Narragansett Bay
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A Protocol for Long-term Monitoring of Harbor Seals (*Phoca vitulina concolor*) in Narragansett Bay, Rhode Island

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Executive Summary

Harbor seals (*Phoca vitulina concolor*) are the most common pinniped species in Narragansett Bay, RI. They travel south to use the Bay as a winter foraging ground from approximately late September through late April/early May. While in the Bay, harbor seals haul-out on exposed rocks or rock outcroppings away from shore during low tide. At least 24 seal haulout sites have been identified throughout Narragansett Bay. Seal numbers have been monitored at some haulout sites in the Bay for at least 30 years. As of 2000, temporal trends in abundance at frequently monitored sites had been quantified, and a few estimates of seal abundance throughout Narragansett Bay had been made. However, long-term and current trends in Bay-wide seal abundances are not well-defined due to a limited amount of quantitative population data from coordinated Bay-wide surveys. In addition, a variety of factors can affect seal use of haulout sites, and by extension survey accuracy; the influence of these factors can vary among individual haulout sites and regions. The goal of this study was to combine historic and current survey data to examine the effects of multiple factors on seal abundance and develop a quantitative protocol that can be used to estimate harbor seal abundance on a Bay-wide scale. This protocol could then be used to track seal abundance over time and facilitate comparisons of trends in Narragansett Bay with larger-scale patterns in the northwest Atlantic Ocean. This will also allow researchers and managers to better understand the role that harbor seal populations play in the winter ecology of Narragansett Bay and help to better protect these charismatic marine mammals.

This document is presented in two parts. The first part provides a comprehensive background and justification for the needs and development of the protocol. It is formatted much like a peer-reviewed scientific manuscript with Introduction, Methods, and Results/Discussion sections that detail the scientific process used to develop the protocol. The second part of this document is where the monitoring protocol itself is presented. This includes a concise step-by-step protocol, a datasheet template for conducting surveys in the field, and an Appendix with one page dedicated to each of 24 known seal haulout sites in Narragansett Bay. The goal in presenting this protocol is to allow researchers and volunteers to easily conduct coordinated and quantitative seal surveys throughout Narragansett Bay, thereby collecting data that are directly comparable over time to discern long-term patterns in seal abundances in the Bay.

Part 1. Background and Justification for the Seal Monitoring Protocol

Introduction

Harbor seals (*Phoca vitulina concolor*) are the most common pinniped in United States Atlantic waters and are distributed from northern Canada to New Jersey (Schroeder 2000). In the northern part of their range, the harbor seal pupping season lasts from mid-May to July and the molting season from July through August. In winter, harbor seals migrate south from the Gulf of Maine to warmer waters following abundant food resources (Gilbert et al. 2005).

Harbor seals commonly haul-out of the water on a variety of substrates including sand, rock, and ice (Bengtson et al. 2005). Seals haul-out for a variety of reasons, including rest, thermoregulation, and predator avoidance (Terhune and Brillant 1996). In the northern part of their range, the number of seals hauled-out peaks during the pupping and molting seasons (Simpkins et al. 2003); consequently, most studies of harbor seals in this region are also conducted during these times. Further south, haul-out peaks occur anywhere from early winter to early spring. For example, peaks in seal abundance in coastal Massachusetts occurred in both January and March (Schneider and Payne 1983; Payne and Seltzer 1989). In Narragansett Bay, RI, the peak occurs in late March or early April, although this varies temporally over a multi-decadal time period and spatially among different regions of the Bay (Schroeder 2000).

A number of factors affect harbor seal use of haulout sites, including season, tidal stage, temperature, wind speed and direction, sea state, and disturbance (Olesiuk et al. 1990; Barlas 1999; Baird 2001 and references within each). However, the effects of most of these factors are often not consistent among studies and in fact can vary on scales ranging from individual haulout sites to regions (Harvey 1987; Baird 2001). Due to this variability it has been recommended that the specific effects of these and other factors be examined on a site-specific basis to develop and calibrate local monitoring and survey protocols for harbor seals (Baird 2001).

Harbor seals utilize Narragansett Bay, located in the center of Rhode Island, as a winter residence from late September to early May (Schroeder 2000). While in the Bay, they are typically only found hauled-out on exposed rocks away from shore. Mirroring larger geographic trends (e.g., Stobo and Fowler 1984; Payne and Seltzer 1989; Gilbert et al. 2005), harbor seal abundance has increased dramatically over the last few decades in Narragansett Bay (Schroeder 2000). Concurrent with this increase, the number of haulout sites has more than doubled over a similar time frame in the Bay. However, this population trend assessment is based on a limited amount of data and even fewer data are available after 2000. In fact, aside from the analysis by Schroeder (2000) and monitoring by volunteers at select haulout sites, very little is known about the ecology of harbor seals in Narragansett Bay and efforts to accurately monitor trends in seal abundance over time are necessary.

The goal of this study is to develop a quantitative protocol for monitoring harbor seal abundance in Narragansett Bay, RI. This study will 1) quantify patterns of haulout site use by harbor seals at multiple temporal scales, 2) compare observed temporal patterns across multiple haulout sites, and 3) quantify the effects of meteorological factors and time of day on the use of haulout sites by harbor seals. If implemented, this protocol will allow researchers and managers to estimate the number of seals using Narragansett Bay on an annual basis and, by extension, to quantify trends in abundance over time. These data will in turn provide insight into the value of Narragansett Bay as an overwintering ground for harbor seals and form the basis for better understanding the ecological effects these top predators have while present in the Bay.

Methods

Study Sites

Current and historical data used in this study were collected from four harbor seal haulout sites in Narragansett Bay, RI. Each of the haulout sites is comprised of nearshore rocks or rock outcroppings that are exposed at low tides. In the winter of 2007 to 2008, harbor seal counts were conducted at the long-term seal haulout site near T-wharf on Prudence Island in the Narragansett Bay National Estuarine Research Reserve (NBNERR) (Figure 1). During this same time period, supplementary counts were conducted at the Rome Point and Brenton Point haulout sites in North Kingstown and Newport, respectively. These three sites were selected for the collection of current data because each consistently supports large numbers of seals and each is relatively easy to access. Historical data were also used from Brenton Point and the Church Cove haulout site in Bristol to help examine the effects of season, time of day, and weather on seal counts. The Brenton Point and Church Cove sites were chosen for these historical data to expand the extent of the study area from the mouth to upper Narragansett Bay and therefore ensure that the monitoring protocol is applicable on a Bay-wide scale. The locations of these four haulout sites, along with the 20 additional haulouts known to exist in Narragansett Bay, are shown in Figure 1.

Seasonal Patterns

Best-fit nonlinear regression analysis techniques were used to relate seal abundance to survey date and to model the seasonal patterns in seal abundance at the T-wharf, Brenton Point, and Church Cove haulout sites. At T-wharf, 50 seal counts were conducted between October 2007 and April 2008 by NBNERR staff. Counts were made as close as possible to the time of predicted low tide. During each count, all seals were identified to species and counts were made of seals hauled-out on rocks and swimming in the water. In addition, records were kept of survey time, general weather conditions, and instances of human disturbance. Seasonal patterns were also modeled at Brenton Point using historical data collected by volunteers between October 1996 and April 2002 (n=48

surveys), and at Church Cove using volunteer data between October 1995 and April 2002 (n=46 surveys). Since data spanned multiple years at the latter two sites, all data were standardized into a single dataset at each site by converting calendar dates to the number of days before and after January 1st.

Tidal Patterns

High-frequency seal counts were conducted at T-wharf on 11/21/2007, 12/20/2007, and 2/4/2008 to determine the relationship between seal abundance and tidal height. Each survey began approximately 3 hours before predicted low tide and lasted until approximately 3 hours after low tide. During this 6-hour period, seal counts were conducted every 10 minutes and data recorded as described above. Six-hour surveys were also conducted at Brenton Point on 12/20/2007 and at Rome Point on 2/4/2008 to provide spatial replication of the high-frequency counts at T-wharf.

All data within each high-frequency survey were standardized as a percentage of the maximum number observed during that survey to seamlessly combine all data from the five individual surveys. The time of each count in relation to tidal stage was also standardized by calculating the number of minutes away from the observed time of low tide (which was visually determined by the person conducting the seal counts) that each survey was conducted. The relationship between standardized measures of tide level and seal abundance was then determined using best-fit nonlinear regression analysis.

Effects of Time of Day and Meteorological Factors

In order to examine the effects of time of day and meteorology on seal counts, the confounding effects of season on seal abundance were first removed. This was accomplished by fitting a best-fit nonlinear regression to survey data from T-wharf, Brenton Point and Church Cove as described above, and then calculating model residuals. These residuals represent the difference between predicted and actual seal counts and were used as dependent variables to assess the effects of time of day and meteorological factors.

The effects of time of day, air temperature, and wind speed and direction on seal counts were all independently examined by using simple linear regression to relate each variable to the seasonal model residuals that were calculated for each site as described above. Wind speeds were then further categorized into two sub-datasets based on the geomorphology of the surrounding shoreline: one when the haulout site was in the lee of the wind and seals were therefore relatively protected, and another when the site and seals were fully exposed to wind stress. Linear regression was used to relate model residuals to wind speed for both wind conditions and assess the effects of wind direction and speed on seal counts.

The effect of precipitation (rain and snow were not differentiated) on seal counts was only assessed at T-wharf; suitable data were not available from the other two sites. A paired t-test was used to compare actual seal counts between days with and without precipitation. For each of five precipitation events in 2007 to 2008, the closest count immediately before and after the count on the precipitation day were averaged to provide a sample size of five for each treatment (precipitation and no precipitation).

Weather data for the T-wharf haulout site were obtained from the NBNERR weather station located approximately 6.5 km north of the T-wharf on Prudence Island. Weather data to accompany the historical datasets at Brenton Point and Church Cove were obtained from the NOAA Historical Weather Data Archives using the T.F. Greene Airport station in Warwick, RI.

All graphing and statistical analyses were performed using SigmaPlot version 9.01 and SYSTAT version 12.02, both © SYSTAT Software, Inc.

