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Newport Naval Station Marine Mammal Technical Report

Prepared by:

Naval Undersea Warfare Center Division

Newport, Rhode Island

Executive Summary

Naval Station Newport proposes to construct a wind energy project on its property. The project would involve the installation and operation of wind turbines at a subset of 12 potential sites such that it would produce sufficient energy to generate up to 9 megawatts of electricity. This report examines marine mammal populations that would be present in the project area and the potential effects to those populations from the operation of the wind turbines. The information contained in the report will be incorporated into an Environmental Assessment being prepared for the project.

All marine mammals are federally protected under the Marine Mammal Protection Act. The only marine mammals that would be present in the project area are harbor seals (*Phoca vitulina*). This species is a seasonal resident to Narragansett Bay from September to May. They haul out during periods of low tide on an intertidal ledge in close enough proximity to the project area that they may experience effects from the project. A non-systematic survey determined that harbor seals hauled out on the ledge on 53% of the days sampled.

The potential effects to harbor seals from the project are acoustic harassment and behavioral disturbance from shadow flicker. An analysis of acoustic effects determined that in-air sound generated from a worst case scenario (maximum size turbines at 12 sites) would reach the haul-out site. When compared to effects thresholds for permanent and temporary threshold shifts in hearing, and for behavioral effects, the analysis predicts that the seals would not be affected. However, the spectral characteristics of the turbine generated sound compared to the hearing range and vocalization frequencies of harbor seals indicates that masking of biologically important sounds may occur. An analysis of shadow flicker shows a potential coincidence with the presence of hauled-out seals. When corrected for monthly sunless days and turbine orientation based on wind direction, the expected annual amount of shadow flicker is 58 hours and 4 minutes. This would be further reduced since seals may not be present during periods of shadow flicker due to coincident high tides and observed low tide periods when seals did not haul out. Nonetheless, it is reasonable to assume that they would be subject to shadow flicker at some point. The effect of flicker on seals is not known but could potentially cause temporary abandonment of the haul-out site. Seals may habituate to stimuli; however, instances in which marine mammals are behaviorally disturbed would be considered harassment under the Marine Mammal Protection Act. In this case, Naval Station Newport would be required to apply for a Letter of Authorization from National Marine Fisheries Service.

In conclusion, the wind turbine project, as it would be implemented, would not cause harassment to seals from the in-air sounds generated. However, shadow flicker from turbines operating near Coddington Point has the potential to disrupt haul-out behavior which would be in violation of the Marine Mammal Protection Act should it occur without the Navy securing a Letter of Authorization. If the three turbines that would cause shadow flicker on the haul-out site were eliminated as a location for a wind turbine, the Navy would not need to apply for a Letter of Authorization. A possible solution to this situation would be to not operate turbines at Coddington Point (sites 7), Navy Lodge (site 8), and Pritchard Field North (site 10a) during the periods when they cast shadow flicker on the haul-out site.

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
dB	decibel
dBA	decibel, A weighted scale
EA	Environmental Assessment
FR	Federal Register
ft	feet
km/h	kilometers per hour
kW	kilowatt
m	meter
mi	mile
mph	miles per hour
MMPA	Marine Mammal Protection Act
MW	megawatt
NAVSTA	Naval Station
PTS	permanent threshold shift
re: 20 µPa	referenced to 20 microPascal
RMS	root means square
SPL	sound pressure level
TS	threshold shift
TTS	temporary threshold shift
U.S.	United States
U.S.C.	United States Code

CHAPTER 1 INTRODUCTION

1.1. BACKGROUND

Naval Station Newport (NAVSTA) proposes to construct a wind energy project that would produce up to nine (9) megawatts (MW) of electricity. The proposed project involves the installation and operation of wind turbines on Naval Station property. Twelve potential sites are proposed (Figure 1-1). Site selection will be based on the results of an Environmental Assessment (EA) being prepared for the project. This report examines the marine mammal populations that would be present in the project area and analyzes the potential effects to those populations from the operation of the wind turbines. The results of this analysis will be incorporated into the EA.

1.2. MARINE MAMMAL PROTECTION ACT

The Marine Mammal Protection Act (MMPA) (16 United States Code [U.S.C.] §§ 1361 et seq.) established, with limited exceptions, a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. The Act further regulates "takes" of marine mammals in United States (U.S.) waters and by U.S. citizens on the high seas. The term "take," as defined in Section 3 of MMPA (16 U.S.C. § 1362), means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" further was defined in the 2004 amendments to MMPA. The term "harassment" means any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment).

1.3. MARINE MAMMAL PRESENCE IN NARRAGANSETT BAY

Two types of marine mammals, pinnipeds and cetaceans, inhabit Rhode Island waters during at least a portion of the year. There are no marine mammal species that occur regularly in Narragansett Bay listed under the Endangered Species Act.

Several species of ESA listed whales occur seasonally in the waters off of Rhode Island including Humpback (*Megaptera novaeangliae*), Fin (*Balaenoptera physalus*), Sei (*Balaenoptera borealis*), Sperm (*Physeter macrocephalus*) and North Atlantic Right whales (*Eubaleana glacialis*). These whales are seasonally present in New England waters; however, due to the depths of Narragansett Bay and near shore location of the action area, listed marine mammals are unlikely to occur (United States Department of the Commerce 2009).

1.3.1. Pinnipeds

Four species of seals (gray, harp, hooded, and harbor seals) have been recorded in Narragansett Bay. Three species, gray, harp and hooded seals, have stranded in Narragansett Bay but are considered to be only occasional visitors (Kenney 2005). Harbor seals are seasonal residents of Narragansett Bay, inhabiting these waters from September through late May (Barlas 1999; Schroeder 2000; Schroeder and Kenney 2001; DeHart 2002).

Harbor seals are a year-round resident of the coastal waters of eastern Canada and Maine (Katona et al. 1993), and occur seasonally along the southern New England and New York coasts from September through late May (Schneider and Payne 1983; Barlas 1999; Schroeder 2000; DeHart 2002). The best abundance estimate for this stock is 99,340 (coefficient of variation = 0.097), increasing each year (Waring et al. 2008). Based on uncorrected haul-out counts over the 1981 to 2001 survey period, the harbor seal population is growing at approximately 6.6% (Gilbert et al. 2005).

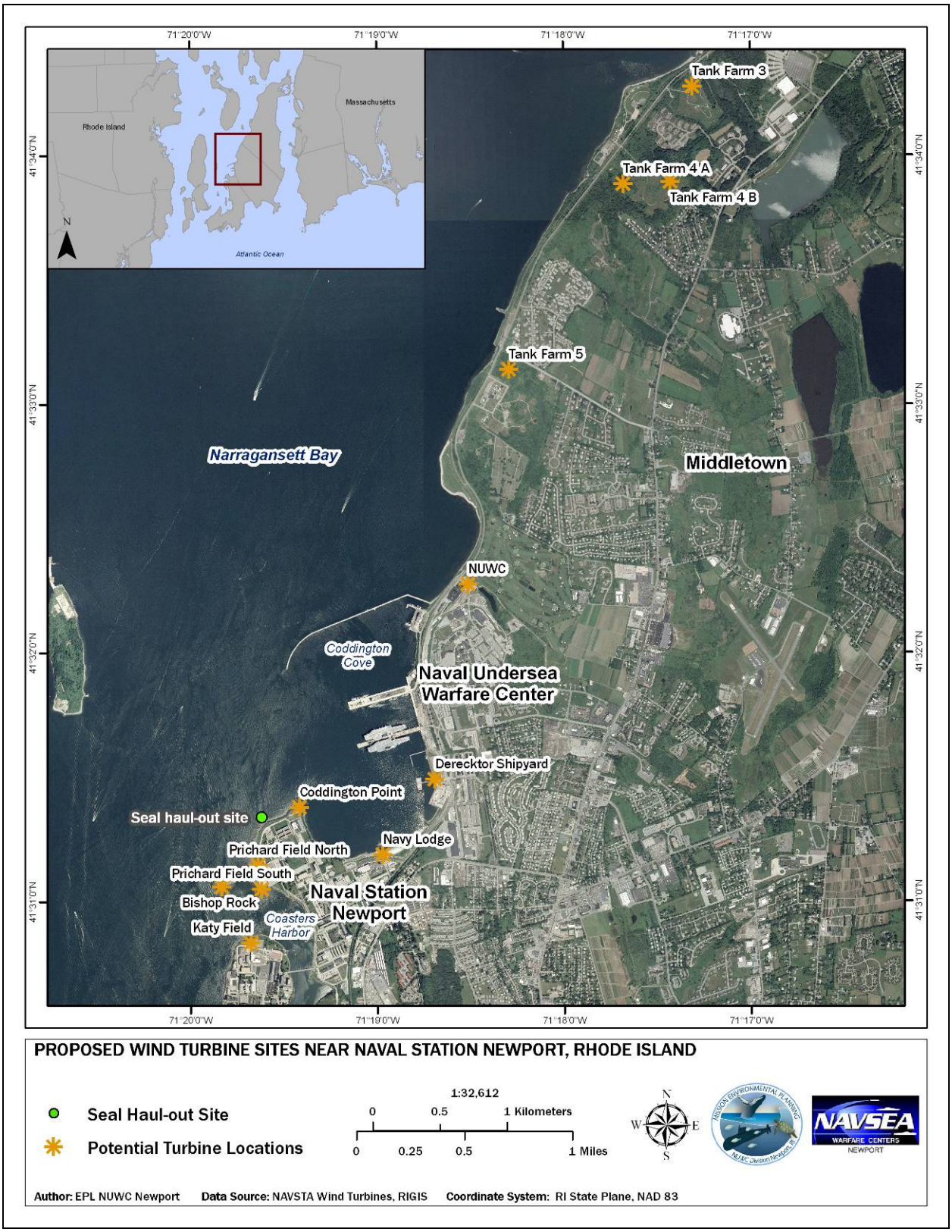

Figure 1-1. Potential NAVSTA Newport wind turbines locations.

Seals are an amphibious mammal and spend a portion of their lifecycle in a variety of terrestrial habitats (Riedman 1990). This behavior is known as hauling out. Seals haul out on a wide variety of substrates including intertidal and subtidal rock outcrops, sandbars, sand shoals, mud flats, sandy beaches, and even sand-peat hummocks and salt marshes (Payne and Selzer 1989; Schroeder 2000). These animals haul out for a variety of reasons including breeding, raising young, molting, thermoregulation, predator avoidance and resting (da Silva and Terhune 1988; Riedman 1990; Watts 1992). It is a vital part of a seal's life cycle. In the western north Atlantic, seals begin coming ashore with the falling tide and return to the water on the incoming tide to forage (Schroeder 2000).

Twenty-four harbor seal haul-out sites have been identified within Narragansett Bay and are shown in (Figure 1-2) (Schroeder 2000; Narragansett Bay Estuary Program 2001). In Rhode Island waters harbor seals prefer to haul out on well-isolated intertidal rock ledges and outcrops. Generally, the number of seals hauled out gradually increases from September until early spring, when the peak is reached, after which the numbers rapidly decline (Schroeder 2000). Numerous Naval Station employees have reported seals hauled out on an intertidal rock ledge north-northwest of Coddington Point named "The Sisters" on National Oceanic and Atmospheric Administration nautical chart 13223 (Figure 1-1). This haul-out site had not been previously identified. In order to verify seal presence and frequency of use at this haul-out site a non-systematic survey was conducted during the period from December 2010 to the beginning of March 2011. The results of the survey verify regular seal presence at the site and are described in detail in Chapter 2.

1.3.2. Cetaceans

Based on historical records of cetacean species in Narragansett Bay, the likelihood of encountering any cetacean is minimal. The best available scientific literature and historic records indicate that harbor porpoises and Atlantic white-sided dolphins are the most likely cetacean to enter the bay. Most recently in October 2007, a pod of common dolphins was seen in Narragansett Bay. They are an offshore species generally distributed along the outer continental shelf and typically would not be present in the Bay. Nonetheless, the proposed action involves land based activities and would not introduce potential stressors into the water. Therefore, there would be no effect to cetaceans and they will not be further addressed in this analysis.

