SEPTEMBER 2017

DISTURBANCE EFFECTS FROM KITESURFING

REVIEW

COWI

ADDRESS COWI A/S
Parallelvej 2
2800 Lyngby
Denmark

TEL +45 56 40 00 00
FAX +45 56 40 99 99
WWW cowi.com

SEPTEMBER 2017

DISTURBANCE EFFECTS FROM KITESURFING

REVIEW

PROJECT NO.	DOCUMENT NO.
A101232	A101232

VERSION	DATE OF ISSUE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0.1 **DRAFT**	25.09.2017		MDBE/SBJ	SHC/TBKR	SBJ

CONTENTS

1 Background

The objective of this study is to provide a review of the current knowledge regarding disturbance responses of kitesurfing on birds.

Recreational activities in coastal regions can have profound effects on bird populations, migratory as well as breeding birds, due to the disturbance caused by the activities. In recent years, the extent and diversity of the forms of recreational activities have greatly expanded and now include types like windsurfing, kitesurfing, jetscooters, kayaking etc. on the water and driving with various types of vehicles on the beach and on tidal flats. These activities come on top of traditional, recreational beach front activities such as bathing, walking with dogs, jogging etc. The disturbance effects of such activities on birds and coastal mammals have been widely documented but only rarely has specific and systematic efforts been made to distinguish between the various types of activities and temporal (incl. variations summer/winter) and spatial issues, site-specific characteristics etc.

The consequence has been that regulations that are issued in order to control these activities often have a generic content that does not reflect the actual disturbance effects or allow for the various activities to take place at optimal sites with little disturbance effects.

The study will focus on kitesurfing as a specific activity, since kitesurfing is widely regarded as a major source of disturbance in coastal regions despite that kitesurfing requires certain weather conditions and specific topographical features that strictly limit the periods and sites acceptable for kitesurfing. The review has been initiated partly in response to studies that show a common tendency to underestimate or disregard some key characteristics of kitesurfing when assessing the effects on birds, in particular the specific temporal and spatial limitations to kitesurfing that restrict the occurrence and frequency of kitesurfing.

The overall objective of the study is to prepare an elaborated basis for sound and appropriate management responses to kitesurfing. The way kitesurfing is conducted and the circumstances with which kitesurfing can be carried out leave a number of specific management options available to be deployed in a site-specific manner. This study should hopefully facilitate a more detailed approach to stipulations that may regulate kitesurfing in the future.

2 Approach

2.1 Literature review

A literature review was carried out, based on a systematic search for published scientific literature and unpublished reports available (commissioned reports, grey literature). A dialog was held with a few key authors and organisations were contacted for unpublished material (British Trust for Ornithology (BTO), DoC and The Wildfowl & Wetlands Trust).

Databases searched include Google, Google scholar, Web of Science, Aarhus University Library, Scopus (Elsevier B.V.) To focus the search boolean operators (AND, OR) were used. Due to the range of names for the sport databases were searched for the words 'kite surfing', 'kitesurfing', 'parasurfing', 'kiteboarding' and 'kite boarding'.

The inclusion criteria for literature were based on relevance to the subject by including reference to kitesurfing in general and specifically to kitesurfing and bird disturbance collectively. Literature on human disturbance on birds was searched and included when relevant. Searches were carried out in September 2017.

The scientific literature published on the specific subject of kitesurfing and bird disturbance is very limited. Searching the database Scopus for literature on kitesurfing and disturbance reveals for example only two hits; Newton (2007) and Davenport and Davenport (2006), and accessing Aarhus University Library's electronic databases with the specific search *kite boarding OR kitesurfing OR kite surfing AND disturbance AND Birds* revealed 17 hits.

As kitesurfing is a relative new sport, the oldest literature included is from 2006.

Literature on bird disturbance from human activities such as recreational activities is abundant, and literature concerning human disturbances in coastal areas were included in this review. The reference list included is a general overview on the subject of human disturbance effect on birds in coastal areas and should not be regarded as a comprehensive/complete list of literature available.

The languages for literature compiled is English, Danish, Dutch and German. One single Norwegian reference was found.

Many references found were commissioned reports that have not necessarily been peer reviewed.

2.2 Perspective of the review

As can be deducted from a number of review studies of the disturbance effects of kitesurfing and other recreational activities on birds in coastal areas (see e.g. Krijgsveld et al, 2008, Krüger 2016, Laursen et al 2011, Laursen et al 2017) the following highly generic conclusions appear in basically all studies:

- Kitesurfing (like other recreational activities) may disturb birds,
- Escape distances are species specific and may increase with speed, noise, and visual volume of the disturbance factor and also with flock size and stress levels of birds,
- Disturbance effects may be cumulative or even synergistic,
- The impacts of disturbance on bird populations in the longer term are not known.

It can also be determined that very few studies, if any at all, have been designed to distinguish between the individual recreational activities taking place at the same time or head and tail with each other. Repeated disturbance results in increased alertness, larger escape distance and fewer birds present (ref…) but without a specific study design that make it possible to distinguish between the effects of the individual recreational activities it is not possible to isolate the actual effects from kitesurfing.

Hence, even without ongoing recreational activities at a given site, the presence of birds at the site may be compromised by disturbances taking place earlier or even as a long-term effect of disturbance in the past.

The perspective of this review is to analyse the available data material that deals with effects from kitesurfing on birds in order to scrutinize the circumstances where kitesurfing may cause disturbances. Given the limited places and weather conditions that allow kitesurfing to take place it appears reasonable to try and obtain a better understanding of the actual sites and periods that create conflicts between kitesurfing and nature protection objectives.

From a first screening of a number of papers and documents that reports on studies of effects of kitesurfing (e.g. literature compiled by Krüger 2016) it appears that there is a general lack of details about the actual circumstances under which the studies were made. Before details about the site, the weather, the frequency of kitesurfing at the site, other recreational activities at the site, movements and responses of bird populations etc. are included in a study, it will remain challenging to conclude about the effects of kitesurfing beyond the immediate disturbance created by humans (with or without a kite) at the site.

2.3 Disturbance – a definition

A disturbance can be defined as "any phenomenon that causes a significant change in the dynamics or ecological characteristics of populations of birds" (EU Commission, 1992) though this definition appears to relate to the long-term effects rather than the immediate response. Kirky et al (2004) suggest that disturbance is a change to bird behaviour compared to how it would have behaved in the absence of disturbance, and Platteeuw and Henkens (1997) describe disturbance as "any human activity inducing unusual behaviour" on birds.

When discussing disturbance it is important to distinguish between effects and impacts (Kirby et al 2004), where effects relate to a measurable change in the behaviour of the disturbed birds as a immediate response, whereas the impacts are the longer term changes to population levels of bird populations. By this definition effects can lead to impacts if the affected bird populations are unable to compensate for the immediate effects of the disturbances.

In this review, we will not look at impacts as they will always be a conglomerate of various effects accumulated over time. In fact, due to obvious methodological complexities few studies have addressed the impacts and hence very little is known about long-term effects of cumulative disturbances. Instead, it is widely assumed that more disturbances create stronger impacts at the population levels which may seem plausible.

It is widely considered that disturbance of birds indirectly affect fitness and population dynamics because of the energy used for avoidance and lost opportunities for feeding, foraging, preening etc. Thus, disturbance can cause:

- Reduction of time available for foraging,
- Reduction of space for feeding,
- Reduction of time to carry out fitness-enhancing activities, such as feeding, parental care, preening or mating.

In this review, we see disturbance as a displacement event that involves the following factors (following Delaney et al. 1999; Beale & Monaghan 2005):

- Number of flight events,
- Distance from bird to source of disturbance (escape distance),
- Number of birds in flight,
- Escape distance,

- Time away from resting, feeding or breeding site.

