Digital Aerial Baseline Survey of Marine Wildlife in Support of Offshore Wind Energy

Survey Plan Summer 2016, Digital Survey #1

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

NORMANDEAU ASSOCIATES Environmental Consultants

APEM

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Survey Plan Summer 2016, Digital Survey #1

Prepared for
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Introduction

Normandeau/APEM will complete quarterly high resolution aerial digital surveys for three years over the New York Bight, defined as the area of the ocean from the south shore of Long Island to the continental shelf break. This matches New York State Department of State's Offshore Planning Area (OPA). The approximate size of the area is 12,650 square nautical miles, or 43,356 square kilometers. Transect surveys will cover a minimum of 7% of the OPA. In addition, a 20% grid based survey of the Wind Energy Area (WEA) with a 4-km buffer will be completed for which half of the imagery collected in the WEA, representing 10% of the WEA area, will be analyzed. The planned image resolution of all the imagery for the project will be 1.5 cm ground sampling distance (GSD) at the surface of the ocean. The following describes the general survey plan for the three years.

Survey Design

Survey by Transect & Grid

For the OPA, linear transects will be flown to cover a minimum of 7% of the area's sea surface. For the first survey there will be 52 parallel transects across the OPA at an approximately 4.8-km distance apart from each other (Figure 1a). For subsequent surveys there will be 28 transects at an approximately 8.3-km distance apart from each other (Figure 2a). For the transect surveys, abutting imagery will be generated. For the first survey, the planned abutting footprint will be 0.044 km^2. For subsequent surveys, the planned abutting footprint will be a 0.064 km^2. This is due to a different camera system being used for the first survey. The survey will be planned with dedicated planning software that allows the planned nodes to abut, which will minimize overlap with the neighboring image along the transect.

The survey area covers the OPA from the coast, within about 750 meters of the shoreline, to the continental shelf. Flights will be planned to begin at a transect point next to the coast and surveyed until the end of the line. The transects are generally oriented in a north to south direction. Once a line is complete, the neighboring line will be flown in the opposite direction. This will vary depending on the time of year, but will be subject to suitable weather conditions. Please note that the number of transect lines and the sequence flown may differ in the final flight plan and the values in this document are representations of the survey design as planned.

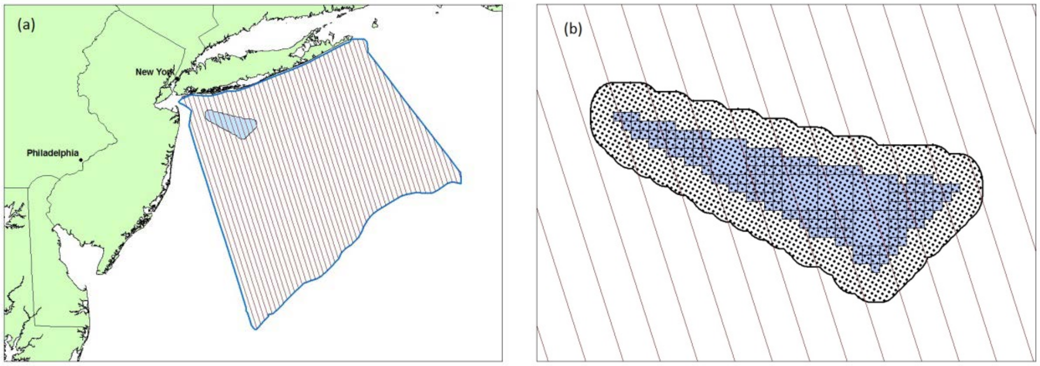

Figure 1. (a) New York Offshore Planning Area (OPA) showing transect survey protocol to achieve 7% coverage with Shearwater II. (b) The WEA (blue) and the 4-km buffer area (grey) showing combination of transects (lines) and grid (dots) image capture points for the Shearwater II.