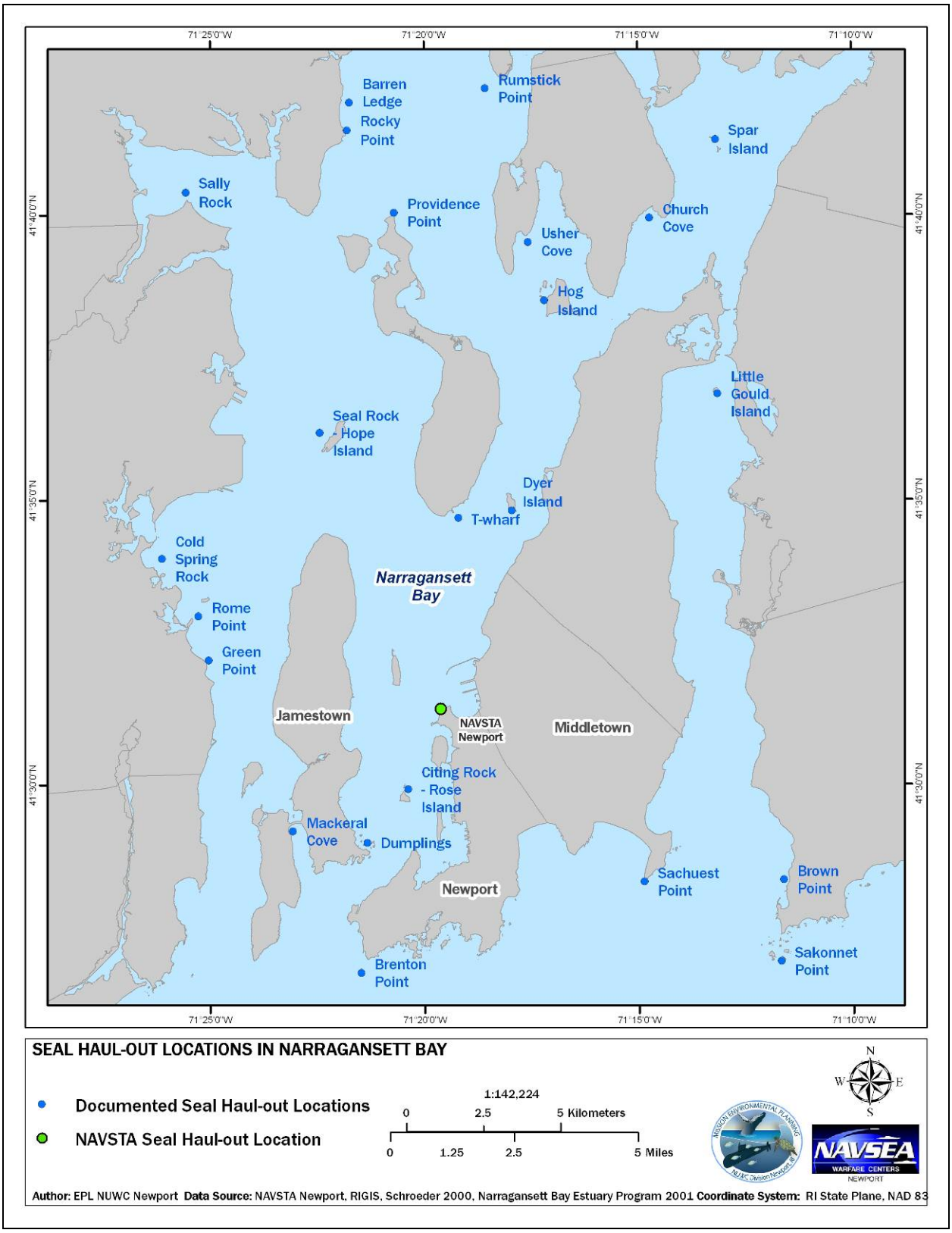

Figure 1-2. Documented harbor seal haul-out sites (Schroeder 2000).

CHAPTER 2 DATA SUMMARY

2.1. SEAL PRESENCE

The intertidal ledge known as "The Sisters" near Naval Station Newport (41°31'17"N 71°19'44"W) serves as a seal haul-out site (Figure 2-1). These rocks are exposed for a period of time before and after low tide, depending on the tidal range and wave height. The haul-out site was observed at low tide on 45 days between December 13, 2010 and March 2, 2011. Seals were counted using binoculars and photographed with a Canon EOS 20D camera and an attached Canon EF 300 millimeter zoom lens with image stabilizer. The observation point was located on the jogging path along the NAVSTA Newport shoreline, approximately 220 feet (ft; 67 meters [m]) from the haul-out site. The jogging path is adjacent to a one-way Navy road and across the street from the NAVSTA mess hall. The seals were not observed to respond to observers or other human presence.

Figure 2-1. Five seals hauled out on December 29, 2010.

Seals were observed hauled out 24 days or 53% of the days sampled (Figure 2-2). This percentage is similar to a study in California that observed harbor seals hauled out fewer than 51% of the time (Yochem et al. 1987). When seals were hauled out, the number ranged from 1 – 26 seals.

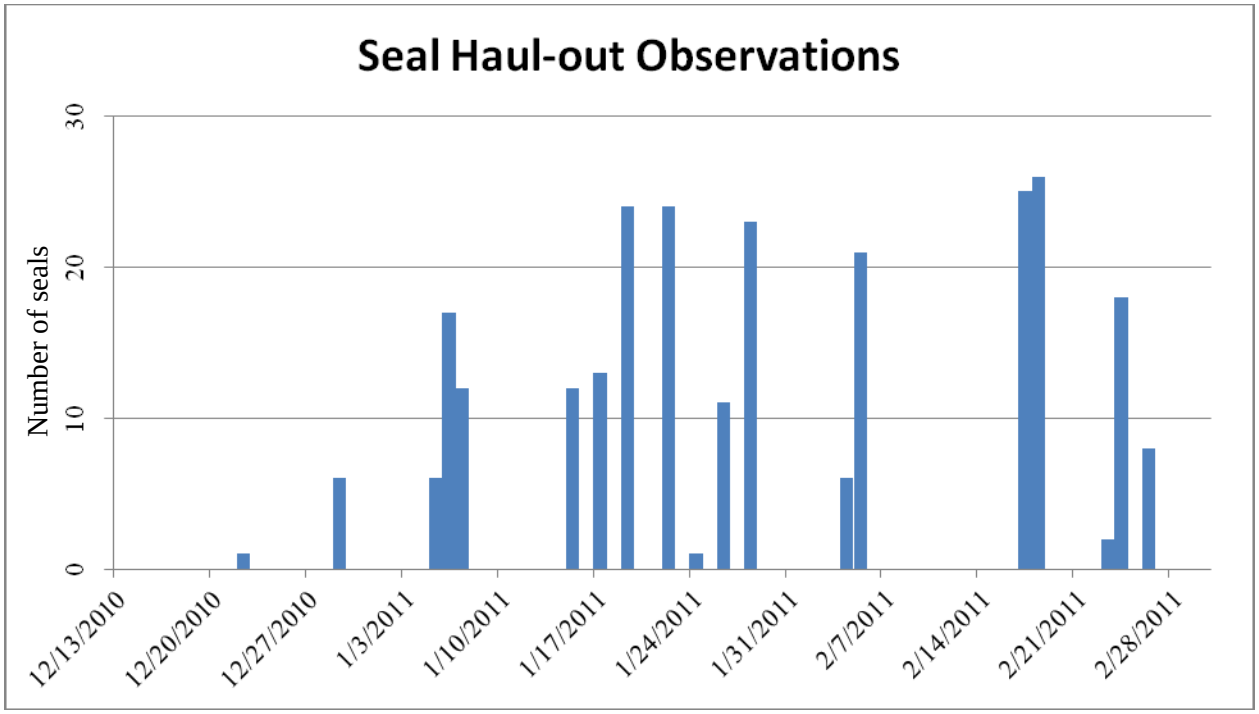

Figure 2-2. Seals observed from December 13, 2010 – February 28, 2011.

2.2. ENVIRONMENTAL OBSERVATIONS

To examine various environmental parameters as a potential factor influencing seal presence, time of observation and weather observations were recorded in the field. Data was also collected for air temperature, visibility, tidal range, lunar phase, wind speed, and wind direction. Large groups of seals were present in the morning, afternoon and evening hours, with no apparent temporal pattern. Diel haul-out patterns have been recorded in other studies (i.e. Yochem et al. 1987), but no apparent temporal pattern was found in our data.

Mean temperatures on observation days ranged from 8 – 46 degrees Fahrenheit (°F; -13 – 8 degrees Celsius [°C]). There was no correlation between temperature and seal presence. Seals were also present in a range of weather conditions including sunny clear skies, rain and snow. Visibility ranged from 3-10 miles (mi). Seals were not observed when the visibility was less than 5 mi, although the data was not robust enough to support a correlation analysis.

During the observations, the predicted tidal range was from -0.9 ft (0.3 m) to 0.6 ft (0.2 m) above mean sea level. Tidal range was not observed to have an impact on seal presence. Seals were observed hauled out at low tide and for an approximate two hour window before and after low tide. Most large group observations were taken 1 – 1.5 hours after low tide.

Lunar phases during observation days were recorded and compared to the number of seals observed. All lunar phases were represented (Figure 2-3) during the observation period, with the most observations occurring during a full moon (n=8). Seals were present during all phases and there was no significant correlation between lunar phase and seal presence.

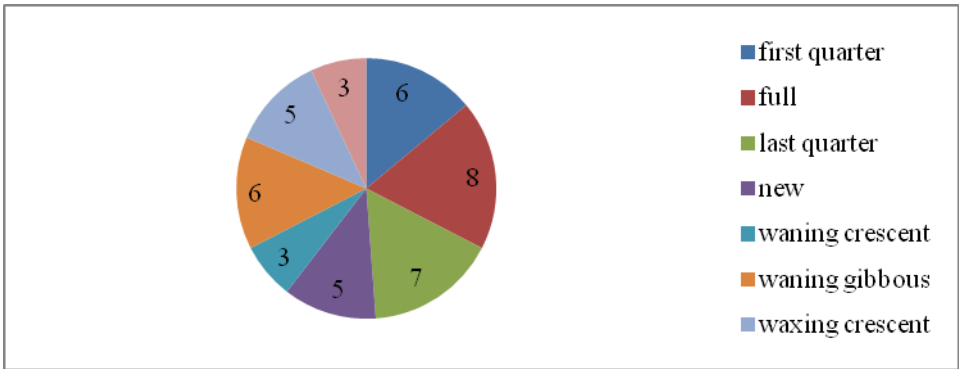

Figure 2-3. Number of observations during each lunar phase.

Wind direction and speed are variables that could potentially affect the amount of rock exposed during low tide and therefore the presence of seals. Wind speed and wind direction measurements were obtained from the meteorological tower at Naval Station Newport (Figure 2-4) and compared to archived data from National Oceanographic and Atmospheric Administration weather observations at Newport State Airport (www.crh.noaa.gov/data/obhistory/KUUU.html). The predominant wind directions were Northwest (n=8) North Northwest (n=8), and West Northwest (n=8), comprising 53% of the observations. Seals were found to be present regardless of wind direction.

Figure 2-4. Meteorological tower at NAVSTA Newport.

Wind speed has been shown to be a significant factor on seal haul-out behavior (Bjorge et al. 2002; Carlens et al. 2006). During observation days when wind speeds were less than 10 miles per hour (mph; 16 kilometers per hour [km/h]), seals were not present on 11 observation days and present 16 days. When wind speeds were greater than 10 mph (16 km/h), seals were not present on 13 days and present 3 days. Seals were not observed during wind speeds greater than 13 mph (21 km/h) (Figure 2-5).

