Strategic Compensation Studies

Overview of Red-throated Diver Compensation Measures and Opportunities for Improving Ecological Outcomes

Offshore Wind Evidence + Change Programme | THE CROWN ESTATE | SCS Strategic Compensation Studies | OffshoreWind Industry Council

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Acronyms

Acronym	Term
AEoSI	Adverse Effect on Site Integrity
CO	Conservation Objective
DAS	Digital Aerial Survey
DCO	Development Consent Order
EA1	East Anglia ONE (OWF)
EA1N	East Anglia ONE North (OWF)
EA2	East Anglia TWO (OWF)
EA3	East Anglia THREE (OWF)
JNCC	Joint Nature Conservation Committee
MMO	Marine Management Organisation
NRW	Natural Resources Wales

Acronym	Term
OWF	Offshore Wind Farm
RR	Relevant Representation
RTD	Red-throated Diver *Gavia stellata*
SACOs	Supplementary Advice on Conservation Objectives
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area

Document Control

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About OWEC SCS Project: The Strategic Compensation Studies (SCS) is a £3.5 million project running until the end of 2027 which forms part of the Offshore Wind Evidence and Change programme (OWEC), led by The Crown Estate (in partnership with the Department for Energy Security and Net Zero and Department for environment, Food & Rural Affairs). Alongside the OWEC programme funding, the SCS project is supported through financial and in-kind contributions from participating Offshore Wind Industry Council (OWIC) members.

Further information can be found via the Strategic Compensation Studies webpage.

Purpose of this Report: This report forms part of the supporting measures work package and aims to provide an overview of the current status of key wintering red-throated diver populations, identify key knowledge gaps and provide recommendations for further work required in the context of strategic compensatory measures for red-throated diver.

1 Introduction

This technical note has been prepared by Environmental Resources Management Ltd (ERM) for the Offshore Wind Industry Council (OWIC) led Offshore Wind Evidence and Change (OWEC) Strategic Compensation Studies (SCS) project. The aim is to provide an up-to-date overview of red -throated diver *Gavia stellata* (RTD) compensation measures and opportunities for improving ecological outcomes which could be applied by the offshore wind farm (OWF) sector.

RTD is the most common diver species in the UK, with breeding populations present in Scotland and overwintering (non-breeding) populations in more southern regions on the east and west coasts. The focus here is on overwintering populations, which are known to also include some individuals using sites as 'lay-overs' during migration, in English and Welsh waters: specifically those which are classified under the EU Birds Directive, and which are qualifying features of designated Special Protection Areas (SPAs) (see Table 1, Section 2).

Over the winter period (generally the beginning of November to the end of March), RTD make use of large inshore bays and the outer extents of estuaries (O'Brien *et al.*, 2008; Guse *et al.*, 2009; Skov *et al.*, 2016). In these habitats individuals spend several months on the water, feeding on a variety of prey resources (Guse *et al.*, 2009). At the end of the winter period (during February and March) individuals form aggregations on the sea surface before leaving over a short number of days for the spring migration back to breeding grounds in northern Scotland, Scandinavia, Iceland, and Russia (Duckworth *et al.*, 2022; Kleinschmidt *et al.*, 2022).

Populations are subject to a number of threats, both from anthropogenic activity and natural/environmental changes. Disturbance/displacement due to infrastructure and marine activity is considered to constitute the key threat to wintering RTD. Other threats may include loss or alteration of supporting habitat and prey species; barrier effect and collision with infrastructure during migration; bycatch in fisheries; and natural threats such as bird flu and climate change.

The RTD knowledgebase is expanding, regarding abundance and distribution, with recent and ongoing surveys of SPA populations (e.g. the Outer Thames Estuary in 2018, and the Greater Wash due to be published in 2025). In addition, observations and monitoring are progressing regarding

responses to infrastructure projects and vessel activities (APEM, 2016; Burger *et al.*, 2019; Allen *et al.*, 2020), and the effects of displacement on individuals (e.g. Thompson *et al.*, 2023).

There is a need to review, understand, and potentially offset displacement of RTD from wintering habitats. This is predominantly due to increasing infrastructure developments, and associated vessel activity, such as recent and proposed OWF projects in the North Sea (e.g. East Anglia ONE North and East Anglia TWO (EA1N and EA2) and North Falls) and in the Irish Sea (e.g. Morecambe OWF).

