Offshore Wind
orjip
working to accelerate offshore consenting

ORJIP Bird Collision Avoidance study flight height measurements using laser rangefinders

MEMO FOR USERS

Collecting data on bird flight altitudes can be challenging and is particularly challenging offshore. Relatively few studies have therefore measured flight altitudes although it is an essential part of collision risk modelling. Flight heights have been estimated, for example, visually by observers (during ship surveys or on stable platforms), or measured by laser rangefinders operated by observers, by birds equipped by transmitters, by radars or by digital aerial surveys (Thaxter *et al*. 2015).

The data that has been used most commonly in Band collision risk modelling (Band 2012) is, however, based on data collected during ship surveys by visual estimation (Johnston *et al*. 2014). There is a large degree of uncertainty coupled with visual assessments, and classification of birds into height classes (Thaxter *et al*. 2015). For example, by using digital aerial survey a different flight height distribution was obtained for many species when compared against analysis results obtained using data from visual ship surveys (Johnston and Cook 2016). Important reasons for this is that the resolution from digital surveys is higher and the degree of human error or subjectivity less. The number of studies reporting altitudes collected utilising more accurate approaches are increasing, using telemetry (e.g. Cleasby), digital surveys (e.g. Johnston and Cook 2016) and laser rangefinders (e.g. Borkenhagen 2018).

Few studies have, however, monitored flight heights, continuously, at an offshore windfarm, but see e.g. Krijgsveld *et al*. (2011) and Skov *et al*. (2012). Krijgsveld *et al*. (2011) estimated species-specific flight heights visually, using panorama scans, while Skov *et al*. (2012) measured species-specific flight heights with the help of laser rangefinders. Rangefinders have also been used for measuring flight height of seabirds by Kahlert *et al*. (2012), Mendel *et al*. (2014) and Borkenhagen *et al*. (2018).

According to Borkenhagen *et al*. (2018), the rangefinder data was biased to higher flight altitudes, because birds flying close to the sea surface was difficult to hit with the rangefinder. They operated, however, the rangefinders from ships that are unstable. Based on DHI's experience it can be challenging to work with rangefinders on an unstable platform, also noted by Thaxter *et al*. (2015). Nevertheless, Borkenhagen *et al*. (2018) reported that rangefinders are useful for collecting data on flight heights even from ships. Operating rangefinders from stable platforms makes it easier to hit a targ*et al*so closer to the sea surface. Kahlert *et al*. (2012) noted, on the other hand, that the rangefinder data might underestimate the flight height because birds flying very high are missed by the observers. Nevertheless, overall rangefinders can be considered as a very useful tool for collecting flight height data on a fixed platform offshore (Thaxter *et al*. 2015).

It is important to also note that rangefinders, as all other methods, also have disadvantages. The disadvantages with rangefinders is that data is collected only during "good" weather conditions and during the day. Bird targets are also initially detected by observers, which might introduce some human errors. The zero altitude (sea surface) as estimated by the GPS, needs to be calibrated which also introduces some uncertainty. However, despite these disadvantages, it is currently difficult to name another approach, that is more accurate for collecting species-specific data on seabirds at offshore windfarms for extensive periods of time. In ORJIP' Bird Collison Avoidance study (BCA), laser rangefinders were used to collect data, continuously, from two stable platforms.

Comparison of altitudes collected by ORJIP BCA study with other studies

When the measured altitudes in the ORJIP BCA Study are compared against the traditionally used flight heights collected by boat surveys they seem to be very high (Johnston *et al*. 2014). The flight altitude for Northern Gannet are more in line with the altitudes reported by Krijgsveld *et al*. (2011) and Skov *et al*. (2012) for example. The Gannet data collected in the ORJIP BCA study is also strikingly similar to the results reported by Cleasby *et al*. (2015), with a bimodal distribution at similar altitudes (Figure 1, Table 1). One altitude peak for commuting birds flying low and one peak for foraging birds looking for food at higher altitudes. The patterns collected at the two different turbine platforms (G01 and G05, located on a corner and side respectively of the windfarm) are very similar, showing the same distribution (Figure 2). Many studies have reported similar median or mean flight altitudes for Gannets in comparison with the ORJIP BCA study (Table 1).

