Egretry Flightline Surveys: towards a standardised methodology

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Abstract

Land supply for development in Hong Kong Special Administrative Region (SAR) is at a premium. Sites best-suited for building are in lowland areas close to wetlands where there are potential conflicts between development and breeding ardeids. Large scale developments are required to undergo an Environmental Impact Assessment (EIA) in Hong Kong. Egretry Flightline Surveys are sometimes conducted to assess impacts to either the flightlines of breeding birds and/or their foraging habitats. There is no standardised methodology for undertaking such surveys in Hong Kong, or elsewhere. Here we review 10 EIA reports and the Egretry Flightline Surveys conducted as part of this process in Hong Kong, supplemented by our own findings and observations on active egretries in the Mai Po Inner Deep Bay Ramsar Site. This paper has been prepared to provide guidance for EIA practitioners and conservationists alike in developing flightline surveys and outlining the factors that need to be considered. We provide a short glossary to allow consistency with terminology.

Key words: Chinese Pond Heron; egretry; Environmental Impact Assessment (EIA); flightline; Hong Kong; Little Egret; methodology.

Introduction

In the Hong Kong Special Administrative Region (SAR), Egretry Flightline Surveys (hereafter 'flightline surveys') are an important tool in investigating the foraging grounds used collectively by birds breeding at an egretry (or resident at non-breeding roost sites) and also the airspace utilised when accessing those areas; understanding both may be essential to the long-term protection of an egretry. However, there remains no standardised methodology for undertaking such surveys in Hong Kong, or elsewhere.

A *flightline* is defined here as a route which is regularly followed for local movements of multiple individual birds (unlike a flight path, which is the route of a single flying bird on a single occasion, or a flyway which is a broad route followed by a large number of migrating individuals over a long distance). An egretry flightline therefore refers to the route taken from the egretry to foraging areas

by egrets. Geographical features may influence the location of flightlines; for example, ardeids tend to follow water features such as rivers and may follow valleys even when a route crossing a line of hills would be shorter (Ove Arup and Partners Ltd. 2013a).

In Hong Kong, flightline studies have been used to identify preferred foraging areas of breeding ardeids (Wong 1991, Young 1993, Smith 1995, Wong *et al.* 1999, 2001, Kwok and Dahmer 2002, Wong and Young 2009). Elsewhere, flightline surveys of colonial waterbirds are implemented as a census technique at nesting colonies (Erwin 1981, Jones 2008) or to investigate habitat use (Custer and Osborn 1978, Pratt 1980, Erwin 1983, 1984, Hafner and Britton 1983, Maccarone and Parsons 1988, Smith 1995, Wong 2002).

As part of the statutory Hong Kong Environmental Impact Assessment (EIA) process, flightline surveys may be conducted to assess impacts of proposed developments close to egretries. There is much pressure for development of lowland habitats of Hong Kong; these areas are often lower elevations, where topography is more conducive to development and often have transport linkages to neighbouring Shenzhen and the Greater Bay Area. The 1,500 ha wetland mosaic that forms the Mai Po Inner Deep Bay Ramsar Site, is in close proximity to many of these potential developable areas and as a result, there are conflicts between egretries and increased urbanisation (see Fig. 1). Whilst these wetlands are afforded some protec-