This note aims to provide an overview of the current status of key wintering RTD populations, and place this in perspective with reference to OWF projects, and potential compensatory measures.

2 Current Status of Red-throated Diver

2.1 Distribution and Abundance

The key sites which support wintering RTD populations in the UK are the Greater Wash SPA, the Outer Thames Estuary SPA, the Northern Cardigan Bay/Gogledd Bae Ceredigion SPA, and the Liverpool Bay/Bae Lerpwl SPA. These locations supported a combined total of 10,229 individuals at the time of classification of the populations/SPA designation (JNCC, 2024). Scottish SPAs supported an additional 1,786 individuals across five sites when designated (with the Solway Firth SPA having a classified wintering population across Scottish and English waters). UK SPAs where RTD is a classified wintering population feature are listed in Table 1.

Table 1: UK Special Protection Areas with classified wintering populations of red-throated diver *Gavia stellata* and associated population estimates

Special Protection Area Name	Relevant Country(ies)	Region	Cited Population	Latest Population	Data Collected
Firth of Forth	Scotland	Northern North Sea	90	Not updated	1993/94-1997/98
Greater Wash	England	Southern North Sea	1,407	Not updated	2002/03-2005/06
Liverpool Bay/Bae Lerpwl	England, Wales	Irish Sea	922	1,800	2015-2020
Medway Estuary and Marshes[1]	England	Southern North Sea	Unknown	Unknown	1993
Moray Firth	Scotland	Northern North Sea	324	320	2001/02-2006/07
Northern Cardigan Bay/ Gogledd Bae Ceredigion	Wales	Irish Sea	1,186	1,186	2000/01-2003/04
Outer Firth of Forth and St Andrews Bay Complex	Scotland	Northern North Sea	851	850	2001/02-2004/05
Outer Thames Estuary	England	Southern North Sea	6,446	18,079	2012/13-2017/18
Solway Firth	England, Scotland	Irish Sea	521	530	2001/02-2005/06

[1] As part of the waterbird assemblage long list. Noting that there is some movement of birds away from the Medway during high tide to sites within the Thames and the Swale (Banks *et al.*, 2005)

Since designation, additional surveys have been conducted at the Outer Thames Estuary SPA (Irwin *et al.*, 2019) and at the Liverpool Bay/Bae Lerpwl SPA (Natural England *et al.*, 2022). Digital aerial survey (DAS) data suggest respective populations of 18,079 (up from 6,466) and 1,800 (up from 1,170). The increases have been attributed to advances in survey methodology and equipment resolution, rather than a naturally occurring increase in RTD abundance. As no repeat surveys for the other RTD wintering SPAs have been published[2], the population trends at those sites, and UK-wide, is currently unknown. Natural England (2024) suggest that the Outer Thames Estuary SPA continues to support the same proportion of the national population as when initially classified.

Within the RTD wintering SPAs[3], the distribution of individuals varies depending on many factors (Burt *et al.*, 2022), including: environmental variables; anthropogenic activity; and spatial parameters, such as distance to coast. Through literature search and review, Nelson *et al.* (2024), showed that key environmental parameters, likely representing preferential supporting habitat, were found to include: bathymetry (Black *et al.*, 2015; Dierschke *et al.*, 2017); seabed slope (Maclean *et al.*, 2006; Hostetter *et al.*, 2015; Skov *et al.*, 2016); sandbanks (del Hoyo *et al.*, 1992; Snow and Perrins, 1998); salinity (Skov *et al.*, 2008); tidal fronts and eddies (Skov & Prins, 2001; Skov *et al.*, 2016) and prey habitat suitability (Guse *et al.*, 2009; Dierschke *et al.*, 2017).

RTD abundance was found to correlate with environmental factors, with complex relationships and interactions included in models in a number of studies (Burt *et al.*, 2022). Density within wintering grounds was typically higher: in water depths of 15-25 m (Black *et al.*, 2015); on the northern flanks of sandbanks (Maclean *et al.*, 2006); in areas of 32-33 psu salinity (Skov *et al.*, 2008); and hydrodynamic factors (Heinänen, 2016; Skov *et al.*, 2016). Complex interactions between multiple variables have been considered in some models (e.g. Black *et al.*, 2015; APEM, 2016; Žydelis *et al.*, 2016). Distance from the coast was also found to be an indicator of abundance (Hostetter *et al.*,

[2] It is understood that digital aerial surveys of the Greater Wash SPA were commissioned by Natural England and have been completed, with the results due to be published in spring 2025.

