Apr 11

Avian Radar Baseline Study

Final Survey Report for the Proposed Reedsport Ocean Power Technologies Wave Park

Prepared by Geo-Marine, Inc. on behalf of Oregon Wave Energy Trust

This work was funded by the Oregon Wave Energy Trust (OWET). OWET was funded in part with Oregon State Lottery Funds administered by the Oregon Business Development Department. It is one of six Oregon Innovation Council initiatives supporting job creation and long-term economic growth.

Oregon Wave Energy Trust (OWET) is a nonprofit public-private partnership funded by the Oregon Innovation Council. Its mission is to support the responsible development of wave energy in Oregon. OWET emphasizes an inclusive, collaborative model to ensure that Oregon maintains its competitive advantage and maximizes the economic development and environmental potential of this emerging industry. Our work includes stakeholder outreach and education, policy development, environmental assessment, applied research and market development.

AVIAN RADAR STUDY

FOR PROPOSED WAVE ENERGY DEVELOPMENT OFF THE OREGON COAST

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April 20, 2011

EXECUTIVE SUMMARY

Geo-Marine, Inc. (GMI) conducted an offshore avian radar baseline study for Oregon Wave Energy Trust (OWET) for a wave energy study located northwest of Reedsport, Oregon from 25 August through 29 October 2010. The study was conducted from shore with GMI's Mobile Avian Radar System (MARS®). The MARS® was equipped with a 3-centimeter (cm) wavelength 50-kilowatt (kW) radar with a 2.5-degree (°) parabolic antenna for horizontal scanning, and a 3-cm, 25-kW radar with an open array antenna for vertical scanning. Diurnal land-based nearshore and diurnal and nocturnal boat-based radar validation surveys were conducted specifically to determine whether the radar could detect birds flying at low attitudes above the water.

Comparison between the nearshore and offshore (study area) observer bird passage rates and the nearshore and offshore radar passage rates revealed low correlation between diurnal observations and radar data. The correlation analysis values were all too low (<.307) to develop a correction factor to apply to the radar data.

Sea clutter was identified as the limiting factor. When algorithms to reduce false tracks from sea clutter were applied, tracks of real birds were eliminated because they could not be separated from sea clutter false tracks. At present there is no technology known that can accurately remove bird detections from sea clutter. This problem was further magnified in this study because radar visual validation surveys revealed that a major portion of the bird movement both nearshore and offshore occurred at altitudes from 1-30 feet (ft) above sea level. At that altitude it is impossible to separate birds from wind-driven waves and high swells that are common in the study area during fall. The visual validation data documented that the radar was ineffective when birds were flying close to the surface.

In addition to providing data to facilitate passage rate comparisons between observer and the radar, the radar validation surveys provided data on bird flight behaviors within and adjacent to the study area. These data, which were requested to be collected for this study, included information on nearshore and offshore (study area) bird species occurrence, passage rates, flight altitudes and speeds, flight directions, and flock sizes.

During the diurnal land-based nearshore avian surveys 43 bird species were identified; 32 bird species were observed during the boat-based offshore surveys. One federally-listed bird species, Marbled Murrelet (threatened), was observed occasionally during nearshore and offshore surveys.

Diurnal nearshore bird passage rates ranged from 30-390 birds/nautical mile (NM)/hour (hr) from 0 to 1 NM offshore and from 10-142 birds/NM/hr from 1 to 2 NM offshore. Offshore (study area) passage rates ranged from 142-268 birds/NM/hr; offshore nocturnal passage rates ranged from 3-53 birds/NM/hr.

The majority of birds flying over both nearshore (94%) and offshore (93%) waters were flying from 1-100 ft above sea level (asl). The majority of these birds were flying from 1-30 ft asl (nearshore, 75%; offshore, 83%). The dominant flight directions were to the south and the majority of birds sighted were in the 1-5 flock category.

This Avian Radar Baseline Study was contracted to assist in collecting data that could potentially be used to meet these requirements. Avian radar validation surveys were designed specifically by GMI for this study to determine the accuracy of the radar data in predicting the number of birds that would potentially collide with the 30-ft tall wave buoys. The results of the avian radar validation surveys from this study indicate that avian radar is not able to collect accurate altitude flight data within the potential bird-wave power buoy collision zone (1-30 ft asl) because of the presence of sea clutter (high wind waves and/or swells) in the study area; however, diurnal avian radar validation bird survey data collected from shore and from a boat in the study area provided information requested by the Scope of Work including on nearshore and offshore (study area) species occurrence, avian passage rates (number of bird tracks/NM/hr), frequency of avian flight altitudes within and above the bird-wave power buoy collision zone, flock size frequency, and flight direction frequency. In addition, a nocturnal thermal imaging camera was used to conduct nighttime avian studies and provided data on nighttime bird passage rates.

GMI recommends, based on the findings of this Avian Radar Baseline Study, that seasonal radar studies recommended by the FERC Study Plan be replaced with diurnal boat surveys and nocturnal boat surveys using stabilized remote sensing technologies (e.g., thermal imaging, high definition cameras). These methods will, in GMI's opinion, provide the best data on nocturnal passage rate (bird abundance) and altitude use within the potential bird-wave power buoy collision zone (1-30 ft asl).

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LIST OF ACRONYMS AND ABBREVIATIONS

°	Degree(s)
µm	Micron(s)
asl	Above Sea Level
cm	Centimeter(s)
DVD	Digital Video Data
E	East
F	Fahrenheit
FERC	Federal Energy Regulatory Commission
FPA	Focal Plane Array
ft	Foot (Feet)
GMI	Geo-Marine, Inc.
hr	Hour
HSR	Horizontally Scanning Radar
Hz	Hertz
km	Kilometer(s)
kph	kilometers per hour
kt	Knot
kW	Kilowatt(s)
m	Meter(s)
MARS®	Mobile Avian Radar System®
mbar	Millibar(s)
MHz	Megahertz
mm	Millimeter(s)
mph	Mile(s) per Hour
N	North
NE	Northeast
NFEC	Naval Facilities Engineering Command
NM	Nautical Mile(s)
NOAA	National Oceanic and Atmospheric Administration
ns	Nanosecond(s)
NW	Northwest
OPT	Ocean Power Technologies
OWET	Oregon Wave Energy Trust
PM	Project Manager
PRF	Pulse Repetition Frequency
QA/QC	Quality Assurance/Quality Control
rpm	Revolution(s) per Minute
S	South
s	second
SE	Southeast
STE	Standard Error
SW	Southwest
TI	Thermal Imaging
TIC	Thermal Imaging Camera
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
VSR	Vertically Scanning Radar
W	West

1.0 INTRODUCTION

One of the potential environmental concerns with wave energy projects is the possibility that low flying seabirds may collide with wave energy buoys, especially when low visibility conditions exist. As part of its mission to facilitate wave energy development in Oregon, Oregon Wave Energy Trust (OWET), a non-profit organization, created and funded by the Oregon Innovation Council, through the 2007 Oregon Legislative Assembly, identified the need to conduct an avian radar study to address the potential for bird-wave buoy collisions.

In the Request For Proposal, the key data identified by OWET to be collected for the *Avian Radar Baseline Study* included (to the extent feasible for the methodology) seasonal information on movement rates through the project location (birds/kilometer [km]/hour [hr]), distance offshore, flock sizes (number of birds/flock), flight altitudes (in meters [m] above sea level [asl]), flight directions, and flight speeds. Avian radar and diurnal boat survey data will be used for a future risk-assessment modeling study, for which existing models for estimating seabird fatalities at wind farms and other tower structures will be adapted for application to wave energy projects.

OWET awarded the contract for the *Avian Radar Baseline Study* to Geo-Marine, Inc (GMI). This report provides information on the selected study area, avian radar ornithology, methods used during the study and the study results.

2.0 STUDY AREA

This section describes the location of study area and the environmental setting in the study area. The environmental setting describes regional landforms, physical oceanic processes, and coastal and offshore habitats for birds.

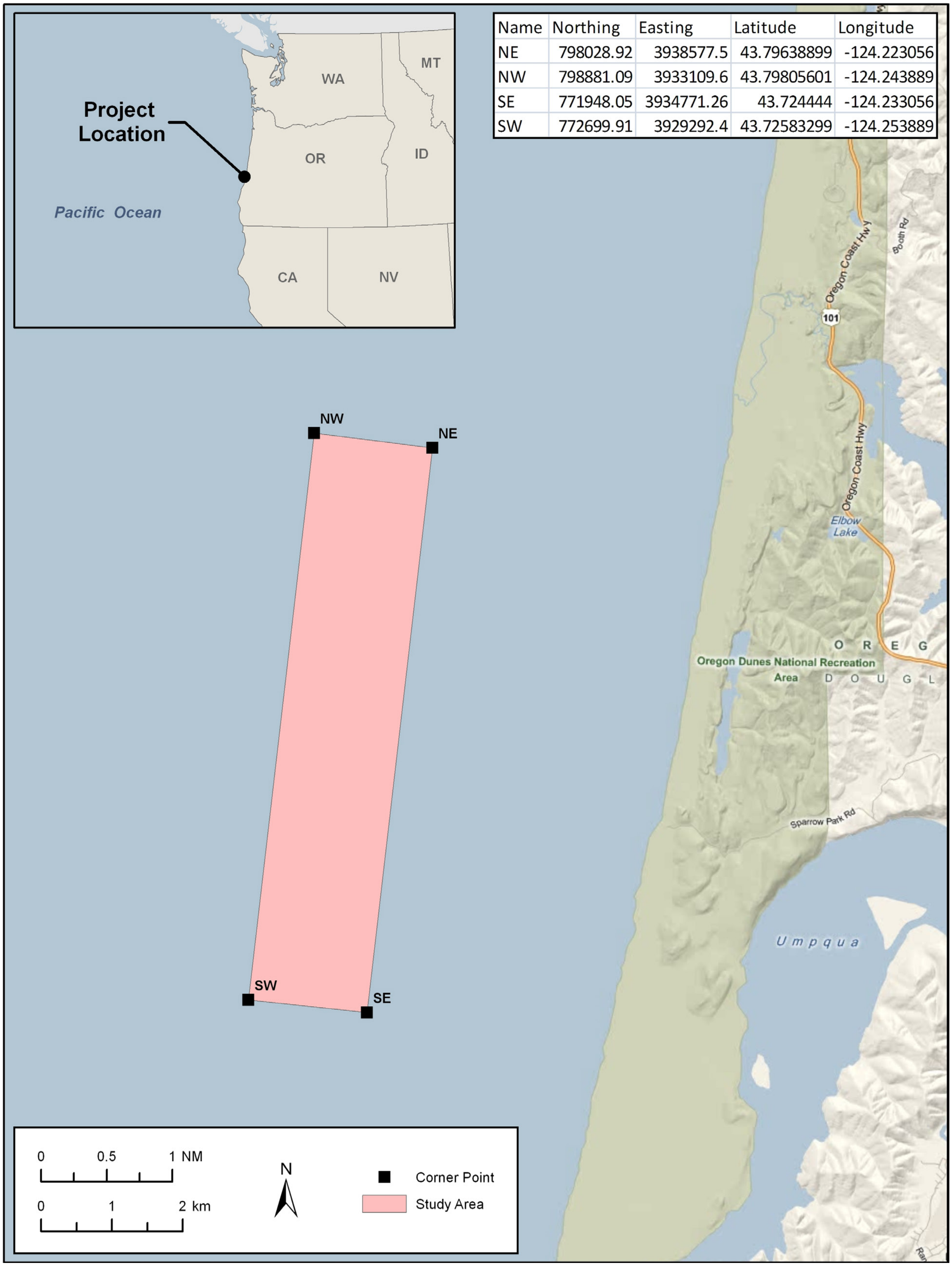
2.1 LOCATION

The proposed study area is located in the Pacific Ocean northwest of Reedsport, Oregon off Oregon Dunes National Recreation Park (**Figure 2-1**). The study area is the proposed location for the Reedsport Ocean Power Technologies (OPT) wave energy project. The rectangular study area ranges from 2.2 to 3.2 nautical miles (NM) offshore of its northern boundary and from 1.8 to 2.8 NM offshore of its southern boundary and is located in waters that range from 150 to 210 feet (ft; 45 to 65 m) deep (Reedsport OPT Wave Park LLC 2006). The approximate center coordinates of the OPT project site are 43.75501 degrees (°) North (N), -124.23521° West (W). Study area boundaries are based on coordinates provided by OPT for a 50 wave buoy project site.

2.2 ENVIRONMENTAL SETTING

The Pacific Northwest contains a diversity of coastal and offshore habitats. The dynamic geological history of the Pacific Northwest, where the Pacific, North American, and Juan de Fuca plates converge, has created an oceanic region containing submarine canyons, banks, and fjords (**Figure 2-2**).

The California current, and the outflow of the Columbia River; undercurrents, tides and winds drive circulation within the inshore regions along the Oregon coast. The upwelling of deep water supplies the region with the majority of nutrients for production of food sources for seabirds. Upwelling occurs near the coastline in the Pacific Northwest Region (**Figure 2-2; Naval Facilities Engineering Command [NFEC 2006]**) and offshore banks in the upwelling area create circulation jetties (**Figure 2-3; NFEC 2006**).



Name	Northing	Easting	Latitude	Longitude
NE	798028.92	3938577.5	43.79638899	-124.223056
NW	798881.09	3933109.6	43.79805601	-124.243889
SE	771948.05	3934771.26	43.724444	-124.233056
SW	772699.91	3929292.4	43.72583299	-124.253889

Figure 2-1. Location of the Proposed OPT Wave Park.

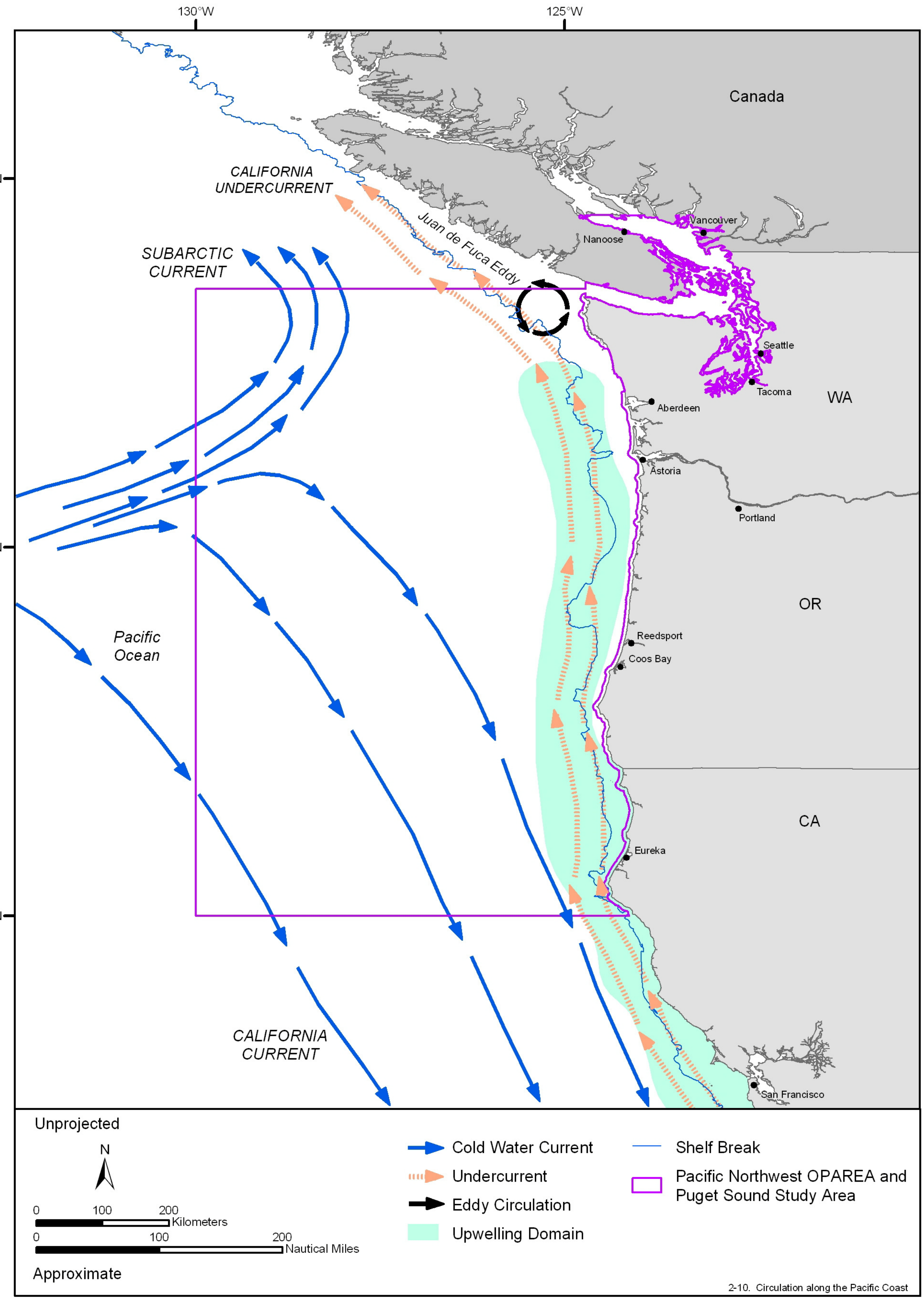


Figure 2-2. Circulation along the Pacific Coast.

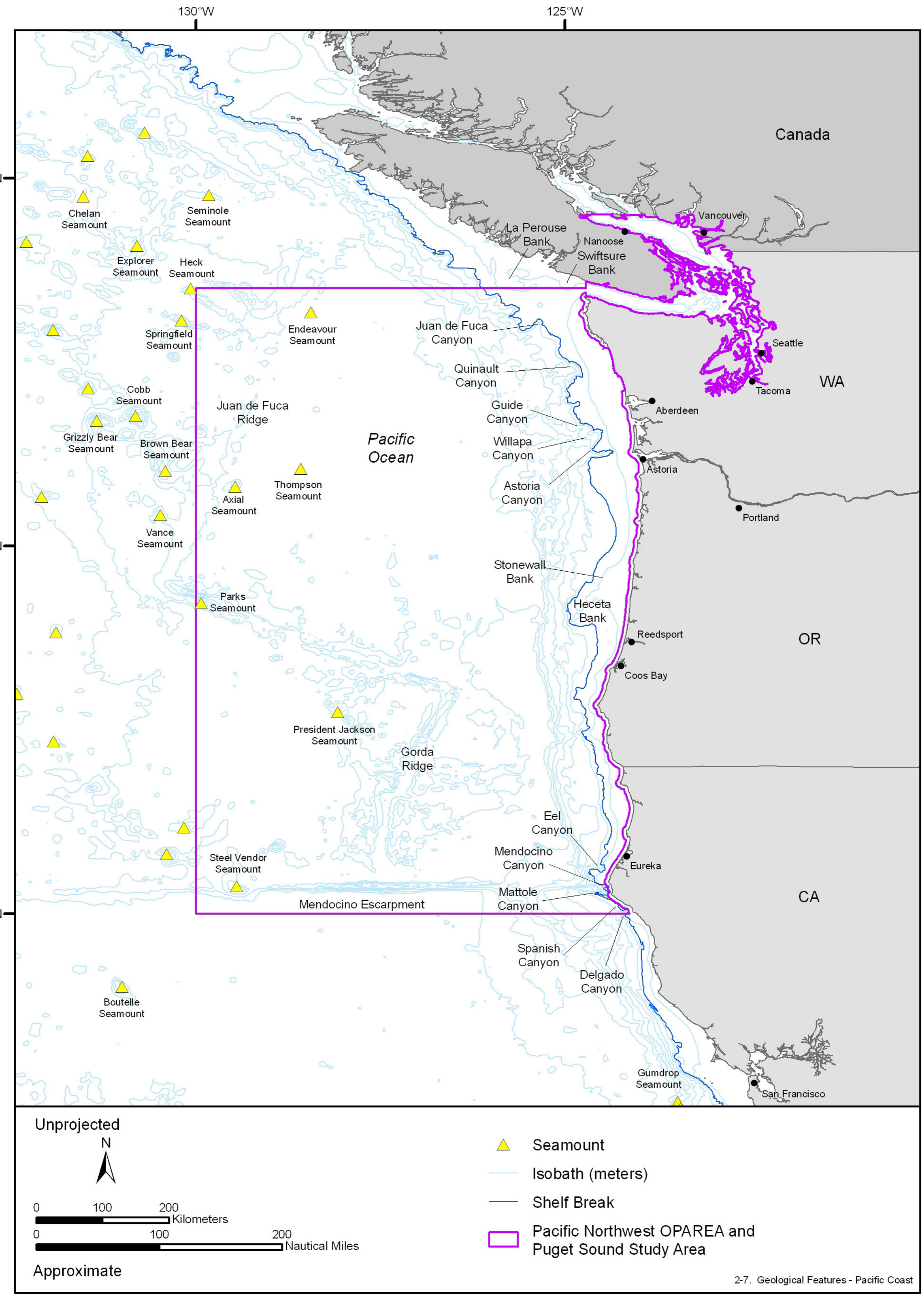


Figure 2-3. Offshore Geological Features along the Pacific Coast.

The varied and unique landforms comprising the Pacific Northwest marine waters and shorelines provide habitat for a diversity of bird species associated with marine environments. From Grays Harbor, Washington south through Oregon and California, land topography has not been influenced by past glacial activity. Shorelines are generally beaches which provide foraging habitat for shorebirds. The shorelines are intersected by coastal headlands and rocky islands, which provide nesting and roosting habitat for cormorants, pelicans, and gulls that forage in coastal and offshore waters. Three prominent features influence the oceanic ecology off Oregon. The first is the Columbia River plume. Depending on the season, the Columbia River plume effluent amounts to between 60% and 90% of the freshwater inflow to the Pacific Ocean between the Strait of Juan de Fuca and San Francisco Bay (Barnes et al. 1972). The second feature is the Heceta and Stonewall Bank complex, a bend in the continental shelf that acts as a circulation jetty, especially during the April to October upwelling season (**Figure 2-3**). The third feature is Cape Blanco on the southern Oregon coast. This feature, jutting into the sea, tends to concentrate winds, which coupled with bottom topography intensifies upwelling (Freeland and Denam 1982; Hickey and Banas 2003). Concentrations of plankton and aggregations of seabirds occur at both Stonewall Bank and Heceta Bank (Ainley et al. 2005; Ressler et al. 2005). Waterfowl, loons, shorebirds, and seabirds (pelicans, shearwaters, petrels, gulls, and alcids) migrate along the Pacific coast (i.e., Pacific Flyway) in spring to summer breeding sites in northern North America and in fall to coastal wintering sites from Washington south to Baja California (Burton 1992; Elphick 1995).

3.0 AVIAN RADAR ORNITHOLOGY

Radar is an acronym for Radio Detection and Ranging. All radars transmit a radio signal, and then receive the reflected signals (echoes) from objects in the atmosphere. The farther away a biological target, the longer it takes for an echo to return to the receiver and the weaker that echo is. Almost any object will reflect radar signals; the strength of the echo is dependent upon the object's composition, the wavelength of the radar signal, the power of the signal, and the distance from the radar to the object. Metal objects reflect radar energy strongly; water and land reflect less strongly. A bird has approximately the same reflectivity as a similar mass of water. Bird echoes are small and weak relative to those of larger metal objects (e.g., boats, airplanes). Therefore, radars are only capable of detecting birds at shorter ranges (usually within 2 – 4 km [1.1 – 2.2 NM] for small birds and out to 12 – 14 km [6.5 – 7.6 NM] for flocks of large birds). Empirical evidence shows that the strength of echoes, or "signals", from birds is generally related to the wavelength of the radar signal (10 centimeter [cm] for S-band radars; 3 cm for X-band radars), the distance from the radar to the bird, the size of the bird, and the profile the bird presents towards the radar. Bird targets are generally more difficult to detect at increasing distance from the radar because the amount of reflectivity) returned to the radar is small. The smaller the biological target (small reflective surface or cross-section), the more difficult it is for the radar to detect. Therefore, low numbers of small biological targets are more likely to be detected at 3.2 km (1.7 NM) from the radar than at 6.4 km (3.5 NM); larger biological targets (i.e., flocks or large birds) can be detected at greater distances (i.e., throughout the radar coverage area). The kilowatt (kW) power of the radar also affects the distance that bird biological targets can be detected.