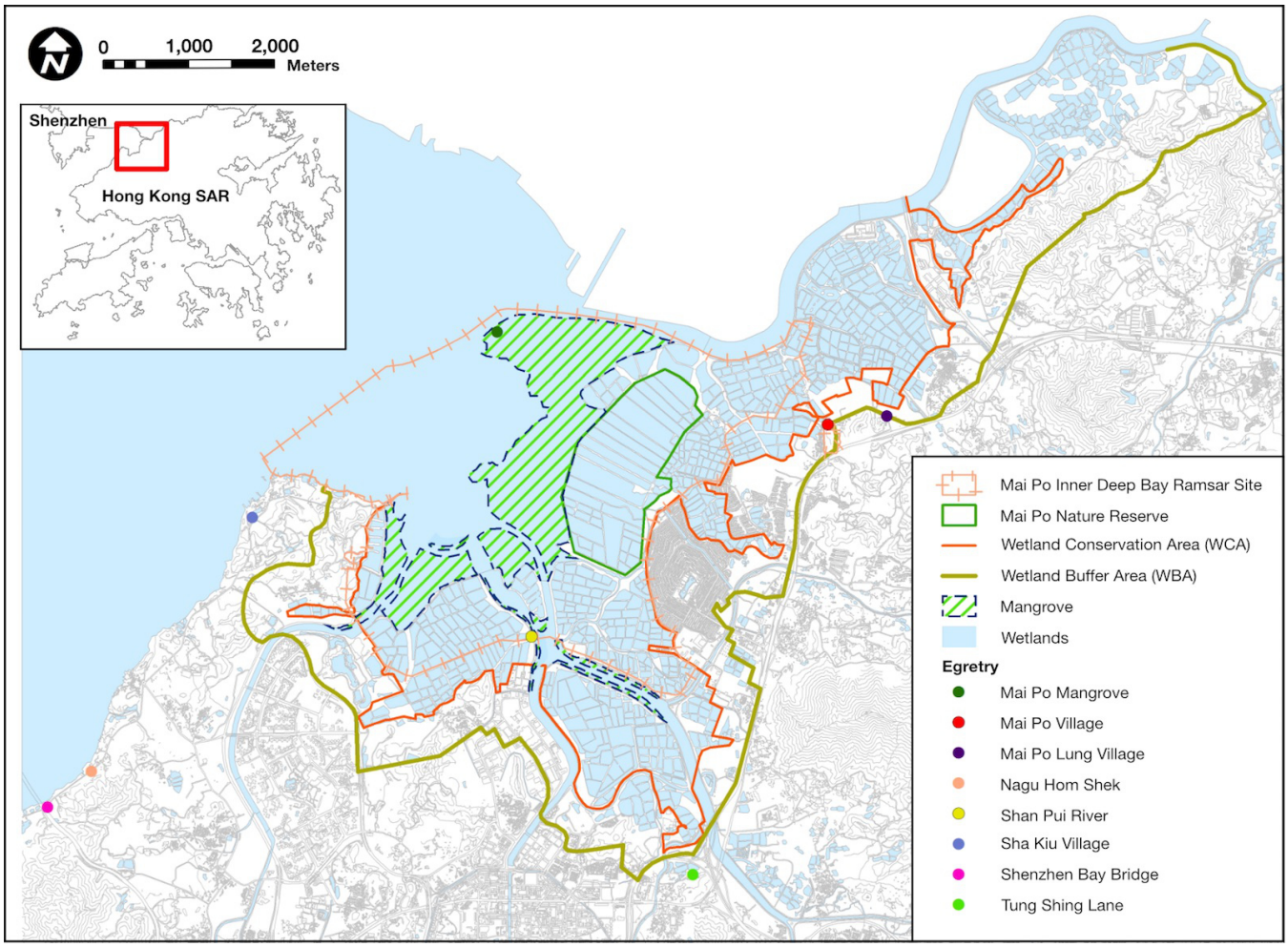


Figure 1. The Mai Po Inner Deep Bay Ramsar Site and locations of the Inner Deep Bay Egretries. The topography along with the proximity to Shenzhen makes this area attractive for housing, infrastructure and commercial developments.

tion through the Wetland Conservation Area, there is increasing pressure to develop the Wetland Buffer Areas. In 2020, there were eight recognised egretries in the Inner Deep Bay area, ranging in size from three to 757 nests (Anon. 2021).

Whilst guidelines have been produced for construction work near egretries by The Hong Kong Birdwatching Society (2016), the only recommendation with respect to flightlines in this document is that 'flight line [sic.] of egrets and herons between the roost and their foraging ground should not be blocked by the construction works, construction materials, machineries or any temporary structures' with no further elaboration. There are currently no protocols or guidelines in place for flightline studies for breeding, or non-breeding, ardeids in Hong Kong.

This paper has been prepared to summarise previous flightline studies in Hong Kong and to provide guidance to practitioners in developing flightline surveys and the factors that need to be considered, not just in Hong Kong but also so they can be adapted and implemented elsewhere and for other colonial waterbird species. Here we have focused on flightlines of ardeids departing from breeding sites to foraging habitat, taken from previous EIA reports supplemented with findings from our own observations.

Methods

A literature review was undertaken investigating the use of flightlines by breeding ardeids. Hong Kong has an open EIA process and numerous EIA studies have been published for proposed developments in lowland Hong Kong that potentially affect breeding ardeids. Accordingly, a comprehensive review was undertaken of EIA reports available at the Environmental Protection Department website (https://www.epd.gov.hk/eia/).

EIA reports provide various graphical presentations to demonstrate the results of flightline surveys and to inform the assessment of the potential impacts of a particular development. For this study, we created a hypothetical egretry in Hong Kong's northwest New Territories (the Mai Po Inner Deep Bay area) and overlaid the actual survey data from a separate study using the various styles of figures typically employed for EIAs. By standardising the data and egretry location, a better comparison of presentation methods can be ascertained.

Results

Of 136 EIA reports published between 2002 and 2020, 10 included egretry flightline surveys. It was notable that each survey differed in its methodology and did not follow any set guidance or precedents. Two additional EIAs presented findings of flightlines studies for all birds, not with a specific focus on breeding ardeids (AECOM 2009, Ove Arup and Partners Ltd 2013b); these EIAs are not considered in this review. A summary of the 10 EIAs referred to in this paper is detailed in Table 1.

Presentation of Findings

Graphical and visual presentation of flightlines was variable throughout all the EIA studies; however, these may need to be specific to particular projects. Examples of data presentation styles of flightline studies from published Environmental Impact Assessments can be seen in Figures 2a-g.

One of the EIA studies presented flightlines departing egretries by sectors to demonstrate foraging habitat use, based on Young (1993). This is represented in Figure 2a. This option can be easily overlaid onto a habitat map or aerial photograph.

Multiple flightlines were plotted onto a map to demonstrate each individual flightline (Fig. 2b).

Table 1. Summary of previously used methodologies in Environmental Impact Assessment reports.