Results and Discussion

Seasonal Patterns

Seal abundance at T-wharf from 2007 to 2008 increased steadily through early April, and then fell off precipitously (Fig. 2A). A peak in late-March was also seen at Church Cove, while abundance peaked in early-to-mid-March at Brenton Point. These findings are consistent with the overall seasonal pattern described by Schroeder (2000) for many sites in Narragansett Bay, including the heavily used Rome Point site in North Kingstown (Fig. 2B). At T-wharf, the data were best fit with a modified Gaussian 5 parameter regression model (R^2=0.36, F=5.67, p=0.001). At Brenton Point the data were best fit with a Weibull 4 parameter model (R^2=0.51, F=15.13, p<0.001). Finally, at Church Cove the data were best fit with a Weibull 5 parameter model (R^2=0.24, F=10.68, p<0.001).

Not all sites in Narragansett Bay exhibit the same pattern described above; Schroeder (2000) observed a bimodal peak in abundance at the Cold Spring Rock haulout site in North Kingstown, while a linear increase in abundance was observed at T-wharf in previous years (although in the latter case the lack of a clear peak may be due to limited data collected at the end of the season). However, when considering Narragansett Bay as a whole, Schroeder (2000) found that the highest number of seals in the Bay nearly always occurs in March (Fig. 2C). Despite a few site-to-site differences, the available data strongly demonstrate that overall seal abundance currently peaks sometime between mid-March and early-April; therefore, concurrent Bay-wide surveys aimed at determining the total number of seals in Narragansett Bay should be conducted within this time window.

Tidal Patterns

Seal abundance was significantly related to the amount of time away from low tide based on a quadratic regression model (R^2=0.88, F=150.29, p<0.001). Other studies have also found that tide stage is a dominant determinant of harbor seal use of haulout sites (e.g., Schneider and Payne 1983; Olesiuk et al. 1990). Based on standardized data from the five high-frequency surveys in this study, seal abundance peaked approximately 55 minutes after the time of the observed low tide (Fig. 3). Further, the distribution of seal abundances that fell within 10% of this peak was skewed, ranging between 37 minutes before low tide to 146 minutes after. These data suggest that accurate estimates of seal abundance in Narragansett Bay can be attained by conducting surveys at all haulout sites between approximately 0.5 hours before to 2.5 hours after low tide. Data from surveys that are conducted outside of this window should not be used because they reflect a decreased ability to represent the true number of seals present at that location during peak haul-out. However, this 3-hour survey window is important since it will often not be possible to visit each site directly at low tide, especially if individual volunteers are assigned to survey more than one haulout site per day. Having an observing window also allows for some flexibility when conducting surveys since the predicted and observed times of low tide are not always the same.

Time of Day

After accounting for changes in abundance across the winter season, there was no significant effect of time of day on seal counts at T-wharf (Fig. 4A; linear regression, R^2=0.01, F=0.25, p=0.62). This result was corroborated using historical data from both Brenton Point (linear regression, R^2<0.001, F=0.002, p=0.96) and Church Cove (linear regression, R^2=0.001, F=0.18, p=0.67). Survey times at all three sites in this analysis ranged from 6:20 am to 7:00 pm, which indicates that accurate seal counts can be made at any point during daylight hours in Narragansett Bay.

In other geographic areas, especially those where tidal effects on seal haul-out behavior are minimal, time of day can be an important factor when considering seal use of haulout sites. For example, Stewart (1984) found that more seals hauled-out in the afternoon (presumably when it was warmer) in California where tides are relatively small compared to regions further north. Pauli and Terhune (1987) found that during morning low tides in New Brunswick, Canada, harbor seals tended to haul-out close to or after low tide but during afternoon low tides, seals hauled-out earlier in the tidal cycle. If this latter pattern holds true in Narragansett Bay (adequate data were not available to test this in this study), it suggests that as the day progresses, seal counts should be conducted earlier within the 3-hour survey window defined above.

Meteorological Factors

At T-wharf, seal abundance was not significantly related to air temperature after accounting for seasonal effects (Fig. 4B; linear regression, R^2=0.005, F=0.2, p=0.66).

Significant relationships between air temperature and seal abundance were also not found at either Brenton Point (linear regression; $R^2<0.001$, $F=0.03$, $p=0.88$) or Church Cove (linear regression; $R^2<0.001$, $F=0.10$, $p=0.75$). For the most part, temperatures included in these regressions were relatively high compared to regions at higher latitudes. Temperatures ranged from -4.4 °C to 19.4 °C at Brenton Point, from -12.2 °C to 22.2 °C at Church Cove, and from -11.7 °C to 16.4 °C at T-wharf. Based on these data, it appears that seal counts are not affected by air temperatures as low as -12 °C, but it is not possible to extrapolate this to lower temperatures based on the results from this study. In nearby Massachusetts, Schneider and Payne (1983) found that seal abundance tended to decrease with increasing air temperatures, although this was probably related more to changes in seasonal abundance, which was not accounted for in their study. Based on the results from the present study, air temperature alone should not be a consideration when conducting seal surveys. However, to be conservative, extremely cold days should be avoided until the effects of temperatures below -12 °C on haul-out behavior can be determined in Narragansett Bay.

In contrast, seal counts decreased significantly with increasing wind speeds at T-wharf after accounting for seasonal effects (all directions combined; linear regression, $R^2=0.18$, $F=9.54$, $p=0.004$) (Fig. 5A). When wind speed was partitioned into whether or not the haulout site was in the lee of the wind or not, it was found that wind speed did not affect seal counts when in the lee of the wind (linear regression, $R^2<0.001$, $F<0.001$, $p=0.99$) (Fig. 5B), but it did affect counts when not in the lee (linear regression, $R^2=0.23$, $F=7.63$, $p=0.01$) (Fig. 5C). Similarly, seal counts at Brenton Point decreased significantly as wind speeds increased overall (linear regression, $R^2=0.26$, $F=9.42$, $p=0.005$) and as wind speeds increased when the haulout site was not in the lee of the wind (linear regression, $R^2=0.23$, $F=4.94$, $p=0.04$). Wind speed did not affect seal counts when the haulout site was in the lee at Brenton Point (linear regression, $R^2=0.38$, $F=3.74$, $p=0.10$). At Church Cove, wind speed did not significantly affect seal counts when considering all wind directions combined (linear regression, $R^2=0.02$, $F=1.40$, $p=0.24$) or when the haulout site was in the lee of the wind (linear regression, $R^2=0.04$, $F=1.96$, $p=0.17$). However, a significant negative relationship was seen between wind speed and seal counts when the haulout site was not in the lee (linear regression $R^2=0.20$, $F=5.11$, $p<0.05$).

These results indicate that, in general, as wind speeds increase, seal counts will likely decrease significantly, especially when the haulout site is not protected from direct wind impacts. This further suggests that at individual haulout sites, both wind speed and direction (and whether the site will be leeward or windward) should be considered when conducting counts. However, when conducting concurrent surveys at all sites throughout the Bay, only wind speed should be considered since for every direction from which the wind is coming, some subset of the 24 haulout sites included in this protocol will be in the lee of the wind, while the others will not. These results are consistent with a number of other studies that have shown that either wind speed or direction, or both, as well as sea state (which is a function of wind) can all affect seal use of haulout sites (e.g., Schneider and Payne 1983; deHart 2002). In contrast, an earlier study at T-wharf (Norris 2007) found that seal numbers were not affected by wind speed (or temperature); however, only 12 surveys (7 during the day and 5 at night) were conducted during this

study, which may not provide enough statistical power to truly assess the effects of these factors.

It is more difficult to determine the wind speed at which seal counts should not be conducted due to the linear relationship between wind speed and seal counts and because no clear break-point was observed at any of the three sites. However, based on the regression at T-wharf, lower than predicted seal counts begin to occur when wind speeds reach approximately 4 m sec^{-1} (~9 mph) (i.e., when the regression line fell below a seal count residual of zero; Fig. 5A), and the same was true at Brenton Point (this exercise was not performed using data from Church Cove since the relationship between seal counts and wind speed overall was not significant). In summary, these results did not reveal a definitive wind speed cut-off for conducting surveys; however, a more subjective assessment suggests that seal counts may be lower than expected once wind speeds reach approximately 9 mph. Based on these results, and allowing for some flexibility in conducting concurrent surveys, it is recommended that counts should be conducted when wind speeds are not expected to exceed approximately 10 to 15 mph.

Seal counts were significantly lower at T-wharf when it was either raining or snowing compared to days with no precipitation (Fig. 6; paired t-test, $t=-2.7$, $p=0.05$). The effects of precipitation could not be assessed at either Brenton Point or Church Cove since counts were not taken frequently enough for this type of analysis. Based on these findings, concurrent Bay-wide surveys in Narragansett Bay should not be conducted when either rain or snow is expected.

Summary

Based on the results from the current and previous studies, the basic framework for a long-term protocol for monitoring peak seal abundance throughout Narragansett Bay should include the following elements:

- Three to four Bay-wide surveys should be conducted each year to provide replication and account for weather and other causes of short-term variability;
- Bay-wide surveys should be conducted from mid-March to early April when seal abundance peaks;
- the first survey should be conducted early during this seasonal window to ensure there is sufficient time to conduct all surveys (i.e., to budget enough time to allow for delays due to inclement weather or disturbance);
- surveys at each haulout site should be conducted from 0.5 hours before low tide to 2.5 hours after low tide when abundance should be near its peak;
- counts should be made of seals hauled-out on rocks as well as those swimming in nearby waters;
- surveys should only be conducted when wind speeds are less than 15 mph, although less than 9 or 10 mph is ideal;
- surveys should not be conducted when it is expected to rain or snow;

- surveys can be conducted any time during daylight hours and in any temperature, although when possible efforts should be made to avoid conducting surveys when air temperatures drop below -12 °C;
- concurrent surveys should be conducted at all known haulout sites on the same day during the same low tide period;
- when possible, additional potential haulout sites should be checked for use by seals.