The results for gannets can therefore be interpreted as realistic and the data regarded as highly useful in collision risk modelling.

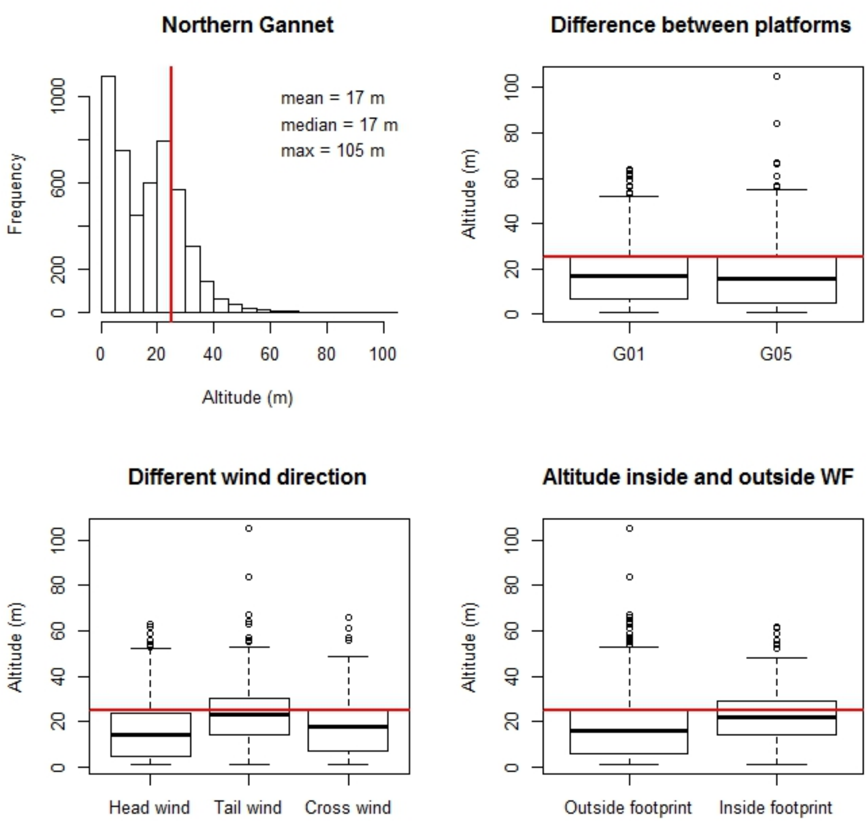

Figure 1. Histogram of flight height distribution of Northern Gannet (upper left) and boxplots comparing heights at the two platforms (upper right), for different wind direction (lower left) and outside and inside the wind farm footprint (lower right). The red line indicates 25 m, which is the lowest tip of the rotor at the Thanet wind farm. The "boxes" in the box plots indicates the first quartile (bottom of the box), the third quartile (top of the box) and the thick black line indicates the median value. The error bars indicate the range (minimum and maximum excluding outliers) and the open circles indicate outliers.