Criterion	Notes
Purpose of Studies	Two reports focused on identifying the location of ardeid feeding habitats.
Survey commencement	Survey commencement for studies conducted on breeding colonies, where stated, was generally vague with wordings such as 'early morning', 'shortly after dawn', '30 minutes before dawn', 'sunrise' or where times are shown fixed at '0600-0630'.
Duration of survey	Survey duration varied between two – five hours, though a two-hour survey was the most frequently cited.
Number of visits	Varied between one and five visits per month. Single, monthly visits were most commonly used.
Duration of Study	Between one to four months.
Months surveyed	April (four reports); May (six); June (five); July (four)
Height of flight	Three reports recorded height data.
Foraging Habitats	Detailed in two reports.
Tidal Conditions	Only discussed in two reports, although at some egretries, this may be irrelevant.

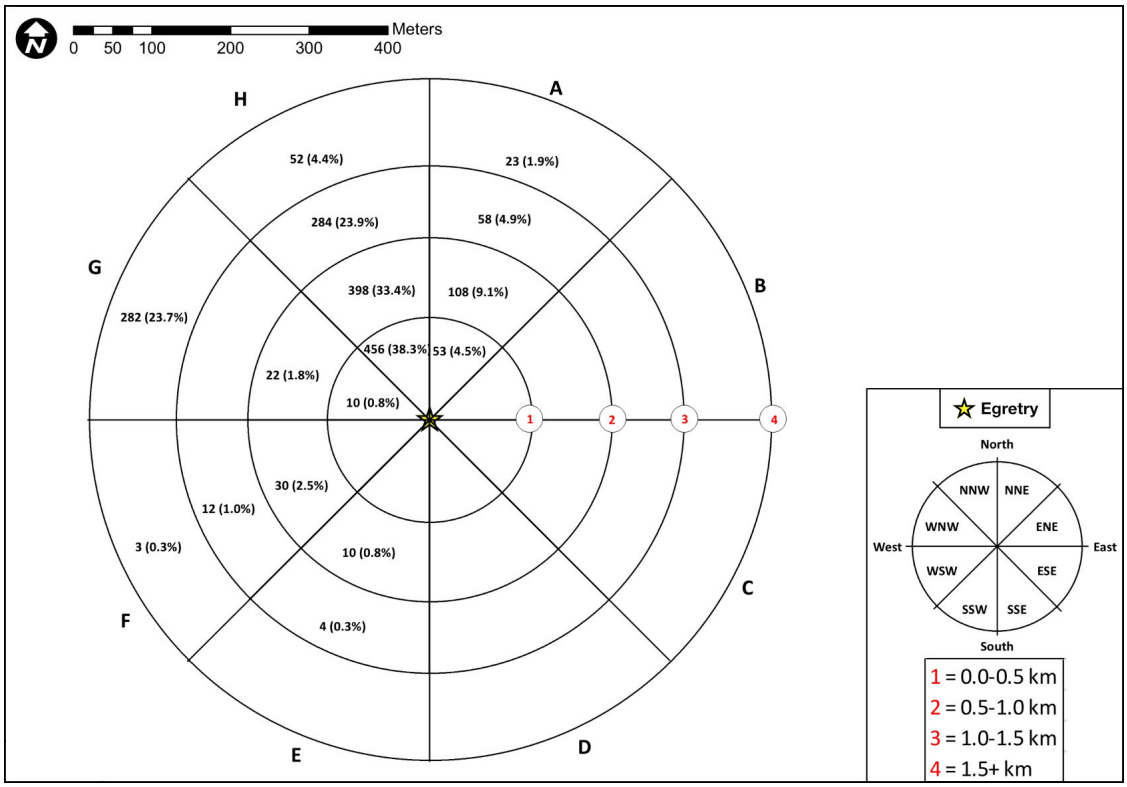


Figure 2a. Flightlines departing from egretries presented using sectors to demonstrate foraging habitat use, based on Young (1993). This option can be easily overlaid onto a habitat map or aerial photograph.

Figure 2b. Multiple flightlines plotted onto a map to demonstrate each individual flightline. This style reveals the total findings, though does not reveal distinct flightlines; however, some egretries may not have distinct flightlines and this figure demonstrates this.

