wind direction, I again used Kruskal-Wallis 1-way ANOVAs. However, to remove any confounding effects on the weights of the birds, I performed a forward stepwise linear regression on their log-transformed weight, with wing chord, date (in number of days since Jan. 1) and weighing method fitted to the model. All non-significant variables were dropped to make final models. The residuals of each model were then used in the Kruskal-Wallis ANOVAs. Similarly, a model was created for fat scores, with date (in number of days since Jan. 1) and a dichotomous dummy observer variable fitted to the model. The residuals of this model were then used in the Kruskal-Wallis analyses-of-variance to test for the effect of wind direction on the fat scores of each species.

When necessary, data were log-transformed to meet assumptions of normality. Normality was assessed using histograms and quantile plots (SPSS 1996). In all tests in this study, significance was accepted when $p < 0.05$. When a test resulted in a p-value less than 0.10, the result was also discussed.

RESULTS

EFFECT OF WIND DIRECTION ON TOTAL CAPTURE RATE:

Dawn wind direction caused significant variation in the total capture rate of southwest-migrating species (all species except Blackpoll Warblers; 1995 and 1996 combined) ($H= 15.3$, $df=7$ $p=0.03$; Figure 3). Contrary to my hypothesis, however, capture rates during southwest winds were not significantly greater than those of other wind directions combined (Mann-Whitney, $z=-7.08$, $p=0.36$; Figure 3). In fact, northwest and west wind directions at dawn appeared to be associated with the largest average capture rates on Bon Portage.

Table 1 shows the top ten days (cutoff decided arbitrarily) with the largest daily capture rates and the corresponding dawn and previous evening wind directions. On each of the four days with the largest daily capture rate, both the dawn wind direction and the wind direction of the previous evening were from the northwest. On two more of the top ten days, dawn wind as well as the previous evening wind were from the west. Furthermore, on the two days with winds from the north at dawn, the previous evening's winds were from the northwest. Both Table 1 and Figure 3 suggest that the largest number of birds came to Bon Portage when the wind direction had a west-northwest component. These wind directions would be the most likely to cause southwest-migrating landbirds to be forced offshore and thus be forced to make a dawn

reorientation, described previously only in radar studies in Atlantic Canada (Richardson 1972, 1976, 1978b).

FAT DEPOSITION:

Of the 18 species for which sample sizes allowed at least three criteria to be tested, I only found evidence of fat deposition in three: Myrtle Warbler, White-throated Sparrow, and Blackpoll Warbler. Of these three, Myrtle Warbler was the only species that met all four fat-deposition criteria conclusively (Table 2). They were recaptured at a rate of 3.7%, and recaptured individuals stayed an average of 3.0 days (Table 3). Heavier Myrtle Warblers were also captured later in the day (Table 4). However, Myrtle Warblers were not assigned higher fat scores later in the day (Table 5). To illustrate these trends, the data used in the weight and fat score models for Myrtle Warblers are plotted (Figure 4). Finally, there was a significant increase in the weights of recaptured individuals between first capture and last capture ($t=-2.66$, $df=17$, $p=0.011$) (Table 6).

To illustrate the relationship between weight and fat scores, both are graphed for Myrtle Warblers in Figure 5. With the fat scoring system I used, I assigned individuals a 2 score more than any other score, and these individuals weighed an average of 12.1 g. Very few birds were assigned a 4 fat score, and none were assigned a 5 score (Figure 5). Fifty-seven (14.9%) individuals were assigned a 0 fat score (no visible fat reserves) and these birds weighed an average of 10.4 g. The majority

(approximately 85%) of Myrtle Warblers then, had at least some visible fat reserves (i.e. were assigned a 1 or more fat score) when they were captured on Bon Portage, and weight increased with fat score (Figure 6).

White-throated Sparrows met 3 of the 4 fat-deposition criteria (Table 2). They were recaptured at a rate of 13.8% and recaptured individuals stayed an average of almost five days (Table 3). Although not significant, recaptured individuals tended to gain weight (Table 6). White-throated Sparrows captured later in the day were heavier (Table 4) and were assigned higher fat scores later in the day (Table 5), providing strong evidence that this species can deposit fat on Bon Portage.

Blackpoll Warblers may also be able to deposit fat on Bon Portage. Blackpolls met 3 of the 4 fat-deposition criteria (Table 2). Over 3% of the Blackpoll Warblers captured on Bon Portage were later recaptured, and recaptures stayed an average of four days (Table 3). Blackpolls also were significantly heavier and were assigned significantly greater fat scores later in the day (Tables 4 and 5). However, because of the small recapture sample size, I could not test my fourth criterion. The fact that they met all of my other criteria provides strong evidence that this species is able to deposit fat on Bon Portage.

The remainder of the species tested for fat deposition only met the first two criteria (Table 2). However, since the sample sizes for some species (e.g. Solitary Vireos, Ruby-crowned Kinglets) were less than 25

individuals, additional data may be required to show whether these species can deposit fat on Bon Portage.

SEASONAL DISTRIBUTION OF MYWA, REVI, BLPW, and WTSP:

To illustrate the seasonal distribution of the three species used in the next analysis (Myrtle Warblers, Red-eyed Vireos, and Blackpoll Warblers), the daily capture rates of each is graphed for 1995 and 1996 (Figures 6-8). The daily capture rate of White-throated Sparrow is also graphed here (Figure 9) since I found evidence of fat deposition in this species (above). In each graph, only hatch-year birds are shown. Daily capture rates of Myrtle Warblers peaked in October in both 1995 and 1996 (Figure 6). Red-eyed Vireos were most abundant by mid-September in 1995 but were later in migrating in 1996 (Figure 7). Blackpoll Warbler numbers on Bon Portage were highest by late September and early October in both years (Figure 8). Figure 9 shows that White-throated Sparrows began their main migratory movement in early October in both years. In summary, the banding program covered the bulk of the Red-eyed Vireo and Blackpoll Warbler migrations (Figures 7 and 8) through Bon Portage. The later migration of the temperate-wintering Myrtle Warblers (Figure 6) and White-throated Sparrows (Figure 9) means that the banding seasons each year may have missed some individuals of these species that migrated in November.

EFFECT OF WIND DIRECTION ON MYWA, REVI, and BLPW:

Myrtle Warblers

The wind direction at dawn did not have significant effects on daily capture rates of Myrtle Warblers on Bon Portage ($H=3.9$, $df=5$, $p=0.57$; Figure 10). I did not, therefore, test whether southwest headwinds brought the most birds to the island. However, it appears that more Myrtle Warbler individuals were captured when the dawn wind was from the west or northwest (Figure 10). Furthermore, days when the most Myrtle Warblers were captured were those that had dawn winds from the northwest and west (Table 7). Eight of the top 10 days had dawn winds either from the northwest or west. On 4 of the top 5 days, wind direction at dawn and the previous evening were both from the northwest.

There were fewer than five Myrtle Warblers for which I had wing chord measurements captured during north and northeast winds. Therefore, I did not test for the effect of wind direction on the weights of this species. However, there were adequate data to test for the relationship between wind direction and fat scores of this species. There was significant variation in the mean ranks of fat scores relative to dawn wind direction ($H=13.8$, $df=5$, $p=0.02$; Figure 11). Mean ranks correspond to the relative fat scores of birds captured in each wind class. In other words, the fat reserves of Myrtle Warblers on the island on any given day are related to the dawn wind direction that day. However, contrary to my hypothesis, Myrtle Warblers captured during north and northeast winds

did not have lower fat scores than during other wind directions combined (Mann-Whitney, $z=-0.20$, $p=0.27$; Figure 11).

Red-eyed Vireos

No Red-eyed Vireos were captured when the dawn wind was from the south or the southeast, even though 12 days with these wind directions were recorded (Figure 12). There was significant variation in these capture rates (SE+S class not included; $H=14.9$, $df=5$, $p=0.02$). However, the daily capture rates of Red-eyed Vireos on southwest days were not significantly larger than those of the other days combined (Mann-Whitney, $z=-0.00$, $p=0.111$; Figure 12). Furthermore, five of the top ten daily capture rates of Red-eyed Vireo were days when the dawn wind was from the northwest and two were when it was from the north (Table 8).

No significant variation in weight residuals of Red-eyed Vireos was detected among dawn wind directions ($H=5.2$, $df=5$, $p=0.39$; Figure 13) but there was variation in fat score residuals with respect to dawn wind directions ($H=11.9$, $df=5$, $p=0.04$; Figure 13). Contrary to expectation, Red-eyed Vireos that came to the island during north and northeast winds did not have less fat than those in other wind directions (Mann-Whitney, $z=0.06$, $p=0.26$; Figure 13).

Blackpoll Warblers

Wind direction during the previous evening influenced the

numbers of Blackpoll Warblers that were captured the next day ($H=14.6$, $df=7$, $p=0.04$; Figure 14). However, capture rates of Blackpolls after southeast and south winds were not significantly greater than those after all other evening wind directions combined (Mann-Whitney, $z=-0.00$, $p=0.26$; Figure 14). Seven of the top ten Blackpoll days came when the previous evening wind was from the northwest (Table 9).

There were too few days (with at least one Blackpoll Warbler captured) with no evening wind (calm) to include this wind condition in the analysis of Blackpoll Warbler weights; however, there were sufficient numbers of days to include calm wind in the analysis of fat scores. There was significant variation in weight residuals ($H=13.3$, $df=3$, $p=0.00$; Figure 15) but no significant variation in fat score residuals with respect to evening wind direction ($H=7.63$, $df=4$, $p=0.106$; figure 15). There was a tendency for Blackpoll Warblers to weigh less on days after north and northwest winds than on all other days combined (Mann-Whitney, $z=-0.31$, $p=0.07$; Figure 15). This is consistent with my hypothesis concerning the effect of wind direction on the fat reserves of this species.

In summary, I found no evidence that headwinds caused large accumulations of either SW-migrants or Blackpoll Warblers on Bon Portage, contrary to my prediction. Furthermore, I found no evidence that the lightest (i.e. carrying least amount of fat) SW-migrating individuals were associated with tailwinds on Bon Portage, also contrary

to my prediction. Blackpoll Warblers, however, tended to be lighter after tailwinds the previous evening, agreeing with my prediction.

DISCUSSION

For the majority of migrants, Bon Portage Island appears to be a temporary rest area during fall migration. Most southwest-migrating birds may initially come to Bon Portage simply because of its location (i.e. they may be merely looking for a place to land after dawn reorientation). Several findings in this thesis provide evidence for these conclusions. First, birds come to the island in the greatest numbers after lateral dawn winds (west and northwest). This was the case when the total capture rate of southwest-migrating birds combined was examined, and when the capture rates of non-fat-depositing Red-eyed Vireos and fat-depositing Myrtle Warblers were investigated separately. These birds all appear to be looking for a place to land near the coast after having been blown offshore by lateral winds. This is consistent with the radar observations of Richardson (1972, 1976, 1978b) over Nova Scotia. Second, low recapture rates of most species indicates that few birds, even those capable of remaining on the island, actually remained for long periods on Bon Portage. Many species initially came to the island, often en masse, but few stayed longer than one day. Most birds appeared to require only a resting area until nightfall when they could continue their nocturnal migration. Finally, of the 45 commonly captured species on Bon Portage in the fall, only one species, Myrtle Warbler, conclusively demonstrated fat deposition. Furthermore, the amount of fat Myrtle Warblers deposited on Bon Portage was small (approximately 2% of body

weight deposited/day).

That the number of migrants that come to a stopover site (Bon Portage) in any given day is related to the dawn wind direction that day is a finding previously not described for any site on the Atlantic Coast. Hence, not only does wind direction affect the number of birds migrating each night (Richardson 1976), it also influences how many birds will be observed on land during the day. However, the highest number of grounded migrants may not necessarily correspond to the highest number of migrants flying the night before. I found that Bon Portage was most heavily used during northwest winds, while Richardson (1972, 1976) observed the most migrants flying with north and northeast tailwinds.

That the heaviest use of the island occurs after northwest winds was an unexpected result. Reoriented migration has been well-documented in the Maritimes using radar (Richardson 1976, 1978b), however the resulting large accumulations of grounded birds after reoriented migration has not been previously observed in the Maritimes. In fact, reoriented migration appears to be the most influential factor determining the number of birds that come to Bon Portage. The reason for this is unknown to me. However, the fact that wind direction does influence the numbers of migrants that come to Bon Portage has important implications to banders at migration monitoring stations in

Atlantic Canada, and perhaps along the northern Atlantic Coast. They can now use dawn wind direction to prepare for each day. This information may also help banders to plan which nets to open or keep closed. On days when the dawn wind is northwest, for example, personnel on Bon Portage may want to operate only the most easily accessible nets. This practice could ensure that the number of birds trapped never exceeds the banders' capability to extract them from the nets, thus reducing mortality.

Myrtle Warbler was the only species that conclusively met all fat-deposition criteria. However, the fact that less than 4% of Myrtle Warblers were recaptured suggests that despite being able to, few individuals actually stayed and replenished fat stores on the island. Rappole and Warner (1976) reached the same conclusion based on observations of color-banded migrant Northern Waterthrushes at a stopover site. Rappole and Warner attributed this to the territorial behaviour of migrants at the site. Those with a territory deposited fat while those without moved on. This could have contributed to the small recapture rate of Myrtle Warblers on Bon Portage; once all available territories were filled, surplus individuals were forced to move on, resulting in few individuals remaining on the island. This could also explain why direct headwinds did not result in the largest accumulations of migrants, as I had predicted. Bon Portage may only be able to accommodate a certain number of territorial individuals when birds are

forced to land and wait for favourable tailwinds.

An alternative explanation for why few Myrtle Warblers use the island to deposit fat is that the majority of them do not need to replenish or add to their fat reserves when they reach the southern tip of Nova Scotia. Fat reserves of Myrtle Warblers captured on Bon Portage provide support for this explanation. More Myrtle Warblers were assigned a 2 fat score than any other. Many Myrtle Warblers thus appeared to have at least some existing fat supply. Furthermore, if one assumes that the average 10.5 g weight of individuals with a 0 fat score approximates the fat-free weight of Myrtle Warblers, then birds with a 2 fat score would be carrying an average 1.5 g of fat. Estimated flight range by a bird this size with this amount of fat (from Pennycuick 1975) is approximately 500 km in still air. Because these birds are usually migrating with a moderate tailwind, this amount of fat would be more than sufficient to make the 400-500 km flight (depending on take-off and landing sites) across the Gulf of Maine. Hence, many Myrtle Warblers simply may not require additional fat when they reach Bon Portage (cf Moreno 1989). The fact that Myrtle Warblers captured with dawn tailwinds were not assigned significantly lower fat scores than those in other directions is consistent with this statement. I had previously thought that during favourable tailwinds, individuals that came to Bon Portage must require additional fat, and thus would have small fat reserves. However, these individuals did not have smaller fat scores than in other wind directions. Thus, even

these individuals appeared to already have at least some existing fat reserves.

If it is true that the majority of Myrtle Warblers do not require additional fat on Bon Portage, one could then ask why the recaptured Myrtle Warblers stayed and deposited fat? The answer to this may be that these individuals did require at least some additional fat. To address this question, I compared the linear regression residuals of the fat scores of those Myrtle Warblers that were later recaptured to those that were never recaptured. There were not enough data to compare weight residuals. The fat score residuals of recaptured birds were significantly lower than those of non-recaptured birds (one-tailed t-test, $t=-1.84$, $df=23$, $p=0.04$), suggesting that the individuals that did remain on the island (i.e. those that were later recaptured) may have done so out of necessity. These birds may have been forced to remain on Bon Portage to deposit additional fat. This is consistent with previous studies on the Atlantic Coast (e.g. Morris 1996, Morris et al. 1996, Parrish 1997); lean birds are more willing to stay and will deposit more fat at stopover sites than fat birds.