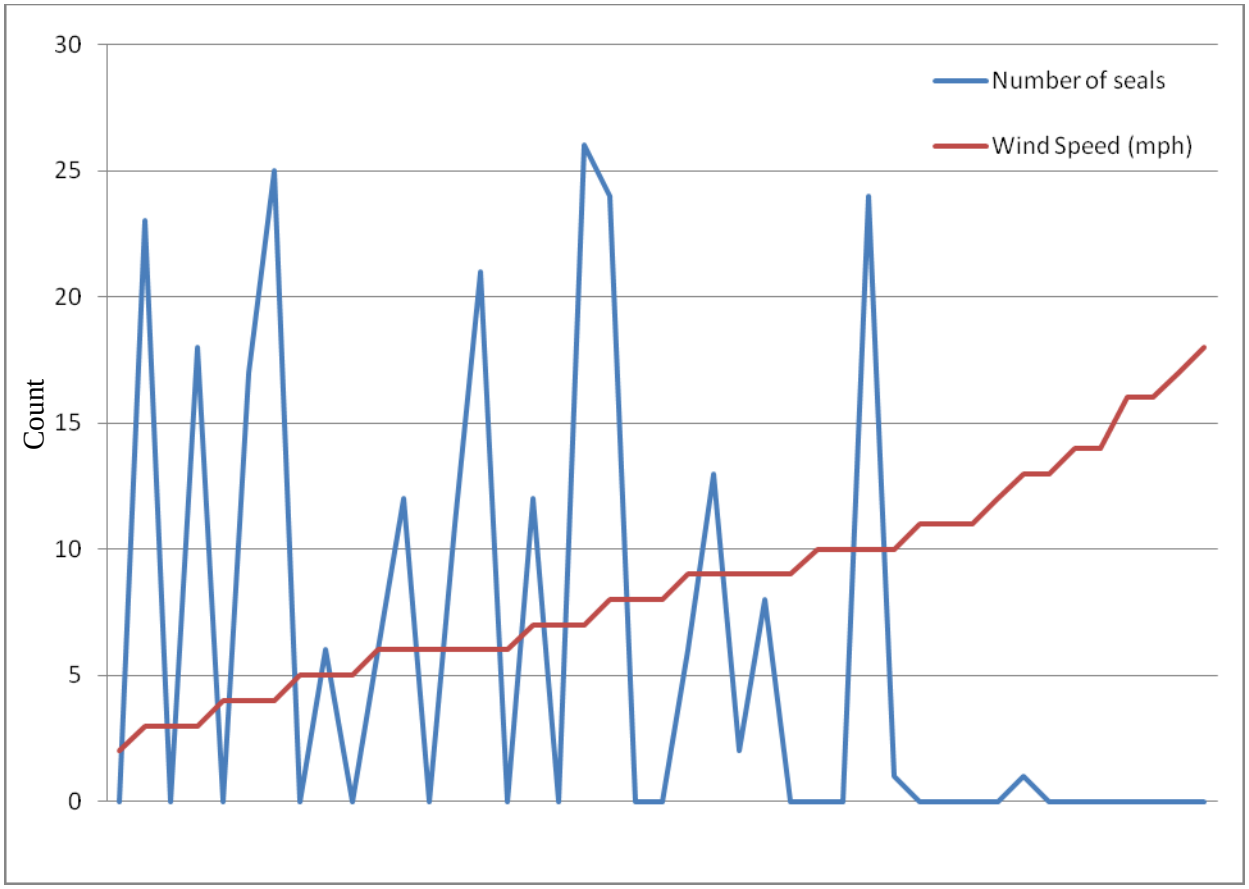

Figure 2-5. Wind speed and number of seals observed during observation period.

CHAPTER 3 ACOUSTIC AND FLICKER ANALYSIS

3.1. ACOUSTIC EFFECTS

With the confirmation of a harbor seal haul-out site off Coddington Point and in the vicinity of the proposed wind turbine at Coddington Point, the potential exists for seals to be harassed as defined under the MMPA. The only acoustic stressor for marine mammals from the wind turbine project would be from the generation of in-air noise from the operation of one or more wind turbines. The project is land based and would not transmit acoustic energy into the waters of Narragansett Bay. The following sections discuss the types and levels of harassment that could potentially be experienced by hauled out seals and provides an analysis of in-air acoustic effects from the wind turbine project.

3.1.1. Criteria and Thresholds

3.1.1.1. Criteria

Harassment, as defined by the MMPA, is described in Section 1.2. Sound exposure may affect multiple biological characteristics of a marine animal; however, MMPA regulations provide guidance as to which characteristics should be used when determining effects. Specifically, effects that qualify as Level A harassment involve injury. Effects that qualify as Level B harassment involve behavioral disruption. A "physiological effect" is defined herein as one in which the "normal" physiological function of the animal is altered in response to sound exposure. Physiological function is any of a collection of processes ranging from biochemical reactions to mechanical interaction and operation of organs and tissues within an animal. A physiological effect may range from the most significant of impacts (i.e., mortality and serious injury) to lesser effects that would define the lower end of the physiological impact range, such as the non-injurious distortion of auditory tissues. This latter physiological effect is important to the integration of the biological and regulatory frameworks and will receive additional attention in later subsections. A "behavioral effect" is one in which the "normal" behavior or patterns of behavior of an animal are overtly disrupted in response to an acoustic exposure. Examples of behaviors of concern can be derived from the harassment definitions in the MMPA implementing regulations.

It is reasonable to expect some physiological effects to result in subsequent behavioral effects. For example, a marine mammal that suffers a severe injury may be expected to alter diving or foraging to the degree that its variation in these behaviors is outside that which is considered normal for the species. If a physiological effect is accompanied by a behavioral effect, the overall effect is characterized as a physiological effect; physiological effects take precedence over behavioral effects with regard to their ordering. This approach provides the most conservative ordering of effects with respect to severity, provides a rational approach to dealing with the overlap of the definitions, and avoids circular arguments.

The severity of physiological effects generally decreases with decreasing sound exposure and/or increasing distance from the sound source. The same generalization does not consistently apply to behavioral effects because they do not depend solely on the received sound level. Behavioral responses also depend on an animal's learned responses, innate response tendencies, motivational state, the pattern of the sound exposure, and the context in which the sound is presented.

Categorizing potential impacts as either physiological or behavioral effects allows them to be related to the harassment definitions. Level A harassment means any act of pursuit, torment, or annoyance which

has the potential to injure a marine mammal or marine mammal stock in the wild. Injury, as defined in this analysis and previous rulings (66 Federal Register [FR] 87; 67 FR 136; 69 FR 124), is the destruction or loss of biological tissue. The destruction or loss of biological tissue will result in an alteration of physiological function that exceeds the normal daily physiological variation of the intact tissue. Therefore, this analysis assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings, all injuries (slight to severe) are considered Level A harassment.

Level B harassment means any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild. Unlike Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may cause Level B harassment.

Some physiological effects can occur that are non-injurious but that can potentially disrupt the behavior of a marine mammal. These include temporary distortions in sensory tissue that alter physiological function, but that are fully recoverable without the requirement for tissue replacement or regeneration. For example, an animal that experiences a temporary reduction in hearing sensitivity suffers no injury to its auditory system, but may not perceive some sounds due to reduction in sensitivity. As a result, the animal may not respond to sounds that would normally produce a behavioral reaction. This lack of response qualifies as a temporary disruption of normal behavioral patterns – the animal is impeded from responding in a normal manner to an acoustic stimulus.

Very high sound levels may rupture the eardrum or damage the small bones in the middle ear (Yost 2000). Lower level exposures may cause permanent or temporary hearing loss; such an effect is called a noise-induced threshold shift, or simply a threshold shift (TS) (Miller 1974). A TS may be either permanent, in which case it is called a permanent threshold shift (PTS), or temporary, in which case it is called a temporary threshold shift (TTS). Still lower exposures may result in auditory masking, which may interfere with an animal's ability to hear other concurrent sounds or disruption of normal behaviors without any physiological effects. Masking may interfere with an animal's ability to hear other concurrent sounds, which may be biologically significant, at or near the same frequency of the masking sound.

Because the tissues of the ear appear to be the most susceptible to the physiological effects of sound and TS tends to occur at lower exposures than other more serious auditory effects, PTS and TTS are used as the biological indicators of physiological effects. The amount of TS depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure. Threshold shifts will generally increase with the amplitude and duration of sound exposure. For continuous sounds, exposures of equal energy will lead to approximately equal effects (Ward 1997). For intermittent sounds, less TS will occur than from a continuous exposure with the same energy, but some recovery will occur between exposures (Kryter et al. 1966; Ward 1997). The magnitude of TS normally decreases with the amount of time post-exposure (Miller 1974). If TS eventually returns to zero (the threshold returns to the pre-exposure value), TS is considered TTS.

Based on available evidence, marine animals are likely to exhibit any of a suite of potential behavioral responses or combinations of behavioral responses upon exposure to sounds. Potential behavioral responses include, but are not limited to: avoiding exposure or continued exposure, behavioral disturbance (including distress or disruption of social or foraging activity), habituation to the sound, becoming sensitized to the sound, or not responding to the sound.

Existing studies of behavioral effects of human-made sounds in marine environments remain inconclusive, partly because many of those studies have lacked adequate controls, applied only to certain kinds of exposures (which are often different from the exposures being analyzed in the study), and had limited ability to detect behavioral changes that may be significant to the biology of the animals that were being observed. These studies are further complicated by the wide variety of behavioral responses marine mammals exhibit and the fact that those responses can vary substantially by species, individuals, and the context of an exposure. In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lesser received levels (Richardson et al. 1995; Wartzok et al. 2003/2004; Southall et al. 2007). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict.

The following criteria are used in the analysis of in-air acoustic effects to harbor seals:

- The onset of PTS defines the lowest level of effect that triggers Level A harassment.
- The onset of TTS defines the lowest level of effect that triggers Level B harassment with recoverable physiological effect.
- Behavioral disruption defines the absolute lowest level of effect that triggers Level B harassment.

3.1.1.2. Thresholds

The Navy has not promulgated policy establishing thresholds for MMPA Level A or Level B harassment for pinnipeds for in-air sounds. However, a behavioral based Level B harassment threshold has been recommended and been through the rulemaking process. Southall et al. (2007) proposes, for various marine mammal groups and sound types, levels above which there is a scientific basis for expecting that exposure would cause an effect . This study defines three sound types:

1. Single pulse – A single acoustic event with a greater than 3 decibel (dB) difference between the received level using impulsive vs. equivalent continuous time constant.
2. Multiple pulses – Multiple discrete acoustic events within a 24 hour period with a greater than 3 dB difference between the received level using impulsive vs. equivalent continuous time constant.
3. Nonpulses – Single or multiple discrete acoustics events within a 24 hour period with a less than 3 dB difference between the received level using impulsive vs. equivalent continuous time constant.

Based on these definitions, the sound type produced by an operating wind turbine is nonpulse. For nonpulses, Southall (2007) proposes an in-air sound exposure level for the onset of TTS for harbor seals of 143 dB referenced to 20 microPascals (re: 20µPa), and based on empirical measures of TTS growth rate, a value for the onset of PTS of 149 dB re: 20µPa.

As noted above, the lack of controls and interpretation of responses in various behavioral response studies make it difficult to interpret in terms of exposure received levels and to discern whether a response was induced by the sound or some other correlated variable such as visual presence. However, a number of technical reports and analyses of rocket launches were relevant for determining a behavioral threshold. These studies were complicated by the fact that all the studies were conducted in the same general area with subjects likely habituated to the presence of launch noise. Therefore, the limitation of these and other applicable studies resulted in a limited data set for the determination of a behavioral threshold.

Nonetheless, Southall (2007) does categorize the reported root means square (RMS) received unweighted sound pressure levels (SPL) in 10 dB bins and correlates these to a severity of response score of 0 to 9 from no response to the most severe response, respectively. Based on this analysis, received SPLs of 110 to < 120 dB re: 20µPa correlated to a severity score of 6 (minor/moderate avoidance, visible startle, extended modification or cessation of vocal behavior) while the only other received SPLs (60 to 70 dB re: 20µPa) in this analysis correlated to a severity score 0 (i.e., no response). Although a threshold for behavioral response was not recommended one would surmise, based on these data, the threshold would be somewhere between 70 and 110 dB re: 20µPa.