[3] The Greater Wash SPA, The Outer Thames Estuary SPA and the Liverpool Bay/Bae Lerpwl SPA have predominantly been the focus of research and SNCB casework advice compared to the other RTD wintering SPAs listed in Table 1.

2015). A significant effect on RTD abundance, density and distribution was observed when OWF developments and shipping are included in models (APEM, 2016; Mendel *et al.*, 2019).

2.2 Conservation and Management Advice

Conservation advice for wintering RTD has evolved over recent years with developments in understanding the key pressures and threats to wintering populations.

Current advice relating to OWF developments is that a 10 km buffer is applied to the project array boundary and displacement effects within this area are considered, with 100% displacement and 1-10% mortality applied within the array area itself. Outside the array area (extending to, and potentially beyond, 10 km), displacement effects may diminish, and, with agreement with the relevant SNCB, a displacement gradient may be applied (SNCB, 2022). In its Relevant Representations (RRs) for the Morecambe OWF, Natural England indicated that the applicant's approach of applying an 'effective area of displacement' may not be appropriate. Instead, the area of sea over which any level of displacement may occur should be considered in the assessment (Royal HaskoningDHV, 2025). As part of this approach, Natural England also advised that it could not conclude no Adverse Effect on Site Integrity (AEoSI) for the Liverpool Bay/Bae Lerpwl SPA classified population when the 10 km buffer overlapped with 21.2 km² (1.24%) of the SPA.

Recent advice received from the Marine Management Organisation (MMO) in consultation with Natural England (April 2025) on a marine aggregate extraction licence application (MLA/2024/00227) indicated that circa two cumulative days of disturbance over a five-month period (November to March) could be acceptable before the potential for AEoSI needs to be considered. This position was derived from a Natural England evidence review undertaken by ornithologists (Nichols, 2025) and is considered a 'rule of thumb', rather than a fixed threshold for acceptable levels of disturbance relating to vessels and vessel movements.

Following advice from Natural England received during examination, EA1N were required to reduce the array area to provide an 8 km buffer between EA1N and the Outer Thames Estuary SPA. Natural England concluded that the package of compensation measures (described in more detail below and in Table 2) provided a reasonable prospect of the coherence of the national site network being maintained. It should be noted that this advice was

provided in the specific scenario of an 8 km buffer for EA1N and a 10km buffer for the EA2. The Secretary of State, however concluded that the shared package of compensatory measures would adequately compensate for the residual adverse effects on the RTD feature of the SPA with a buffer distance of 8 km between EA1 and the Outer Thames Estuary SPA as well as the full adverse effects of EA2 at 8.3 km from the Outer Thames Estuary SPA.

As part of the Development Consent Orders (DCOs) for the EA1N and EA2 OWFs (The East Anglia ONE North Offshore Wind Farm Order 2022; The East Anglia TWO Offshore Wind Farm Order 2022), winter surveys of the entire Outer Thames Estuary SPA, are required to be undertaken (between November and March), to inform updated displacement models for RTD. Additionally, to assess project-level displacement effects, pre and postconstruction surveys of the array area plus 10 km buffer are required.

In addition to fixed project boundaries, recent DCOs require vessel movements and transits through RTD wintering SPAs to be assessed (e.g. The East Anglia ONE North Offshore Wind Farm Order 2022). For example, EA1N and EA2 are mitigating impacts on RTD from OWF-related vessel movements by re-routing operation and maintenance vessels to remain 2 km from the Outer Thames Estuary SPA boundary (where possible). Unavoidable trips through the SPA are being compensated for by re-routing vessels from consented EA1N and East Anglia THREE (EA3) projects.

Advice from Statutory Nature Conservation Bodies (SNCBs) and regulators states that a 'RTD Best Practice Protocol' is implemented and followed at minimum. In some instances, where works must occur inside, or within 2 km of, an RTD wintering SPA, a seasonal restriction may also be advised, generally in place from November to March, inclusive. This management approach has been implemented as mitigation for OWF projects (e.g. EA1N, EA2, North Falls) and for other sector projects (e.g. Marine Licence Conditions for aggregate extraction areas).