The amount of fat actually deposited by Myrtle Warblers appeared small, which may further support the idea that most Myrtle Warblers may not require additional fat when they reach Bon Portage. The positive diurnal trend in weight indicated a gain of approximately 0.13 g per day

(Fig. 4). Furthermore, the average 0.5 g increase in weight of recaptured individuals over an average of 3 days means a daily increase of 0.17 g. This, for a 10g Myrtle Warbler, is approximately 2% of its body weight. Such small increases in weight (which I assumed to represent increases in fat) while on the island suggest that Bon Portage is not a crucial, or necessary, stopover site for most Myrtle Warblers. This may also be true for other species. Although not significant, White-throated Sparrows gained an average of only 0.4 g over an average of approximately 5 days. Thus, White-throated Sparrows may also use Bon Portage mainly as a resting, or staging area where they only maintain, or add small deposits to their existing fat reserves.

An alternative explanation for the small amount of fat deposition I observed in migrants on Bon Portage may simply be that only hatch-year individuals were studied. Recent evidence has shown age-related differences in stopover ecology in the fall (Woodrey and Chandler 1997, Woodrey and Moore 1997, Yong et al. 1998). Yong et al. (1998) found that hatch-year Wilson's Warblers stayed longer and put on smaller amounts of fat than adult birds at an autumn stopover site in New Mexico. More data are required to determine if adult Myrtle Warblers deposit more fat than hatch-year individuals on Bon Portage.

Nonetheless, since hatch-year individuals of many species (Table 3) use Bon Portage most heavily, the greater importance of Bon Portage may be as a resting area for hatch-year birds, where they can either maintain or

deposit small amounts of fat. Furthermore, although it is known where some landbirds are able to deposit fat (e.g. Winker et al. 1992a, Morris et al. 1994, 1996), it has yet to be clarified just how much fat is required by any species, and just where (geographically) these fat depositions are necessary. The small amounts of fat deposited on Bon Portage may be all that is required at this point in the migratory journey.

The abundance and fat reserves of Blackpolls on Bon Portage were influenced by the local wind direction. Similar to SW-migrants, most Blackpolls appeared to come to the island when the previous evening wind was from the northwest; however, Blackpoll Warblers captured after evenings with north and northwest tailwinds tended to weigh less than those captured after evenings when the wind was from other directions. One possible explanation for these results is that these accumulations after tailwinds were Blackpolls that were migrating with the tailwinds the previous night, but had to set down by dawn because they did not have enough fat to continue migrating. However, Blackpolls on Bon Portage did not appear to deposit large amounts of fat. This island then, may not be the final stopover site for Blackpolls before the main trans-oceanic flight.

An alternative explanation to results observed for Blackpolls is that the Blackpolls I encountered on Bon Portage are not trans-oceanic migrants. The migration strategy of Blackpoll Warblers has not yet been

clearly interpreted. In fact, Murray (1976, 1989) has argued that this species does not undertake a transoceanic flight at all. The fact that similar to SW-migrants, the most Blackpolls came to Bon Portage after northwest winds could be taken as evidence that this species merely migrates along with the rest of the SW-migrants, and also reorients to the coast after lateral winds. Furthermore, although it was not one of my objectives in this thesis, I found that very few Blackpoll Warblers on Bon Portage were carrying, or deposited, sufficient fat reserves to complete a non-stop, trans-oceanic flight from Nova Scotia to South America, based on Pennycuik's (1975) calculations. The majority of Blackpolls captured on Bon Portage weighed between 11 and 15g. Based on Pennycuik (1975), a bird the size of a Blackpoll Warbler (approx. 10-12 g fat-free) would need approximately 50% of its body weight as fat to make a non-stop flight (in still air) of over 3000 km. This may be an overestimate of the fat required by Blackpolls, since these birds are able to exploit moderately strong tailwinds during flight (Richardson 1972, 1976). Nonetheless, from Nova Scotia to the northernmost coast of South America is over 4000 km, so a value of 50% may be at least close to the actual amount required. Furthermore, Richardson (1976) suggested that Blackpolls may require as much as 50% of their body weight when they depart from Nova Scotia. This translates into 5-6 g of fat (for a 10-12 g Blackpoll Warbler), or at least a 4 fat score. In addition, Nisbet et al. (1963) found that Blackpoll Warblers left Massachusetts after fattening

to 20-23 g. Presumably, a Blackpoll Warbler that initiates a trans-oceanic flight from Nova Scotia must have at least as much fat, if not more, than those that start from Massachusetts. Therefore, it is reasonable to assume that Blackpolls need to be 20 g or more to make a trans-oceanic flight from Nova Scotia. However, on Bon Portage, I only encountered six Blackpolls out of the total 245 individuals that were 20 g or above and that had at least a 4 fat score.

Nisbet et al. (1963) found that immature Blackpoll Warblers tended to settle in marginal habitats where they deposited fat more slowly. This meant that they departed Massachusetts weighing between 13.5 and 19.5 grams. If this is also the case on Bon Portage, then although Blackpolls may be able to remain on the island and deposit small amounts of fat, they may do so at a sub-optimal rate. However, this raises an important question: if all Blackpolls are trans-oceanic migrants, and if these young Blackpoll Warblers are not depositing sufficient fat stores on Bon Portage to allow them to successfully complete their trans-oceanic migration, what happens to them? Do they attempt their migration after leaving Bon Portage with inadequate fat loads, and subsequently perish in the attempt? Alternatively, do they move on to Massachusetts to put on the fat they need?

Murray (1979, 1989) has repeatedly argued that the majority of Blackpoll Warblers do not complete a trans-oceanic flight at all. Similar

to my study, at Island Beach, New Jersey, Murray (1979) found that very few Blackpolls departed with sufficient fat stores for a trans-oceanic flight. However, the evidence for Blackpoll Warblers making a trans-oceanic flight is substantial (Nisbet et al. 1995). I suggest then that either Bon Portage is not the final stopover area before the trans-oceanic migration, or the Blackpolls that stop at Bon Portage are not those that complete a trans-oceanic migration. If the former is true, young Blackpolls with too little fat may leave Bon Portage to search for a better area with more or better resources. Furthermore, future explorations of other areas in southern Nova Scotia may reveal areas where Blackpolls remain for longer periods than on Bon Portage, and where they gain the necessary amounts of fat. If no such areas are found, it may be that Blackpoll Warblers find a suitable area to deposit the necessary fat reserves on the other side of the Gulf of Maine. Clearly, more study is needed on Blackpoll Warblers and its potentially unique migration strategy.

There were many other species commonly captured on Bon Portage in the fall that may also deposit fat. Ruby-crowned Kinglets, for example, had a relatively high recapture rate, an average stopover greater than one day, and tended to increase in weight between first and last captures (table 5). Similarly, both Black-and-white Warblers and Black-throated Blue Warblers had high recapture rates and stopovers greater than 3 days. I had insufficient data to test more fully whether these species are

able to deposit fat on Bon Portage, or if they can only maintain their existing fat supply.

Red-eyed Vireos and Dark-eyed Juncos appeared not to deposit fat on Bon Portage, and not unexpectedly, did not remain long on the island. Red-eyed Vireos were the third most abundant migratory species but had one of the lowest recapture rates. Furthermore, recaptured Red-eyed Vireos did not stay longer than one day. Similarly, only one Dark-eyed Junco out of 58 was later recaptured. However, this individual was present on the island for at least 24 days, which suggests that it was not a migrant. Furthermore, in neither of these species was there a trend of heavier and fatter individuals later in the day. Northern Waterthrush is the only species that may have lost fat while on Bon Portage. There was a significant trend of individuals with smaller fat scores later in the day. However, this was not unexpected, as other authors have found differences in species' abilities to use the resources (i.e. habitats) at particular sites (e.g. Winker 1995a). With species each having different foraging strategies, and habitat preferences, some species would be capable of depositing fat at a stopover site while others would not, and may experience losses in fat reserves (Winker et al. 1992b). However, an alternative explanation is that non-fat depositing species such as Red-eyed Vireos and Dark-eyed Juncos simply do not need to deposit any fat on Bon Portage. Approximately 77% of the Red-eyed Vireos processed by the author had at least some visible fat reserves, and thus may not have

required additional fat to continue migrating. Species such as Red-eyed Vireos may have previously accumulated enough fat to cross the Gulf of Maine before they reached Bon Portage. Furthermore, compared to the entire travelling distance of neotropical migrants such as Red-eyed Vireos and temperate-wintering migrants such as Dark-eyed Juncos, many of these birds would be in the early stages of their migratory journey when they arrive on Bon Portage. Species that do not deposit fat on Bon Portage, therefore, may be using Bon Portage only as an area where they can stop and rest, perhaps merely for the daylight hours. Alternatively, if Red-eyed Vireos and Dark-eyed Juncos do require fat replenishment, and if they cannot find suitable resources on Bon Portage, then what areas in southern Nova Scotia are suitable?

Behavioural plasticity could explain why Myrtle Warblers, White-throated Sparrows and Blackpoll Warblers are able to deposit fat on the island while Red-eyed Vireos, Dark-eyed Juncos, and Northern Waterthrushes do not. Fat-depositing species may be able to adapt to, and subsequently use, the resources (i.e. habitats) on Bon Portage enough to deposit fat. They may be able to use a variety of habitats on the island, or they may be able to adapt their foraging strategy enough to use one particular habitat on the island that they would not normally choose. An ability to adapt to suboptimal habitats would certainly be beneficial to migrants, which continuously encounter new and varying habitats during migration.

If one assumes that the lack of behavioural plasticity is the reason Red-eyed Vireos do not deposit fat on Bon Portage, one could then reason that there is a physiological threshold where behavioural plasticity occurs. Loria and Moore (1990) found that fat-depleted Red-eyed Vireos became behaviourally plastic in their foraging strategies after crossing the Gulf of Mexico, a distance of over 1000 km. Since Red-eyed Vireos do not deposit fat on Bon Portage, it may be that migrants are not energetically stressed enough when they reach Bon Portage to compel them to be behaviourally plastic. Hence, Red-eyed Vireos may adapt to unfamiliar environments or habitats only when the need arises, such as after an extremely long flight.

In contrast to plasticity, some authors have suggested that foraging strategies of migrants are innately programmed, and thus migrants may only be able to forage in certain habitats (Martin and Karr 1990, Moermond 1990). If so, the presence or absence of the preferred habitat of a species should then determine whether the species can deposit fat at a stopover site. If this were the case, one could then reason that migrants must make an initial exploration of all available habitats at each newly encountered site. Winker (1995b) found no evidence for this exploration hypothesis at the macrohabitat level, and suggested it may occur at a smaller scale and may be very

rapid. However, if species do have preferred habitats, more study is needed to determine if, and how much, these preferences vary geographically, seasonally, or with age or sex.

In this thesis, I have shown that Bon Portage is mainly a temporary rest area for the majority of fall migrating landbirds. Most migrants come to Bon Portage after being carried offshore by lateral winds, and use the island as a place to rest until the next night. Nonetheless, several species are able to remain on the island for extended periods, and are able to deposit small amounts of additional fat. Furthermore, I have shown that wind direction influenced the numbers of migrants that come to the island, and to some extent, how much fat these individuals carry.

Identifying important fat-deposition sites or resting areas should be a priority for future research of migratory landbirds, especially neotropical migrants. Because natural landscapes are being developed for human use, especially in coastal areas, crucial migration areas are being lost at an alarming rate. This increases the urgency to identify and protect critical areas. This thesis provides a starting point for stopover ecology research on Bon Portage Island, and in other areas in the Maritimes. I encourage future researchers to use any or all of the criteria I used to identify fat-depositing and passage migrants at other sites. I also suggest that more researchers use wind direction data

along with banding data in their examination of stopover ecology.

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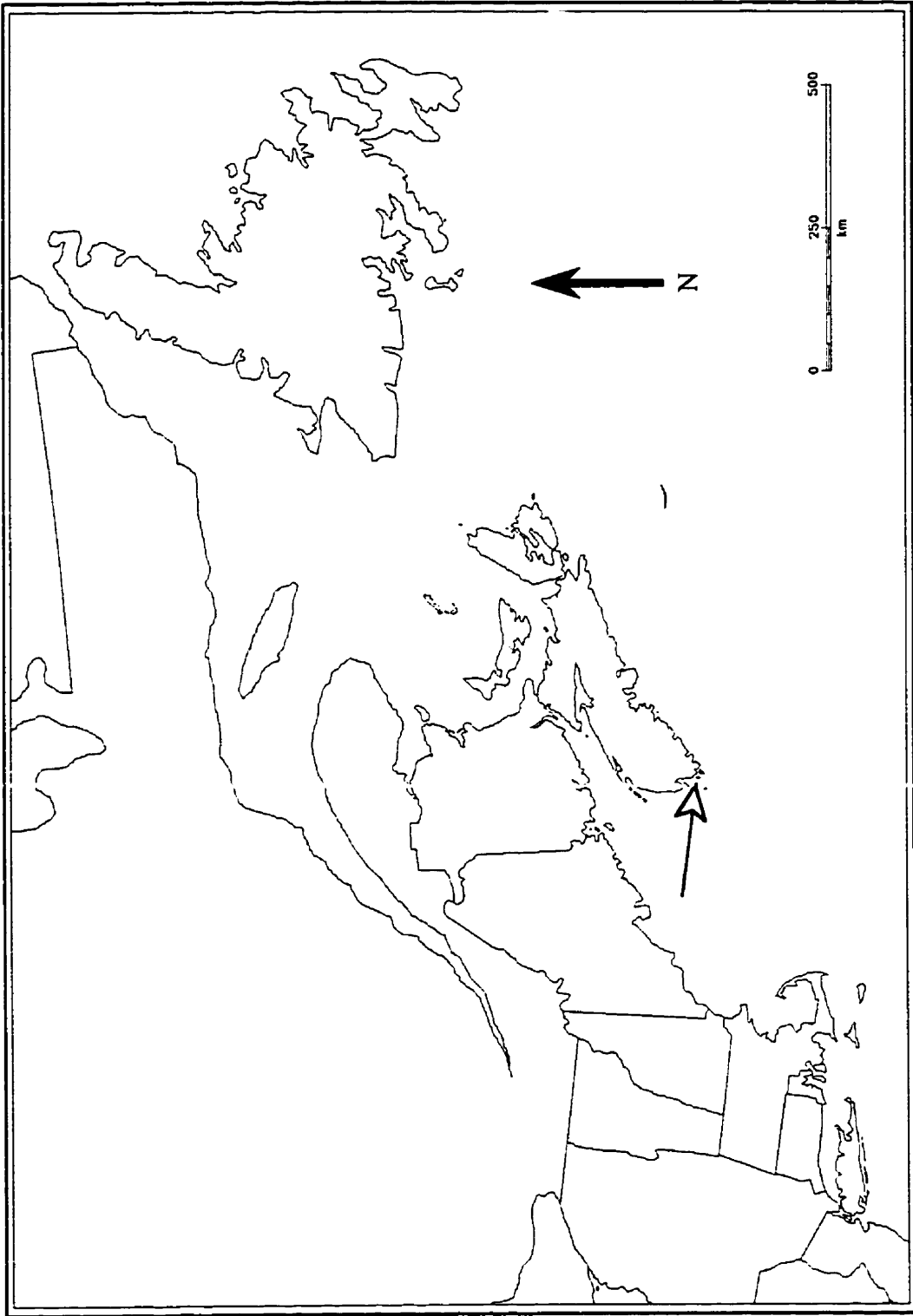


Figure 1: Location of Bon Portage Island in Nova Scotia.

