Land based Visual Observations

Data collection protocols: Billia Croo Wave Site

Project Name:	EMEC Billia Croo Visual Observations Protocol
Reference:	MMM.0908.EME_001
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1 SUMMARY

Land based visual observations will be carried out by observers on a hilltop overlooking the Billia Croo wave site in Orkney. Watches will be carried out by an experienced observer during daylight hours, ranging between 04:00hrs and 20:00hrs. The study area will be scanned and the time and location of any marine mammal or seabird sightings will be recorded. Where possible, the geographic location of each marine mammal or seabird group will be recorded using the horizontal and declination angle measurements from 'Big-Eye' binoculars (e.g. Hammond, Berggren et al. 2002). Although marine mammals and seabirds will be identified to species whenever possible, due to the difficulty in differentiating between marine mammal and bird species, especially at distance, additional categories of 'unidentified species' will be included in the species list. Additional information about species sighted will be collected. For marine mammals, group size will be estimated if animals are seen in groups and the location of centre of the group should be recorded. Information about direction of movement and behaviour will also be recorded. Surveys will encompass all states of tide and times of day (during daylight hours) in a systematic manner to ensure there is appropriate sampling of all environmental states. Tide state will be defined in relation to time since the previous high tide recorded at Stromness. Data on several weather variables including precipitation, sea state, cloud cover, and wind speed and direction will also be collected. To ensure the data collection is an efficient monitoring tool, and to provide error free and consistent data, an Access 2007 database has been developed to complement these protocols. This will allow appropriate data to be exported directly into the analytical stages with fewer transcription stages. It should be highlighted that data from the land based study described here will provide information on distribution and 'relative' abundance of animals in and around the study area. To inform the analysis about the probability of detecting animals from land, it is suggested that the land based observations are augmented with boat based surveys along transect lines placed perpendicular to the coast. This information would then enable detectability and any genuine changes in abundance to be disentangled and would lead to more robust impact assessment results. Furthermore, baseline monitoring of a site with similar characteristics to the test site, yet relatively undisturbed, would be valuable in determining if potential changes observed are restricted to the wave test site.

2 STUDY AREA

The study area will be a hemispherical shape extending offshore from the coastguard lookout site. This will encompass the whole of the Billia Croo wave site and areas surrounding the wave site. The study area will extend to approximately 5km from shore as this is around the sighting limit for small cetaceans from a clifftop this height (around 90m) (Hastie 2000).

3 SURVEY EFFORT

This land based study will record wildlife 'sightings' during daily 'watches' by making regular 'scans' of the study area (detailed above). The definitions of each of these processes are provided in Figure 1.

Figure 1: Definitions of a watch, scan, and sighting used in these protocols.

3.1 Watch rota

The watch rota for 2009 has been designed to ensure relatively even temporal coverage across daylight hours and tidal states. The number of hours surveyed is based on 5 working days of 4 hours (20 per week / 80 per month). It should be noted that this number of hours is a nominal figure based on existing studies at EMEC; if the relative sighting rates are found to be significantly different to the existing tidal site study, these may have to change (increase or decrease) to provide sufficient power to detect changes. Analyses at the end of the first year's data collection should inform this.

To calculate the number of four-hour watches that should be carried out each day in different months, the time between sunrise and sunset was divided by four and rounded to the nearest whole number. This resulted in 2 different watches for Jan, Feb, Mar, Oct, Nov, and Dec; 3 watches for Apr, and Sep; and 4 watches for May, Jun, Jul, and Aug. These encompass the periods between 0400 and 2000 (Table 1).

Table 1: Number of watches for each month during 2009; the time between sunrise and sunset was divided into between 2 and 4 watches.

Month	Sunrise	Sunset	Daylight	# of watches	Watch 1	Watch 2	Watch 3	Watch 4
Jan	09:06	15:25	06:19	2	09:00-13:00	11:00-15:00		
Feb	08:22	16:30	08:08	2	09:00-13:00	12:00-16:00		
Mar	07:08	17:42	10:34	2	08:00-12:00	13:00-17:00		
Apr	05:38	18:55	13:17	3	06:00-10:00	10:00-14:00	14:00-18:00	
May	04:14	20:06	15:52	4	05:00-09:00	09:00-13:00	12:00-16:00	16:00-20:00
Jun	03:10	21:11	18:01	4	04:00-08:00	08:00-12:00	12:00-16:00	16:00-20:00
Jul	03:05	21:26	18:21	4	04:00-08:00	08:00-12:00	12:00-16:00	16:00-20:00
Aug	04:00	20:35	16:35	4	05:00-09:00	09:00-13:00	12:00-16:00	16:00-20:00
Sep	05:10	19:12	14:02	3	06:00-10:00	10:00-14:00	14:00-18:00	
Oct	06:17	17:44	11:27	2	08:00-12:00	13:00-17:00		
Nov	07:31	16:19	08:48	2	09:00-13:00	12:00-16:00		
Dec	08:40	15:22	06:42	2	09:00-13:00	11:00-15:00		

Each of the watches has been transcribed into a rota (Table 2) that is designed to provide relatively uniform coverage across diurnal and tidal cycles. Although it is understood that some watches will not be carried out for reasons such as weather conditions, it is hoped that the rota can be adhered to as far as possible. If a watch is not carried out on a particular day, there is the scope to transfer that rota number to a day on the following weekend.