2.2.1 Conservation Objectives and Advice on Operations

To meet the requirements of current conservation advice it must be ensured that anthropogenic activities do not prevent the Conservation Objectives (COs) of the site being met.

COs, Supplementary Advice on COs (SACOs) and Advice on Operations vary across the English and Welsh SPAs. This variation is dependent upon several factors: the relevant SNCB advising the relevant regulating body; site-specific environmental factors; and site-specific pressures and threats.

A common theme to reduce disturbance and displacement (location, frequency, and/or intensity) can be seen across the RTD wintering SPAs. Many COs state the requirement to 'restore' the extent, distribution and availability of suitable habitat and/or to 'reduce' the frequency, duration and/or intensity of disturbance; rather than 'maintain' the features (e.g. the Greater Wash SPA and Liverpool Bay/Bae Lerpwl SPA both require restoration of supporting habitat feature and preventing further deterioration). It is these COs that most frequently results in projects requiring to deliver mitigation and/or compensation.

The Greater Wash SPA, Outer Thames Estuary SPA and Liverpool Bay/Bae Lerpwl SPA have a CO associated with reducing any existing anthropogenic influences impacting the extent and quality of supporting habitat features (including water quality). This factor is unlikely to be a constraint for future OWF project arrays as none are proposed, or likely to be proposed, directly within an RTD wintering SPA. However, pressures associated with construction, and operation and maintenance, of associated transmission cables will have to be considered for many currently planned, and likely future, projects.

Where more recent survey data are available (Outer Thames Estuary SPA and Liverpool Bay/Bae Lerpwl SPA), the feature-specific SACOs refer to larger abundance estimates as 'targets' (to maintain as a minimum population), altering the original cited populations (at the time of designation).

Advice on Seasonality

The seasonality of the RTD wintering period has historically been advised as the period from 01 November to 31 March. This is the period that RTD start to arrive at the RTD wintering SPAs, and during which they are present in the sites (noting that some birds may be present within the site outside of this period and may need consideration during these times, depending on the nature of the proposed activity) (Natural England, 2019, 2023; Natural England, Natural Resources Wales, and Joint Nature Conservation Committee, 2022). The abundance of RTD increase through the early winter, generally reaching the highest abundances and densities during January and February. During March there is an exodus of the classified populations as the birds migrate out of the SPA. This northwards movement to their breeding grounds occurs often over only a period of two to three days (Natural England, 2019, 2023).

There are known aggregations of RTD that occur in more dispersed distributions outside of the RTD wintering SPAs during the non-breeding season e.g. along parts of the south coast of England (MarineSpace, 2022). During the end-of-winter migration some of these birds may 'lay-over' in the RTD wintering SPAs or may be considered part of multiple SPA populations (e.g. birds travelling north along the east or west coast may 'lay-over' in the more northern SPAs, such as Liverpool Bay/Bae Lerpwl). This results in a fluctuation in the classified wintering populations and may slightly obscure the actual classified population's abundances and densities during the end of winter/spring migration period. However, it is recognised that these individuals may still constitute part of the wintering classified SPA population.

The latter information has resulted in recent revisions to the advice on seasonality for the Greater Wash SPA and Outer Thames Estuary SPA. Natural England's current standing advice, as provided within the relevant site conservation advice packages, is that the RTD classified wintering populations in these two SPAs should now be assessed as being present (as a feature) for the period 01 September to 31 May. This 'Advice on Seasonality' may have significant implications of assessment of disturbance and displacement effects associated with some activities and associated pressures. For example, it could be conceived that an activity is restricted to just three months of the year. This also presents a difficulty in assessing potential impacts during some months, given that surveys informing SPA populations are typically conducted over the peak winter period (December to February). However, it is ERM's experience that SNCB advice currently follows the previous advice requiring assessment for the period 01 November to 31 March, with this being the period where RTD are considered most sensitive.

3 Compensation Measures

Where AEoSI cannot be excluded, even with implementation of mitigation, and no alternative solutions and Imperative Reasons of Overriding Public Interest can be demonstrated, compensation measures are required to offset adverse effect on classified features.

Compensation measures can be in the form of pressure reduction, such as minimising or removing existing threats to populations, both biological (e.g. predation) and anthropogenic (e.g. disturbance). Alternatively, measures can work to enhance a population, such as increasing prey availability or the

quality of supporting habitat, such as nesting or foraging areas. An overview of RTD compensation measures is provided in Table 2.