The Navy applied for a Letter of Authorization under the MMPA to take certain numbers of pinnipeds (harbor seals, elephant seals and California sea lions) incidental to rocket launches at San Nicholas Island, California. In their September 2008 application, the Navy used 109 dB re: 20µPa for pinnipeds in-air exposed to prolong sounds as a threshold for behavioral disturbance. This threshold was carried through rule making with the Final Rule (75 FR 28587) issued May 21, 2010. This threshold was presented in an EA prepared by the National Marine Fisheries Service (United States Department of Commerce et al. 2009) for the Issuance of Regulations to Take Marine Mammals by Harassment Incidental to U.S. Navy Missile Launch Activities at San Nicolas Island, California. Because of the paucity of quantitative studies on the effects of prolonged, nonpulse in-air sounds on pinnipeds, these two documents (Southall et al. 2007; United States Department of Commerce et al. 2009) will be basis for establishing the following SPL effects thresholds for this analysis:

- PTS – 149 dB re: 20µPa
- TTS – 143 dB re: 20µPa
- Behavioral disturbance – 109 dB re: 20µPa.

3.1.2. Analysis Results

To support an EA for the proposed wind turbine project at NAVSTA, an analysis of received sound levels at sensitive receivers for individual and combined turbines was conducted (Geo-Marine Inc. 2011a). Although the analysis was intended to determine received sound levels at non-Navy residences, the resultant acoustic contours can be used to ascertain received sound levels at the seal haul-out site. Based on the results of the acoustic analysis, the seal haul-out site would receive between 50 and 55 decibels, A weighted scale (dBA) of cumulative sound energy with all 12 turbines operating simultaneously (Figure 3-1). This is based on the largest turbine that would be allowable for each of these sites namely, a 3.0 MW Vestas V112 at sites 7, 9, 10a, 10b and 10c, a 1.5 MW GE 1.5sle at site 3, 5, 6 and 8 and a 900 kilowatt (kW) PowerWind 56 at sites 1, 2 and 4. The spectral characteristics and source level of each of these turbines are presented in Table 3-1.

The analysis also assumes the following:

1. All wind turbines were assumed to be operating simultaneously for the cumulative impact analysis.
2. Wind turbine sound power levels correspond to the International Standard IEC 61400-11 maximum sound power level plus the uncertainty factor K in IEC Technical Specification 61400-14 that quantifies the sound power measurement uncertainty and the unit-to-unit turbine production variability. For this analysis a typical value of K = 2.0 dBA was included in the turbine sound power levels.

3. The acoustic model assumed the most favorable conditions for sound propagation, corresponding to a ground-based temperature inversion, such as might occur on a calm, clear night, or during a downwind condition (International Standard ISO 9613-2).
4. No attenuation from trees or other vegetation was assumed.
5. Winter frozen ground conditions were assumed for minimal ground absorption.
6. Excess attenuation from wind shadow effects and daytime air turbulence were ignored.

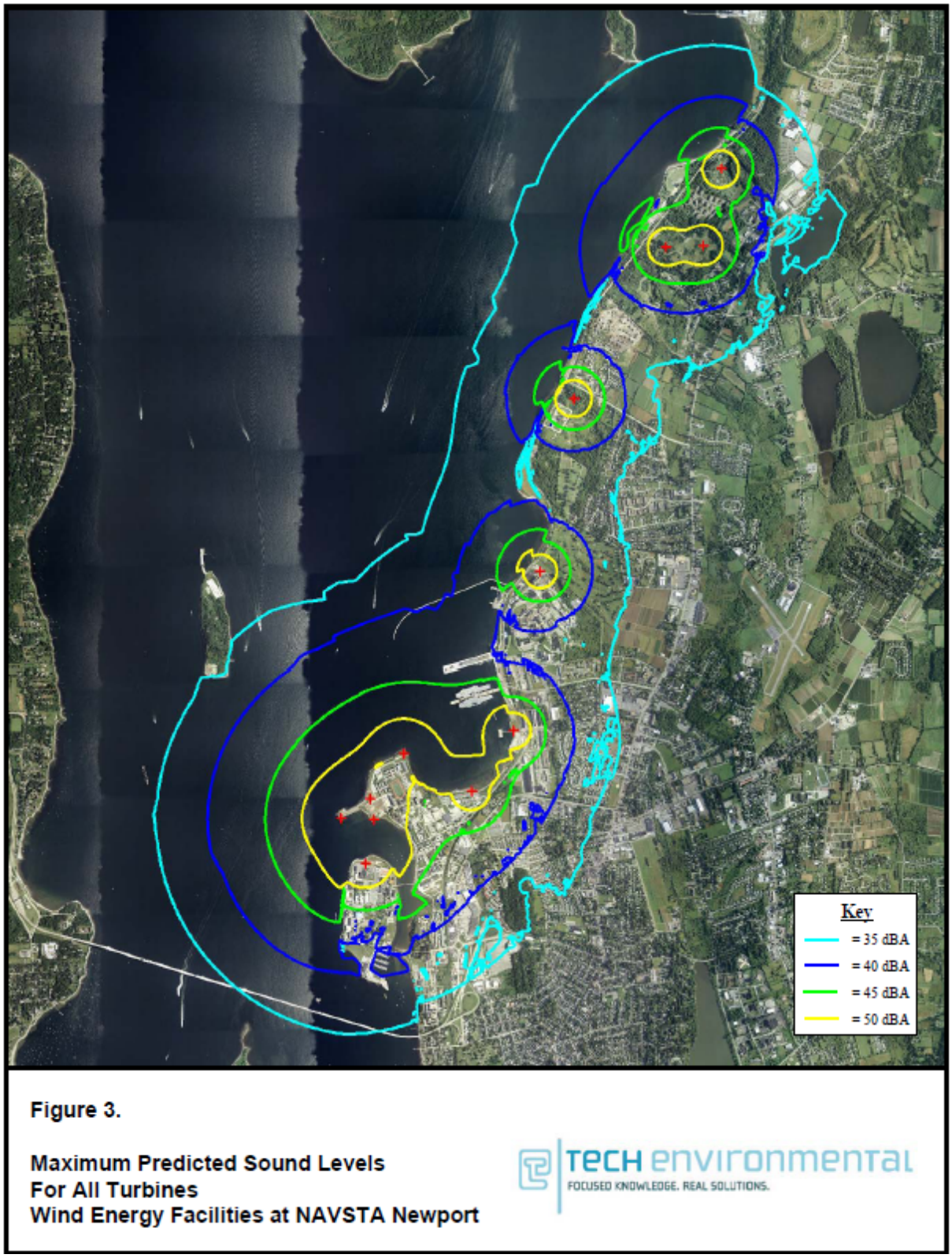

Figure 3-1. Maximum predicted cumulative received sound levels at various sensitive receptors (including the seal haul-out site) from all turbines operating simultaneously.

Table 3-1. Spectral and source level characteristics of each wind turbine analyzed.

Turbine Type	Octave Band Center Frequency (Hertz)									Linear[1]	dBA[1]
	31	63	125	250	500	1000	2000	4000	8000		
3.0 MW Vestas V112	123.7	119.7	114.0	108.4	105.7	101.6	98.8	97.9	94.0	125.6	108.5
1.5 MW GE 1.5sle	117.0	111.6	110.3	108.4	104.7	99.6	94.2	87.6	85.7	119.4	106.0
Power-Wind 56	117.7	113.3	107.5	106.8	102.1	100.3	99.8	95.8	88.0	119.8	106.5

[1] Linear represents an unweighted bandwidth source level whereas dBA is the A-weighted bandwidth source level.

Therefore, the analysis is conservative and seals hauled out at this location would not be receiving sound energy as high as this analysis predicts. Primarily, since the objective of the wind turbine project is to produce up to 9 MW of electricity, the construction of 12 turbines of the maximum size allowable would not occur. Nonetheless, the predicted received sound level needs to be compared to the effects thresholds in order to determine if there would be an effect. The effects thresholds are presented as unweighted SPLs; whereas, the acoustic analysis reports the received sound levels as an A-weighted value. In order to make a valid comparison these need to be converted to the same units. This can be accomplished by simply adjusting the received SPL values by the difference between a wind turbine unweighted and weighted bandwidth source levels since the distance from source to the receivers is relatively small. In keeping with the conservative approach, the difference between the weighted and unweighted source levels for the largest turbine (3.0 MW Vestas) is 17.1 dB. This difference is added to the A-weighted received levels and renders an unweighted received level of 67.1 to 82.1 dB re: 20µPa. As can be seen from this very conservative analysis, hauled out seals would not experience sufficient sound energy to induce PTS or TTS nor would they receive sound levels sufficiently high to cause a behavioral reaction. Further, the bandwidth sound output at the source of each of the wind turbines used in the analysis is below the PTS and TTS thresholds (see Table 3-1).

It is possible that at the first encounter with an operating wind turbine, especially if one is constructed at Coddington Point, hauled out harbor seals may exhibit some sort of a behavioral reaction. These may range from increased alertness to avoidance of the haul-out site. However, it is expected that over time the seals will habituate to the sound and possibly the presence of a turbine. This refers to the gradual waning of responses when a repeated or ongoing stimulus lacks any consequences for the animal. For instance, a seal may initially react to its first encounters with the presence of, or sound produced by, a wind turbine, but upon repeated exposure with no adverse consequences, the animal would resume its previous behavior (i.e., hauling out). Richardson et al. (1995) addresses habituation and cites numerous examples of marine mammal species habituating to a variety of noise sources and stimuli.

Another potential effect from sound produced by a wind turbine is masking. This is a process by which background noise, may prevent detection of sound signals at nearby frequencies (Richardson et al. 1995). The consequence of this is that it may prevent or reduce the ability of an animal to hear biologically significant sounds from conspecifics (i.e., mating calls, mother/pup location, antagonistic signals from other males), predators or potential danger. Van Parijs and Kovacs (2002) reports in-air vocalizations of harbor seals at the lowest measurable frequency as low as 200 Hertz and the frequencies with the greatest energy ranging from 1.1 to 4.3 kilohertz. When compared to Table 3-1, the frequencies of sounds produced by a wind turbine clearly coincide with the vocalizations and also fall within the hearing range of harbor seals. Therefore, operation of the wind turbines may result in a masking effect.

3.2. SHADOW FLICKER EFFECTS

Shadow flicker from a wind turbine may be a stimulus that elicits a behavioral reaction from seals hauled out at "The Sisters" haul-out site. Shadow flicker refers to the shadows that a wind turbine casts over structures and observers at times of the day when the sun is directly behind the turbine rotor from an observer's position. During intervals of sunshine, wind turbines will cast a shadow on surrounding areas as the rotor blades pass in front of the sun, causing a flickering effect while the rotor is in motion. Shadow flicker does not occur when fog or clouds obscure the sun, or when turbines are not operating. The effect of shadow flicker on hauled out pinnipeds is not known. No studies could be found in the literature that specifically addresses this phenomenon. However, it is known that seals will react to visual stimuli which can cause them to leave their haul-out site.

An analysis of shadow flicker from the wind turbine project (Geo-Marine Inc. 2011b), in support of the EA, was conducted to determine potential effects on residents living near the turbines. The analysis determined that three proposed turbines at sites 7, 8, and 10a would cast intermittent shadow flicker on the haul-out site (Figures 3-2, 3-4, 3-6). The analysis predicts the total number of shadow flicker days, hours/ minutes per year and the time of day the shadow flicker would occur (Figures 3-3, 3-5, 3-7). The total number of days and hours/ minutes of predicted shadow represent a worst case scenario assuming full sunlight on all days and turbine orientation for maximum shadow. However, not every day would be completely sunny and variation in wind direction would affect the turbine orientation. Therefore, the analysis is further corrected for sun and wind direction reductions for each month, thereby reducing the worst case total shadow time to an expected shadow time (Table 3-2). This is a more realistic number to use in determining the total amount of shadow flicker that hauled out seals may be subject to because it accounts for cloudy or foggy days and turbine orientation as a function of wind direction.