The escape or flight distance of waterbirds when disturbed varies with a range of factors, such as the species in question, flock size, frequency of disturbances, weather, season etc. (Laursen et al. 2005). The diversity of factors involved in the escape distance makes it challenging to draw simple connections between the type of disturbance and the response displayed by birds. Despite this, the escape distance is often used to illustrate the sensitivity of birds to various human disturbances and numerous studies have provided escape distances in relation to various disturbance factors without providing details on the number of issues that influences the response behaviour.

Birds may also respond differently to disturbance dependent on their condition, time of year etc. (Beale and Monaghan 2004). In early winter resources may be more freely available and birds may respond quicker and appear more sensitive to disturbance, whereas later in winter when food is more scarce bird may react to disturbance differently as they are forced to optimize their foraging time and therefore show delayed response to disturbance (Goss-Custard et al 2006).

The issues are complex and the impacts of disturbance cannot be assessed from simply recording the behaviour of birds and how they respond to human activity. Seen in isolation behavioural change does not provide a clear evidence of impacts (Drewitt 2007, Sutherland 2007).

2.3.1 Disturbance – why

There are many speculations concerning the actual nature of human disturbance: Why is it that humans disturb birds and what are the relations between human behaviour and the birds' natural enemies, such as birds of prey. Studies indicate that disturbance may be an effect of visible volume, movements and niose emitted from the human behaviour in the sense that more visible volume, higher speeds and louder noise may result in more significant responses by birds (refs...). Also, birds respond to birds of prey and to structures that simulate birds of prey.

However, with time and in particular when no attacks or lethal consequences are experienced by the birds, a habituation gradually takes place (Laursen & Rasmussen 2002). The habituation counters the responses to immediate or apparent danger and thus reduces the effect of disturbance.

This question remains highly complex and the actual mechanisms behind disturbance may not be relevant for the present review. What remains important is the specific effect of kitesurfing and other recreational activities, eg. measures by escape distance.

3 Kitesurfing – how, when and where

3.1 When and where

Kitesurfing relies on specific conditions regarding wind, water depth and general coastal topography in order to take place:

- The wind speed should be more than 6-8 m/sec and can be carried out with wind speeds up to a max. of 20 m/sec,
- Wind direction should be towards the coastline,
- Water depth of at least 100 cm (in order to avoid submerged stones, sand banks etc. in troughs),
- The coastal landscape should be open and without gradients such as cliffs, high banks and forest cover.
- The heavy equipment and need to change from wet to dry kit means that kitesurfers will need direct access by car to the launch location where parking spaces must be available.

The main pulse of activity is between April and September although for dedicated surfers the season will extend into the cold months. It is estimated that during the winter period only 10 % of the full number of surfers are active (from Martin, ref). The popularity of the sport has grown substantially over the years and is continuing to do so (Fearnley, 2012).

From a British study it was found that on average kitesurfing trips last 1 hour and 26 minutes and cover an average distance of 9.3km whilst the area covered is relatively small at 0.32km^2 (Liley et al, 2011, check other similar studies). This site-specific information is likely to vary significantly with location and conditions and can as such only be regarded as an indication.

Generally, kitesurfers need wind speeds of at least 6-8 m/sec (10-13 knots). The windspeed depends on the equipment used, body weight of the rider and type of riding, as greater wind speeds are required for jumping. Kifesurfers typically reach an average speed of 25-35 km/h and rarely reach speeds of more than 40 km/h. In addition to sufficient wind, each location should ideally have specific tidal and wind conditions which favour kitesurfing. Ideally kitesurfing takes places in tidal areas where launching can take place from sand banks during incoming tide as opposed to launching from the shore.

Coastal areas with woodland and cliffs are not suitable for kitesurfing as the kite may tangle with the trees and cliffs if coming too close (correct??) and coasts that have no access roads and parking spaces cannot be utilised as well.

3.2 Equipment

The equipment used in kitesurfing includes:

- The kite, in various designs: flat skin, inflatable, ram foils etc.,
- Lines, typically between 20-40m,
- Control and safety gear, and
- Kiteboard, uni-directional or bi-directional

The kite and its pattern and colouring may have some effects on the disturbance effects of kitesurfing, as may have the length of the lines. The lines limit the area that may be swept or overflown by the kite and hence the longer the lines the bigger area may be covered by the kite.

3.2.1 Spatial and temporal constraints

Kitesurfing is spatially and temporarily limited in occurrence and perhaps more so than most other recreational activities in the coastal zone, due to the specific requirements for access and launching sites as well as coastal morphology and wind speed and direction. This perspective needs to be taken into consideration when assessing the disturbance effects and their consequences on bird populations.

Kitesurfing has the potential to disturb birds where the activity takes place at or near bird sites and in this respect kitesurfing does not differ from any other recreational and physical activities that are being carried out where birds occur. However, the definite limitations in time and space that govern the occurrence and frequency of kitesurfing and the numbers of kitesurfers taking part in an event makes it critical to assess the consequences properly beyond the immediate response of birds during a specific kitesurfing event.

4 Disturbance of birds in coastal areas

4.1 General patterns of occurrences

4.1.1 Habitats

Coastal areas in northwestern Europe generally holds an enormous importance for birds. The coastal areas in Europe are used as flyways for thousands or even millions of birds on their way between breeding areas in northern Europe and Artic areas and wintering areas in Southern Europe and Africa. In particular, these flyways involve waterbirds such as geese, ducks and waders but also gulls, terns and other groups of birds that are associated with marine and coastal habitats.

Table 1 The East Atlantic Flyway - an important migratory path for a large number of waterbirds. Map source: Wadden Sea Flyway Initiative (WSFI).

As an example, the Wadden Sea alone may be visited by 10 to 12 million birds during autumn migration (WSFI 2017) and the shallow coastal sea areas hold other millions of ducks and other waterbirds during migration and during winter.

Also, breeding sites for birds are concentrated in many types of coastal areas in Europe. Breeding birds in coastal areas are dominated by the same groups of birds that use the flyways along the coastal areas.

Birds occurring in the coastal areas occupy a range of different habitats that constitute a subset of coastal habitats in northwestern Europe. The most important habitats for waterbirds are mudflats and tidal areas, marshes, beach/sandy shores and shallow coastal waters.

Mudflats and tidal areas

Mudflats and tidal areas constitute some of the richest natural habitats in the world, with an enormous production of invertebrates, fish and other biodiversity, nourished by the constant influx of nutrients from the sea. Being regularly exposed due to tidal water regimes or wind pressures these resources are readily available for feeding birds, in particular ducks, geese and waders that are all highly specialised in feeding in muddy, shallow substrates.

The Wadden Sea is the most prominent example of a tidal system that provides almost endless food resources for breeding and migratory birds, and with its 10.000 km^2 the Wadden Sea is of global importance for birds. In northwestern Europe many sites with similar ecological characteristics are found scattered along the coastlines and all sites play a significant role in sustaining bird populations of local and international origin and their ability to make efficient use of the East Atlantic Flyway.

Marshes

In coastal areas with a shallow topographical profile and flat areas along estuaries marshes and salt marshes may form and develop into important bird habitats. Coastal marshes have traditionally been utilised for livestock grazing and has thus been kept open and maintained as important habitats for birds. Today, some of our most rarest and red-listed breeding bird species are dependent on coastal marshes and salt marshes throughout Europe.

Beaches and sandy shores

Sandy shores are found all over northwestern Europe, with major occurrences in Germany, Denmark, southern Sweden and the Netherlands. Sandy shores and beaches are of less importance to migratory birds even if concentrations of waders, gulls and terns can be found in such habitats. For breeding birds sandy shores can locally be of significant importance as they may hold breeding colonies of terns and more scattered breeding sites for waders. Generally, the presence of breeding birds of some importance depends on the regular use of the beaches for recreational activities. Long-term use with recreational activities will in most cases have caused major breeding bird occurrences to disappear.