Table 2: Overview of compensation measures for classified wintering red-throated diver *Gavia stellata* populations in English and Welsh waters

Measure	Project(s)	Details	Status
Vessel Management	Primary measure for EA1N and EA2 OWFs	Reduce vessel-related disturbance associated with other projects: East Anglia ONE (EA1) and East Anglia THREE (EA3).	Consented in 2022. Compensation measures proposed by developer. DCO requires compensation plan is updated and agreed with RTD working group prior to construction.
Bycatch Reduction	Secondary measure for EA1N and EA2 OWFs	Consultation and adaptive management with fishing industry to reduce seabird bycatch.	
Provision of nesting rafts	North Falls OWF	Installation of artificial rafts at Scottish lochs already used by RTD (or lochs in adjacent areas that do not support RTD but may do so with raft nest raft provision) to enhance breeding populations connected to the Outer Thames Estuary SPA (North Falls OWF) and Liverpool Bay/Bae Lerpwl SPA (Morecambe OWF) wintering populations.	Both projects under examination. Without prejudice compensation measure described by the developers.
	Morecambe OWF		
Breeding site protection	North Falls OWF	Erosion protection at breeding lochs in Scotland to maintain quality of nesting habitat used by breeding populations connected to the Outer Thames Estuary	
	Morecambe OWF		

Measure	Project(s)	Details	Status
		SPA (North Falls OWF) and Liverpool Bay/Bae Lerpwl SPA (Morecambe OWF) wintering populations.	
Fisheries closure	N/A	Closure of fisheries to reduce pressures on prey species populations could increase prey availability to wintering RTD (Furness *et al.*, 2013a).	No fisheries have been closed with specific objectives to enhance RTD populations.
Pollution prevention	N/A	Prevention of oil spills or pollution events could result in reduced pressure on RTD (Furness *et al.et al.*, 2013a). Although included by Furness *et al.et al.* (2013a) and discussed by McGregor *et al.* (2022), pollution prevention could be considered more akin to mitigation measures than compensation.	Projects generally include measures to reduce the risk of accidental pollution within project specific Environmental Management Plans, Vessel Management Plans, or Pollution Contingency Plans.
Sanctuary Zones	N/A	McGregor *et al.* (2022) described improving quality of available supporting habitat within the Outer Thames Estuary SPA, such as shallow sandbanks. This could be achieved through restricting activities temporarily, seasonally, or permanently.	There is no current legal mechanism for managing/excluding shipping activity and therefore implementation of sanctuary zones within existing SPAs in English and Welsh waters. Such measures would require policy changes and strategic approaches with collaboration across several sectors/industries. The potential for sanctuary zones as a strategic compensation measure is currently being investigated by the Collaboration on Offshore

Measure	Project(s)	Details	Status
			Wind Strategic Compensation (COWSC) RTD Expert Group.
Reducing displacement	N/A	Removal of existing sources of displacement, such as vessels or infrastructure could 're-open' areas of suitable supporting habitat.	Removal of infrastructure (e.g. existing OWFs) has not been proposed as compensation. The EA1N and EA2 developer proposed mitigation to reduce vessel related disturbance associated with its other projects in the same region: EA1 and East Anglia THREE (EA3).

4 Knowledge Gaps and Recommendations

4.1 Knowledge Gaps

Reviewing threats to, current status and distribution of, management advice regarding, and potential compensation measures for RTD in English and Welsh waters, it is apparent that a number of knowledge gaps remain.

Knowledge of the key threats to RTD populations are now well documented, with a wide number of studies showing displacement and disturbance responses to human activity and infrastructure (e.g. Furness and Wade, 2012; Furness *et al.*, 2013; Burger *et al.*, 2019; Fliessbach *et al.*, 2019; Mendel *et al.*, 2019; Dorsch *et al.*, 2020; Vilela *et al.*, 2020). However, there may be merit in further studies testing the effects of vessel speed, frequency of presence and potentially vessel size on RTD disturbance and resettlement, albeit these will likely be very complicated. High levels of RTD habituation to infrastructure (e.g. OWFs) or frequently used vessel routes has not been recorded (Schwemmer *et al.*, 2011; Percival, 2014; Burger *et al.*, 2019). Although, a limited number of birds have been recorded within OWF array footprints (Irwin *et al.*, 2019). The understanding of RTD recovery from displacement and disturbance is limited, with one study suggesting resettlement periods from vessels can take around seven to 11+ hours (Burger *et al.*, 2019). Disturbance, and subsequent resettlement, has not only been linked to vessel presence, but also to vessel characteristics, including vessel length, number of vessels, and vessel speed (Burger *et al.*, 2019; Mendel *et al.*, 2019; Burt *et al.*, 2022).