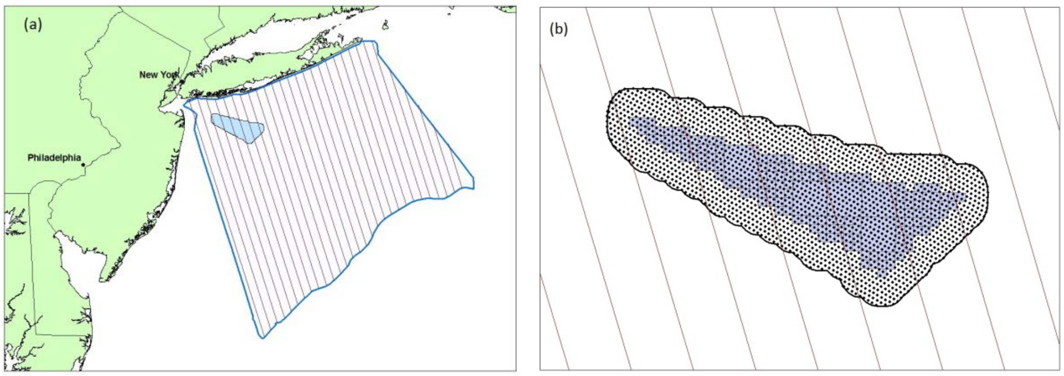

Figure 2. (a) New York Offshore Planning Area (OPA) showing transect survey protocol to achieve 7% coverage with Shearwater III. (b) The WEA (blue) and the 4-km buffer area (grey) showing combination of transects (lines) and grid (dots) image capture points for the Shearwater III.

For the OPA, an abutting transect design allows higher coverage to be collected for a lower cost per unit area. This is because a transect design requires less flying time compared to a gridded survey designed to achieve the same level of coverage. Additionally, when surveying large areas such as the OPA, weather conditions are more likely to change thus reducing flying hours and increasing the chance of completing the survey within a suitable weather window and reducing temporal variation in the data.

The grid survey design will be used for the WEA. Grid surveys employ ecological first principles, essentially using the image footprint as a traditional quadrat to achieve an even and systematic coverage of an area. Grids were chosen for the WEA because there are a number of statistical sampling benefits that will be important when using the data to compare between preconstruction, construction, and postconstruction of potential windfarms in the WEA. A grid design is less prone to miss areas of possible significance because the sample locations are evenly spaced across the area. A more even coverage of survey is especially important for clumped species distribution such as many scoter species known to use the OPA. If large groups of wildlife are present in the gaps between transects, they may be missed, reducing the reliability of the population estimate. There is less chance of this occurring with a grid design. In addition, there are more samples because each footprint is treated as a separate sample area as compared to the fewer number of transects running through an area. Using grids generates a greater sample size and provides greater confidence (e.g., smaller confidence intervals) in the population estimate as compared to transects, making it easier to assess changes over time (e.g., displacement). Due to grid cells normally being separated by equal distances, each individual cell can be considered a separate and independent sample. The independence of the cells can be formally tested to ensure that there is no pseudo-replication. Grid surveys thus normally have a much greater sample number, and as they sample a smaller area they have less variation between images than transects, resulting in a greater confidence in the estimate and a high degree of precision.

For the WEA, the grid imagery footprint will be a minimum of 0.074 km^2. A minimum of 20% of the WEA plus the buffer will be collected; however, only half of the images (representing 10% of the WEA area) will be analyzed. The remaining unanalyzed data can be used if needed in the future to increase sampling size and statistical confidence for key species of interest.

Efforts have been made during the planning phase to minimize the overlap between neighboring imagery with footprints planned to abut and produce a 0% overlap. However, due to slight deviations in the survey altitude, this may not always be achieved. Standard operating procedures for detecting duplicated birds will be followed where any wildlife is captured within the overlap area. Potential duplicated wildlife detected within the overlap area can be discerned based on the shape (wing shape and flight direction for birds for example), behavior (flying, sitting, submerged or surfacing), and if the wildlife is near any distinctive objects or wave crests and the position of the wildlife on the image. If duplicated wildlife is detected it will be noted during the analysis and only counted once.

Unless the survey is instantaneous (e.g., if the whole survey area is recorded in a single photograph) or the survey target is static, double counting can be an issue with almost any survey methodology where a defined area is being sampled over time to obtain a percent coverage of a larger area and the results are used to create population estimates. Double counting can also be an issue with 100% coverage if the target is moving during the survey. However, due to the speed of coverage of digital aerial surveys the probability of double counting is extremely low and for this survey because of size of the OPA and WEA is close to zero.