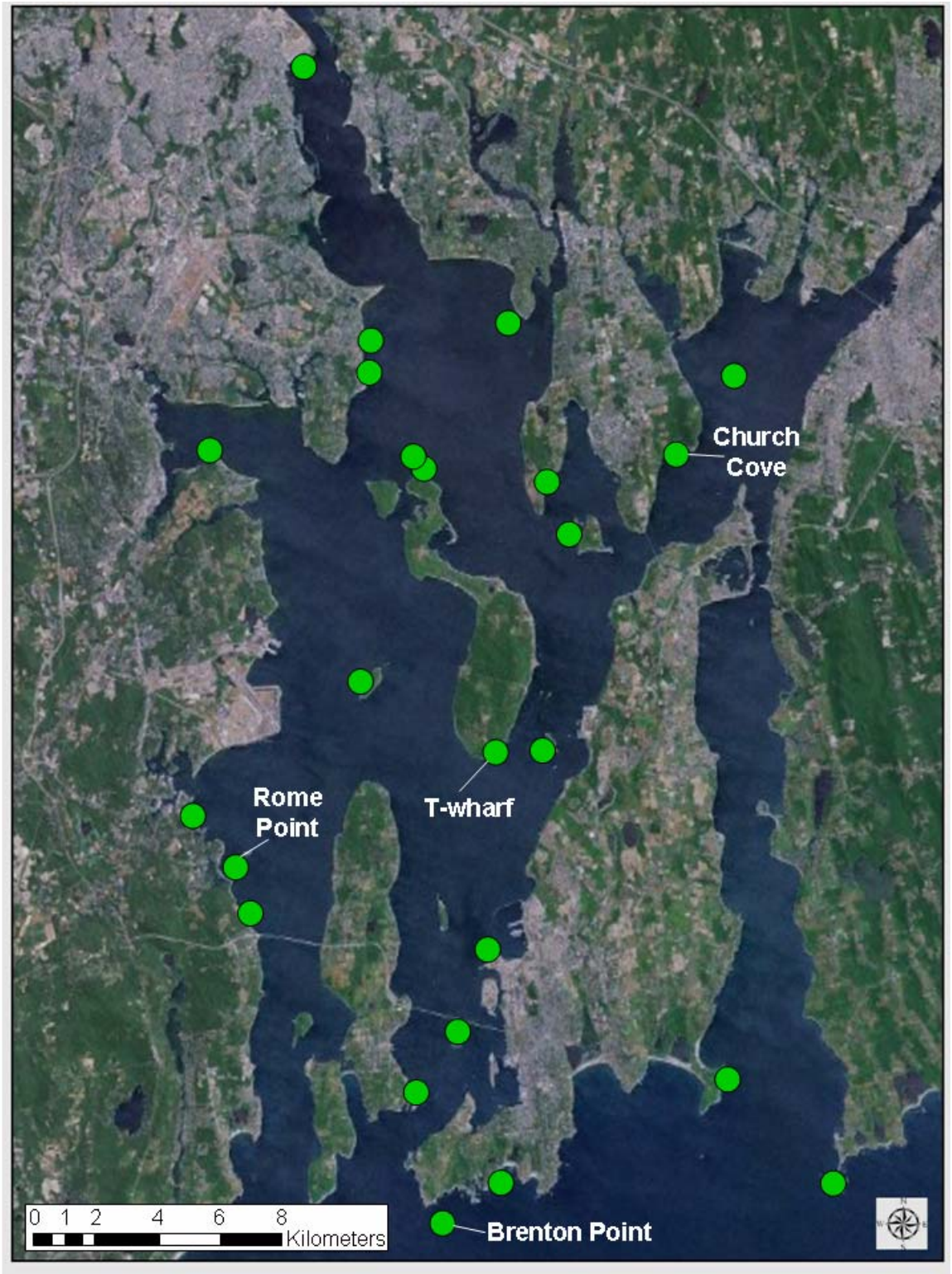

Figure 1. Map of existing haulout sites in and around Narragansett Bay, RI that are included in this study and monitoring protocol. The haulout sites at Brenton Point, Church Cove, Rome Point and T-wharf are highlighted. See Appendix I for names and descriptions of the remaining haulout sites.

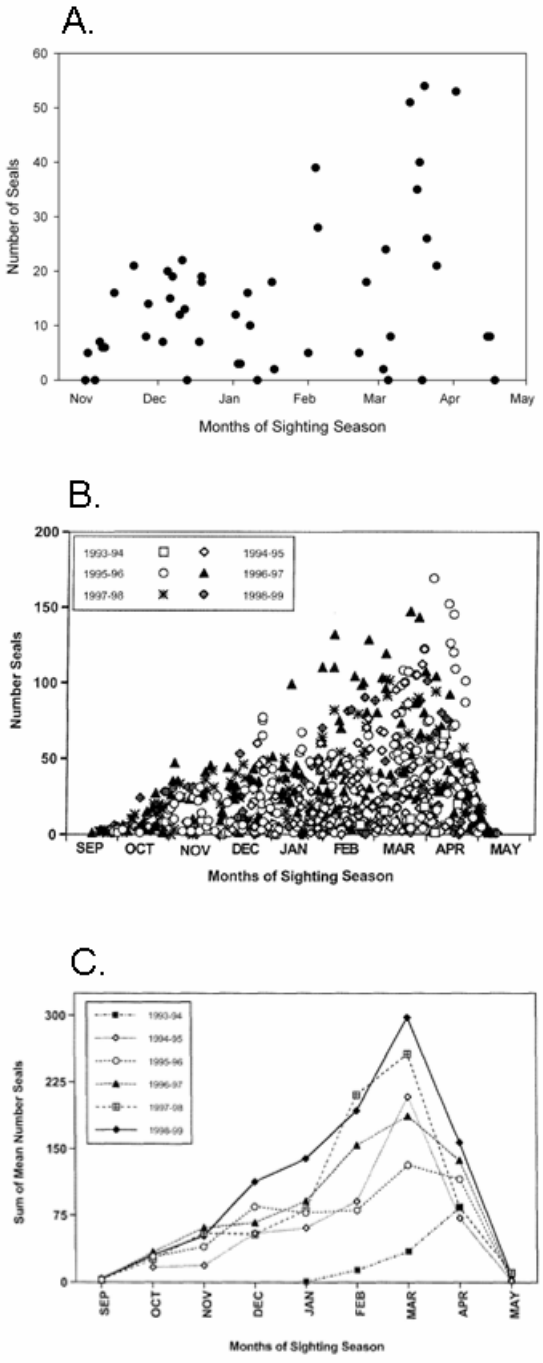

Figure 2. Seasonal patterns in seal abundance at A) T-wharf in 2007-2008, B) Rome Point from 1993-1999, and C) from multiple Narragansett Bay sites combined from 1993-1999. The latter two figures were reproduced from Schroeder (2000).

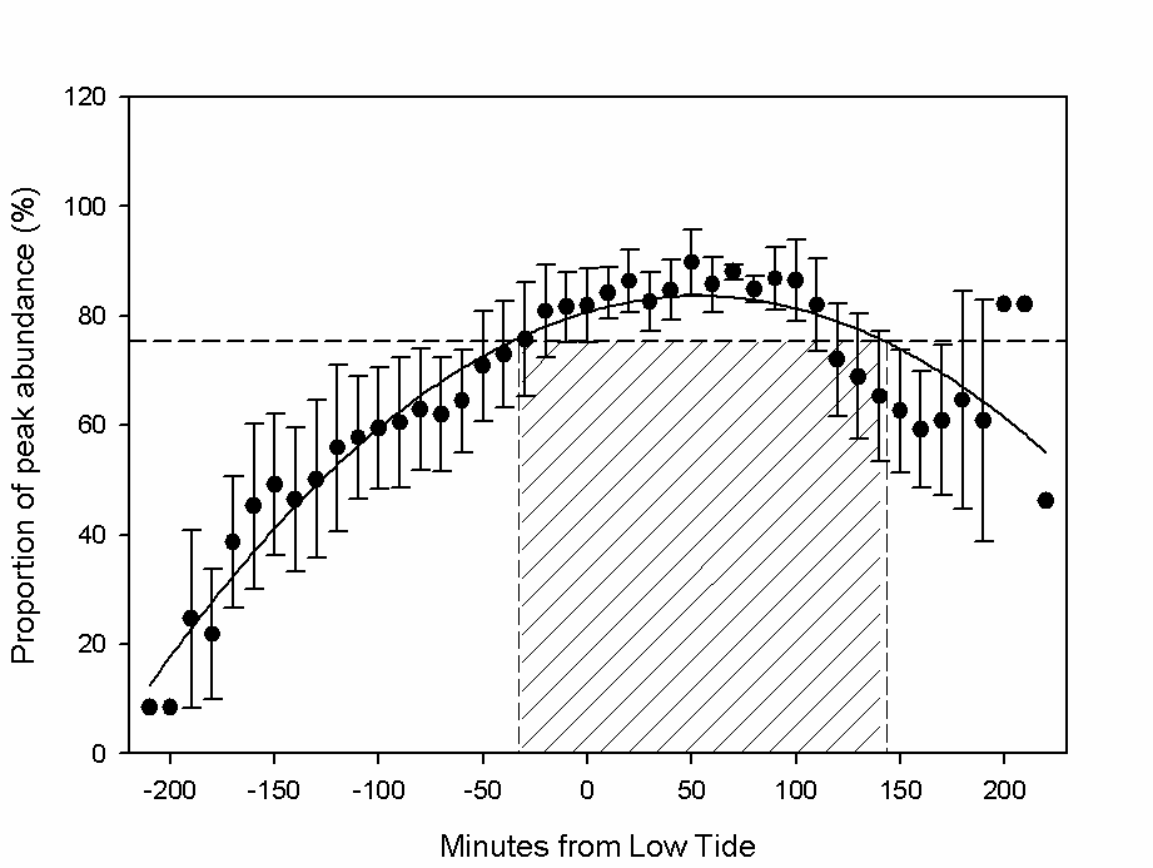

Figure 3. Harbor seal abundance in relation to the amount of time away from observed low tide. Data are from five 6-hour surveys centered around low tide. For each survey, all data were converted to proportions of the observed peak. Each data point in the plot is the proportion of the peak at that time averaged across all surveys. Error bars are ±1 SE. The data were best fit with a quadratic regression model. The horizontal reference line represents 90% of the modeled mean peak abundance. Vertical drop lines framing the shaded box indicate the window of time around low tide when abundance is within 10% of the true peak.