Table 2: Daily watch rota for 2009; the watch number for each day should be referenced to the watch times and months in Table 1. Although it is understood that poor weather or unforeseen circumstances will limit the number of days surveying, this rota should be adhered to as far as possible.

	Month											
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1				1	1	2	4		1	1		2
2		1	1	2		3	1		2	2	1	1
3		2	2	3		4	2	3	3		2	2
4		1	1		2	1		4	1		1	1
5		2	2		3	2		1		1	2	
6	2	1	1	1	4		3	2		2	1	
7	1			2	1		4	3	2	1		2
8	2			3	2	3	1		3	2		1
9	1	2	2	1		4	2		1	1	2	2
10		1	1	2		1	3	4	2		1	1
11		2	2		3	2		1	3		2	2
12	2	1	1		4	3		2		2	1	
13	1	2	2	3	1		4	3		1	2	
14	2			1	2		1	4	1	2		1
15	1			2	3	4	2		2	1		2
16	2	1	1	3		1	3		3	2	1	1
17		2	2	1		2	4	1	1		2	2
18		1	1		4	3		2	2		1	1
19	1	2	2		1	4		3		1	2	
20	2	1	1	2	2		1	4		2	1	
21	1			3	3		2	1	3	1		2
22	2			1	4	1	3		1	2		1
23	1	2	2	2		2	4		2	1	2	2
24		1	1	3		3	1	2	3		1	1
25		2	2		1	4		3	1		2	
26	2	1	1		2	1		4		2	1	
27	1	2	2	1	3		2	1		1	2	
28	2			2	4		3	2	2	2		2
29	1			3	1	2	4		3	1		1
30	2		1	1		3	1		1	2	1	2
31			2				2	3				

3.2 Survey protocol

Observations will be made with a pair of fix-mounted 25x power binoculars (Big eyes) (Rugh, Lerczak et al. 2002). These will be mounted on a robust tripod with horizontal and declination angle boards to allow estimates of the geographical locations of wildlife to be made (see Section 4). The 'Big eyes' will be housed inside a coastguard lookout station on a clifftop overlooking the Billia Croo wave test site. Each day, the horizontal and declination angles should be checked and realigned if necessary. This should be carried out using reference points defined at the start of the study.

Observing the area with the 'Big eyes' should be carried out in a consistent manner from left to right at a series of distances from land ensuring the whole study area is covered. It is anticipated that the study area will be fully covered with two sweeps using the 'Big eyes' (a near and a far sweep) and an ad-hoc sweep of the near-shore area using binoculars. The observer should align the 'Big eyes' at the appropriate declination and horizontal angles (to be confirmed after equipment setup) for the 'far' area (1400-5000m from the shore) and sweep from left to right. Rather than a continual sweeping motion, the observer should fix the tripod at the start angles and watch for a short period (to be confirmed after equipment setup). This should then be repeated for each adjacent field of view to the right until the 'far' study area has been covered (Figure 2). Once complete, the observer should then re-align to the appropriate the declination and horizontal angles to sweep the mid area (800-1400m). For the area closer to land ('near' area), it is likely to prove more efficient to use other sighting equipment (binoculars/naked eye) for observations. Therefore, once the mid area sweep is complete, the observer should use the binoculars to sweep the near area (shore -800m) for a set period (to be confirmed after equipment setup). The details of any sightings (see section 4) made in the 'mid' and 'far' areas should be recorded on a Dictaphone before moving to the next adjacent field of view. Sightings made in the near area should be located with the 'Big eyes' after initial sighting with the binoculars and should be recorded on the Dictaphone.