Radars work primarily along line-of-sight and scan in a circular sweep; therefore, radars cannot detect biological targets behind other objects. Obstructions, such as towers or large vessels, create a shadow, which obscures objects behind them. Such obstructions, as well as the ground or sea (i.e., waves), also reflect energy back to the radar; these echoes are known as clutter echoes. Echoes from waves are of similar or greater strength than bird echoes while tower and or vessel echoes are usually much stronger than bird echoes. Combinations of topographic features (static and/or dynamic) and obstructions can block radar coverage and create "blind spots."

4.0 MOBILE AVIAN RADAR SYSTEM

The GMI Mobile Avian Radar System (MARS®) system was used from shore to monitor bird movements over the proposed project site off of Reedsport, Oregon. The following sections provides a description of the MARS® used for this study including standard operations and capabilities, and discusses the real-time data processing performed by the MARS®.

For this study, the MARS® was equipped with two radar systems (**Figure 4-1**):

- A TracScan (Horizontally Scanning Radar [HSR]) with a 2.5° parabolic dish that determines the range, flight direction, speed, and heading of biological targets in a narrow cone sample volume and is used to determine mean traffic rate (birds/km/hr).
- A VerCat (Vertically Scanning Radar [VSR]) that determines the altitude and range of biological targets.

Figure 4-1. GMI MARS® System showing both VerCat (vertically scanning) antenna (left) and TracScan (horizontally scanning) parabolic dish antenna (right) and transmitter/receivers unit.

Both the TracScan (HSR) and VerCat (VSR) use commercially available marine-band radars to transmit radio signals and receive reflected signals from targets (echoes). These radars transmit for a very short duration (pulse length) and then receive signals from echoes until it is time to transmit the next pulse. The number of times per second that radar transmits a pulse and receives is the pulse repetition frequency (PRF). Radar manufacturers fix combinations of pulse length and PRF in the radar hardware. Commercially available marine-band radars effectively see in two dimensions, using the time between pulse and detection to determine the distance to the biological target, and the orientation of the radar antenna to determine bearing of the biological target.

4.1 TracScan (HSR) Radar

The MARS® (HSR) is used to track bird movements in the horizontal plane. Data on speed and direction of movement, echo intensity, and several other parameters are measured for each track automatically. The MARS® HSR radar scans in the horizontal plane at 24 revolutions per minute (rpm), completing one scan (a full 360° rotation) every 2.5 seconds (s; **Figure 4-2**). Given a PRF of 3,000 times a second, the HSR can transmit 20.83 pulses for every degree of radar rotation. The parabolic antenna projects a 2.5° conical beam that can be tilted to different elevation angles.

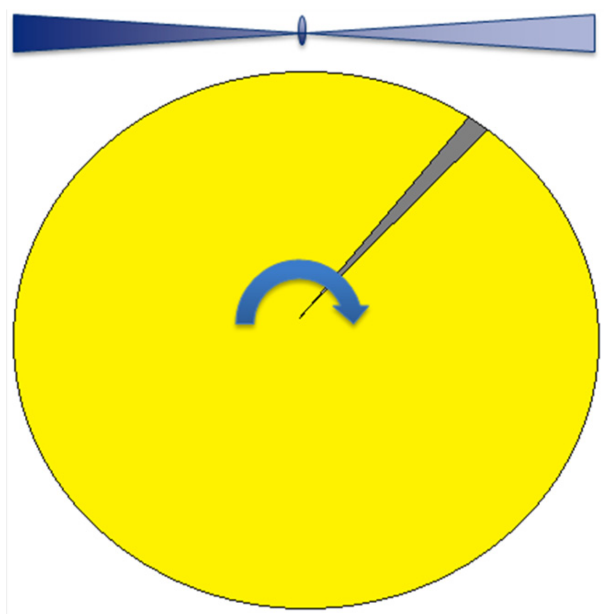


Figure 4-2. TracScan (HSR) Coverage Pattern.

4.2 VerCat (VSR) Radar

The MARS® VerCat (VSR) scans a 20° wedge in a vertical sweep from the horizon, through zenith to the opposite horizon (**Figure 4-3**). No signal is transmitted while the antenna is pointing below horizontal; however, given the 0.95° vertical resolution of the antenna, when the radar transmits a pulse horizontally, almost one half of the energy is projected below the horizon towards the water. The radar scans at 24 rpm, completing one scan (a full 360° rotation) every 2.5 s. Given a PRF of 2,200 pulses per second, it can transmit 15.3 pulses for every degree of radar rotation. The radar signal is transmitted through an 8-ft long array (T-bar) antenna. The antenna focuses the signals into a fan-shaped beam, which is 0.95° in the vertical scanning plane and extends 10° to either side of the scanning plane (20° total). Radar antennas are designed to operate scanning horizontally, not vertically. When the antenna is pointing at the sky, some radio energy leaks out the backside of the standard antenna and bounces off the ground. The MARS® VerCat (VSR) antenna has been fitted with a custom-designed shield to minimize the impact of this ground-bounce clutter.

The VerCat (VSR) scan pattern results in a "radar curtain," that samples biological targets as they fly through the 20° by 180° scanning volume within 3 NM of the radar. For this study the VerCat (VSR) was set to sample from 4° above the water to 20° above land. The radar determines biological target altitude and downrange distance from the MARS® site. The VerCat (VSR) vertical beam width of 0.95° provides fine angular resolution from which estimates of biological target altitude can be determined. Biological targets flying within the beam parallel to the VSR scan can be tracked and accurate ground speeds measured; however, biological targets crossing perpendicular to the sweep of the beam appear stationary and biological targets crossing the sweep at angles between parallel and perpendicular have ground speeds reduced from true ground speeds. Consequently, the VerCat (VSR) is used only to measure the altitude of biological target. Wind speeds in excess of 30 to 35 knots (kts) along the VerCat (VSR) scan axis will trip the VerCat's (VSR) motor safety breaker and shut down the radar. By shutting down operation, the radar protects itself from damage.

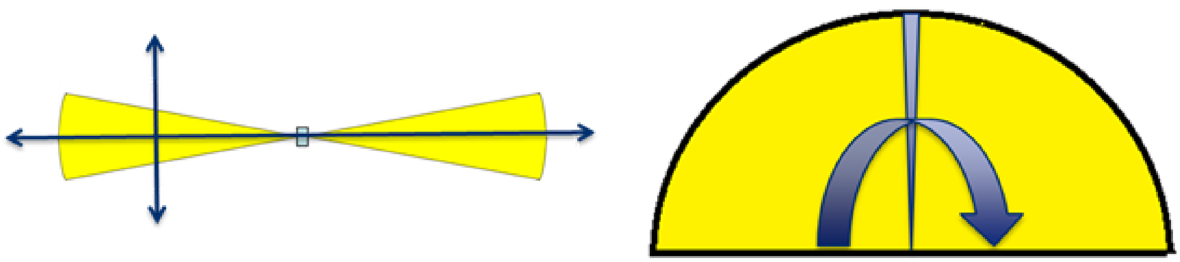


Figure 4-3. VerCat (VSR) Coverage Pattern.

4.3 DATA PROCESSING

The GMI MARS® replaces commercial marine radar processors with high-resolution processors. Radar echoes are digitally captured and sampled at 4,096 levels of resolution. After each radar scan, the MARS® software processes these high-resolution data to generate dynamic maps of background clutter and exploit the small differences between clutter and biological targets.

GMI proprietary algorithms attempt to exploit the distinction between background clutter (even temporary clutter like a rain cloud) and moving biological targets in order to detect small radar echoes in the presence of background clutter. The MARS® software maintains a real-time clutter map that incoming radar echoes are compared against. "Detection" is any echo with a reflectivity that is sufficiently above the real-time background clutter. After making the detection, MARS® automatically archives information about each detection in a track (range bearing, bearing, size, and strength) to a database for future analysis. The definition of "sufficient" is complicated by the variable nature of radar echoes. Biological target echo strength depends upon the biological target's reflective area (radar cross-section) and this is dependent on the size of the bird, flight orientation relative to the radar, and even wing position. These variables can change greatly and rapidly between successive 360° radar scans.

5.0 SURVEY METHODOLOGY

This section describes the avian radar and thermal imaging survey design and methods, quality control procedures, and data analysis for the avian radar validation and radar surveys of the study area.

5.1 AVIAN RADAR SURVEYS

5.1.1 Survey Design, Equipment, and Operating Parameters

As previously discussed, sea clutter is a serious issue for all onshore and offshore-based radars that are being used to collect offshore avian data because sea clutter (waves) when recorded and processed produces false tracks that may resemble bird tracks. The standard MARS® radar system was modified for this project with the intent of reducing false biological targets from sea clutter to improve the detection of low-flying birds. GMI's standard TracScan (HSR) typically consists of a 30-kW S-band marine radar fitted with an open array antenna spinning in the horizontal plane. The standard VerCat (VSR) is a 25-kW X-band marine radar with an open array antenna spinning in the vertical plane. The open array antenna transmits a nearly equal amount of energy below the plane as it does above the plane. Thus, in the horizontal mode, the open array antenna transmits a large portion of its power downward into the sea and receives a large amount of returned energy from waves. For this reason, GMI replaced the open array antenna with a parabolic antenna, which can be tilted upward to radiate energy and receive signals above the waves.

Based on the lessons learned during our radar work off the New Jersey coast and the study during the fall of 2009 in Oregon, GMI used a 3-cm wavelength 50-kW radar with a 2.5° parabolic antenna for horizontal scanning, and a 3-cm, 25-kW radar with an open array antenna for vertical scanning when monitoring bird movements through the study area for a 60+ day period.

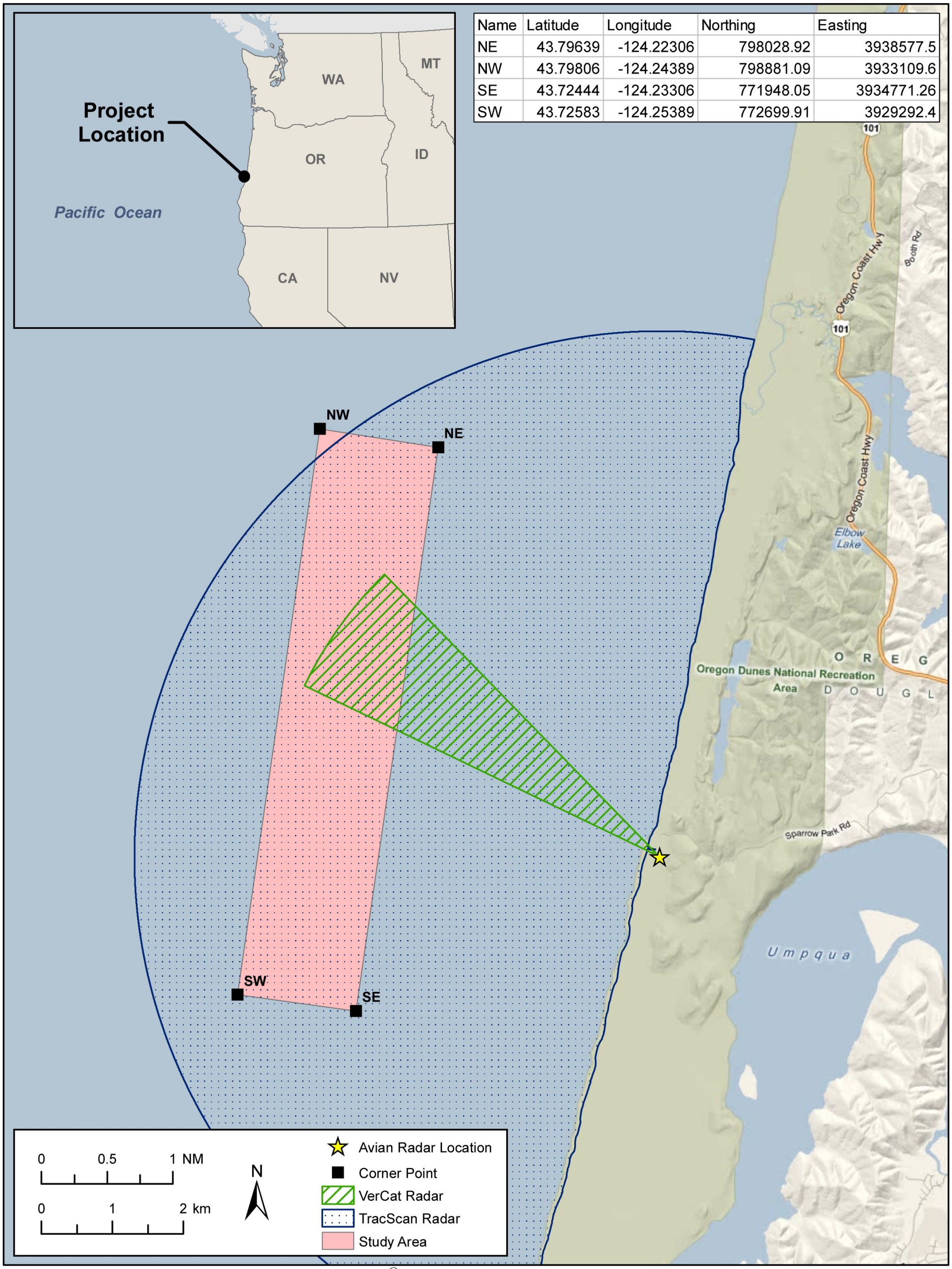
5.1.2 MARS® Site Setup and Testing

As scheduled, the MARS® arrived in Reedsport, Oregon on 22 August 2010. The location selected for the radar was at the end of Sparrow Park Road on the backside of a dune within Oregon Dunes National Recreation Park (**Figure 5-1**).The MARS® was towed to the site on 23 August 2010. The radar unit set-up was completed on 24 August 2010 and testing was initiated. The TracScan (HSR) was set to collect data to 4 nautical miles (NM) and the VSR radar was set to collect data out to 3 NM (**Figure 5-1**). The VerCat (VSR) orientation was 304° and was set to stop transmission 4° above the ocean and at 20° above land.

Dr. Sidney Gauthreaux, GMI's Technical Director of Wildlife Remote Sensing and Technology, was present during the site set-up and testing the system on 25 August 2010. During the testing, Dr. Gauthreaux determined the optimal tilt (3°) of the parabolic antenna on the TracScan (HSR) for monitoring birds moving through and within the project study area; however, he also noted that on stormy days during the study, sea clutter echoes in the study area will obscure echoes from flying birds. If the antenna is elevated to reduce the echoes from sea clutter on these days, the radar will be sampling higher altitudes well above the potential bird–wave buoy impact zone (1-30 ft). The MARS® unit was considered to be operational on 25 August 2010. Radar parameters for this study are listed in **Table 5-1**.

5.1.3 Radar Operations

A GMI radar operator was present daily at the study site to monitor radar operations. The avian radar operator ensured that the unit was level and that the radars, processing computers, and weather station were operational. The radar operator checked the radar display for sea clutter in the study area during the day and noted the extent of the wave clutter on a daily weather sheet. The radar operator adjusted the tilt of the parabolic dish antenna to eliminate to the greatest extent possible sea clutter within the study area. Sample attitudes for various tilt angles used during the study are presented in **Table 5-2**. Daily weather, sea clutter, and parabolic tilt angle data collected during the study are listed in **Appendix A**.



Name	Latitude	Longitude	Northing	Easting
NE	43.79639	-124.22306	798028.92	3938577.5
NW	43.79806	-124.24389	798881.09	3933109.6
SE	43.72444	-124.23306	771948.05	3934771.26
SW	43.72583	-124.25389	772699.91	3929292.4

Figure 5-1. MARS® Radar Coverage of the Study Area.

Table 5-1
MARS® Radar Operating Parameters for 2010 Study

Radar Parameters	Vertical Scanning Radar	Horizontally Scanning Radar
Radar Type	FR 2127	FR 2155BB
Band Type	X-band	X-band
Transmit Peak Power	25 kW	50 kW
Transmit Frequency	9415±30 megahertz (MHz)	9415±30 MHz
Transmit Pulse Length	80 nanosecond (ns)	70 ns
Pulse Repetition Frequency	2200 hertz (Hz)	3000 Hz
Beam width	20° wide vertical sweep	2.5°
Beam width	Vertical 0.95°	2.5°
Maximum Study Range	3 NM (7.4 km)	4 NM (7.4 km)
Antenna Polarization	Vertical	Horizontal
Wave Length	3 cm	3 cm

Table 5-2
Altitudes Sampled by the TracScan Parabolic Dish Antenna

Antenna Elevation	Beam Coverage (ft)	Distance from Radar Site			
		1 NM	2 NM	3 NM	4 NM
0 degrees	top	40.4	80.8	121.2	161.6
	middle	0.0	0.0	0.0	0.0
	bottom	-40.4	-80.8	-121.2	-161.6
1 degree	top	72.2	145.4	218.1	290.8
	middle	32.3	64.7	97	129.3
	bottom	-8.1	-16.1	-24.2	-32.3
2 degrees	top	105.0	210.0	315.0	420.0
	middle	64.4	129.4	194.0	258.6
	bottom	24.4	48.6	72.8	97.0
3 degrees	top	137.2	274.5	4411.7	549.0
	middle	96.9	194.1	291.0	387.9
	bottom	56.6	113.3	169.8	226.3
4 degrees	top	169.5	338.9	508.4	677.8
	middle	129.2	258.8	388.0	517.2
	bottom	88.8	178.0	266.8	355.6

As identified during last year's study, on the test days the VerCat (VSR) had moderate sea clutter echoes when the antenna sampled low altitudes above the water. There are no known technology adjustments that can be made to reduce low altitude sea clutter in the VSR. Therefore, the TracScan (HSR) was operated for the majority of the time during the radar survey. The TracScan (HSR) radar was scheduled to operate on average for 22 hrs/day and the VerCat (VSR) for up to 2 hrs/day. The MARS® operated approximately 61 days from 25 August to 29 October 2010. One day was lost to the failure of a computer component and approximately two days were missed because of generator failure. Daily MARS® operational hours are listed in **Appendix B**.

5.2 QUALITY CONTROL METHODS

In order to relate target identification and counts of birds to radar data, visual avian surveys were conducted from shore and from a boat within the study area (weather permitting: no surveys were conducted in rain, fog). Two types of visual surveys were conducted: land-based near-shore observations from the radar location and offshore observations from a boat. In addition, boat-based nocturnal thermal imaging surveys were conducted in the proposed study area.

In areas with high rates of bird movements it is almost impossible to capture bird activity in three dimensions and relate the visual data to the radar data. To simplify this process GMI has developed a line-intercept protocol for making offshore observations from the shoreline and from a boat (**Appendix C**). This protocol represents a straight-forward way to identify sources of radar echoes when the radar is in surveillance mode. Because the protocol concentrates on birds crossing a specific azimuth line over the water, estimates of bird target range, altitude, and flight direction along with the identity and number can be made by the observer.

5.2.1 Nearshore Radar Validation Survey

An avian biologist conducted land-based nearshore radar validation surveys using a tripod-mounted Kowa TSN 2 spotting scope with a 20X ocular and a 1.7° field of view. The scope was positioned inside the MARS® so that the biologist could look out the open door through the scope and look at the radar screens after an observation was made. For TracScan (HSR) validation, the observation azimuth was set at 307°; the observation azimuth for VerCat (VSR) was 304°. The line-intercept protocol (**Appendix C**) was employed to conduct the surveys. Avian data collected included; identity (nearest identifiable taxon), number observed, estimated flight altitude by flight height range bin (<15: 16-30; 31-100, 100+ ft asl), range to the bird (Near: 0-1 NM; Far: 1-2 NM; Very Far: 2-3 NM), and flight direction. Nearshore radar validation surveys were conducted on 19 days; 41.4 hrs of validation data were collected during the study period (**Table 5-3**).

Table 5-3
Land-based Nearshore Radar Validation Survey Dates and Effort

Survey No.	Survey Date	Survey Time (hr)	Survey No.	Survey Date	Survey Time (hr)
1	8-27-10	5.9	**11**	10-06-10	4.0
2	8-31-10	6.2	**12**	10-07-10	3.0
3	9-04-10	0.4	**13**	10-08-10	2.0
4	9-09-10	0.9	**14**	10-09-10	3.0
5	9-16-10	2.6	**15**	10-10-10	1.0
6	9-19-10	0.5	**16**	10-17-10	1.1
7	9-20-10	1.8	**17**	10-18-10	0.7
8	10-03-10	1.0	**18**	10-19-10	0.5
9	10-04-10	3.2	**19**	10-21-10	0.6
10	10-05-10	3.0	**TOTAL**		41.4

5.2.2 Offshore Radar Validation Surveys

Offshore radar validation surveys were used to supplement the land-based nearshore validation data and provide visual data from within the study area. Two potential boat survey methods (stationary and transect) were tested during the first survey on 29 August 2010.

For the stationary boat surveys, four fixed points (P1-P4) were selected within study area (**Figure 5-2**). All of the stationary point survey locations were positioned at the same latitude as the MARS®, and set approximately 500 m apart. The survey effort was divided to afford 30-40 minutes of survey time at three of the four points for each morning or afternoon validation survey.

For the boat transect surveys, equally spaced line transects were developed with a geographic-based information system (**Figure 5-2**). Two transects, T2 and T3, were surveyed on 29 August 2010 while the boat traveled the transect lines at 10 kts.

Survey methods for both survey types followed the line-intercept protocol (**Appendix C**). The azimuth for observation from the boat was set at 270° away from shore for morning and at 90° towards shore for the afternoon survey. Avian survey data were collected for flying birds from 1 to 500 m along the transect line. Avian data included; identity (nearest identifiable taxon), number observed, estimated flight altitude by flight height range bin (<15: 16-30; 31-100, and 100+ ft asl), range to the bird (0-50 m; 51-100 m; 101-150 m; 151-300 m; and 301-500 m), and flight direction.

The data collected during the three stationary surveys were combined and compared to the combined data from the two transect surveys to determine the preferred survey method. When the survey results were compared, the boat transect surveys had a lower number of detected birds (19) and a lower passage rate (56.29 birds/NM/hr) than the stationary surveys (50/185.18 birds/NM/hr). This result was attributed to the high swell conditions (which were common in the study area throughout the study period) and the difficult observer survey conditions on the moving boat that decreased observer detection of birds. The stationary point method was selected as the method to be used for the remaining offshore radar boat validation surveys.