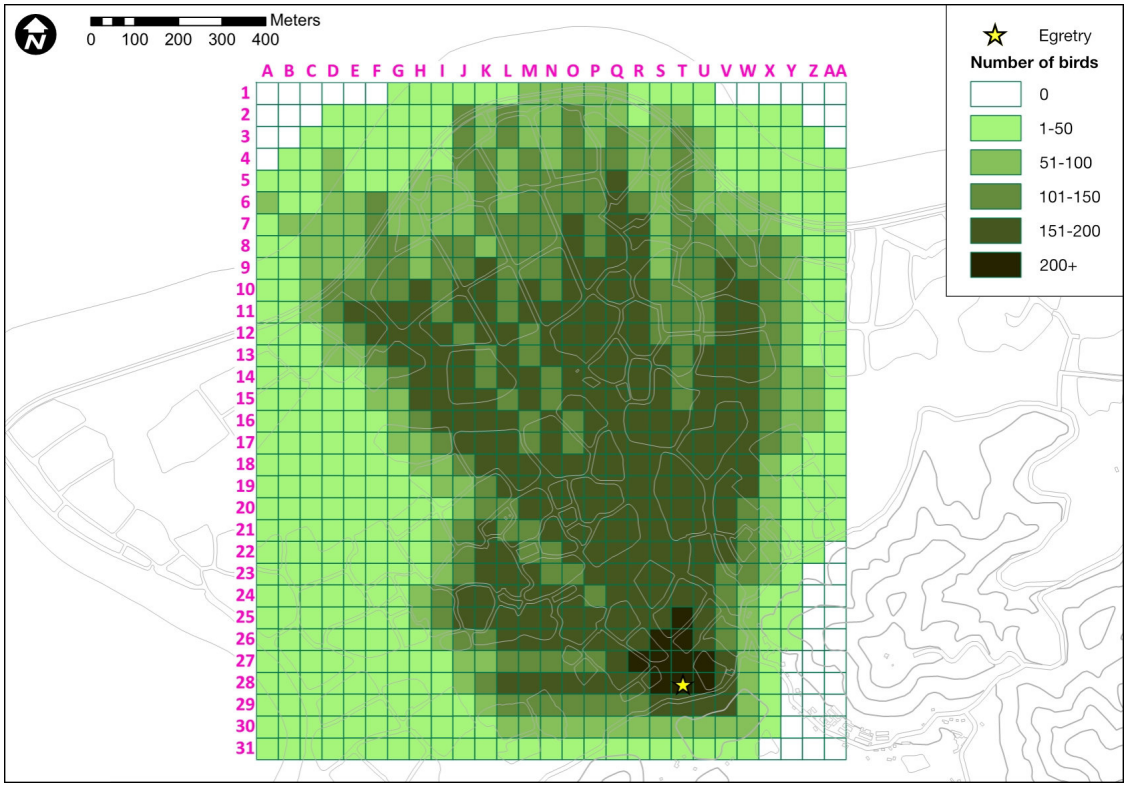


Figure 2c. This is a variation of Figure 2b, and portrays information as a density grid. This may help with the quantification of impacts to flightlines or amending master layout plans to avoid impacts.

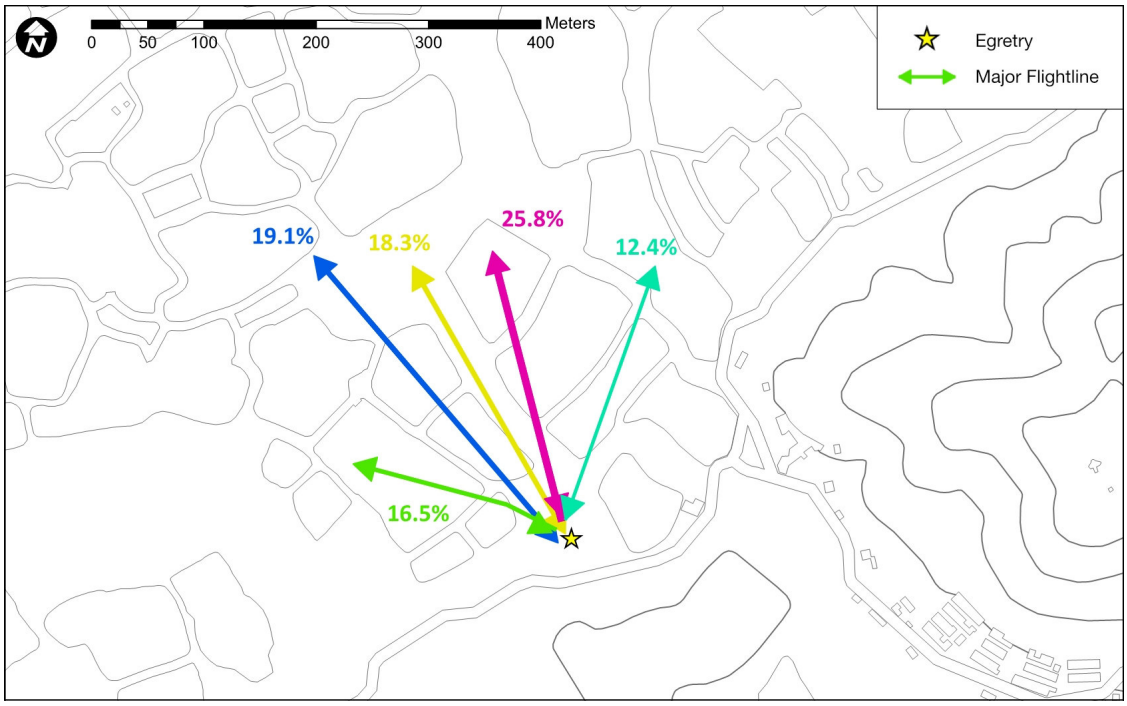


Figure 2d. Indicative flightlines as arrowed lines overlaid on a location to demonstrate direction of flight. Thickness of line allows some quantification of use of a particular flightline though unclear if birds flight extends beyond end of arrows. Percentages displayed can cause confusion on 'importance' of a flightline depending on size of egretry. Likewise, use of terminology, i.e., 'Major' in the key can be misleading.

