A “three dimensional” Review of the Impacts of Hovercraft and Paramotor on Waterbirds

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Abstract

Recreational hovercraft and paramotor activities have been identified as disturbing to waterbirds in the Solent European Marine Site. It was assumed that hovercraft and paramotor disturbance may have a long term negative effect on waterbirds. This paper investigated direct and indirect effects of hovercrafts and paramotors on waterbirds from three different perspectives; existing literature [1] national and international review of bird disturbance on Ramsar sites [2] (intended for managers, governmental and non-governmental agencies and individuals involved with the management of Ramsar sites) and finally through monitoring the effects of a hovercraft survey [3] in Langstone and Chichester Harbours. The recreational activities' main impact is (behavioural) disturbance, however there is hardly any direct research on hovercraft and/ or paramotor disturbance on waterbirds, which makes the effectiveness of the existing management techniques uncertain. The questionnaire gauged current perceptions of the extent of the recreational activities. Paramotors were flagged as the main source of disturbance and the most difficult to manage. Recreational hovercraft activity is relatively rare on the coasts of the UK and not present in the rest of Europe. In the UK paramotoring and hovercrafting is primarily popular on the south and south east coast. Current management techniques do not include particular sections on hovercraft and paramotor management, but ready to accommodate them if needed. Byelaws and designated areas for hovercraft use exist on few sites to protect waterbirds from disturbance, while on others where there are no regulations and these activities are present and considered highly disturbing. During the Environment Agency's annual hovercraft survey (23-24.03.2014) in Langstone and Chichester Harbours, experienced wildlife surveyors had to opportunity to monitor waterbirds' response to the presence and controlled activity of the survey hovercraft. Birds have reacted with panicky flights and flushing distances ranged between 75-500m (average: 200m) from the craft. Overall it was concluded that hovercrafts and paramotors have the potential to adversely affect waterbirds/ Current legislation (particularly Article 12 (33) of The Habitats Directive) may be of some help for wetland managers provided the importance of waterbirds is thought along with regional specifications of protected sites during the paramotor and hovercraft training courses, this way deliberate disturbance of waterbirds may be reduced and possibly eliminated.

Keywords: hovercraft, paramotor, paragliding, disturbance, Ramsar wetland, recreational disturbance, Langstone Harbour, Chichester Harbour.

Abbreviations and terms used:

CHC- Chichester Harbour Conservancy

EA – Environment Agency

EMS – European Marine Sites

Hovercraft – Air cushion vehicle, capable of going over land and water

LHB- Langstone Harbour Board

LNR – Local Nature Reserve

MPA- Marine Protected Area

NE – Natural England

NNR – Natural Nature Reserve

Paraglider – Light, free-flying, foot launched glider aircraft with no rigid structure

Paramotor – Powered paraglider

PWC – Personal watercraft

SEMS – Solent European Marina sites

SPA – Special Protection Area,

SSSI – Site of Special Scientific Interest

1. INTRIDUCTION

1.1 Background

Ramsar sites are designated to support nationally and internationally important waterbirds. Through legislation and different directives impacts on these birds are prevented; including coastal development, tourism and so on. However, there is a possible issue between recreational hovercraft and paramotor activity and birds.

Recreational hovercraft and paramotor activities have been recently flagged as high risk activities in the Solent and are being used more frequently than in previous years (SEMS, 2012). Coastal development is reaching new heights and consequently the demand for recreational, residential and industrial areas are increasing exposing waterbirds to higher levels of disturbance. Hovercrafts are used for commercial, leisure, military and rescue activities as well, while paramotors are used for recreational activities mainly.

With watercrafts becoming more readily available for recreational use (i.e. online guides to “build your own”) there is a risk that they may negatively impact waterbirds and thus the productivity of designated sites. Hovercrafts and paramotors are seen as threat to waterbirds with long term negative effects on their numbers and potentially their genetics. Managers have indicated that there is little information and evidence available to support this hypothesis.

This research is therefore set out to test the above hypothesis through a literature review, a wetland survey and the collection of empirical data with the aim to increase the evidence base for or against hovercraft and paramotor presence at designated wetlands.

1.2 Scope

This report has been commissioned by the University of Southampton, the Solent Forum and Natural England. It is aimed to serve as a management tool for current wetland managers to reduce the impacts of recreational hovercraft and paramotors on waterbirds and their habitat. This report also aims to provide with the current national and international perspective of hovercraft and paramotor use in and around nature designated sites. These aims will be delivered through the following objectives;

1.3 Objectives

1) review existing literature on the impacts of hovercrafts and paramotors on waterbirds and their habitat;

2) gauge the current level of disturbance to waterbirds from hovercrafts and paramotors understood by coastal managers, management agencies, private groups and individuals in the UK, Belgium, Denmark, Germany, Netherlands and Sweden;

3) quantify the response of birds to an EA hovercraft survey from empirical data;

4) recommend future management options

1.4 Reasons for research

There are currently no particular management plans for hovercrafts or paramotors. With the current increase in recreational activities and thus increased exposure of waterbirds to disturbance it is deemed necessary to make further investigation in the subject area. Even more so as only few papers are concerned with the issue and only a couple have been published. This is a project that should set the foundation for future management techniques of hovercrafts and paramotors in the UK may their popularity increase.

2. METHODOLOGY

2.1 Study sites and species

2.1.1 Literature review

Literature found online and in the university library were reviewed. Peer reviewed journals were primarily investigated regardless of origin to maintain an unbiased approach to research

2.1.2 Wetlands' questionnaire

During the summer of 2014 a questionnaire was sent out to gauge the current national level of hovercraft and paramotor disturbance on Ramsar sites in the UK. To gain an international perspective of the issue, countries found on between latitude 50°N- 62°N and longitudes of 0°E -15°E were also surveyed. This included Belgium, Denmark, the north of Germany, Netherlands and the south of Sweden.

Questionnaire to investigate perceived disturbance from hovercraft and paramotors was sent to people from local ornithological groups, government agencies and non-governmental agencies. The aim of the questionnaire was to gain an understanding of the scale of current paramotor and hovercraft disturbance statuses of Ramsar sites in the UK and abroad.

2.1.3 Empirical study

Response of waterbirds to a hovercraft survey were studied within Langstone and Chichester Harbours in the UK. Where the following species were present; Black Headed Gulls, Brent Goose, Cormorant, Curlew, Dunlin, Godwit, Herring Gulls, Mute Swan, Oystercatcher, Red Breasted Merganser, Redshank, Shelduck, Teal and Wigeon. The above species were in smaller or larger groups foraging or roosting on the mudflats of the designated research area.