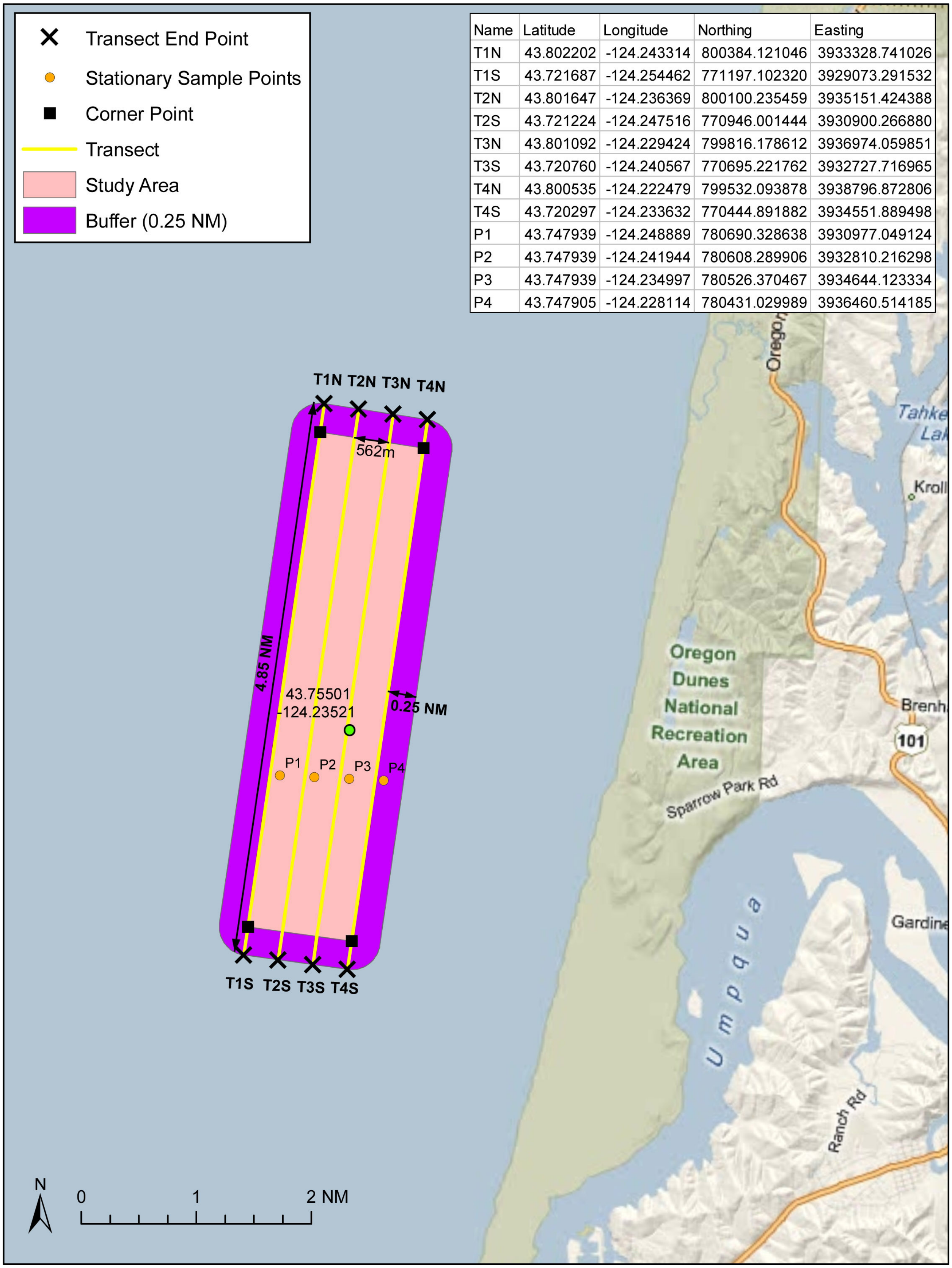
5.2.2.1 Diurnal Visual Boat Surveys

Boat-based daytime validation surveys were conducted on four dates: 29 August 2010 (2 surveys), 10 September 2010 (1 survey) and 21 September 2010 (2 surveys), and 13 October 2010 (2 surveys). During the first two dates afternoon surveys were conducted; on the last two survey dates all-day excursions were scheduled during which both a morning and afternoon survey was completed. Survey effort totaled 14 hrs.

5.2.2.2 Nighttime Thermal Imaging Boat Surveys

A thermal imaging camera (TIC) and recording system were used to determine the nocturnal presence/absence and number of low-flying birds to validate nocturnal radar data. The TIC is able to detect heat signals from a target and record movement of the target as it passes through the camera's field of view. This section briefly describes the components of the TIC/recording system.

The TIC is a fixed focus, un-cooled thermal imaging (TI) camera (FLIR SR-35, FLIR Systems, Inc., Goleta, California) with a 35-millimeter (mm) lens and a 20° field of view. This TI camera is well-suited for short range surveillance use (i.e. monitoring bird activity) with a minimum focus distance of only 1 m. It has a standard resolution focal plane array (FPA) of 320 x 240 pixels with a pixel pitch of 38 microns (µm) and a spectral range of 7.5 to 13 µm. The camera is able to operate in temperatures ranging from -25° Fahrenheit (F) to 130°F. The data are stored on discs via a Digital Video Data (DVD) recorder.



Name	Latitude	Longitude	Northing	Easting
T1N	43.802202	-124.243314	800384.121046	3933328.741026
T1S	43.721687	-124.254462	771197.102320	3929073.291532
T2N	43.801647	-124.236369	800100.235459	3935151.424388
T2S	43.721224	-124.247516	770946.001444	3930900.266880
T3N	43.801092	-124.229424	799816.178612	3936974.059851
T3S	43.720760	-124.240567	770695.221762	3932727.716965
T4N	43.800535	-124.222479	799532.093878	3938796.872806
T4S	43.720297	-124.233632	770444.891882	3934551.889498
P1	43.747939	-124.248889	780690.328638	3930977.049124
P2	43.747939	-124.241944	780608.289906	3932810.216298
P3	43.747939	-124.234997	780526.370467	3934644.123334
P4	43.747905	-124.228114	780431.029989	3936460.514185

Figure 5-2. Offshore Radar Validation Survey Locations.

The TIC was held and stabilized by the avian biologist during the 21 September 2010 surveys and suspended and stabilized by straps tied to the cabin doorframe during the 13 October 2010 surveys. During both exercises the TIC was inside the survey vessel's wheelhouse and aimed out of the cabin door. The passive, suspended method represents an improvement in methods and prevented fatigue that occurred with hand-stabilization methods; the TIC recording from the second survey was more stable and allowed for a more effective analysis. The TIC was positioned approximately 12 ft asl and pointed horizontally. The TIC and DVD recorder were time-synched to the MARS® at the start of the survey. The survey effort was divided to afford 30-32 minutes of survey time at three of the four points for each nighttime validation survey. The surveys were conducted before dawn and after dusk on 21 September 2010 and 13 October 2010. The effective range of the TIC was limited to 300 m by high swells. Survey effort was approximately 8 hrs.

5.3 DATA ANALYSIS METHODS

5.3.1 Radar Validation

5.3.1.1 Observer-Radar Data Correlation

The number of avian sightings by the observer and the observer detection time data were compiled for each land-based nearshore and offshore boat radar validation survey (see Section 5.2.3.3 for radar processing methods). For the nearshore survey, TracScan (HSR) data were processed to determine the number of radar sightings (detections) within a 2.5° cone from the observation azimuth (observers field of view through the spotting scope was 1.7°). For the offshore survey, the number of avian sightings along the 500 m azimuth was compiled and the number of radar sightings within the study area was determined during the avian observation period. A correlation analysis was then conducted to determine the correlation between the observer passage rate (number of avian sightings/NM) and the radar passage rate (birds tracks/NM/hr).

5.3.1.2 Species Occurrence

Species occurrence was determined by review of radar validation survey data. Species occurrence lists were generated for both the land-based nearshore and offshore boat survey effort.

5.3.1.3 Passage Rate

Passage rate (bird sightings/NM/hr) by survey date was determined for land-based nearshore and offshore boat validation surveys. The number of observer sightings per survey was divided by the observer detection time to determine the passage rate.

5.3.1.4 Bird Flight Altitudes

Nearshore and offshore radar validation surveys were analyzed to provide data on bird flight altitudes by survey date. Bird flight altitudes were categorized into the following flight altitude ranges (ft asl): 1-30, 31-100; >100. The total number of sightings per altitude range per day was determined and the percentage of birds sighted per altitude range was calculated.

5.3.1.5 Flock Size

Bird flock size data was determined for nearshore and offshore validation surveys by categorizing bird observations by flock size by flock category by date. Flock categories were: 1-5; 6-10, 11-25; 26-50; 51-100; and 100+ birds.

5.3.1.6 Flight Direction

Bird flight direction data were compiled from the nearshore and offshore boat validation surveys. The number of sightings was compiled for each of the following eight cardinal directions (north [N]; northeast (NE); east [E], southeast [SE]; south [S]; southwest [SW]; west [W]; and northwest [NW]).

5.3.1.7 Nocturnal Thermal Imaging

The identity (to the lowest identifiable taxon) and number of birds passing through the thermal imaging field of view were determined by replaying the DVD stored survey data on a computer. Gulls were attracted by the lights on the boat during the nocturnal surveys. Gulls circling within 50 m of the boat were eliminated from consideration in the passage rate analysis. The nocturnal passage rate (birds/NM/hr) was reported for each survey.

5.3.2 Avian Radar

The altitude and flight speed data collected during this project are intended to be used for the determination of the number of potential bird-wave energy structure collisions and other impacts to birds in the study area. For this reason, a conservative approach was taken in regard to data processing and the reporting of data results. The data analysis was conducted based on the current state of avian radar technology used to collect and analyze the data. Avian radar data were reviewed to eliminate to the extent possible the generation of false tracks, but this procedure also eliminates bird tracks when sea clutter is present.

5.3.2.1 Introduction

European radar studies of local and migratory bird movements in offshore areas selected for wind development projects have noted that rain and waves affect marine radar performance when the radar is operated in the conventional horizontal scan mode (Tulp et al. 1999, Christensen et al. 2004). Off-the-shelf marine radars with array antennas project half of their radiation below the horizontal, and even slight wave action can generate sea clutter echoes that make tracking echoes from birds difficult to impossible. This problem has resulted in some individuals conducting bird movement studies only when the sea is relatively calm. In a study of bird movements and collision risks at the offshore wind farms at Horns Rev, North Sea, and Nysted, Baltic Sea, in Denmark, Blew et al. (2006) used marine radar in a horizontal scanning mode with a range of 2,780 m (1.5 NM). They stated that "A prerequisite for the use of horizontal radar is a calm sea state (wind speeds less than 4.48 miles per hour [mph: 3.9 kts]). Otherwise the signals will be concealed by sea clutter, caused by the reflection of the radar waves by a rough water surface" (Blew et al. 2006). Marine radar has a sea clutter filter but use of this filter may decrease the detection of small birds. At least one European offshore radar study has reported results from a horizontally scanning marine radar (S-band, 30 kW, 25° beam width, 11-km [6-NM] range) with digital processing similar to MARS® TracScan (Kreijgsveld et al. 2005). The authors noted that sea clutter produced 85% of the tracks (false tracks) and cautioned readers that even after the application of a clutter removing procedure, the data still contained an unknown number of false tracks within the ranges affected by sea clutter.

5.3.2.2 Data Processing and Analysis

On land, ground clutter is much more consistent than biological target echoes, although ground clutter may vary slowly over multiple scans. If the reflectivity from a biological target of interest is not much above the reflectivity of background clutter, then the biological target is eliminated when background clutter is eliminated. At sea, clutter varies greatly from scan to scan, and although the MARS® algorithms take the nature of the biological target and the clutter variations into account when determining whether to record the detection as a moving biological target, the dynamic reflectivity of waves often makes this task impossible. In high sea clutter conditions biological targets of interest may be blocked by waves or reflectivity from waves may be processed as bird detections. Rain also produces undesirable dynamic clutter, and in VerCat, echoes from rain and virga (rain not reaching the ground) may greatly inflate the number of detections and lead to the generation of many false tracks. Rain and sea clutter issues were addressed during processing of radar data.

Analysis of MARS® TracScan Data

Processing of TracScan data was evaluated by GMI for the New Jersey Department of Environmental Protection Ocean/Wind Ecological Baseline study report (New Jersey study; GMI 2009). Based on this research GMI developed a series of filtering algorithms to reduce the false tracks associated with sea clutter from land-based and ocean-based radar systems. The algorithms are discussed below and these algorithms were used to process some of the radar data collected for this project.

For the New Jersey study analysis, the distribution and velocity of processed detections were plotted for each day. Velocities recorded by the TracScan (HSR) and VerCat (VSR) were not similar (**Figure 5-3**; **Figure 5-4**). The high mode of TracScan velocities (100-310 kts) was hypothesized to be the result of sea clutter because the majority of birds are not known to fly at these velocities.

To examine the relationship between sea clutter detections and wind velocity the maximum range of detections was determined by inspecting the daily plots of all detections. The density of detections is greatest near the radar (red colored targets) and decreases as a function of range (orange>yellow>green> light blue>dark blue; **Figure 5-5**). The range at which the outer edge of the dark blue targets occurred was recorded. These measures were then correlated with the mean wind velocity at the 1000-millibar (mbar) level (approximately 91 m [300 ft] above the sea) from data posted at http://vortex.plymouth.edu/upcalc-u.html. The resulting relationship (**Figure 5-6**) indicates that about 83% of the variation in maximum range of detections can be explained by mean wind velocity. Because 85% of the recorded data from TracScan type radar can be attributed to sea clutter (Kreijgsveld et al. 2005) and sea clutter conditions are related to mean wind speed, it is possible to predict sea clutter conditions in the TracScan data from data on wind conditions. This is important because tracks resulting from detections from sea clutter (and rain) must be removed in data processing to assure that the results of the analyses relate to tracks of biological targets and not to false tracks.

<u>Reduction of False Tracks</u>

The following procedures were completed during the analyses of Oregon TracScan data to reduce the number of false tracks that result from detections of sea clutter:

1) Eliminated tracks with distances greater than 0.06 NM between successive detections (i.e., tracks with velocities above 51 m/s [100 kts]; **Figure 5-7**)

This procedure eliminated the detections with speeds greater than 185 kilometers per hour (kph) (100 kts) and eliminated the mode of velocities between 51 and 162 m/s (100 and 315 kts; compare **Figures 5-3** and **5-7**).

2) Selected only tracks with nine or more continuous detections (number of echoes per track) (**Figure 5-8**).

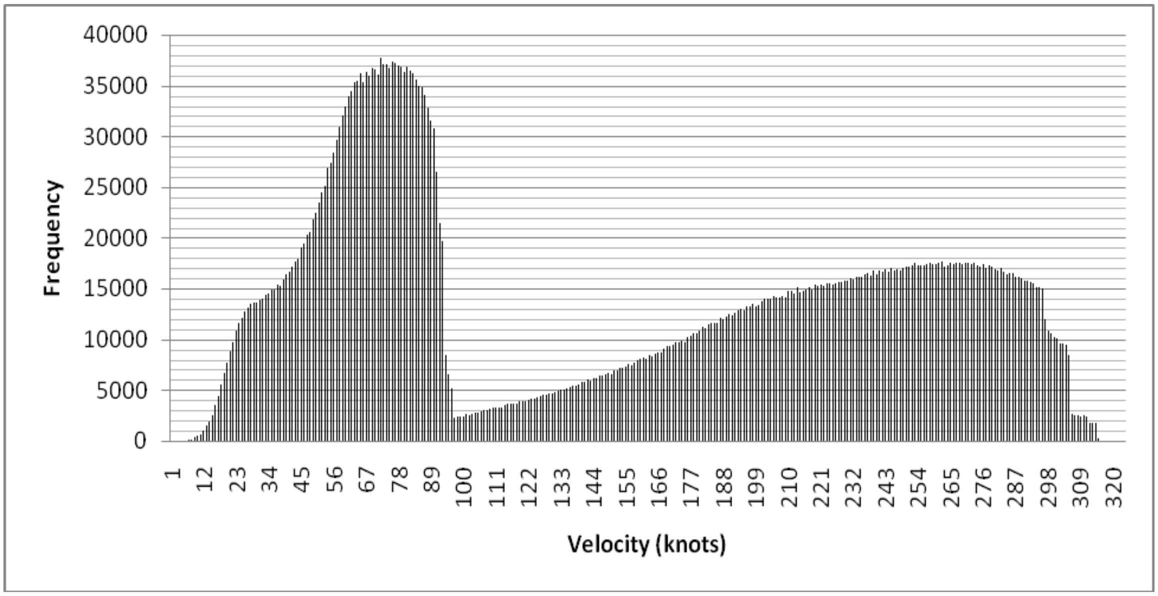


Figure 5-3. Histogram of total ground speeds between detections for 15 March 2008 from MARS® TracScan during the New Jersey study. Note the extraordinary number of detections and the extremely high velocities with no filtering.

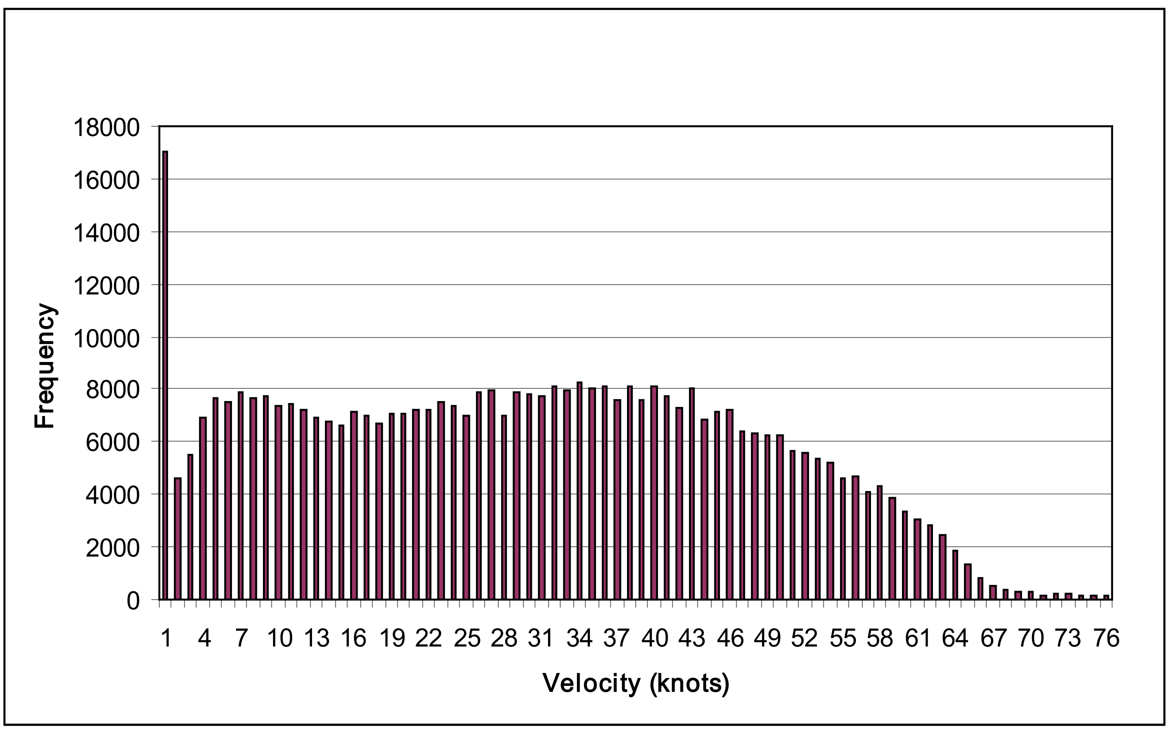


Figure 5-4. Histogram of total ground speeds between detections for 15 March 2008 from MARS® VerCat during the New Jersey study. Note the absence of a second mode of velocities and the lower frequency of velocities above 46 knots (24 m/s or 79 ft/s).

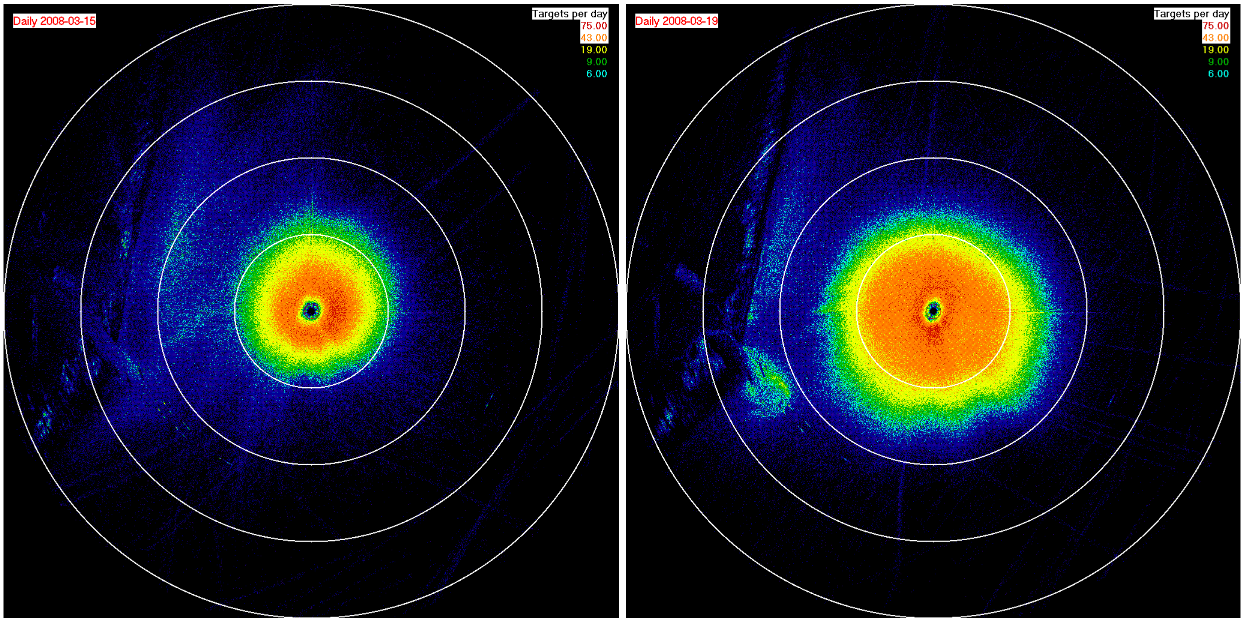


Figure 5-5. Total TracScan detections per day for 15 March 2008 (left) and 19 March 2008 during the New Jersey study (right). Maximum winds on 15 March were 7 to 8 kts and on 19 March were 18 to 19 kts.

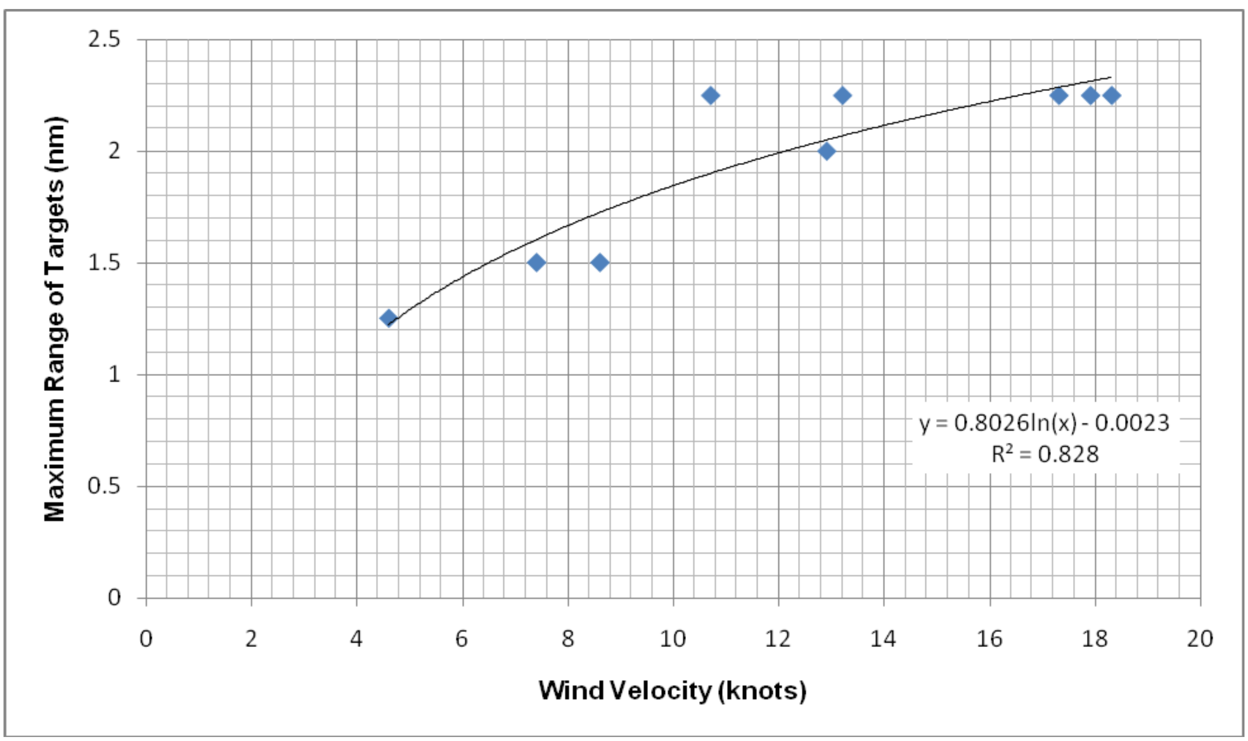


Figure 5-6. Relationship between mean wind velocity and maximum range of targets (sea clutter) in TracScan during the New Jersey study. Note that 82% of the maximum range of targets can be explained by wind velocity.