Rocky shore, cliffs

Rocky shores and coastal areas with a steep topography are rarely important as bird habitats. An exception to this are rocky cliffs that may host breeding sites of auks and a few other species of cliffnesting seabirds, but such sites are very scarce and highly localised in distribution.

Open sea

Most northwestern European countries border open sea areas, including the exposed sea areas in the North Sea and sheltered seas in the areas between Germany, Denmark and Sweden. Open sea constitute a habitat for seabirds that spend winter on the open sea and that may use open sea areas for foraging. During moulting, some species of ducks may spend their time in open sea. Except for a few highly specialised sea birds open sea areas are rarely frequented during breeding season.

Lakes and lagunes

Along northwestern European coasts, large lakes and lagunes are frequently found. If of a sufficient size such areas may be suitable for kitesurfing given the right wind conditions and at the same time lakes and lagunes can be of significant importance for birds. Due to their fresh or brackish water they often host a different bird fauna than coastal bird habitats and because of their sheltered location they can be very important for staging or wintering birds, in particular grebes, ducks and geese.

4.1.2 Birds

Birds that rely on coastal habitats in northwestern Europe during parts of their lifecycles are typically belonging to the following groups of birds, collectively grouped as waterbirds:

- Wildfowl (geese, ducks, swans),
- Waders (stints, sandpipers, plovers etc.),
- Terns and gulls,
- Divers and grebes,
- Herons,
- Cormorants.

These birds utilize coastal habitats for roosting, feeding, breeding, moulting. Coastal areas are important as stop over sites during migration.

Many studies on birds and human disturbances are species specific, however in this review disturbances will not be described at species level, and birds will be referred to as waterbirds in general.

4.2 Types of recreational activities and effect on birds

4.2.1 Types of recreational activities

The coastal areas of northwestern Europe are host to a large range of recreational and outdoor activities that collectively gathers millions of people. The recreational activities have diversified significantly over the last decade and the use of the individual activities have intensified enormously during the same period. In some areas with easy access to the coast and where the topography and coastal type attracts visitors the effects of the human activities on biodiversity can be significant and can lead to local pressures on birds and other biodiversity. However, when compared to all other human pressures on coastal ecosystems disturbance ranks below much more notable risks such as habitat loss, infrastructure development, pollution, resource exploitation, erosion and general effects of climate change (see e.g. EEA 2010).

The recreational activities include a long range of activities on the shore and in the water and include the following main types:

- On shore: Walking (with/without dog), sunbathing, hunting, biking, birdwatching, driving with cars and ATVs,

- On the sea: Windsurfing, kitesurfing, paragliding, sailing (kayaks, rowboat, sailboats, motorboats, jetscooter), swimming, fishing, bait-digging.

The types of activities that are carried out vary with the coastal characteristics and are as such unevenly distributed along the European coastlines. Again, the most frequented areas are shallow and easily accessible coastlines with sandy beaches. A large share of the recreational sailing also takes place at and near places with easy public access, though sailboating occur over larger distances and at longer distances from the shore.

4.2.2 Effects on birds of coastal recreational activities

Human activities result in disturbances of birds and disturbances may keep birds away from optimal feeding grounds, from breeding sites and from protection from weather, birds of prey etc. The distance within which the birds take to flight as a response to a disturbance is called the escape distance. The escape distance depends on a number of specific conditions, including:

- The species of bird(s),

- The flock size,

- Type of activity causing the disturbance,

- Time of the year,

- Frequency of disturbances,
- The behaviour of the birds.

Numerous studies have been carried out to look at recreational activities and bird disturbance. Studies are frequently commissioned by local authorities facing challenges such as managing recreational pressure, implementing planning policies, requirements by European legislation such as Habitat Directive. These studies tend to focus at European protected areas and their designated features (Natura 2000 sites).

4.3 Temporal and spatial issues

The temporal aspect of when recreational activities/human disturbances are likely to cause a disturbance to birds are linked with the spatial issues of where the recreational activity/disturbance occur. Human disturbance can negatively affects birds feeding, roosting and breeding strategies, ultimately modifying spatial and temporal patterns of habitat selection and abundance.

The shore, marshes, intertidal zones, cliffs and open water offers important habitats to a range of birds at different times of the day, year and stages of the lifecycle (see chapter 4.1). Understanding this temporal habitat usage is important in assessing *when* disturbance may occur. Understanding this spatial habitat usage is important in assessing *where* disturbance may occur. These spatial and temporal patterns of habitat usage are species specific.

4.3.1 Temporal issues

Season/time of year

It is generally agreed that during the winter (November – March) disturbance is likely to have the greatest effect on birds. In European estuaries wintering bird numbers generally start building from August, peaking in December (see eg. Liley at al 2011, Laursen & Frikke 2013). Reduced food availability, reduced fat reserves and low temperatures force birds to spend more time on feeding in order top maintain their body condition. Severe weather conditions can mean additional stress to birds (Clark et al., 1981, in Hoskin et al., 2008). Thus the cost of responding to disturbance during the winter is higher as displacement will give less time for feeding and the consequence is that birds may respond differently (less) to disturbance events during winter than when resources are richer (Beale & Monaghan 2004). This also means that there is no simple relation between the magnitude and type of disturbance and the escape distances (Laursen et al. 2017).

Intertidal food resources are typically of higher food value during the summer but become depleted during the autumn and early winter. Overwintering birds along the coast feed intensively during the autumn to build up fat reserves and bird loos condition over the winter (Stilman, 2012, from study on brent geese).

Weather conditions, especially wind speed and direction influences escape distance (Weston et al 2012).

In autumn food resources are freely available and birds may respond quicker and appear more sensitive, whereas later in winter when food is more scarce birds may react to disturbance differently as they are forced to optimize their foragin g time (Goss-Custard et al., 2006).

In addition, the effects of habituation create a significant problem when assessing the responses of birds to disturbances. Habituation constitutes a highly complex issue as it may arise during generations of birds and it is likely to be species specific as well as site specific (Laursen & Holm, 2011). Further, as illustrated by urban grey-lag goose breeding populations this species may be highly tolerant to humans during the breeding season but when the individuals join other geese while on migration they may show a high degree of shyness (Kampp & Preuss, 2005). Repeated disturbances following a fixed pattern within a short period (one to few days) may also reduce shyness and thus shorten escape distances due to habituation (Laursen & Rasmussen, 2002).

Breeding

Disturbance to breeding birds may cause nest failure, predation to nests and young, causing a potential reduction in population size. Disturbance to nesting birds is likely to be caused mainly by human activities that take place onshore where most nests of waterbirds are located. Kitesurfing may disturb when accessing the open water and breeding birds feeding on or above open water may also be disturb by kitesurfing.

During the breeding period breeding birds may reduce their escape distance and stay longer on the nest to reduce the risk of nest predation (Laursen et al., 2017) and breeding birds may be less likely to display obvious responses to disturbance.

Human disturbance during the summer has been implicated as the cause for decline in coastal breeding populations of ringed plover in the UK (Liley and Southerland 2007) and modelling carried out on plovers predicts the population would increase by 85% if human disturbance were absent (Liley and Southerland, 2007). It must be emphasized that this study does not distinguish between disturbance types and there is no evidence that kitesurfing plays a notable role in the disturbance of breeding waders.

In general, kitesurfing is likely to result in less disturbance to nest sites and breeding birds on nests as kitesurfing normally takes places at some distance from suitable nest sites on shore. Thus, even if kitesurfing is more frequent during summer and hence in the breeding season, the resulting effects are more pronounced outside the breeding season.