2.2 Approaches to data collection

2.2.1 Literature review

Scientific papers on the impacts of paramotors and hovercrafts were searched via the key words: disturbance, paramotor, hovercraft, personal watercraft, recreation and waterbird. It was found that there is a large amount of research, mainly in the USA and the Netherlands on human disturbance to waterbirds. There are relatively few papers dealing directly with hovercrafts and paramotors disturbance to waterbirds, while there is more literature in the impacts by personal watercrafts in general that does apply in some cases.

In the UK there have been some studies related to hovercrafts (related to scouring effects and the retardation of aquatic plant growth) and some earlier studies in Switzerland on the impacts of paramotors on waterbirds (focusing on their resemblance to large predatory birds; Davenport, 2004).

2.2.2 Wetlands' questionnaire

Correspondences were found via google search of the site's name and the potential managing organisation. For example: Tiree_Nature_Reserve_Ranger

The questionnaire (see in Appendix I) contained 6 short questions to gather information on:

- Are waterbirds subject to disturbance by paramotors and/ or hovercraft on site
- Are paramotors and hovercrafts managed in the area
- Current management plans for hovercrafts and paramotors
- How long have disturbance by the recreational activities been present
- Expected future changes in the recreational activities
- Is there any evidence of the recreational activities having a negative effect on waterbird

2.2.3 Empirical study

- Monitoring hovercraft survey effects on waterbirds -

Chichester and Langstone Harbours are both designated MPAs SSSIs and Ramsar sites. They have been subject to some paramotor disturbance in the past (2011-2012 respectively), which was reduced to none in the past 2 years. Recreational hovercrafts currently require a permit to use the harbour by byelaws, and so far have not been granted one based on environmental grounds. Recently, there have been an increasing number of permission requests from individuals and clubs to operate within the harbours and the Solent (MacCallum, 2014). At the moment there is a lack of direct evidence that suggest that hovercraft effect waterbirds negatively, ort how sensitive waterbirds are to their presence.

Given the opportunity of the EA bethnic invertebrate survey on the 23rd and 24th of March 2014, Langstone Harbour Board (LHB) and Chichester Harbour Conservancy (CHC) have conducted a study to monitor the effect of the EA hovercraft survey on waterbirds in Langstone and Chichester Harbour.

Its methodology was similar to that of the Solent Disturbance and Mitigation Project fieldwork. Observers[1] included experienced wildlife surveyors of great local knowledge, they were divided into groups of two or three equipped with:

- binoculars
- telescopes
- maps of the area, and the planned survey rout
- stop watches
- recording forms

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The two observation points were chosen (2/ day/ harbour) based on the sample point maps and proposed hovercraft routes provided by the EA. Waterbirds were counted within a 500m radius of the observation point on the mudflat, marked and noted on the observation sheet. Activities with the potential to cause disturbance asides the hovercraft, were also noted.

Once the hovercraft arrived inside or near the vicinity of the observation points' wildlife response to different operational actions of the hovercraft were noted. The previous also included estimation of flushing distances for species and for mixed species and the distance of displacement against particular hovercraft actions.

<u>Actions included</u>: First sight of craft; Transit over water; Transit over intertidal; Stopped with engine off; Engine restart; Final sight of craft.

20 minutes after the final sighting of the hovercraft waterbirds were counted again within the vicinity of the sample area to monitor the effects of the hovercraft survey along with the time taken for birds to return to their normal activities.

Furthermore, a handheld Garmin eTrex GPS was carried aboard the hovercraft to record accurate location and speed data of the craft.

2.3 Defining human disturbance

Previous report on hovercrafts and jetskis (Collins, 2000) have considered three types of impacts of watercrafts on waterbirds.

2.3.1 Presence

The presence of activity and/ or humans have the potential to cause disturbance to waterbirds. Disturbance is difficult to define, Collins (2000) has used a modified definitions of disturbance which will be brought forward to in this paper: *Any relatively discrete event in time that has the potential to cause a response in animals. The response can be behavioural, physiological, or can influence numbers or survival.*

Potential sources of stimuli to disturbance include: speed, sounds, size, visual intrusion and characteristics of craft movement (on water, land or in air) (UK Marine SACs Projects, 2001).

2.3.2 Habitat Alteration or destruction

Watercrafts may compromise waterbird habitats by altering wave patterns (indirect) or intentional human induced processes (tourist development construction – direct) (Collins, 2000). Small aircrafts like paramotors, thus far have no receivable habitat alteration potentials.

2.3.3 Direct harm

Direct harm includes physical contact between water- and aircrafts and waterbirds. For example, eggs laid among grass taller than 10 cm is said to be safe from trampling from hovercrafts (Cruising Hovercraft Club UK, 2014), while eggs laid on shingle may not be.

2.4 Methods of Analysis

2.4.1 Wetland's questionnaire

Questions aimed to gain as much information as possible with no restrictions on the answering style (i.e. some answered with yes or no, while others gave a detailed accounts) therefore they were analysed on a one by one basis.

2.4.2 Empirical study

Minimum, maximum and average approach distances were identified between single species and mixed species groups and then compared.

3. LITERATURE REVIEW

3.1 Migration

Langstone and Chichester harbour is home to many internationally important waterbird that migrate between the UK and Siberia or the north of Iceland. The harbours allow birds to overwinter, recharge their fat reserves and prepare for breeding season in Siberia or the north of Iceland. Birds are always present in the harbour, may they be the over wintering species (around September- March) or the species returning to breed during the summer months (around March- September). Other birds spend some time here in spring and again at late summer and autumn and to rest between their breeding and wintering places (Langstone harbour board, 2014; Chichester harbour conservancy, 2014). Birds use these habitats to prepare for migration, build up energy/fat reserves through insufficient feeding. Therefore, one of the most sever threats to migratory birds is starvation. Human disturbance and habitat degradation continues to be the leading cause of improper fat reserve development and thus causes numerous bird deaths every year (U.S. Fish and Wildlife Service, 2002).

Human disturbance was found to limit the capacity of an area to support migrating shorebirds, long term data showed that human disturbance has a negative impact on shorebird movement patterns because of displacement of shorebirds from preferred areas because it encourages abandonment of the study area (Pfister, 1992).

3.2 Disturbance to breeding activities

(After Korschgen, 1992) in alphabetical order

- Breeding chronology interrupted
- Brood breakup
- Brood rearing disrupted e.g. Desertion of breeding areas by all or part of a breeding populatio
- Deterrence from settling to breed
- Increased destruction or predation of eggs
- Increased mortality of young chicks from predation, exposure, trampling or disorientation
- Nesting disturbed – egg loss and hatching failure
- Nesting success reduced
- Reduced number of young birds fledging, lower juvenile survival, reduction in recruitment rate
- Reduction in nest densities

Breeding birds are generally drawn to sheltered areas to be protected from the elements, potential predators and disturbance. Preferred places include; large areas with greater isolation and greater plant cover preferred by birds. Habitat alteration along with increased predation and disturbance in coastal habitats resulted in scarcer suitable breeding habitats in the Drana lagoon, Greece (Gouthner, 1997). Breeding birds have committed to spending a long period of time (up to 7 months) at their breeding grounds to rear their young, therefore are less likely to move away from the area as it would mean abandoning the nest.