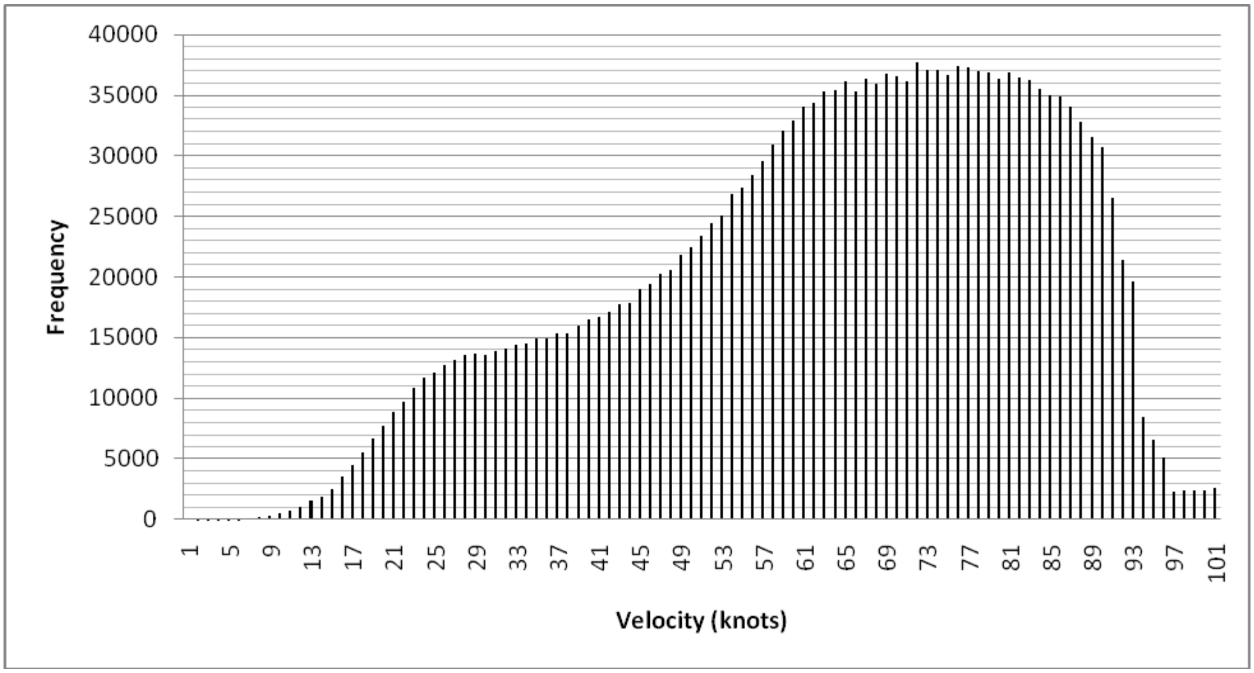


Figure 5-7. Histogram of total ground speeds between detections for 15 March 2008 with velocities greater than 100 kts removed for MARS® TracScan during the New Jersey study.

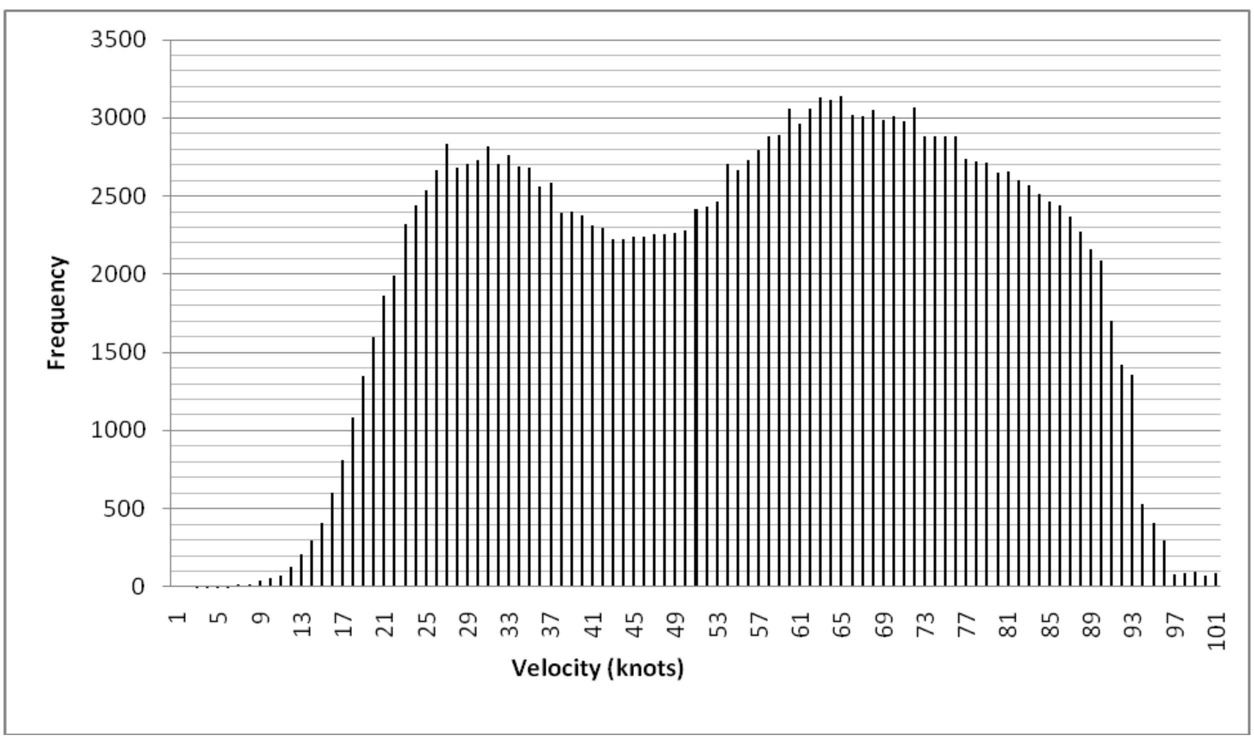


Figure 5-8. Histogram of total ground speeds between detections for 15 March 2008 during the New Jersey study after eliminating tracks that did not have nine continuous detections in a track for MARS® TracScan.

This procedure had a tremendous effect on the frequency of velocities. The highest velocity counts dropped from nearly 37,000 to approximately 3,000 and the histogram showed a bimodal distribution (compare **Figures 5-3** and **5-8**).

3) Sea clutter filter

This filter was developed to eliminate false tracks that resulted from detections of sea clutter within 3 km (1.5 NM) of the radar. When applied the second mode of the ground speed histogram was greatly reduced (**Figure 5-9**) and the speeds were comparable to those measured with VerCat (VSR) (**Figure 5-4**) during the same time period.

Although the above procedures likely eliminated some real bird tracks, it is better to follow a more conservative approach and avoid the possibility of having a large number of false tracks generated by sea clutter.

Rain Clutter Elimination

The following procedures were completed during the analysis of TracScan data to eliminate echoes from rain within the surveillance area:

1) Rain filter

This filtering algorithm is identical to that for sea clutter. The filter greatly reduces false tracks based on detections from rain and clouds of small insects.

Summary of Oregon Study TracScan Data Analysis Protocols

TracScan data were used for calculating the passage rate of birds (bird tracks/NM/hr) within the study area. Biological target tracks in the proposed study area were determined with GMI proprietary data analysis software. Before initiating data processing, time periods with rain were removed from the TracScan database. In summary, the following protocols were conducted during the analyses of TracScan data to further reduce the number of detections produced by sea clutter and false tracks:

1) Tracks with distances greater than 0.06 NM between successive detections (i.e., tracks with velocities above 100 kts) were eliminated prior to final processing.
2) All tracks with gaps in detections were treated as separate tracks to avoid treating two unrelated tracks as one and generating false tracks.
3) All tracks with corners more than 80° were split into separate tracks
4) Only tracks with nine or more continuous detections (number of echoes per track) were included in the analysis.

TracScan data for the study area were then processed to determine passage rate.

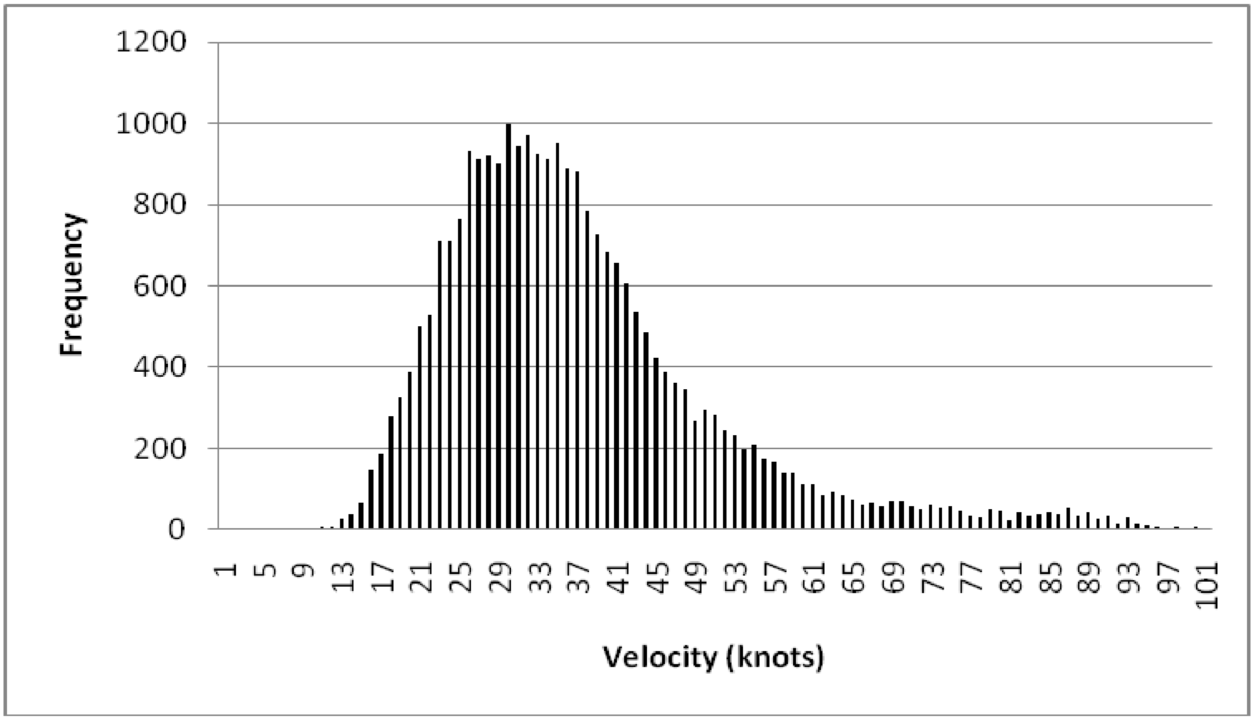


Figure 5-9. Histogram of total ground speeds between detections for 15 March 2008 after applying clutter reduction protocols and the sea clutter filter to the New Jersey data from MARS® TracScan in all weather conditions.

VerCat Data

VerCat data are used for calculating the altitudinal distribution of targets. After the auto capture and on-site processing of the data were completed, the data were removed from the host computer for further analysis. Because VerCat can detect and process precipitation (i.e., rain, sleet, snow), the detections can be processed and generate false tracks and greatly increase the median altitude of targets aloft. It is important to remove false tracks that result from detections of precipitation and sea clutter to assure that the results of the analyses relate to biological targets and not to false tracks.

Rain Contamination

The following procedures were completed during the analyses of VerCat data to eliminate the number of detections from rain:

1) Rain contaminated data were not processed.

Reduction of Sea Clutter Detections

The following procedures were completed during the analyses of VerCat (VSR) data to reduce the number of false tracks that resulted from detections of sea clutter:

1) Did not process the lowest 2° of the VerCat beam (0-2° above the horizontal [sea surface]).

2) Eliminated tracks with less than five detections.

Bird detection data were summarized into daily diurnal and nocturnal tables. Because the distribution of altitudes was not a normal "bell" curve, altitude quartile tables were developed with GMI software programs to describe the distribution of the bird detection altitudes. Relevant descriptive statistics for the observed diurnal and nocturnal altitude distributions include the mean, median, and the 25% and 75% quartiles. The 25% and 75% quartiles are calculated in order to assess the potential presence of altitudinal outliers at the two extremes of the altitude distribution. For example, the presence of high-altitude outliers (e.g., several anomalously high-flying birds) will tend to increase the altitude value of the 75% quartile relative to the value that would occur if no outliers were present. Likewise, the presence of low-altitude outliers (or a greater number than the usual or expected number of low-flying birds) will tend to decrease the altitude value of the 25% quartile. The median altitude (or, equivalently, the 50% quartile) is defined as that altitude at which half the total number of birds observed are flying below the median, and half are flying above the median.

After this processing was completed, the data were reviewed for the presence of missed false detections (**Table 5-4**; **Table 5-5**). Precipitation that falls from clouds, but evaporates before hitting the ground is called "virga". "Virga" can be detected by VerCat and generate false tracks. Virga is detected by examining the data for days with very high median altitudes and high flying counts. Several "virga" days were identified (e.g. 23 October 2009, **Table 5-4**; 13 October 2009; **Table 5-5**). Wave clutter false detections were identified by examining the data for days with very low median altitudes (30 October to 3 November, **Table 5-4**; 01-03 November; **Table 5-5**). Virga and wave clutter detections were then eliminated from the database (gray highlighted dates).

Re-analysis of MARS® VerCat 2009 Data

The VerCat (VSR) altitude data in the 2009 report remained a concern because of some of the high flying counts which still existed after the completion of the sea clutter and virga filtering process (e.g., 21-22 October, **Table 5-4**; 28-29 October, **Table 5-5**). The 2009 VerCat (VSR) data were re-analyzed for report.

The lowest 2° of the radar beam above the water (0-2°) was eliminated from the data to further minimize the effects of sea clutter and the data were reprocessed using the standard reduction of sea clutter algorithms. The sea clutter and virga screening process was then completed on the reanalyzed data.

With the lowest 2° of the VerCat (VSR) beam removed, the bottom of the VerCat beam over the project area is at 533 ft asl. A review of the re-processed 2009 data revealed the occurrence of bird altitudes below the bottom of the VerCat radar beam within the 25% altitude quartile. These data (shaded) are false tracks resulting from wave clutter detections (e.g., 14-27 October, **Table 5-6**; 10-18 October, **Table 5-7**). This contamination may be associated with radar side lobe energy reaching the ocean's surface. In addition, several virga days (e.g., 11 October, **Table 5-6**; 11 November: **Table 5-7**) were identified during the data screening process. Days with false detections from wave clutter and virga were removed from the database.

Even with the additional analyses, altitude data from VerCat (VSR) presented as results in this report should be used with caution. The lowest 2° of the beam contained detections from bird targets as well as return from sea clutter. When the lowest 2° were eliminated from analysis some tracks from sea clutter likely remained and some real tracks were eliminated from the data. All false (sea clutter) detections cannot be removed during data processing.

Table 5-4
Diurnal Biological Target Altitude Data Summary for the Study Area in 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
9/16	4.7	39	86	139	1,705	63	7,977
9/17	9.7	1	34	26	1,998	54	14,586
9/18	3.2	20	73	145	2,745	55	1,585
9/30	0.4	1	1	1	1	0	9
10/1	12.6	1	1	20	29	1	3,875
10/2	11.3	20	116	173	154	3	12,793
10/3	10.6	20	3,135	5,887	3,504	24	20,242
10/4	11.7	1	20	956	1,033	20	8,675
10/5	12.1	20	20	109	83	10	2,757
10/6	10.5	38	109	162	204	19	5,342
10/7	8.5	1	20	45	595	95	1,355
10/8	9.5	1	20	56	52	2	5,023
10/9	12.2	1	1	20	32	1	4,792
10/10	10.1	20	109	12,780	6,823	262	1,634
10/11	8.5	20	20	13,143	7,087	146	5,442
10/12	10.7	73	127	2,996	1,510	10	53,094
10/13	6.9	166	209	251	261	11	554
10/14	9.0	162	216	262	213	3	737
10/15	8.9	198	696	2897	1,816	15	35,631
10/16	11.5	216	935	8,105	4,390	33	28,371
10/17	8.7	572	3135	6,065	3,685	30	11,030
10/18	10.3	234	13,221	15,831	8,897	29	69,644
10/19	10.6	180	216	269	1,247	39	14,419
10/20	8.6	180	216	280	1,656	38	20,526
10/21	9.8	180	248	1,757	1,132	7	60,260
10/22	10.4	180	226	287	2,339	19	59,764
10/23	6.0	1,800	7,799	11,989	7,550	12	234,953
10/24	10.8	180	216	251	335	10	23,296
10/25	11.3	187	234	1,277	2,400	22	54,243
10/26	7.8	170	234	305	1,262	22	20,970
10/27	6.7	294	4,809	10,103	5,674	13	167,351
10/28	11.0	7,913	10,245	12,299	9,136	8	341,642
10/29	2.0	1	91	707	441	13	3,734
10/30	8.6	1	1	1	63	7	30,591
10/31	9.5	1	1	1	2,045	28	51,083
11/1	7.3	1	1	1	98	10	18,112
11/2	9.3	1	1	1	65	12	10,779
11/3	10.8	1	1	1	1,258	43	13,659
11/4	11.0	1	1	160	2,062	72	7,668
11/5	9.5	1	171	239	152	2	4,172

Table 5-4 (*continued*)
Diurnal Biological Target Altitude Data Summary for the Study Area in 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
11/6	4.1	167	214	249	207	4	320
11/7	6.8	-	-	-	-	-	-
11/8	4.5	989	3,759	7,490	4,641	8	239,234
11/9	3.1	-	-	-	-	-	-
11/10	9.4	49	99	127	258	13	21,007
11/11	1.2	63	110	152	273	22	8,348
11/12	6.7	60	99	135	187	5	43,489
11/13	5.5	81	152	3,609	1,241	74	491
11/14	9.0	60	99	124	330	13	17,190
11/15	8.8	56	99	135	183	6	37,425
11/16	7.2	-	-	-	-	-	-
11/17	2.9	67	117	156	138	2	25,983
11/18	7.6	78	117	152	121	3	14,952
11/19		-	-	-	-	-	-
11/20		-	-	-	-	-	-

Note: No VerCat samples were collected from 19-29 September and 19-20 November. Gray highlighted cells indicated high sea clutter/precipitation contaminated dates that were eliminated
Alt = Altitude
STE = Standard Error

Table 5-5
Nocturnal Biological Target Altitude Data Summary for the Proposed Project Area[1] in 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
9/16	3.1	53	1,610	2,560	3,949	65	14,122
9/17	8.6	91	1,999	6,647	5,926	55	26,590
9/18	5.5	56	654	13,422	7096	84	13,331
9/30	5.5	1	1	20	14	1	2,580
10/1	10.2	1	20	109	89	6	3,323
10/2	11.4	56	127	266	299	10	2,407
10/3	10.2	1,020	3,812	7,294	4,499	22	29,771
10/4	8.4	1	45	2,601	1,134	21	6,075
10/5	10.5	1	20	45	466	36	6,044
10/6	6.4	1	20	20	277	39	2,403
10/7	5.7	1	20	109	264	17	2,338
10/8	9.8	1	20	91	87	4	5,055
10/9	7.8	20	56	152	2,689	83	8,013
10/10	10.8	48	344	14,884	7,704	114	8,951
10/11	11.6	52	105	6,275	5,282	92	10,843
10/12	11.9	1,088	2,854	4680	3,042	7	11,249
10/13	4.9	2,623	5,570	8,500	5,866	7	292,939
10/14	8.0	166	209	248	231	4	27,723

Table 5-5 (*continued*)
Nocturnal Biological Target Altitude Data Summary for the Study Area in 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
10/15	4.0	1,052	2,900	5,766	3,729	16	47,943
10/16	11.1	173	198	234	581	43	3,953
10/17	10.0	216	590	2,206	1,393	7	70,578
10/18	12.0	198	668	3,911	3,991	29	44,163
10/19	7.2	184	251	1,355	3,348	55	10,526
10/20	10.0	159	194	234	614	21	21,083
10/21	6.1	1049	4,307	10,540	6,451	16	151,458
10/22	11.3	323	8,842	13,791	8,341	28	53,522
10/23	9.9	1113	3,534	6,813	4,364	9	16,0947
10/24	9.4	180	219	315	2,881	29	48,229
10/25	12.4	981	2,409	4,741	3,078	9	92,297
10/26	4.7	305	4,819	9,561	5,478	13	134,594
10/27	9.2	262	3,025	8,294	4,928	10	263,291
10/28	12.6	184	1,202	4,488	2,392	7	131,988
10/29	12.0	20	1,818	3,359	2,022	4	190,129
10/30	11.3	1	1	1	27	3	48,254
10/31	5.2	1	205	3,840	1,834	9	54,634
11/1	6.3	1	1	1	122	9	28,960
11/2	12.7	1	1	1	129	10	26,654
11/3	11.6	1	1	1	363	23	13,929
11/4	11.7	1	142	210	128	1	21,288
11/5	5.5	1	171	249	487	5	47,984
11/6	2.5	110	730	6,910	3,641	20	46,687
11/7	1.4	61	107	146	105	1	7,374
11/8	5.4	67	106	142	109	1	21,257
11/9	2.0	63	110	152	254	6	29,840
11/10	4.7	63	99	138	125	2	52,911
11/11	3.8	60	99	124	134	5	26,185
11/12	5.7	63	99	135	166	10	15,466
11/13	3.8	60	99	152	110	5	1,714
11/14	6.3	63	99	135	103	1	10,114
11/15	10.3	46	99	152	106	2	11,190
11/16	8.1	63	113	160	112	2	1,930
11/17	4.4	53	110	156	171	5	26,105
11/18	5.0	63	106	149	108	1	1,8273
11/19	-	-	-	-	-	-	-
11/20		-	-	-	-	-	-

Note: No VerCat samples were collected from 19-29 September and 19-20 November. Gray highlighted cells indicated high sea clutter/precipitation contaminated dates that were eliminated
Alt = Altitude
STE = Standard Error