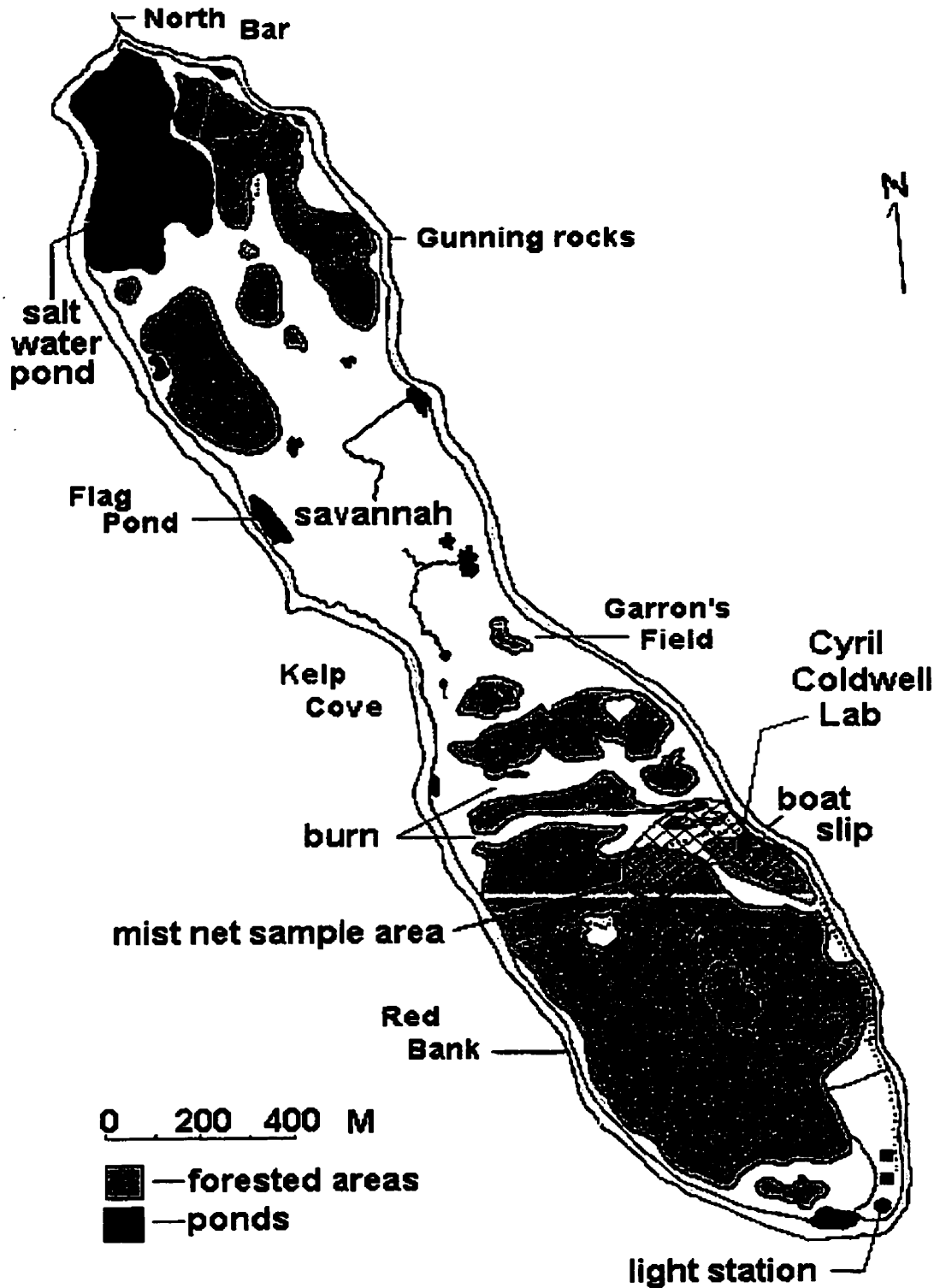


Figure 2: Map of Bon Portage Island showing the location of the Cyril Coldwell Laboratory and mist net sample area

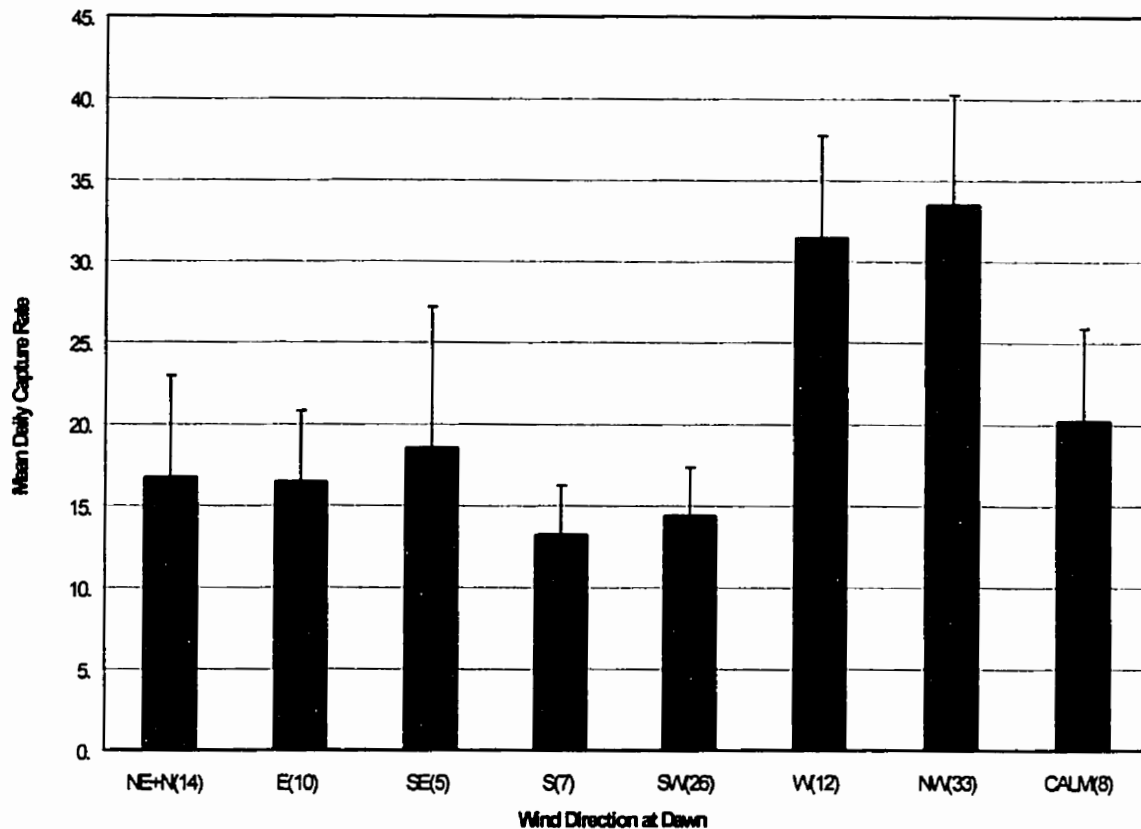


Figure 3: Mean daily capture rates for all southwest-migrating species captured during each dawn wind direction on Bon Portage (1995 and 1996 combined). Daily capture rate calculated as (total # of birds/total net hours) x 100. Number of days with each wind direction is shown in parentheses. Standard error bars are shown.

Table 1: Wind directions at dawn and during the previous evening for the days with the ten highest total capture rates. Rate calculated as total # of birds/ # of net hours x 100.

Date	Previous Evening Wind	Morning wind	Capture rate
18-Oct-95	NW	NW	208.3
12-Oct-96	NW	NW	109.7
4-Oct-96	NW	NW	92.7
1-Oct-96	NW	NW	90.6
16-Sep-95	NW	N	80.6
11-Oct-96	SE	NW	67.3
19-Oct-95	SW	SW	67.2
26-Oct-95	W	W	66.7
24-Sep-95	NW	N	65.0
24-Oct-95	W	W	56.7

Table 2: Summary of fat deposition criteria assessments for all species for which at least three criteria could be tested. Species listed in alphabetical order. Refer to Appendix A for common and scientific names of species.

Species	Criteria Attainment			
	Criterion 1 Recaptured individuals	Criterion 2 Stopover length >1d	Criterion 3 ^a Diurnal wt. or fat increase	Criterion 4 ^b Recap. Individuals increase wt. or fat
BAWW	Y	Y	N	N
BCCH	Y	Y	N	not tested
BLPW	Y	Y	Y	not tested
BTBW	Y	Y	N	N
BTNW	Y	Y	N	not tested
GRCA	Y	Y	N	not tested
HETH	Y	Y	N	not tested
MAWA	Y	Y	N	not tested
MYWA	Y	Y	Y	Y
NAWA	Y	Y	N	not tested
NOWA	Y	Y	N	not tested
PHVI	Y	Y	N	not tested
RBNU	Y	Y	N	not tested
RCKI	Y	Y	N	N
REVI	Y	N	N	not tested
SWSP	Y	Y	N	not tested
WTSP	Y	Y	Y	N
YBFL	Y	Y	N	not tested

^a Only species with 20 or more HY individuals were tested.

^b Only species with 10 or more (HY) recaptured individuals were tested.

TABLE 3: Age breakdown, recapture rate, and stopover duration for all species with 5 or more individuals captured during the fall banding period in 1995 and 1996. Species with more than one recaptured individual are shown on the left while those with one or no recaptured birds are on the right. Species are listed in order of decreasing recapture sample size. Standard deviations are given with each average stopover length Refer to Appendix A for alpha codes of species.

Species	n	# HY	%HY ^a	# recap	% recap	Average Stopover(d)	Species	n	# HY	% HY ^a	# recap	% recap	Stopover(d) ^b
MYWA	545	477	86.5	18	3.7	3.0 ± 2.0	DEJU	58	54	93.1	1	1.9	24
WTSP	126	115	91.3	17	13.8	4.7 ± 5.9	WIWA	46	39	84.8	1	2.6	2
BAWW	109	99	90.8	15	15.0	3.4 ± 2.1	SOVI	40	40	100.0	1	2.5	5
BTBW	62	54	87.1	13	23.2	3.0 ± 2.4	AMGO	30	29	96.7	1	3.3	2
RCKI	66	57	86.4	10	16.1	6.8 ± 9.0	BRCR	20	19	95.0	1	5.0	1
NOWA	110	90	81.8	8	8.9	2.1 ± 1.3	INBU	8	6	75.0	1	12.5	3
BLPW	245	187	76.3	7	3.7	4.1 ± 3.2	BBWA	8	5	62.5	1	16.7	4
BTNW	94	79	84.0	7	8.8	3.0 ± 2.4	CHSP	6	3	50.0	1	20.0	2
HETH	25	23	92.0	7	30.4	5.6 ± 7.1	SAVS	6	6	100.0	1	16.7	1
MAWA	71	63	88.7	5	7.9	2.6 ± 2.2	CEDW	40	25	62.5	0	0	
GRCA	36	34	94.4	5	14.7	3.8 ± 1.3	NOPA	28	21	75.0	0	0	
REVI	166	158	95.2	4	2.5	1.0 ± 0.0	OVEN	26	25	96.2	0	0	
YBFL	88	70	79.5	4	5.7	5.5 ± 4.2	LEFL	25	25	100.0	0	0	
NAWA	49	40	81.6	4	9.3	5.8 ± 5.9	BAOR	24	21	87.5	0	0	
BCCH	44	43	97.7	4	9.3	2.0 ± 1.4	YSFL	22	22	100.0	0	0	
PHVI	14	12	85.7	4	33.3	1.8 ± 1.0	YPWA	21	19	90.5	0	0	
RBNU	40	33	82.5	3	8.8	9.0 ± 0.0	CAWA	16	12	75.0	0	0	
SWSP	23	23	100.0	3	13.0	2.7 ± 2.1	CSWA	14	13	92.9	0	0	
YBSA	10	10	100.0	3	30.0	1.3 ± 0.6	PUFI	13	11	84.6	0	0	
YBCH	10	10	100.0	2	20.0	3.5 ± 3.5	AMRO	12	12	100.0	0	0	
WAVI	6	6	100.0	2	33.3	4.5 ± 5.0	MOWA	9	9	100.0	0	0	
DOWO	5	5	100.0	2	40.0	1.0 ± 0.0	BLBW	9	7	77.8	0	0	
							VEER	8	8	100.0	0	0	

^a Percentage of known age birds

^b Stopover calculated as date of last capture-date of first capture+1 (following Lavee et al. 1991).

TABLE 4: Significance of explanatory variables and of model in linear regression analyses of weight. To be included, species had to have 20 or more HY individuals captured whose wing chord measurements were taken. Species in which no variables were significant are not included. Refer to Appendix A for alpha codes of species.

Species	df	constant	β wing	β date	β method	β time	F	R ²	% variation explained by time (r ²)
MYWA	251	-0.61	0.85 ***	NS	0.09***	0.13 ***	22.3 ***	0.21	2.6
BLPW	122	-1.79	1.31 ***	0.00 ***	0.07***	0.25 ***	29.3 ***	0.49	8.2
REVI	105	1.18	NS	NS	0.04**	NS	9.4 **	0.08	
NOWA	78	-0.63	0.98 ***	NS	0.06***	NS	12.0 ***	0.24	
BAWW	68	-5.92	3.81 **	NS	NS	NS	9.5 **	0.12	
YBFL	60	-0.49	0.64 *	0.00 *	0.14**	NS	5.0 **	0.20	
BTNW	44	-0.11	0.73 *	-0.00 **	0.05***	NS	8.1 ***	0.36	
WTSP	44	-0.43	0.89 **	NS	0.09***	0.21 **	29.7 ***	0.67	7.2
BTBW	38	0.91	NS	NS	0.07***	NS	23.5 ***	0.38	
NAWA	32	0.83	NS	NS	0.09**	NS	11.6 **	0.27	
WIWA	27	0.77	NS	NS	0.11***	NS	13.9 ***	0.34	
RBNU	25	-4.21	2.87 ***	NS	NS	NS	17.8 ***	0.42	
SOVI	21	1.14	NS	NS	0.05***	NS	20.7 ***	0.50	
RCKI	19	-2.12	1.66 **	NS	NS	NS	13.4 **	0.41	

* P<0.05, ** p<0.01, *** p<0.001

TABLE 5: Significance of explanatory variables and of model in linear regression analyses of fat score of all new migrants with 20 or more HY individuals captured. Species in which no variables were significant are not included. Refer to Appendix A for alpha codes of species.

Species	df	Constant	β		F	R ²	% variation explained by time (r ²)
			observer	date			
MYWA	471	-2.56	-0.57 ***	0.02 ***	NS	20.2 ***	0.08
BLPW	184	-12.85	NS	0.05 ***	3.65 **	72.8 ***	0.44
WTSP	112	-4.98	NS	0.02 *	2.67 *	4.2 *	0.07
NOWA	86	3.75	NS	NS	-4.22 **	9.4 **	0.10
BTNW	76	-6.93	NS	0.03 ***	NS	51.6 ***	0.40
YBFL	68	1.36	-0.63 **	NS	NS	9.2 **	0.12
MAWA	60	1.41	-0.61 *	NS	NS	5.9 *	0.09
RCKI	54	-8.26	NS	0.04 ***	NS	54.5 ***	0.50
BCCH	41	1.21	-0.61 **	NS	NS	11.9 **	0.22

* P<0.05, ** p<0.01, *** p<0.001

TABLE 6: Change in weight and fat scores between first and last capture for all species with 10 or more recaptured HY individuals on Bon Portage in 1995 and 1996. Fat score is according to Helms and Drury (1960). P-values are for 1-tailed comparisons (paired t-tests). Refer to Appendix A for alpha codes of species.