There have been numerous studies concerning human disturbance of nesting birds (Watson, 2014 Blackmer, 2004). With an increase in the popularity of recreational activities there was further need to investigate the effects boating, air crafting, water based recreation and walk-in disturbances all of which have a negative effect on the whole of the breeding process and survival rate (Stillman, 2009). Species nesting colonially are thought to be particularly sensitive to disturbance due to the density of their nests and because if one specimen gets disturbed enough the rest will follow (Collins, 2000).

3.3 Disturbance during courtship and nest building

Previous studies have recognised that nesting site choice is strongly influenced by disturbance, in many cases, referred nest sites were abandoned for less favourable nesting sites when human disturbance was present or became too intense (Hockin, 1992). Often human disturbance involves increasing development, modification of existing beaches and thus habitat loss all of which plays a role in choosing nesting sites and all of these disturbances are currently present in the Solent (These issues are summarised in Table 1).

Table 1 The effects of human-induced disturbance on choice of nest sites, after Collins 2000 and Hockin 1992 for full references see Appendix III.

Source	**Species**	**Scientific name**	**Stimulus**	**Results**
Storey 1987	Common Tern	*Sterna hirundo*	Human presence	Displacement, less optimal sites chosen for nesting
Haworth 1990	Charadiiformes		Human presence	Avoidance of areas prone to disturbance
Burger 1979	Herring gull	*Larus argentatus*	Human presence	Used soil deposition sites and alternative to developed barrier beaches
Van der Zande 1985	Common kestrel	*Falco tinnunculus*	Human presence	Avoidance of areas close to human activities
Fraser 1985	Bald Eagle	*Haliaeetus leucocephalus*	Human pressencce	Nests on developed shorelines are further away from water
Yalden 1992	Common Sandpiper	*Actitis hypoleucos*	Angling	Avoidance of establishing territories in heavily disturbed areas

3.4 Disturbance during incubation and chick rearing

The most common effect of disturbance during chick rearing is nest abandonment and thus the reduction of hatching success. Predation and trampling of the eggs become more prominent along with increased thermal stress (Borgmann, 2010; Hockin, 1992; Lord, 1997) during frequent nest abandonment (see table 2).

Borgmann (2010) found that birds that flush in response to disturbance might not return to their original site, while breeding birds tend to return to their nest site to attend to their young. It was also discovered that breeding birds are likely to return sooner to their original sites, however it may not be perceived as a positive trait as it will wear off those females that do, who will in turn can produce poorer quality offspring (Mikola, 1994).

Blackmer (2004) found, that more intense human disturbance (i.e. daily and weekly investigator disturbance and handling) is said to not only reduce hatching success by 50-56% but also have resulted in significant mate changes from season to season. This, in the long term may have some severe evolutionary impacts.

Paramotor flights are found to disturb all aspects of chick rearing, nest attendance and this have an overall negative effect on nestling adults (Beaud, 1995). Experimental paragliding flights in areas with no prior activity, have caused increased heart rates in incubating hens, which is similar to their reaction to predators, followed by fleeing the area (Ingold, 1993).

Documented boating and PWC impacts of flight behaviour of Common Tern (New Jersey, USA) have also shown disturbance and displacement of parents from their nests by jet-skis and motor boats. Birds showed greater disturbance by PWC than by motor boats, it is thought to be the effect of higher speed and noise generation as well as the unfamiliar paths chosen by the vehicles (Collins, 2000). This shows, that while a certain amount of adaptation is possible, recreational PWC users who seek the thrill of their vehicles and do not stick to designated pathways, will cause significant disturbance.

PWCs have been reportedly causing harm by colliding with chicks learning to fly around the water bodies. Brown (1981) has reported the loss of sea-ducks near Chicago (USA) when hens and accompanying broods were run over by water-skiers and PWCs.

Mikola (1994) reported that broods of disturbed (8.5 times a day by boats) velvet scooter were generally smaller than undisturbed broods with 60% mortality pf ducklings before the age of three weeks. Predator incidents have also increased 3.5 fold in disturbed than in undisturbed situations.

Table 2 Effect of human disturbance during incubation and chick rearing after Collins, 2000. For full references see Appendix III.

Source	**Species**	**Scientific name**	**Stimulus**	**Results**
Anderson 1980	Brown Pelican	*Pelecanus occidentalis*	Recreationists, educational groups,	Brood rearing disrputed, increased predation of eggs/ chicks
Blackmer, 2004	Leach's storm petrel	*Oceanodroma leucorhoa*	Investigator disturbance	Desertion of breeding area, reduction of hatching success, egg desertion
Robert 1975	Western Gulls	*Larus occidentalis*	Human presence	Nesting disturbance, reduction of nest densities
Watson 2014	European storm petrel	*Hydrobates pelagicus*	Tourism	Increased mortality of chicks
Burger 2003	Little tern	*Sternula albifrons*	PWC, boat activity	Reduction of nest densities
Glahder 2011	Eurasian oystercatcher	*Haematopus ostralegus*	Human presence	Reduction of nest densities
Burger 1998	Common Tern	*Sterna hirundo*	PWC (jetsiks)	Increased absence from nests, physical destruction of nests by craft
Kury 1975	Double crested Cormorant	*Phalacrocorax auritus*	Boating, sailing	Increased predation of eggs
Batten 1977	Great Crested Grebe	*Podiceps cristatus*	sailing	Increased nest failure

3.5 Disturbance outside breeding season

Motorised boats and air traffic is considered the main source of disturbance in California, causing 26-67% of Cormorant flushes in California (Acosta, 2008, Acosta, 2007). Egrets have been known to abandon territories (intertidal creeks) after experimental disturbance was present (Peters, 2006).

Hang gliding and para-gliding has also resulted in the abandonment of specific areas by birds and other animals to avoid exposure to noise in the Bavarian Alps (Georgii, 1994).

Table 3 contains more noted effects of human disturbance outside breeding season.

Table 3 Effect of human disturbance on waterbirds outside breeding season, after Collins, 2000 and Hockin 1992.For full references see Appendix III.