Table 5-6
Re-analyzed Diurnal Biological Target Altitude Data for the Study Area in 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
9/16	4.7	1,985	2,028	2,161	1,854	276	7
9/17	9.7	251	922	3,694	1,886	192	119
9/18	3.2	56	127	5,053	3,396	1103	24
10/1	12.6	554	579	661	521	40	33
10/2	11.3	643	914	1,700	1,301	91	120
10/3	10.6	547	796	1,117	951	54	116
10/4	11.7	561	953	1,455	1,602	174	143
10/5	12.1	518	572	593	533	32	18
10/6	10.5	679	1,821	2,366	1,704	75	116
10/7	8.5	536	629	732	807	99	76
10/8	9.5	522	625	711	691	64	79
10/9	12.2	145	163	178	150	9	32
10/10	10.1	554	590	625	582	18	9
10/11	8.5	750	6,211	6,418	7,829	4227	7
10/12	10.7	1,551	1,672	4,221	2,749	327	21
10/13	6.9	2,331	2,352	2,402	2,062	291	7
10/14	9.0	177	244	376	305	31	41
10/15	8.9	198	835	892	680	73	26
10/16	11.5	145	942	1,096	915	240	16
10/17	8.7	49	522	549	350	77	16
10/18	10.3	163	307	776	851	119	123
10/19	10.6	64	181	240	193	12	145
10/20	8.6	54	67	141	99	9	37
10/21	9.8	23	37	58	52	11	21
10/22	10.4	178	213	240	769	113	103
10/23	6.0	53	149	272	167	20	32
10/24	10.8	39	54	168	124	9	304
10/25	11.3	41	51	61	57	4	100
10/26	7.8	43	63	363	189	18	139
10/27	6.7	51	170	447	290	9	1,154
10/28	11.0	960	2,875	3,298	2,076	187	54
10/29	2.0	533	572	572	553	14	2
10/30	8.6	13	27	170	75	21	14
10/31	9.5	37	203	388	848	233	49
11/1	7.3	9	20	47	116	31	56
11/2	9.3	121	216	225	197	25	29
11/3	10.8	11	146	188	345	249	16
11/4	11.0	18	61	134	153	48	88
11/5	9.5	67	120	183	348	27	307

Table 5-6 (*continued*)
Re-analyzed Diurnal Biological Target Altitude Data Summary for the Study Area in 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
11/6	4.1	55	110	142	97	13	18
11/7	-	-	-	-	-	-	-
11/8	4.5	1,287	1,340	1,376	1,120	72	45
11/9	3.1	41	45	52	47	11	5
11/10	9.4	22	30	43	29	4	8
11/11	1.2	31	42	70	73	18	18
11/12	6.7	35	52	254	192	13	479
11/13	5.5	28	48	271	172	10	503
11/14	9.0	169	230	2,558	1,191	185	49
11/15	8.8	1900	2,007	2,037	1,902	141	29
11/16	7.2	35	87	3,903	1,173	305	33
11/17	2.9	42	57	233	248	38	177
11/18	7.6	30	47	85	306	116	43
11/19	5.6	38	64	127	177	107	10
11/20	-	-	-	-	-	-	-

Note: No VerCat samples were collected from 19-30 September and 7, 20 November. Gray highlighted cells indicated high sea clutter/precipitation contaminated dates that were eliminated.
Alt = Altitude
STE = Standard Error

Table 5-7
Re-analyzed Nocturnal Biological Target Altitude Data Summary for the Study Area in 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
9/16	3.1	67	661	689	3,304	2,732	6
9/17	8.6	376	782	3,039	1,066	584	4
9/18	5.5	-	1	-	1	0	1
10/2	11.4	-	768	-	768	0	1
10/3	10.2	696	700	878	758	49	3
10/4	8.4	3,566	3,801	3,979	4,219	219	50
10/5	10.5	554	1,490	14,464	5,948	2,351	8
10/6	-	-	-	-	-	-	-
10/7	5.7	579	1,106	2,199	1,743	262	35
10/8	9.8	590	664	3,705	1,545	249	33
10/9	7.8	173	317	478	716	97	90
10/10	10.8	536	718	874	737	23	118
10/11	11.6	583	785	1,159	875	29	137
10/12	11.9	1,590	6,169	6,866	4,265	682	16
10/13	4.9	166	251	259	266	23	5
10/14	8.0	187	251	625	2,155	1,230	16
10/15	4.0	6, 236	6,332	6,578	5,860	686	9
10/16	11.1	164	192	318	390	161	11

Table 5-7 (*continued*)
Re-analyzed Nocturnal Biological Target Altitude Data Summary for the Study Area in 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
10/17	10.0	452	487	748	798	117	82
10/18	12.0	172	219	380	245	17	82
10/19	7.2	140	246	830	448	126	7
10/20	10.0	57	212	266	184	16	52
10/21	6.1	40	3,950	4,196	2,285	437	22
10/22	11.3	56	357	2730	946	274	18
10/23	9.9	141	215	305	224	7	384
10/24	9.4	179	233	374	342	25	125
10/25	12.4	257	366	463	381	28	70
10/26	4.7	36	56	144	119	27	51
10/27	9.2	42	65	322	523	65	249
10/28	12.6	743	905	967	851	63	48
10/29	-	-	-	-	-	-	-
10/30	11.3	24	30	43	197	105	50
10/31	5.2	39	216	263	171	15	56
11/1	6.3	7	19	119	66	11	54
11/2	12.7	19	141	174	120	7	126
11/3	11.6	86	127	164	135	17	41
11/4	11.7	66	184	371	271	30	73
11/5	5.5	47	76	850	351	64	46
11/6	2.5	93	106	124	106	5	25
11/7	-	-	-	-	-	-	-
11/8	5.4	22	46	57	35	9	4
11/9	2.0	376	873	1,199	905	73	100
11/10	4.7	467	481	493	437	48	60
11/11	3.8	38	41	160	69	16	1,228
11/12	5.7	28	60	150	89	14	27
11/13	3.8	81	1,239	1,255	910	112	30
11/14	6.3	44	1,512	1,620	890	185	17
11/15	10.3	38	48	221	115	21	32
11/16	8.1	55	864	1,287	977	110	108
11/17	4.4	61	2,297	2,608	1,613	184	38
11/18	5.0	504	711	984	783	78	55
11/19	-	-	-	-	-	-	-
11/20	-	-	-	-	-	-	-

Note: No VerCat samples were collected from 19 September – 01 October, 6 and 29 October, and 7 and 19-20 November; Cells with normal text size have a minimum of 40 minutes of radar survey effort while those with smaller font have 10-39 minutes of radar survey effort. Gray highlighted cells indicated high sea clutter/precipitation contaminated dates that were eliminated.

Alt = Altitude

STE = Standard Error

Analysis of MARS® 2010 VerCat Data

The analysis of the 2010 VerCat data was based on the analysis methods used for the re-analyzed 2009 VerCat (VSR) data. Final data processing and screening processes were identical to that stated above for the 2009 data (**Table 5-8** and **Table 5-9**).

Table 5-8
Diurnal Biological Target Altitude Data Summary for the Study Area[1] in Fall 2010

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
8/26	0.4	-	1,216	-	1,216	0	1
8/27	1.1	1,097	1,178	1,358	1,234	45	9
8/28	1.1	1168	1254	1353	1264	5	564
8/30	1.0	1,145	1,178	1,244	1,193	14	26
9/2	2.3	1,173	1,225	1,334	1,286	22	203
9/4	1.1	1,216	1,315	1,415	1,325	8	340
9/5	1.0	1,154	1,173	1,225	1,363	124	22
9/6	3.2	1,273	1,401	1,543	1,539	83	326
9/8	1.4	898	931	931	915	12	2
9/9	1.0	770	4,781	6,452	4,225	337	57
9/11	1.9	717	760	864	925	131	305
9/12	1.4	751	793	1,016	1,027	182	12
9/13	3.3	793	926	1,002	1,115	109	185
9/15	0.2	850	888	888	869	13	2
9/16		-	10	-	10	0	1
9/21	1.0	836	2,602	2,659	2,171	263	24
9/23	0.7	1,648	2,122	2,516	1,818	280	10
9/24	3.1	556	698	698	627	50	2
9/28	0.6	366	1,334	1,410	1,033	156	10
9/29	0.7	271	461	513	338	81	4
10/2	1.2	-	23,180		23.180	0	1
10/4	2.0	190	285	366	291	40	20
10/5	1.3	176	200	238	205	15	3
10/6	1.0	637	3,561	3,917	3,870	788	31
10/7	2.2	-	333	-	333	0	1
10/8	2.1	224	271	9,979	4,417	1,830	7
10/11	2.0	-	224	-	224	0	1
10/13	1.3	224	698	3,214	1,695	455	11
10/15	1.0	176	247	432	277	34	19
10/19	1.1	190	233	508	277	68	4
10/20	1.11.1	-	1,059	-	1,059	0	1
10/21	0.7	17,526	17,949	18,381	17,984	216	6
10/25	0.9	266	4,453	4,453	2,360	1,480	2

[1] Only for altitudes above 533 ft asl.

Note: Cells with normal text size have a minimum of 40 minutes of radar survey effort while those with smaller font have 10-39 minutes of radar survey effort. Gray highlighted cells indicated high sea clutter/precipitation contaminated dates that were eliminated.

Alt = Altitude

STE = Standard Error

Table 5-9
Nocturnal Biological Target Altitude Data Summary for the Study Area[1] in Fall 2010

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
9/2	0.6	1,145	1,220	1,311	1,209	37	38
9/6	0.2	1,439	1,472	1,539	1,474	20	11
9/29		442	527	565	474	51	16
10/2		262	793	1,088	1,246	596	13

[1] Only for altitudes above 533 ft asl.
Note: Cells with normal text size have a minimum of 40 minutes of radar survey effort while those with smaller font have 10-39 minutes of radar survey effort. Gray highlighted cells indicated high sea clutter/precipitation contaminated dates that were eliminated.
Alt = Altitude
STE = Standard Error

5.4 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

For this project the Project Manager (PM)/Senior Avian Biologist and GMI's Senior Radar Ornithologist were responsible for radar data quality control. The PM/senior avian biologist independently reviewed the radar data processed by the data analyst. Upon completion of the initial review, the Senior Radar Ornithologist reviewed the data and met with the Senior Avian Biologist and discussed their concerns and made decisions regarding the need for additional testing and final decisions regarding data analysis and presentation.

After final processing, radar and thermal imaging data analysis and conclusions, including charts and graphs, were independently reviewed for content and logic errors and any data anomalies by GMI's Senior Radar ornithologist; final corrections to the report were then made to the report

6.0 RESULTS

6.1 AVIAN RADAR VALIDATION

Diurnal and nocturnal radar validation survey results are compared to radar data in this section. Bird species occurrence, bird passage rates, altitude distribution, flock size, and flight direction data are also presented for the diurnal nearshore and offshore visual radar validation surveys and nocturnal thermal imaging validation surveys. All dates listed correspond to Greenwich Standard Time (Universal Time Clock). Daily diurnal and nocturnal bird flight speed histograms are provided separately on a compact disc.

6.1.1 Diurnal Nearshore

6.1.1.1 Visual Validation

TracScan radar passage rate data calculated from radar tracks passing through a 2° cone centered on 307° were compared with observer passage rate data from telescopic observations of birds crossing a line oriented toward 307° of azimuth. Data were analyzed for range bins of 0-1 NM, 1-2 NM, and 2-3 NM. The results can be found in **Table 6-1**. Because of the sea clutter return at ranges out to 2 NM, the radar data were filtered to reduce false tracks from sea clutter detections (see **Section 5.3.2.2**). This procedure likely also reduced the number of bird tracks, and this is evident when the visual observations are compared with radar observations (**Tables 6-1**, **6-8**, and **6-14**). Raw data for the radar validation study can be found in **Appendix D**.

Table 6-1
Comparison of TracScan HSR tracks passing through a 2° cone centered at 307° of azimuth and filtered for sea clutter with birds observed through a telescope crossing a line at 307° azimuth for Fall 2010

Date	Radar Survey Effort (hrs)	Observer Detection Effort[2] (hrs)	Observer Passage Rate[3] 0-1 NM[1]	Radar Passage Rate[4] 0-1 NM[1]	Observer Passage Rate[3] 1-2 NM[1]	Radar Passage Rates[4] 1-2 NM[1]	Observer Passage Rate[3] 2-3 NM[1]	Radar Passage Rate[4] 2-3 NM[1]
27-Aug	3.37	0.88	69.32	0.59	29.54	1.48	0	0
31-Aug	6.15	2.02	55.94	2.11	29.2	9.76	3.96	0.97
4-Sep	0.4	0.07	171.4	0	142.86	0	0	0
9-Sep	0.92	0.1	390	1.09	120	2.17	10	0
16-Sep	1.93	0.35	91.42	0	34.28	0	17.14	0
19-Sep	0.47	0.79	30.38	0	43.04	0	16.45	2.12
20-Sep	1.8	0.35	348.57	0	42.86	1.67	40	1.11
3-Oct	1	0.19	68.42	2	36.84	7	0	0
4-Oct	3.2	0.39	115.38	0	58.97	2.19	25.64	1.87
5-Oct	3	0.55	118.18	0	14.54	0.33	0	1.25
6-Oct	4	0.72	91.67	0	16.67	1.5	16.67	1.25
7-Oct	3	0.37	140.54	0.68	108.11	0.33	48.65	0.33
8-Oct	2	0.36	127.78	0	22.22	2	5.55	0.5
9-Oct	3	0.89	50.56	0	13.83	0	7.86	0
10-Oct	1	0.19	163.16	0	10.53	0	10.53	0
17-Oct	0.8	0.26	165.38	2.5	84.67	12.5	0	8.75
18-Oct	0.8	0.21	200	5	76.19	13.75	0	0
19-Oct	0.5	0.2	150	0	25	0	0	0
21-Oct	0.6	0.25	108	0	60	1.67	4	0

[1] Distance from shore
[2] Visual observation time
[3] birds/NM/hr
[4] 2° cone analysis

The product moment correlation coefficient between observer passage rate and radar passage rate was 0.125 for the 0-1-NM range, 0.160 for the 1-2-NM range, and -0.052 for the 2-3-NM range. The correlations are low because removal of tracks resulting from sea clutter also removed many tracks of birds. At 2-3-NM range, many of the birds observed were flying at altitudes below the coverage of the radar beam (see **Table 6-4**). This is also the reason the correlations are so low for comparison of offshore visual validation surveys and radar coverage over the project area.

6.1.1.2 Avian Species Occurrence

A total of 43 bird species were identified during the nearshore radar validation surveys (**Table 6-2**). Twenty-two bird species were sighted during August 2010, 26 bird species were observed during September 2010, and 23 species were identified in October 2010. Survey effort was 12.1 hrs in August, 6.2 hrs in September, and 23.1 hrs in October.

Table 6-2
Avian Species Observed – Fall 2010 Diurnal Nearshore Radar Validation Surveys

Family Common Name, *Scientific name*	**2010**		
	August	**September**	**October**
Anatidae (geese, swans, and ducks)			
Brant, *Branta bernicla*			X
Cackling Goose, *Branta hutchinii*			X
Canada Goose, *Branta canadesnis*			X
American Widgeon, *Anas americana*	X		
Gadwall, *Anas strepera*			X
Northern Pintail, *Anas acuta*	X	X	X
Lesser Scaup, *Aythya affinis*		X	
Surf Scoter, *Melanitta perspicillata*	X	X	X
White-winged Scoter, *Melanitta fusca*	X	X	X
Black Scoter, *Melanitta niger*			X
Long-tailed Duck, *Clangula hyemalis*			X
Gaviidae (loons)			
Red-throated Loon, *Gavia stellata*	X		X
Pacific Loon, *Gavia pacifica*	X	X	X
Common Loon, *Gavia immer*	X	X	
Podicipedidae (grebes)			
Red-necked Grebe, *Podiceps grisegena*		X	
Western Grebe, *Aechmophorus occidentalis*	X	X	X
Procellariidae (petrels and shearwaters)			
Northern Fulmar, *Fulmarus glacialis*		X	
Pink-footed Shearwater, *Puffinus creatopus*		X	
Buller's Shearwater, *Puffinus bulleri*		X	
Sooty Shearwater, *Puffinus griseus*	X	X	X
Pelecanidae (pelicans)			
Brown Pelican, *Pelecanus occidentalis*	X	X	X
Phalacrocoracidae (cormorants)			
Brandt's Cormorant, *Phalacrocorax penicillatus*		X	
Double-crested Cormorant, *Phalacrocorax auritus*	X	X	X
Pelagic Cormorant, *Phalacrocorax pelagicus*	X	X	X
Falconidae (falcons)			
Peregrine Falcon, *Falco peregrinus*			X
Scolopacidae (sandpipers)			
Whimbrel, *Numenius phaeopus*	X	X	
Sanderling, *Calidris alba*		X	X
Western Sandpiper, *Calidris mauri*	X		
Red-necked Phalarope, *Phalaropus lobatus*		X	
Laridae (gulls and terns)			
Parasitic Jaeger, *Stercoarius parasiticus*		X	
Western Gull, *Larus occidentalis*	X	X	X
Glaucous-winged Gull, *Larus hyperboreas*	X		X
Heermann's Gull, *Larus heermanni*	X		
California Gull, *Larus californicus*	X	X	X
Herring Gull, *Larus argentatus*		X	
Caspian Tern, *Hydroprogne caspia*		X	

Table 6-2 (*continued*)
Avian Species Observed – Fall 2010 Diurnal Nearshore Radar Validation Surveys

Family Common Name, *Scientific name*	**2010**		
	August	**September**	**October**
Laridae (gulls and terns)			
Common Tern, *Sterna hirundo*		X	
Alcidae (auks)			
Common Murre, *Urai aalge*			X
Pigeon Guillemot, *Cepphus columba*	X		
Marbled Murrelet, *Brachyramphis marmoratus*			X
Cassin's Auklet, *Ptychoramphus aleuticus*	X		
Rhinoceros Auklet, *Cerorhinca monocerta*	X	X	
Tufted Puffin, *Frateracula cirrhata*	X		

6.1.1.3 Passage Rate

Passage rates ranged from 30 to 390 bird sightings/NM/hr from 0-1 NM offshore and from 10-142 bird tracks/NM/hr from 1-2 NM offshore (**Table 6-3**). Passage rates in the 1-2-NM range may be underestimated because of decreasing observer detection efficiency at increasing distances from the survey site.

Table 6-3
Diurnal Passage Rate - Fall 2010 Nearshore Avian Radar Validation Surveys

Date	Observer Survey Effort (hrs)	Observer Detection Effort (hrs)	Passage Rate[1] 0-1 NM	Passage Rate[1] 1-2 NM
8-27	5.9	0.88	69.32	29.54
8-31	6.2	2.02	55.94	29.20
9-04	0.4	0.07	171.40	142.86
9-09	0.9	0.10	390.00	120.00
9-16	2.6	0.35	91.42	34.28
9-19	0.5	0.79	30.38	43.04
9-20	1.8	0.35	348.57	42.86
10-3	1.0	0.19	68.42	36.84
10-4	3.2	0.39	115.38	58.97
10-5	3.0	0.55	118.18	14.54
10-6	4.0	0.72	91.67	16.67
10-7	3.0	0.37	140.54	108.11
10-8	2.0	0.36	127.78	22.22
10-9	3.0	0.89	50.56	13.83
10-10	1.0	0.19	163.16	10.53
10-17	1.1	0.26	165.38	84.67
10-18	0.7	0.21	200.00	76.19
10-19	0.5	0.20	150.00	25.00
10-21	0.6	0.25	108.00	60.00
TOTAL	41.4	9.14	-	-

[1] bird tracks/NM/hr

6.1.1.4 Altitude Distribution

Throughout the 25 August 25 to 29 October 2010 study period, the majority of birds (94%) were observed were flying at or below 100 ft asl (**Table 6-4**). In the 1-100-ft asl altitude range, 74% were flying between 1 and 30 ft asl. The daily variation noted in altitude percentage for each altitude range may be associated with the dominant species present on the survey day, the weather and sea state condition, and the survey duration.

6.1.1.5 Flock Size

Most of the birds sighted during the nearshore radar validation surveys (87.9%) were in the 1-5 individual flock category (**Table 6-5**). Flock size frequency decreased with an increase in flock size category. The majority of the birds in the 6-10, 11-25, and 26-50 size category were dabbling and diving ducks (e.g., Northern Pintail and scoters) and Double-crested Cormorants. Shorebirds (e.g. Sanderling, Red-necked Phalarope) and gulls (e.g., Western Gull) were the dominant species/guilds in the 51-100 and 100+ flock size categories.

Table 6-4
Diurnal Nearshore Altitude Distribution (Sightings per Altitude Range [ft asl]) - Fall 2010 Radar Validation Surveys

Date	Effort (hrs)	No. 1-30 ft	No. 31-100 ft	No. 100+ ft	Total No.	Percent 1-30 ft	Percent 31-100 ft	Percent >100 ft
8-27	5.9	67	14	5	86	77.91	16.28	5.81
8-31	6.2	147	27	7	181	81.22	14.92	3.86
9-04	0.4	12	8	1	21	57.14	38.10	4.76
9-09	0.9	46	6	-	52	88.46	11.54	-
9-11	1.0	17	9	1	27	62.96	33.34	3.70
9-16	2.6	85	7	2	94	90.42	7.45	2.13
9-19	0.5	143	8	2	153	93.46	5.23	1.31
9-20	1.8	201	12	1	214	93.92	5.61	0.47
10-03	1.0	15	5	-	20	80.00	20.00	-
10-04	3.2	32	29	18	79	40.51	36.71	22.78
10-05	3.0	46	12	16	74	62.16	16.22	21.62
10-06	4.0	54	27	9	90	60.00	30.00	10.00
10-07	3.0	57	36	17	110	51.82	32.73	15.45
10-08	2.0	39	13	4	56	69.65	23.21	7.14
10-09	3.0	49	14	1	64	76.56	21.88	1.56
10-10	1.0	33	2	-	35	94.29	5.71	-
10-17	1.1	33	28	4	65	50.77	43.08	6.15
10-18	0.7	43	12	3	58	74.13	20.70	5.17
10-19	0.5	12	21	2	35	34.29	0.60	5.71
10-21	0.6	26	16	1	43	60.47	37.21	2.32
TOTAL	42.4	1,157	306	94	1,557	74.31	19.66	6.03

Table 6-5
Diurnal Flock Size Frequency - Fall 2010 Nearshore Radar Validation Surveys

Date	Number/Flock Size Category					
	1-5	6-10	11-25	26-50	51-100	100+
8-27	81	4	1	-	-	-
8-31	156	3	8	8	3	2
9-04	20	-	-	-	-	-
9-09	49	1	1	-	-	-
9-16	61	1	-	-	-	-
9-19	61	6	2	-	-	1
9-20	204	8	-	4	-	-
10-3	11	1	4	3	-	-
10-4	53	10	8	6	1	-
10-5	60	3	4	4	1	-
10-6	78	4	2	2	3	2
10-7	91	9	9	-	-	-
10-8	58	-	1	-	-	-
10-9	60	2	1	-	-	-
10-10	28	1	11	11	-	-
10-17	60	1	4	-	-	-
10-18	51	2	3	-	-	-
10-19	31	2	2	-	-	-
10-21	39	-	-	1	-	1
TOTAL	1,252	58	61	39	8	6

6.1.1.6 Flight Direction

Dominant flight directions varied by survey date (**Table 6-6**). As expected, the dominant flight direction was to the south. Peak southbound migration dates were 31 August and 19-20 September and on 4, 6, 17, 18, 19 October 2010.

6.1.1.7 Incidental Observations

Birds

Thirteen bird species not identified during land-based nearshore radar validation surveys were found incidentally while observing nearshore areas near the radar site (**Table 6-7**). Numerical estimates of all birds observed incidentally from shore are listed in **Appendix E**.