Moult

Moulting generally occur in late summer from July to September or longer. During this period wildfowl (duck, gees, swans) cannot fly for a period of about 3 weeks and are resting at relatively shallow water at 4-8 m deep (Laursen et al., 2017). Waders are partially flightless during the moult.

During this flightless period waterfowl are especially vulnerable (Gehrold, 2014, Mosbech and Boertmann, 1999, O'Connor 2008 in Ruddock & Whitfield, 2007). Moulting areas are usually areas of low predation and abundant food resources and moulting areas can be important stop overs on migratory routes. Moulting areas can be lagoons, inland lakes, shallow offshore areas and estuaries. The salt marshes of the Wadden Sea is an important moult site for millions of migratory waterbirds (Birdlife, 2009). However, many moulting areas are not mapped.

Time of day

Disturbance occurring to feeding in the morning can be compensated for in the afternoon, however disturbances occurring in the afternoon have been observed compensated for by foraging at night or early next morning (study on pink-footed goose, Schilperoord & Schilperoord-Huisman 1984, Belanger & Bedard, 1990, in Platteeuw and Henkins, 1997). The disturbance effect of kitesurfing on feeding/foraging waterbirds may therefore be higher when occurring duringthe afternoon.

4.3.2 Spatial issues

Several coastal types offer important habitats to a large range of birds (see chapter 4.1.1). Despite the general value of northwestern European coastal areas for waterbirds there are significant differences in importance between the different coastal habitat types. Also, within-site spatial issues such as vegetation, exposure to wind and waves and human disturbance typically result in uneven distribution patterns of birds within the individual habitats and sites.

Along coasts with mudflats, tidal areas and beaches birds congregate at high tide along the high tide line and at high tide roosts which are slightly raised areas that are not flooded during high tide. At low tide birds tend to spread out on the exposed tidal flats that often offers a very rich foraging habitat.

Human traffic and recreational activities at high tide are likely to cause a much higher disturbance than at low tide due to the significant concentration of birds. A British study showed that human activities at high tide were more than twice as likely to cause a disturbance to birds (Ravencroft et al, 2007).

The impact of activities is site specific and related to parameters like the state of tide, number of birds present, mudflat types and upper shore characteristic (Ravenscroft, 2007). Events on the shore caused most disturbance at high tide and events occurring offshore most at low tide (Liley et al 2010).

There was also a significant interaction between escape distance and tide, indicating that the way in which birds responded varied according to tide. At high tide more birds are likely to take flight at closer distance (Liley and Fernley, 2011) and also major flights were more likely at high tide.

In a study in Great Britain Liley et al. (2011) showed by using GPS tags that at intermediate tide the average area lost due to disturbance from a windsurfer or kitesurfer would be around 8 ha, while a dog walker on the mudflats resulted in an area loss of around 3 ha. Such findings are obviously highly dependent on the topography of the study site and does not take into consideration the frequency of kitesurfing and dog walking. Also, off-leash dogs may behave very differently, with some dogs actively chasing birds out in the water. In a modelling study of disturbance in the Solent (UK) disturbance events was assumed to disturb 41 ha of intertidal habitat (mean of general and dog off-leash disturbance area) (Stillman et al., 2012).

In Laursen et al. (2017) species-specific escape distances are compiled from various studies (insert figure). Escape distance varies depending on which type of vessel caused the disturbance, windsurfers and kitesurfers mean escape distance was 390 m. Many coastal activities (walking, dog walking, kayaking etc) causing disturbances to birds have no requirement to weather, season or certain water levels and are carried out throughout the year and in all coastal habitats.

The pressure from these activities is difficult to regulate in areas of open access as there is no requirement for permits.

5 Kitesurfing - basic findings

Many studies have reported and documented that kitesurfing may disturb birds when kitesurfing takes place on sites where birds are present (see compilations eg. by Krijgsweld et al. 2008, Krüger 2016, Laursen et al. 2017, Weston et al. 2012). Studies that include observations of disturbance-initiated escape flights provide evidence that kitesurfing tend to result in somewhat larger flight distances than recreational activities that are conducted with less speed or less visual volume (see eg. overview table in Laursen et al. 2017), in line with crafts like windsurfboards, motorboats and jetscooters.

However, a number of methodological issues imbedded with the majority of the cited studies require specific elaborations. The main issue is that kitesurfing takes place at sites limited in number and size due to a range of restrictions to where kitesurfing can be conducted (specific conditions regarding weather, time of season, coastal morphology, water depth, access etc). This fact makes it difficult to compare the disturbance effect of kitesurfing to other more widespread recreational activities in the coastal zones and tend to overestimate the actual disturbance effects and impacts of kitesurfing when generalised across temporal and spatial scales.

Also, studies rarely take into consideration that disturbances may not be assessed in isolation. In the majority of the studies the effects of kitesurfing are surveyed and assessed without consideration for addtional recreational activities, either taking place in the site at the same time or just prior to the study on kitesurfing. Some studies report on cumulative effects of disturbance (eg. Laursen & Holm 2011) but the aspect of bird responses to ongoing or recent disturbances may be far more complex than assumed in the individual site-specific studies of kitesurfing. One one hand effects and impacts are likely to show cumulative or even synergistic responses but on the other hand there will also be some habituation to a varying degree, which may show up as shortened flight distances and shorter recuperation. These factors are rarely or never studied and may indeed be highly challenging to include in a scientific study.

In conclusion, due to these methodological challenges we recommend that assessments of the disturbance effects of kitesurfing are conducted on broader temporal and spatial scales rather than single-site studies as has generally been the case in the majoroty of the studies.

In the following sections we provide more details on the specific context that kitesurfing takes place within as this has profound significance for the study and assessment of disturbance from kitesurfing.

5.1 Temporal disturbance

There are a number of temporal aspects that govern where and when kitesurfing can be executed:

- Seasonality: The summer months are preferred for kitesurfing due to acceptable wind and water temperatures,
- Weather: Kitesurfing depends on certain wind conditions as regards direction and speed,
- Water level/tide: Kitesurfing needs a certain water depth and becomes hazardous at depth beyond where the surfer can still reach the seabed.

Seasonality

The main season for kitesurfing is the summer months from April to early autumn as the wind and water temperatures are reasonable during this period. A few kitesurfers may continue into the winter but due to the critically low water temperatures the number of active surfers in winter is insignificant compared to the numbers during the summer season.

Potential conflicts with seasonal occurrences of birds include breeding birds in May and June and early migratory movements of birds in late summer and early autumn. The majority of bird migration in coastal areas take place in early to mid autumn (Aug – Oct) and again in spring (Mar – May) and this leaves a certaibn overlap between the main season for kitesurfing and the main presence of birds. At a local scale the presence of birds may differ significantly from this generalized patterns but it serves an overall indication of the actual periods where the main temporal conflicts may appear.

Weather

The optimal weather conditions for kitesurfing include wind speeds between 6 – 20 m/s and wind directions in angles between directly towards or parallel to the coast. This means that coasts exposed to the west are likely to be suitable more often than coasts exposed to the east due to the western wind regime that dominates northwestern Europe.

Also, with higher wind speeds kitesurfers will keep longer distances to the coastline in order not risk running against banks and the shore itself.

The risk of conflicts with birds are reduced though not eliminated with wind exposure and wind speed. Birds that rest on open water will if possible locate for sheltered water parts with no or reduced wind exposure and impacts from waves in order to minimize efforts for maintaining position and reduce the risk of cooling.

Birds that feeds on tidal areas and sandy areas along the shoreline will be relocated to areas with less wind exposure and wave movements as feeding become obstructed with wave movements. With stronger winds this effect becomes more significant.