While there are more sophisticated ways to account for double counting, a simple way to think about double counting probability is to multiply the percent area that each footprint represents for a survey by the percent time it takes to acquire that footprint during the total time of the survey. This simple probability is a function of the percent chance a target will be in two different sampling locations at the exact time the camera is collecting imagery at both those locations. As an example, for the first OPA transect survey, the percent area of each footprint represents is 0.000102% [0.044 km2 / (0.07 × 43,356 km^2)]. For illustrative purposes, the camera can acquire about one footprint every 2 seconds and the total transect survey time will take about 45 hours without turns and refueling. Thus the percent time it will take to acquire that footprint during the total time it will take to complete the transect surveys is 0.00031% [0.5 footprint/second / (45 hours × 60 minutes × 60 seconds)]. The product of those two percentages is 4.5E-011%, a simple probability estimate for double counting a target for the first set of transect surveys. This result provides relative indication of the scale double counting could potentially affect population estimates from these digital surveys and illustrates two of the advantages of digital wildlife surveys; sample area and sampling time can be fixed rather than an estimate.

At the end of each year, NYSERDA will evaluate data from the four adjacent quarterly survey events and decide whether the survey methodology should be modified for the subsequent year(s) as part of NYSERDA's overall adaptive approach. The primary goal of the project is to create baseline seasonal information on the distribution of birds, mammals, turtles, rays, sharks, and other wildlife targets found in the digital imagery. The *a priori* assumption for this study is that digital aerial survey results will reveal new information about the hot spots, distribution, and population estimates for the OPA, which necessitates distributing the transects equally across the OPA. There have been human observer based surveys in the OPA conducted using different methodologies and technology (e.g., by boat and air). That information has been used to define the targeted survey periods for the quarterly surveys rather than to predetermine potential hotspots. NYSERDA acknowledges that the digital survey method could reveal similar spatial patterns found in earlier studies, although patterns could certainly differ. By conducting an annual review, NYSERDA will be able to evaluate whether adjusting the level of effort from one area within the OPA to another might produce better overall baseline information for the OPA. For example, it is possible that at the end of Year 2, the results confirm that a there are consistent patterns showing very low wildlife activity in certain areas compared to other areas and those results are also supported by historical and ongoing observer based surveys. In that event, NYSERDA may want to reduce the coverage in those areas and increase coverage in areas of higher wildlife density. This could result in tighter population confidence intervals and would also increase the likelihood of finding rare species in known hot spots. This will only be known after sufficient data are collected. Any changes by NYSERDA to the methodologies would be done with feedback from the Project Advisory Committee (PAC) and other key stakeholders. Changes to the survey plan would only be implemented if they furthered the confidence in the baseline survey results.

Survey Schedule

Starting in July 2016, 12 aerial digital still surveys of OPA and WEA (Figures 1 and 2) will be carried out over 3 years with one survey delivered per season (spring, summer, fall, winter) per year. Surveys will coincide with peak biological activity and associated weather patterns affecting seasonal movements of birds to maximize hot spot identification. The survey schedule was developed to capture peak times of abundance for as many taxa based on historical data collected within the area and region. This provided a broad overview of the likely species and abundances that could be expected. A month prior to the start of the seasonal survey window, long term weather forecast and local weather trends will be monitored to determine a suitable time to mobilize for the survey.

The following outlines the targeted periods and the abundant taxa that will likely be recorded based on the historical data.

- Winter: End Feb/Mar—Ducks, Loons, Grebes, Puffin, Jaeger, Skua, Pilot Whale
- Spring: End Apr/May—Ducks, Loons, Grebes, Puffin, Jaeger, Skua, Cormorant, Pilot Whale
- Summer: End July/Aug—Fin Whale, Minke Whale, Humpback Whale, Pilot Whale Turtles, Loon, Grebe, Jaeger, Skua
- Fall: End Oct/Nov—Ducks, Loons, Grebes, Puffin, Jaeger, Skua, Cormorant, Turtles, Pilot Whale

The endangered Northern Right Whale could be recorded during all periods but will most likely be recorded during the Spring target period. The greatest chance to find a threatened Roseate Tern will also be in the Spring and possibly during the Summer.

Each seasonal survey will require an estimated 50 hours of combined aerial survey time spread over 10–15 days. For planning purposes, there will be about 5 hours per day on average of actual data collection in addition to daily transit to/from the airport and refueling. However, the number of hours of actual data collection will vary depending on season and weather.