Mammals

Harbor porpoise (*Phocoena phocoena*) and California sea lion (*Zalophus califoricus*) were observed on approximately 50% of the land-based nearshore radar validation survey days.

Table 6-6
Diurnal Flight Direction Frequency - Fall 2010 Nearshore Radar Validation Surveys

Date	Flight Direction							
	N	NE	E	SE	S	SW	W	NW
8-27	49	-	-	3	27	-	1	2
8-31	50	4	-	-	110	8	2	4
9-04	8	-	-	-	11	-	-	1
9-09	11	-	1	3	30	4	-	2
9-16	12	-	1	3	41	-	-	-
9-19	6	-	-	-	66	-	-	-
9-20	38	1	-	1	290	1	-	2
10-3	10	-	-	-	10	-	-	-
10-4	4	-	1		70	-	-	-
10-5	12	1	-	3	24	1	-	1
10-6	20	-	-	3	61	-	2	1
10-7	30	-	-	-	24	-	-	4
10-8	39	-	-	-	17	-	-	-
10-9	29	-	-	2	29	2	-	2
10-10	20	-	-	-	15	-	-	-
10-17	12	-	-	1	46	1	-	1
10-18	18	3	-	2	30	1	-	-
10-19	-	-	-	-	33	2	-	-
10-21	26	-	-	1	13	-	-	3
Total	394	9	3	22	947	20	5	23

Table 6-7
Additional Avian Species Observed during Incidental Diurnal Nearshore Surveys

Family Common Name, *Scientific name*	**2010**		
	August	**September**	**October**
Anatidae (geese, swans, and ducks)			
Wood Duck, *Aix sponsa*		X	
Mallard, *Anas platyrhynchus*	X	X	
Northern Shoveler, *Anas clypeata*	X	X	
Green-winged Teal, *Anas creeca*	X	X	
Greater Scaup, *Aythya marla*		X	
Podicipedidae (grebes)			
Eared Grebe, *Podiceps nigricollis*	X		
Procellariidae (petrels and shearwaters)			
Northern Fulmar, *Fulmarus glacialis*		X	
Ardeidae (herons and egrets)			
Great Blue Heron, *Ardea herodias*	X	X	
Accipitridae (falcons)			
Osprey, *Pandion haliaetus*	X	X	
Northern Harrier, *Circus cyaneus*		X	
Bald Eagle, *Haliaeetus leucocephalus*	X		
Scolopacidae (sandpipers)			
Semi-palmated Plover, *Charadrius semipalmatus*	X		
Killdeer, *Charadrius vociferus*	X		

6.1.2 Diurnal Offshore

6.1.2.1 Visual Validation

The passage rate of visually detected birds and the passage rate of radar tracks for daytime observations offshore can be found in **Table 6-8**. This table shows for each sampling date the survey effort in hours and the passage rates (the number of birds observed crossing per 1 NM/hr for visual observations and the number of tracks crossing per 1 NM/hr recorded by radar.

Table 6-8
Comparison of passage rates of TracScan HSR tracks and bird passage rates from diurnal visual offshore validation surveys for Fall 2010

Date	Observer Radar Survey Effort (hrs)	Observer Passage Rate[1]	Radar Passage Rate[2]
30-Aug	1	185.2	0.43
10-Sep	1.8	141.99	0
22-Sep	2	233.35	6.42
23-Sep	1.75	268.8	1.17
14-Oct	1.9	235.89	0
15-Oct	1.8	221.18	0

[1] Bird crossings/NM/hr
[2] Tracks on radar/NM/hr

The product correlation coefficient between observer passage rate and radar passage rate was 0.306 for daytime samples. The correlation is poor because nearly all of the birds observed were flying at altitudes below the radar beam. By comparison far more birds were flying low over the project area than at altitudes where radar could detect them (see **Table 6-11**).

6.1.2.2 Avian Species Occurrence

A total of 32 bird species were identified during the offshore radar validation surveys (**Table 6-9**). Fourteen bird species were observed during August, 25 were sighted in September, and 21 species were located in October 2010.

6.1.2.3 Passage Rate

Transect and stationary point survey count methods were compared during the first offshore boat radar validation survey on 29 August 2010. The avian biologist reported that observation conditions were more difficult during the boat transect survey than conducting during the stationary boat survey. During the transect surveys, boat movement through the swells (8 ft) resulted in lower detection percentages, and therefore passage rate of birds than during the stationary boat surveys. Only stationary boat surveys were conducted during subsequent offshore radar validation surveys. Offshore passage rates for the stationary point counts ranged from 142-269 birds/NM/hr (**Table 6-10**).

Table 6-9
Avian Species Observed – Fall 2010 Diurnal Offshore Boat Radar Validation Surveys

Family Common Name, *Scientific name*	**2010**		
	August	**September**	**October**
Anatidae (geese, swans, and ducks)			
Cackling Goose, *Branta hutchinsii*			X
Wood Duck, *Aix sponsa*		X	X
American Widgeon, *Anas americana*		X	
Northern Pintail, *Anas acuta*		X	X
American Green-winged Teal, *Anas crecca*		X	
Harlequin Duck, *Histrionicus histrionicus*			X
Surf Scoter, *Melanitta perspicillata*	X	X	X
White-winged Scoter, *Melanitta fusca*			X
Loons			
Red-throated Loon, *Gavia stellata*	X	X	
Pacific Loon, *Gavia pacifica*	X	X	X
Common Loon, *Gavia immer*		X	X
Procellariidae (petrels and shearwaters)			
Northern Fulmar, *Fulmarus glacialis*	X	X	
Pink-footed Shearwater, *Puffinus creatopus*	X	X	
Buller's Shearwater, *Puffinus bulleri*	X	X	
Sooty Shearwater, *Puffinus griseus*	X	X	X
Pelecanidae (pelicans)			
Brown Pelican, *Pelecanus occidentalis*			X
Phalacrocoracidae (cormorants)			
Brandt's Cormorant, *Phalacrocorax penicillatus*		X	
Double-crested Cormorant, *Phalacrocorax auritus*	X	X	
Pelagic Cormorant, *Phalacrocorax pelagicus*		X	X
Scolopacidae (sandpipers)			
Red-necked Phalarope, *Phalaropus lobatus*	X	X	
Laridae (gulls and terns)			
Pomarine Jaeger, *Stercoarius pomarine*		X	
Parasitic Jaeger, *Stercoarius parasiticus*		X	X
Western Gull, *Larus occidentalis*	X	X	X
Glaucous-winged Gull, *Larus hyperboreas*		X	X
Heerman's Gull, *Larus heermanni*			X
California Gull, *Larus californicus*		X	X
Herring Gull, *Larus argentatus*	X		
Alcidae (auks)			
Common Murre, *Urai aalge*	X	X	X
Marbled Murrelet, *Brachyramphis marmoratus*			X
Pigeon Guillemot, *Cepphus columba*	X	X	X
Cassin's Auklet, *Ptychoramphus aleuticus*	X	X	X
Rhinocorus Auklet, *Cerorhinca monocerta*		X	X

Table 6-10
Passage Rate - Fall 2010 Diurnal Offshore Avian Radar Boat Validation Surveys

Date	Observer Survey Effort (hrs)	Observer Detection Effort (hrs)	No. Birds per 500 m	Passage Rate[1]
8-29[2]	2.00	1.25	19	56.30
8-30[3]	2.00	1.00	50	185.20
9-10[3]	2.00	1.80	69	141.99
9-22[3]	2.00	2.00	126	233.35
9-23[3]	2.00	1.75	127	268.80
10-14[3]	2.00	1.90	121	235.89
10-15[3]	2.00	1.80	107	220.18
Total	14.00	11.50	-	-

[1] birds tracks/NM/hr
[2] transect survey
[3] stationary point survey

6.1.2.4 Altitude Distribution

The majority of birds observed (93%) during the diurnal visual offshore boat radar validation surveys in the study area were sighted flying from 1-100 ft asl (**Table 6-11**). Most the birds within this altitude category were flying between 1 and 30 ft asl. As previously discussed, the variation noted in altitude percentage for each altitude range may be associated with the dominant species present on the survey day, the weather and sea state condition, and the survey duration.

Table 6-11
Offshore Altitude Distribution (Sightings per Altitude Range [ft asl]) – Fall 2010 Radar Boat Validation Surveys

Date	Survey Effort (hrs)	Number 1-30 ft	Number 31-100 ft	Number >100 ft	Total Number	Percent 1-30 ft	Percent 31-100 ft	Percent >100 ft
8-29[1]	1.25	15	2	2	19	79.90	10.55	10.55
8-30[2]	1.00	48	2	-	50	96.00	4.0	-
9-10[2]	1.80	49	23	2	74	66.2	31.10	2.70
9-22[2]	2.00	119	34	13	166	71.68	20.48	7.84
9-23[2]	1.75	122	16	25	163	74.85	9.82	15.33
10-14[2]	1.90	111	14	1	126	88.09	11.11	0.80
10-15[2]	1.80	94	18	5	117	80.34	15.38	4.28
TOTAL	11.50	558	109	48	715	78.04	15.25	6.71

[1] transect survey
[2] stationary point survey

6.1.2.5 Flock Size

Most of the birds sighted during the diurnal offshore boat radar validation surveys (98.2%) were in the 1-5 individual category (**Table 6-12**). Very few flocks with greater than 5 individuals were sighted during the offshore surveys.

Table 6-12
Diurnal Flock Size Frequency - Fall 2010 Offshore Radar Validation Surveys

Date	Number/Flock Size Category					
	1-5	6-10	11-25	26-50	51-100	100+
8-29[1]	24	-	-	-	-	-
8-30[2]	50	-	-	-	-	-
9-10[2]	69	-	-	-	-	-
9-22[2]	163	3	1	-	-	-
9-23[2]	162	2	1	-	-	-
10-14[2]	122	3	-	-	1	-
10-15[2]	105	1	-	1	-	-
TOTAL	695	9	2	1	1	-

[1] transect survey
[2] stationary point survey

6.1.2.6 Flight Direction

Dominant flight directions varied by survey date (**Table 6-13**). Overall, the dominant flight direction was from the south to the north or from the north to the south. Southbound migration occurred on 22-23 September and on 15 October 2010.

Table 6-13
Diurnal Flight Direction Frequency - Fall 2010 Offshore Radar Validation Surveys

Date	Flight Direction							
	N	NE	E	SE	S	SW	W	NW
8-29[1]	12	1	-	1	4	-	-	1
8-30[2]	39	2	-	-	6	3	-	1
9-10[2]	26	-	-	-	31	2	2	5
9-22[2]	11	3	-	3	132	13	1	2
9-23[2]	2	-	1	1	145	15	1	-
10-14[2]	75	6	1	2	43	-	-	1
10-15[2]	17	2	1	2	82	19	1	2

[1] transect survey
[2] stationary point survey

6.1.2.7 Incidental Observations

Birds

On the 29 August 2010 diurnal visual offshore boat survey, approximately 350 Red-necked Phalaropes, 4 Marbled Murrelets, 13 Pigeon Guillemots, and 20 Rhinoceros Auklets were observed sitting in the study area during the two transect surveys. On the 10 September 2010 diurnal visual survey, approximately 100 Sooty Shearwaters, 15 Pink-footed Shearwaters, 600 Common Murres, 3 Pigeon Guillemots, 20 Rhinoceros Auklets, and 1 Tufted Puffin were observed sitting and while transiting to and between the stationary point count stations. On 21 September 2010, 332 Sooty Shearwaters, 1 Brandt's Cormorant, 124 Red-necked Phalaropes, 80 Western Gulls, 33 California Gulls, 1 Pomarine Jaeger, 27 Common Murres, and 1 Rhinoceros Auklet were observed sitting on the water and while transiting between the stationary survey points.

Mammals

Two large whales were briefly observed in the study area on the 10 September 2010 survey. During the 13 October 2010 boat survey, 10 Killer whales (*Orcinus orca*) were spotted within the study area.

6.1.3 Nocturnal Offshore

6.1.3.1 Thermal Imaging Validation

A comparison of passage rates of birds observed through the thermal imaging camera during nocturnal boat validation surveys and the passage rates of radar tracks for the same nocturnal observation times can be found in **Table 6-14**.

Table 6-14
Comparison of passage rates of TracScan HSR tracks and bird passage rates from nocturnal thermal imaging offshore validation surveys for Fall 2010

Date	Observer Radar Survey Effort (hrs)	Observer Passage Rate[1]	Radar Passage Rate[2]
22-Sep	1.75	3.53	1.17
23-Sep	1.63	11.36	2.59
13-Oct	1.73	28.54	2.28
14-Oct	1.63	53.02	0.47

[1] Bird crossings/NM/hr
[2] Tracks on radar/NM/hr

The product correlation coefficient between observer passage rate and radar passage rate was -0.517 for nocturnal samples. A negative correlation would be expected if radar recorded fewer bird tracks when observers saw more birds at low altitudes and when radar recorded more birds at higher altitudes while observers saw fewer birds at low altitudes. In this case the correlation is poor because nearly all of the birds observed were at altitudes below the radar beam. The negative value of the correlation is spurious because of the small number of tracks for radar samples. In every instance when the radar beam was lowered to detect lower flying birds, the amount of sea clutter in the radar beam obscured return from birds.

The observer passage rate was higher during the day than at night (compare **Tables 6-8** and **6-14**). This difference could be real, but use of the thermal imaging camera may have limited the detection of more birds crossing the intercept line at night during offshore boat validation surveys.

6.1.3.2 Avian Species Occurrence

Identification of birds to the species level with thermal-imaging imaging cameras is not normally possible. Families and/or guilds of birds can sometimes be identified by using physical (shape) and behavioral (flight) characteristics. Most of the birds detected by the thermal imaging camera during the surveys were not identifiable to guild. Several birds were identified as gulls or shearwaters during the survey (**Table 6-15**).

Table 6-15
Fall 2010 Nighttime Offshore Thermal Imaging Survey Results

Survey Date	Zulu Start/End Time	Identification	Number	Comments
9/22/10	13:13:50	Unidentified Bird	1	
9/22/10	14:58:57			
9/23/10	3:21:18	Unidentified bird	1	Brown pelican?
9/23/10	4:59:25	Gull	2	
10/13/10	13:14:15	Unidentified bird	1	
		Unidentified bird	6	Brown pelican?
	14:58:57	Unidentified bird	1	Gull?
10/14/10	2:39:20	Gull	1	
		Gull	1	
		Gull	3	
		Unidentified bird	1	
		Unidentified bird	1	Gull?
		Gull	1	
		Unidentified bird	2	Shearwater?
		Unidentified bird	1	Shearwater
		Unidentified bird	1	Gull?
		Gull	1	
10/14/10	4:17:35	Shearwater	1	

6.1.3.3 Passage Rate

The nighttime passage for the sampled days ranged from 3.53-53.02 bird sightings/NM/hr (**Table 6-16**). The sampling distance was limited to 300 m because of high swell conditions (common in the study area).

Table 6-16
Nighttime Avian Offshore Thermal Imaging Survey Results

Survey Date	Survey Time	No. of Birds	Passage Rate[1]
9/22/10	1.75	1	3.53
9/23/10	1.63	3	11.36
10/13/10	1.73	8	28.54
10/14/10	1.63	14	53.02

[1] bird sightings/NM/hr

6.1.3.4 Flock Size

Sixteen of the 17 bird sightings during the nighttime thermal imaging surveys were comprised of 1 to 5 individuals. One sighting was made of 6 individuals (**Table 6-15**).

6.2 AVIAN RADAR

6.2.1 TracScan Radar

Diurnal passage rates were low (<6 bird tracks/NM/hr) over the majority of dates and altitudes (60-424 ft asl) sampled by TracScan (HSR) (**Table 6-17**). Peak diurnal passage rates (>10 bird tracks/NM/hr) occurred on 26-28 September and 24-25 October 2010.

Table 6-17
Fall 2010 Diurnal Passage Rate[1] Data Summary for the Study Area

Survey Date	Radar Survey Effort (hrs)	Radar Antenna Tilt Angle	Altitude Sampled (ft asl)	TOTAL Passage Rate
8/25	10.6	3 degrees	141-343	1.26
8/26	12.5	1 degree	(-) 8 - (+)182	0.74
8/27	11.8	0 degrees	(-)61-(+)100	3.24
8/28	13.2	3 degrees	141-343	2.09
8/29	8.5	4/2 degrees	222-424/60-262	0.57
8/30	11.7	4 degrees	222-424	0.33
8/31	14.1	4 degrees	222-424	1.42
9/1	6.0	4 degrees	222-424	2.02
9/2	-	-	-	-
9/3	6.7	3.5/2 degrees	181-383/60-262	2.98
9/4	5.0	2/3.5 degrees	60-265/181-383	2.46
9/5	12.8	3/2 degrees	141-343/60-262	2.05
9/6	10.5	2 degrees	60-262	0.50
9/7	-	-	-	-
9/8	10.2	2 degrees	60-262	1.96
9/9	12.4	2 degrees	60-262	1.25
9/10	6.7	2 degrees	60-262	1.41
9/11	6.4	3/2 degrees	141-343/60-262	3.04
9/12	5.9	3.5 degrees	181-383	2.41
9/13	9.8	3.5 degrees	181-383	2.62
9/14	10.6	3.5 degrees	181-383	0.46
9/15	9.9	3 degrees	141-343	0.50
9/16	10.4	2 degrees	60-262	0.30
9/17	5.8	2 degrees	60-262	0.39
9/18	2.3	2 degrees	60-262	0.57
9/19	10.1	4/2.5 degrees	222-424/100-304	0.96
9/20	8.6	2.5 degrees	100-303	0.41
9/21	11.9	1.5 degrees	26-221	4.11
9/22	13.2	2.5/1.5 degrees	100-303/26-221	2.98
9/23	12.3	3.5 degrees	181-383	1.05
9/24	6.9	1.5 degrees	26-221	0.78
9/25	12.1	3 degrees	141-343	2.48

Table 6-17 (*continued*)
Fall 2010 Diurnal Passage Rate[1] Data Summary for the Study Area

Survey Date	Radar Survey Effort (hrs)	Radar Antenna Tilt Angle	Altitude Sampled (ft asl)	TOTAL Passage Rate
9/26	12.1	1.5/3.0 degrees	26-221/141-343	10.17
9/27	12.1	1.5 degrees	26-221	11.10
9/28	11.6	3 degrees	141-343	14.74
9/29	12.1	3 degrees	141-343	5.00
9/30	12.6	degrees	141-343	0.31
10/01	3.9	3 degrees	141-343	0.22
10/02	10.5	2/4 degrees	60-262/222-424	6.04
10/03	9.9	4/2 degrees	222-424/60-262	1.29
10/04	9.8	2 degrees	60-265	4.42
10/05	7.7	3 degrees	141-343	3.68
10/06	6.6	3 degrees	141-343	2.62
10/07	9.5	2.5 degrees	100-303	0.18
10/08	9.4	2.5 degrees	100-303	0.18
10/09	9.0	2.5 degrees	100-303	0.09
10/10	6.6	2.5/4 degrees	100-304/222-424	1.55
10/11	9.5	2.5 degrees	100-303	3.11
10/12	10.9	2.5 degrees	100-303	4.15
10/13	10.5	2.5 degrees	100-303	1.31
10/14	12.1	2.5 degrees	100-303	3.65
10/15	5.1	2.5 degrees	100-303	1.13
10/16	12.0	2.5 degrees	100-303	4.28
10/17	11.9	2.5 degrees	100-303	8.09
10/18	11.9	2.5 degrees	100-303	5.87
10/19	6.7	3 degrees	141-343	1.18
10/20	10.5	2 degrees	60-262	1.31
10/21	10.9	2 degrees	60-262	0.61
10/22	8.6	2 degrees	60-262	2.5
10/23	9.7	2 degrees	60-262	8.54
10/24	9.6	2 degrees	60-262	19.96
10/25	7.5	2 degrees	60-262	19.52
10/26	6.1	2 degrees	60-262	6.41
10/27	10.4	2 degrees	60-262	0.81
10/28	11.2	2 degrees	60-262	0.59
10/29	2.3	2 degrees	60-262	2.67

Note; No diurnal TracScan radar data was collected on 2 and 7 September 2010.
[1] bird tracks/NM/hr

Nocturnal passage rates were low (<6 bird tracks/NM/hr) over the majority of dates and altitudes (26-424 ft asl) sampled by TracScan (HSR) (**Table 6-18**). Peak nocturnal passage rates (>10 bird tracks/NM/hr) occurred on 11 and 12 September and 24-25 October 2010.

Table 6-18
Fall 2010 Nocturnal Passage Rate[1] Data Summary for the Study Area

Survey Date	Radar Survey Effort (hrs)	Radar Antenna Tilt Angle	Altitude Sampled (ft asl)	TOTAL Passage Rate
8/25	9.4	3 degrees	141-343	0.33
8/26	9.5	1 degree	(-) 8 - (+)182	2.54
8/27	9.6	0 degrees	(-) 61-(+)100	3.81
8/28	9.6	3 degrees	141-343	6.67
8/29	9.6	4/2 degrees	222-424/60-262	1.52
8/30	9.7	4 degrees	222-424	1.05
8/31	9.8	4 degrees	222-424	1.78
9/1	5.2	4 degrees	222-424	0.09
9/2	3.9	4 degrees	222-424	1.81
9/3	9.4	3/2 degrees	141-343/60-262	0.52
9/4	9.9	2.5	100-303	2.11
9/5	10.0	2 degrees	60-262	1.68
9/6	6.3	2 degrees	60-262	6.57
9/7	-	-	-	-
9/8	9.9	2 degrees	60-262	0.72
9/9	10.2	2 degrees	60-262	3.17
9/10	7.2	2 degrees	60-262	5.30
9/11	9.3	3.5 degrees	181-383	20.33
9/12	10.4	3.5 degrees	181-383	19.07
9/13	5.4	3.5 degrees	181-383	7.07
9/14	5.1	3.5 degrees	181-383	0.17
9/15	9.5	3.5 degrees	141-343	0.17
9/16	8.1	2 degrees	60-262	0.37
9/17	10.7	3 degrees	141-343	0.33
9/18	9.7	2 degrees	60-262	0.46
9/19	6.7	2/4 degrees	60-262/222-424	0.28
9/20	10.8	2.5 degrees	100-303	3.87
9/21	10.9	1.5 degrees	26-221	9.18
9/22	10.9	1.5 degrees	26-221	4.26
9/23	6.4	1.5 degrees	26-221	2.85
9/24	11.0	1.5 degrees	26-221	1.94
9/25	11.1	3.0 degrees	141-343	2.46
9/26	11.1	3.0 degrees	141-343	6.33
9/27	11.2	1.5 degrees	26-221	3.2
9/28	10.6	3 degrees	141-343	7.81
9/29	10.6	3 degrees	141-343	4.85
9/30	12.6	3 degrees	141-343	1.14
10/01	3.9	3 degrees	141-343	0.80
10/02	10.5	2/4 degrees	60-265/222-424	7.63

Table 6-18 (*continued*)
Fall 2010 Nocturnal Passage Rate[1] Data Summary for the Study Area

Survey Date	Radar Survey Effort (hrs)	Radar Antenna Tilt Angle	Altitude Sampled (ft asl)	TOTAL Passage Rate
10/03	9.9	4/2 degrees	222-424/60-262	2.11
10/04	9.8	2 degrees	60-265	2.61
10/05	7.7	3 degrees	141-343	5.00
10/06	6.6	3 degrees	141-343	3.53
10/07	9.5	2.5 degrees	100-303	0.25
10/08	9.4	2.5 degrees	100-303	0.18
10/09	9.0	2.5 degrees	100-303	1.72
10/10	6.6	2.5/4 degrees	100-304/222-424	3.80
10/11	9.5	2.5 degrees	100-303	4.63
10/12	10.9	2.5 degrees	100-303	4.31
10/13	10.5	2.5 degrees	100-303	2.85
10/14	12.1	2.5 degrees	100-303	2.96
10/15	5.1	2.5 degrees	100-303	2.66
10/16	12.0	2.5 degrees	100-303	4.68
10/17	11.9	2.5 degrees	100-303	8.05
10/18	11.9	2.5 degrees	100-303	6.76
10/19	6.7	3 degrees	141-343	1.61
10/20	10.5	2 degrees	60-262	0.44
10/21	10.9	2 degrees	60-262	0.44
10/22	8.6	2 degrees	60-262	0.53
10/23	9.7	2 degrees	60-262	0.57
10/24	9.6	2 degrees	60-262	8.44
10/25	7.5	2 degrees	60-262	11.87
10/26	6.1	2 degrees	60-262	24.09
10/27	10.4	2 degrees	60-262	0.75
10/28	11.2	2 degrees	60-262	2.22
10/29	2.3	2 degrees	60-262	3.39

Note; No nocturnal TracScan radar data was collected on 2 and 7 September 2010.
[1] bird tracks/NM/hr

6.2.2 VerCat Radar

Although the 2009 VerCat (VSR) data were screened to reduce detections from sea clutter and precipitation (based on the best available technology) for the original report, analysts were concerned that the radar data may still contain false tracks. The 2009 VerCat (VSR) data were re-analyzed for this report because of advances made in processing sea clutter data had been made during more recent offshore avian radar studies conducted by GMI. The VerCat (VSR) sampling effort was much higher in 2009 than 2010 because the fall 2010 sampling design placed an emphasis on collecting passage rate data with the TracScan (HSR).