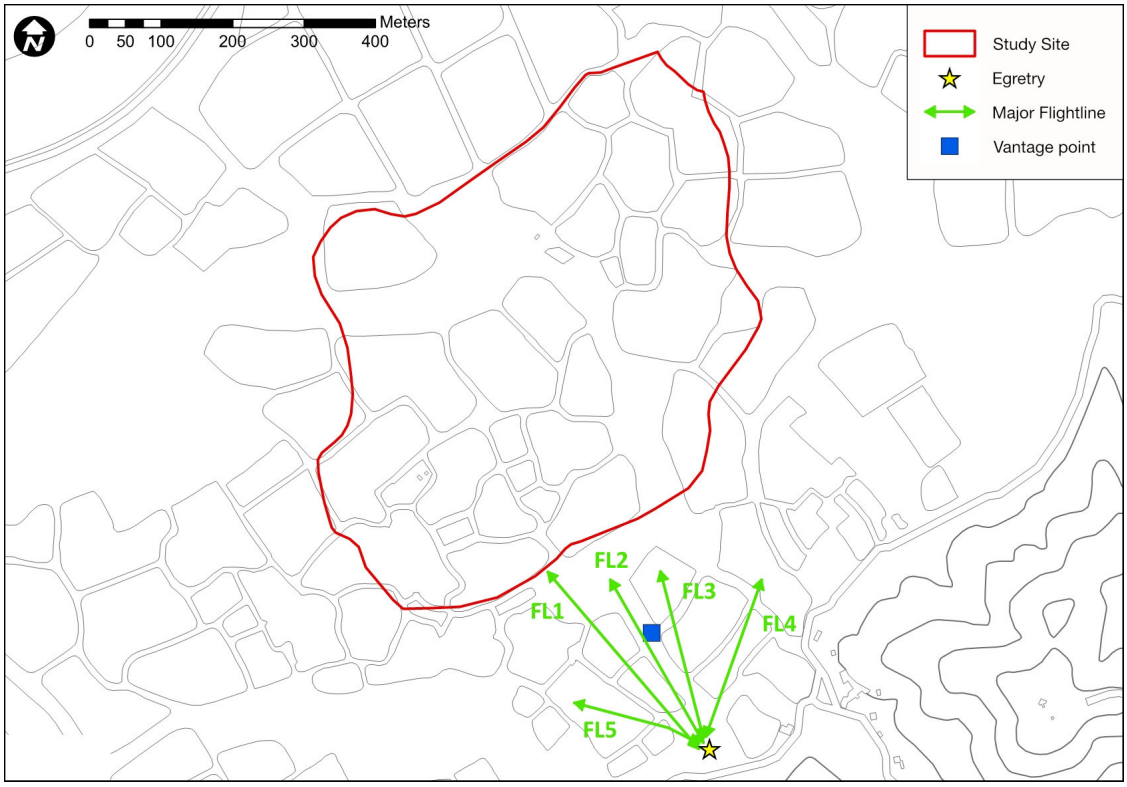
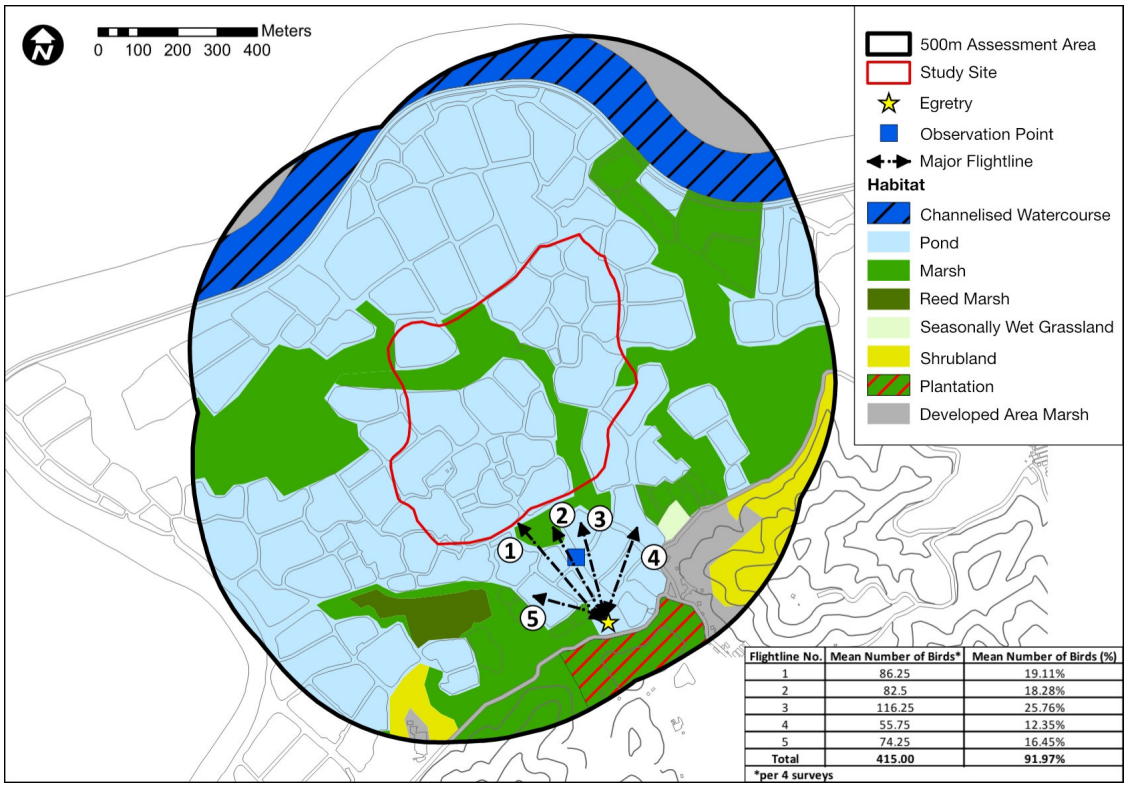