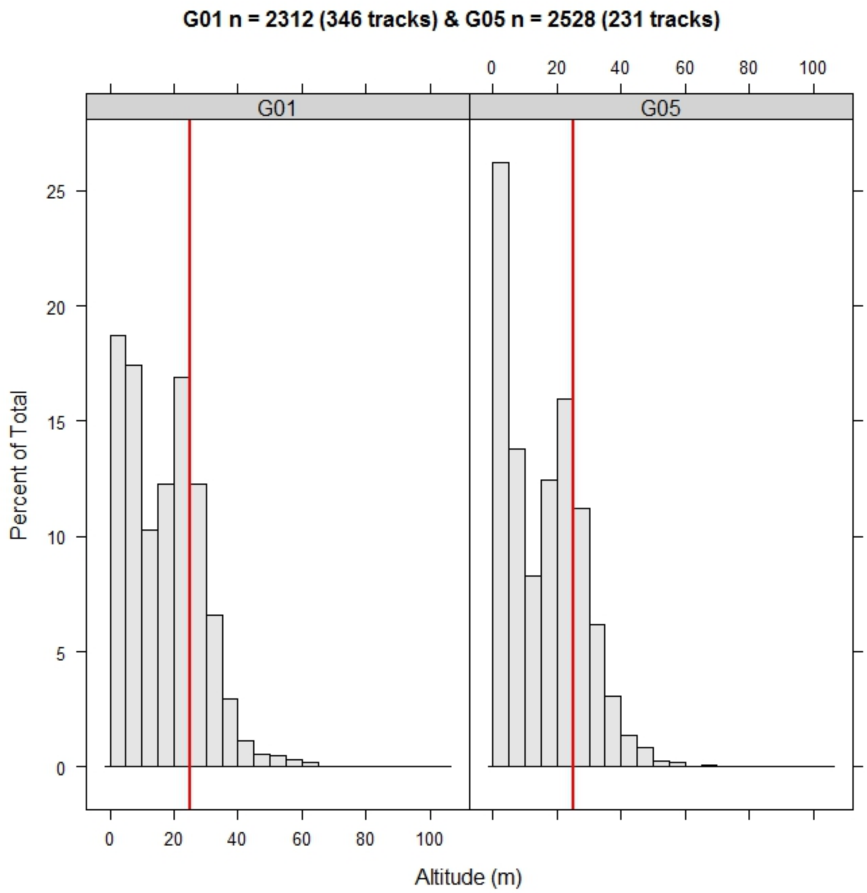

Figure 2. Northern Gannet flight height distribution by platform, sample sizes indicated in the title, number of height recordings and number of tracks in parenthesis.

Interestingly birds, seem to fly higher inside the windfarm (Figure 1, Figure 3). This has also been reported by other studies (Camphuysen 2011, Skov *et al*. 2012). According to Camphuysen (2011) Lesser Black-backed Gulls flew higher inside the windfarm in comparison to outside. Skov *et al*. (2012) modelled the flight altitude in relation to a set of variables. According to the model large gull flight height increased when distance to turbine decreased. This is most likely one of the main reasons for why the ORJIP BCA study flight height estimates are higher than particularly visual ship based survey in areas without a windfarm. Krijgsveld *et al*. (2011) also reported high flight altitudes of local gulls searching for food with a mean altitude of 50 m. This is high in comparison with the median flight altitude of 31 m for Lesser Black-backed Gulls (Figure 3), and also higher than the other large gull species as reported by ORJIP BCA study (Table 1). Krijgsveld *et al*. (2011) further reported that 60% of the gulls were flying at rotor height.

It might well be that the flight altitude of local gulls in the vicinity of a windfarm is generally higher than for example commuting gulls or gulls following a fishing boat observed during a ship survey in an area without a windfarm. Species-specific flight altitudes of Kittiwakes from a windfarm site are not easy to find. The sample size in Skov *et al*. (2012) was too low for modelling and the mean and median values were therefore not reported. Studies including also data away from windfarms report a much lower median flight height than measured in the ORJIP BCA study (Table 1). In other words, birds seem to behave differently inside or close to a windfarm in comparison to areas without a windfarm and therefore flight height data collected at a windfarm is highly valuable.