Species	Recaps	Weight (g)			Fat Score		
		First Capture	Last Capture	p-value	First Capture	Last Capture	p-value
MYWA	18	11.1 ± 1.6	11.6 ± 1.7	0.01	1.5 ± 1.0	1.4 ± 1.0	0.84
WTSP	17	20.9 ± 2.0	21.3 ± 2.1	0.15	1.2 ± 1.0	1.3 ± 0.9	0.63
BAWW	15	10.3 ± 1.1	10.7 ± 1.0	0.10	2.1 ± 0.8	2.4 ± 1.0	0.31
RCKI	10	6.0 ± 1.0	6.3 ± 0.9	0.08	1.2 ± 1.2	1.7 ± 1.3	0.18
BTBW	13	8.7 ± 0.5	9.0 ± 0.7	0.18	1.1 ± 1.0	1.6 ± 0.8	0.51

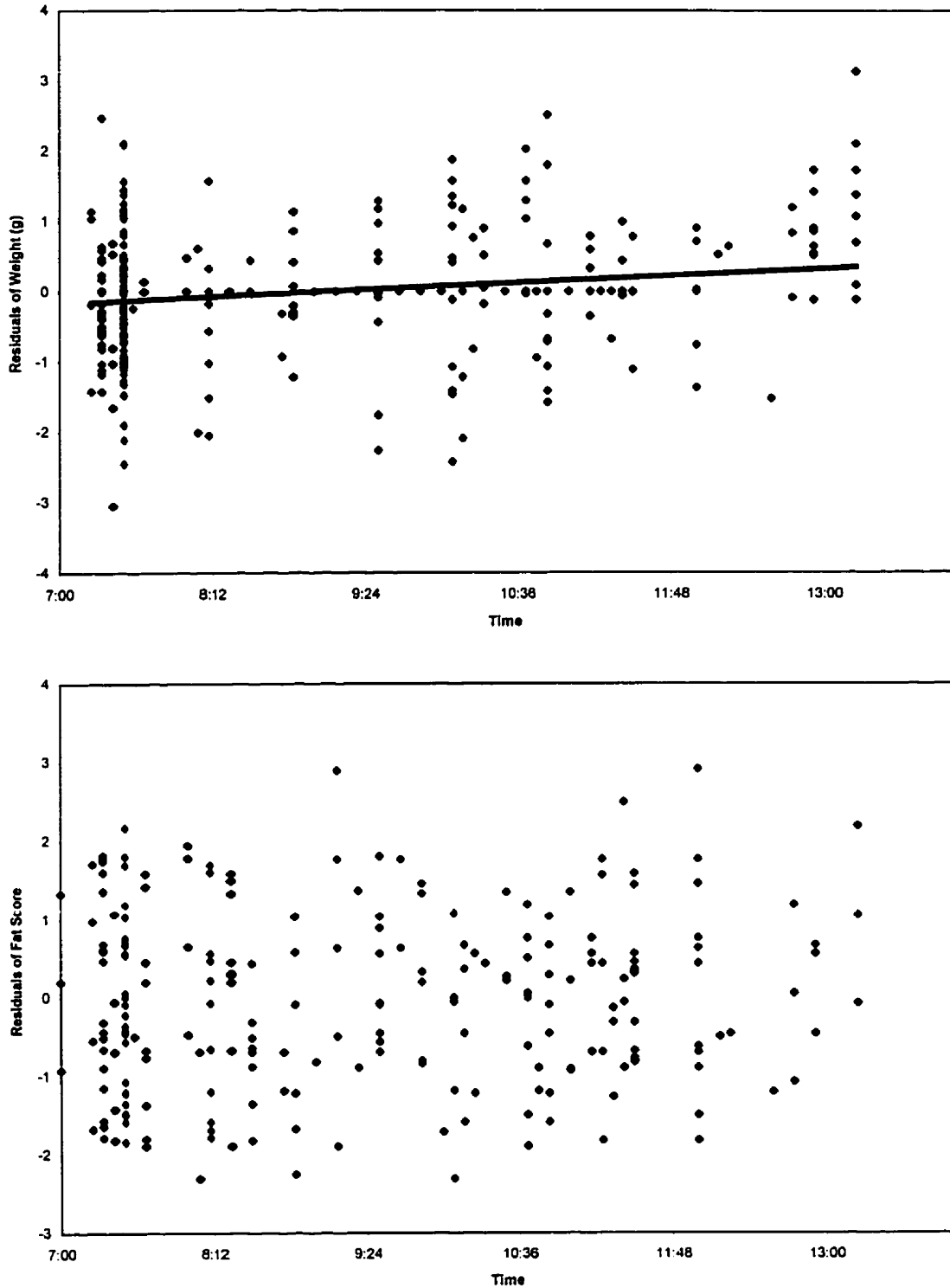


Figure 4: Plot of daily weight gain (top) and fat score gain (bottom) of all new Myrtle Warblers (1995 and 1996 combined).

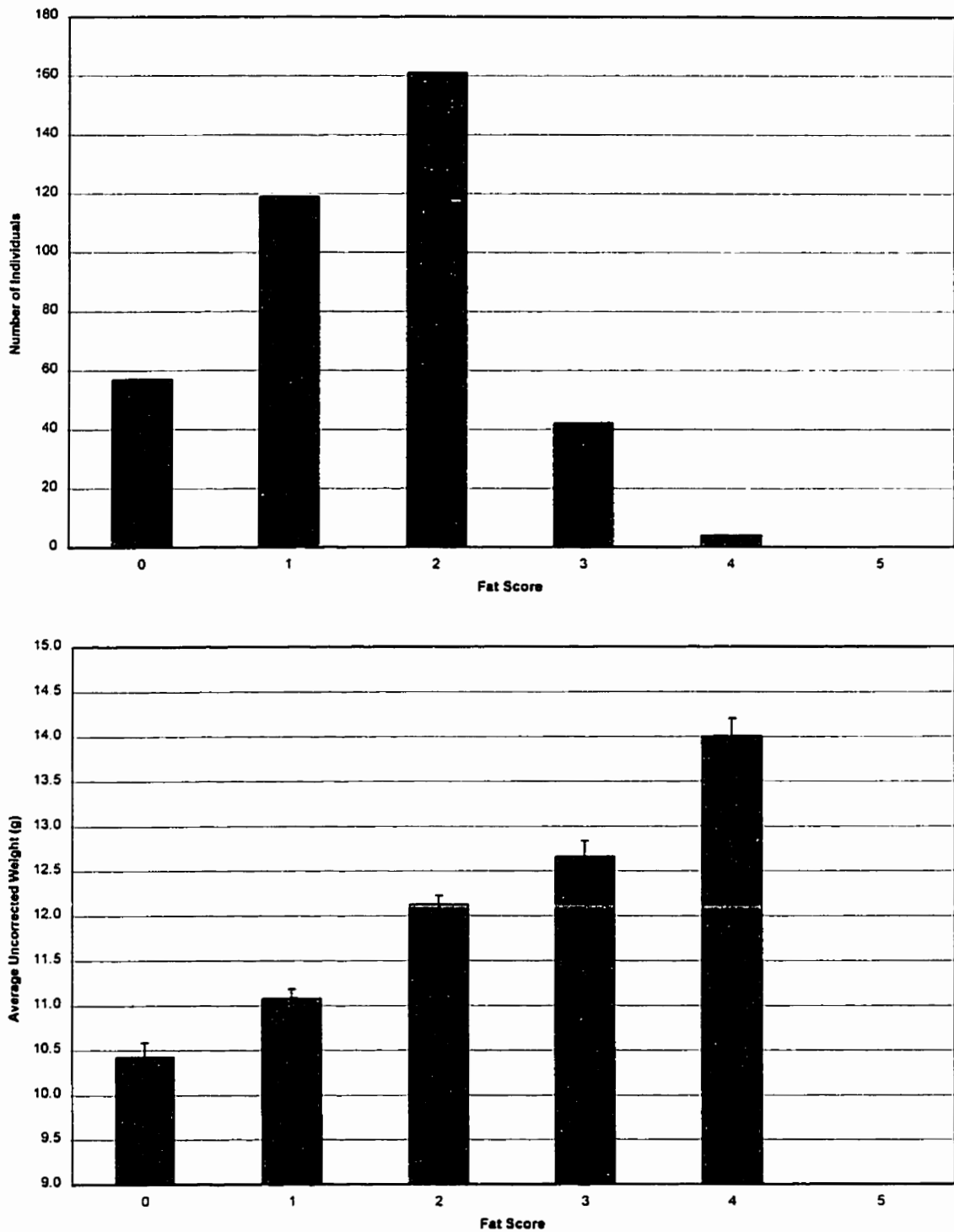


Figure 5: Number of Myrtle Warblers assigned to each fat score (top) and average uncorrected weights of Myrtle Warblers assigned each score. Only those individuals processed by the author are included.

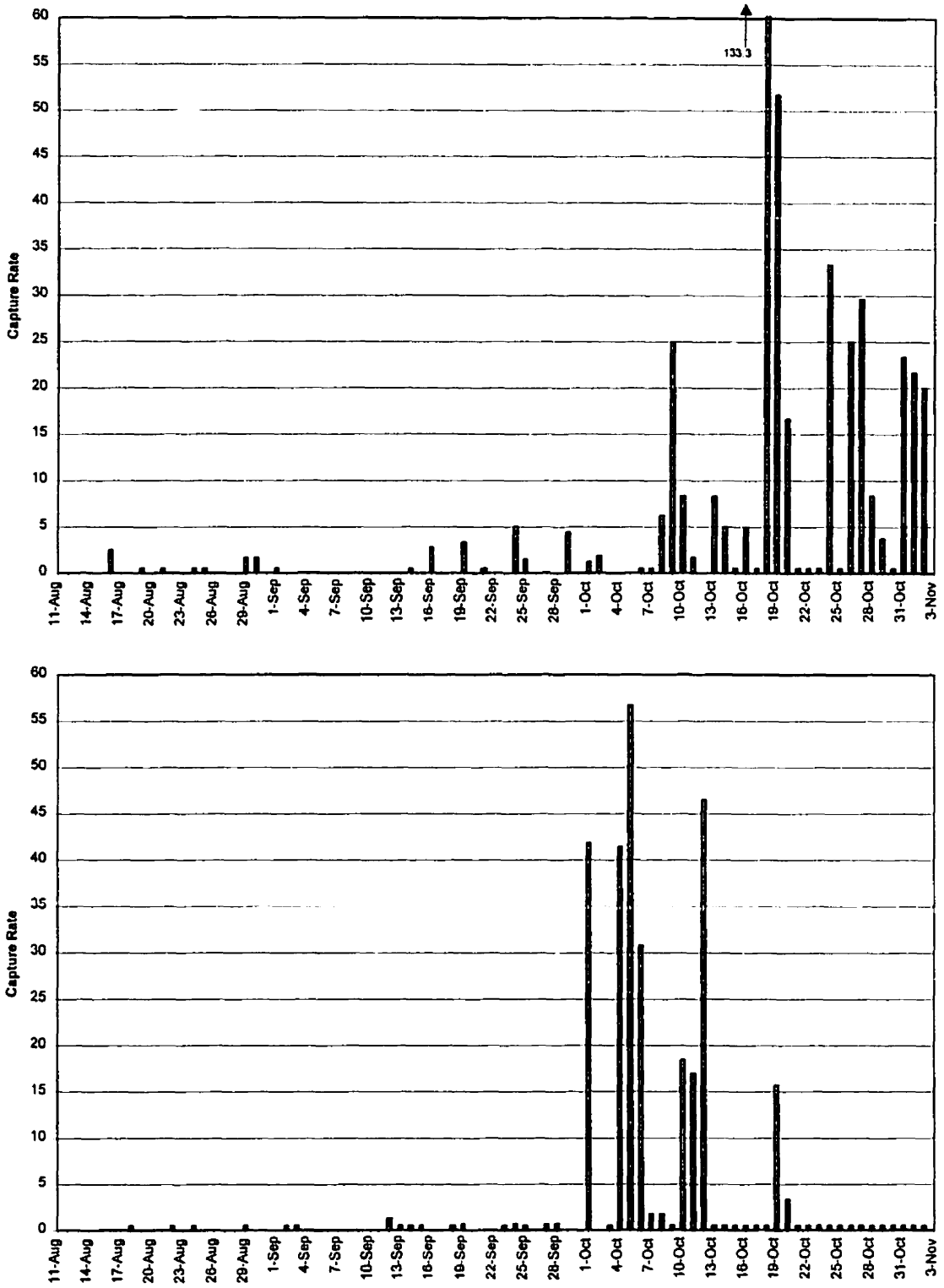


Figure 6: Daily capture rates of all new Myrtle Warblers on Bon Portage in 1995 (top) and 1996 (bottom). Daily capture rate calculated as total # of birds/total net hours x 100. Days when nets were not opened indicated with small black columns.