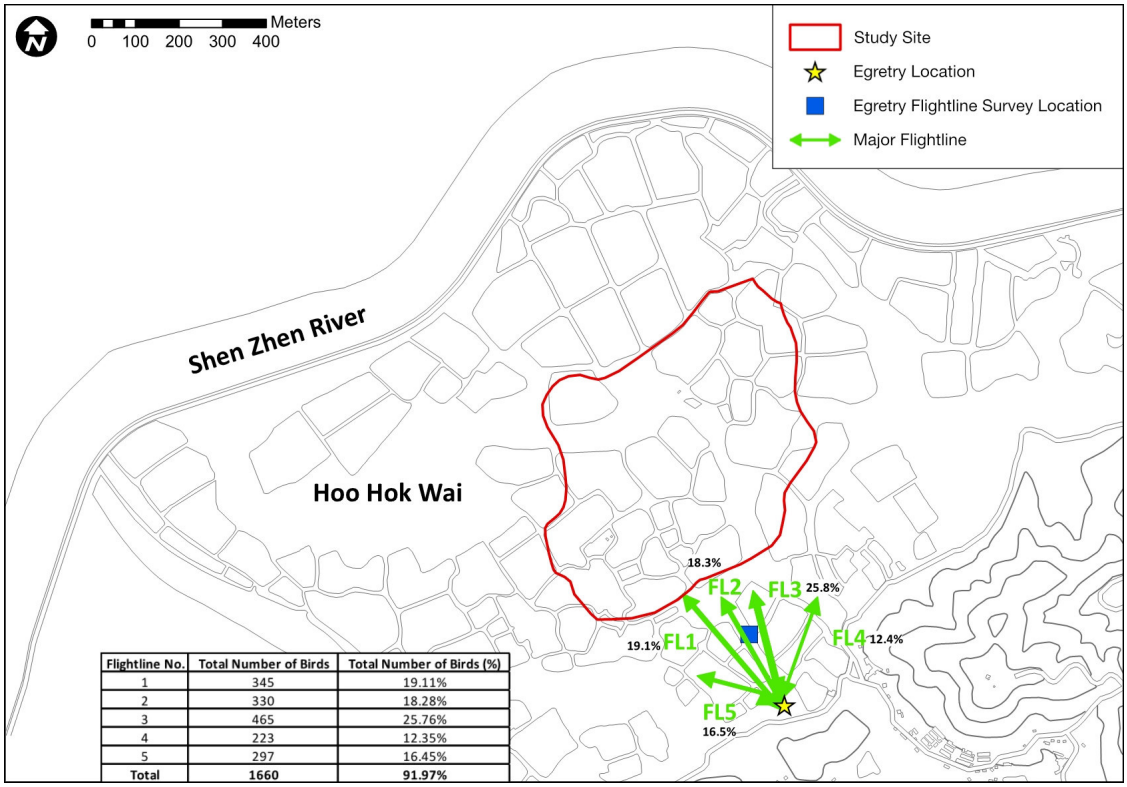
Figure 2e. Indicative flightlines as arrowed lines overlaid on a location to demonstrate direction of flight. This presentation is limited by the location of the vantage point and difficult to assess any potential impacts to flightlines from development of the Study Site.



Flightline No.	Mean Number of Birds*	Mean Number of Birds (%)
1	86.25	19.11%
2	82.5	18.28%
3	116.25	25.76%
4	55.75	12.35%
5	74.25	16.45%
Total	**415.00**	**91.97%**

*per 4 surveys

Figure 2f. This is similar to Figure 2e, but with habitats mapped to give better indication of land use. Broken lines are used to demonstrate that flightlines are perhaps not definite and there will be some deviation from those shown on figures. Table helps to demonstrate significance of flightline use.



Flightline No.	Total Number of Birds	Total Number of Birds (%)
1	345	19.11%
2	330	18.28%
3	465	25.76%
4	223	12.35%
5	297	16.45%
Total	**1660**	**91.97%**

Figure 2g. In conjunction with the table, the thickness of lines allows the reader to better understand the significance of flightlines that they represent.

Whilst this reveals the total findings, this is can be confusing and does not reveal distinct flightlines; however, some egretries may not have distinct flightlines and this figure demonstrates this. Figure 2c is a variation on this and perhaps allows the quantification of impacts.