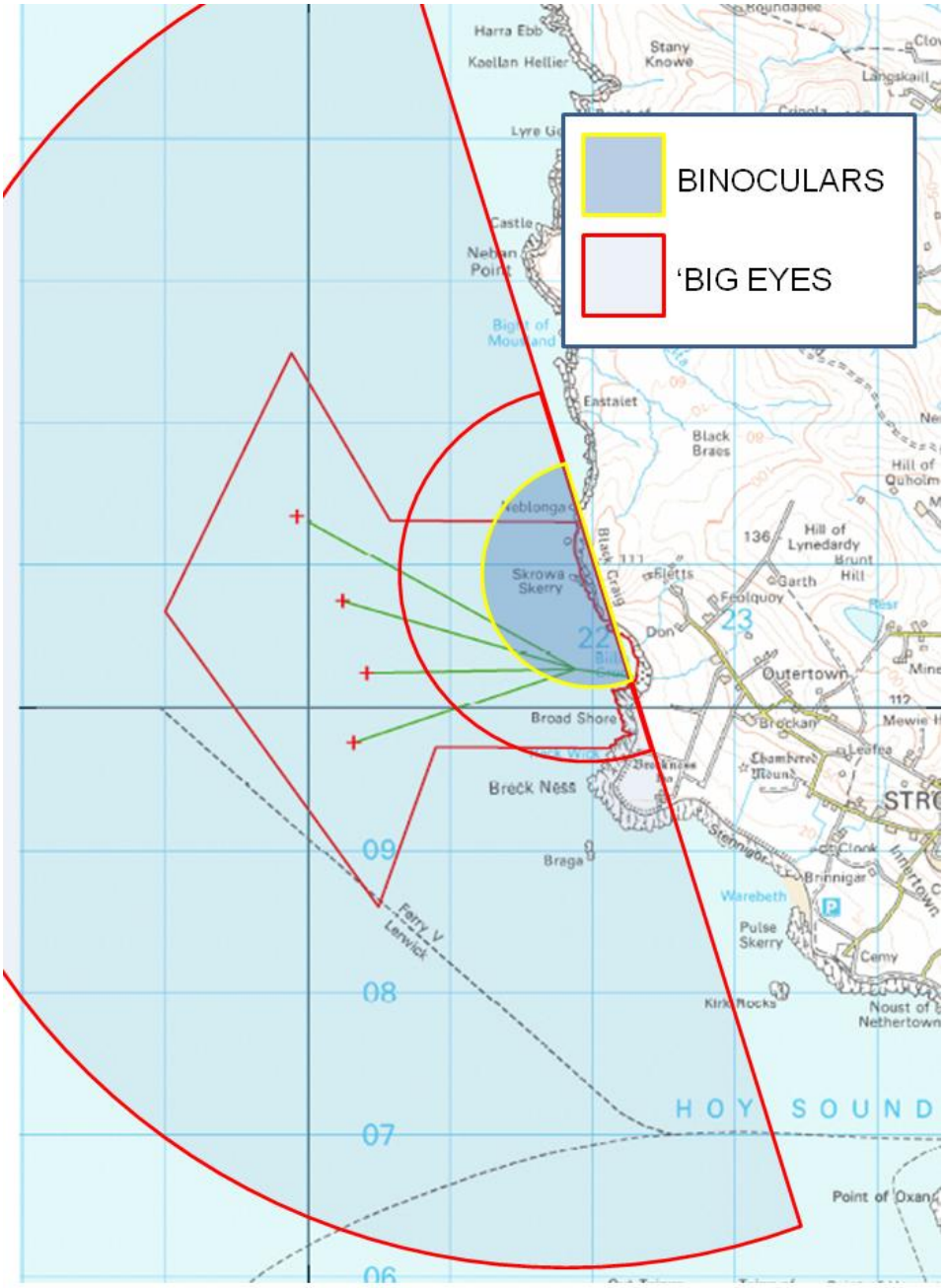


Figure 2: Map of the Billia Croo wave site showing the study area. The study area extends from the shoreline to approximately 5km offshore. The area is divided in 3 sub areas (Near, Mid, and Far) that will be scanned by the 'Big eyes' (Mid and Far sub areas) and binoculars (near sub area).

The period required to carry out a single scan of the entire survey area will be designed to maximise the probability of sighting wildlife whilst minimising observer fatigue; this will be determined at the start of the fieldwork. However, it is anticipated this will be approximately 20 minutes. A period of 10 minutes should be taken between scans to reduce observer fatigue and to allow data entry to be completed. This should allow 2 scans to be carried out per hour (8 per watch/40 per week).

To avoid potential subliminal observer bias associated with knowledge of operations within the survey area (e.g. over or under reporting of animal occurrence/behavior), it is

important that the observer is not made aware site operations. Although it is clear that operations such as ship movements will be observed and interpreted, as far as possible, communication of operations such as device activity (active/not operating) to the observers should be minimized.

3.3 Database

To ensure the data collection is efficient, and to provide error free and consistent data, an Access 2007 database has been developed to complement these protocols. This will allow appropriate data to be exported directly into the analytical stages with fewer transcription stages. Data should be entered in the field during periods between scans.

The database has a structure of 5 data forms and one lookup table that contains information on species, sighting equipment, and environmental conditions etc. The information that can be entered into the 5 data forms is subject to a robust set of data conventions that should reduce the potential for errors in data entry. Although it is not recommended that the data in the lookup table is accessed, if it is found that other information (e.g. other species or vessel types) is regularly required and is not currently included in the database; it can be added in this table.