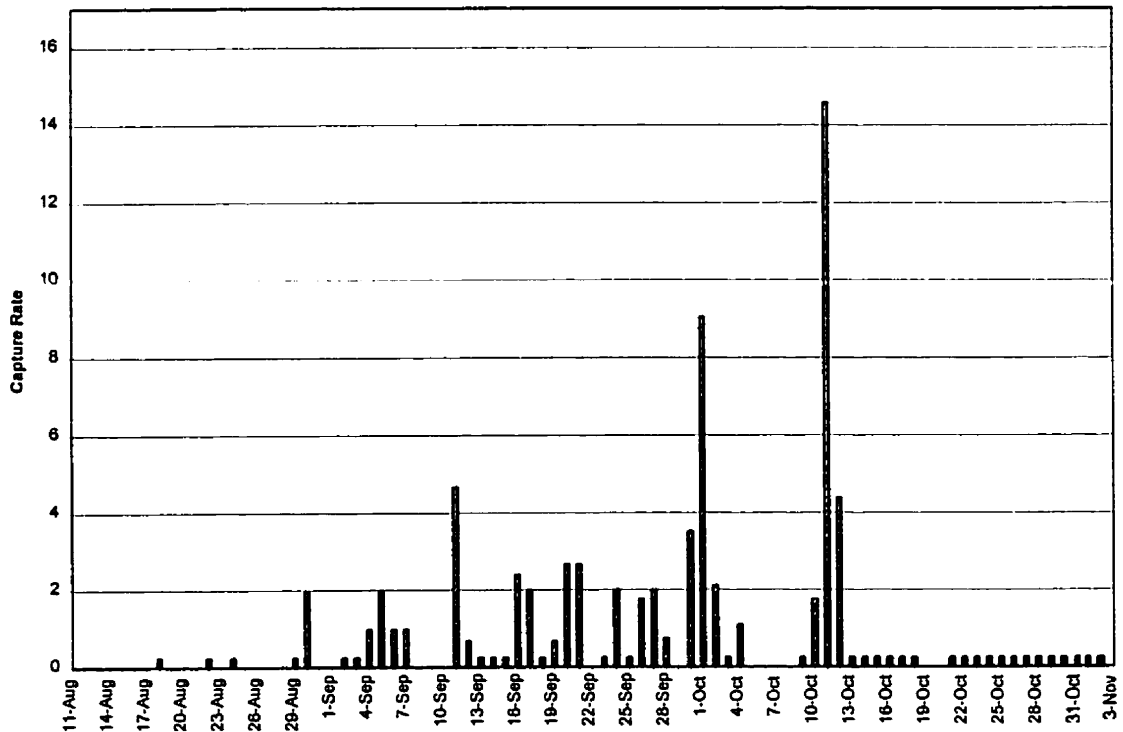
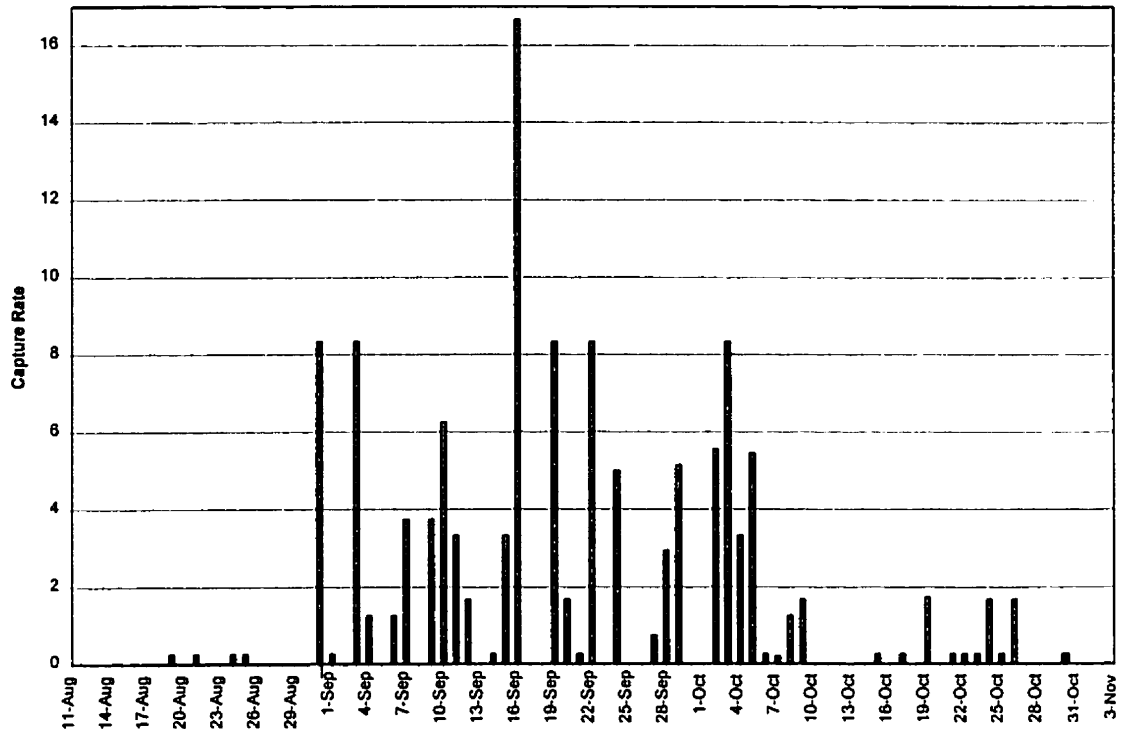


Figure 7: Daily capture rates of all new Red-eyed Vireos on Bon Portage in 1995 (top) and 1996 (bottom). Daily capture rate calculated as total # of birds/total net hours x 100. Days when nets were not opened are indicated with small black columns.

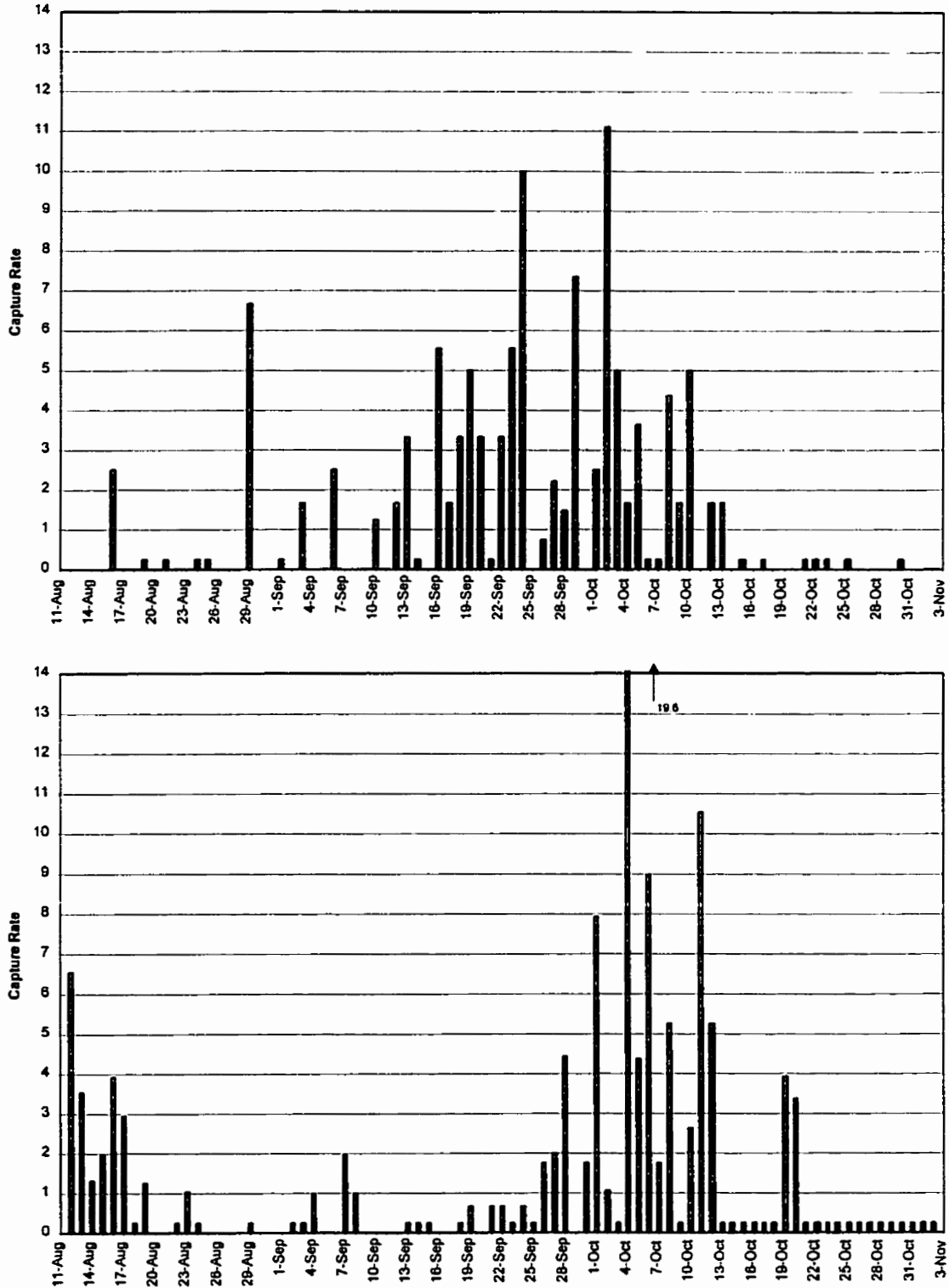


Figure 8: Daily capture rates of all new Blackpoll Warblers on Bon Portage in 1995 (top) and 1996 (bottom). Daily capture rate calculated as total # of birds/total net hours x 100. Days when nets were not opened are indicated with small black columns.

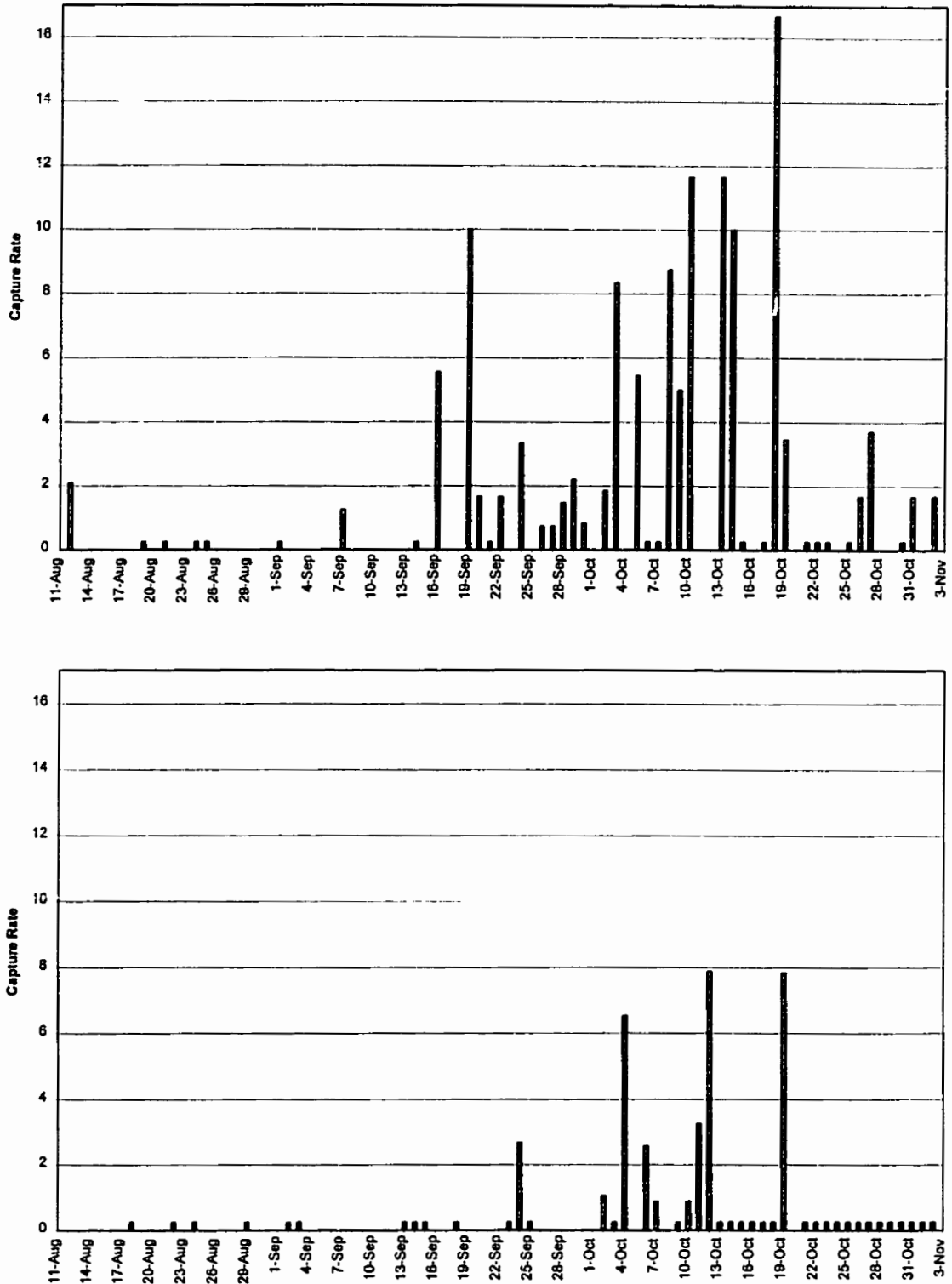


Figure 9: Daily capture rates of all new White-throated Sparrows on Bon Portage in 1995 (top) and 1996 (bottom). Daily capture rate calculated as (total # of birds/total net hours) x 100. Days when nets were not opened are indicated with small black columns.

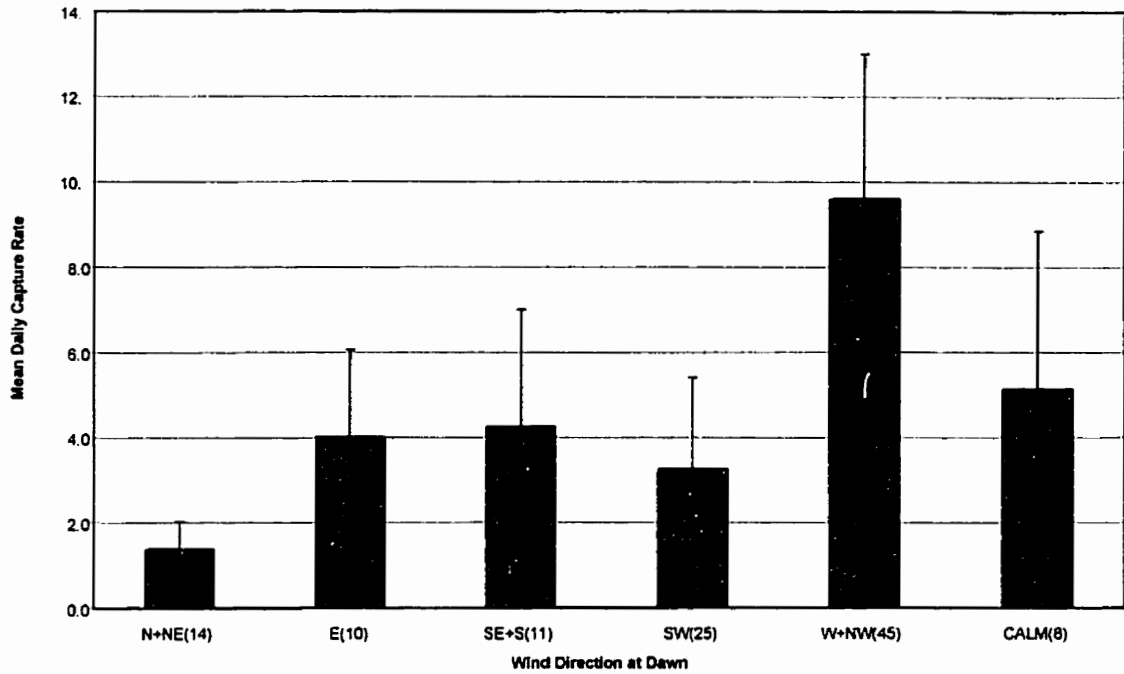


Figure 10: Mean daily capture rates of new Myrtle Warblers captured in each morning wind direction on Bon Portage from 29 Sept. – 2 Nov. 1995 and from 1 Oct. – 20 Oct. 1996. Number of days with each wind direction is shown in parentheses. Capture rate calculated as total # of birds/# of net hours x 100. Standard error bars are shown.

Table 7: Wind directions at dawn and during the previous evening for the ten highest daily capture rates of Myrtle Warblers. Rate calculated as total # of birds/# of net hours x 100.