Flight Planning

Planning

The Shearwater II and Shearwater III camera systems are integrated with custom flight planning software that allows each survey transect to be accurately mapped out before the aircraft leaves the ground. Each image capture node for both transects and grid surveys are precisely defined, allowing the system to fire the camera exposures at exactly the right location. The planning systems also enable tolerances on flight path along survey lines to be set, automatically aborting survey lines if the aircraft deviates too far off the planned flight line. An associated flight planning document (Appendix 1) will be available to the pilot and camera technician. It contains the basic technical information needed to successfully plan and undertake a specific aerial survey. This document is maintained and version controlled. The flight planning document includes:

- **Project details**: this section provides basic details including the project name, project code, and survey areas for reference. For background information, a brief description of the aims of the project and relevant details about the survey location are provided. Points of contact including the client and APEM project manager are also included.
- **Camera information**: this is essential technical information for the pilot and camera technician to allow replication of the survey design.
- **Maps of the survey area**: maps are provided to assist when planning the aerial survey and for reference. Maps will include the survey areas, image nodes, scale bar, and location in relation to the coast.
- **Timings**: estimated task time is provided to allow the survey team to plan the survey within the survey window taking into account weather conditions.
- **Specific requirements**: these are requirements unique to the project, such as if the survey team is required to record shipping activity within the survey area.
- **Survey windows**: this can be specific dates, or months, or intervals required between each survey if multiple surveys are required.
- **Weather conditions**: absolute and preferred weather criteria needed to undertake the survey including visibility, cloud cover, sea state, and wind.

Survey Aircraft

Each survey specific flight plan will specify the aircraft that will be deployed but the following are requirements for all the aircraft that will be used:

- **Twin engines**: this is essential from a health and safety perspective when flying for prolonged periods over the sea
- **Survey modified**: a survey hatch through the floor of the aircraft to position the camera systems, so they can look vertically downwards, and an available power supply
- **Slow flying**: aircraft capable of relatively slow flight speed (less than 140 knots) improve image quality due to reduced motion blur
- **Long endurance**: aircraft capable of flying for several hours between refueling stops for survey efficiency
- **Reliable**: aircraft are well maintained from both a health and safety and survey efficiency point of view

As the project will be over three years and the exact survey times may change due to weather and other factors, three air charter companies (Williams Aviation, AV Watch, and Landvue) have been identified as suitable to be used for the project that meet the above requirements. Having three, rather than one company, provides the flexibility required to ensure a suitable aircraft is available when the project requires it.

Weather, Altitude, and Deployment

For the period of each survey, the aircraft will transit and be based out of a local airfield close to the survey area. The most likely airfields used for this will be Farmingdale (KFRG), Islip (KISP), Shirley (KHWV), Westhampton (KFOK), and East Hampton (KHTO), all of which are located along Long Island.

For the first survey, the survey flight altitude will be 1,009 ft, and for subsequent surveys a survey altitude of 1,360 ft has been selected to optimize coverage and minimize interference from cloud cover. However, if required for any reason, the altitude could be increased or decreased by changing lenses with minimal impact to image quality. Flying at a higher altitude would likely increase the number of days lost to low cloud cover however.

Aircraft will fly at a target ground speed of approximately 120 knots to reduce motion blur and ensure a high image quality. The execution (i.e., the order in which the transect lines and grids will be flown) of each flight will take into consideration weather conditions and migratory pathways, and may therefore vary for each survey. In addition, the execution may also be affected by other aerial and boat based surveys being done in area by NYSDEC or AMAPPS as well as by air traffic control restrictions. The survey team will regularly communicate with other potential survey aircraft/air traffic in the vicinity of the survey area and will inform the appropriate personnel of their plans to be on task.

Surveys will be undertaken in weather conditions that do not limit the ability to identify marine fauna at or near the water surface. These conditions are cloud base >1,400 ft, visibility >5 km, wind speed <30 knots, and sea state 4 or less, aiming for 2 or less to maximize turtle encounters.

In addition, on days with little cloud cover, surveys will avoid mid-day to minimize the risk of collecting images with glint (strong reflected light off the sea) that makes finding and subsequently identifying the marine fauna recorded in the images more difficult. During the survey the onboard camera technician will complete an offshore weather report documenting the percent cloud cover, visibility, outside air temperature, pressure, sea state, wind speed, and wind direction at a maximum interval of every two hours (Appendix 1). The onboard camera technician will continuously monitor the weather conditions and images collected. If the images collected cease to be of sufficient quality, image acquisition will cease until suitable conditions return. In addition, extra imagery will be collected to replace potentially glint-affected images.