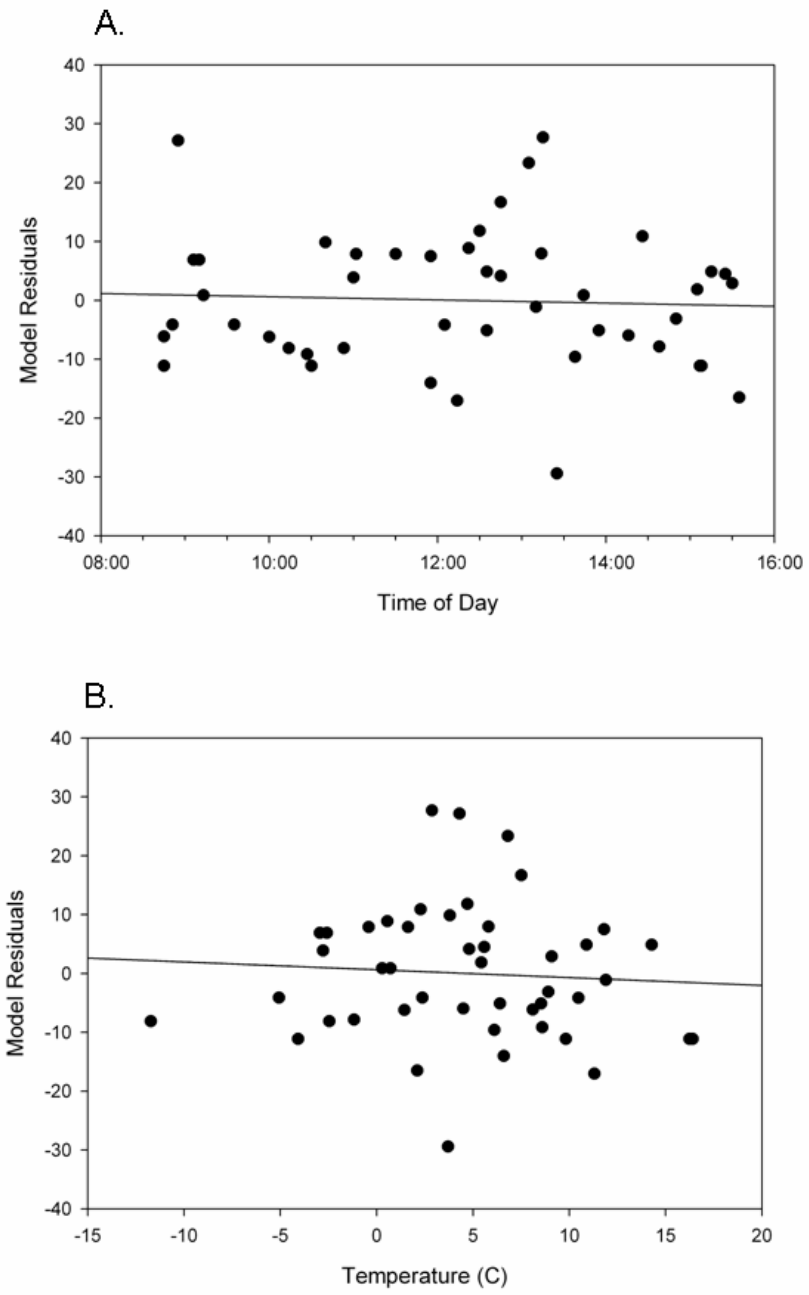

Figure 4. The effects of time of day and air temperature on counts of harbor seals at T-wharf in winter 2007-2008. A) Time of day did not significantly affect seal counts (linear regression, R^2=0.01, F=0.25, p=0.62). B) Air temperature also did not significantly affect seal counts at T-wharf in 2007-08 (linear regression; R^2=0.005, F=0.2, p=0.66). Data used in both plots are residuals derived from fitting a modified Gaussian 5 parameter model to the original sighting data at T-wharf to remove the effects of seasonal changes in abundance.

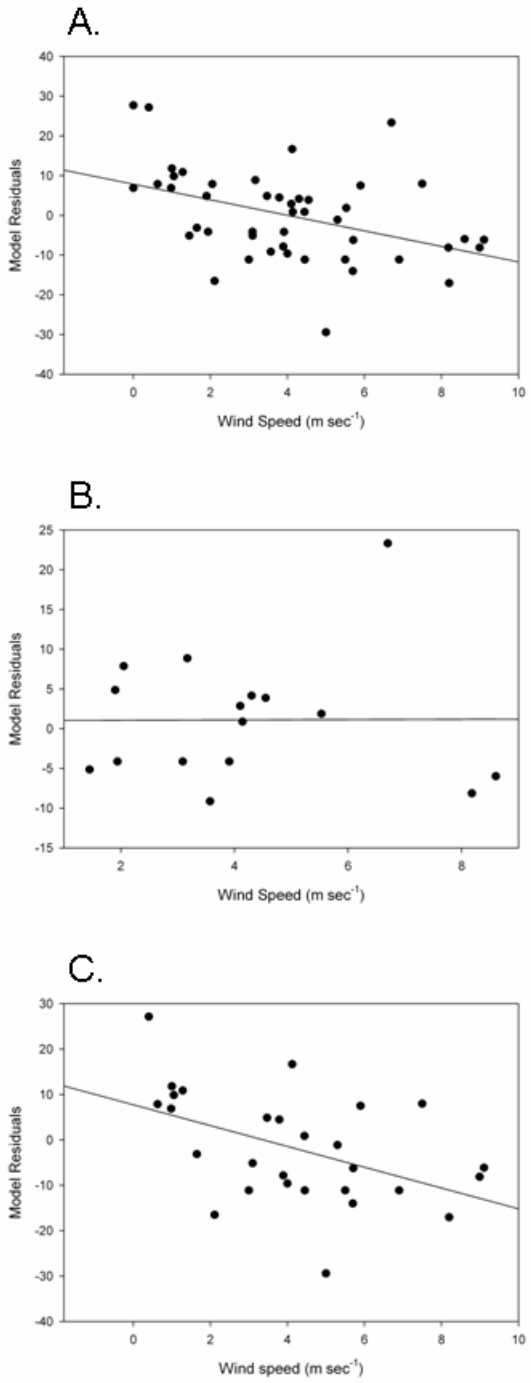

Figure 5. The effects of wind speed and direction on the number of seals observed at T-wharf in winter 2007-2008. A) All wind directions combined (linear regression; R^2=0.18, F=9.54, p=0.004). B) Only data when seals were in the lee of the wind (linear regression; R^2<0.001, F<0.001, p=0.99). C) Only data when seals were exposed to wind (linear regression; R^2=0.23, F=7.63, p=0.01).

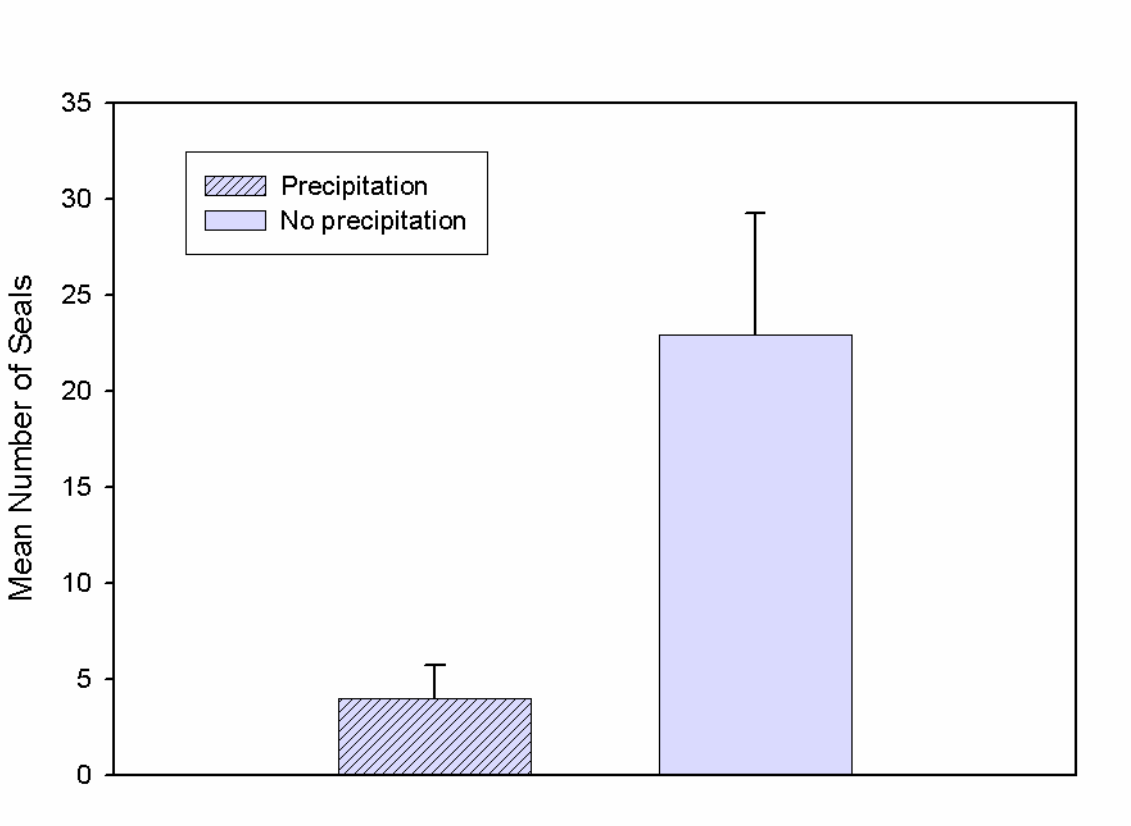

Figure 6. Mean seal abundance during precipitation (rain or snow) and non-precipitation events at T-wharf during 2007-08. Abundance was significantly lower when it was either snowing or raining (paired t-test, t=-2.7, p=0.05). Errors bars are 1 SE.

Part 2. The Narragansett Bay Harbor Seal Monitoring Protocol

Overall harbor seal abundance throughout Narragansett Bay can be quantified by sampling during specific seasonal windows, tides, and weather conditions, and by surveying all harbor seal haulout sites concurrently. The ten specific components of the Narragansett Bay seal monitoring protocol are outlined below and each protocol component is followed by a brief explanation/justification. This is followed by detailed, step-by-step instructions for conducting concurrent surveys at the haulout sites.