Date	Previous Evening Wind	Morning wind	Rate of MYWA
18-Oct-95	NW	NW	133.3
19-Oct-95	SW	SW	51.7
12-Oct-96	NW	NW	46.5
1-Oct-96	NW	NW	41.9
4-Oct-96	NW	NW	41.5
24-Oct-95	W	W	33.3
27-Oct-95	CALM	CALM	29.6
9-Oct-95	NW	W	25.0
26-Oct-95	W	W	25.0
31-Oct-95	NW	NW	23.3

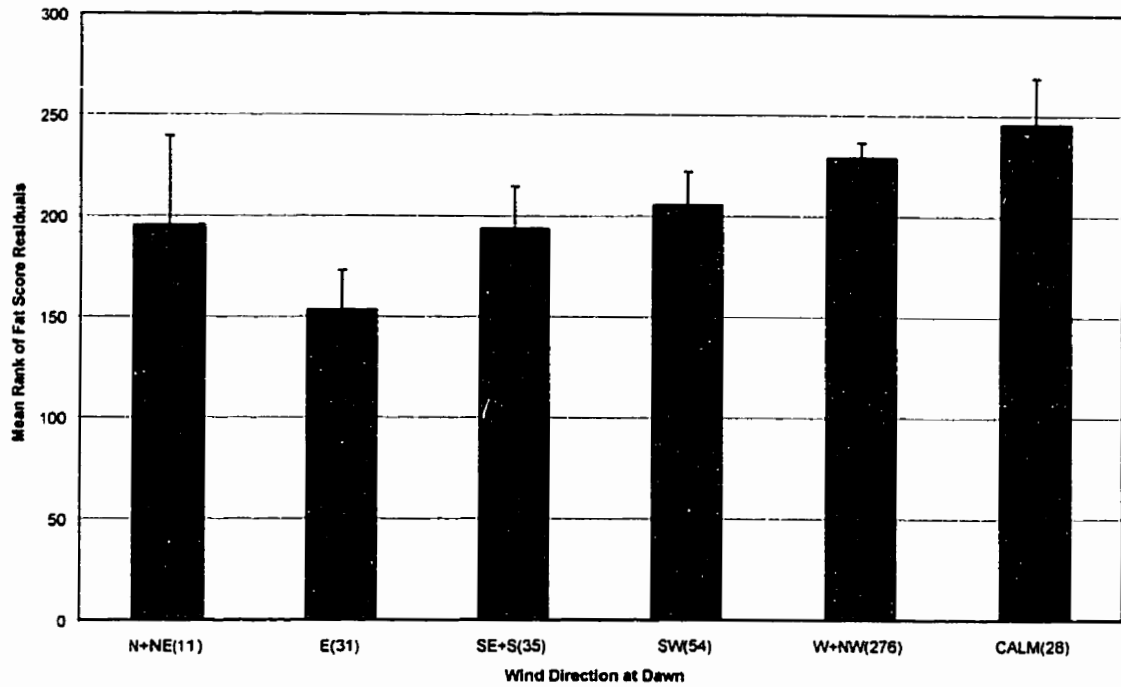


Figure 11: Mean rank of fat score residuals of new Myrtle Warblers captured in each morning wind direction on Bon Portage from 29 Sept. – 2 Nov. 1995 and from 1 Oct. – 20 Oct. 1996. Number of birds captured during each morning wind direction is shown in parentheses. Standard error bars are shown.

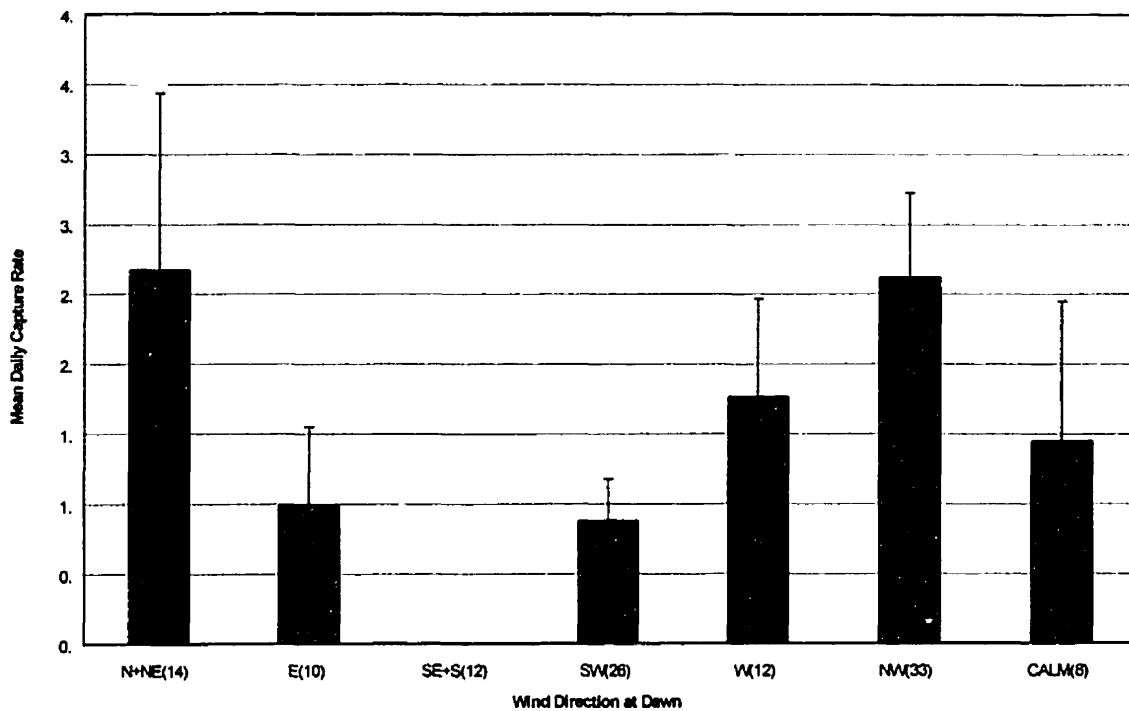


Figure 12: Mean daily capture rates of Red-eyed Vireos captured on Bon Portage with each dawn wind direction (1995 and 1996 data combined). Daily capture rate calculated as total number of birds/total net hours x 100. Number of days with each wind direction is shown in parentheses. Standard error bars are shown.

Table 8: Wind directions at dawn and during the previous evening for the ten highest daily capture rates of Red-eyed Vireos. Rate calculated as (total # of birds/ # of net hours) x 100.

Date	Previous Evening Wind	Morning wind	Rate of REVI
16-Sep-95	NW	N	16.7
11-Oct-96	SE	NW	14.6
1-Oct-96	NW	NW	9.1
19-Sep-95	NW	NW	8.3
3-Oct-95	NW	W	8.3
22-Sep-95	NE	CALM	8.3
3-Sep-95	W	N	8.3
31-Aug-95	NW	NW	8.3
10-Sep-95	NE	NW	6.3
2-Oct-95	NE	E	5.6

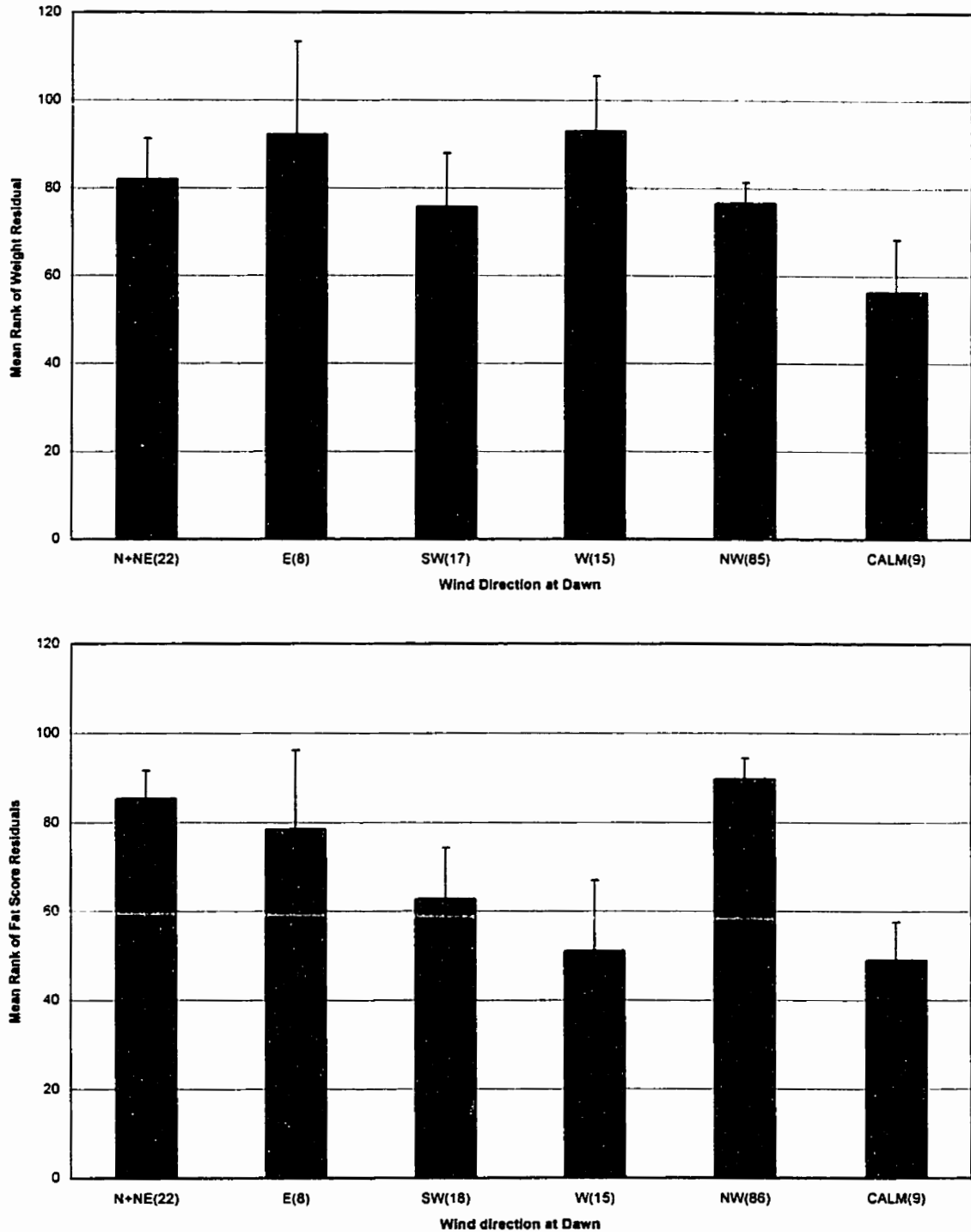


Figure 13: Mean rank of weight residuals (top) and fat score residuals (bottom) of new Red-eyed Vireos captured on Bon Portage with each morning wind direction in 1995 and 1996. Number of Red-eyed Vireos captured in each wind direction is shown in parentheses (only those with wing measurements for weight residuals). Standard error bars are shown.

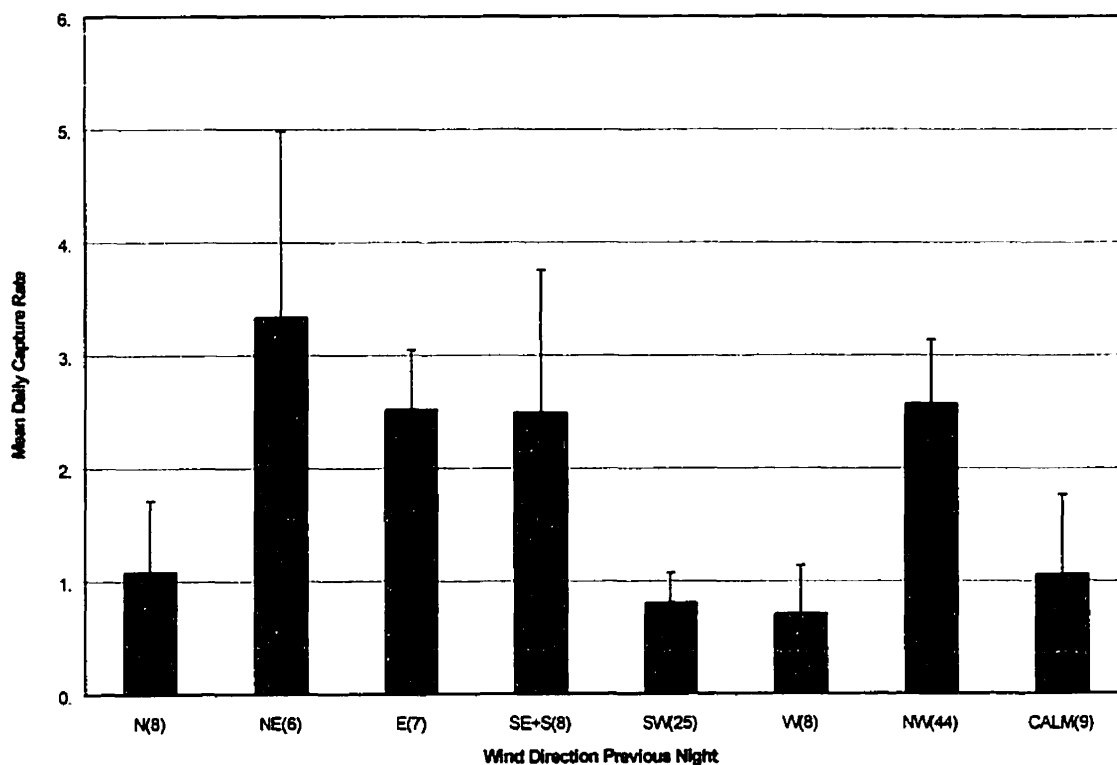


Figure 14: Mean daily capture rates of new Blackpoll Warblers captured in mornings after each wind direction the previous night on Bon Portage (1995 and 1996 data combined). Number of days with each wind direction is shown in parentheses. Capture rate calculated as total # of birds/# of net hours x 100. Standard error bars are shown.

Table 2: Wind directions at dawn and during the previous evening for the ten highest daily capture rates of Blackpoll Warblers. Rate calculated as total # of birds/ # of net hours x 100.

Date	Previous Evening Wind	Morning wind	Rate of BLPW
4-Oct-96	NW	NW	19.6
2-Oct-95	NE	E	11.1
11-Oct-96	SE	NW	10.5
24-Sep-95	NW	N	10.0
1-Oct-96	NW	NW	7.9
29-Sep-95	NW	NW	7.4
29-Aug-95	NW	S	6.7
12-Aug-96	NW	NW	6.5
16-Sep-95	NW	N	5.6
23-Sep-95	CALM	S	5.6

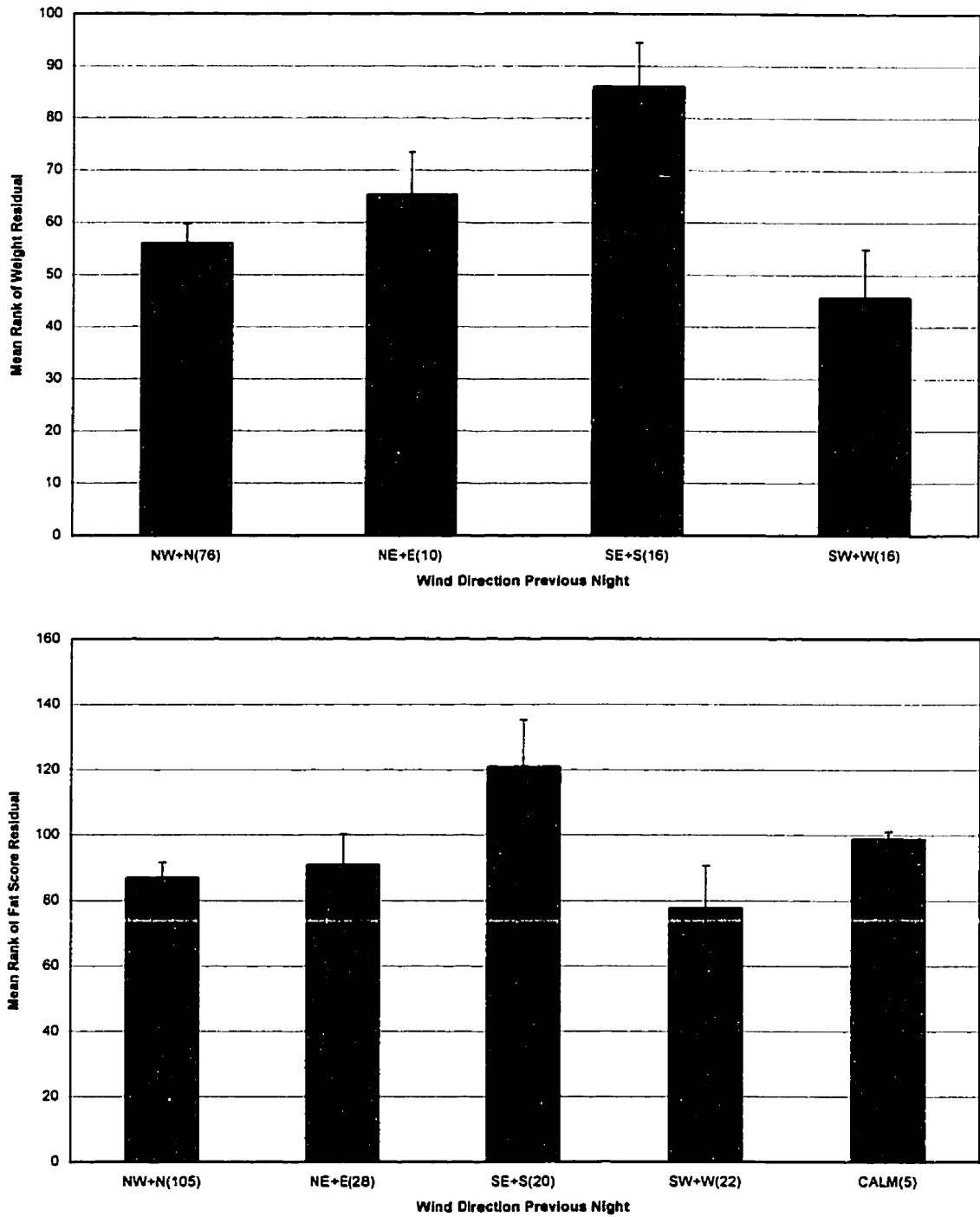


Figure 15: Mean rank of weight residuals (top) and fat score residuals (bottom) of new Blackpoll Warblers captured in mornings following each night's wind direction on Bon Portage in 1995 and 1996. Number of birds captured following each wind direction is shown in parentheses (only those with wind chord measurements for weight residuals). Standard error bars are shown.