A Coddington Point turbine (Site 7) is predicted to present the least amount of shadow. A turbine at this site would only cast a shadow for ten days in the month of May for an expected total of 1 hour and 35 minutes per year. Shadow would first appear May 7th and persist until August 5th; however, seals are expected to emigrate from the Bay by mid-May (Schroeder 2000). Therefore, May 16th is used as the last day that shadow flicker could affect hauled out seals. The minimum daily flicker would be 4 minutes and the maximum would be 43 minutes. A Navy Lodge turbine (Site 8) is predicted to produce shadow flicker at the haul-out site in the months of September, October, and March totaling 19 days of flicker. Expected total annual shadow flicker would be 58 minutes with a daily minimum of 2 minutes and maximum of 14 minutes. A Pritchard Field North turbine (Site 10a) is predicted to produce the most shadow flicker of the three sites. The shadow initiates on October 30th and persists until February 12th resulting in a total of 135 days in which shadow flicker could be cast on the haul-out site. The minimum daily shadow would be 13 minutes and the maximum 1 hour 39 minutes. The total annual shadow for this site is predicted to be 55 hours 31 minutes. Should turbines be in operation at all 3 potential sites the total expected annual shadow flicker would be 58 hours 4 minutes.

In order for shadow flicker to have an effect on the seals, the period of shadow would need to coincide with periods of low tide and seals being present at the haul-out site. Since periods of low tide would not always coincide with the occurrence of shadow flicker, the total annual expected shadow flicker of 58 hours and 4 minutes would be reduced by varying amounts since the time of day and time of month for the low tide varies month to month and year to year. Moreover, seals would not always be hauled out during every low tide cycle. The results of the survey of "The Sisters" haul-out site showed that seals hauled out on only 53% of the days sampled. Although, a 53% haul rate may not apply during the whole seal season, it's evident that there will be low tide periods where seals would not be present. To definitively quantify the number of days and seals that would be subject to shadow flicker over the period in which wind turbines would be operational at Coddington Point is not realistic. This is because the time of occurrence of low tide varies year to year, plus the number of seals that would haul out on a given day

and the number of days in which seals would haul out are unpredictable. Nonetheless, based on the information available, it is reasonable to assume that hauled out seals would be subject to shadow flicker.

Although no studies could be found in the literature specifically addressing effects of shadow flicker on pinnipeds, it is known that hauled out seals will react to various visual stimuli with reactions varying from increased alertness to abandoning a haul-out site. Irrespective of the fact that seals would be exposed to shadow flicker for only brief periods each year, exposure may result in a behavioral disturbance.

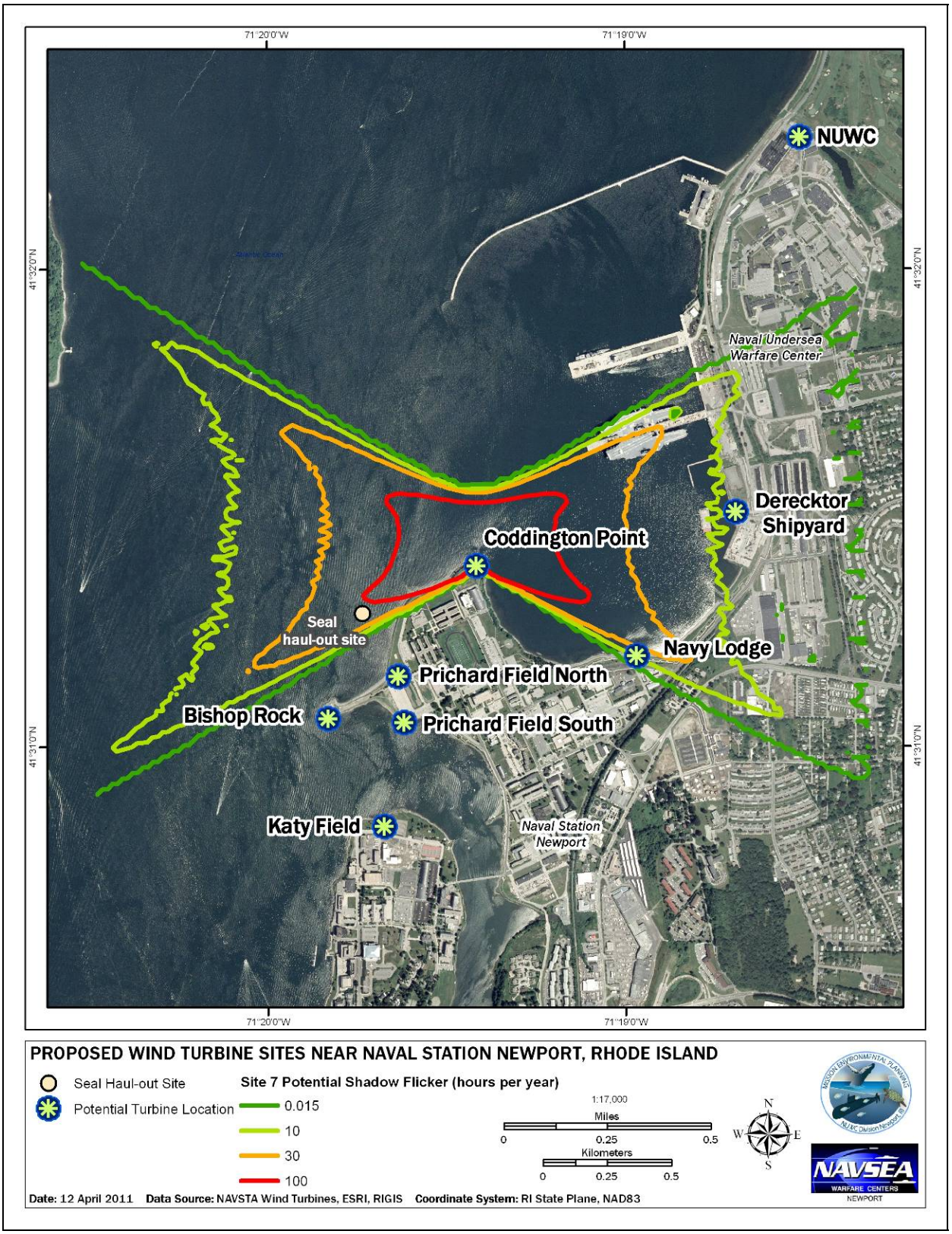

Figure 3-2. Potential shadow flicker at site Coddington Point (site 7).

SHADOW - Calendar

Shadow receptor: G - 7G

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.33	6.13	6.91	7.59	8.42	9.24	9.37	8.58	7.75	6.77	4.93	4.78

Operational time

N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
691	432	259	155	155	155	432	518	950	1,209	864	518	432	604	691	691	8,756