1. **Conduct surveys from mid-March to early April**
    - Conducting Bay-wide surveys within this brief window would be the most effective use of volunteer time and result in optimal results as seal abundances in Narragansett Bay are known to peak during this time (Fig. 2 and Schroeder 2000). However, the timing of the peak has changed over time in the past, and it may do so again as the Bay gets warmer (Nixon et al. 2003). Therefore, additional data (outside of this protocol) should be collected to allow researchers to determine if the timing of this abundance peak is shifting; if it is, this survey window should also shift accordingly.
2. **Conduct at least three concurrent surveys each year**
    - At least three concurrent Bay-wide surveys should be conducted each year to provide replication of abundance estimates and also to account for extraneous variables that might affect survey counts.
3. **Ensure that concurrent counts are spread across the survey window**
    - Counts should be spread out from mid-March through early April to account for possible shifts in the timing of abundance peaks within the survey window due to inter-annual differences in environmental variables such as temperature (e.g., the three Bay-wide surveys should not all be conducted during the same week).
4. **Only conduct seal counts between 0.5 hours before to 2.5 hours after the time of predicted low tide**
    - Seal abundances peaked at Brenton Point, Rome Point and T-wharf within this specific window during this study (Fig. 3). However, these data were plotted against the actual time of observed low tide. Since it is not possible to determine this during spot field surveys, the window must be determined relative to the time of the predicted low tide.
5. **Surveys can be conducted any time during daylight hours**
    - There was no significant relationship between time of day and seal abundance during this study; concurrent Bay-wide seal surveys can therefore be conducted any time during the day when there is sufficient light for optimal sightability of seals.
6. **Air temperature should not be a factor when conducting seal surveys**
    - Air temperature was found to have no effect on seal abundance in Narragansett Bay during this study. However, the lowest temperature during this study was -12 °C; until the effects of temperatures lower than this can be examined in Narragansett Bay, efforts should be made to avoid conducting surveys below this temperature.

7. **Only conduct counts when wind speeds are expected to be at or below 10 to 15 mph**
    - Relationships between seal abundance and wind speeds in this study were difficult to quantify, but abundance generally declined as wind speeds increased. In order to provide some flexibility while still ensuring accurate counts, surveys should only be conducted when wind speeds are less than approximately 10 to 15 mph.
8. **Precipitation**
    - In this study, seal abundance was significantly lower at one haulout site when it was either raining or snowing. Concurrent Bay-wide seal surveys should therefore only be conducted when no precipitation is forecast.
9. **Only conduct counts at a haulout site if there is no effect from human disturbance**
    - Human disturbance has been shown to significantly affect seal use of haulout sites (e.g., Schneider and Payne 1983). If seals are disturbed at a haulout site during these surveys, observers should wait until seals return before making counts. If counts cannot be made at a haulout site, especially if it is one of the primary sites that support large numbers of seals, Bay-wide estimates may be compromised and consideration should be given to discounting data from all sites during these surveys. Notes should be taken on the time of human disturbance and the time at which seals began repopulating the haulout after the disturbance.
10. **Ensure that surveys are conducted at all known and suspected seal haulout sites in Narragansett Bay**
    - At least 24 seal haulout sites are known to exist, or to have existed in the past, in Narragansett Bay. For accurate estimates of Bay-wide abundance, all sites that are accessible (see Appendix I) must be visited during each concurrent survey. In addition, efforts should be made to investigate other sites in the Bay where offshore rocks/rock outcroppings are exposed at low tide to determine if seals are expanding the number of haulout sites used in the Bay, or if they are shifting from using some sites that are currently in use to new ones.

If these ten overarching guidelines are properly followed, quantitative estimates of seal abundances in Narragansett Bay can be made. More details on the specifics of actually conducting the surveys are provided below.

- Care should be taken when approaching each viewing station to not disturb hauled-out seals, especially if the station is approached by car or boat. Voices should be kept low and dogs should be kept away from the observation point;
- Seal counts should be made using either binoculars or spotting scopes. The specific viewing equipment that is recommended or required for each haulout site is provided in Appendix I;
- At each haulout site, three consecutive counts of seals should be conducted to ensure the most accurate counts are obtained;

- All seals should be recorded, including those that are hauled-out on rocks and those that are still in the water (records of both categories should be kept separately);
- All species of seals should be separately recorded and counted. It is likely that only harbor seals and gray seals (*Halichoerus grypus*) will be observed in the Bay;
- All data should be recorded on the datasheet provided in this protocol (Fig. 7). One datasheet can be used repeatedly over time for each haulout site. Ensure that all parts of the datasheet are completely filled out for each survey and that any notes particular to a survey are recorded;
- Prior to each individual Bay-wide survey, the coordinator (currently Wenley Ferguson at Save The Bay) will identify, contact, and coordinate all volunteer observers to ensure that all haulout sites are covered. This will include identifying volunteers with boats to conduct surveys at Hope and Rose islands. The coordinator will send out contact information and specific instructions (including the conditions under which a given survey will be cancelled due to weather or other reasons) to all observers before each survey;
- All survey sheets should be delivered to the coordinator of the Bay-wide surveys, preferably in electronic format. Hardcopy datasheets that are filled out in the field can be transcribed to electronic form after surveys have been completed.

Narragansett Bay Seal Sighting Data

Site Name:

Monitor Name:

Date	Time	Tide	Air Temp	Weather	Wind	Species	Number	HO/Water	Monitor's Name	Comments
		time of low tide	(F)	clear, cloudy, rain or snow	calm, breezy or windy			hauled out (HO) and/or in water		

Figure 7. The datasheet that should be used when conducting counts of the number of seals observed at individual haulout sites as part of the concurrent Bay-wide surveys. Datasheet provided by Wenley Ferguson, Volunteer Coordinator, at Save The Bay.

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Acknowledgements

We would like to thank Kristin Van Wagner for collecting seal survey data from Brenton Point during the high-frequency 6-hour survey in December 2007. We would also like to thank Wenley Ferguson at Save The Bay for providing all historical data used in this study and Kathy Vigness Raposa and Cheryl Schroeder for providing technical comments on the manuscript.

Appendix I. Maps and Station Descriptions

This appendix includes one-page synopses for each of 24 seal haulout sites in Narragansett Bay. Each one-pager includes information including haulout site name, general location, coordinates, maps, and directions for getting to and counting seals from each site. Haulout sites are listed in alphabetical order according to name.

There are additional previously-used, existing, and potential haulout sites in Narragansett Bay that are not included in this Appendix. For example, Patience Island was once used for hauling-out by harbor seals, but according to Schroeder (2000), it has not been used for many years. The lack of seals, coupled with the need for a boat to access this site makes monitoring there a low priority. Other sites are known to support small numbers of hauled-out seals, but cannot be included in this protocol due to access limitations. Brown Point in Little Compton and Mackerel Cove in Jamestown are two such sites that cannot be surveyed easily due to private property access restrictions. It is likely that the relatively small number of seals found at these sites (e.g., up to three seals are typically found at Brown Point from January through March according to Schroeder [2000]) would do little to alter the overall results from concurrent Bay-wide surveys. In addition, the key to this protocol is to systematically repeat surveys at the same sites over time (unless seals expand their range to include new sites). This will lead to repeatable, quantitative abundance estimates, even if a few minor sites are not included. If it is found that seals begin to consistently use new sites or return to previously abandoned sites, then the protocol should be revised to include these new sites in each Bay-wide survey to ensure that counts are accurate.

Site name: Barren Ledge

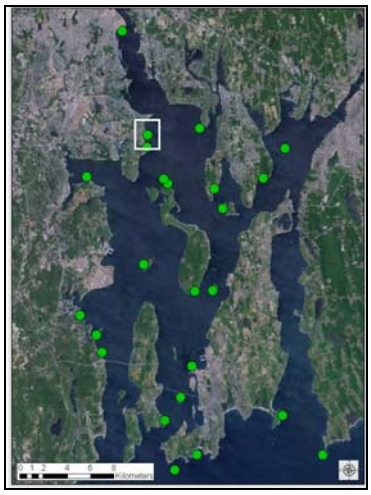
Town: Warwick

Coordinates: 41° 42.07’ N / 71° 21.39’ W

General Location: The haulout site is off the eastern side of Warwick Neck

Viewing Equipment: Binoculars (required); Spotting scope (recommended)

Maps:



Directions and Sampling Instructions: Proceed to the parking area at end of Samuel Gorton Road in the Warwick Neck section of Warwick, RI 02889. Barren Ledge comprises two piles of rocks offshore and to the right (south) of the viewing station. The Rocky Point haulout site can be seen in the distance to the south.

Site name: Bear Point

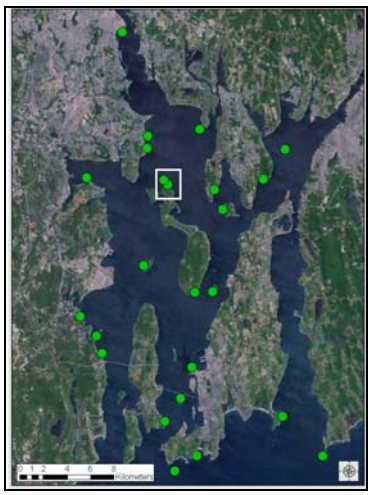
Town: Portsmouth (Prudence Island)

Coordinates: 41° 39.50’ N / 71° 20.38’ W

General Location: The haulout site is a small clump of rocks near the eastern shore of the north end of Prudence Island.

Viewing Equipment: Binoculars (required); Spotting scope (recommended)

Maps:



Directions and Sampling Instructions: From the Prudence Island ferry landing, proceed approximately 5 km to the northeast to reach the entrance gate to the North End Unit of the Narragansett Bay National Estuarine Research Reserve. Proceed north past the gate for approximately 2.4 km to the North End Farm (an historic farm site that is maintained with signage by the Reserve). Turn right at the Farm and proceed east to the viewing station on the shoreline of the Bay. The haulout site is approximately 415 m to the north along the shoreline.