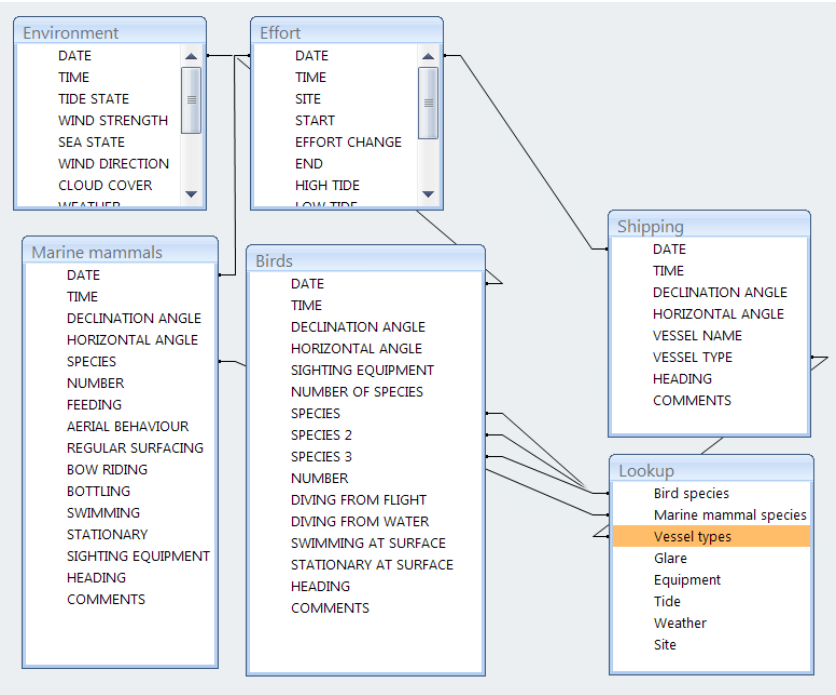


Figure 3: Relationship links between the tables in the Access 2007 database.

When opening the database, an entry form will appear with 9 form access buttons [Effort (Effort and Environment), Sightings (Marine mammals, Shipping, and Birds), and Information (General Info, Cetacean Info, Seal Info, and Bird Info)] (Figure 4a). When clicked, each of these opens a secondary form that either provides a means to enter data or provides further information. The data forms (e.g. Figure 4b) allow data to be entered by typing information or clicking on appropriate tick boxes. Pressing Tab will cycle forward between

boxes and <Alt> Tab will cycle back. To enter a new record, the symbol at the base of the page should be clicked. If a mistake is made during data entry that the database rules allow (e.g. the wrong time or date is entered), the data can be corrected by cycling back through the data (clicking) and correcting the appropriate record. Individual forms can be closed by clicking the x at the top right of each form tab (**not** the x at the top right of the database window). The database can be closed by clicking on the button at the top left and choosing 'Close Database'.

The database should be backed up on a regular basis (daily). This can be done by closing the database and manually copying and pasting the file in Explorer to an external hard drive or backup device. At least two up-to-date copies of the database should be stored in secure locations.

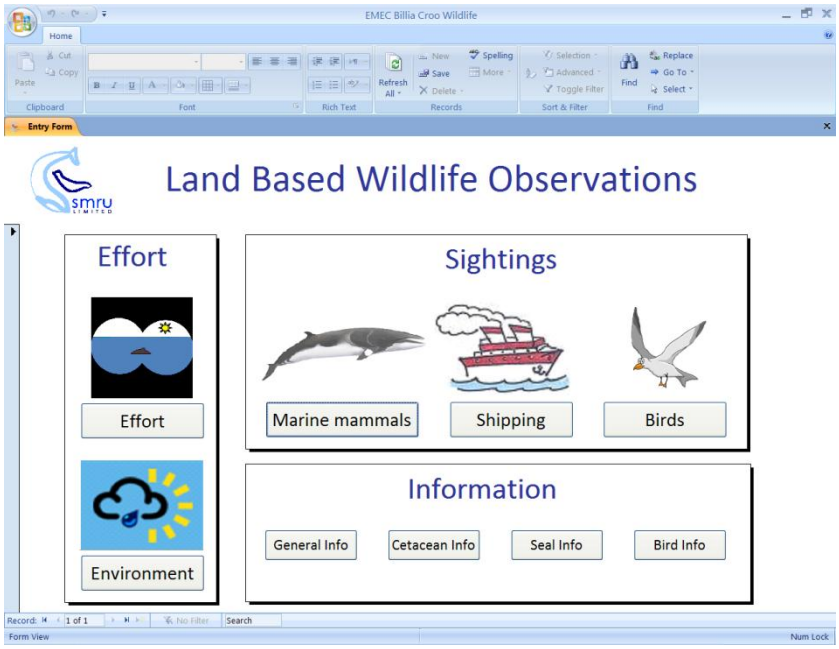
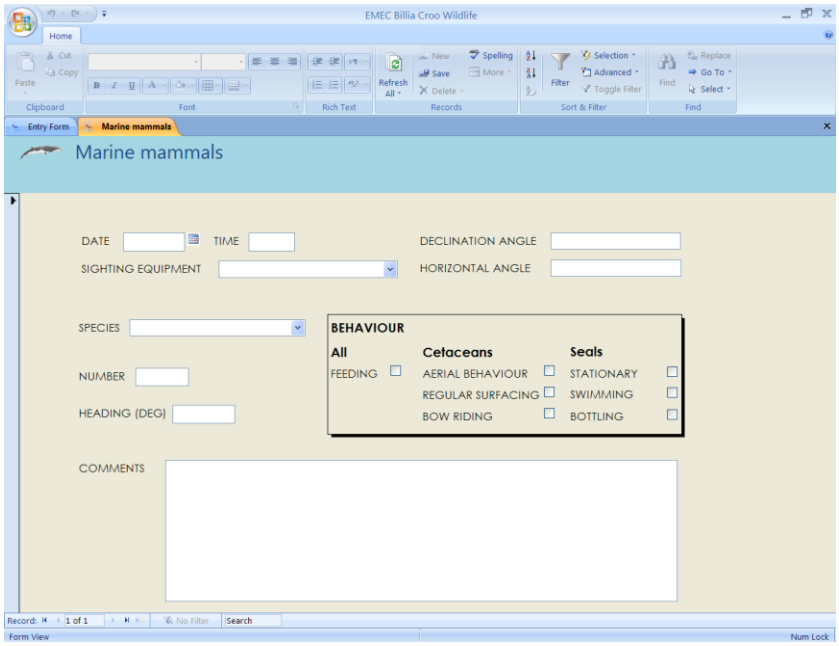


Figure 4 (a): The database entry form which provides access to all data entry [e.g. Figure 4b] and information forms in the database.