Thus, the potential conflicts between birds and kitesurfers are reduced in areas with wind exposure and the significance of the conflict may decrease with increased wind speed which may force resting and feeding birds to move to other and more sheltered areas.

Water level/tide

The ideal water depths for kitesurfing lie between 1.0 and 1.5 m as lower water depths leaves the risk of hitting banks and the sea bottom between the waves, and higher water levels makes it difficult to control the kite and board when capsizing.

In general, at water depths of more than 0.3-0.4 m present birds will be waterbirds, mainly ducks, geese and grebes, that are either resting/sleeping or feeding by means of diving. Waders and other shorebirds will not be present at such water depths.

Concerns have been expressed where kitesurfing allows access to otherwise remote areas of intertidal habitat, especially with onshore winds when kites will tend to drift over feeding/roosting birds (Stillman, 2009). However, the relevance of a concern of this type should ideally be tested against the availability of suitable water depths that allow kitesurfers to approach habitats for feeding and roosting birds.

As mentioned above, when the wind has gained a certain speed the open water will no longer constitute an attractive habitat for resting/feeding birds due to wind and wave exposure. Local topographical features may obviously provide certain conditions that create suitable habitats for birds despite wind and wave exposure but in general the above relation between water depth and bird occurrence should be included in specific, local assessments of possible conflicts between kitesurfing and birds.

5.2 Spatial disturbance

There are a number of spatial aspects that govern where and when kitesurfing can be executed:

- Coastal types (morphology and topography): Kitesurfing depends on the availability of specific water depths, ideally between 1.0 and 1.5 m [correct?], and becomes hazardous where cliffs or trees are found near the shore,

- Access: Surfers need access with a car to the site and a parking space in order to bring their equipment to the launching area,

- Surfing site: The availability of the required water depths should have a certain volume (width, length) so that it makes sense to kitesurf.

Coastal type

The coastal topography and morphology play a dominant role for the features that makes kitesurfing possible. There is a clear relation between coastal types, gradients and water depths which makes is possible to a large degree to map suitable areas for kitesurfing just by knowing the coastal type/morphology.

For the importance of water depths for kitesurfing and birds see above under *Water level/tide*.

Other features of the coastal type that influence the suitability for kitesurfing include steep features on shore, such as cliffs, trees, masts etc that may tangle with the kite if the surfer comes too close to the shoreline.

In general the importance of the coastal type for birds decreases with the steepness of the profile, mainly because the topographical gradients become too steep and leaves less room for feeding in shallow areas.

5.3 Frequency of kitesurfing

As a part of an overall assessment of the importance of kitesurfing as a disturbance factor in coastal areas the actual numbers of kitesurfers and their frequency of activity should also be considered. In particular, when the actual numbers of kitesurfers are considered together with the temporal and spatial restrictions to kitesurfing the resulting frequency of surfing per coastal length is indeed very low.

As a specific example it has been demonstrated that in some areas disturbance is mainly caused by other activities, such as in the Exe Disturbance Study (Liley et al., 2011) kitesurfing accounted for 1 % (14) of all activities registered. Disturbance was caused by 14 % (188) of all activities observed in the estuary, resulting in a major flights of birds (>50 m flight distance), however 62 % (445) of all activities caused no response from the birds in the study areas. Dog walkers with their dogs off leads on the intertidal caused the highest percentage of major flights from all the observed potential disturbance events (Liley et al., 2011). Only 4 % (4) of all major flight events (103) was caused by kitesurfers. The effect of a single kitesurfer can however have a large impact, as in the same study 85% (12) of kitesurfers on water caused a major flight event.

Even if the study in the above example was comprehensive in studying human disturbance to wintering waterfowl in a busy estuary with easy access for a range of recreational activities, the results relating specifically to kitesurfing were based on just 14 observations of kitesurfers.

While the actual numbers of kitesurfers and their occurrence along northwest European coasts are not known it can safely be concluded that kitesurfing is executed by a very small number of practitioners and the number is likely to be insignificant when compared to the combined number of persons that regularly take part in recreational activities along the coasts.

Hence, the overall disturbance pattern that are being documented and presented in many studies during the last years should preferably be modified by taking into account the highly limited number of practitioners when seen over a larger geographical scale and in the light of the temporal and spatial limitations to kitesurfing. Obviously, on the individual sites the actual number of surfers is less important as a single kitesurfer can create as much disturbance as a group of surfers, but when reviewing the impacts of kitsurfing over a larger scale the small number of practitkiones should certainly be taken into account.

As no actual numbers are known [is this true? Or can numbers be indicated eg. on a regional or local basis?] it remains problematic to include kitesurfing frequency in a specific way in assessments of the disturbance pattern. However, on a local and site-specific scale the potential numbers of kitesurfers should be included in assessments in order to provide a reasonable impression of the scale of surfing in order to set proportions relative to other recreational activities in the same area/site.

Table 2 Overview of literature covering kitesurfing and bird disturbance DRAFT EXAMPLE TABLE

Reference	**Kitesurfing**	**Sample size N (kitesurfers)**	**Season /month**	**Habitat**	**Issu**
Jensen (2017)	Study conclusion: 7 % of disturbances were caused by kitesurfers.	Kitesurfere: 128 Kitesurfing disturbance: 99 Total activities: 1236 Total disturbances: 1017	July-august	estuary	Our

Jensen (2017)	Study conclusion: Kitesurfers cause major flights.	Kitesurfere: n.a. Kitesurfing disturbance: 99 Total activities: n.a. Total disturbances: n.a.	July-august	estuary	
Bayne, S. and Hyland, V. (2016).	7% of disturbances were caused by kitesurfers.	?	January 2010-December 2011	?	Data from Bird Distur by kent Wi data not pu
Beauchamp, A. J. (2009)	Kitesurfing disturbs waders at high tide roost sites.	11	March	Estuary intertidal	No standar for recordin disturbance Survey per Survey ove kitesurfing days.
Cruickshanks, K., Liley, D., Fearnley, H., Stillman, R., Harvell, P., Hoskin, R. & Underhill-Day, J. (2010).	2 out of 36 interviewed thought kitesurfing is causing disturbance (6%). Kitesurfing ranks middle of scale of recreational disturbance (Score 66, walking 420, rowing 18).	-	-	Intertidal	Desk based interviews
Cruickshanks, K. (2014)	474 kitesurfers registered.	474	June-August 2014	Estuary/harbour	No disturba sample of watersports
Fearnley, H., Liley, D. & Cruickshanks, K. (2012)	Uncommon activity (<1%). The main pulse of activity is between April and September.	4	Winter	Estuary/harbour	Interview kitesurfers, disturbance
Laursen et al (2017).	Escape distance xxxm	X?			
Le Corre, N., Gelinaud, G. and Brigand, L.	Kitesurfing ranks 8th as disturbing activity by Breton Conservation Managers. the sport	-	-	-	Anecdotal Based on i wildlife ma

(2009).	accounts for 2,7% of total coastal activities.				quo
Liley, D., Pickess, B., & Underhill-Day, J. (2006).	No disturbance recorded from kitesurfer	1	October-March	Estuary	One (par 29 c
Liley, D., Stillman, R. & Fearnley, H. (2010).	No disturbance recorded for kitesurfing. 20% of potential disturbance events within 200 m study areas caused disturbance to birds.	4	December - February 2008/2009 and 2009/2010	Estuary	No c in re
Liley, D., Cruickshanks, K., Waldon, J. & Fearnley, H. (2011).	Kitesurfers cause major flights. Average kite route is 9.3 km long and covers an 0.32 km² area.	14	September - April . At optimal weather for kitesurfing	Estuary, Shore, 500 m study areas	36 C kites cour But distu
Liley and Fernley (2011)	No kitesurfers in study	0	December- March (2010-2011)	Intertidal habitats, marshes	No k 12 s 34 F or w wind acro iner caus 50% resp
Liley, D. & Fearnley, H. (2012).	40 kitesurfers on water, account for 1% of potential disturbance vents. Kitesurfing flushed 24 birds in total over 4 event (1%). 3 of tehse caused a major flight.	40	Nov- Feb	Estuary/harbour	Kite 1 da wate peop