Contingency Planning and Coordination with Other Survey Teams

Weather windows can be short-lived in New York waters. The Team has analyzed the weather data in the OPA to determine approximately how many days may have to be cut short or cancelled due to weather and added this to our project planning. The survey window of 10–15 days per survey includes an average of five days of delays and/or standby due to weather and other environmental factors that affect image quality and staff safety such as glare. However, the survey windows cover multiple weeks when historical data shows seasonal peaks in marine fauna, further reducing the already low risk of a seasonal survey being missed.

During the three survey years there will be other observer based surveys being conducted in the OPA and region. These include surveys being done for BOEM's AMAPPS program and NYSDEC's whale monitoring project. As part of planning process for each survey, APEM will be proactively coordinating with key representatives from these groups prior to and during survey times when multiple groups will be in the region. This will be done to ensure safety of all parties but also to ensure that data being collected by each group is not affected by the activities of the other groups. A working group of BOEM, NYDEC, NYSERDA, and NYDOS and their contractors has been established to coordinate activities and share results.

Camera and GPS/GNSS Systems

The surveys will be completed using two camera systems (see *Planning* above). The first survey will be completed with the Shearwater II. Subsequent surveys will be completed using the Shearwater III camera system. Shearwater III has a larger footprint than the Shearwater II, which will enable the subsequent surveys of the OPA to be done with fewer flight lines. The Shearwater III has an array of high specification sensors, which can be mounted in a variety of configurations to provide flexible surveying adapted for the needs and conditions of each study. The preferred method for mounting both camera systems is bolting them into a hole/hatch in the belly of an aircraft ranging from 17 to 22 inches. Although the Shearwater III is capable of capturing imagery at 1 cm GSD, operating it at this resolution would significantly reduce the survey footprint without increasing the data quality (i.e., the ability to identify small individuals to species). We have designed the system (including flight altitude) to obtain optimum resolution for species identification while providing cost-effective large image footprints. It is possible that during the annual review of the survey plan, the question of image resolution versus survey footprint will be revisited.

Both the Shearwater II and Shearwater III collect vertical imagery rather than oblique imagery and use still imagery. Custom flight planning software preprograms the survey transects and grids, while system-specific, aircraft-mounted GPS/GNSS systems ensure that surveys are flown as accurately as possible. APEM's GPS/GNSS system has a manufacture quoted accuracy of 5 to 10 meters. The navigational systems are calibrated with aircraft control systems and continuously monitored. Image acquisition is automatic, removing human error; data capture occurs over specified locations. As data capture occurs, GPS data are automatically logged with each exposure including the xyz coordinate and heading of the camera at the point of capture. It is impossible to fly in a perfect line at constant altitude due to effects of weather and atmospheric pressure on aircraft during flight. Commonly, an aircraft moves up and down 10 to 45 m during surveys and consequently each captured image is likely to have some small deviation from the planned vertical position. Automatically recorded spatial information in real time, in particular the z coordinate (camera sensor height), is crucial.

Image resolution of 1.5 cm is considered the optimum image resolution to enable accurate target species identification while still providing cost-effective coverage for this project. APEM routinely captures imagery at 2 cm resolution in Europe, which is more than sufficient for identifying most European seabirds to species level, and increasing 2 cm resolution to 1.5 cm will further increase confidence in identification of smaller birds such as the federally listed roseate tern. The Shearwater III is capable of capturing imagery at 1 cm resolution, but even at that resolution, it is unlikely to attain species level differentiation of shorebirds, such as the federally listed piping plover. Consequently, 1.5 cm gives optimum resolution for species identification while providing cost-effective large image footprints.

Survey Staff

For each survey's Flight Plan, the staff and aircraft providers will be detailed with applicable contact details of the parties involved. The following are the key staff involved with the planning of the surveys.