(b)

Figure 4 (b): The marine mammal data form which allows data on marine mammal sightings to be entered in real time or post hoc.

3.4 Daily Effort data entry

To accurately interpret the data collected (e.g. sighting rates), it is critical that a robust record of 'observer effort' is provided. The EFFORT form should therefore be filled in at the start and end of each daily watch. If the survey effort changes during the watch (e.g. additional or different observers carry out survey or there is a pause in surveying due to weather), the form should also be filled in.

The data should include:

DATE	Date of the watch.
TIME	Time (GMT) of the effort change.
START	This should be checked at the start of the watch
EFFORT CHANGE	This should be checked if the effort changes during a watch
END	This should be checked at the end of the watch
SITE	The location of the observations. Data is limited to 'Billia Croo' or 'Control' (if a control site is determined).
HIGH TIDE	The time (GMT) of the high tide at the nearest port during the watch day.

LOW TIDE	The time (GMT) of the low tide at the nearest port during the watch day.
NUMBER OF OBSERVERS	The number of observers surveying during the watch.
OBSERVER NAMES	The initials (2 letters) of the observers' name.
COMMENTS	Any additional details related to survey effort (e.g. additional observers join survey).

3.5 Environment data entry

Clearly, environmental conditions play an important role in dictating an observer's ability to sight marine wildlife. Factors such as sea conditions or precipitation will have an effect on both the probability of sighting animals and the range that they can be observed. It is therefore important that a regular record of the weather and sea conditions is maintained throughout the watch. The ENVIRONMENT form should be completed immediately after filling in the effort form at the start of the watch and every thirty minutes (on the hour and half hour) thereafter. Observations should only be carried out in sea states up to Beaufort 4 (inclusive), and should be terminated in the event of significantly reduced sighting conditions (e.g. thick fog or torrential rain). Details of the Beaufort scale are provided in the database 'General Info' form.

The data should include:

DATE	Date of the watch
TIME	Time (GMT) of the environment recording
TIDE STATE	The state of the tide; Flood, Ebb, or slack (within one hour either side of high or low tide
WEATHER	The current weather conditions. Data is limited to FAIR, RAIN, FOG, or SNOW
VISIBILITY	The estimated visibility range (km). NB: The distance to the horizon from the coastguard lookout is 34 km.
CLOUD COVER	The estimated cloud cover in octaves where 0 represents a clear sky and 8 is overcast
WIND STRENGTH	The current wind strength as described by the Beaufort scale.
WIND DIRECTION	The current wind direction (the direction it comes from) as an approximate compass angle (N, NE, E, SE, S, SW, W, and NW). If there is no wind, enter NA.

SEA STATE	The current sea state as described by the Beaufort scale
SWELL HEIGHT	The estimated height of the sea swell in metres
GLARE ANGLE	The angle (from the big eyes horizontal angle) of sun glare if any is present of the surface
GLARE EXTENT	The extent of sun glare if any is present of the surface. Date is limited to NONE, SLIGHT, MODERATE, and SEVERE
COMMENTS	Any additional details about the current weather conditions

4 SIGHTINGS

A wildlife 'sighting' is defined as the observation of an individual or group of birds or marine mammals (or other relevant species e.g. basking shark) made during a visual scan of the study area. It is important that the consistent nature of the scan (as described above) is maintained throughout each scan (i.e. the observer should not scan directly to a bird or marine mammal group that has been sighted prior to the scan or in a previous scan). If a unique sighting is made outside the scan period that needs to be recorded, details should be recorded in the 'Comments' section following environment data entry.

An individual or group is defined as all animals within approximately 100m of each other. Consequently, animals further than this distance will be defined as different groups or individuals. Distance estimation at sea is often challenging and it can be useful to train observers to estimate distance using marks of known range (e.g. marker buoys) or size (e.g. ships and boats). When a group of wildlife is sighted, key information about its location, group size, and behaviour should be recorded. This should be done using a Dictaphone to minimize disruption to the scan. Sighting information can then be entered into the database into the database during the period between scans. It should be noted that only birds that are on the water or are hovering directly above it (within a few metres) should be recorded as a sighting. Birds flying higher than this or birds that are clearly on transit through the study area should not be included as sightings.

To estimate the geographical location of the animal(s), the angle of declination and horizontal angle from the tripod will be used, together with information on tidal height to calculate range and bearing to the animal(s). When sighting a group of animals, the centre of the group should be aligned with the centre of the 'Big eyes' field of view. If a group is sighted with a different set of sighting equipment (i.e. binoculars), the 'Big eyes' should then be used to locate the group spatially. Calibration of the locations can be carried out using a boat based differential GPS system; the boat should be maneuvered around the study area and the locations calculated using the tripod angles can be compared to the GPS locations. It is anticipated that this should take around a half day and should be carried out near the start of the study.