Linaker (2012)	62 kitesurfer events in data set. 45% caused disturbance, all at one study site.	62	Oct-march		
Swandale, T.,Waite, A. (October 2012), Pegwell Bay, Kent: Bird Disturbance Study 2010-2011.					
Smith (2006)	A significant drop in waders coincide with the arrival of kitesurfing. Kitesurfers are a major source of bird disturbance	-	Winter 2002/2003	-Estuary	Informal. Bas volunteer bir data.
Stillman, R. A., Cox, J., Liley, D., Ravenscroft, N., Sharp, J. & Wells, M. (2009)	Reports of problems were reported as occurring where kitesurfing takes place near to winter wader roosts or where there are concentrations of diving birds (e.g. grebes or eider duck).	-	-	-	Anecdotal e

5.4 Mitigation measures

An array of conservation measures have typically been introduced to manage recreational activities in coastal areas (see eg. overviews and compilations in Brøgger-Jensen et al. 2015, Krüger 2016, Laursen et al. 2016, Therkildsen et al. 2013):

- Designation of wildlife reserves and protected areas,
- Publishing Codes of Conduct for regulating human behaviour,
- Establishing zones explicitly for certain activities and buffer zones against vulnerable and sensitive areas, with buffer zones respecting acknowledged flight distances,
- Regulating access and parking in order to reduce activities at the access and preparation points,
- Launching targeted information campaigns for active users of coastal areas, with signposts, flyers, information boards etc,
- Conducting impact assessments on a strategic level (regions, larger areas) and on project/activity level (specific sites),

- Elaborating spatial plans.

Zones and access regulations will often be of a temporary character or with fixed periods for access, reflecting the specific periods where activities may conflict with vulnerable bird occurrences. As an example there is evidence that late summer and early autumn may constitute a period of potential conflict between kitesurfing and the early migratory movements of birds, and in order to reduce actual conflicts kitesurfing zones could be designated at suitable sites in this period.

There are numerous examples from around European coasts of zones for particular water-based activities, such as water-skiing or kitesurfing. These zones are often set out in local or regional codes of conduct, usually developed with local users and user groups. The codes of conduct are sometimes also linked to bylaws, and the implementation of the zones is often driven by safety issues rather than with the aim to minimise disturbance (Brøgger-Jensen et al. 2015).

Impact assessments can be a strong tool for assessing and planning for a certain activity and is legally mandatory in EU member states for a large range of projects, structures and activities as specifies in the EU EIA Directive (2014/52/EC). While recreational activities on the sea are not included on the Annex I or II on the Directive the principles and approach given by the EIA procedure may prove beneficial to apply in certain cases where kitesurfing appears to be conflicting with different points of view and opinions. An impact assessment carried out by an independent body, done along the principles laid out by the directive, should elicudate, describe and assess the actual activity against eg. natural values, including bird occurrences, and draw up recommendations for the planning and regulating authorities.

Spatial plans may provide the overall framework for more detailed, local regulations of activities and will as such be a valuable instrument for avoiding conflicts while establishing the regulatory framework for exisiting and planned activities. In line with the assessment of specific projects by means of the stipulations in the EIA Directive spatial plans should likewise be assessed in compliance with the EU Directive on Strategiv Environmental Assessment, Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment. If conducted in a comprehensive manner the SEA will inform the spatial planning process and help avoiding major conflicts of interests subsequent to the planning process.

5.5 Cumulative impacts

Bird disturbances are being amplified when more disturbances take place simultaneously or continuously (Smit & Visser, 1992, Laursen & Holm, 2011). The responses of birds to disturbances are more prominent when raptors are present (Laursen & Rasmussen, 2002) and Linaker (2012) found that the disturbance caused by dog-walkers with dogs off leash was intensified with the simultaneous presence of bait-diggers or kitesurfers.

Further, it is well documented (eg. Laursen et al. 2017) that hunting creates a certain stress level that results in a higher alertness and shyness towards other recreational activities.

With the increasing and intensifying recreational activities taking place in northwestern European coasts it is likely that cumulative effects may become more and more promiment and should be included in future studies of the effects of recreational activities in coastal areas. Facing this is the process of habituation to human disturbances that gradually develops when the disturbance is perceived as non-lethal by the birds.

6 Conclusions and recommendations

6.1 Conclusion

When seen in isolation kitesurfing can be a significant disturbance factor for birds at the specific site where it is being carried out. However, an important perspective to bring forward when making an overall or generalized assessment of the disturbance of kitesurfing on birds is the limited extent of the sites where kitesurfing is carried out and the restricted periods when kifesurfing can be conducted.

Thus, compared to other recreational activities in coastal areas there is evidense that kitesurfing belongs to one of the less frequent activities. This fact has seldom been brought to light in the studies carried out so far.

In general, there is a major lack of empirical evidence that demonstrates the actual disturbance effect when seen in connection with other recreational activities that take place in the same area. The many studies that have looked at kitesurfing in isolation are not able to make detailed conclusions on the effect of kitesurfing as one of several recreational activities in coastal regions. The simple statement that 'kitesurfing may disturb birds' that remains the major conclusion in several studies can not be used in the overall coastal zone planning and management.

Major risks

The following major risks for conflicts with birds have been identified:

- Surfing near high tide roosting sites for birds where migratory birds are highly concentrated and can occur in very large numbers,

- Prolonged surfing near major and extensive feeding sites, in particular during the winter months,

- Late summer and early autumn, where the first pulse of migratory birds pass through northwest European coastal regions towards their wintering quarter may be the period over the course of a year where there is greatest risk for conflicts between kitesurfing and vulnerable bird occurrences.

The above major risks can be mitigated by zonation and temporal regulation of access and surfing.

Major findings

The review has retrieved the following major findings concering kitesurfing as a factor (out of several) in the recreational pressure in coastal regions:

- Kitesurfing is severely restricted in terms of time and space as to where and how frequent it can be conducted,
- The demand for specific weather conditions and water levels give kitesurfing more limitations than most coastal activities in terms of when it can be carried out,
- Kitesurfing takes place at water levels that under many circumstances reduce the potential impact on the most significant breeding and resting/feeding bird sites, in particular in the Wadden Sea area, as the required water levels are found sufficiently far from the shore or from tidal/mudflats to avoid major disturbance situations,
- The space required for kitesurfing may be less than projected as kitesurfing most often takes place within a certain polygon rather than by means of long unidirectional excursions along the coast like motorboating, kayaking/canoing etc. This reduces the impact even in situations with many kitesurfers at the same place.
- The requirements for certain water depths and for a certain minimum wind speed limit the possibility for kitesurfers to enter areas with shallow or calm water, which in most cases are the preferred habitats for resting and feeding birds. Large parts of eg. the Wadden Sea and lagunes and lakes along the coast are not accessible due to these constraints.

6.2 Recommendations for further studies

Short- and long-term effects of kitesurfing

The review has first of all revealed a significant gap in the specific knowledge about the actual disturbance patterns that result from kitesurfing. There is a rather notable need to undertake studies that aims at establishing short-term and long-term effects of kitesurfing on bird populations, with the specific purpose of building a solid picture of the explicit circumstances that may lead to conflicts between kitesurfing and bird occurrences.