The data informing the abundance and distribution of wintering RTD are dated, with initial SPA surveys taking place in the early to mid-2000s. Whilst more recent data are available at some sites (e.g. the Outer Thames Estuary SPA and Liverpool Bay/Bae Lerpwl SPA), information at most other RTD wintering SPAs is limited (noting that SPA data for the Greater Wash SPA is expected to be available later in 2025). DAS data are useful in providing a snapshot of the locations of birds at the time the survey was undertaken. Such data can be modelled to produce density and abundance estimates, and patterns can be observed; such as changes in density with distance to OWFs (e.g. APEM, 2013, 2016; Irwin *et al.*, 2019). However, further development in the understanding of how factors affect the abundance and distribution of English and Welsh RTD populations could benefit from: review/analysis of concurrent environmental data, such as sea surface temperature (SST), Chlorophyll a, salinity; and acquisition of concurrent anthropogenic activity

data, such as; real time vessel movements; non licensable activities (e.g. fishing); and recreational activities. It is noted that there are limited or no data available on some factors discussed above, This knowledge gap should be recognised and could be filled in the future.

In addition to understanding the extent and distribution of factors affecting RTD, it is also important that supporting habitat characteristics are understood. Model based approaches have been used, pairing RTD abundance with environmental factors. Such studies can be used to develop the understanding of what constitutes preferred or marginal supporting habitats for wintering RTD. For example, higher densities of RTD have been associated with water depths around 1525 m (Black *et al.*, 2015; Dierschke *et al.*, 2017); salinity between 32 and 33 psu (Skov and Prins, 2001; Skov *et al.*, 2008); and north facing bank slopes >17° (Hostetter *et al.*, 2015; Skov *et al.*, 2016). Importantly, Skov and Prins (2001) and later Skov *et al.* (2016) considered the location of tidal fronts and eddies to be influential. However, these data may not be available for some SPAs, or not at the required resolution to allow conclusions to be drawn about their influence on wintering RTD distribution or densities.

When considering compensatory measures, whether these are reducing pressures or enhancing habitat, it is important that they are implemented in locations that RTD can utilise. Local and site-specific environmental data could, therefore, be used to supplement RTD observation data within SPAs. The data could be used to identify areas which are under-utilised by RTD (e.g. Nelson *et al.*, 2024).

For compensation at breeding sites to be effective, the connectivity between breeding and wintering populations must also be fully understood. Individual birds show high site fidelity. However, the Russian breeding population is divided between different migratory stopover and wintering sites, including: the Baltic Sea; German Bight; North Sea; and Irish Sea (Kleinschmidt *et al.*, 2022). Duckworth *et al.* (2020) found that there was very little crossover between tracked individuals from different breeding locations in their wintering locations, further supporting strong individual site fidelity. Both of these studies tagged breeding birds therefore, it may be more pertinent to do the reverse when considering breeding site compensation to enhance wintering populations i.e. tag individuals at their wintering sites to inform understanding of where they are breeding.

Information on migration and connectivity between breeding and wintering sites (Duckworth *et al.*, 2020; Kleinschmidt *et al.*, 2022) could also be used to provide higher resolution and more definitive periods of site occupancy, which can be used to inform implementation of strategic compensation measures. The Conservation Advice packages suggest that RTD are present in the Greater Wash SPA from September to April (Natural England, 2023), in the Outer Thames Estuary SPA from October to May (Natural England, 2019), in the Liverpool Bay/Bae Lerpwl SPA from October to April (Natural England *et al.*, 2022), and in the North Cardigan Bay/Gogledd Bae Ceredigion SPA from September to February (NRW, 2019). Some are informed by dated (2007-2013) Wetland Bird Survey (WeBS) data (Natural England, 2019, 2023) with others drawing from more generic UK-wide studies. Higher resolution site-specific data could be obtained to better inform both impact assessments and implementation of mitigation and strategic compensation measures.