An estimate of the number of individuals in each group should be made. For cetaceans, this can be challenging in the field (particularly from land based observation platforms) because all animals are rarely observed at the surface at the same time. When observing a group of cetaceans, group size can be estimated through interpreting the synchrony of surfacings, spatial locations of surfacings relative to each other, and the identification of distinctive individuals (e.g. calves and adult male killer whales). However, a good rule of thumb that is often used to support estimated cetacean numbers is to count the total number of surfacings sighted within the mean dive duration of each species (Appendix 1).

Calibration of group size estimates between observers should be carried out during the study. This will require both observers making independent group size estimates for the same groups. No communication about estimates should be made between the observers during this calibration. It is estimated that a total of at least 12 comparisons should be made for each animal group (cetaceans, seals, birds).

4.1 Marine mammal data entry

The following information should be entered into the database for every marine mammal sighting made during the scans:

DATE	Date of the watch
TIME	Time (GMT) of the sighting
SIGHTING EQUIPMENT	The equipment used to sight the marine mammal(s)
DECLINATION ANGLE	The vertical angle to the group as read off the tripod
HORIZONTAL ANGLE	The horizontal angle to the group as read off the tripod
SPECIES	The species sighted. If the species does not appear on the list, use 'Other Species' and provide details in the COMMENTS section.
NUMBER	Estimated number of animals in the group
HEADING	The direction the group is swimming as an approximate compass angle (N, NE, E, SE, S, SW, W, and NW). If no progress is being made, enter NA.

Details of the following animal behaviours should also be recorded. These are provided as a short list in the database. Any combination of these can be included.

Behaviour - All

FEEDING	Any sighting where a fish is observed being chased or manipulated at the surface.

Behaviour - Cetaceans

AERIAL BEHAVIOUR	Any overt behaviour where all or part of the body clears the water (excluding REGULAR SURFACINGS)
REGULAR SURFACING	The dorsal portion of the body, excluding the tail flukes, clears the water in a forward roll motion.
BOW RIDING	Any behaviour where the animal(s) are in close proximity to a vessel (<10m)

Behaviour - Seals

STATIONARY	The seal is stationary at the surface with its head above the water surface.
SWIMMING	The seal is making progress at the surface with its head above the water surface.
BOTTLING	The seal is stationary at the surface with its head above the water surface for an extended period. The orientation of the head is perpendicular to the water surface so that the nose is pointing directly upwards.

COMMENTS	Any other relevant information about the sighting should be included here. This may include details such as a record of the age classes of the animals (i.e. if there are any relatively small animals in the group), or any other species sighted that are not included in the species list.

4.2 Birds data entry

The following information should be entered into the database for every seabird sighting made during the scans (it should be noted that only birds that are on the water or that or hovering directly above it (within a few metres) should be recorded as a sighting [ensure that the angles to the location on the water below hovering birds is recorded]):

DATE	Date of the watch
TIME	Time (GMT) of the sighting

SIGHTING EQUIPMENT	The equipment used to sight the bird(s)
DECLINATION ANGLE	The vertical angle to the group as read off the tripod
HORIZONTAL ANGLE	The horizontal angle to the group as read off the tripod
NUMBER OF SPECIES	As birds often form mixed groups, provide the number of species within each group.
SPECIES	The species sighted (if there are several species in the group, enter the majority species in this column). As it is often difficult to distinguish birds to species levels, the option is given to enter 'Unidentified [family]'. Further details can be provided in the COMMENTS section.
SPECIES 2	If there are several species in the group; enter the second most abundant species in the group in this column.
SPECIES 3	If there are several species in the group; enter the third most abundant species in the group in this column. NB If there are more than 3 species present, provide details of other species in the COMMENTS section.
NUMBER	Estimated total number of birds (regardless of species) in the group
HEADING	The direction the group is moving as an approximate compass angle (N, NE, E, SE, S, SW, W, and NW). If no progress is being made, enter NA.

Details of the following bird **behaviours** should also be recorded. These are provided as a short list in the database. Any combination of them can be included.

DIVING FROM FLIGHT	One or more birds diving underwater from a hovering or flying position
DIVING FROM WATER	One or more birds diving underwater from a position on the water surface
SWIMMING AT SURFACE	The birds are making progress at the surface.
STATIONARY AT SURFACE	The birds are stationary at the surface.

COMMENTS	Any other relevant information about the sighting should be included here. This may include details such as a record of the age or sex classes of the birds (i.e. if there are any relatively small animals in the group or if there are predominantly males

	or females), or any other species sighted that are not included in the species list.

4.3 Shipping data entry

The following information should be entered into the database for every vessel sighted during the scans.