Source	**Species**	**Scientific name**	**Stimulus**	**Results**
Owens 1977	Brent Goose	*Branta bernicla*	Aircraft, agriculture	Reduction in time spent feeding, increase in time spent in flight
Hume 1976	Smew	*Mergellus albellus*	PWC	PWC disturbed birds 200m away
Korschgen 1985	Ducks	-	Boating	Ducks abandon area
Galhoff 1984	Common Pochard	*Aythya farina*	Boating Surfing	Changed day time roosts in response to activities
Lok 1988	Great Cormorant	*Phalacrocorax Carbo*	Water based activities	Avoidance of lakes with activities

3.6 Disturbance to roosting

Roosting plays a major role in preserving waterbirds energy and accounts for around 50% of the birds' daily time budget (Collins, 2000). Flocks of roosting birds can contain either one species or a mixture of species and usually forms around high tide when most if not all the feeding areas are covered with sea water. Once again preferred roosting sites and time of roosting will vary between species, but one of the major criteria is minimum disturbance on the site (Goutner, 1997).

Loss of roost sites have been reported to be a major factor in declines in population numbers in Britain, the Netherlands and the United States (Collins, 2000). The Dee Estuary (Mitchell, 1988) and Hartlepool (Burton, 1996) have both reported a decline in local bird population numbers and a decline in in the number of birds using traditional roost sites due to the sites becoming overly disturbed and thus unfavourable for the local bird species after an increase in boating within the area.

There have been also numerous reports of displaced flocks (Tundra Swans, Brent Geese) of waterbirds and abandonment of roosting areas after an increase I boating near or at the roost sites (Berry, 1988; Einarsen, 1965). Tundra Swans were exposed to boating once or twice prior to displacement and in case of the Brent Geese, continual disturbance by heavy boat traffic and loss of favourable roosting sites has led to fatalities amongst the flock.

Hovercraft operate commercially both in Australia, near Roebuck Bay and in the UK between the Portsmouth and the Isle of Wight. These commercial hovercrafts are much larger (able to host 101 passengers plus 3-4 crew) compared to the recreational ones (1-4 passengers approx. plus 1 crew). They travel on mapped out routs at regular intervals near roosting and feeding sites. Observations in the past suggested they are able to pass within c.300m of a roost without causing an upflight in Australia (Collins, 1995) and c50m in the UK (Taha, 2013). Species involved were not specified in the observations.

3.7 Disturbance to feeding

Disturbance during feeding causes losses in time spent on foraging and eating. As established in section 2.2, feeding and the amount of food consumed can have a huge impact on survival especially on that of migrating waterbirds. Studies have reported disturbance as both an energetically expensive process as an agent that reduces time spent on foraging (Wood, 2007; Goss-Custard, 2006; Borgmann, 2010). It was also found that migrants are less tolerant to disturbance than resident birds (Klein, 1995). This suggest, that disturbance during winter; when these birds require a rapid increase in fat reserves (Rehfisch, 1996); has more severe consequences than during the summer period.

So far, only one species have been monitored and declared be able to compensate for loss of feeding time by human disturbance. Intake rates of disturbed and undisturbed oystercatchers showed little variation amongst them after a multiple regression analysis (Urfi, 1996). The disturbed birds have extended their feeding time after disturbance and remained longer on the muscle bed to compensate for the loss of time, this suggest that these birds may be able to habituate to the frequent presence of people and reduce the distance at which they may take flight and overall reduce the tome lost to disturbance (Urfi, 1996). As this is reassuring, many questions remain; how long are they able to compensate for, what otherwise this time be spent on, will they be able to fully compensate for stronger and more intense stimuli?

Other studies suggest birds are unable or not as effective in compensating for noise (of machinery) disturbance during feeding, which has negatively impacted breeding success (Borgmann, 2010; Madsen, 1994; Berger, 1977). A 30 min increase in flush flights for a lean Great Knot means a 13.3% increase in energy expenditure (Rogers, 2006) and for a Snow Goose and the same amount of disturbance increases energy expenditure for a Snow Goose by 2.7 kj/hr, with a 4-51% decrease in foraging (Belanger, 1990) compensation for this may be questionable.

By sailboats Batten (1977) observed "Minimum Approach Distances" (the distance to which feeding flocks could be approached before showing signs of disturbance (Collins, 2000)) of 100-475m of seven different species of ducks by sailboats. He also concluded that larger flocks were more sensitive than smaller ones.

3.8 Changes to feeding areas.

Summary of indirect hovercraft disturbance. As Paramotors are airborne, they have very limited indirect disturbance (see section 2.8.4)

3.8.1 Erosion and deposition

There is a risk of damage to the terrain (mudflats or the shore) due to hovercraft movement, skirt pressure or lift air escape. Which can involve the displacement of surface material or compaction (Cruising Hovercraft Club UK, 2014).Watercraft is also thought to increase the natural rate of erosion and deposition in feeding areas and thus may influence the type of vegetation in the area and consequently the bethnic invertebrate population in the area (Collins, 2000).

Hovercrafts have the potential to cause wash and wave action caused by craft can make conditions unsuitable for shoreline foraging or wading (Collins, 2000).

3.8.2 Turbidity

Turbidity created by PWC in shallow seas can reduce the effectiveness of adult terns hunting for food, which can lead to starvation of dependent nestlings (Collins, 2000)

3.8.3 Change to profiles and invertebrate communities

Changes to sediment distribution can change mud and seagrass flats elevation above water level. Reduced elevation can result in areas remaining submerged at low tide, which can also deplete the size of foraging areas (Collins, 2000), furthermore, it can be detrimental to certain types of seagrass and enhance the negative effects of sea level rise.

At the Ramsgate Hoverport (UK) McGrorty (1976) compared the intertidal invertebrate densities in areas within hovercraft and outside hovercraft flightpath, there was no evidence to suggest that hovercraft has reduced the invertebrate densities, however the density of invertebrates between sites was very low and results were made inconclusive.

3.8.4 Other

Light hovercrafts have a hover-clearance of 2-3cm off ground followed by a 15-25cm tall soft-skirt, which prevents hovercrafts to operate on vegetation taller than 10cm (Cruising Hovercraft Club UK, 2014). Abrasion of smaller plants however is still possible, which carries the risk of plant disease transmission around a coastal area. Past studies show that damage is limited to detached vegetation with weak root systems (Abele, 1977).

Hovercrafts and paramotors possess a risk of ground or sea pollution by leakage of fuel and oil. Paramotors possess a higher risk of leakage into sea as their engine is not enclosed, while hovercraft engine is enclosed within the hull.

Paramotors may resemble predatory birds as they use warm rising air currents much the same way as birds (Davenport, 2004.)