6.2.2.1 2009 Data

During VerCat testing, accurate bird altitude data from the radar system were determined to be very limited at low altitudes above the sea because false tracks from sea clutter could not be separated from "real bird tracks". VerCat data processing had to be restricted to birds flying >533 ft asl to reduce to the greatest extent possible of the inclusion of false tracks in the reported data.

Diurnal and nocturnal flying counts were low over the study area (<15 bird tracks/ hour) (**Table 6-19** and **Table 6-20**). Median flight altitudes for the presented data ranged from 572 to 2,875 ft asl during the day and from 664 to 6,332 ft asl at night.

Table 6-19
Re-analyzed Diurnal Biological Target Altitude Data Summary[1] for the Study Area in Fall 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
9/16	4.7	1,985	2,028	2,161	1,854	276	7
10/2	11.3	643	914	1,700	1,301	91	120
10/3	10.6	547	796	1,117	951	54	116
10/4	11.7	561	953	1,455	1,602	174	143
10/6	10.5	679	1,821	2,366	1,704	75	116
10/7	8.5	536	629	732	807	99	76
10/10	10.1	554	590	625	582	18	9
10/12	10.7	1,551	1,672	4,221	2,749	327	21
10/13	6.9	2,331	2,352	2,402	2,062	291	7
10/28	11.0	960	2,875	3,298	2,076	187	54
10/29	2.0	533	572	572	553	14	2
11/7	-	-	-	-	-	-	-
11/8	4.5	1,287	1,340	1,376	1,120	72	45
11/15	8.8	1900	2,007	2,037	1,902	141	29
11/20	-	-	-	-	-	-	-

[1] Only for altitudes above 533 ft asl

Note: No VerCat samples were collected from 19-30 September and 7, 20 November; Cells with normal text size have a minimum of 40 minutes of radar survey effort while those with smaller font have 10-39 minutes of radar survey effort.

Alt = Altitude

STE = Standard Error

Table 6-20
Re-analyzed Nocturnal Biological Target Altitude Data Summary[1] for the Study Area in Fall 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
10/2	11.4	-	768	-	768	0	1
10/3	10.2	696	700	878	758	49	3
10/4	8.4	3,566	3,801	3,979	4,219	219	50
10/5	10.5	554	1,490	14,464	5,948	2,351	8
10/6	-	-	-	-	-	-	-
10/7	5.7	579	1,106	2,199	1,743	262	35
10/8	9.8	590	664	3,705	1,545	249	33

Table 6-20 (*continued*)
Re-analyzed Nocturnal Biological Target Altitude Data Summary[1] for the Study Area in Fall 2009

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
10/10	10.8	536	718	874	737	23	118
10/11	11.6	583	785	1,159	875	29	137
10/12	11.9	1,590	6,169	6,866	4,265	682	16
10/15	4.0	6, 236	6,332	6,578	5,860	686	9
10/17	10.0	452	487	748	798	117	82
10/28	12.6	743	905	967	851	63	48
10/29	-	-	-	-	-	-	-
11/7	-	-	-	-	-	-	-
11/18	5.0	504	711	984	783	78	55
11/19	-	-	-	-	-	-	-
11/20	-	-	-	-	-	-	-

[1] Only for altitudes above 533 ft asl
Note: No VerCat samples were collected from 19 September – 01 October, 6 and 29 October, and 7 and 19-20 November; Cells with normal text size have a minimum of 40 minutes of radar survey effort while those with smaller font have 10-39 minutes of radar survey effort.
Alt = Altitude
STE = Standard Error

6.2.2.2 2010 Data

Limited VerCat (VSR) data was collected in 2010 because the survey design emphasized the collection of TracScan (HSR) data (**Appendix B**). Diurnal flying counts were variable over the study area during the survey dates (**Table 6-21**). Median diurnal flight altitudes for the presented data ranged from 698 to 4,781 ft asl. Nocturnal data is very limited (**Table 6-22**).

Table 6-21
Diurnal Biological Target Altitude Data Summary for the Study Area[1] in Fall 2010

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
8/26	0.4	-	1,216	-	1,216	0	1
8/27	1.1	1,097	1,178	1,358	1,234	45	9
8/30	1.0	1,145	1,178	1,244	1,193	14	26
9/2	2.3	1,173	1,225	1,334	1,286	22	203
9/5	1.0	1,154	1,173	1,225	1,363	124	22
9/6	3.2	1,273	1,401	1,543	1,539	83	326
9/8	1.4	898	931	931	915	12	2
9/9	1.0	770	4,781	6,452	4,225	337	57
9/11	1.9	717	760	864	925	131	305
9/12	1.4	751	793	1,016	1,027	182	12
9/13	3.3	793	926	1,002	1,115	109	185
9/15	0.2	850	888	888	869	13	2

Table 6-21 (*continued*)
Diurnal Biological Target Altitude Data Summary for the Study Area[1] in Fall 2010

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
9/21	1.0	836	2,602	2,659	2,171	263	24
9/23	0.7	1,648	2,122	2,516	1,818	280	10
9/24	3.1	556	698	698	627	50	2
10/6	1.0	637	3,561	3,917	3,870	788	31
10/20	1.1	-	1,059	-	1,059	0	1

[1] Only for altitudes above 533 ft asl.
Note: Cells with normal text size have a minimum of 40 minutes of radar survey effort while those with smaller font have 10-39 minutes of radar survey effort.
Alt = Altitude
STE = Standard Error

Table 6-22
Nocturnal Biological Target Altitude Data Summary for the Study Area[1]

Date	Effort (hrs)	25% Alt	Median Alt	75% Alt	Mean Alt	STE	Flying Count
9/2	0.6	1,145	1,220	1,311	1,209	37	38
9/6	0.2	1439	1472	1539	1474	20	11

[1] Only for altitudes above 533 ft asl.
Note: Cells with normal text size have a minimum of 40 minutes of radar survey effort while those with smaller font have 10-39 minutes of radar survey effort.
Alt = Altitude
STE = Standard Error

7.0 DISCUSSION/SUMMARY OF RESULTS

7.1 AVIAN RADAR VALIDATION

7.1.1 Visual Validation

Comparisons between the nearshore and offshore observer bird passage rates and the nearshore and offshore radar passage rates revealed low correlation between diurnal observer and radar data. The amount of sea clutter return within 2 NM of the radar made realistic comparisons impossible, because echoes from birds were nearly impossible to distinguish from echoes from sea clutter. When algorithms to reduce tracks from sea clutter were applied, tracks from real birds were also eliminated. This is a generic problem in radar ornithology, and at present there is no way to accurately remove only detections from sea clutter. This problem was magnified because the visual observations revealed that a major portion of the bird movement occurred at altitudes below 30 ft above the ocean surface. At that altitude it is impossible to separate birds from waves and swells in radar return.

Fortunately, the visual validation data helped document that radar was ineffective when birds were flying close to the ocean surface.

7.1.2 Species Occurrence

Forty-three bird species were observed during the diurnal nearshore radar validation surveys and 32 bird species were observed during the offshore surveys. Nearshore survey effort totaled 41.4 hrs and offshore survey effort was 14 hrs.

One United States (U.S.) Fish and Wildlife Service (USFWS) listed species for the study area (USFWS 2010), Marbled Murrelet (threatened), was observed during the radar validation surveys and incidentally while observing birds from shore. Fifteen were observed on 26 August 2010 and 2 were found on 30 August 2010 while observing birds from shore close to the radar unit. One Marbled Murrelet was identified during the 3 October nearshore radar validation survey. Five Marbled Murrelets were observed during an offshore boat survey in the study area on 14 October 2010.

Five USFWS listed "Birds of Conservation of Concern" for the Northern Pacific Forest Bird Conservation Region (USFWS 2008) were found during the nearshore and offshore radar validation bird surveys. Four species, Western Grebe, Peregrine Falcon, Whimbrel, and Caspian Tern were observed during the nearshore surveys and one species, Pink-footed Shearwater, was found during the offshore surveys.

7.1.3 Passage Rates

Nearshore diurnal passage rates were generally higher closer to shore than farther offshore (i.e., 30 to 390 bird sightings/NM/hr from 0-1 NM offshore and from 10-142 bird tracks/NM/hr from 1-2 NM); however, passage rates in the 1-2 NM range may be underestimated because of decreasing observer detection efficiency at increasing distances from the survey site. Offshore diurnal passage rates during the stationary boat surveys in the study area ranged from 142-268 bird sightings/NM/hr.

7.1.4 Altitude Distribution

The majority of birds flying over nearshore and offshore waters were observed were between 1 and 100 ft asl (nearshore 94%; offshore 93%). Nearly 75% were flying between 1 and 30 ft asl over nearshore waters while 83% were flying below 30 feet offshore.

7.1.5 Flock Size

Most of the birds sighted during both the nearshore radar validation surveys (87.9%) and during the diurnal offshore boat radar validation surveys (98.2%) were in the 1-5 individual flock category. More flocks with greater than five individuals were sighted during the nearshore surveys than the offshore radar validation surveys.

7.1.6 Flight Direction

Dominant flight directions varied by survey date. Overall, the dominant flight direction was to the south during the study period.

7.1.7 Nocturnal Validation

The use of thermal imaging to survey birds offshore at night worked well, but the technique requires additional development. Clearly bird movements occurred in the project area after dark with passage rates ranging from 3.53 to 53.02 birds/NM/hr. These rates are lower than those recorded offshore during the day, but until the thermal imaging camera is compared with binocular observations during the day, one cannot conclude that the thermal imaging camera is under-sampling birds within 300 m of the vessel. At present there is no better way to sample bird activity at night close to the ocean surface.

7.2 AVIAN RADAR

7.2.1 TracScan Radar

The diurnal and nocturnal passage rates during the majority of the study period were low (i.e., <6 bird tracks/NM/hr). These low counts are verified by comparing offshore passage rates and altitudinal flight distribution. The majority of birds (94%) were flying below the altitudes (60-424 ft asl) most frequently sampled by the radar on the majority of the survey dates.

7.2.2 VerCat Radar

7.2.2.1 2009 Study

The data were reprocessed to further eliminate false tracks resulting from detections of sea clutter by removing the lowest 2 degrees of the radar sweep over the project area (0-2 degrees asl). This procedure dramatically reduced false tracks generated from sea clutter but limited the data to altitudes above 533 ft.

Diurnal and nocturnal flying counts were low over the study area (<15 bird tracks/ hour). Median flight altitudes ranged from 572 to 2,875 ft asl during the day and from 664 to 6,332 ft asl at night.

7.2.2.2 2010 Study

Limited VerCat (VSR) data were collected in 2010 because the survey design emphasized the collection of TracScan (HSR) data. Diurnal flying counts were generally low over the study area (<15 bird tracks/hr) during the majority of the survey dates. Median diurnal flight altitudes for the presented data ranged from 698 to 4,781 ft asl. Nocturnal data are very limited.

8.0 REVIEW OF FEDERAL ENERGY REGULATORY COMMISSION STUDY PLAN/ RECOMMENDATIONS

With reference to radar sampling, the Federal Energy Regulatory Commission (FERC) Study Plan (FERC 2010) states that "a shore-based radar surveillance system will be used to collect data on the relative numbers of seabirds active during diurnal and nocturnal hours, which then can be applied to pre-installation boat-based surveys in order to estimate the number of birds present in the proposed project area at night." The survey requirements stated in plan included four hours of diurnal and nocturnal sampling to be spaced throughout the year to document seasonal differences in daily activity patterns. The radar sampling was recommended to occur after one year of boat-based surveys in the project area.

This Avian Radar Baseline Study was contracted to assist in collecting data that could potentially be used to meet these requirements. Avian radar validation surveys were designed specifically by GMI for this study to determine the accuracy of the radar data in predicting the number of birds that would potentially collide with the 30-ft tall wave buoys. The results of the avian radar validation surveys from this study indicate that avian radar is not able to collect accurate altitude flight data within the potential bird-wave power buoy collision zone (1-30 ft asl) because of the presence of sea clutter (high wind waves and/or swells) in the study area; however, diurnal avian radar validation bird survey data collected from shore and from a boat in the study area provided information requested by the Scope of Work including on nearshore and offshore (study area) species occurrence, avian passage rates (number of bird tracks/NM/hr), frequency of avian flight altitudes within and above the bird-wave power buoy collision zone, flock size frequency, and flight direction frequency. In addition, a nocturnal thermal imaging camera was used to conduct nighttime avian studies and provided data on nighttime bird passage rates.

During the avian radar validation surveys, little variability was documented in diurnal flight altitude of seabirds in the nearshore and offshore environment. Bird passage rates varied throughout the study and more diurnal and nocturnal passage data from all seasons are needed for the bird-collision model to be developed to meet the final requirements of the Risk Assessment Model in the FERC Study Plan (**Section 5.3.1**).

GMI recommends, based on the findings of this Avian Radar Baseline Study, that seasonal radar studies recommended by the FERC Study Plan be replaced with diurnal boat surveys and nocturnal boat surveys using stabilized remote sensing technologies (e.g., thermal imaging, high definition cameras). These methods will, in GMI's opinion, provide the best data on nocturnal passage rate (bird abundance) and altitude use within the potential bird-wave power buoy collision zone (1-30 ft asl).

The diurnal avian boat survey design in FERC Study Plan should be followed; however, avian flight altitude data and flight direction data needs to be added to the survey methodology. Night avian remote sensing surveys needed to be added to the two day survey effort. GMI's remote sensing technology group will be willing to assist OWET with further development of survey equipment and protocols to conduct nocturnal avian boat-based surveys.

During summer and winter GMI recommends that one set of boat surveys be completed in the middle of the season. Abundance and movements of birds during non-migratory seasons are generally not highly variable. In contrast, daily variability during the spring and fall migration season can be high, and therefore, if possible, the number of surveys in these seasons should be increased above that recommended in the FERC Study Plan.

Sea state conditions (wind waves, swell heights) in the study area are problematic with smaller survey vessels during the fall, winter and spring seasons. A large research ship is recommended for the remaining avian surveys. Partnerships with universities and government agencies (National Oceanic and Atmospheric Administration [NOAA], USFWS) should be investigated to meet this need.

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APPENDICES

APPENDIX A

DAILY WEATHER AND SEA CLUTTER CONDITIONS

Date	Sky Conditions	Precipitation	Radar Clutter Distance (NM)
8/26/2010	Clear	None	0.5
8/27/2010	Mostly Cloudy	None	0.5
8/28/2010	Cloudy	Fog	2.75
8/29/2010	Mostly Cloudy	None	0.75
8/30/2010	Cloudy	Light Rain	2.0
8/31/2010	Cloudy	Fog/Drizzle	1.0
9/01/2010	Cloudy	Fog/Light Rain	Rain
9/02/2010			
9/03/2010	Clear	None	2.0
9/04/2010	Cloudy	Fog	2.0 to 3.0
9/05/2010	Clear	Fog	1.0
9/06/2010	Clear	None	2.0
9/07/2010	Partly Cloudy	None	1.5 to 3.0 (Changed through day)
9/08/2010	Cloudy	Fog	1.5
9/09/2010	Cloudy	None	1.5 to 2.0
9/10/2010	Clear	None	1.5 to 2.0
9/11/2010	Clear	None	2.0
9/12/2010	Clear	None	1.0
9/13/2010	Cloudy	Drizzle	1.0
9/14/2010	Partly Cloudy	None	0.75
9/15/2010	Mostly Cloudy	Fog	1.0
9/16/2010	Cloudy	Fog	1.5
9/17/2010	Cloudy	Moderate Rain	Rained out
9/18/2010	Cloudy	Moderate Rain	Rained out
9/19/2010	Cloudy	Fog	2.0
9/20/2010	Cloudy	Fog	1.75
9/21/2010	Partly Cloudy	Fog	2.0
9/22/2010	Clear	None	0.5
9/23/2010	Cloudy	Light Rain	Rained out
9/24/2010	Cloudy	Fog/Drizzle	1.0
9/25/2010	Mostly Cloudy	Fog	1.5
9/26/2010	Cloudy	Fog	3.0
9/27/2010	Cloudy	Fog	0.5
9/28/2010	Cloudy	Fog	2.25
9/29/2010	Clear	Fog	2.75
9/30/2010	Clear	None	1.0
10/01/2010	Cloudy	Fog	1.5 to 3.0
10/02/2010	Cloudy	Fog	1.5
10/03/2010	Clear	None	1.5
10/04/2010	Mostly Cloudy	Fog	1.5
10/05/2010	Clear	None	3.0
10/06/2010	Clear	None	1.0
10/07/2010	Partly Cloudy	None	1.5
10/08/2010	Cloudy	None	2.5

Date	Sky Conditions	Precipitation	Radar Clutter Distance (NM)
10/09/2010	Cloudy	Light Rain	Rained out
10/10/2010	Cloudy	Fog	1.5
10/11/2010	Clear	None	0.75
10/12/2010	Partly Cloudy	None	2.5
10/13/2010	Clear	None	1.5
10/14/2010	Clear	None	1.0
10/15/2010	Partly Cloudy	None	2.25
10/16/2010	Partly Cloudy	Fog	0.5
10/17/2010	Clear	None	0.5
10/18/2010	Partly Cloudy	None	0.75
10/19/2010	Clear	None	1.5
10/20/2010	Clear	Fog	0.75
10/21/2010	Mostly Cloudy	Fog	2.25 to 4.0
10/22/2010	Mostly Cloudy	Fog	1.0
10/23/2010	Mostly Cloudy	Fog/Light Rain	Rained out
10/24/2010	Cloudy	Fog/Drizzle	3.0 to 4.0
10/25/2010	Cloudy	Fog/Light Rain	3.0
10/26/2010	Cloudy	Fog	2.5
10/27/2010	Cloudy	Clear	1.5
10/28/2010	Cloudy	Moderate Rain	Rained out

APPENDIX B

MARS OPERATIONAL HOURS

Appendix B-1

TracScan 2010 Operational Hours

Date	Diurnal[1]					Nocturnal[2]					Total Hrs[3]
	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	
8/25/10	7.4	3.2					9.5			9.5	20.2
8/26/10	7.5	5.0			10.6	0.4	9.1			9.5	22.0
8/27/10	8.9	2.9			12.5	4.5	5.1			9.6	21.4
8/28/10	12.2	1.0			11.8	5.6	4.0			9.6	22.8
8/29/10	6.5	2.0			13.2	3.7	6.0			9.7	18.1
8/30/10	4.4	7.3		1.0	8.5	1.0	8.7			9.7	22.4
8/31/10	8.8	5.2			12.7		9.8			9.8	23.8
9/01/10	4.1	1.9			14.1	0.2	5.0			5.2	11.2
9/02/10	0.6				6.0	2.9	1.0			3.9	4.5
9/03/10	4.8	1.9			0.6	1.0	8.4			9.4	16.1
9/04/10	2.6	2.5			6.7	1.0	8.9			9.9	14.9
9/05/10	11.1	1.8			5.0	7.8	2.3			10.0	22.8
9/06/10	9.8	0.7			12.8	1.6	4.8			6.3	16.8
9/07/10		0.8		0.2	0.8	1.0	2.8		1.0	4.8	5.6
9/08/10	5.6	4.6			11.6		7.3		2.8	10.1	21.7
9/09/10	8.7	3.7			12.4		9.9			9.9	22.4
9/10/10	5.0	1.7			6.7	0.9	9.4			10.3	16.9
9/11/10	3	2.9			6.4	0.8	6.4			7.2	13.6
9/12/10	2.3	3.6			5.9		9.3			9.3	15.2
9/13/10	8.2	1.6			9.8	2.0	8.4			10.4	20.2
9/14/10	4.0	6.6			10.6		5.4			5.4	16.0
9/15/10	9.9				9.9	5.1				5.1	15.0
9/16/10	9.4	1.0		0.9	11.3	5.5	4.0		1.1	10.6	21.8
9/17/10	1.9	3.9		4.3	10.1	2.1	6.0		2.5	10.6	20.7
9/18/10		2.3		6.7	10.0	1.0	9.7			10.7	20.7
9/19/10	7.6	2.5			12.1	6.2	3.5		1.0	10.7	22.8
9/20/10	8.6				8.6	0.2	6.4			6.7	15.2
9/21/10	8.7	3.2			11.9		10.8			10.8	22.7
9/22/10	12.4	0.7			13.2	5.6	5.3			10.9	24.0
9/23/10	12.3				12.3	9.9	1.0			10.9	23.2
9/24/10	5.3	1.7			7.0		6.4			6.4	13.3
9/25/10	7.6	4.5			12.1	3.4	7.7			11.0	23.2
9/26/10	12.1				12.1	4.1	7.0			11.1	23.1
9/27/10	9.2	2.9			12.1		11.1			11.1	23.2
9/28/10	7.3	4.3			11.6	2.5	8.7			11.2	22.8
9/29/10	8.8	3.3			12.1		10.6			10.6	22.7
9/30/10	7.9	4.7			12.6	1.0	10.2			11.2	23.8