Site name: Brenton Point

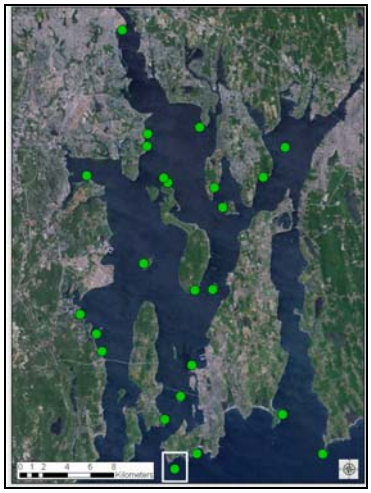
Town: Newport

Coordinates: 41° 26.39’ N / 71° 20.50’ W

General Location: The haulout site is on a large clump of rocks approximately 0.8 km off the southern end of Brenton Point State Park in Newport.

Viewing Equipment: Spotting scope (required)

Maps:



Directions and Sampling Instructions: This haulout site is locally known as ‘Seal Rock’ and it sits approximately 0.8 km southeast of Brenton Point in Newport RI 02840. To get there, proceed to Brenton Point State Park and drive until reaching the area immediately to the east of the extreme southwestern point of the Park. Alternatively, seals can also be observed on other nearby rocks from the end of Harrison Ave. in Newport. In general, there are many rocks throughout this area and they should all be scanned for seals.

Site name: Church Cove

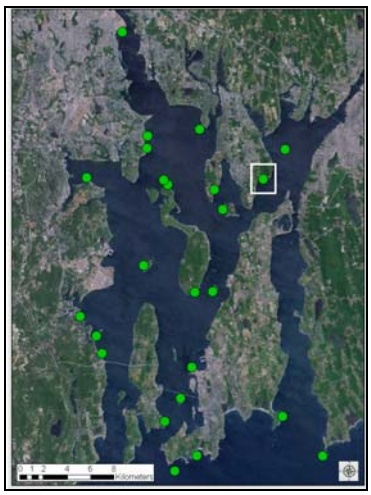
Town: Bristol

Coordinates: 41° 39.57’ N / 71° 14.39’ W

General Location: The haulout site is locally known as Seal Island, which sits within the sheltered Church Cove south of Mount hope Farm in Bristol.

Viewing Equipment: Binoculars (required)

Maps:



Directions and Sampling Instructions: Proceed to Mount Hope Farm (250 Metacom Ave. Bristol RI 02809). Drive in on the road south of the Farm and park in the dirt lot at the end of the drive; walk down the paved path through the trees. At a large open field on the left, look for an inlet to the Bay on the right. Walk all the way down the inlet to the beach. The haulout site includes the two to three sets of rocks to the southwest of the viewing station.

Site name: Cold Spring Rock

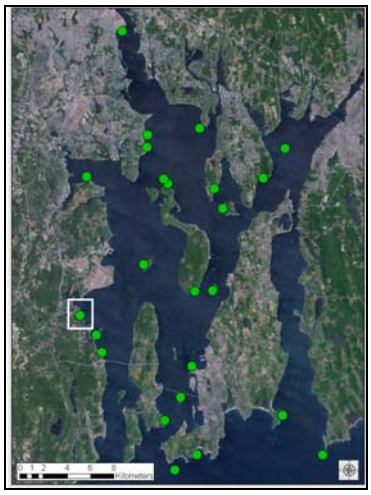
Town: North Kingstown

Coordinates: 41° 33.56’ N / 71° 26.03’ W

General Location: The haulout site is a clump of rocks off North Kingstown Town Beach

Viewing Equipment: Spotting scope (required)

Maps:



Directions and Sampling Instructions: Proceed to the North Kingstown Town Beach parking lot at the end of Beach Street in North Kingstown, RI 02852. Walk out to the viewing station which is along the beach to the south of the parking lot. The haulout site is comprised of two sets of rocks off the southeastern end of the beach. A different perspective can also be obtained from Earle Drive (also in North Kingstown) by parking at the small beach near the end of the road and walking towards the Bay. However, the overall viewing angle is not as good as it is from the Town Beach.

Site name: The Dumplings

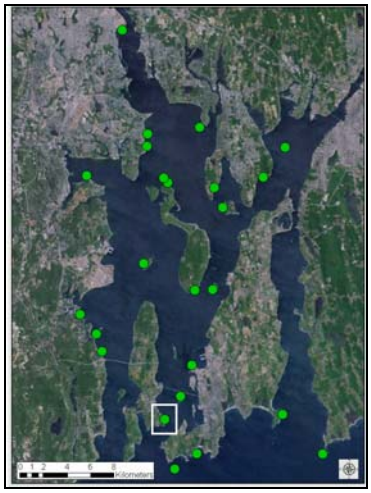
Town: Jamestown

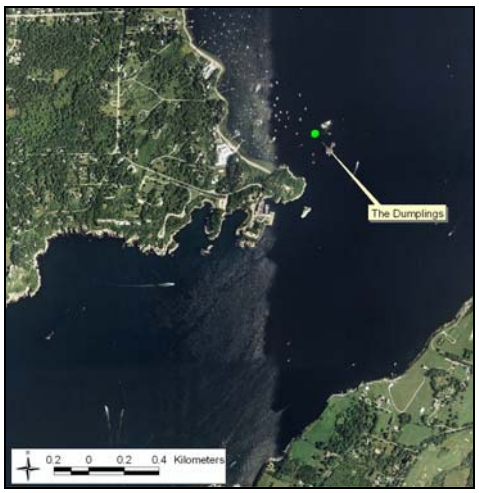
Coordinates: 41° 28.59’ N / 71° 21.15’ W

General Location: The haulout site is near Bull Point, which is located near Fort Wetherill on the southeast corner of Jamestown.

Viewing Equipment: Binoculars (required); Spotting scope (strongly recommended)

Maps:





Directions and Sampling Instructions: Proceed to Racquet Road (Jamestown RI 02835) and follow it to Dumpling Drive. Proceed on Dumpling Drive until reaching the Jamestown Boat Yard. Park along the road near a small beach before the Boat Yard. All rocks that are part of The Dumplings are visible a short distance from shore (the dot in the second map is a general location only; the potential haulout rocks are located throughout the area around the dot). An additional vantage point may be obtained by walking under the piers, southeast along the beach.

Site name: Dyer Island

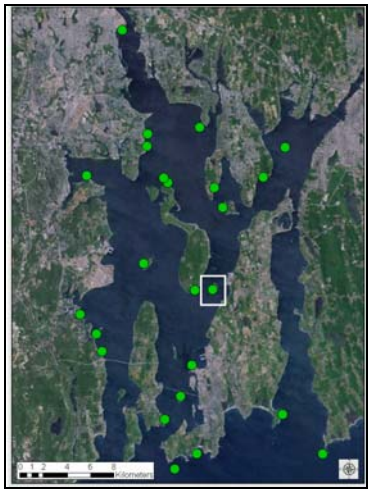
Town: Portsmouth

Coordinates: 41° 34.50’ N / 71° 18.04’ W

General Location: The haulout site is a loosely clustered group of rocks off the southern end of Dyer Island.

Viewing Equipment: Spotting scope (required)

Maps:



Directions and Sampling Instructions: Follow the directions for getting to the T-wharf haulout site viewing station. From there, use a spotting scope to view seals on a series of dispersed rocks off of the south end of Dyer Island, which is approximately 1.5 km to the east. Scan for seals on rocks directly adjacent to the southwestern tip of the island as well as on rocks scattered along a low-tide spit that extends 300 m to the south of the island.

Site name: Gooseberry Island

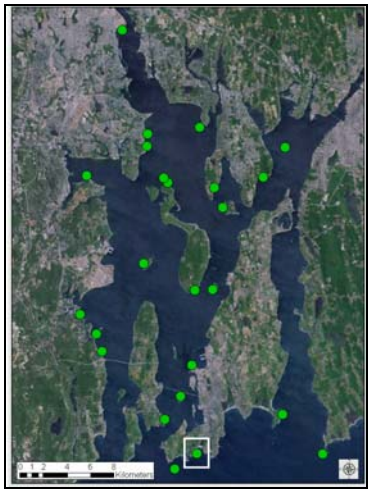
Town: Newport

Coordinates: 41° 27.21’ N / 71° 19.27’ W

General Location: The haulout site is located directly to the north of Gooseberry Island, which lies off of the southern shore of Newport.

Viewing Equipment: Binoculars (required); Spotting scope (recommended)

Maps:



Directions and Sampling Instructions: Proceed to the intersection Carroll Ave and Ocean Ave. in Newport, RI 02840. Turn right off of Carroll Ave. onto Ocean Ave. and proceed to the beach on the left. Park outside the beach lot, which is closed in winter, and walk to the beach. The haulout site is on rocks off the northern shore of Gooseberry Island. Any seals present can be viewed from either Gooseberry or Hazard's Beach. In general, there are many rocks throughout this area and they should all be scanned for seals.

Site name: Green Point

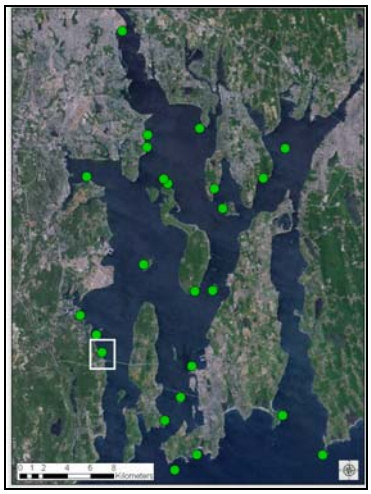
Town: North Kingstown

Coordinates: 41° 32.12’ N / 71° 25.02’ W

General Location: The haulout site is a small clump of rocks near the shore located approximately midway between Rome Point and the western base of the Jamestown Bridge.

Viewing Equipment: Binoculars (required)

Maps:



Directions and Sampling Instructions: Proceed to the parking area for the John H. Chafee Nature Preserve at Rome Point on Boston Neck Road in North Kingstown, RI 02852. The parking area is approximately 1.2 km north of the intersection of Boston Neck road and Rt. 138. Hike down the main trail at Rome Point, but do not turn left after the power lines; instead continue straight to the beach. At the beach, turn right (south) and walk until the Green Point haul-out rocks (in front of the Jamestown Bridge) are within sight. This haulout site can also be viewed from the parking area at Plum Point Beach (at the end of Riptide Dr. in North Kingstown) if the gates are open.