3.9 Disturbance during moult

Barshep (2013) defined moulting as a major component of the annual cycle of birds, the timing and extent of which can affect body condition, survival and future reproductive success through carry-over effects. All species of bird changes their plumage depending on maturity and breeding status. It is an energetically expensive process that is spread out over several months (6-7 weeks) (Collins, 2000). In the northern hemisphere moulting takes place around May-October depending on the bird species, which in some areas overlaps with the 'boating-season' in the Wadden sea where numerous leisure craft is found near or in sensitive areas for birds and in some cases seals also (Thiel, 1992). During the moulting season birds become flightless and are at higher risk of collision with PWCs and may possible have poorer tolerance to disturbance, depending on the species, sensitivity to human disturbance can cause a significant increase in heart rate and increased stress and stress hormone levels (Ellenberg, 2006).

In the US, there is recorded evidence of the abandonment of an area favoured by two species of duck undergoing moult which has led to overcrowding at other moulting sites and further problems of greater competition for feeding areas, increased risk of disease spread and contamination and increased predation (Bergman, 1973).

Weight loss is a natural phenomenon during moulting, which disturbance may increase if significant; thus the chance of successful completion of moult and migration is doubtful (Miller, 1994). Helicopter disturbance on moulting Pacific black brent geese were considered significant and have caused increased weight loss.

Recreational crafts (Windsurfers, kitesurfers, PWCs and sailboats) are thought to mainly cause abandonment of certain sites due to their unpredictable movements that is considered more disturbing to birds (Smith, 1991).

4. RESULTS

4.1 Response for the wetlands' questionnaire

There are currently 147 designated Ramsar sites in the UK (excluding overseas crown dependencies- 23 sites) (The Ramsar Convention on Wetlands, 2013). Some sites are managed by the same personnel or belong to the same management area.

Fifty four questionnaires were returned (51% of those sent out) that covered 104 wetlands (71% of the designated wetlands in the UK). 99% of the questionnaires were answered from governmental agencies and other environmental agencies while 1% of the questionnaires were answered by individuals with a special interest in the area. Some wetlands were covered by more than one person, more often one person was responsible for several wetlands or counties.

The geographical distribution of Ramsar sites and the number of wetlands covered in this paper are outlined in table 4.

Table 4 Number of Ramsar sites in the UK and the number of Ramsar sites covered in this paper

Country	Number of Ramsar Sites	Number of Ramsar sites covered in this paper
England	68	43
England/Scotland	1	1
England/Wales	3	2
Northern Ireland	18	18
Scotland	50	40
Wales	7	0
United Kingdom	147	104

The list of sites covered in this paper are found in Appendix II.

4.2 Utilisation of wetlands

Waterbirds use the wetlands covered by this survey for all aspects of their lives; breeding, moulting, feeding roosting and staging. Some wetlands or areas within wetlands are used as specific bird sanctuaries and thus are protected from most human disturbance.

Other wetlands are used for both human recreation; such as: walking, dog walking, cycling, horseback riding, boating, bird watching, angling and so on.

4.3 Current level of disturbance by hovercrafts and paramotors

Hovercraft and paramotors are present in 26 of the sites surveyed (25% overall) and are considered disturbing on 21 sites and are present but not an issue on 6 sites (see table 5).

Table 5 List of designated Ramsar sites in the UK with some level of paramotor and hovercraft activity that is not considered disturbing

Site Name	HC	PM	Notes
Firth of Tay & Eden Estuaries	+		HC can be used near Tentsmuir, but are not a problem on important sites, as they are not approaching them.
Lindisfarne Newham NNR	+	+	Recreational activities are not allowed near site, spatial and temporal limitation of HC and PM use.
North West Norfolk Reserves		+	PM have been present at site for the past 5-8 years with a spike in activity 3 years ago. There is no evidence of long term negative effects, but there already a lot of disturbance on site.
Poole harbour / Studland	+		There is hovercraft training near, but is restricted to reduce disturbance to Studland bay marine life.
Tiree		+	There have been 2 paramotorists spotted in the past 3 years. 1 Paramotorist has negotiated to be able to fly above the site.

HC= hovercraft, PM= paramotor, + = present

12 sites in the UK have experience disturbance by hovercrafts, paramotors or both (see table 6).

Table 6 List of Ramsar sites in the UK where there is paramotor and/ or hovercraft activity which is considered disturbing

Site name	HC	PM	Length	Notes
Devon Cornwall Isles of Scilly Penhale Dunes	+	+		HC and PM presence perceived as negative, *sites include: Braunton burrows, Dawlish Warren, Sidmouth to West Bay and Exe Estuary
Dee Estuary North Wirral Mersey Narrows	+	+	PM - 10 years	Paramotor activity has reduced in the past year, Micro-light activity is more disturbing, however easier to manage due to the registration number on the wing
Essex Coast		+		Paramotors have been observed disturbing birds during the summer months.
Langstone Harbour		+	5 years	Byelaws do not permit HC in the area. PM have purposely disturbed birds in 2012, haven't since.
Minismere North Warren Dingle Marshes		+		There have been recent paramotor disturbances, which I currently being pursued. Frequent flushes have been reported
North Norfolk Coast	+	+	Many years	Observed disturbance to roosting and feeding birds
North Solent NNR		+	5 years	Photographs of PM flying very close to nesting sites
Rye Harbour LNR of Dungeness Pett level SPA		+	5 years	Observed flushes of birds
Plymouth	+		many years	HC training area, but spatially limited to protect marine life
Thanet coast, Sandwich bay	+		Past disturbance	Commercial HC activity in the past, landowners' approval to launch hovercraft has been revoked. HC uses inland sites
Stodmarsh and Pegwell bay	+		Past disturbance	Commercial HC port in the past, was economically not feasible and noisy to sustain.
The Wash	+	+		RNLI hovercraft training area, spatially restricted. Personal HC users are discouraged by monitoring slipways.

HC= hovercraft, PM= paramotor, + = present

4.4 Current methods to reduce disturbance to waterbirds

Human disturbance of any kind is recognised as a growing problem and reducing or eliminating unnecessary noise disturbance is an increased priority.

Currently 7% (n=104) of the site surveyed currently have restricted areas or byelaws to prevent hovercrafts going near sensitive areas and virtually none for paramotors. While many sites possess management plans none of them deal specifically with hovercrafts or paramotors.

It is common to have seasonal facilities (April- September) near important wintering birds and marine life (Thanet Coast, Tees Coast). Specific wildlife sensitivity is usually highlighted in leaflets and fliers provided by management agencies.

Managing or restricting access points for water craft is an effective way of managing disturbance in Berwickshire & North Norfolk Coast.

Humber Estuary code of conduct highlights the importance of activity zones for water craft and suggest a 500m buffer in altitude for aircrafts in general and 1000m for helicopters.

Generally, recreationist are suggested to pass wildlife in a calm respectful manner and are discouraged from triggering flight responses from birds.