APPENDIX A: Alpha codes and scientific names of all landbirds mentioned in this study. Species are listed in taxonomic order.

Alpha	Common Name	Scientific Name	Alpha	Common Name	Scientific Name
YBSA	Yellow-bellied Sapsucker	<i>Sphyrapicus varius</i>	MAWA	Magnolia Warbler	<i>Dendroica magnolia</i>
YSFL	Yellow-shafted Flicker	<i>Colaptes auratus</i>	CMWA	Cape May Warbler	<i>Dendroica tigrina</i>
YBFL	Yellow-bell. Flycatcher	<i>Empidonax flaviventris</i>	BTBW	Black-th. Blue Warbler	<i>Dendroica caerulescens</i>
LEFL	Least Flycatcher	<i>Empidonax minimus</i>	BTNW	Black-th. Green Warbler	<i>Dendroica virens</i>
BCCH	Black-capped Chickadee	<i>Parus atricapillus</i>	BLBW	Blackburnian Warbler	<i>Dendroica fusca</i>
BOCH	Boreal Chickadee	<i>Parus hudsonicus</i>	YPWA	Yellow Palm Warbler	<i>Dendroica palmarum</i>
RBNU	Red-breasted Nuthatch	<i>Sitta canadensis</i>	BBWA	Bay-Breasted Warbler	<i>Dendroica castanea</i>
BRCR	Brown Creeper	<i>Certhia americana</i>	BLPW	Blackpoll Warbler	<i>Dendroica striata</i>
WIWR	Winter Wren	<i>Troglodytes troglodytes</i>	MYWA	Myrtle (Yellow-rumped) War.	<i>Dendroica coronata</i>
GCKI	Golden-crowned Kinglet	<i>Regulus satrapa</i>	BAWW	Black-&-White Warbler	<i>Mniotilta varia</i>
RCKI	Ruby-crowned Kinglet	<i>Regulus calendula</i>	AMRE	American Redstart	<i>Setophaga ruticilla</i>
VEER	Veery	<i>Catharus fuscescens</i>	OVEN	Ovenbird	<i>Seiurus aurocapillus</i>
SWTH	Swainson's Thrush	<i>Catharus ustulatus</i>	NOWA	Northern Waterthrush	<i>Seiurus noveboracensis</i>
HETH	Hermit Thrush	<i>Catharus guttatus</i>	MOWA	Mourning Warbler	<i>Oporornis philadelphia</i>
AMRO	American Robin	<i>Turdus migratorius</i>	COYE	Common Yellowthroat	<i>Geothlypis trichas</i>
GRCA	Gray Catbird	<i>Dumetella carolinensis</i>	WIWA	Wilson's Warbler	<i>Wilsonia pusilla</i>
CEDW	Cedar Waxwing	<i>Bombycilla cedrorum</i>	CAWA	Canada Warbler	<i>Wilsonia canadensis</i>
SOVI	Solitary Vireo	<i>Vireo solitarius</i>	YBCH	Yellow-breasted Chat	<i>Icteria virens</i>
PHVI	Philadelphia Vireo	<i>Vireo philadelphicus</i>	CHSP	Chipping Sparrow	<i>Spizella passerina</i>
WAVI	Warbling Vireo	<i>Vireo gilvus</i>	SAVS	Savannah Sparrow	<i>Passerculus sandwichensis</i>
REVI	Red-eyed Vireo	<i>Vireo olivaceus</i>	FOSP	Fox sparrow	<i>Passerina iliaca</i>
TEWA	Tennessee Warbler	<i>Vermivora peregrina</i>	SOSP	Song Sparrow	<i>Melospiza melodia</i>
NAWA	Nashville Warbler	<i>Vermivora ruficapilla</i>	SWSP	Swamp Sparrow	<i>Melospiza georgiana</i>
NOPA	Northern Parula	<i>Parula americana</i>	WTSP	White-throated sparrow	<i>Zonotrichia albicollis</i>
YWAR	Yellow Warbler	<i>Dendroica petechia</i>	DEJU	Dark-eyed Junco	<i>Junco hyemalis</i>
CSWA	Chestnut-sided Warbler	<i>Dendroica pensylvanica</i>	BAOR	Baltimore (Northern) Oriole	<i>Icterus galbula</i>
			PUFI	Purple Finch	<i>Carpodacus purpureus</i>

APPENDIX B: Recommendations for future research.

To my knowledge, this was the first study of landbird stopover ecology conducted in the Maritimes. The recent establishment of The Atlantic Bird Observatory, with long-term banding sites on Bon Portage and Seal Island, provide opportunities for further research. Here I make several suggestions of areas where future research dealing with stopover ecology of migrants could be conducted. When larger data sets become available, age and sex-related differences in stopover behaviour could be studied (see Morris et al. 1996). Furthermore, now that there is a long-term banding facility on the island that gathers data in the spring, there are a host of spring-fall comparative studies that could be performed. Bon Portage is ideally suited for such studies, since Bon Portage is located next to the Gulf of Maine. On Bon Portage, birds captured in the spring would have just crossed a 400-500 km stretch of water, while in the fall, they will be preparing to cross it. As such, birds may display differences between spring and fall in foraging rates, weight gains/losses, stopover lengths, etc.

There is an immediate need for stopover studies that examine species-habitat relationships. Now that I have established that Myrtle Warblers are able to deposit fat on Bon Portage, future studies can then examine how this species is able to do so. In other words, what habitat(s) on the island are Myrtle Warblers able to exploit? Furthermore, are they able to do so because they are able to shift their foraging strategies to

adapt to these habitats? Even a study that only determined which habitats are used most heavily would be useful.

Seal Island should be examined for its importance as a stopover site or as a resting area. However, birds may stop on Seal Island for different reasons than they do on Bon Portage, perhaps because Seal Island is over 10 km from the mainland. Birds may not be able or willing to cross this stretch of water in order to search for a suitable stopover site. McLaren (1981) showed that this island seems to attract a large number of rare vagrants because of the nature of autumn storms and the prevailing westerly wind directions in this area. However, an analysis of the fat loads of migrants after such storms and during these wind conditions may prove helpful in clarifying this "birder-hotspot" phenomenon. If rare migrants come to Seal Island because they were pushed off-course by wind directions, they may have lower fat reserves than what would be expected. If rare migrants come to Seal Island with large fat reserves, then it may be that they originated from a closer location than was once thought.

There are many forested islands similar to Bon Portage just off the coast of southwestern Nova Scotia. If mist nets could be operated on some of these islands, even for a short time, in concert with those on Bon Portage and Seal Islands, we could get an idea of just how important Bon Portage and Seal Island are to migrants, compared to these other areas.

It would also help to know if the results I obtained on Bon Portage could be applied to all areas in southwestern Nova Scotia.

A project that would open up migration research in Nova Scotia is a stable-isotope study of the migrants on Bon Portage and Seal Islands. We need to know where the birds that stop on either island are coming from, and such a study will allow this (e.g. Chamberlain et al. 1997). Richardson (1972) showed that birds from Newfoundland fly over Nova Scotia in a southwest direction along with the birds from mainland Nova Scotia. However, we do not know if Newfoundland birds make a stop in Nova Scotia (i.e. Bon Portage or Seal Island) or continue past the entire province. We do not know how many stops a migrant on Bon Portage or Seal Island has already made by the time it gets to these sites. If we did know, we could then generate some useful migration energy requirement estimates for each common species on either island. Such a study would also be a useful way to determine what each species' food requirements are prior to migration (during prebasic molt). Once that is known, the food requirements during migration could then be compared.

Another area for possible future research on Bon Portage is on behavioural plasticity in migrants. One could duplicate the experiments of Loria and Moore (1990) to determine if Red-eyed Vireos show the same behavioural plasticity in foraging strategies on Bon Portage Island. Birds could be captured in the spring *after* making the relatively shorter

overwater flight across the Gulf of Maine. Perhaps there is a “physiological threshold distance” below which, passage migrants such as Red-eyed Vireos do not need to become behaviourally plastic to regain lost fat reserves.

One could also attempt to determine if fat-depositing migrants are able to use more habitats on Bon Portage than migrants that are not able to deposit fat. Mist nets or behavioural studies could be used to determine the extent of habitat use on the island by both stopover and passage migrants. A behaviourally plastic migrant should either be found in many habitats, or in certain habitats that do not correspond to or resemble their breeding or wintering habitats.

There are a host of other behavioural studies that could be performed on Bon Portage. One could test whether territoriality occurs in migrants on the island, for example. If there were some type of social hierarchy among migrants while on Bon Portage, this may explain why so few individuals remain on the island. If so, floaters might be identifiable by differences in weight gain, stopover length, or some other trait.

Bon Portage is ideally located for a variety of studies that further examine the possible influences of wind on the stopover of landbird migrants. No other area in North America has as much known about the large-scale effect of weather on bird migration, thanks to the radar

studies by Richardson and others. This may be the reason so few researchers have examined the stopover of birds in relation to weather, because so few researchers already know, for example, what wind directions cause birds to reorient themselves, or even in which specific direction the majority of birds are heading. With additional data on Bon Portage, one could more closely examine the recaptures of a particular species in relation to wind direction. Specifically, one could address the questions such as, do birds that initially come to the island under one wind direction, have longer stopovers, or gain more weight, than those that come to the island under other wind directions? A large sample of recaptured birds would be needed for such an examination, which would take a number of years, since so few birds are recaptured.

With the backdrop of radar studies to build upon, with the island's "migrant trap" location, its proximity to the Gulf of Maine, and with the establishment of a long-term banding facility on the island, Bon Portage now has the potential to provide important information on landbird migration in Atlantic Canada.

APPENDIX C: Recommendations to banding supervisors/station managers.

Here I make some suggestions to both banders and banding supervisors on Bon Portage and Seal Island, that have stemmed from my first-hand experience at both collecting and analyzing banding data on Bon Portage.

1. It is crucial that all banders and volunteers process birds in a standardized fashion. This goes for measuring wing chords, weights, skulling, and especially fat scoring, which is a subjective measurement. As Krementz and Pendleton (1990) showed, even minute differences in the way birds are held when fat scoring can cause significant observer variation in the values obtained.

Only two other (very experienced) banders and I collected the data for this research, but there were still significant observer differences in wing chords and fat scores. This is a normal occurrence, as all banders will have slight variations in the way they handle/process birds. However all banding supervisors should ensure that banders, and especially inexperienced volunteers, are performing every measurement in the same fashion. An alternative solution is that all of the banding and processing of birds be limited to a few people, and not the day-to-day volunteers. This would minimize the observer variability.

Furthermore, each year each bander at the station should simultaneously process a sample of birds of common species (i.e. Myrtle

Warblers). For this, a number of birds would be processed by one bander, who would then immediately give the same birds to the next bander to process, and so on. This could be done in blocks on slow days until a large sample size is reached. With this data, exact comparisons between banders' measurements could be made and accounted for in any analysis.

2. Perhaps the most important weather variable that must be measured on a daily basis is the wind direction, both at dawn and in the evening. For my data, I used a hand-made, temporary weather vane. However, for the long-term, and so that the year-to-year data and between-site data is standardized, a permanent weather vane at each site should be established. An ideal improvement would be to establish an automatic weather station on each island, close to the banding station.

3. Everything about the mist nets should be standardized. Most importantly, all nets should be both the same mesh size (I recommend 30 mm), and the same length and height (12 m x 2.5 m is the most widely used). Not only will this allow for more accurate comparisons with other studies and other stations, but will allow for comparisons of capture rates between nets or habitats. Nets with different size mesh will have different rates of capture for many species (Pardieck and Waide 1992). It would therefore be meaningless to compare the capture rate of Hermit Thrushes, for example, in a 36 mm net, to that in a 30 mm net.

Furthermore, nets purchased from different sources can have slight differences in their construction. Some nets may have deeper pockets than others, and thus would be able to hold more birds. Every effort should be made to minimize this potential bias.

As well, the amount of lateral tension and spacing between tiers should be standardized, not only between nets, but also from year to year. Even minor differences between these can cause differences in capture rates (Remsen and Good 1996).

4. Net-runs should also be standardized. I have found that 25-30 minute net-runs is an optimal balance between keeping the birds from being too tangled and leaving enough time for them to be captured. Furthermore, no one should be allowed near the nets except on a net-run. This includes birders walking the trails. People around the nets causes birds to vacate the area and thus artificially reduce the true capture rates of the nets in that area. Every effort must be made to keep people away from the nets except during net-runs. Furthermore, net-runs should be made as quickly as possible for the same reason.

5. All nets should be checked only once. This means that in a net-run, no net should be passed on the way back, after it has already been checked once. Net-runners, especially inexperienced volunteers will often remove birds from these nets again, and thus those nets get checked twice. This will also artificially increase the capture rates of these nets,

as some birds will invariably escape from a net between net-runs.

However, checking those nets more often than the others means that those (usually larger) birds that would have normally escaped are now captured.

All banders and banding supervisors must ensure that either all nets are checked only once, or that a net-run trail is made such that it does not double back on previously-checked nets.

6. The practice of not operating certain nets because they “do not catch anything” should be weighed carefully. If the object of the banding sites were to catch as many birds as possible with the least amount of effort, then this would be a legitimate practice. However, if the object were to sample as many habitats and thus, as many migrating species as possible, then all nets, no matter what their capture efficiency, should be operated with equal effort. Furthermore, if the relatively unproductive “trail” nets do not catch many birds on Bon Portage now, they may have high capture rates in the near future, because of the successional shrubs and fruiting trees that may soon grow in this area. By operating them now, even if they don’t catch anything, the data gathered could be used to compare with future capture rates. Furthermore, on slow days, the mist nets should be operated for just as long as on large volume days. As I showed with this research, slow days yield just as much, if not more information than heavy days. I found that 6 hours is an optimal length of

time on most days to operate the station.