Site name: Hog Island

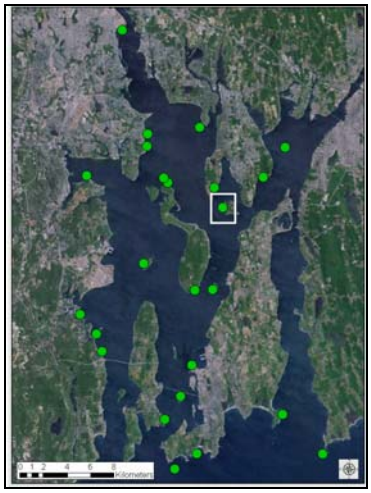
Town: Portsmouth

Coordinates: 41° 38.34’ N / 71° 17.18’ W

General Location: The haulout site is along the western side of Hog Island, which is located outside the mouth of Bristol Harbor and west of the Mount Hope Bridge.

Viewing Equipment: Binoculars (required)

Maps:



Directions and Sampling Instructions: This haulout site is best viewed either by personal boat or from the Prudence Island ferry, which makes 8-10 passes by Hog Island each day. Seals have been observed hauling-out on a small clump of rocks along the western side of Hog Island, but there are additional rocks scattered to the north and south of this clump; all rocks along the western side of the island should be scanned. It might also be possible to view the haulout site with a spotting scope from the tip of Poppasquash Point in Bristol, although this has not been attempted.

Site name: Hope Island

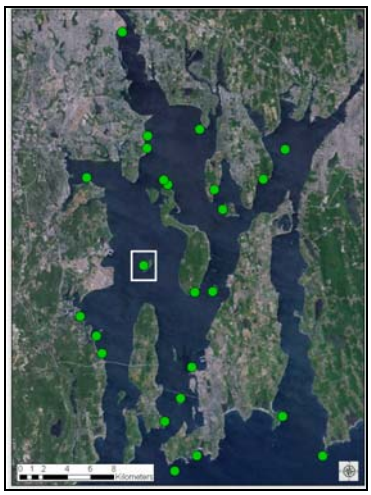
Town: Portsmouth

Coordinates: 41° 36.11 N / 71° 22.14’ W

General Location: The haulout site is on Seal Rock, which is a large rock outcrop directly off of the west side of Hope Island in the West Passage of Narragansett Bay.

Viewing Equipment: Binoculars (required)

Maps:



Directions and Sampling Instructions: This haulout site is on Seal rock to the west of Hope Island and must be viewed with binoculars from a small boat. Seals may also haul-out on Scup Rock, which lies off the eastern shore of Hope Island; this site should also be checked. Care must be taken to not get closer to the seals than 300 ft. as mandated by the Marine Mammal Protection Act.

Site name: Naval Station Newport

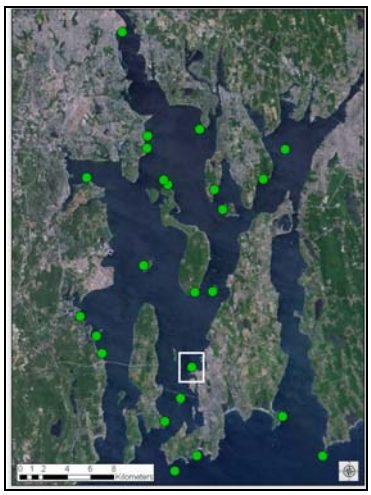
Town: Newport

Coordinates: 41° 31.20’ N / 71° 19.37 W

General Location: The haulout site sits close to the shore off the Naval Station Newport Base in Newport.

Viewing Equipment: Binoculars (recommended)

Maps:



Directions and Sampling Instructions: Proceed to Capodanno Dr. on the Naval Station Newport Base in Newport, RI 02840. Access is restricted to the Base however; viewers must either obtain a visitor’s pass or identify someone on the base to conduct the counts. The haulout site is a small clump of rocks very close to the shore off Capodanno Dr.

Site name: Providence Point

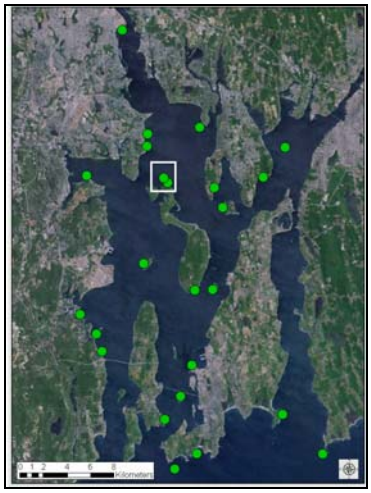
Town: Portsmouth (Prudence Island)

Coordinates: 41° 40.03’ N / 71° 20.41’ W

General Location: The haulout site is a dispersed set of small rocks directly off of the northern tip (Providence Point) of Prudence Island.

Viewing Equipment: Binoculars (required)

Maps:



Directions and Sampling Instructions: From the Prudence Island ferry landing, proceed approximately 5 km to the northeast to reach the entrance gate to the North End Unit of the Narragansett Bay National Estuarine Research Reserve. Proceed north past the gate for approximately 2.9 km until reaching the edge of a salt marsh (the road proceeds through the marsh, but driving is not recommended into the marsh). Walk the remaining 0.15 km to the viewing station. The haulout rocks are located to the north, close to shore. Scan for seals on all rocks to the left (west) and right (east).

Site name: Rocky Point

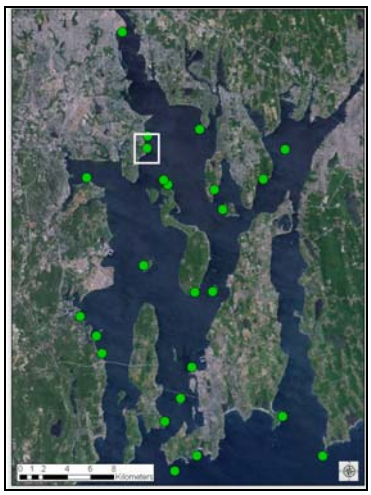
Town: Warwick

Coordinates: 41° 41.29’ N / 71° 21.44’ W

General Location: The haulout site is on a large clump of rocks off of Rocky Point, which is along the east side of the Warwick Neck section of Warwick.

Viewing Equipment: Spotting scope (required)

Maps:



Directions and Sampling Instructions: Proceed to Ogden Ave in Warwick RI 02889, then to the dead end public right of way that provides access to the beach. The haulout rocks are off of Rocky Point, which is visible approximately 540 m to the south (right). Additional rocks in the vicinity of Rocky Point should also be scanned for seals.

Site name: Rome Point

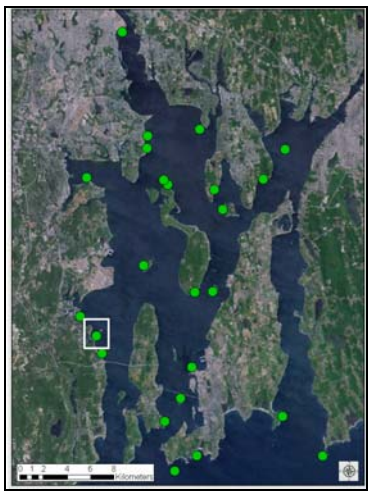
Town: North Kingstown

Coordinates: 41° 32.58 N / 71° 25.16’ W

General Description: The haulout site is on a large clump of rocks off of the tip of Rome Point in North Kingstown, RI.

Viewing Equipment: Binoculars (required); Spotting scope (strongly recommended)

Maps:



Directions and Sampling Instructions: Proceed to the parking area for the John H. Chafee Nature Preserve at Rome Point on Boston Neck Road in North Kingstown, RI 02852. The parking area is approximately 1.2 km north of the intersection of Boston Neck road and Rt. 138. Hike approximately 1 km down the main trail until reaching the power lines and turn left. Continue 0.25 km until the intersection with an old unpaved road, then turn right and walk out to the tip of Rome Point (0.8 km). The haulout site is approximately 220 m from the viewing station on the beach.

Site name: Rose Island (Citing Rock)

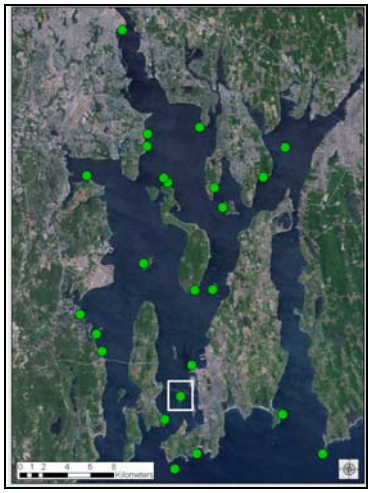
Town: Newport

Coordinates: 41° 30.02’ N / 71° 20.23’ W

General Location: The haulout site is located off of the northern tip of Rose Island, which is located approximately 0.8 km south of the eastern end of the Pell Bridge.

Viewing Equipment: Binoculars (required)

Maps:



Directions and Sampling Instructions: This haulout site must be accessed by boat. Counts are typically taken by Save The Bay and the Rose Island Lighthouse Foundation as part of their winter seal tours.

Site name: Rumstick Point

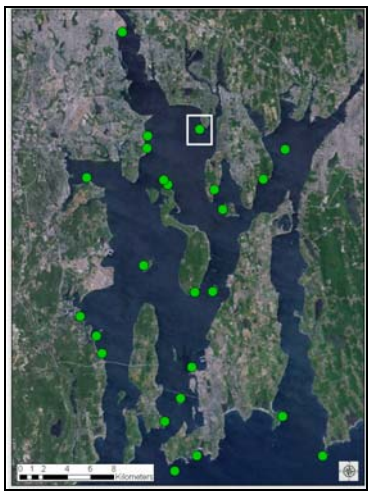
Town: Barrington

Coordinates: 41° 42.13’ N / 71° 18.26’ W

General Location: The haulout site lies off the southern tip of Rumstick Point in Barrington

Viewing Equipment: Binoculars (required); Spotting scope (strongly recommended)

Maps:



Directions and Sampling Instructions: Proceed to the bike path at the intersection of Gibson Rd. and Shore Rd. in Bristol, RI 02809. The haulout site can be seen off the southern tip of Rumstick Point to the northwest while looking between two houses.