5. Survey of wetlands in Europe for evidence of hovercraft and/ or paramotor disturbance

In many cases responses came from ministries and commissions and an overview of the county's situation was given. Response rates from each country varied between 0-40% not including automated mails for annual leave.

Table 7 The number of Ramsar sites found in Belgium, Denmark, Germany, Netherlands and Sweden and the number of sites covered in this paper from each country

Country	Number of Sites	Sites covered
Belgium	10	4
Denmark	29	0
Germany	35	14
Netherlands	44	14
Sweden	39	10

5.1 Current levels of disturbance by hovercrafts and paramotors and their regulation in Europe

Belgium

In Belgium observing from or flying over nature reserves with motorised vehicles is restricted. To overfly at low altitudes by means of planes, helicopters or to use them as target for skydiving for a military exercise is forbidden unless the Minister of Agriculture has authorised it.

Paramotors are not specifically regulated in areas covered by the European Birds Directive or by any other regulation and have been found causing disturbance to birds. It is open to the public to call initiatives.

Recently a paraglider was found to disrupt the Flora and Fauna Act on De Biesboch Natura 2000 site and had to litigate. While there are no restrictions of ship types, operating speeds of 6-9km/h would not be suitable to hovercrafts, similarly to the operating speed if 6 knot speed limit in the Hamble Point Marina.

Germany

Hovercrafts and paramotors are very rare and so far issues have not been raised. Kite surfing, however has been flagged as potentially harmful for the environment and is currently being addressed by the Nature and Biodiversity Conservation Union (NABU) headquarters.

Other areas such as Chiemsee have special regulation not permitting hovercrafts and paramotors within their vicinity.

Netherlands

So far the Forestry Commission of Netherland faced no issues related to hovercrafts or paramotors. There seems to be little or no recreational use of hovercrafts in the Netherlands.

Paramotors are also rare, and it is possible that laws and regulations (related to altitude) prevent them from causing disturbance in excess, however there have been some incidents with paramotors near the coast of Dollard.

Sweden

Sweden has not got a recognised problem with hovercrafts and paramotors, and their disturbances come from jet skis and kite surfers mainly. Hovercrafts mainly belong to the Swedish Sea Rescue society and are used for missions and training when the risk of disturbance to breeding birds is small (1^{st} April-31^{st} July) with restriction zones of 100m around sensitive areas.

In general the use of hovercraft in Sweden is regulated and a permit is necessary, the legislation also states that the driver is responsible to adjust speed in order to not disturb birds or people and avoid damage to the vegetation. The need for a permit is restricting the use of hovercrafts in Sweden.

6. Results from the hovercraft disturbance study in Langstone and Chichester harbours

The birds monitored in the study were roosting or feeding. Generally waterbirds were in large mixed groups (table 9), but when subject to stimuli some species sensitivity (table 8) was shown.

Table 8 Shows single species responses to the EA hovercraft survey which stood out from the larger groups of mixed waders

Species	number	Flushing distance(m)	Displacement distance (m)	Notes
Curlew	-	150	-	Present both inside and outside of count radius
Curlew	-	200		
Curlew	40	250	-	
Black headed Gulls	10	50-100	Short flight	
Black headed Gulls	50	200	-	
Black headed Gulls (juvenile)	3	200	Short flight	
Cormorant	3	100	Long flight	
Herring Gulls	5	400	-	Birds flushed after the hovercraft engine was off and crew started moving
Shelduck	6	500	-	
Wigeon	10	500	-	
Mute Swan	6	-	-	
Oystercatcher	10	100-200	400-500	
Oystercatcher	10	-	-	Craft passed within 150m
Brent Goose	50	75	400-500	
Godwit	40	400	-	

Table 9 Shows groups of mixed waterbirds response to hovercraft survey

Species	number	Flushing distance (m)	Displacement distance (m)	Notes
Red Breasted Merganser	100	200-300	400-500	Red Breasted Merganser seemed particularly sensitive to craft presence
Brent Goose				
Oystercatcher				
Brent Goose	20	100-200	400-500	Bird returned to site and began feeding 5 minutes after craft departure
Oystercatcher				
Curlew				
Shelduck				
Teal	20	100-200	400-500	
Oystercatcher				
Curlew				
Brent Goose	300	100-200	400-500	
Oystercatcher				
Curlew				
Redshank				
Curlew	80	100-200	400-500	Birds flew in panicky flight, but returned soon (60s) after craft departure
Dunlin				
Brent Goose				
Curlew	80	100-200	400-500	
Brent Goose				
Curlew	110	200-300	400-500	
Dunlin				
Curlew	110	100-200	400-500	
Oystercatcher				
Brent Goose				
Mixed waders[1]	40	250	-	
Mixed waders[2]	20	200	-	
Mixed waders[3]	20	200	-	

Statistics based on table 8 and 9 are shown in table 10.

Table 10 Conclusions from table 8 and 9

Tables	Flushing distance (m)			Displacement distance (m)		
	Min	Max	Average	Min	Max	Average
Table 8	50	500	228	Short flight	500	-
Table 9	100	300	182	400	500	450

6.1 Implications from the hovercraft survey

The above results suggest greater variability in single species response; flushing and displacement distances than in mixed wader groups. It also shows that mixed waders are likely to have similar flushing and displacement distances regardless of species composition and group size. However, disturbance by the hovercraft survey seemed to impact mixed waders more, than single species, as on average their displacement distance was further and were deterred for longer amounts of time. This is in accordance with Batten (1977) observation of: large flocks are more sensitive than smaller groups of birds.

However overall the average flushing distance of mixed and single species groups is close to 200m (Other observed buffer distances are listed in Appendix IV). The study also showed that on average there was no birds present within 200m of the craft regardless weather its engine was on or off (MacCallum, 2014).

This data holds true for sites with no previous hovercraft activity, or very minimal (1-2/ year) when the hovercraft is driven in a controlled manner with no sudden changes in speed or direction.

7. Discussion

This study has employed three techniques to examine the effects of hovercrafts (literature review, a questionnaire and an empirical study) and two techniques to examine the effects of paramotors (literature review and a questionnaire).

7.1 Literature review

The thorough literature review showed that while there exist a vast amount of research on disturbance to birds by humans in general, there is very little recorded information on disturbance to birds by hovercrafts or paramotors. There are only two current papers available; an Impact review of hovercraft on waterbirds and their habitat and a Hovercraft Survey Report; that presents the sensitivity and potential habituation of birds to hovercraft. Existing papers suggest, loud noise, high speed and sudden turns, characteristics of recreational hovercraft are highly disturbing to and may have long term negative effects on birds (Georgii, 1994; Burger, 1998).

There are even less papers available on the effects of paramotors, whose negative characteristics include high noise levels and resemblance to large predatory birds.