Date	Diurnal[1]					Nocturnal[2]					Total Hrs[3]
	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	
10/01/10	2.9	0.9			3.9	6.5	4.8			11.3	15.1
10/02/10	10.2	0.3			10.5	8.5	2.0			10.5	21.0
10/03/10	9.9				9.9	7.4	4.0			11.4	21.3
10/04/10	7.9	1.8			9.8	4.6	6.8			11.4	21.1
10/05/10	7.7				7.7	4.1	6.0			10.1	17.8
10/06/10	5.7	0.9			6.6	6.6	5.0			11.6	18.2
10/07/10	9.4	0.1			9.5	10.7	0.9			11.6	21.1
10/08/10	8.7	0.7	1.3		9.4	3.8	5.9	1.0	1.0	11.7	21.0
10/09/10	5.0	4.0		2.6	11.6	1.0	5.7		4.9	11.7	23.3
10/10/10	4.0	2.6			11.6	2.0	7.8		1.9	11.8	23.3
10/11/10	9.5				9.5	4.8	7.0			11.8	21.2
10/12/10	10.1	0.8			10.9	3.9	8.0			11.9	22.8
10/13/10	10.5				10.5	2.4	4.9			7.4	17.9
10/14/10	2.0	10.1			12.1	4.0	4.3			8.3	20.3
10/15/10	5.1				5.1	7.0	1.0			8.0	13.1
10/16/10	12.0				12.0	11.0	1.0			12.0	24.0
10/17/10	10.0	1.9	1.0		11.9	7.0	5.1			12.1	24.0
10/18/10	10.0	1.9	2.0		11.9	2.0	8.0			10.0	21.9
10/19/10	6.7				6.7	3.1	3.0			6.1	12.8
10/20/10	8.7	1.9			10.5	1.1	11.1			12.2	22.7
10/21/10	9.2	1.7			10.9	10.0	2.2			12.2	23.1
10/22/10	7.1	1.5			8.6	11.1	1.2			12.3	20.9
11/23/10	9.7			1.0	11.6	6.2		0.9	4.2	11.4	23.0
10/24/10	9.6			2.0	11.6	6.3	2.0	4.0		12.3	23.9
10/25/10	7.5			3.0	10.5	8.4		2.0	1.2	11.5	22.1
10/26/10	6.1			1.0	7.1	1.2	5.0			6.2	13.3
10/27/10	10.4				10.4	6.4	6.0			12.4	22.8
10/28/10	9.6	1.7			11.3	2.3	7.3		3.0	12.6	23.8
10/29/10	0.7	1.7			2.3		6.3			6.3	8.7
TOTAL	**487.7**	**130.4**	**11.3**	**21.6**	**650.9**	**238.8**	**382.2**	**7.9**	**24.6**	**653.6**	**1303.3**

[1] Diurnal occurs from Civil Sunrise to Civil Sunset
[2] Nocturnal occurs from Civil Sunset to Civil Sunrise
[3] Totals are rounded to the nearest 0.1 hour (columns may not total)
Hrs = hours

Appendix B-2

VerCat 2010 Operational Hours

Date	Diurnal[1]					Nocturnal[2]					Total Hrs[3]
	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	
8/26/10	0.4				0.4						0.4
8/27/10	1.1		0.1		1.2						1.2
8/28/10	1.1				1.1						1.1
8/30/10	1.0				1.0						1.0
9/02/10	2.3				2.3	0.6				0.6	2.9
9/03/10		0.9			0.9		0.4			0.4	1.3
9/04/10	1.1				1.1						1.1
9/05/10	1.0				1.0						1.0
9/06/10	3.2				3.2	0.2				0.2	3.3
9/07/10				0.8	0.8						0.8
9/08/10	1.4		0.6		2.0						2.0
9/09/10	1.0				1.0						1.0
9/11/10	1.9				1.9						1.9
9/12/10	1.4				1.4						1.4
9/13/10	3.3				3.3						3.3
9/15/10	0.2				0.2						0.2
9/16/10	1.1				1.1						1.1
9/19/10	1.0				1.0						1.0
9/21/10	1.0				1.0						1.0
9/23/10	0.7				0.7						0.7
9/24/10	3.1				3.1						3.1
9/25/10		0.7			0.7						0.7
9/26/10	0.7				0.7						0.7
9/27/10	0.8				0.8						0.8
9/28/10	0.6				0.6						0.6
9/29/10	0.7				0.7	0.5	0.1			0.6	1.2
10/01/10	1.1	1.0			2.1	0.8				0.8	2.1
10/02/10	0.5	0.7			1.2						2.0
10/03/10	1.1	1.0			2.0						2.0
10/04/10	1.0	1.0			2.0						2.0
10/05/10	1.3				1.3						1.3
10/06/10	1.0				1.0						1.0
10/07/10	2.2				2.2						2.2
10/08/10	1.7	0.3	0.1		2.1						2.1
10/11/10	1.3	0.8			2.0						2.0
10/12/10		1.0			1.0						1.0
10/13/10	1.3				1.3						1.3

Date	Diurnal[1]					Nocturnal[2]					Total Hrs[3]
	Hrs Clear	**Hrs Fog**	**Hrs Rain**	**Hrs Mist**	**Total Hrs**	**Hrs Clear**	**Hrs Fog**	**Hrs Rain**	**Hrs Mist**	**Total Hrs**	
10/15/10	1.0				1.0						1.0
10/19/10	1.1				1.1						1.1
10/20/10	1.1				1.1						1.1
10/21/10	0.3		0.5		0.7						0.7
10/25/10	0.9				0.9						0.9
10/27/10	0.1		0.8		1.0			0.1			1.0
TOTAL	**47.1**	**7.4**	**2.1**		**57.2**	**2.1**	**0.5**	**0.1**		**2.7**	**59.6**

[1] Diurnal occurs from Civil Sunrise to Civil Sunset
[2] Nocturnal occurs from Civil Sunset to Civil Sunrise
[3] Totals are rounded to the nearest 0.1 hour (columns may not total)
Hrs = hours

Appendix B-3

VerCat 2009 Operational Hours

Date	Diurnal[1]					Nocturnal[2]					Total Hrs[3]
	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	
9/16/09	4.7		0.3		5.0	3.1	2.0	2.0		5.1	10.1
9/17/09	9.7	1.2			10.9	8.6	2.0	2.0		10.6	21.6
9/18/09	3.2				3.2	5.5				5.5	8.7
9/19/09											
9/20/09											
9/21/09											
9/22/09											
9/23/09											
9/24/09											
9/25/09											
9/26/09											
9/27/09											
9/28/09											
9/29/09											
9/30/09	0.4				0.4	5.5				5.5	5.9
10/01/09	12.6				12.6	10.2	1.0			11.2	23.9
10/02/09	11.3				11.3	11.4				11.4	22.7
10/03/09	10.6				10.6	10.2				10.2	20.8
10/04/09	11.7		0.2		11.8	8.4	2.0	0.8		11.3	23.1
10/05/09	12.1				12.1	10.5	1.0			11.5	23.6
10/06/09	10.5				10.5	6.4				6.4	16.9
10/07/09	8.5				8.5	5.7				5.7	14.2
10/08/09	9.5	1.4			10.9	9.8	1.9			11.7	22.6
10/09/09	12.2				12.2	7.8	3.0			10.8	23.0
10/10/09	10.1	1.6			11.8	10.8	1.0			11.8	23.5
10/11/09	8.5				8.5	11.6				11.6	20.1
10/12/09	10.7				10.7	11.9				11.9	22.6
10/13/09	6.9		3.6		10.4	4.9		1.0		11.9	22.3
10/14/09	9.0		1.9		10.9	8.0		1.0	2.0	12.0	22.8
10/15/09	8.9		2.0	0.9	11.8	4.0	1.0	2.0		12.0	23.8
10/16/09	11.5				11.5	11.1	1.0	1.0		12.0	23.5
10/17/09	8.7		3.0		11.7	10.0	2.0	2.0		12.0	23.7
10/18/09	10.3	1.0			11.3	12.0				12.0	23.3
10/19/09	10.6	1.0			11.6	7.2	4.0		1.0	12.2	23.7
10/20/09	8.6	0.9			9.5	10.0	2.1			12.1	21.6
10/21/09	9.8	1.0	0.8		11.7	6.1	4.0			12.2	23.9
10/22/09	10.4				10.4	11.3	1.0			12.3	22.7

Date	Diurnal[1]					Nocturnal[2]					Total Hrs[3]
	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	Hrs Clear	Hrs Fog	Hrs Rain	Hrs Mist	Total Hrs	
10/23/09	6.0	0.8	4.8		11.6	9.9	2.2			12.3	23.8
10/24/09	10.8				10.8	9.4	3.0			12.4	23.2
10/25/09	11.3				11.3	12.4				12.4	23.7
10/26/09	7.8		3.0	0.7	11.5	4.7	1.9	3.0	1.3	10.8	22.3
10/27/09	6.7		4.7		11.4	9.2		3.3		12.5	23.9
10/28/09	11.0				11.0	12.6				12.6	23.5
10/29/09	2.0	1.7	5.7	2.0	11.4	12.0	0.3	0.3		12.6	23.9
10/30/09	8.6	2.7			11.3	11.3	1.4			12.6	23.9
10/31/09	9.5	1.0	0.6		11.2	5.2	1.0	4.4	1.0	11.6	22.8
11/01/09	7.3				7.3	6.3				6.3	13.6
11/02/09	9.3				9.3	12.7				12.7	21.9
11/03/09	10.8				10.8	11.6	1.0			12.6	23.4
11/04/09	11.0				11.0	11.7	1.0			12.7	23.7
11/05/09	9.5		1.6		11.0	5.5	1.0	3.4		9.8	20.9
11/06/09	4.1				4.1	2.5				2.5	6.7
11/07/09	6.8		1.0		7.8	1.4				1.4	9.2
11/08/09	4.5		1.0		5.5						5.5
11/08/09	1.8		0.1		1.8	5.4	1.0	0.1		6.5	8.3
11/09/09	3.1		6.6		9.6	2.0	1.3	2.5	0.7	6.5	16.1
11/10/09	9.4	0.4	0.3		10.1	4.7	3.5	4.8		12.9	23.0
11/11/09	1.2				1.2	3.8		3.4		7.2	8.3
11/12/09	6.7		3.9		10.6	5.7	2.0	5.4		13.1	23.7
11/13/09	5.5		3.8	1.0	10.2	3.8		2.8		6.6	16.8
11/14/09	9.0		1.6		10.6	6.3		0.3		6.6	17.2
11/15/09	8.8		1.0		9.8	10.3		2.9		13.1	23.0
11/16/09	7.2		3.4		10.5	8.1		5.2		13.3	23.8
11/17/09	2.9		7.5		10.5	4.4		7.9	1.0	13.4	23.8
11/18/09	7.6		2.9		10.5	5.0		5.9		10.9	21.3
11/19/09	8.5		1.3		9.8	6.7				6.7	16.5
11/20/09								6.7		6.7	6.7
TOTAL	449.1	14.6	66.4	4.6	534.7	426.3	49.4	81.0	7.0	563.7	1098.4

[1] Diurnal occurs from Civil Sunrise to Civil Sunset
[2] Nocturnal occurs from Civil Sunset to Civil Sunrise
[3] Totals are rounded to the nearest 0.1 hour (columns may not total)
Hrs = hours

APPENDIX C

RADAR VALIDATION SURVEY PROTOCOL

Line-Intercept Method of Validation of Radar Tracks

Introduction

The identification of the sources of radar echoes is of great importance with respect to quality control/quality assurance (QC/QA) of the data gathered during radar studies of bird movements. This is particularly important in circumstances when automatic data processing (tracking algorithms) may produce false tracks from radar detections of waves (sea clutter) and precipitation. Validation of tracks is necessary if the number of false tracks is to be assessed accurately. Validation is also necessary to determine the effectiveness of filtering rules that eliminate false tracks produced by sea clutter and precipitation. Observer detection time budget data provides passage rates and helps to resolve both radar and visual detection issues. The line-intercept validation procedure is also necessary for determining the maximum distance that certain species can be detected by the TracScan radar. Estimated flight altitude data helps to further validate any confirmed radar detections.

The protocol that follows represents a straightforward way to identify the sources of radar echoes when mobile radar is in a horizontal surveillance mode and monitoring the near-shore ocean from the shore. The protocol can also be used to monitor bird movements from a stationary ship, boat, or platform offshore. By using this approach, the radar operator does not bias the surveillance of the on-shore observer and the observations of the onshore observer do not bias the radar operator.

Protocol

The protocol for validating sources of radar tracks is a variation of the line-intercept sampling protocol used by ecologists to count animal tracks crossing a line or count the stems of plants touching a line of a fixed length (Sutherland 2006:153; Fonseca et al. 2007). A stopwatch is used to record the time the observer spends watching the line for each detection or group of detections occurring at the same time. When a bird(s) crosses the vertical plane of this imaginary line, the stopwatch detection time, the bird's identity, estimated distance and altitude, direction of flight, and flight behavior are recorded along with a GPS time stamp. It is important that the GPS time stamp be taken as soon as the stopwatch has been stopped upon detection of the bird(s).

A limited field of view for the observer (i.e., through a fixed telescope) may be employed with these methods to further delineate the potential detections across the intercept line. This technique yields a limited data sample that may provide better density estimates similar to exercises of moon-watching for bird passage rates and flight densities (Nisbet 1959)

Setup

Onshore observers should position themselves so that they are looking at an azimuth nearly perpendicular to the shore or centrally located within the horizontal radar's sweep of the coastline and ocean (**Figure 1**). Their GPS position and the azimuth of their observation "line" should be recorded so that the location and azimuth line can be added to the radar display. Before the beginning of a validation session the GPS time on the field observer PDA should be synchronized so that the time stamp will correspond with that of the radar. Sea-state and visibility conditions should be recorded at the beginning of each watch. Additional weather data will be recorded at the radar trailer.

An observer using a high-quality binocular and a fixed spotting scope should look for birds flying over the line. The scope is pointed down the survey line and is used to identify the time when the bird(s) cross the line. A variation of the protocol may use the telescope in a fixed position (e.g., water to horizon line taking up the bottom 1/3 of the field of view) as the entire sample of bird detection and validation data taken. The vertical coverage of the radar beam of TracScan with a parabolic dish is 2.5°. An observer should keep in mind that the vertical sample volume is small close to the radar and increases with distance. Observers should not record birds too close to the radar, because the radar cannot detect targets within 30 m of the antenna.

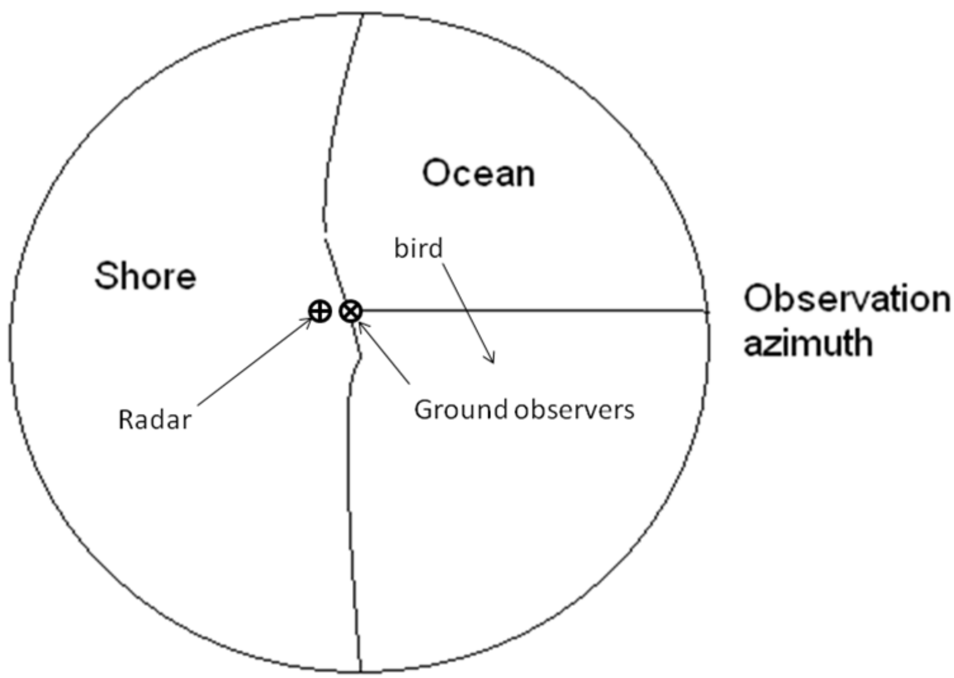

Figure 1. Diagram showing location of radar and observer on-shore and azimuth of observation intercept line (vertical plane above it) extending from shore to offshore. The length of the line can be changed depending on how the observer is measuring distance (by bin or by meters from observer). The estimate of distance will be used to relate the direct visual crossing to the appropriate radar track during post-processing.

Data Recording

The pertinent data on a crossing will be entered into a PDA Survey Program (version 2010-08-29). The observer begins his/her detection of birds over the intercept line with the start of a stopwatch. When a bird crosses the vertical plane above the line, the stopwatch detection time, the bird's identity, estimated distance and altitude, direction of flight, and flight behavior are recorded (along with a GPS time stamp).

Distance data may be taken in bins most suitable for the situation. Observers may be most familiar with meters because of widespread use in bird surveys; however, TracScan records in nautical miles. This discrepancy makes observer calibration and conversion of units especially important in the radar validation exercise. Estimating the distance of the crossing can be difficult, and observers should have practiced distance estimation before doing validation exercises. If at all possible a reference distance should be used such as a buoy offshore at a fixed distance. If a boat passes offshore one observer should check the radar to determine the distance from the observers to the boat. Real-time comparisons between visual and radar detections (via communication between the observer and the radar technician) can yield actual distances directly from the radar output. In these instances, when possible, accurate distance data for the validation survey is provided and the observer distance estimation is further calibrated and checked. If the observer thinks that the bird is possibly too low to be detected by the radar, this can be noted for the entry.

Because flight directions are hard to determine in horizontal observations, directions should be entered with respect to the movement toward the line of observation (e.g., “north” for a bird moving from left to right or up the coast and “south” for a bird moving from right to left or down the coast). If a target is approaching the shore or flying away from the shore the following can also be recorded: “I” for incoming and “O” for outgoing. Flight behavior (e.g., circling) can be noted in the comment section.

The line-intercept procedure can also be used from a fixed platform offshore or from a boat or ship offshore looking back toward the onshore radar. GPS positions of the boat and the azimuth of the surveillance line need to be recorded so they can be added to the radar display during post-processing.

Because the validation exercises are designed, in part, to determine the extent of false tracks produced by sea clutter, it is important to gather samples in different sea-state conditions.

Discussion
The line-intercept method of identifying sources of TracScan radar tracks is a straightforward approach to gathering the data required for validation of the radar processing algorithms. When sea clutter is present, false tracks are generated by digital processing algorithms, and validation data sets can be used to measure the effectiveness of filtering rules that eliminate false tracks from sea clutter.

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APPENDIX D

RADAR VALIDATION RAW DATA

Fall 2010 Visual and Radar HSR Survey Raw Data for Nearshore Avian Radar Validation Surveys

Date	Sea Clutter Distance[1]	Radar Survey Effort (hrs)	Observer Detection Effort[2] (hrs)	Observer Sightings 0-1 NM[1]	Radar Confirmed Sightings[3] 0-1 NM[1]	Observer Sightings 1-2 NM[1]	Radar Confirmed Sightings[3] 1-2 NM[1]	Observer Sightings 2-3 NM[1]	Radar Confirmed Sightings[3] 2-3 NM[1]
8-27	1.0-2.0	3.37	0.88	61	2	26	5	0	0
8-31	0.75-1.00	6.15	2.02	113	13	59	60	8	6
9-04	2.0-3.0	0.40	0.07	12	0	10	0	0	0
9-09	1.5	0.92	0.10	39	1	12	2	1	0
9-16	1.75	1.93	0.35	32	0	12	0	6	0
9-19	1.75	0.47	0.79	24	0	34	0	13	1
9-20	1.75	1.80	0.35	122	0	15	3	14	2
10-3	1.5	1.0	0.19	13	2	7	7	-	0
10-4	1,5	3.2	0.39	45	0	23	7	10	6
10-5	3.0	3.0	0.55	65	0	8	1	-	5
10-6	1.0	4.0	0.72	66	0	12	6	12	5
10-7	1.5	3.0	0.37	52	2	40	1	18	1
10-8	2.5	2.0	0.36	46	0	8	4	2	1
10-9	3.0	3.0	0.89	45	0	12	0	7	0
10-10	1.5	1.0	0.19	31	0	2	0	2	0
10-17	0.5	0.8	0.26	43	2	22	10	-	7
10-18	0.75	0.8	0.21	42	4	16	11	-	0
10-19	1.5	0.5	0.20	30	0	5	0	-	0
10-21	2.3-4.0	0.6	0.25	27	0	15	1	1	0

[1] distance from shore (nautical miles)
[2] observer observation time
[3] 2° cone analyses

Fall 2010 Offshore Avian Radar Boat Validation Surveys Raw Data

Date	Observer Survey Effort (hrs)	No. Birds Per 500 m
8-29[2]	1.25	19
8-30[3]	1.00	50
9-10[3]	1.80	69
9-22[3]	2.00	126
9-23[3]	1.75	127
10-14[3]	1.90	121
10-15[3]	1.80	107

[1] birds per NM per hour
[2] transect survey
[3] point survey

APPENDIX E

NEARSHORE INCIDENTAL BIRD OBSERVATIONS

Estimates of Nearshore Bird Species Abundance during the Avian Radar Baseline Study, Fall 2010

Common Name	8/26	8/27	8/30	8/31	9/16	9/19	9/20
Brant	-	-	55	-	60	-	-
Canada Goose	20	3	-	-	-	45	-
Wood Duck	-	-	-	-	-	5	-
American Widgeon	-	-	8	-	-	17	1
Mallard	45	-	-	-	-	4	-
Northern Shoveler	-	-	12	2	-	40	50
Northern Pintail	60	12	220	500	115	1105	60
Green-winged Teal	15	-	-	12	4	175	32
Greater Scaup	-	-	-	-	-	12	-
Lesser Scaup	-	-	-	-	-	-	22
Surf Scoter	50	40	28	125	8	85	117
White-winged Scoter	70	50	40	155	11	93	130
American Scoter	10	-	-	-	-	-	1
Red-throated Loon	-	8	-	30	-	8	-
Pacific Loon	3	2	2	2	12	45	40
Common Loon	6	1	1	-	-	4	1
Red-necked Grebe	-	-	-	-	-	1	-
Eared Grebe	1	-	-	-	-	-	-
Western Grebe	7	1		5	1	3	1
Northern Fulmar	-	-	-	-	-	2	-
Pink-footed Shearwater	-	-	-	-	2	9	4
Buller’s Shearwater	-	-	-	-	-	62	-
Sooty Shearwater	8	30	45	15	30	605	700
Brandt’s Cormorant	2			2	6	76	200
Double-crested Cormorant	30	50	15	45	40	11	11
Pelagic Cormorant	2	1	1	1	1	9	3
Brown Pelican	45	15	-	1	30	28	7
Great Blue Heron	3	1	-	-	-	1	-
Turkey Vulture	15	14	-	4	5	3	2
Osprey	-	3	-	3	1	-	-
Bald Eagle	1	2	-	1	-	-	-
Northern Harrier	-	-	-	-	-	-	1
Peregrine Falcon	1	-	1	-	-	1	-
Semi-palmated Plover	3	4	10	2	-	-	-
Killdeer	-	-	4	-	-	-	-
Whimbrel	-	-	3	7	-	2	-
Sanderling	45	1	200	35	90	80	95

Estimates of Nearshore Bird Species Abundance during the Avian Radar Baseline Study, Fall 2010 (*continued*)

Common Name	8/26	8/27	8/30	8/31	9/16	9/19	9/20
Western Sandpiper	400	200	625	50	10	45	22
Red-necked Phalarope	-	-	-	200	-	75	60
Heerman's Gull	2	-	2	-	-	4	-
Western Gull	175	175	75	210	220	310	625
California Gull	30	35	25	35	25	91	235
Glaucous-winged Gull	2	-	-	4	-	3	-
Caspian Tern	-	-	-	-	1	-	-
Common Tern	3	-	-	2	-	-	8
Parasitic Jaeger	1	-	-	-	-	3	-
Common Murre	15	2	100	45	20	22	35
Pigeon Guillemot	20	17	2	6	-	-	1
Marbled Murrelet	15	-	2	-	-	-	-
Cassin's Auklet	3	-	3	6	-	-	-
Rhinoceros Auklet	15	3	18	25	8	11	4
Tufted Puffin	-	4	-	-	-	-	-
Survey Duration	8.5	2.5	2.0	4.5	4.5	4.5	3.0