DATE	Date of the watch
TIME	Time (GMT) of the vessel sighting
SIGHTING EQUIPMENT	The equipment used to sight the vessel
DECLINATION ANGLE	The vertical angle to the vessel as read off the tripod
HORIZONTAL ANGLE	The horizontal angle to the vessel as read off the tripod
VESSEL NAME	The name or registration number of the vessel if visible.
VESSEL TYPE	The type of vessel. Data is limited to FERRY, FISHING VESSEL, KAYAK, LARGE COMMERCIAL VESSEL, POWERBOAT (<10M), POWERBOAT (>10M), WAVE ENERGY DEVICE, and YACHT. If a different type of vessel is sighted, enter the closest match and provide further details in the COMMENTS section.
HEADING	The direction the vessel is moving as an approximate compass angle (N, NE, E, SE, S, SW, W, and NW). If no progress is being made, enter NA.
COMMENTS	Any other relevant information about the vessel should be included here. This may include details such as the activity of the vessel (e.g. fishing), or any other vessel types that are not included in the species list.

5 ESTIMATING THE RANGE DETECTION FUNCTION

An important caveat associated with studying the distribution of animals from a fixed location that is that the probability of sighting an animal, or group of animals, decreases as an unknown function with distance from the observer. It is important therefore, to highlight that data from the land based observations described in these protocols will only provide information on the distribution and 'relative' abundance of animals in and around the study area. This issue of detectability with range is also particularly important in a study such as this one where wave devices may be moored several kilometres from shore; the power to

detect changes will inherently be lower at greater ranges without knowledge of the detection probabilities.

To inform the analysis about detectability, it is suggested that the land based observations are augmented with boat based surveys along transect lines placed perpendicular to the coast. This would provide sound information about the detectability rates for a range of distances from the observation point. The information collected from the boat would allow the observer based numbers recorded from the observation point to be calibrated and would inform the analysis about the detectability of the animals at various distances from the observation point. This information would then enable detectability and any genuine changes in abundance to be disentangled.

Without prior knowledge about animal densities in the survey area, it is challenging to determine survey frequency. However, to obtain as much information as possible, it is suggested using transect lines as close together as practicality and/or cost allows and to survey these lines as often as practicable; monthly surveys along survey tracks of the type shown in Figure 5 are likely to provide a suitable initial design. Augmentation of the land based survey design by boat would lead to an analysis which combines both detectability and abundance aspects of the impact assessment, leading to more defensible impact assessment results.

The transect lines should be covered at a constant speed. For each sighting made during the surveys, the same information that is recorded from land should be noted (except the tripod angles). In addition, the boat position at the time of the sighting (LAT LONG), and the range (metres) and angle to the sighting (as an angle from the ships heading, where directly ahead would be 0^{o}, off the starboard beam would be 90^{o}, and off the port beam would be 270^{o}) should be recorded. A datasheet or modified database could potentially be provided if this augmented survey approach is pursued.

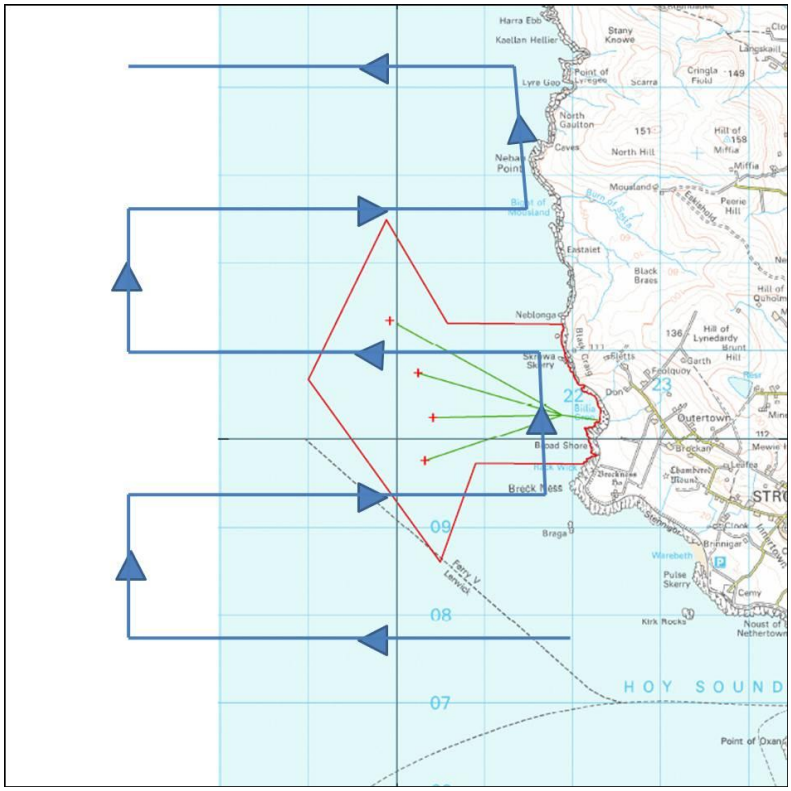


Figure 5: Potential survey design for boat based transects of the survey area. The survey lines are shown by the blue arrows. Results would provide information on the detection probability of animals with range from the observation site.

6 CONTROL SITE

Baseline monitoring of a site with similar characteristics to the test site, yet relatively undisturbed, would be valuable in determining if potential changes observed in the wave test site are restricted to the impact site. In the absence of a 'control site' it would be extremely challenging to determine if changes in animal abundance at the wave test site were widespread and in particular, widespread decline of a species could be incorrectly attributed to an impact. A control site would allow a Before-After-Control-Impact (BACI) analysis to be carried out which would provide crucial information about any apparent declines since a widespread decline should also be evident at a control site.