Site name: Sachuest Point

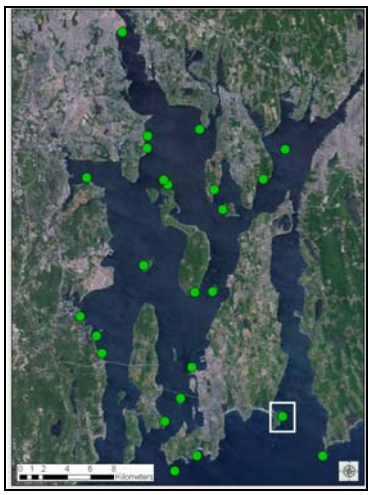
Town: Middletown

Coordinates: 41° 28.54’ N / 71° 14.09’ W

General Location: The haulout site is located off the eastern shore of the Sachuest Point National Wildlife Refuge in Middletown.

Viewing Equipment: Binoculars (required); Spotting scope (recommended)

Maps:



Directions and Sampling Instructions: Proceed to the Sachuest Point National Wildlife Refuge (Middletown RI 02842). Walk behind the parking lot on a path and proceed to the large wooden watchtower. Climb to the top of the watchtower and look down and to the east to scan all possible rocks for hauled-out seals (the dot in the second map is a general location only; the potential haulout rocks are located throughout the area around the dot). A closer look can also be obtained by walking closer to the cliffs and shoreline.

Site name: Sakonnet Point

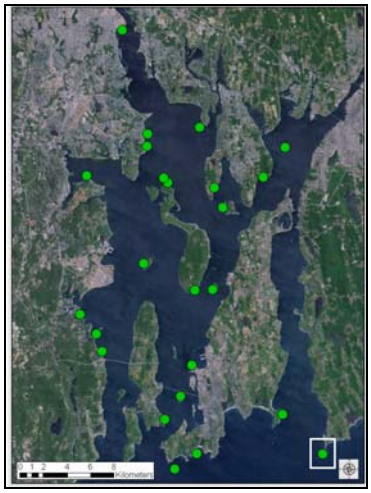
Town: Little Compton

Coordinates: 41° 27.10’ N / 71° 11.43’ W

General Location: The haulout site is located on exposed rocks directly south of the farthest tip of Sakonnet Point in Little Compton.

Viewing Equipment: Spotting scope (required)

Maps:



Directions and Sampling Instructions: Go to end of Rhode Island Road (Little Compton, RI 02837). Park along the side of the road and walk out approximately 0.4 km along the path or beach to the tip of Sakonnet Point to see all possible haulout rocks (the dot in the second map is a general location only; the potential haul-out rocks are located throughout the area around the dot). Look both to the east and west of the tip of Sakonnet Point to see all possible rocks, which are numerous and located throughout the entire area.

Site name: Sally Rock

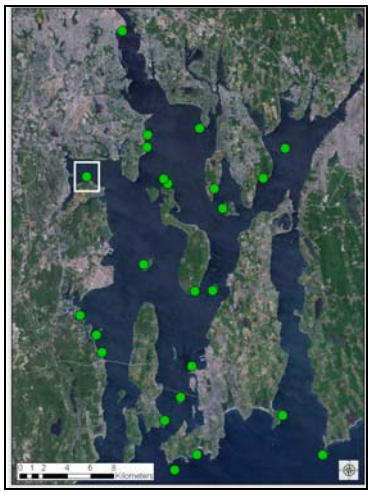
Town: Warwick

Coordinates: 41° 40.24’ N / 71° 25.34’ W

General Location: The haulout site sits directly off of Sally Rock Point, which is located near the northeastern boundary of Goddard State Park on the southern shore of Greenwich Bay.

Viewing Equipment: Binoculars (required)

Maps:



Directions and Sampling Instructions: Enter Goddard State Park (1095 Ives Rd. Warwick, Rhode Island 02818) at the main entrance gate. Continue straight on the road until reaching the parking lot near the Park’s carousel. After parking, walk east (to the right) down the beach until arriving at Sally Rock and the jetty. Scan all rocks in the area.

Site name: Save The Bay (Field's Point)

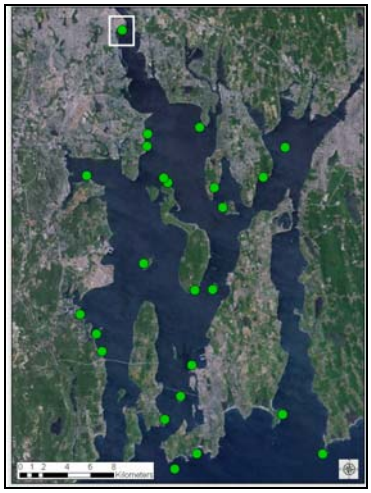
Town: Providence

Coordinates: 41° 47.03' N / 71° 22.54' W

General Location: The haulout site consists of two rocks directly to the south of the Save The Bay center on Field's Point in Providence.

Viewing Equipment: Binoculars (recommended)

Maps:



Directions and Sampling Instructions: Proceed to the Save The Bay Center at 100 Save The Bay Dr. in Providence, RI 02905. The haulout site can be viewed from inside the Center by looking out the rear windows through the Center's large viewing scope, or by walking outside behind the building.

Site name: Spar Island

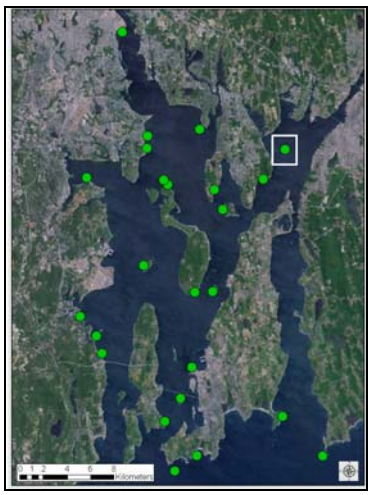
Town: Bristol

Coordinates: 41° 41.09’ N / 71° 13.06’ W

General Location: The haulout site is approximately 1.6 km off the east side of Bristol in Mount Hope Bay.

Viewing Equipment: Spotting scope (required)

Maps:



Directions and Sampling Instructions: Go to the Haffenreffer Museum (300 Tower Street, Bristol RI 02809). Park in back entrance and walk down to water. From the parking lot walk towards the water until reaching a clearing with steps down to the water. Seals haul-out on the southern tip of Spar Island, which lies approximately 1.6 km from shore.

Site name: T-wharf

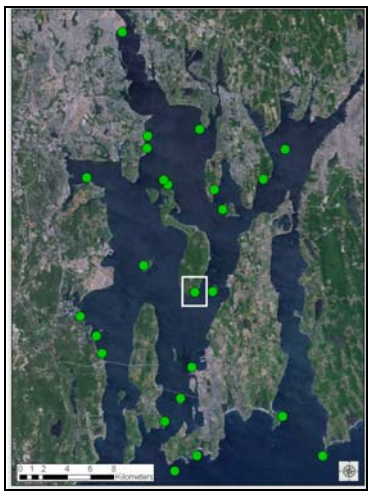
Town: Portsmouth (Prudence Island)

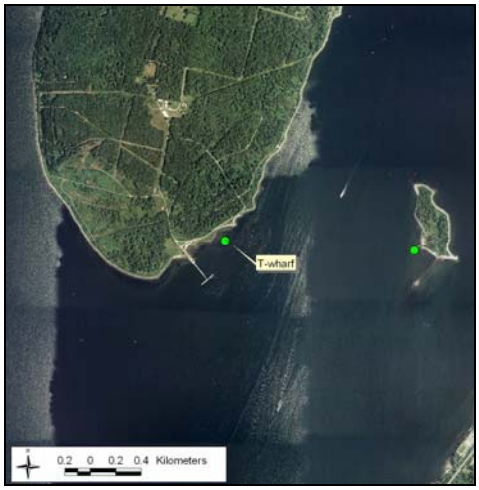
Coordinates: 41° 34.53’ N / 71° 19.08’ W

General Location: The haulout site is a cluster of rocks directly northeast of the base of the T-wharf, which is a large Navy pier located on the southeast tip of Prudence Island.

Viewing Equipment: Binoculars (required)

Maps:





Directions and Sampling Instructions: From the Prudence Island ferry landing, travel approximately 2.6 km south on Narragansett Ave. to the entrance sign for the Narragansett Bay National Estuarine Research Reserve. Turn right into the Reserve and follow South Reserve Dr. for 1.8 km. Turn left and follow T-wharf Rd. for 1.1 km to the T-wharf. The viewing station is along the road, slightly north (left) of the wharf. Scan the entire area for additional seals, particularly on exposed rocks to the southwest of T-wharf along the shore where 1-2 seals are occasionally seen.

Site name: Usher Cove

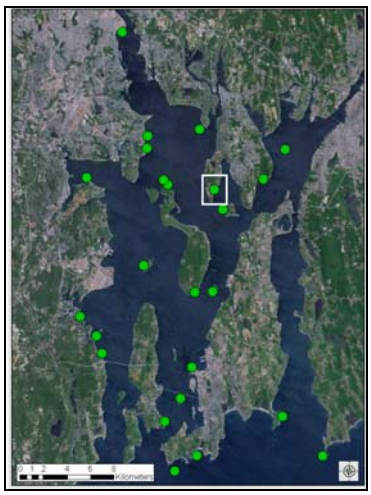
Town: Bristol

Coordinates: 41° 39.31’ N / 71° 17.37’ W

General Location: The haulout site is a small clump of rocks in Usher Cove, which is a small cove on the southeastern side of Poppasquash Point in Bristol.

Viewing Equipment: Binoculars (required); Spotting scope (recommended)

Maps:



Directions and Sampling Instructions: Proceed to Poppasquash Rd in Bristol, RI 02809. Drive down Poppasquash Road, through the security gate, down to Reliance Drive and pull over on the Bay (east) side of the road. The seals haul-out on rocks in middle of the cove when looking towards the center of town (across the cove).