Long-term effects of disturbances are notoriously difficult to study in more detail due to the many factors involved when assessing population pressures and measuring the physiological response. Models that describe aspects of bird population viability have been developed many times over the recent decades (typically termed PVA, Population Viability Analysis, see eg. Horswill et al. 2016 and O'Brien et al. 2016) but most models are compromised by the immense amount of parameters that are needed for the model to become operational. For basics models the simplistic approach to map population characteristics and essential population factors leave the models too vulnerable to flawed input data.

GIS-mapping of kitesurfing sites

In order to be more precise about the actual location of suitable kitesurfing sites it can be suggested to make a GIS-based mapping of sites that match the physical/topographical requirements as well as accessibility (access roads, parking spaces) along the Northwest European coastline. Though it may be a significant task to conduct such a mapping exercise it would constitute a major tool for conservation planning in coastal areas and potentially help avoiding conflicts between kitesurfing and conservation interests. Currently there is a lot of focus on spatial planning in coastal areas for climate adaptation purposes and it can be argued that planning for recreational activities should be an integrated part of the spatial planning in coastal regions due to the massive recreational values and nature conservation values of Northwest European coasts.

Buffer zones

The disturbance zones are species and site specific and any Codes of Conducts and exclusion zones needs to reflect this. It is inappropriate to set general buffer distances as responses to disturbance vary between species and between individuals of the same species (Blumstein 2003, Beale & Monaghan 2004). The ecology of the species present and the site specific features must be taken in to account when identifying potential disturbance and impact.

Site-specific impact assessments

Perhaps the most important conclusion that can be drawn from the present review is that it is impossible to generalize about the potential impacts from kitesurfing. So rather than exploiting the lack of site- and area-specific knowledge by issuing general bans on kitesurfing it may be useful to undertake site-specific assessments of possible conflicts between birds and kitesurfing as an impact assessment is likely to reveal and pinpoint the actual areas of conflicts – if any. Based on the findings on an impact assessment it is then possible to establish specific and targeted regulations and zones that may serve to allow for a preservation of the bird fauna as well as provide access to kitesurfing under certain rules.

An impact assessment must obviously also include an assessment of all other activities in the specific place so that a thorough understanding of the recreational activities and their combined effects on the bird fauna present can be revealed and discussed. This may lead to broader measures in order to regulate the recreeational traffic or it may result in a area-specific Code of Conduct.

7 References

Databases (accessed September 2017)

https://www.statsbiblioteket.dk/au/

http://library.au.dk/

https://www.scopus.com/

Websites (accessed September 2017)

http://www.solentems.org.uk/natural_environment_group/SRMP/SDMP/

http://www.birdaware.org/

http://www.langstoneharbour.org.uk/environment-harbourcare.php

https://www.nps.gov/caco/learn/nature/upload/2012-Shorebird-Report_Final.pdf

Contacts made

Natural England: investigating – no data

British Trust Ornithology: investigating – no data

Wildfowl and Wetland Trust: no papers on the subject

Ed Rowell (Solent Recreation Mitigation Partnership)

Richard Smith (Dee Estuary)

Literature

NOT COMPLETE

A vision for the conservation of a Natural Heritage. Vogelbescherming Nederland, Dansk Ornitologisk Forening & NABU

Bale, C. (2007). The Behavioral Ecology of Disturbance Responses. International Journal of Comparative Psychology, 20(2).

Bathe, G. (2007). Political and social drivers for access to the countryside: the need for research on birds and recreational disturbance. Natural England

Bayne, S. and Hyland, V. (2016). Strategic Access Management and Monitoring Plan In respect of the Thanet section of the Thanet Coast and Sandwich Bay SPA.

Beale, C. (2004). Human disturbance: people as predation-free predators? Journal of Applied Ecology Vol. 41, No. 2 (Apr., 2004), pp. 335-343

Beale, C. (2007) Managing visitor access to seabird colonies: a spatial simulation and empirical observations. Ibis (2007), 149

BEAUCHAMP, A. J. (2009): Distribution, disturbance and birds movement during a spring tide and kite surfing period at Ruakaka Estuary – 10-15 March 2009. Unpublished report, 16pp. Northland Conservancy, Department of Conservation, Whangarei

Beauchamp, A.j. and Parrish, G.R. Wader (Charadriiformes) and royal spoonbill (Platalea regia) use of roosts in Whangarei Harbour and Ruakaka Estuary, Northland, 1973-2000. Notornis, 2007, Vol. 54: 83-91

Birdlife (2009). The Wadden Sea

Blumstein (2003). Testing a key assumption of wildlife buffer zones: is flight initiation distance a species-specific trait? Biological Conservation Volume 110, Issue 1, March 2003, Pages 97-100

Borough of Poole. Habitat Regulations Assessment Record. Footprint Ecology / David Tyldesley Associates / Poole Borough Council

Brown, A.C. and McLachlan A. (2001). Sandy shore ecosystems and the threats facing them: some predictions for the year 2025. Environmental Conservation 29 (1): 62–77

Calvão et al (2013). Impact of human activities on coastal vegetation – A review. Emir. J. Food Agric. 2013. 25 (12): 926-944

Chan, K. and Dening, J. (2007). Use of sandbanks by terns in Queensland, Australia: a priority for conservation in a popular recreational waterway. Biodiversity and Conservation (2007) 16:447–464.

COLIN M. BEALE & PAT MONAGHAN 2003. Behavioural responses to human disturbance: a matter of choice? ANIMAL BEHAVIOUR, 2004, 68, 1065–1069

Cruickshanks, K. (2014) VALMER Recreational Watersports and Birdwatching Survey of Poole Harbour. Footprint Ecology/Dorset Coast Forum

Cruickshanks, K., Liley, D., Fearnley, H., Stillman, R., Harvell, P., Hoskin, R. & Underhill-Day, J. (2010). Desk Based Study on Recreational Disturbance to birds on the Humber Estuary. Footprint Ecology / Humber Management Scheme.

Davenport, J. and Davenport, J. (2006). The impact of tourism and personal leisure transport on coastal environments: A review. Estuarine, Coastal and Shelf Science 67 (2006) 280e292.

Division of Natural Resources (2012). Shorebird Monitoring and Mangement. Cape Cod National Seashore.

Drewitt, A. (2007) Birds and Recreational Disturbance. Ibis (2007), 149 (Suppl.1), 1–2.

Exe Estuary Management Partnership (2014) Exe Estuary Recreational Framework.
Fearnley, H, Liley, D and Floyd L. (2014). Thanet Coast and Sandwich Bay SPA Visitor Survey. Unpublished report for Canterbury City Council

Fearnley, H., Liley, D. & Cruickshanks, K. (2012). Results of the recreational visitor surveys across the Humber Estuary. Footprint Ecology, unpublished report for Humber Management Scheme

Fenn, H. 2016. Identifying methods for managing recreational disturbance of wildlife at coastal sites: Review of literature. Project Report, May 2016. The Walsh & North Norfolk Coast European Marine Site.

Finney, S.K., Pearce-Higgins, J.W. & Yalden, D.W., 2005. The effect of recreational disturbance on an upland breeding bird, the golden plover Pluvialis apricaria. Biology Conservation. 121, 53-63

Fox et al (2013). Current and Potential Threats to Nordic Duck Populations — A Horizon Scanning Exercise. Ann. Zool. Fennici 52: 193–220.

Gil et al (2001). The Effects of Disturbance on Habitat Use by Black-Tailed Godwits Limosa limosa. The Journal of Applied Ecology, Vol. 38, No. 4 (Aug., 2001), pp. 846-856

Gill, J. (2007). Approaches to measuring the effects of human disturbance on birds. Ibis (2007), 149 (Suppl. 1), 9–14.