However, there is a large degree of variability in flight height depending on location as well. For example if Gannets are feeding in an area the flight height frequency distribution can be expected to be much higher than in an area where Gannet are not feeding (Cleasby *et al*. 2015). Similarly, for large gulls and Kittiwakes, the flight altitude can be expected to vary depending on location, for example if fishing boats are close to the windfarm or farther away, or not around at all. The reason for this is that birds fly at different altitude depending on what they are doing; searching for food, feeding or commuting or migrating for example. Here, it should be noted that during the ORJIP BCA study all five target species of seabirds were frequently observed feeding around and inside the Thanet windfarm. In Table 1 a comparison of reported flight height form a range of studies are presented.

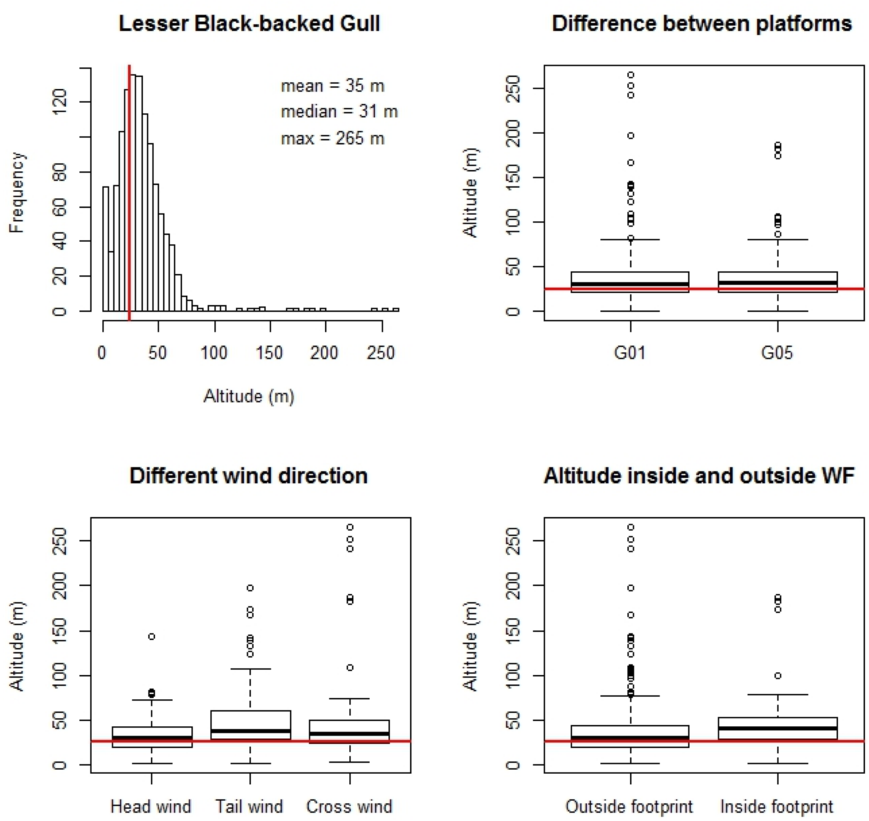

Figure 3. Flight height distribution of Lesser Black-backed Gull (upper left) and boxplots comparing heights at the two platforms (upper right), for different wind direction (lower left) and outside and inside the wind farm footprint (lower right. The red line indicates 25 m, which is the lowest tip of the rotor at the Thanet wind farm. The "boxes" in the box plots indicates the first quartile (bottom of the box), the third quartile (top of the box) and the thick black line indicates the median value. The error bars indicate the range (minimum and maximum excluding outliers) and the open circles indicate outliers.