Most EIA studies produced figures that display indicative flightlines as arrowed lines (Figs. 2d-g), overlaid on a location or habitat map to demonstrate direction of flight. In some figures, the thickness of lines represented the proportion of flightlines they represent (Figs. 2d and 2g). Broken lines were used to demonstrate that flightlines are perhaps not definite and there will be some deviation from those shown on figures (Fig. 2f).

Recommended approach to flightline surveys

Field Methods

In theory, the methodology for conducting a flightline survey is simple; an observer or observers, based at a suitable vantage point(s), will observe ardeids as they depart an egretry, presumably to preferred foraging areas. The species, direction of flight, landing point and flying height should all be recorded as a minimum. Wong *et al.* (2001) suggest that a census technique is more efficient for assessing the use of habitats while suggesting flightlines are best used to investigate overall use of a landscape during the breeding season, though they do not provide a detailed methodology (from Wong *et al.* 1999) in how to undertake such a census.

Criteria employed in other flightline studies are listed in Table 1, though these are inconsistent. To develop a standardised methodology for flightline surveys, we propose the following criteria that should be considered by the surveyor.

1. Timing of individual surveys

Whilst flightline surveys can be conducted throughout the day, this is often not practical, and in our experience unnecessary in that surveys that focus on peak periods of activity can capture sufficient data for the purpose of study. It is generally accepted that the period of peak activity of birds departing from an egretry, a nocturnal roost or waterbird colony is significantly higher in the early morning (Young 1993).

Previous studies have shown that for Little Egrets, (*Egretta garzetta*), and Chinese Pond Heron, (*Ardeola bacchus*), departure times peak during the 30 minutes prior to sunrise and a steady decrease in departure activity thereafter (aec Ltd., unpubl. data). The peak departure time will vary with the species.

In a Hong Kong context, it is recommended that surveys should commence at least 30 minutes prior to sunrise and should last for a minimum of two hours; researchers could obtain more data more efficiently before sunrise. Larger colonies (i.e., more than 50 breeding pairs) may require a longer survey, more individual surveys (see below) or more surveyors.

2. Survey duration

Surveys aim to capture data on foraging departures; however, the timing of the breeding season varies according to species. There can also be differences between the timing of breeding within the same region. For example, breeding activity of an egretry in neighbouring Macau (some 40 km west across the Pearl River Delta) commences earlier in the year than those in Hong Kong (aec Ltd., unpubl. data). To compensate for this, regular surveys of the egretry will be required to inform when surveys should commence.

In Hong Kong, the peak foraging departures for Chinese Pond Heron and Little Egret are in mid-late June but do extend into July (aec Ltd., unpubl. data). Ideally such surveys are recommended from late March until mid-July and should be con-

ducted at least twice per-month until mid-July. However, the frequency can be adjusted for the nature of the study and resources available. More regular survey visits would allow for any variation in feeding habits during different stages of the breeding cycle and may be better suited for more scientific research and behavioural studies.

3. Species composition of breeding site
Our study has focused on Chinese Pond Heron and Little Egret. Should other colonially-nesting ardeid species be recorded at the egretries, e.g., Eastern Cattle Egrets (*Bubulcus coromandus*) and Black-crowned Night Heron (*Nycticorax nycticorax*) in a Hong Kong context, the survey methodology would need further refinement. Eastern Cattle Egrets may have low, early morning flight frequencies as this may reflect low abundance of invertebrates, their food source, at that time of day (Maccarone and Parsons 1988); surveys may need to commence later in the morning. Likewise, egretries supporting Black-crowned Night Heron, a crepuscular and nocturnal feeder, would require adjustment to capture their departure times though there may be difficulties in properly assessing distance and/or direction depending on departure times and levels of light.

4. Vantage point
Finding a suitable vantage point is often the most problematic issue when undertaking flightline surveys. Ideally, the vantage point is such that the entire egretry and all potential foraging areas are in view (Erwin 1981, Young 1993, Wong *et al.* 2001, Jones 2008). In reality, this is rarely possible given the topography, tree coverage, buildings, distance to the feeding area or the extent of the egretry. Furthermore, in Hong Kong, Little Egrets and Chinese Pond Heron can range as far as 5.5 km (Anon. 2009) and 3.3 km (Wong *et al.* 2001), respectively, from the egretry making the ideal vantage point the exception rather than the rule. It is desirable to have up to three surveyors, each strategically located during each survey. The number and location of these will depend on the aims of the survey and size of egretry.

5. Height of flight
Recording flying height is especially important when dealing with the potential impacts of a proposed development and may be less important in other types of studies. Flying height is difficult to ascertain by naked eye and is best recorded relative to nearby features, e.g., buildings, pylons and trees for which the height can be accurately measured or is known. The use of a drone may help in measuring such features more accurately. Flying height will also vary with distance away from the egretry (especially if the egretry is at a higher elevation than the surrounding area) or if there is undulating topography. In such cases, height should be measured in the area where there is the potential for any impacts, or at a consistent point (e.g., when crossing a watercourse or road).

6. Tidal conditions
In marine areas, the state of the tide can have a profound effect on the foraging areas utilised (McNeil *et al.* 1993, Wong and Young 2009). Tide levels should be an important consideration in coastal sites where surveys should be conducted at different stages of the tides, covering at least the very low and very high tides. This may require more survey events to ensure sufficient data are collected at different stages of the tide.