Gill, J. et al (1996) A method to quantify the effects of human disturbance on animal populations. Journal of Applied Ecology 1996, 33, 786-792

Hardiman, N. and Burgin, S. (2010). Recreational impacts on the fauna of Australian coastal marine ecosystems. Journal of Environmental Management 91 (2010) 2096e2108.

HELLDIN, J.-O. (2004): Effekter av störningar på fåglar – en kunskapssammanställning för bedömning av inverkan på Natura 2000-objekt och andra områden. Naturvårdsverket Rapp. 5351, 63 Seiten. Naturvårdsverket, Stockholm.

Hoskin, R., Liley, D., Underhill-Day, J. & Tyldesley, D. (2007). Core Strategy for the Borough of Poole. Habitat Regulations Assessment Record. Footprint Ecology / David Tyldesley Associates / Poole Borough Council

Kirby, J., N. Davidson, N. Giles, M. Owen & C. Spray 2004: Waterbirds & Wetland Recreation Handbook. A review of issues and management practice. – Wildfowl & Wetlands Trust, Slimbridge

Krijgsveld, C.E., R.R. Smit & J. van der Winden 2008: Verstoringsgevoeligheid van vogels: Update literatuurstudie naar de reacties van vogels op recreatie. – Vogelbescherming, Nederland. Bureau Waadenburg, Culemborg.

Kruger, T. 2016: Zum Einfluss von Kitesurfers auf Wasser- und Watvogel - eine ubersicht. – Niedersachsischer Landesbetrieb fur Wasserwirtschaft, Kusten- und Naturschutz, no. 1.

Lake, S. (2010) Assessment of recreational impacts on Dawlish Warren Special Area of Conservaton. Teignbridge District Council/Footprint Ecology.

Laursen, K. & T.E. Holm (2011). Disturbance of birds by human recreational activities – an overview. Dansk Orn. *In Danish with English summary.* Foren. Tidsskr. 105 (2011): 127-138.

Laursen, K., T. Bregnballe, O.R. Therkildsen, T.E. Holm, R.D. Nielsen (2017). Disturbance of waterbirds by water-based recreational activities – a review. *In Danish with English summary.* Dansk Orn. Foren. Tidsskr. 112 (2017)

Le Corre (2013). Wintering waterbirds and recreationists in natural areas: a sociological approach to the awareness of bird disturbance.

Le Corre (2009). Bird disturbance on conservation sites in Le Corre, N., Gelinaud, G. and Brigand, L. (2009). Brittany (France): the standpoint of geographers. J Coast Conserv (2009) 13:109-118

Lefferty, K.(2000). Birds at a Southern California beach: seasonality, habitat use and disturbance by human activity. *Biodiversity and Conservation* 10: 1949–1962, 2001.

Liley, D. & Fearnley, H. (2011). Bird Disturbance Study, North Kent 2010/11. Footprint Ecology.

Liley, D. & Fearnley, H. (2012). Poole Harbour Disturbance Study. Report for Natural England. Footprint Ecology Ltd., Wareham, Dorset.

Liley, D. & Tyldesley, D. (2013). Solent Disturbance and Mitigation Project: Phase III. Towards an Avoidance and Mitigation Strategy. Unpublished report. Footprint Ecology/David Tyldesley & Associates

Liley, D. (eds) (2013). Habitats Regulations Assessment of North Dorset Local Plan, Submission Version. Footprint Ecology.

Liley, D. (eds) (2013). Habitats Regulations Assessment of North Dorset Local Plan, Submission Version. Footprint Ecology.

Liley, D. and Sutherland, W. (2007). Predicting the population consequences of human disturbance for Ringed Plovers Charadrius hiaticula: a game theory approach. Ibis,149 (Suppl.1), 82–94

Liley, D., Cruickshanks, K., Waldon, J. & Fearnley, H. (2011). Exe Estuary Disturbance Study. Footprint Ecology

Liley, D., Pickess, B., & Underhill-Day, J. (2006). The numbers and distribution of black-necked grebes and other waterbirds at Studland, Dorset. Poole Harbour Study Group / Footprint Ecology.
Liley, D., Stillman, R. & Fearnley, H. (2010). The Solent Disturbance and Mitigation Project Phase 2: Results of Bird Disturbance Fieldwork 2009/10. Footprint Ecology / Solent Forum.

Linaker (2012). Recreational Disturbance at the Teesmouth and Cleveland Coast European Marine Site. Bird disturbance field work Winter 2011/2012. University of York

Lowen, J., Liley, D., Underhill-Day, J. & Whitehouse, A. (2008). Access and Nature Conservation Reconciliation: supplementary guidance for England. Unpublished report by Footprint Ecology. Commissioned by Natural England

Madsen (1995). Impacts of disturbance on migratory waterfowl. lBlS 137: S67-S74

Nabu (2xxx).Kitesurfen in Nord- und Ostsee. Im Konflikt von Wassersport und Naturschutz.

Natural England 2009. (Liley) Comparison of the abundance and distribution of birds along the northern shore of Poole Harbour by day and by nightNECR017.

Newton (2007). The Migration Ecology of Birds.

Platteeuw M. and Henkens R. (1997). Possible impact of disturbance to waterbirds: individuals, carrying capacity and populations. Wildfowl (1997) 48: 225-236. The Wildfowl and wetland Trust.

Ravenscroft et al (2007). Disturbance to waterbirds wintering in the Stour-Orwell estuaries SPA*. A Report from Wildside Ecology to the Suffolk Coast and Heaths Unit*.

Ruddock, M. and Whitfield, D.P. (2007) A Review of Disturbance Distances in Selected Bird Species. A report from Natural Research (Projects) Ltd to Scottish Natural Heritage

Shorebird US Department of the Interior (2015) Management Plan Environmental Assessment. Cape Cod National Seashore. national Park Services.

Smith (2006). The Effect of Kite Surfing on Wader Roosts at West Kirby,Dee Estuary. unpublished report. http://www.deeestuary/co.uk./decgks.htm

Southerland et al (2012) . horizon scanning assessment of current and potential future threats to migratory shorebirds. Ibis (2012), 154, 663–679
Stillman, R. A., Cox, J., Liley, D., Ravenscroft, N., Sharp, J. & Wells, M. (2009) Solent disturbance and mitigation project: Phase I report. Report to the Solent Forum

Stillman, R. A., West, A. D., Clarke, R. T. & Liley, D. (2012) Solent Disturbance and Mitigation Project Phase II: Predicting the impact of human disturbance on overwintering birds in the Solent. Report to the Solent Forum.

Stillman, West, Durell, Caldow, McGrorty, Yates, Garbutt, Yates, Rispin, Frost (2005). Estuary Special Protection Areas - Establishing Baseline Targets for Shorebirds. Centre for Ecology and Hydrology

Underhill-Day, J. C. 2006. A condition assessment of Poole Harbour European Marine Site. Unpublished report, Footprint Ecology/Natural England. Dorset. England.

Vistad, O. I. (2013): Brettsegling, kiting og surfing på Lista. Særpreg og utfordringar. Norwegian institute for nature research

Weston A, M. A., McLeod E. M., D. Blumstein T. and Guay P.-J. (2012) A review of flight-initiation distances and their application

WestonA, M. A., McLeod E. M., D. Blumstein T. and Guay P.-J. (2012) A review of flight-initiation distances and their application to managing disturbance to Australian birds. *Emu*, 2012, **112**, 269–286.

Natural England (2012) A simple method for assessing the risk of disturbance to birds at coastal sites. Unpublished report by Natural England in partnership with Suffolk Coast and Heaths and Wildside Ecology

Fenn, H. (2016). Identifying Methods for Managing Recreational Disturbance of Wildlife at Coastal Sites. Review of Literature. The Wash & North Norfolk Coast European Marine Site