Primary sales of personal watercraft (PWC); including hovercrafts; in the United States have steadily increased from 1987 to 1995, with a slight decrease after 1995 (Burger, 2000). There are currently around 20 British Hang Gliding & Paragliding Association registered paramotor schools in the UK and 10 or so hovercraft branches. While most of the paramotor clubs are located in land, regional hovercrafts branches are usually closer to the coast, which means further increase in their numbers are likely to impact waterbirds.

Burger (1998) in the USA found that PWCs were more common in the middle of the day and towards the evening. By nature of the activities and their exposure to the elements it can be assumed, that they would be more frequent on: sunny, calm and warm days and less frequent on: cold, damp, dark days. Paramotoring is also considered a seasonal leisure (Davenport, 2004). Seasonality of the activities may make it easier to protect overwintering waterbirds from disturbance, and help make room to hovercrafts and paramotors on some areas. On the other hand, attention must be drawn to the sensitivity of the environment and users have to be encouraged to care more about wildlife. A study in 2007 showed that less than 15% of watercraft users stated that the natural environment was of a “great concern” to them (Whitfield, 2007).

Current trends in waterbird population showed that there have been a big drop in numbers in eight of the main wading bird species over 10 years in the UK (Davies, 2014). WEBS data showed that ringed plovers, oystercatchers, redshank and dunlin; the most popular species in the UK; have been undergoing a significant and consistent population drop over the past 10 years. Several factors are responsible for the drop (climate change, coastal squeeze etc.), but the exact reasons are not yet understood. Certainly, recreational activities can contribute also.

One of the main issues with disturbance is the uncertainty in defining it. This has led to some significant misunderstanding in the past. One example is used in the draft of current recreational hovercraft environmental impact assessment (Cruising Hovercraft Club UK, 2014) that only considers disturbance at the level of local populations, and thus defines disturbance as the abandonment of good feeding grounds for poor feeding grounds by a local population. While the above is not incorrect, it has missed out on key concepts regarding individual waterbird preparation for migration and nesting.

There exist a bias towards direct disturbance over indirect disturbance to species. Perhaps, because it is easier to detect and quantify as it effects the physical integrity of a species. Nevertheless indirect disturbance can still be severe as it effects the species over time and impact their survival rate. The Habitats Directive 92/ 43/ EEC has recognised that asides direct and indirect disturbance species sensitivities or reactions to the same disturbance may differ and a species-by-species approach is needed to define the meaning of “disturbance” (European Commission, 2007).

7.2 Wetlands’ Questionnaire

In the UK there is a good network of wetland managers, who have excellent knowledge of their area and understanding of problems waterbirds face. They are approachable and keen to help. Conducting the survey highlighted that there was a lack of networking between sites with similar issues with hovercrafts and paramotors thus sharing information on hovercraft and paramotor management is lacking.

On the continent, site manager correspondences are not readily available online, thus most replies were received from higher organisations (i.e. ministries, commissions). This showed that disturbance levels have not raised a national alarm yet thus the crafts are considered rare or not present at all. Replies from site managers however suggested otherwise. Paramotors are relatively often seen are considered highly disturbing.

The survey suggest that managing hovercrafts is easier than it is to manage paramotors. With zonation and the management of access points hovercrafts may be successfully excluded from sensitive areas. Paramotors may be launched virtually anywhere and individuals cannot be identified, making them particularly difficult to manage.

7.3 Empirical data

Observing the EA survey was an excellent first step to manage hovercrafts. Waterbirds showed a range of responses and some conclusions may be drawn. This one-time observation, however has many variables thus it has produced several new hypothesises rather than firm conclusions.

Flushing distances of 500m may make numerous harbours unable to host hovercrafts during low tide when channels are often not wider than 100m and birds are feeding on the intertidal zones. Hosting hovercrafts during high tide may be an option provided a 500m buffer zone around important sites.

8. Recommendation for Future Management

Education is key, as Article 12, (33) states: “Deliberate” actions are to be understood as actions by a person who knows, in light of the relevant legislation that applies to the species involved, and the general information delivered to the public, that his actions will most likely lead to an offence against species, but intends this offence or, if not, consciously accepts the foreseeable results of his actions. This means that an offence is also committed when a person’s actions will over time lead to capturing or killing a specimen even if the person doesn’t intend to, but disregards known prohibitions. Negligence is not included.

Perhaps legislation brochures should be included in learning packages of paramotor and hovercrafts schools. They could contain local and national data and could be downloadable from online sources or paper copies can be given out at induction courses thus making users aware of the sensitivity of the nearby areas.

The key issue is the inability to successfully identify paramotorists. Registration and displacement of unique registration numbers could reduce the number of incidents and prevent future ones from happening. Registration fees in turn may be used to increase the number of site managers or rangers.

9. Conclusion

Waterbirds are currently subject to numerous disturbances, all of which have a negative impact upon them. The number of important overwintering species is undergoing a steady decline. Allowing birds to be exposed to more disturbance may accelerate their decline or cause complete abandonment of some areas.

This study suggest that reoccurring presence of hovercrafts and paramotors during sensitive periods will impact waterbirds negatively in the long term. The use of hovercrafts and paramotors are rare, however where they are present and not managed by temporal and spatial zonation they are considered highly disturbing.

Education and raising awareness can be a positive way to manage disturbance, however if disturbances become more frequent, intense changes in legislation might be required in order to protect the integrity of wetlands. Many respondents considered an increase in these activities in the future which, along with existing literature and empirical data makes hovercrafts and paramotors worthy of management.

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Appendix I. – Questionnaire

To whom it may concern,

I recently undertook the project focusing on the development of a hovercraft and paramotor management plan for Langstone and Chichester harbours in the Solent, with the collaboration of Natural England, The Solent Forum and The University of Southampton.

Just wondering if you would be able to spend some time answering the questions below for my master's thesis?

1) Are waterfowl on your JNCC, Ramsar and/or Natura2000 or other sites subject to hovercraft and/or paramotor disturbance? (Could you name the site please?)
2) If not, is that because hovercrafts and/or paramotors are not present or that they are managed?

The following questions are relevant to sites where disturbance is present:

3) Have you got a management plan in place to deal with hovercraft and/or waterfowl disturbance, if so could you briefly describe it?
4) Do you think this recreational activity can potentially increase in your area and perhaps will need to be managed in the future?
5) How long had you had issues with hovercrafts and/or paramotors?
6) Have you any evidence of paramotors and hovercrafts having a negative effect on waterfowl?

Do you consent to naming the wetland site to be ID-d in reporting of this research or would you prefer it to remain confidential (thus your identity is protected)?

Yes/ No

Thank you for your time and help!

All the best!