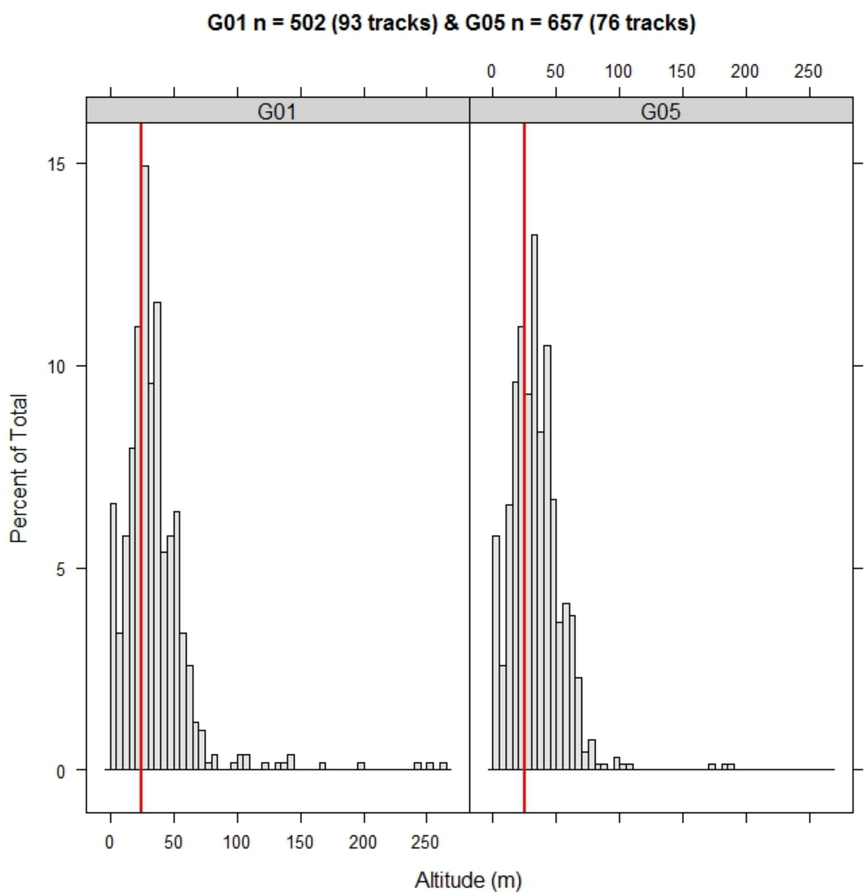

Figure 4. Lesser Black-backed Gull flight height distribution by platform, sample sizes indicated in the title, number of height recordings and number of tracks in parenthesis.

Study	Northern Gannet	Kittiwake	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull
ORJIP BCA study (mean/median)	17/17	34/33	35/31	42/36	45/40
Krijgsveld *et al*. 2005 (mean)	25.6	36.8			

Krijgsveld *et al*. 2011 OWEZ post-construction	<10m (indicated that foraging gulls were flying higher up to 50 m)	~ 26/32 (median/mean) (indicated also that local gulls looking for food were flying in average at 50 m			
Skov *et al*. 2012 (mean) HR1 and HR2 post construction	17.9	not indicated	26.5		
Mendel *et al* 2014 (median) (alpha ventus including data also far from the OWF)	~17 (estimated from fig.)	~15	~28	~32	~35
Borkenhagen *et al*. 2018 (including data far from OWFs)	14	16	21	32	31
Cleasby *et al*. 2015 (including data far from OWFs)	Commuting: 12m Foraging: 27 m				

Table 1. Summary of reported flight height by a range of different studies

How can the flight altitude data collected by the ORJIP BCA study be used?

It is important to note that the variation in flight altitude is large and dependent on many factors, weather, location, distance from windfarm, time and behaviour for example. The data collected in the ORJIP BCA study is from one site only, but on the other hand, collected during a long period.

Keeping this, and the other sources of uncertainties listed above, in mind the data can be used by its own or in combination with other data for defining proportion of birds flying at rotor height. The data can also be converted into a flight height frequency distribution to be used in the extended Band model (Band 2012). This can be done by binning the data into 1m bins and smoothing the frequencies or by using more advanced techniques as described by Johnston *et al*. (2014) and Johnston and Cook (2016) for example. Although the data is showing relatively high flight altitudes, particularly for the large gulls and Kittiwake, there are no obvious signs of strong biases in the data, and therefore no obvious reason for not using this extensive data set on flight altitudes collected at an offshore windfarm. It is however important that accurate data from other offshore windfarms is also collected, which would result in a better spatial coverage and an inclusion of potential variation coupled to this.