7. Simple vegetation surveys around each mist net should be implemented, at least every two years, if not annually. Currently, determining the importance of habitat to migrating landbirds is taking precedence over most other aspects of stopover ecology, because of the increasing destruction of coastal areas for development. Thus, if long-term monitoring of landbird migrants were to take place, a long-term habitat monitoring program at each site would be beneficial to future study of migrant-habitat relationships on Bon Portage or Seal Islands.

8. The practice of vegetation management should be considered, at least every two to three years in certain areas on Bon Portage, and perhaps Seal Island. If the vegetation profile exceeds the height of the mist nets, the ability of the nets to accurately sample the avian fauna using the habitat becomes compromised. An effort should be made to ensure that this does not happen in at least the Alder ("shore") nets and the Viburnum ("burn") nets on Bon Portage, which together yield the greatest number of birds.

9. A new banding table should be constructed, to allow for more banders to process birds at the same time. This may mean purchasing an additional scale, as well as more equipment. In my experience, the number of birds that can be banded at Bon Portage is only limited by the efficiency of the banding operation. The more banders (and net-runners)

you have at Bon Portage, the more birds that can be processed.

10. Bird-holding boxes should be constructed and employed so that more birds could be held and processed. The use of boxes would also eliminate times when the banders run out of bags because all are in use. Such boxes are used at other bird observatories and are simple to construct. Boxes also keep the birds in a darker environment than cloth bags, and darkness keeps the birds calmer (Brian Johnson, pers. comm.). Most box designs involve four compartments, each with a hinged door that only opens inward. As many as ten birds can be placed in one compartment. Care must be taken to ensure that only birds of the same species are placed together, however, as certain species do not get along.

Boxes can be constructed as permanent structures within the Cyril Coldwell Lab, or they could be made portable. Portable boxes can be taken on net runs during busy days.

11. Concerning the data collected, it would be useful to include on the data sheets columns which specify how each bird was aged, how it was sexed, and the amount of skull pneumaticization. This would allow for checks on the validity of the age/sex of the birds. For example, with a skull pneumaticization code of 0-6, with 6 being completely pneumaticized, the accuracy of a bander's skulling ability could be determined. A bander who gets "2" skulls on Eastern Phoebes in October, for instance, probably does not know what he/she is doing.

Furthermore, the banding supervisor must review the data collected at the end of each day, to spot any such discrepancies soon after they happen, and to prevent further mistakes.

12. It must be conveyed to banders/volunteers, that the data they are collecting is not just going to be used to provide a yearly index of bird species' abundance and production. It may also be used in the future to study various aspects of stopover ecology (e.g. habitat use). Hence, the importance of *standardization of data collection* should be stressed to each person collecting the data. With the high turnover of volunteers at both sites every year, this must remain a high priority to banding supervisors.

13. The safety of the birds, and the quality of the data collected relies on the quality of the banding supervisor. Thus, it is imperative that the supervisor have a great deal of experience in all aspects of migration monitoring. This person must not only have impeccable bird-handling skills, but must also be able to teach safe handling skills to the volunteers. The person must have a strong background in analyzing bird-banding data, so that they can minimize common biases and errors in data collection. The banding supervisor would, ideally, have worked in other migration monitoring stations previously, and would thus be able to bring to the observatory fresh ideas and up-to-date methods.

I stress this recommendation here because I feel that it is perhaps

the most important. I recommend that the station supervisor(s) have at least 5 previous (full) seasons of migration monitoring work experience. Furthermore, the person(s) must have banded at least 7000 birds during the fall migration season. Spring banding should not count, nor should breeding season banding, as fall banding entails completely different methods of aging and sexing birds.

I further recommend that the position, as well as qualifications, be advertised in the American Ornithologist's Union Newsletter.

14. A station protocol, or station manual must be developed for Bon Portage and Seal Island. This manual would allow untrained volunteers to more quickly become familiarized with the running of each station. It would also allow trained volunteers to quickly adapt to the methods employed by these stations. In this way, year-to-year continuity in the data is maintained.

15. A Monitoring Avian Productivity and Survivorship (MAPS) station should be established each on Bon Portage and Seal Island during the summer months. There would be several benefits to such a program. First, there are a number of banded individual birds (American Redstarts, Yellow Warblers, etc.) that return each year to the island to nest, often to the same location on the island. Data on these birds and their young could be used to answer many questions about their breeding cycle. Although there are Muskrats in the savannah, the

southern end of Bon Portage is essentially free of large mammalian predators. However, the island also has many avian predators (Herring and Great Black-backed Gulls, American Crows). It therefore may represent an ideal locale for studies on the nesting behaviour or ecology of passerines in the absence of mammalian predators, or in the presence of avian predators.

A MAPS station on Bon Portage may also help to alleviate the problem of residents being captured during the migration season. By banding breeders and their young in the mist net area, one could distinguish these individuals from fall migrants.

Finally, there are few MAPS stations in the Maritimes currently. As the stations on both Bon Portage and Seal Island are long-term banding operations with full-time staff and established net lanes, establishing a MAPS program into the station field season would not require a great deal of additional effort.

APPENDIX D: Summary of landbirds captured on Bon Portage during the breeding season (summer 96).

Date	AMGO	AMRE	BLPW	BOCH	BTNW	COYE	FOSP	GCKI	GRCA	MAWA	MYWA	NOPA	NOWA	PISI	PRAW	RBNU	RCKI	REVI	SOSP	SWTH	TRFL	WIWR	YBFL	YWAR	Total
4-Jun-96																									0
6-Jun-96																									0
9-Jun-96		2	1			4	4			1								12					4	28	
10-Jun-96																									0
12-Jun-96																									0
18-Jun-96		2	1		1	2	5		2											2			4	19	
22-Jun-96																									0
24-Jun-96																									0
28-Jun-96		2	3				2													2	1		2	12	
6-Jul-96																									0
8-Jul-96			1			8	4	2			1					2			8			1	1	28	
9-Jul-96																									0
12-Jul-96																									0
14-Jul-96			1																						1
17-Jul-96			2		1	1	12	2	1		2	1							3	3	2		1	41	
28-Jul-96							1																		1
30-Jul-96		5	3		1	6	3													2		2	1	34	
2-Aug-96		8	3	2			2	7							1					3			1	42	
3-Aug-96		9	11	1	3	11	7	14		1				1					1	6			2	43	
4-Aug-96		3	7	1	3	7	2				2		1						1	3	1		4	48	
6-Aug-96		2	2		2	1	1	1											1				2	15	
7-Aug-96		3	1		1	4	4												2	2		1	2	24	
8-Aug-96			4		3	2	1	7		1									1	1		2	1	6	
9-Aug-96		3	3	2		1	1	1											1	2			3	17	
10-Aug-96			1			2		1					1						3	4			3	16	
11-Aug-96		2	3	2	2	5	2	4											1	4		2	6	33	
Total	2	40	46	8	17	54	51	39	3	3	5	1	2	1	1	2	7	12	22	34	4	8	15	157	534

APPENDIX E: Continued.

Date	Net Hours	Dawn Wind	Prev. Evc. Wind	AMGO	AMRO	BAOR	BAWW	BBWA	BCCH	BLBW	BLPW	BRCR	BTBW	BTNW	CAWA	CEDW	CSWA	DOWO	GCKI	GRCA	HETH	INBU	LEFL	MAWA	MOWA	MYWA	NAWA	NOPA	NOWA	OVEN		
30-Sep-96	114	W	SW			3					2		2	1					1	1			1	3			1	1				
1-Oct-96	88.35	NW	NW			1					7		2	1						3	1		1	2								
2-Oct-96	95	SW	SW			2					1		5	1						2			1									
4-Oct-96	91.65	NW	NW			1					18		2	4	1					2	2		1	1	1	38	2					
5-Oct-96	45.83		NW								2	1									1	1				26	1					
6-Oct-96	78	SE				1					7	1	1						1		1		1			24	1					
7-Oct-96	114	SE	SE					1			2	2	2	1					1		1					2						
8-Oct-96	114	S	SW					5			6								2							2						
10-Oct-96	114	SW	NW					24			3			1												21						
11-Oct-96	123.42	NW	SE					5			13		2							2	2					21	1					
12-Oct-96	114	NW	NW					4			6		3	1					1		1		2			53	1	2				
19-Oct-96	102	E	NW					2			4	2	1						2	1	2		1			16						
20-Oct-96	29.64	E	E								1															1						
Total									43	7	187	19	54	79	12	25	13	5	134	34	23	6	25	63	9	477	40	21	90	25		

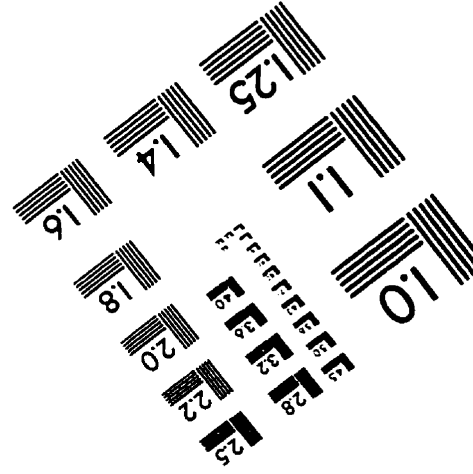
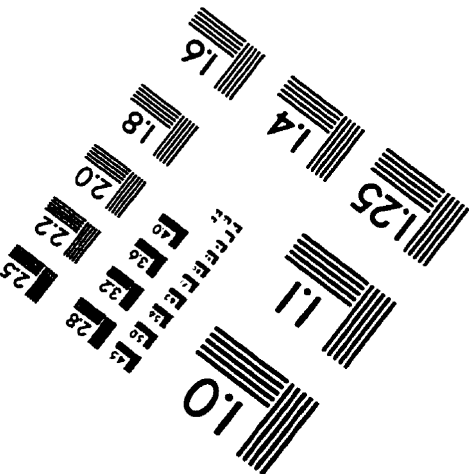
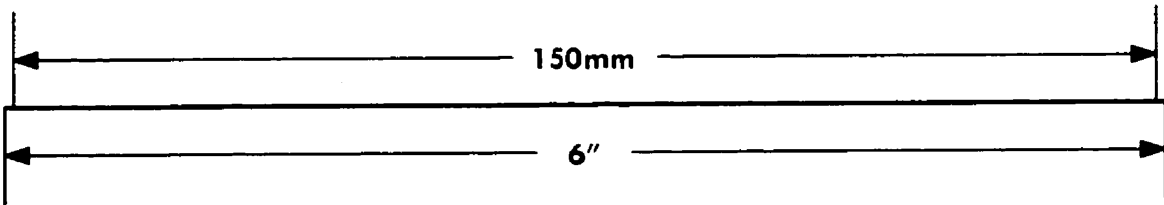
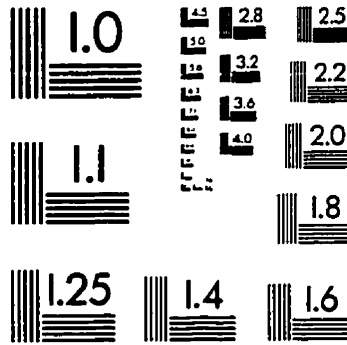
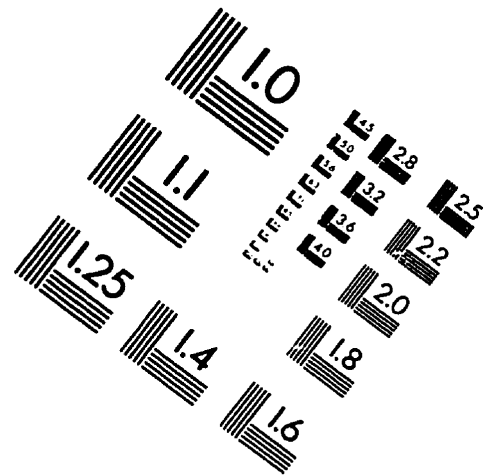
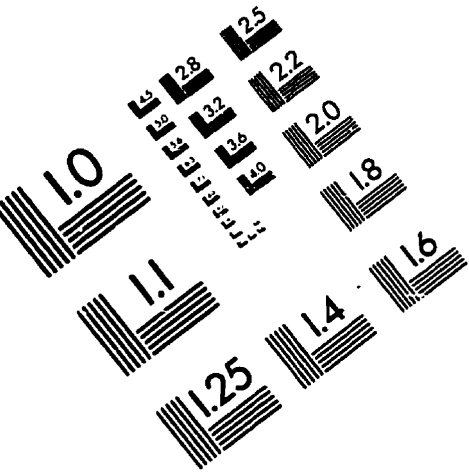
APPENDIX E: Continued.

Date	Net Hours	Dawn Wind	Prev. Eve. Wind	PHVI	PUF1	RBNU	RCKI	REVI	SAVS	SCJU	SOVI	SWSP	VEER	WAVI	WIWA	WTSP	YBCH	YBFL	YBSA	YPWA	YSFL	Total
12-Aug-95	48	SW	SW													1						8
13-Aug-95	40	NW	SW																			9
14-Aug-95	40	W	NW																			3
15-Aug-95	40	E	W																			7
16-Aug-95	40	S	E															3				7
17-Aug-95	40	NW	SW																			2
18-Aug-95	40	NE	NW				1															1
20-Aug-95	40	SW	NE																			2
22-Aug-95	40	SW	SW																			5
23-Aug-95	40	NW	NW																			1
26-Aug-95	40	NW	NW																			3
27-Aug-95	40	SW	NW																			1
28-Aug-95	60	NW	NW		1										2							13
29-Aug-95	60	S	NW			1	1			1												13
30-Aug-95	60	NW	SW		2																	6
31-Aug-95	60	NW	NW					5							2							16
2-Sep-95	54	W	SW																			4
3-Sep-95	60	N	W					5					1		1							22
4-Sep-95	80	CALM	N					1														11
5-Sep-95	80	SW	CALM		2																	5
6-Sep-95	80	SW	SW					1														5
7-Sep-95	80	SW	NW					3								1						8
8-Sep-95	80	N	SW			1																4
9-Sep-95	80	NE	SW					3														13
10-Sep-95	80	NW	NE			2	1															23
11-Sep-95	60	NW	N					5					1		1							15

APPENDIX E: Continued.

Date	Net Hours	Dawn Wind	Prev. Evc. Wind	PHVI	PUFI	RBNU	RCKI	REVI	SAVS	SCJU	SOVI	SWSP	VEER	WAVI	WTWA	WTSP	YBCH	YBFL	YBSA	YPWA	YSFL	Total
30-Sep-96	114	W	SW	1		1		4		1	1			1								24
1-Oct-96	88.35	NW	NW			1	1	8	1			1							2	5		80
2-Oct-96	95	SW	SW			1		2		1	1					1			1		1	23
4-Oct-96	91.65	NW	NW					1		1						6			1	4		85
5-Oct-96	45.83		NW						1								1			3	1	38
6-Oct-96	78	SE					1		2		1					2	1		1	3		48
7-Oct-96	114	SE	SE									1				1						14
8-Oct-96	114	S	SW			1	1													1		21
10-Oct-96	114	SW	NW				1	2								1						53
11-Oct-96	123.42	NW	SE			1	2	18		1	2	1		1	2	4				1		83
12-Oct-96	114	NW	NW			3	4	5			3	1		1	1	9					1	125
19-Oct-96	102	E	NW			1	3			9		1				8						56
20-Oct-96	29.64	E	E																			2
Total				12	11	33	57	158	6	53	36	23	8	6	39	115	10	70	10	19	22	2309

IMAGE EVALUATION TEST TARGET (QA-3)



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