Aniko Gaal

Appendix II. – List of sites covered in this paper

1. Hamford water
2. Colne Estuary
3. Blackwater Estuary
4. Dengie
5. Dee Estuary
6. North Wirral
7. Mersey Narrows
8. Yorkshire
9. Leighton Moss
10. Morecambe Bay
11. North Norfolk Coast
12. Ballynahone Bog
13. Belfast Lough
14. Black Bog
15. Carlingford Lough
16. Cuilcagh Mountain
17. Derryleckagh
18. Dundrum Bay
19. Fairy Water Bogs
20. Fardrum and Roosky Turloughs
21. Garron Plateau
22. Garry Bog
23. Killough Bay
24. Larrne Lough
25. Lough Foyle
26. Lough Neagh and Lough Beg
27. Magheraveely Marl Loughs
28. Outer Ards
29. Pettigoe Plateau
30. Slieve Beagh
31. Strangford Lough
32. Teal Lough
33. Turmennan Lough
34. Upper Lough Erne
35. Port of Portsmouth
36. Tiree Machair
37. North West Norfolk reserves
38. Loch Leven
39. Minismere
40. North Warren
41. Dingle Marshes
42. Poole Harbour
43. Studland
44. North Solent NNR
45. Lindisfarne & Newham NNRs
46. Northumberland
47. Rye Harbour LNR
48. Dungeness to Pett level SPA
49. Redgrave
50. Allfleet's Marsh on Wallasea Island
51. Worchester
52. Langstoen Harbour
53. Chichester Harbour
54. Braunton burrows
55. Dawlish Warren
56. Sidmouth to West Bay
57. Exe Estuary
58. Penhale dunes
59. Isles of Scilly
60. Thanet Coast
61. Sandwich bay
62. Teesmouth
63. Berwickshire & Northumberland
64. Solway Firth
65. Suffolk
66. Humber
67. Plymouth
68. Abberton reservoir
69. Lower Derwent Valley
70. Northumbria
71. Stour and Orwell Estuaries
72. The New Forest
73. The Wash
74. Upper Solway Flats and Marshes
75. Caithness and Sutherland Peatlands
76. Orkney and She Lorna Leask
77. Firth of Forth
78. Firth of Tay & Eden Estuary
79. Loch of Leven
80. Severne Estuary
81. Dorset Heath (Purbeck and Wareham) and Studland Dunes
82. Essex Estuaries
83. Arundel – West Sussex
84. Caerlaverock- Dumfrieshire

85. Castle Espie- County Down
86. Llanelli- Carmarthenshire
87. London- Barnes
88. Martin Mere- Lancashire
89. Slimbridge- Glouchestershire
90. Washington- Tyne & Wear
91. Welney- Norfolk
92. Chichester Harbour
93. Avon valley
94. Alde-ore Estuary
95. Beauly
96. Inverness
97. Cromarty
98. Dornoch Firths
99. Stodmarsh and Pegwell bay
100. Medway Estuary and Marshes
101. The Swale
102. Thames Estuary
103. College Lake
104. Broadland
105. Cairngorm Lochs
106. Muir of Dinnet

Netherlands

Die Biesboch

Haringvliet

Leekstermeergebied

Waddenzee

Belgium

Hautes Fagnes

Germany

Aland Elbe-Niederung und elbaue

Jerichow

Chiemsee

Rheinauen zwischen Eltville und Bingen

Unterer Niederrhein

Sweden

Dumme mosse

Getapulien-Grönbo

Hornborgasjön

Hovran area

Kilsviken

Komosse

Kvismaren

Nittälven

Nordre älv estuary

Södra Bråviken

Stigfjorden

Appendix III- References from tables

Table 1

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Table 3

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Appendix IV. -Recommended disturbance buffer distance from published literature (After Valente 2011.)

Species	Distance (m)	Disturbance	Time of Year	Location of Study	Author
Trumpeter Swan	>300	vehicles, pedestrians, airplanes	breeding	Alaska	Henson and Grant 1991
American Oystercatchers	103	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Black Bellied Plover	88	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Caspian Terns	98	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Common Terns	100	personal watercraft	nesting	Barnegat Bay, New Jersey	Burger 1998
Foster's Terns	87	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Laughing Gulls	107	personal watercraft	nesting	Galveston Bay, Texas	Mueller and Glass 1988
Least Terns	86	personal watercraft	foraging and roosting	Florida	Rodgers and Smith 1995
Ring-billed Gulls	137	personal watercraft	foraging and roosting	Florida	Rodgers and Smith 1997
Royal Terns	137	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Short-billed Dowitcher	82	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Willet	91	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Cattle Egret	100	motor boat	nesting	Florida	Rodgers and Smith 1995
Glossy Ibis	193	airboat	foraging and roosting	Florida	Rodgers and Schwikert 2003
Great Blue Heron	145	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Great Blue Heron	247	airboat	foraging and roosting	Florida	Rodgers and Schwikert

					2003
Great Egret	130	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Great Egret	251	airboat	foraging and roosting	Florida	Rodgers and Schwikert 2003
Great Egret	87	motor boat	nesting	Florida	Rodgers and Smith 1995
Little Blue Heron	113	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Little Blue Heron	207	airboat	foraging and roosting	Florida	Rodgers and Schwikert 2003
Reddish Egret	115	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Roseate Spoonbill	98	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Snowy Egret	118	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Snowy Egret	67	motor boat	nesting	coastal Virginia and North Carolina	Erwin 1989
Tricolored Heron	132	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Tricolored Heron	166	airboat	foraging and roosting	Florida	Rodgers and Schwikert 2003
Tricolored Heron	59	motor boat	nesting	Florida	Rodgers and Smith 1995
White Ibis	146	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
White Ibis	200	Airboat	foraging and roosting	Florida	Rodgers and Schwikert 2003
Wood Stork	118	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Wood Stork	63	motor boat	nesting	Florida	Rodgers and Smith 1995
Wood Stork	77	motor boat	foraging and roosting	Florida	Rodgers and Smith 1997

Anhinga	134	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Anhinga	264	Airboat	foraging and roosting	Florida	Rodgers and Schwikert 2003
Anhinga	89	motor boat	nesting	Florida	Rodgers and Smith 1995
Brown Pelican	183	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Brown Pelican	65	motor boat	nesting	Florida	Rodgers and Smith 1995
Double-crested Cormorant	156	personal watercraft	foraging and roosting	Florida	Rodgers and Schwikert 2002
Double-crested Cormorant	284	Airboat	foraging and roosting	Florida	Rodgers and Schwikert 2003
Double-crested Cormorant	71	motor boat	nesting	Florida	Rodgers and Smith 1995

Particular attention should be given to the buffer zone size of airboat disturbance, as it is similar to hovercrafts.

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