4.2 Recommendations

It is recommended that RTD wintering SPAs are surveyed to provide an update to the abundance estimates. This should include full SPA-wide DAS through the winter period, allowing updated peak population estimates to be calculated. When comparing the outputs with current population estimates, it is important that changes in survey and data analysis methodology and equipment are considered, but it should also be recognised that true changes in population (both longer-term trends and inter-annual short-term fluctuations) are possible.

It is also recommended that factors affecting RTD distribution are considered in the surveys, and additional concurrent data are collected (where feasible). For example, environmental or habitat preference data could be obtained to temporally align with aerial surveys of RTD abundance. Additionally, it is recommended that vessel activity is monitored during the survey periods, recording not only vessel positions but recent vessel activity (e.g. vessel tracks for several hours preceding the survey time (Burger *et al.*, 2019)).

Updated data regarding wintering RTD distribution in relation to environmental factors and human activity could directly feed into targeted strategic compensation. Such data may be used to inform areas of potentially high disturbance which could be reduced, or areas which may benefit from habitat enhancement.

Periods of RTD occupancy at each SPA should also be further investigated. For this, tracking data could be used to understand when birds arrive at and depart from wintering grounds. Such data could also be used to understand connectivity between wintering populations and breeding grounds. This will allow concentration of efforts for strategic compensation or conservation of breeding populations that directly contribute to the wintering population. This could include implementing measures at breeding populations in the UK national sites network, but also to consider breeding populations across the wider National Site Network.

Accurate data regarding the period of site occupancy by wintering RTD could be used to inform when strategic compensation measures would be most effective. For example, reducing disturbance in the 'fringe' months (e.g. September and April) may have a smaller magnitude of effect compared with periods of peak occupancy (e.g. February). If strategic compensation requires an increase in activity (e.g. removal of infrastructure), this may result in temporary displacement. Undertaking such activities in periods of low or no wintering RTD occupancy will reduce the potential for adverse effect.

When mitigation or compensation measures are implemented, appropriate monitoring should also be instigated along with an adaptive management plan to ensure the best likelihood of success. An in-depth review and/or meta-analysis of existing studies and data on conservation interventions and strategic compensation measures could be undertaken and used to inform future proposals.

A collaborative or strategic approach to implementing recommendations and strategic compensation is recommended. This would prevent duplication of efforts and work to reduce overall costs to the industry, for example, EA1N and EA2 OWFs are requested to survey the entirety of the Outer Thames Estuary SPA plus a 10 km buffer as a condition of their DCOs. Additionally, survey design and analysis methodologies should be discussed between, and agreed with, the sector/developers, SNCBs, surveyors, and independent experts to allow repeatability and future comparisons.

Some compensation measures outlined in Table 2 could be applied at a strategic level, it is recommended that the potential for this strategic approach is investigated in further detail.

Vessel management measures could be implemented as strategic compensation. At present, vessel best practice protocols are generally implemented as mitigation measures at individual projects, however, these

could be applied to vessel traffic in general. Restrictions to existing vessel activity could reduce disturbance to wintering RTD. Implementing conditions to ensure vessels remain within established navigation channels, restrictions on vessel speed, and a requirement to avoid rafts of loafing birds could reduce disturbance in areas where vessel traffic is high.

Changes in fishing practices could also be implemented at a strategic level. Fisheries closures within wintering RTD SPAs could work to reduce both direct disturbance of RTDs and indirect effects on prey availability and supporting habitat. Additionally, temporal restrictions on certain fishing types may work to reduce bycatch of wintering RTD.

Displacement due to infrastructure could be reduced as developed projects reach the end of life. Instead of repowering or relicensing a project which is causing displacement, the project could be decommissioned; essentially 'opening up' areas of supporting habitat to wintering RTD within SPAs such as the Greater Wash SPA and Outer Thames Estuary SPA. Noting that careful consideration would be required in this scenario, to strike a balance between conservation of RTD and implications of reducing UK offshore wind capacity on achieving of Clean Power 2030 and net zero targets.

Disturbance and displacement effects could be reduced further with implementation of 'sanctuary zones', where a temporal restriction on activities could be applied. For example, activities that displace RTD could be restricted in areas with the potential to support higher densities of wintering RTD aggregations through the period of peak occupancy. The implementation of sanctuary zones as strategic compensation is being is being investigated by the COWSC red-RTD expert group, however, it is recognised that there is no established mechanism for such zones to be implemented at present.

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