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:12	06:58	06:22	06:30	05:44	05:15	05:15	05:40	06:11	06:42	06:17	06:52
	16:26	17:01	17:36	19:10	19:43	20:12 56	06:40 (1) 20:24 57	06:50 (1) 20:05 33	06:05 (1) 19:20	18:29	16:42	16:17
2	07:13	06:57	06:20	06:29	05:43	05:14	05:44 (1) 05:16	06:47 (1) 05:41	06:38 (1) 06:12	06:43	06:18	06:53
	16:27	17:02	17:37	19:11	19:44	20:13 57	06:41 (1) 20:24 58	06:49 (1) 20:04 30	06:07 (1) 19:19	18:27	16:40	16:17
3	07:13	06:56	06:19	06:27	05:41	05:14	05:45 (1) 05:16	06:47 (1) 05:42	06:37 (1) 06:13	06:44	06:19	06:54
	16:28	17:03	17:38	19:13	19:45	20:14 56	06:41 (1) 20:24 57	06:50 (1) 20:03 26	06:09 (1) 19:17	18:26	16:39	16:16
4	07:13	06:55	06:17	06:25	05:40	05:13	05:44 (1) 05:17	06:47 (1) 05:43	06:35 (1) 06:14	06:45	06:20	06:55
	16:29	17:05	17:39	19:14	19:46	20:14 57	06:41 (1) 20:23 57	06:51 (1) 20:02 20	06:12 (1) 19:15	18:24	16:38	16:16
5	07:13	06:54	06:15	06:24	05:39	05:13	05:45 (1) 05:17	06:48 (1) 05:44	06:32 (1) 06:15	06:46	06:22	06:56
	16:30	17:06	17:40	19:15	19:47	20:15 56	06:41 (1) 20:23 57	06:51 (1) 20:01 14	06:15 (1) 19:14	18:22	16:37	16:16
6	07:13	06:53	06:14	06:22	05:37	05:13	05:45 (1) 05:18	06:48 (1) 05:45	06:29 (1) 06:16	06:47	06:23	06:57
	16:31	17:07	17:41	19:16	19:48	20:16 57	06:42 (1) 20:23 57	06:51 (1) 19:58		19:12	18:21	16:36	16:16
7	07:13	06:52	06:12	06:20	05:36	06:09 (1) 05:12	05:44 (1) 05:19	06:48 (1) 05:46		06:17	06:48	06:24	06:58
	16:32	17:09	17:43	19:17	19:49 4	06:13 (1) 20:16 57	06:41 (1) 20:23 57	06:51 (1) 19:57		19:10	18:19	16:35	16:16
8	07:12	06:51	07:11	06:19	05:35	06:03 (1) 05:12	05:45 (1) 05:19	06:48 (1) 05:47		06:18	06:49	06:25	06:59
	16:33	17:10	18:44	19:18	19:50 17	06:20 (1) 20:17 57	06:42 (1) 20:22 57	06:51 (1) 19:56		19:08	18:17	16:33	16:16
9	07:12	06:50	07:09	06:17	05:34	06:00 (1) 05:12	05:45 (1) 05:20	06:48 (1) 05:48		06:19	06:50	06:26	07:00
	16:34	17:11	18:45	19:19	19:51 23	06:23 (1) 20:18 57	06:42 (1) 20:22 57	06:52 (1) 19:54		19:07	18:16	16:32	16:16
10	07:12	06:48	07:07	06:15	05:33	05:58 (1) 05:12	05:45 (1) 05:21	06:49 (1) 05:49		06:20	06:51	06:28	07:01
	16:35	17:12	18:46	19:20	19:52 27	06:25 (1) 20:18 58	06:43 (1) 20:22 56	06:52 (1) 19:53		19:05	18:14	16:31	16:16
11	07:12	06:47	07:06	06:14	05:32	05:56 (1) 05:12	05:46 (1) 05:21	06:48 (1) 05:50		06:21	06:53	06:29	07:02
	16:36	17:14	18:47	19:21	19:53 31	06:27 (1) 20:19 57	06:43 (1) 20:21 56	06:52 (1) 19:52		19:03	18:12	16:30	16:16
12	07:12	06:46	07:04	06:12	05:31	05:54 (1) 05:11	05:46 (1) 05:22	06:48 (1) 05:51		06:22	06:54	06:30	07:02
	16:37	17:15	18:48	19:22	19:55 34	06:28 (1) 20:19 57	06:43 (1) 20:21 56	06:53 (1) 19:51		19:02	18:11	16:29	16:16
13	07:11	06:45	07:02	06:10	05:29	05:53 (1) 05:11	05:46 (1) 05:23	06:49 (1) 05:52		06:23	06:55	06:31	07:03
	16:38	17:16	18:49	19:23	19:56 37	06:30 (1) 20:20 57	06:43 (1) 20:20 56	06:52 (1) 19:49		19:00	18:09	16:28	16:16
14	07:11	06:43	07:01	06:09	05:28	05:52 (1) 05:11	05:46 (1) 05:24	06:48 (1) 05:53		06:24	06:56	06:32	07:04
	16:39	17:17	18:51	19:24	19:57 39	06:31 (1) 20:20 58	06:44 (1) 20:20 55	06:53 (1) 19:48		18:58	18:08	16:27	16:16
15	07:10	06:42	06:59	06:07	05:27	05:51 (1) 05:11	05:47 (1) 05:24	06:48 (1) 05:54		06:25	06:57	06:34	07:05
	16:40	17:19	18:52	19:26	19:58 41	06:32 (1) 20:21 57	06:44 (1) 20:19 55	06:53 (1) 19:46		18:56	18:06	16:27	16:17
16	07:10	06:41	06:57	06:06	05:26	05:50 (1) 05:11	05:47 (1) 05:25	06:48 (1) 05:55		06:26	06:58	06:35	07:06
	16:41	17:20	18:53	19:27	19:59 43	06:33 (1) 20:21 57	06:44 (1) 20:19 54	06:54 (1) 19:45		18:55	18:04	16:26	16:17
17	07:10	06:39	06:56	06:04	05:25	05:49 (1) 05:11	05:47 (1) 05:26	06:48 (1) 05:56		06:27	06:59	06:36	07:06
	16:42	17:21	18:54	19:28	20:00 44	06:33 (1) 20:22 57	06:44 (1) 20:18 54	06:54 (1) 19:43		18:53	18:03	16:25	16:17
18	07:09	06:38	06:54	06:03	05:25	05:48 (1) 05:11	05:47 (1) 05:27	06:48 (1) 05:57		06:28	07:00	06:37	07:07
	16:44	17:22	18:55	19:29	20:00 46	06:34 (1) 20:22 57	06:44 (1) 20:17 54	06:54 (1) 19:42		18:51	18:01	16:24	16:17
19	07:09	06:37	06:52	06:01	05:24	05:48 (1) 05:11	05:47 (1) 05:28	06:48 (1) 05:58		06:29	07:01	06:39	07:07
	16:45	17:24	18:56	19:30	20:01 48	06:36 (1) 20:22 57	06:44 (1) 20:17 53	06:55 (1) 19:41		18:50	18:00	16:23	16:18
20	07:08	06:35	06:51	06:00	05:23	05:47 (1) 05:12	05:47 (1) 05:29	06:48 (1) 05:59		06:30	07:03	06:40	07:08
	16:46	17:25	18:57	19:31	20:01 49	06:36 (1) 20:23 57	06:44 (1) 20:16 52	06:55 (1) 19:39		18:48	17:58	16:23	16:18
21	07:07	06:34	06:49	05:58	05:22	05:47 (1) 05:12	05:47 (1) 05:29	06:47 (1) 06:00		06:31	07:04	06:41	07:09
	16:47	17:26	18:58	19:32	20:02 49	06:36 (1) 20:23 57	06:44 (1) 20:15 51	06:56 (1) 19:38		18:46	17:57	16:22	16:19
22	07:07	06:32	06:47	05:57	05:21	05:46 (1) 05:12	05:48 (1) 05:30	06:47 (1) 19:36		06:32	07:05	06:42	07:09
	16:48	17:27	18:59	19:33	20:03 51	06:37 (1) 20:23 57	06:45 (1) 20:14 50	06:57 (1) 06:01		18:44	17:55	16:21	16:19
23	07:06	06:31	06:45	05:55	05:20	05:45 (1) 05:12	05:48 (1) 05:31	06:47 (1) 19:36		06:33	07:06	06:43	07:10
	16:50	17:28	19:01	19:34	20:04 52	06:37 (1) 20:23 57	06:45 (1) 20:14 50	06:57 (1) 06:02		18:43	17:54	16:21	16:20
24	07:05	06:29	06:44	05:54	05:20	05:46 (1) 05:13	05:48 (1) 05:32	06:47 (1) 19:35		06:34	07:07	06:44	07:10
	16:51	17:30	19:02	19:35	20:05 52	06:38 (1) 20:23 57	06:45 (1) 20:13 48	06:57 (1) 06:03		18:41	17:52	16:20	16:20
25	07:05	06:28	06:42	05:52	05:19	05:45 (1) 05:13	05:49 (1) 05:33	06:46 (1) 19:33		06:35	07:08	06:46	07:10
	16:52	17:31	19:03	19:36	20:06 53	06:38 (1) 20:24 57	06:46 (1) 20:12 47	06:58 (1) 06:04		18:39	17:51	16:20	16:21
26	07:04	06:26	06:40	05:51	05:18	05:45 (1) 05:13	05:49 (1) 05:34	06:45 (1) 19:31		06:37	07:10	06:47	07:11
	16:53	17:32	19:04	19:37	20:07 54	06:39 (1) 20:24 57	06:46 (1) 20:11 45	06:59 (1) 06:05		18:37	17:50	16:19	16:21
27	07:03	06:25	06:39	05:49	05:17	05:45 (1) 05:14	05:49 (1) 05:35	06:44 (1) 19:30		06:38	07:11	06:48	07:11
	16:55	17:33	19:05	19:39	20:08 54	06:39 (1) 20:24 57	06:46 (1) 20:10 44	06:00 (1) 06:06		18:36	17:48	16:19	16:22
28	07:02	06:23	06:37	05:48	05:17	05:44 (1) 05:14	05:49 (1) 05:36	06:44 (1) 19:28		06:39	07:12	06:49	07:12
	16:56	17:34	19:06	19:40	20:09 55	06:39 (1) 20:24 58	06:47 (1) 20:09 42	06:01 (1) 06:07		18:34	17:47	16:18	16:23
29	07:01		06:35	05:47	05:16	05:45 (1) 05:14	05:49 (1) 05:37	06:43 (1) 19:27		06:40	07:13	06:50	07:12
	16:57		19:07	19:41	20:10 55	06:40 (1) 20:24 58	06:47 (1) 20:08 40	06:02 (1) 06:08		18:32	17:46	16:18	16:24
30	07:00		06:34	05:45	05:16	05:44 (1) 05:15	05:49 (1) 05:38	06:42 (1) 19:25		06:41	07:14	06:51	07:12
	16:58		19:08	19:42	20:10 56	06:40 (1) 20:24 57	06:46 (1) 20:07 38	06:03 (1) 06:09		18:31	17:44	16:17	16:24
31	06:59		06:32		05:15	05:45 (1)	05:39	06:41 (1) 19:23			07:16		07:12
	17:00		19:09		20:11 55	06:40 (1)	20:06 36	06:04 (1) 06:10			17:43		16:25
Potential sun hours	296	297	370	400	450	454	461	06:40 (1) 19:22	375	344	297	286
Total, worst case					1069	1711	1606	429				
Sun reduction					0.58	0.61	0.63	123				
Oper. time red.					1.00	1.00	1.00	0.62				
Wind dir. red.					0.56	0.56	0.56	1.00				
Total reduction					0.32	0.34	0.35	0.56				
Total, real					344	580	562	0.34				
								42				

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Figure 3-3. Predicted annual shadow flicker from Coddington Point (site 7).

Figure 3-4. Potential shadow flicker at the Navy Lodge (site 8).

SHADOW - Calendar

Shadow receptor: T - 8T

Assumptions for shadow calculations

Maximum distance for influence	2,000 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.33	6.13	6.91	7.59	8.42	9.24	9.37	8.58	7.75	6.77	4.93	4.78

Operational time

N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
691	432	259	155	155	155	432	518	950	1,209	864	518	432	604	691	691	8,756

Idle start wind speed: Cut in wind speed from power curve

	January	February	March		April	May	June	July	August	September		October		November	December
1	07:12	06:58	06:22		06:30	05:44	05:15	05:15	05:40	06:11		06:42	07:02 (1)	06:17	06:52
	16:26	17:01	17:36		19:10	19:43	20:12	20:24	20:05	19:20		18:29	14 07:16 (1)	16:42	16:17
2	07:13	06:57	06:20		06:29	05:43	05:14	05:16	05:41	06:12		06:43	07:03 (1)	06:18	06:53
	16:27	17:02	17:37		19:11	19:44	20:13	20:24	20:04	19:19		18:27	13 07:16 (1)	16:40	16:17
3	07:13	06:56	06:19		06:27	05:41	05:14	05:16	05:42	06:13		06:44	07:04 (1)	06:19	06:54
	16:28	17:03	17:38		19:13	19:45	20:14	20:24	20:03	19:17		18:26	12 07:16 (1)	16:39	16:16
4	07:13	06:55	06:17		06:25	05:40	05:13	05:17	05:43	06:14		06:45	07:05 (1)	06:20	06:55
	16:29	17:05	17:39		19:14	19:46	20:14	20:23	20:02	19:15		18:24	11 07:16 (1)	16:38	16:16
5	07:13	06:54	06:15		06:24	05:39	05:13	05:17	05:44	06:15		06:46	07:06 (1)	06:22	06:56
	16:30	17:06	17:40		19:15	19:47	20:15	20:23	20:01	19:14		18:22	9 07:15 (1)	16:37	16:16
6	07:13	06:53	06:14		06:22	05:37	05:13	05:18	05:45	06:16		06:47	07:07 (1)	06:23	06:57
	16:31	17:07	17:41	4	06:33 (1)	19:48	20:16	20:23	19:58	19:12		18:21	7 07:14 (1)	16:36	16:16
7	07:13	06:52	06:12		06:32 (1)	05:36	05:12	05:19	05:46	06:17		06:48	07:08 (1)	06:24	06:58
	16:32	17:09	17:43	6	06:38 (1)	19:49	20:16	20:23	19:57	19:10		18:19	5 07:13 (1)	16:35	16:16
8	07:12	06:51	07:11		07:30 (1)	05:35	05:12	05:19	05:47	06:18		06:49	07:09 (1)	06:25	06:59
	16:33	17:10	18:44	8	07:38 (1)	19:50	20:17	20:22	19:56	19:08		18:17	2 07:11 (1)	16:33	16:16
9	07:12	06:50	07:09		07:28 (1)	05:34	05:12	05:20	05:48	06:19		06:50		06:26	07:00
	16:34	17:11	18:45	10	07:38 (1)	19:51	20:18	20:22	19:54	19:07		18:16		16:32	16:16
10	07:12	06:48	07:07		07:27 (1)	05:33	05:12	05:21	05:49	06:20		06:51		06:28	07:01
	16:35	17:12	18:46	12	07:39 (1)	19:52	20:18	20:22	19:53	19:05		18:14		16:31	16:16
11	07:12	06:47	07:06		07:25 (1)	05:32	05:12	05:21	05:50	06:21		06:53		06:29	07:02
	16:36	17:14	18:47	13	07:38 (1)	19:21	19:53	20:21	19:52	19:03		18:12		16:30	16:16
12	07:12	06:46	07:04		07:23 (1)	06:12	05:31	05:11	05:22	05:51	06:22	06:54		06:30	07:02
	16:37	17:15	18:48	13	07:36 (1)	19:22	19:55	20:19	20:21	19:51	19:02	18:11		16:29	16:16
13	07:11	06:45	07:02		07:23 (1)	06:10	05:29	05:11	05:23	05:52	06:23	06:55		06:31	07:03
	16:38	17:16	18:49	13	07:36 (1)	19:23	19:56	20:20	20:20	19:49	19:00	18:09		16:28	16:16
14	07:11	06:43	07:01		07:24 (1)	06:09	05:28	05:11	05:24	05:53	06:24	06:56		06:32	07:04
	16:39	17:17	18:51	9	07:33 (1)	19:24	19:57	20:20	20:20	19:48	18:58	18:08		16:27	16:16
15	07:10	06:42	06:59			06:07	05:27	05:11	05:24	05:54	06:25	06:57		06:34	07:05
	16:40	17:19	18:52			19:26	19:58	20:21	20:19	19:46	18:56	18:06		16:27	16:17
16	07:10	06:41	06:57			06:06	05:26	05:11	05:25	05:55	06:26	06:58		06:35	07:06
	16:41	17:20	18:53			19:27	19:59	20:21	20:19	19:45	18:55	18:04		16:26	16:17
17	07:10	06:39	06:56			06:04	05:25	05:11	05:26	05:56	06:27	06:59		06:36	07:06
	16:42	17:21	18:54			19:28	20:00	20:22	20:18	19:43	18:53	18:03		16:25	16:17
18	07:09	06:38	06:54			06:03	05:25	05:11	05:27	05:57	06:28	07:00		06:37	07:07
	16:44	17:22	18:55			19:29	20:00	20:22	20:17	19:42	18:51	18:01		16:24	16:17
19	07:09	06:37	06:52			06:01	05:24	05:11	05:28	05:58	06:29	07:01		06:39	07:07
	16:45	17:24	18:56			19:30	20:01	20:22	20:17	19:41	18:50	18:00		16:23	16:18
20	07:08	06:35	06:51			06:00	05:23	05:12	05:29	05:59	06:30	07:03		06:40	07:08
	16:46	17:25	18:57			19:31	20:01	20:23	20:16	19:39	18:48	17:58		16:23	16:18
21	07:07	06:34	06:49			05:58	05:22	05:12	05:29	06:00	06:31	07:04		06:41	07:09
	16:47	17:26	18:58			19:32	20:02	20:23	20:15	19:38	18:46	17:57		16:22	16:19
22	07:07	06:32	06:47			05:57	05:21	05:12	05:30	06:01	06:32	07:05		06:42	07:09
	16:48	17:27	18:59			19:33	20:03	20:23	20:14	19:36	18:44	17:55		16:21	16:19
23	07:06	06:31	06:45			05:56	05:20	05:12	05:31	06:02	06:33	07:06		06:43	07:10
	16:50	17:28	19:01			19:34	20:04	20:23	20:14	19:35	18:43	17:54		16:21	16:20
24	07:05	06:29	06:44			05:54	05:20	05:13	05:32	06:03	06:34	07:07		06:44	07:10
	16:51	17:30	19:02			19:35	20:05	20:23	20:13	19:33	18:41	17:52		16:20	16:20
25	07:05	06:28	06:42			05:52	05:19	05:13	05:33	06:04	06:36	07:08		06:46	07:10
	16:52	17:31	19:03			19:36	20:06	20:24	20:12	19:31	18:39	17:51		16:20	16:21
26	07:04	06:26	06:40			05:51	05:18	05:13	05:34	06:05	06:37	07:10		06:47	07:11
	16:53	17:32	19:04			19:37	20:07	20:24	20:11	19:30	18:37	17:50		16:19	16:21
27	07:03	06:25	06:39			05:49	05:17	05:14	05:35	06:06	06:38	07:11		06:48	07:11
	16:55	17:33	19:05			19:39	20:08	20:24	20:10	19:28	18:36	17:48		16:19	16:22
28	07:02	06:23	06:37			05:48	05:17	05:14	05:36	06:07	06:39	07:12		06:49	07:12
	16:56	17:34	19:06			19:40	20:09	20:24	20:09	19:27	18:34	17:47		16:18	16:23
29	07:01		06:35			05:47	05:16	05:14	05:37	06:08	06:40	07:06 (1)	07:13	06:50	07:12
	16:57		19:07			19:41	20:10	20:24	20:08	19:25	18:32	7 07:13 (1)	17:46	16:18	16:24
30	07:00		06:34			05:46	05:16	05:15	05:38	06:09	06:41	07:03 (1)	07:14	06:51	07:12
	16:58		19:08			19:42	20:10	20:24	20:07	19:23	18:31	12 07:15 (1)	17:44	16:17	16:24
31	06:59		06:32				05:15		05:39	06:10			07:16		07:12
	17:00		19:09				20:11		20:06	19:22			17:43		16:25
Potential sun hours	296	297	370		400	450	454	461	429	375		344		297	286
Total, worst case				88							19		73		
Sun reduction				0.58							0.62		0.61		
Oper. time red.				1.00							1.00		1.00		
Wind dir. red.				0.54							0.54		0.54		
Total reduction				0.31							0.34		0.33		
Total, real				28							6		24		