- Ann Pembroke: Normandeau Project Manager—Overall management of the project and coordination with NYSERDA and APEM. apembroke@normandeau.com, (603) 637-1169
- Christian Newman: APEM Project Manager—High level planning and coordination with Normandeau and NYSERDA. c.newman@apem-inc.com, (352) 559-9155, ext. 1350.
- Julia Robinson Willmott: Normandeau Technical Director—Supervision of Normandeau image analysis, species identification, and overall QA/QC. Survey timing and population estimation. jwillmott@normandeau.com, (352) 327-3262.
- Stuart Clough, APEM Director—Responsible for overseeing the development of the technical survey methodology. Will be available as needed for technical discussions with NYSERDA and Team. s.clough@apemltd.co.uk, (352) 559-9155, ext. 1351.
- Stephanie McGovern: APEM Operations Manager—Day to day management of APEM staff responsible for acquisition, processing, and analysis of the data. Will be responsible for tracking progress of surveys and communicating NYSERDA and Team. S.McGovern@apemltd.co.uk, 011 44 1244 520 460.
- Ben Chapman: APEM Aviation Task Manager—Responsible for interacting with the aviation provider to set up the contract and to ensure that the flight surveys are occurring safely and on time. Also, responsible for providing Flight and Health and Safety Plan. b.chapman@apemltd.co.uk, 011 44 1244 520 460.
- John McCarthy: APEM Camera Task Manager—Responsible for commissioning, building, maintaining and testing camera system. Responsible for overseeing camera technicians using camera systems. Will work closely with Aviation Task Manager to coordinate installation and testing of the equipment in aircraft at the beginning and for each survey and will provide support completing Flight and Health and Safety Plans. j.mccarthy@apemltd.co.uk, 011 44 1244 520 460.

Data Management

When on task each aerial survey will be managed by the APEM camera technician. The camera technician will upload flight plans to the camera system, select which line to capture, adjust the camera exposure settings accordingly and be responsible for in flight Quality Assurance of the captured imagery. The camera technician will record the progress of the mission using an APEM standard Survey Diary (see Appendix 1).

Upon completion of each flight all images acquired will be securely saved and backed-up on a dedicated processing machine at APEM’s mobile field office. At this point, multiple copies of the data will be created and cross-checked. Once relevant checks are completed, one copy of the data will be shipped to APEM HQ and downloaded to secure storage servers. A second copy and the survey disks will remain at the mobile field office to ensure data redundancy in the unlikely event of loss of data in transit.

The management of the data will be overseen by a primary data manager in the US and a secondary data manager in the UK. Appropriate workflows are in place to ensure the rapid transportation and processing of data to allow imagery for analysis and reporting. Once those data have been processed and screened for potential targets, data will be transferred daily via an online FTP to Normandeau. Species analysts at APEM and Normandeau will complete species identification and associated QA/QC of the data.

By the end of the project the entire library of georectified target images and associated data and analyses including all approved reports will be available for download on a dedicated web portal. All data will be added to these databases: Northwest Atlantic Seabird Catalog, a publicly held database housed by the USFWS that is the main repository for observations and survey data collected in Atlantic waters from

Florida to Maine since 1906; the North Atlantic Right Whale database; the NOAA AMAPPS; Mid-Atlantic Regional Council on the Ocean (MARCO) Mid-Atlantic Ocean Data Portal; and New York State Department of State's geographic information gateway.

Appendix 1. Sample Field Data Sheets

APEM

Project Name	
Project Number	
Project Manager	

Dates	
Page 1 of	

Aircraft	
Survey team	
Camera	
Lenses	
Altitude	
Required GSD	

Survey checks	
Confirm current flightplan	
Confirm survey altitude	
Correct Lenses fitted	
Confirm lens focus	
Clean lenses before take off	

Survey comments and issues

End of Day Line Check	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		

Quality control and survey feedback (Office use only)

Image Check		Flight Plan Check		Line Check		Glint Check		

Please scan to file once survey is complete: Y:\Admin\Aircraft Admin\Survey Records\Survey Tech Records

A.S.T. signature and date		Q.C. Signature and date	

Project Name	
Project Number	
Media number	

Dates

Page
of

Run	Line	Bearing	GS (kts)	Time on Line	Time off Line	Sun Angle	GPS	Image Quality	Missing Images	Ship	Notes	Line complete
1		°	kt	:	:	°						
2		°	kt	:	:	°						
3		°	kt	:	:	°						
4		°	kt	:	:	°						
5		°	kt	:	:	°						
6		°	kt	:	:	°						
7		°	kt	:	:	°						
8		°	kt	:	:	°						
9		°	kt	:	:	°						
10		°	kt	:	:	°						
11		°	kt	:	:	°						
12		°	kt	:	:	°						
13		°	kt	:	:	°						
14		°	kt	:	:	°						
15		°	kt	:	:	°						
16		°	kt	:	:	°						
17		°	kt	:	:	°						
18		°	kt	:	:	°						
19		°	kt	:	:	°						
20		°	kt	:	:	°						
21		°	kt	:	:	°						
22		°	kt	:	:	°						
23		°	kt	:	:	°						
24		°	kt	:	:	°						
25		°	kt	:	:	°						