Since it is anticipated that test sites are carefully chosen based on unique characteristics (which lend themselves particularly well to energy generation) a genuine control site might not be available. However, monitoring information from one or more similar sites nearby provide the basis in determining if any changes in abundance are more widespread than the test site. While this additional control-site monitoring is likely to bring additional financial cost, the sampling regime could be less comprehensive at the control site and this extra information would diminish the doubt as to the cause of any changes in animal abundances.

7 REFERENCES

Hammond, P. S., P. Berggren, et al. (2002). "Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters." Journal of Applied Ecology **39**: 361-376.

Hastie, G. D. (2000). Fine-scale aspects of habitat use and behaviour by bottlenose dolphins (*Tursiops truncatus*). Zoology Department. Aberdeen, University of Aberdeen.

Rugh, D. J., J. A. Lerczak, et al. (2002). "Evaluation of high-powered binoculars to detect inter-year changes in offshore distribution of eastern North Pacific gray whales." Journal of Cetacean Research and Management **4**(1): 57-61.

8 APPENDIX 1: Cetacean species frequently sighted around Orkney

Harbour porpoise

The harbour porpoise is the smallest cetacean found off the coast of the UK. It has a small, rotund body, blunt head, no beak, and a small triangular dorsal fin. Adults are approximately 1.4-1.6m in length. Mean dive duration: 20 sec.

White beaked dolphin

The white beaked dolphin is a stout dolphin, about 2.5-2.7m in length; it has a short, often white beak, and black back and a pale grey to white area behind the dorsal fin that extends to a blaze on the flanks. This forms a diagnostic "saddle" on the back. Mean dive duration: 20 sec.

White sided dolphin

This bulky dolphin can be confused with the white beaked dolphin and often forms mixed groups with this species. It reaches around 3m in length and cab be distinguished from the white beaked dolphin by its all-black back and elongated yellow-ochre band on its flanks. Mean dive duration: 20 sec.

Risso's dolphin

The Risso's dolphin is a large, robust dolphin around 3.5m in length. They have a blunt, rounded head, and a slight melon with no beak. It is distinctively grey in colour, often with numerous white scars on the flanks. Mean dive duration: 20 sec.

Killer whale

Killer whales are large, reaching around 9m in length. Males have a very tall, triangular and erect dorsal fin. Immatures and adult females have a smaller sickle-shaped fin. They have a conical shaped black head with a distinctive white oval patch behind the eye, and a grey saddle behind the dorsal fin. Mean dive duration: 40 sec.

Pilot whale

Pilot whales reach approximately 6m in length and have a bulbous, square head. The fairly low, long-based dorsal fin is situated forward of the centre of the back. It is sickel shaped and becomes flag shaped in older animals. The body is black or dark grey in colour. Mean dive duration: 70 sec.

Minke whale

The minke whale is the smallest of the baleen whales in the UK. Growing to a length of 7-8.5m, it can be distinguished by a white diagonal band on the flipper, a small, pointed triangular head, and the lack of a conspicuous blow. Mean dive duration: 60 sec.

9 APPENDIX 2: Seabird species frequently sighted around Orkney

Auks

Razorbill

Guillemot

Black guillemot

Puffin

Little auk

Ducks, swans, and geese

Mute swan

Whooper swan

Common scoter

Eider

Goldeneye

Long tailed duck

Mallard

Pochard

Scaup

Shellduck

Red breasted merganser

Tufted duck

Wigeon

Greylag goose

Pink footed goose

White fronted goose

Terns

Arctic tern

Common tern

Sandwich tern

Cormorants and shags

Cormorant

Shag

Divers

Black throated diver

Red throated diver

Great northern diver

Skuas

Arctic skua

Pomarine skua

Great skua

Long tailed skua

Gulls

Black headed gull

Common gull

Herring gull

Great black backed gull

Lesser black backed gull

Kittiwake

Other

Gannet

Fulmar

Storm petrel

Manx shearwater

10 APPENDIX 3: Identifying seals at sea Harbour seal 	HEADS IN WATER: MARKINGS: BODY SIZE:	Harbour seals have a dished shaped forehead (they have relatively distinct foreheads. Their eyes are very much on the front of the face, close to the nose. In terms of overall head shape, an oval drawn around the head (when viewed face on) would need to be squashed from top to bottom. Harbour seals are usually fairly uniformly spotted. Harbour seals are the smaller of the two species with adults measuring around 1.3-1.7 m long.
Grey seal 	HEADS IN WATER: MARKINGS: BODY SIZE:	Grey seals have relatively flat noses and their eyes are located midway between the nose and the back of the head. Unlike harbour seals, grey seals have 'double chins'. In terms of overall head shape, an oval drawn around the head (when viewed face on) would need to be squashed from side to side. Female grey seals have contrasting pale bellies and darker grey backs, with large irregularly shaped spots and blotches. Male grey seals have darker, more uniform, coats than females. Grey seals are the larger of the two species with adults measuring around 1.8-2.1 m long.