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Figure 3-5. Predicted annual shadow flicker from Navy Lodge (site 8).

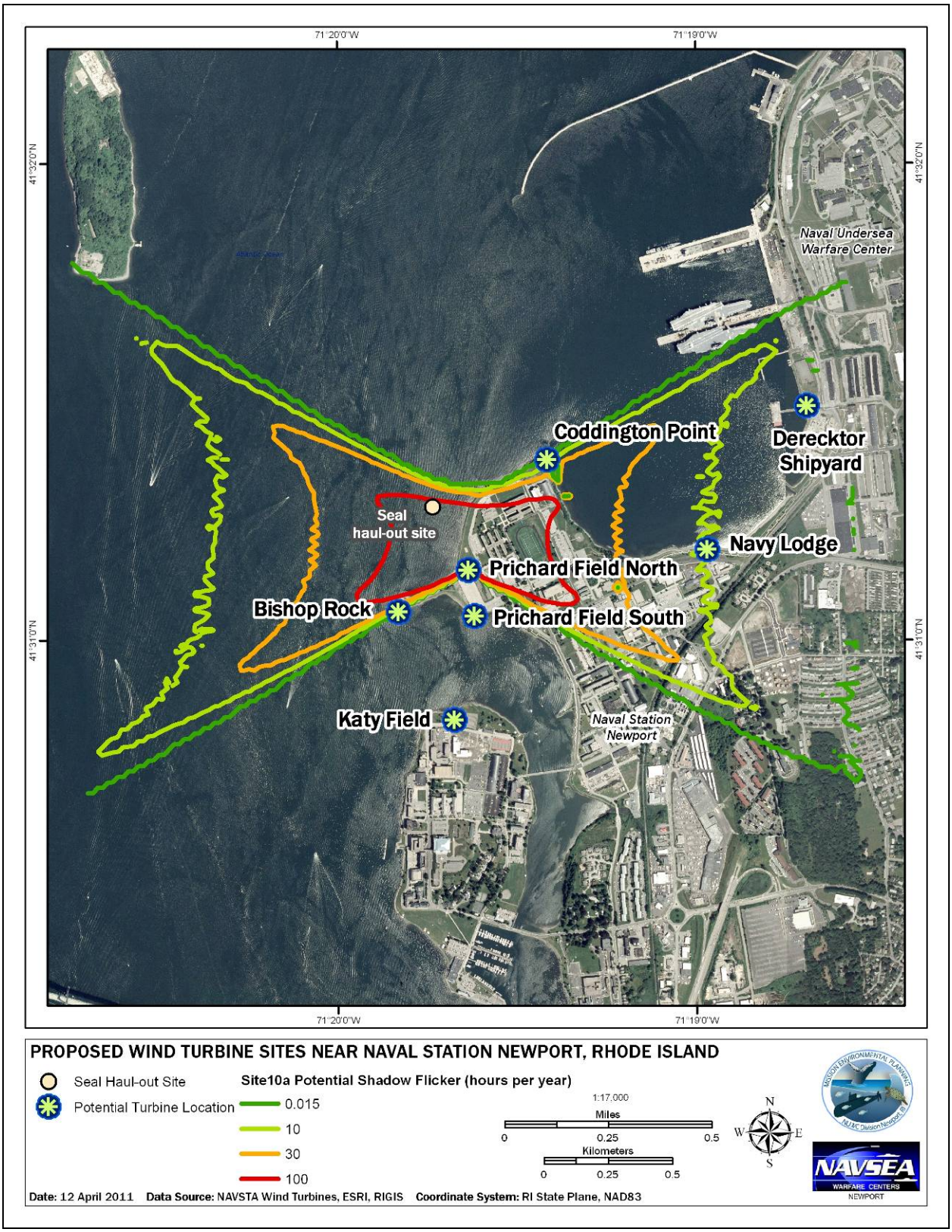

Figure 3-6. Potential shadow flicker at Pritchard Field North (site 10a).

SHADOW - Calendar

Shadow receptor: O - 10aO

Assumptions for shadow calculations

Maximum distance for influence	2,000 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.33	6.13	6.91	7.59	8.42	9.24	9.37	8.58	7.75	6.77	4.93	4.78

Operational time

N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
691	432	259	155	155	155	432	518	950	1,209	864	518	432	604	691	691	8,756