The ORJIP BCA study rangefinder data consist of tracks with several measurements of the same bird/flock close in time. It is advised that the effect of this strong autocorrelation is assessed, by comparing for example how the results changes if only one measurement per track is used in comparison with all measurement. Or by accounting for it in the analysis by using a mixed model for example. The post processing of flight altitude data was not included in the scope of the ORJIP BCA study.

References

Band, W. (2012). Using a collision risk model to assess bird collision risks for offshore windfarms. The Crown Estate, 62pp, available at: https://www.bto.org/sites/default/.../Final_Report_SOSS02_Band1ModelGuidance.pdf

Borkenhagen, K., Corman, A-M. and Garthe, S. (2018). Estimating flight heights of seabirds using optical rangefinders and GPS data loggers: a methodological comparison. Marine Biology 165:17.

Camphuysen, C.J. (2011). Lesser Black-backed Gulls nesting at Texel. Foraging distribution, diet, survival, recruitment and breeding biology of birds carrying advanced GPS loggers. NIOZ-Report 2011-05.

Cleasby, I.R., Wakefield, D.E., Bearhop, S., Bodey, T.W., Votier, S.C. and Hamer, K.C. (2015). Three-dimensional tracking of a wide-ranging marine predator: flight heights and vulnerability to offshore wind farms. Journal of Applied Ecology, 52: 1-9

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M. & Burton, N.H.K. (2014). Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. *Journal of Applied Ecology* 51: 1126-1130. doi:10.1111/1365-2664.12191

Johnston, A. and Cook, A.S.C.P. (2016). How high do birds fly? Development of methods and analysis of digital aerial data of seabird flight heights. BTO research report 676

Kahlert, J., Leito, A., Laubek, B., Luigujõe, L., Kuresoo, A., Aaen, K. & Luud, A. (2012). Factors affecting the flight altitude of migrating waterbirds inWestern Estonia. Ornis Fennica 89.

Krijgsveld, K.L., R. Lensink, H. Schekkerman, P. Wiersma, M.J.M. Poot, E.H.W.G. Meesters & S. Dirksen (2005). Baseline studies North Sea wind farms: fluxes, flight paths and altitudes of flying birds 2003 - 2004. Report 05-041. Bureau Waardenburg, Culemborg.

Krijgsveld, K.L., Fijn, R., Japink, M., Van Horssen, P., Heunks, C., Collier, M., Poot, M.J.M., Beuker, D., Dirksen, S. (2011). Effect studies offshore wind farm Egmond aan Zee. Final Report on fluxes, flight altitudes and behaviour of flying birds. Bureau Waardenburg bv. Nordzee Wind. 330pp

Mendel, B., Kotzerka, J., Sommerfeld, J., Schwemmer, H., Sonntag, N. & Garthe, S. (2014). Chapter 11. Effects of the alpha ventus offshore test site on distribution patterns, behaviour and flight heights of seabirds. In Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Eds.) Ecological Research at the Offshore Windfarm alpha ventus, Federal Maritime and Hydrographic Agency. DOI 10.1007/978-3-658-02462-8_11, © Springer Fachmedien Wiesbaden 2014.

Skov H., Leonhard, S.B., Heinänen, S., Zydelis, R., Jensen, N.E., Durinck, J., Johansen, T.W., Jensen, B.P., Hansen, B.L., Piper, W., Grøn, P.N. (2012). Horns Rev 2 Monitoring 2010-2012. Migrating Birds. Orbicon, DHI, Marine Observers and Biola. Report commissioned by DONG Energy.

Thaxter, C. B, Ross-Smith, V.H. and Cook A.S.C.P (2015). How high do birds fly? A review of current datasets and an appraisal of current methodologies for collecting flight height data: Literature review. BTO research report 666