Comments/Issues

Project Name:		**Date:**	
Project Number:			

Time Local	Boat Type	Degree, Decimal Minute	Degree, Decimal Minute	Bearing

OFFSHORE WEATHER REPORT

TIME	CLOUD COVER (%)			VISABILITY (KM)			OUTSIDE AIR TEMP (^{o}C)			PRESSURE (QNH)			WIND SPEED AND DIRECTION (KTS + ^{o})			SEA STATE (0 - 4)		
	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE
0600-0800																		
0800-1000																		
1000-1200																		
1200-1400																		
1400-1600																		
1600-1800																		
1800-2000																		
2000-2200																		

CLOUD COVER	
0-10%	CLEAR
11-50%	SCATTERED
51-94%	BROKEN
95%-100%	OVERCAST

SEA STATE	
0	CALM (GLASS)
1	CALM (RIPPLED)
2	SMOOTH
3	SLIGHT
4	MODERATE

COMMENTS OR SUGGESTED IMPROVEMENTS

Appendix 2. Sample Flight Plan

Sample Flight Plan

Project Number/Name

Revision and Amendment Register

Version Number	Date	Section(s)	Page(s)	Summary of Changes	Signature

Table of Contents

If printed this document will be considered uncontrolled

Project Details

Project Name:

Project Code:

Project Survey Areas:

Project Type:

Client:

Project Manager:

Project Description

About Location

Camera Information

The table below details the requirements for completing the Survey when using the ______ camera system.

Transect Survey

Flight Plan Title	
Required mount	
Direction of mount	
Len(s) required	
GSD	
Height ft (AGL)	
Altitude ft (AMSL)	
Transects	
Total number of image points	
Total km	
Total transect time / decimal hours	
Total turn time / decimal hours	
Total task time / decimal hours	

Grid Survey

Flight Plan Title	
Required mount	
Direction of mount	
Len(s) required	
GSD	
Height ft (AGL)	
Altitude ft (AMSL)	
Transects	
Total number of image points	
Total km	
Total transect time / decimal hours	
Total turn time / decimal hours	
Total task time / decimal hours	

Aerial Map

Figure 1 - Survey Area

Earth Map

Figure 2 - Survey Area

Individual Survey Maps

Figure 3-

Figure 4-

Timings

Please note all survey timings are in decimal hours. Calculations are worked out assuming the aircraft is flying at ____knots and require ___minutes per turn. This is to ensure a worst case scenario.

Total transect time / decimal hours	
Total turn time / decimal hours	
Total task time / decimal hours	

Table 1 - Total time on survey

Comments and Specific Requirements

If you're likely / required to deviate from the intended survey plan (i.e. it will take longer than instructed), then permission from the project manager must be sought before continuing with survey.

All shipping/boating observations must be completed.

Survey Window(s)

Survey	Dates

Weather

Absolute criteria	Preferred criteria
Visibility:	Visibility:
Cloud Cover:	Cloud Cover:
Wind:	Wind:
Other:	Other:

Note: If unsure please speak to the project manager. The pilot at any time can make the decision to cancel the survey if the weather conditions become dangerous to fly.

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Appendix 3. Survey Transect Endpoints

Transect Survey of OPA (WGS 84)