Idle start wind speed: Cut in wind speed from power curve

	January			February			March	April	May	June	July	August	September	October			November			December		
1	07:12		08:52 (1)	06:58		09:13 (1)	06:22	06:30	05:44	05:15	05:15	05:40	05:11	06:42			06:17		08:58 (1)	06:52		08:40 (1)
	16:26	99	10:31 (1)	17:01	72	10:25 (1)	17:36	19:10	19:43	20:12	20:24	20:05	19:20	18:29			16:42	37	09:35 (1)	16:17	96	10:16 (1)
2	07:13		08:53 (1)	06:57		09:15 (1)	06:20	06:29	05:43	05:14	05:16	05:41	05:12	06:43			06:18		08:55 (1)	06:53		08:40 (1)
	16:27	98	10:31 (1)	17:02	69	10:24 (1)	17:37	19:11	19:44	20:13	20:24	20:04	19:19	18:27			16:40	43	09:38 (1)	16:17	96	10:16 (1)
3	07:13		08:53 (1)	06:56		09:16 (1)	06:19	06:27	05:41	05:14	05:16	05:42	05:13	06:44			06:19		08:54 (1)	06:54		08:40 (1)
	16:28	98	10:31 (1)	17:03	66	10:22 (1)	17:38	19:13	19:45	20:14	20:24	20:03	19:17	18:26			16:39	48	09:42 (1)	16:16	97	10:17 (1)
4	07:13		08:54 (1)	06:55		09:18 (1)	06:17	06:25	05:40	05:13	05:17	05:43	05:14	06:45			06:20		08:52 (1)	06:55		08:40 (1)
	16:29	98	10:32 (1)	17:05	63	10:21 (1)	17:39	19:14	19:46	20:14	20:23	20:02	19:15	18:24			16:38	52	09:44 (1)	16:16	98	10:18 (1)
5	07:13		08:54 (1)	06:54		09:19 (1)	06:15	06:24	05:39	05:13	05:17	05:44	05:15	06:46			06:22		08:50 (1)	06:56		08:41 (1)
	16:30	98	10:32 (1)	17:06	60	10:19 (1)	17:40	19:15	19:47	20:15	20:23	20:01	19:14	18:22			16:37	56	09:46 (1)	16:16	97	10:18 (1)
6	07:13		08:55 (1)	06:53		09:20 (1)	06:14	06:22	05:37	05:13	05:18	05:45	05:16	06:47			06:23		08:49 (1)	06:57		08:41 (1)
	16:31	98	10:33 (1)	17:07	56	10:16 (1)	17:41	19:16	19:48	20:16	20:23	19:58	19:12	18:21			16:36	60	09:49 (1)	16:16	98	10:19 (1)
7	07:13		08:55 (1)	06:52		09:22 (1)	06:12	06:20	05:36	05:12	05:19	05:46	05:17	06:48			06:24		08:47 (1)	06:58		08:41 (1)
	16:32	98	10:33 (1)	17:09	52	10:14 (1)	17:43	19:17	19:49	20:16	20:23	19:57	19:10	18:19			16:35	64	09:51 (1)	16:16	98	10:19 (1)
8	07:12		08:56 (1)	06:51		09:24 (1)	06:11	06:19	05:35	05:12	05:19	05:47	05:18	06:49			06:25		08:46 (1)	06:59		08:42 (1)
	16:33	98	10:34 (1)	17:10	47	10:11 (1)	17:44	19:18	19:50	20:17	20:22	19:56	19:08	18:17			16:33	68	09:52 (1)	16:16	98	10:20 (1)
9	07:12		08:56 (1)	06:50		09:27 (1)	07:09	06:17	05:34	05:12	05:20	05:48	05:19	06:50			06:26		08:45 (1)	07:00		08:42 (1)
	16:34	97	10:33 (1)	17:11	42	10:09 (1)	17:45	19:19	19:51	20:18	20:22	19:54	19:07	18:16			16:32	70	09:55 (1)	16:16	98	10:20 (1)
10	07:12		08:57 (1)	06:48		09:30 (1)	07:07	06:15	05:33	05:12	05:21	05:49	05:20	06:51			06:28		08:44 (1)	07:01		08:43 (1)
	16:35	96	10:33 (1)	17:12	35	10:05 (1)	17:46	19:20	19:52	20:18	20:22	19:53	19:05	18:14			16:31	72	09:56 (1)	16:16	98	10:21 (1)
11	07:12		08:58 (1)	06:47		09:33 (1)	07:06	06:14	05:32	05:12	05:21	05:50	05:21	06:53			06:29		08:43 (1)	07:02		08:42 (1)
	16:36	96	10:34 (1)	17:14	27	10:00 (1)	17:47	19:21	19:53	20:19	20:21	19:52	19:03	18:12			16:30	74	09:57 (1)	16:16	99	10:21 (1)
12	07:12		08:58 (1)	06:46		09:40 (1)	07:04	06:12	05:31	05:11	05:22	05:51	05:22	06:54			06:30		08:42 (1)	07:02		08:43 (1)
	16:37	95	10:33 (1)	17:15	13	09:53 (1)	17:48	19:22	19:55	20:19	20:21	19:51	19:02	18:11			16:29	76	09:58 (1)	16:16	98	10:21 (1)
13	07:11		08:59 (1)	06:45			07:02	06:10	05:29	05:11	05:23	05:52	05:23	06:55			06:31		08:42 (1)	07:03		08:43 (1)
	16:38	95	10:34 (1)	17:16			18:49	19:23	19:56	20:20	20:20	19:49	19:00	18:09			16:28	78	10:00 (1)	16:16	99	10:22 (1)
14	07:11		09:00 (1)	06:43			07:01	06:09	05:28	05:11	05:24	05:53	05:24	06:56			06:32		08:41 (1)	07:04		08:44 (1)
	16:39	94	10:34 (1)	17:17			18:51	19:24	19:57	20:20	20:20	19:48	18:58	18:08			16:27	80	10:01 (1)	16:16	99	10:23 (1)
15	07:10		09:00 (1)	06:42			06:59	06:07	05:27	05:11	05:24	05:54	05:25	06:57			06:34		08:41 (1)	07:05		08:44 (1)
	16:40	94	10:34 (1)	17:19			18:52	19:25	19:58	20:21	20:19	19:46	18:56	18:06			16:27	81	10:02 (1)	16:17	99	10:23 (1)
16	07:10		09:01 (1)	06:41			06:57	06:06	05:26	05:11	05:25	05:55	05:26	06:58			06:35		08:41 (1)	07:06		08:44 (1)
	16:41	93	10:34 (1)	17:20			18:53	19:27	19:59	20:21	20:19	19:45	18:55	18:04			16:26	83	10:04 (1)	16:17	99	10:23 (1)
17	07:10		09:01 (1)	06:39			06:56	06:04	05:25	05:11	05:26	05:56	05:27	06:59			06:36		08:40 (1)	07:06		08:45 (1)
	16:42	93	10:34 (1)	17:21			18:54	19:28	20:00	20:22	20:18	19:43	18:53	18:03			16:25	85	10:05 (1)	16:17	99	10:24 (1)
18	07:09		09:01 (1)	06:38			06:54	06:03	05:25	05:11	05:27	05:57	05:28	07:00			06:37		08:40 (1)	07:07		08:45 (1)
	16:44	92	10:33 (1)	17:22			18:55	19:29	20:00	20:22	20:17	19:42	18:51	18:01			16:24	86	10:06 (1)	16:17	99	10:24 (1)
19	07:09		09:02 (1)	06:37			06:52	06:01	05:24	05:11	05:28	05:58	05:29	07:01			06:39		08:39 (1)	07:07		08:46 (1)
	16:45	92	10:34 (1)	17:24			18:56	19:30	20:01	20:22	20:17	19:41	18:50	18:00			16:23	87	10:06 (1)	16:18	99	10:25 (1)
20	07:08		09:03 (1)	06:35			06:51	06:00	05:23	05:12	05:29	05:59	05:30	07:03			06:40		08:40 (1)	07:08		08:47 (1)
	16:46	90	10:33 (1)	17:25			18:57	19:31	20:01	20:23	20:16	19:39	18:48	17:58			16:23	88	10:08 (1)	16:18	99	10:26 (1)
21	07:07		09:03 (1)	06:34			06:49	05:58	05:22	05:12	05:29	06:00	05:31	07:04			06:41		08:39 (1)	07:09		08:47 (1)
	16:47	90	10:33 (1)	17:26			18:58	19:32	20:02	20:23	20:15	19:38	18:46	17:57			16:22	90	10:09 (1)	16:19	99	10:26 (1)
22	07:07		09:04 (1)	06:32			06:47	05:57	05:21	05:12	05:30	06:01	05:32	07:05			06:42		08:39 (1)	07:09		08:48 (1)
	16:48	89	10:33 (1)	17:27			18:59	19:33	20:03	20:23	20:14	19:36	18:44	17:55			16:21	90	10:09 (1)	16:19	99	10:27 (1)
23	07:06		09:05 (1)	06:31			06:45	05:55	05:20	05:12	05:31	06:02	05:33	07:06			06:43		08:38 (1)	07:10		08:48 (1)
	16:50	87	10:32 (1)	17:28			19:01	19:34	20:04	20:23	20:14	19:35	18:43	17:54			16:21	92	10:10 (1)	16:20	99	10:27 (1)
24	07:05		09:06 (1)	06:29			06:44	05:54	05:20	05:13	05:32	06:03	05:34	07:07			06:44		08:39 (1)	07:10		08:48 (1)
	16:51	86	10:32 (1)	17:30			19:02	19:35	20:05	20:23	20:13	19:33	18:41	17:52			16:20	92	10:11 (1)	16:20	99	10:27 (1)
25	07:05		09:06 (1)	06:28			06:42	05:52	05:19	05:13	05:33	06:04	05:36	07:08			06:46		08:39 (1)	07:10		08:49 (1)
	16:52	85	10:31 (1)	17:31			19:03	19:36	20:06	20:24	20:12	19:31	18:39	17:51			16:20	93	10:12 (1)	16:21	99	10:28 (1)
26	07:04		09:08 (1)	06:26			06:40	05:51	05:18	05:13	05:34	06:05	05:37	07:10			06:47		08:39 (1)	07:11		08:49 (1)
	16:53	83	10:31 (1)	17:32			19:04	19:37	20:07	20:24	20:11	19:30	18:37	17:50			16:19	93	10:12 (1)	16:21	99	10:28 (1)
27	07:03		09:09 (1)	06:25			06:39	05:49	05:17	05:14	05:35	06:06	05:38	07:11			06:48		08:39 (1)	07:11		08:49 (1)
	16:55	81	10:30 (1)	17:33			19:05	19:39	20:08	20:24	20:10	19:28	18:36	17:48			16:19	94	10:13 (1)	16:22	99	10:28 (1)
28	07:02		09:09 (1)	06:23			06:37	05:48	05:17	05:14	05:36	06:07	05:39	07:12			06:49		08:39 (1)	07:12		08:51 (1)
	16:56	80	10:29 (1)	17:34			19:06	19:40	20:09	20:24	20:09	19:27	18:34	17:47			16:18	94	10:13 (1)	16:23	99	10:30 (1)
29	07:01		09:10 (1)				06:35	05:47	05:16	05:14	05:37	06:08	05:40	07:13			06:50		08:40 (1)	07:12		08:51 (1)
	16:57	78	10:28 (1)				19:07	19:41	20:10	20:24	20:08	19:25	18:32	17:46			16:18	95	10:15 (1)	16:24	99	10:30 (1)
30	07:00		09:11 (1)				06:34	05:45	05:16	05:15	05:38	06:09	05:41	07:14		10:08 (1)	06:51		08:40 (1)	07:12		08:51 (1)
	16:58	76	10:27 (1)				19:08	19:42	20:10	20:24	20:07	19:23	18:31	17:44	17	10:25 (1)	16:17	95	10:15 (1)	16:24	99	10:30 (1)
31	06:59		09:12 (1)				06:32		05:15		05:39	06:10		07:16		10:02 (1)				07:12		08:52 (1)
	17:00	74	10:26 (1)				19:09		20:11		20:06	19:22		17:43	29	10:31 (1)				16:25	98	10:30 (1)
Potential sun hours	296			297			370	400	450	454	461	429	375	344			297			286		
Total, worst case		2821			602										46			2314			3061	
Sun reduction		0.56			0.58										0.61			0.50			0.52	
Oper. time red.		1.00			1.00										1.00			1.00			1.00	
Wind dir. red.		0.72			0.72										0.72			0.72			0.72	
Total reduction		0.40			0.41										0.44			0.36			0.37	
Total, real		1126			249										20			826			1130	

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Figure 3-7. Predicted annual shadow flicker from Pritchard Field North (site 10a).

Table 3-2. Shadow flicker analysis results.

Turbine Site	Month	Shadow Days	Minimum Shadow (minutes)	Maximum Shadow (minutes)	Total worst case (hr: min/yr)	Sun Reduction (%)	Wind Direction Reduction (%)	Total Reduction (%)	Total Expected (hr:min)/yr
7	May	**10**	4	43	4:56	58	56	32	1:35
8	September	2	7	12	0:19	62	54	34	0:06
	October	8	2	14	1:13	61	54	33	0:24
	March	9	4	12	1:28	58	54	31	0:28
	Total	**19**			**3:00**				**0:58**
10	October	2	17	29	0:46	61	72	44	0:20
	November	30	37	95	38:34	50	72	36	13:46
	December	31	96	99	50:51	52	72	37	18:50
	January	31	74	99	47:01	56	72	40	18:46
	February	12	13	72	10:02	58	72	41	4:09
	Total	**106**			**147:14**				**55:31**

CHAPTER 4 DISCUSSION AND CONCLUSIONS

Harbor seals occur in Narragansett Bay from September to about mid-May (Schroeder 2000; Narragansett Bay Estuary Program 2001). As reported in Chapter 2, harbor seals were found to haul out on 53% of observation days on an intertidal ledge near Coddington Point at NAVSTA Newport. Because of the proximity of this haul-out site to proposed wind turbine locations, an analysis of potential effects to hauled out seals was performed to determine if the wind project would result in harassment under the MMPA. Two stressors, in-air sounds from operational wind turbines and shadow flicker, were identified as potentially affecting the seals. An analysis of the sounds generated from the wind project showed that seals would not experience PTS, TTS or behavioral disturbance based on in-air effects thresholds established in the literature and through the rule making process. However, because wind turbine generated sound is within the frequency range of harbor seal hearing and vocalizations, masking of biologically important sounds, such as conspecifics, may occur. The analysis was based on sound generated from the maximum sized turbines at all 12 proposed wind turbine locations running concurrently (Geo-Marine Inc. 2011a). In its implementation, the wind turbine project would only operate turbines at a number of sites required to generate up to 9 MW of electricity. Consequently, the cumulative sound from this smaller subset of turbines would be less than that considered in the analysis; therefore, the effect would be less.

An analysis of shadow flicker indicates that flicker generated from turbines located at Coddington Point (site 7), Navy Lodge (site 8) and Pritchard Field North (site 10a) would coincide with low tide periods when hauled out seals would be present (Geo-Marine Inc. 2011b). The potential exists for the shadow flicker to elicit some level of behavioral disturbance ranging from increased alertness to site avoidance or abandonment. No studies could be found that specifically examine the effects of wind turbines on seals; nonetheless, it is common knowledge that seals respond to various types of visual stimuli that result in behavioral disturbance including temporary abandonment of haul-out sites (i.e., Nordstrom 2002). Because of the importance of hauling out in the lifecycle of seals, a disruption of this behavior could be significant. Should a behavioral disturbance be realized, it would be considered harassment under the MMPA. In this case, the Navy would be required to apply for a Letter of Authorization.

In conclusion, the wind turbine project, as it would be implemented, would not cause harassment to seals from the in-air sounds generated. However, shadow flicker from a turbine operating at Coddington Point has the potential of disrupting haul-out behavior which would be in violation of MMPA should it occur without the Navy securing a Letter of Authorization. A possible solution to this situation would be to not operate turbines at sites 7, 8, and 10a during the periods when they cast shadow flicker on “The Sisters” haul-out site. This would result in no more than 58 hours and 4 minutes of lost power generation per year from the three turbines.

Appendix A LIST OF PREPARERS

Name	Role	Education and Experience
DEPARTMENT OF THE NAVY, Naval Sea Systems Command, Warfare Centers		
Thomas Vars	NUWCDIVNPT Marine Biologist: Primary Author	B.S. Natural Resources. 18 years weapon system test and evaluation experience; 13 years environmental planning experience.
MCLAUGHLIN RESEARCH CORPORATION		
Tara Moll	Marine Scientist: Co-Author and GIS Analyst	M.S. Biological Sciences; B.S. Marine Biology. 7 years marine ecology research experience; 4 years environmental planning and GIS analysis experience.

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