Data presentation and points to consider
Presentation of flightlines is dependent on what the purpose of the study is. It is difficult to select any format or style (see Figs. 2a-g) which cannot be misconstrued or misunderstood by the layperson. Graphically presenting too much detail can obscure the flightline(s). Conversely, too little information may unwittingly increase the 'importance' of a flightline to the untrained eye.

The limitation with arrowed lines is that they are indicative only and do not allow for total distance

flown. Likewise, it is not clear if the arrowed lines stop at the foraging area or if they just point in the direction of the birds' flights and end at some undesignated point, beyond the sight of the observer. In this respect, fixed lines or arrows can be misleading, especially to the layperson, as once a line is drawn on a map, even if labelled as 'indicative' or 'approximate' as there is a tendency for the reader to take these lines as fixed and that there will be no deviation from these. Thickness of lines may distort the laypersons perspective of 'importance' of a flightline.

The surveyor is left to make their own choices on suitability of data presentation for their purposes of their study.

Discussion

There is little literature available from elsewhere in the world regarding flightlines studies for breeding/roosting ardeids. The EIA system in Hong Kong has been recognised as one of the best in the world in making all the EIA reports available to the public through a dedicated website (Kilburn 2009) and greatly aids this type of review.

Developments located on a flightline may result in a decrease in the suitability of a foraging, breeding or roosting site by preventing movement to another site or by reducing the efficiency of movement between sites. Any disruption to these flightlines may reduce foraging efficiency, leading to a reduction in survival or productivity (Mott Connell Ltd. 2008, Ove Arup and Partners Ltd 2013b). Whilst distances foraging birds fly varies with the location of egretry and the nature of the surrounding habitats, impeding flightlines through development may increase distances travelled and therefore increase energy expenditure; minor deviations to flightlines are considered negligible (Masden *et al.* 2010, Ove Arup and Partners Ltd 2017). Where impacts have been deemed significant enough for mitigation to be proposed, this has been achieved by way of avoidance through the adjustment of master layout plans to maintain corridors for birds to travel to and from foraging grounds (locally known as NBA – No Build Areas). These corridors may be up to 100 m in width.

It has been suggested that there may also be an increased risk of mortality by collision with structures constructed on or close to a flightline (Ove Arup and Partners Ltd 2013a). This is highly unlikely due to speed, and style, of flight of these species (Stanton and Klick 2018).

Care needs to be taken when proposing surveys across several years, as egretries can be dynamic, with locations changing over time or even abandoned (CH2M HILL Hong Kong Limited 2008, Ove Arup and Partners Ltd 2013a, Ove Arup and Partners Ltd 2017). Even egretries in protected areas with no or limited human disturbance can suddenly relocate for reasons not fully understood by researchers, e.g., Mai Po Nature Reserve (Anon. 2017).

It should be remembered that the effort required for flightline surveys may be limited by external factors. For example, weekly surveys may be ideal and provide a more comprehensive data set but there may not be sufficient funding available for this or conversely this may be limited by observer availability (pre-dawn surveys over an extended period of time may not be possible). The effort must be 'fit for purpose' for the study.

Flightline surveys can never be completely standardised as local conditions will need to be accommodated. Likewise, presentation of findings will need to be designed for each specific study and may be subject to the researcher's personal preference or dictated by the intended audience. Nomenclature and terminology should be consistent among studies and we recommend specific

terminology and points to consider in Appendix 1.

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Appendix 1. Recommended terminology for flightline studies.

Nomenclature and terminology are inconsistent among studies and reports, often with words used interchangeably within a single report. It would be beneficial to produce a suitable glossary for flight terminology for consistent use by surveyors and researchers, such as those for *Courtship, Nesting, Feeding and Maintenance in Herons* described by Kushlan (2011). Here we propose the following terminology, certainly for the Hong Kong context:

- **Ardeid** — any member of the family Ardeidae, the herons, egrets and bitterns. Relevant in these studies as often multiple species may use a single egretry.

- **Egretry** — particular to Hong Kong, the site of a breeding ardeid colony. Used for single or mixed species colonies.

- **Flightline** — single word, no hyphen, describing a route which is regularly followed for local movements of one or more individuals of bird over a period of time. An egretry flightline therefore refers to the route taken from the egretry to foraging areas by egrets, usually when they are feeding dependent young but can be used for incubating birds. This term would also fit for birds departing from a night roost to an associated feeding area.

- **Flight path** — two words, which is the route of a single flying bird on a single occasion, or a flyway, which is a broad route followed by a large number of migrating individuals over a long distance.

- **Corridor** — refers to an open area of no fixed width which permits ardeid movements between built structures. For example, in a Hong Kong context, a No-build-area (NBA) in Master Layout Plans (used for planning purposes) would be such a corridor.

- We recommend avoiding the terms **major/minor** and **significant/insignificant** — avoid use of these terms at all costs, as they can be very misleading, particularly for the layman. It is very difficult to weight the importance of a flightline when we are only really taking information from a snapshot in time. Once labelled, it is often very difficult for the layman to appreciate the dynamism of egretries and flightlines and how these may shift over time.