Transect Number	Start		End	
	X	Y	X	Y
1	-70.575904	39.756602	-70.636538	39.947383
2	-70.721286	40.035521	-70.632168	39.7562
3	-70.690605	39.762584	-70.806614	40.124743
4	-70.891795	40.212777	-70.742886	39.749638
5	-70.790423	39.721911	-70.977192	40.300758
6	-71.062807	40.388685	-70.83938	39.698703
7	-70.890494	39.682282	-71.148642	40.476558
8	-71.235072	40.56551	-70.943415	39.671511
9	-71.000357	39.673196	-71.321351	40.653273
10	-71.407854	40.740979	-71.057303	39.674854
11	-71.112779	39.671946	-71.49458	40.828629
12	-71.581915	40.917355	-71.167883	39.667877
13	-71.222612	39.662648	-71.694846	41.080806
14	-71.752261	41.079904	-71.273993	39.647186
15	-71.324237	39.628298	-71.809676	41.078973
16	-71.864377	41.070085	-71.374081	39.608254
17	-71.422778	39.584785	-71.911296	41.038521
18	-71.964006	41.023922	-71.471816	39.562429
19	-71.522699	39.545717	-72.015525	41.005901
20	-72.066625	40.986724	-71.57168	39.523315
21	-71.618372	39.494092	-72.11848	40.969786
22	-72.169918	40.951693	-71.662386	39.456918
23	-71.703334	39.410661	-72.220935	40.932445
24	-72.272317	40.914304	-71.743849	39.363255
25	-71.78166	39.307902	-72.322883	40.893877
26	-72.373813	40.874558	-71.821681	39.25933
27	-71.865058	39.220935	-72.425112	40.856346
28	-72.476383	40.838111	-71.913705	39.198374
29	-71.962702	39.176924	-72.529218	40.824374
30	-72.581235	40.808352	-72.009002	39.147527
31	-72.047627	39.09547	-72.634028	40.794566
32	-72.686399	40.779625	-72.089252	39.052454
33	-72.133503	39.017342	-72.739148	40.76579

Transect Number	Start		End	
	X	Y	X	Y
34	-72.791877	40.75193	-72.179244	38.986738
35	-72.225713	38.958378	-72.843779	40.735786
36	-72.895656	40.719618	-72.272146	38.929998
37	-72.320468	38.907255	-72.94751	40.703426
38	-72.998528	40.684951	-72.371848	38.893539
39	-72.422436	38.877538	-73.04952	40.666454
40	-73.101703	40.651319	-72.471452	38.856991
41	-72.520828	38.837553	-73.155087	40.639547
42	-73.208453	40.62775	-72.567457	38.810179
43	-72.613662	38.781655	-73.263848	40.62157
44	-73.323747	40.627774	-72.65944	38.75198
45	-72.704399	38.720027	-73.377899	40.618154
46	-73.430388	40.603997	-72.747363	38.682404
47	-72.791065	38.647024	-73.484094	40.593199
48	-73.537783	40.582375	-72.836292	38.616145
49	-72.885801	38.597674	-73.596847	40.586182
50	-73.65384	40.584323	-72.933318	38.573533
51	-72.975681	38.53469	-73.71208	40.585817
52	-73.769489	40.585028	-73.016816	38.492442
53	-73.060271	38.456954	-73.823966	40.576324
54	-73.876271	40.561797	-73.109953	38.439347
55	-73.212138	38.571033	-73.927831	40.545308

Grid survey of WEA (WGS 84)

Transect Number	Start		End	
	X	Y	X	Y
1	-73.1944	40.15581	-73.2786	40.1726
2	-73.2858	40.18185	-73.1853	40.16183
3	-73.1769	40.16795	-73.3039	40.19327
4	-73.3532	40.21086	-73.1685	40.1741
5	-73.1601	40.18024	-73.3848	40.22493
6	-73.4165	40.23901	-73.1519	40.18642
7	-73.1422	40.1923	-73.4646	40.25631
8	-73.4979	40.27067	-73.137	40.19908
9	-73.1318	40.20585	-73.5104	40.28095
10	-73.5438	40.2953	-73.1177	40.21084
11	-73.111	40.21732	-73.5904	40.31225
12	-73.6208	40.326	-73.1013	40.2232
13	-73.0931	40.22938	-73.6378	40.33714
14	-73.6504	40.3474	-73.0849	40.23556
15	-73.0767	40.24173	-73.6616	40.35738
16	-73.6653	40.36591	-73.0685	40.24791
17	-73.0589	40.25381	-73.6691	40.37446
18	-73.6685	40.38216	-73.0524	40.26031
19	-73.0476	40.26718	-73.6683	40.38992
20	-73.6674	40.39756	-73.0437	40.27422
21	-73.0414	40.28157	-73.6651	40.40492
22	-73.6625	40.41222	-73.0402	40.28915
23	-73.04	40.29692	-73.6593	40.41942
24	-73.6537	40.42612	-73.0402	40.30478
25	-73.0405	40.31267	-73.6437	40.43199
26	-73.6178	40.43474	-73.0442	40.32123
27	-73.0517	40.33057	-73.1672	40.35367