A gaps analysis of ornithological information underpinning future environmental planning with respect to aquaculture in Wexford Harbour

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Background

The Aquaculture Licencing Appeals Board (ALAB) was established on 17 June 1998 under Section 22 of the Fisheries (Amendment) Act, 1997.

The function of the Board is to provide an independent authority for the determination of appeals against decisions of the Minister for Agriculture, Food and the Marine on aquaculture licence applications. A person aggrieved by a decision of the Minister on an aquaculture licence application, or by the revocation or amendment of an aquaculture licence, may make an appeal within one month of publication (in the case of a decision) or notification (in the case of revocation/amendment).

In consideration of a number of appeals in relation to mussel aquaculture within Wexford Harbour, Co. Wexford, KRC Ecological Ltd. was commissioned to undertake a review of aquaculture licencing appeals within Wexford Harbour. These applications include T03/30A2, T03/30B & E, T03/30/1, T03/99, T03/35A, B, & C, T03/F & G, T03/72B, T03/90, T03/46A, B & C, T03/47A, B & C, T03/83, T03/85, T03/48, T03/91, T03/49A, B, C & D, T03/77, T03/52A, B & E, T03/55C & F, T03/74A & B & T03/80A for culture of mussel at various locations within Wexford Hbr & Slobs.

An analysis of available waterbird data prepared as a Technical Advisors Report to ALAB in 2023[1] sought to provide an objective analysis to aid decision-making by the Board in respect of the assessment of multiple aquaculture licences with the Wexford Harbour SPA. The report appraised the range of appeals in the context of the ornithological interests of the site, recent trends of qualifying interests, a review of the 2016

[1] KRC Ecological (2023) Technical Advisors Report to ALAB, June 2023; https://alab.ie/media/alab/2023%2006%2006%20ALAB_Wexford_KRCJuneFINAL_v52023.pdf

Appropriate Assessment (AA), and submissions from various parties associated with the appeals.

We concluded that while the 2016 AA was thorough and utilised all available information at the time, it highlighted a number of *likely* significant impacts of aquaculture on a number of species and *potential* impacts on others. We concluded that much of the uncertainty of the potential effects is due to very significant data gaps on waterbird abundance, trends and distribution, as well as behaviour in relation to existing activities. These data gaps were apparent in 2016 and largely still remain. In conclusion, we asserted that it is impossible to assess the potential impacts of aquaculture activity in Wexford Harbour SPA without addressing these information gaps.

Reponses to the June 2023 KRC Ecological Ltd report were summarised in a subsequent report in September 2023[2] which *inter alia* summarised responses to the initial report. On the whole, responses from appellants accepted the findings with respect to data inadequacies, accepting that ALAB are not in a position to review the granting of licences pending further information being available. The KRC Ecological recommendation that a programme of work (such as a 2-3 year scientific study) was required to address these data gaps was required was supported by some, with some appellants supportive of being engaged with any future analysis and to be given opportunities to consider all matters relating to intended analysis.

The purpose of this report is to outline a potential approach which may be required to address the information gap. It refers to the shortcomings which were identified in the Atkins 2016 AA, providing more detail on how these might be undertaken/developed and suggests additional approaches. We explain in greater depth the rationale behind the range of research and monitoring work which would aim to significantly improve the information base and, as such, provide a framework for objective and transparent decision-making for conservation management and sustainable development of Wexford Harbour, with respect to ornithological features and anthropogenic activities including

[2] KRC Ecological Ltd (2023) Supplemental Report to ALAB, September 2023; https://alab.ie/media/alab/2023%2012%2006%20Ap%2034-48%20Wexford_ALAB_SupplReport_KRC_FINAL.pdf

aquaculture. This report is not intended to be a definitive 'shopping list' of actions, but rather aims to set out clearly the information gaps, explain the importance and value in addressing them and, in most cases, suggest outline approaches to the structure and design of a research and monitoring programme.

Context

Legislative context

The EU Birds Directive (2009/147/EC) is the primary legislation in Ireland affording protection to the most important bird areas. In conjunction with the Habitats Directive (92/43/EEC), the network of sites are collectively known as Natura 2000 (N2K) sites in which the primary conservation objective is the maintenance (or restoration) of 'favourable conservation status' of habitats and species of community interest[3].

Article 4 of the Birds Directive requires signatories (in this case, the Irish state) to classify the most suitable territories in number and size as Special Protection Areas (SPAs) for the conservation of wild bird species which are (a) Species listed under Annex 1 of the Birds Directive, (b) regularly occurring migratory species, and (c) wetlands, especially those of international importance[1].

National Parks and Wildlife Service (NPWS), a division within the Department of Housing, Local Government and Heritage (DHLGH), manages the Irish states nature conservation responsibilities under national and European law and international commitments. The criteria used for the selection of SPAs was similar to that underpinning the Ramsar Convention[4] criteria whereby sites which met any or all of the following criteria may be selected as SPAs:

- A site holding 20,000 waterbirds
- A site holding 1% or more of the all-Ireland population of an Annex 1 species
- A site holding 1% or more of the biogeographic population of a migratory species

[3] NPWS (2011) Conservation Objectives: Wexford Harbour & Slobs SPA 004076. Version 1.0. National Parks and Wildlife Service, Department of Arts, Culture and the Gaeltacht.

[4] https://www.ramsar.org

- A site that is one of the *n* most suitable sites in Ireland for a regularly occurring migratory species or Annex 1 listed species (where *n* is a variable which is related to the proportion of the total biogeographical population of a species held in Ireland)

The biogeographic population estimates and recommended 1% thresholds for wildfowl and waders (collectively 'waterbirds') are taken from periodic reviews of populations by Wetlands International[5]. All-Ireland (national) population estimates[6] are also periodically reviewed, reflecting changes in populations through time.

As the competent authority responsible for maintaining favourable conservation status across the designated sites network, NPWS produce site-specific Conservation Objectives (SSCOs) which aims to define favourable condition for habitats and/or species at a site, and their maintenance at individual sites contributes to their maintenance at a national level.

These SSCOs focus on species of Special Conservation Interest (SCIs) which are the list of species for which the site is nationally or internationally important.

The most recent SSCOs for Wexford Harbour SPA (004076), from 2012[7], identifies 39 SCI (qualifying interest) species for the site. Table 1 (from the KRC June 2023) report and shown below lists these species together with the relative ranking/importance of that species at a number of spatial levels – nationally, regionally and within the county. Species for which Wexford Harbour & Slobs SPA numbers rank in the top five at one or more scales are highlighted.

It is evident that the site is extremely important for many species both at a county and regional level. In addition, the national significance is evident, with ten of the 26 species for which ranking is shown falling in the top 1-2 sites at a national level, including being the most important sites for Greenland White-fronted Geese and Grey Plover.

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[5] The most recent population estimates are for 2012; Wetlands International (2012) Waterbird Population Estimates, 5th edition – Summary Report. Wetlands International, Wageningen, The Netherlands.

[6] The most recent national population estimates are for the period 2011/12 – 2015/16; Burke, B., Lewis, L.J., Fitzgerald, N., Frost, T., Austin, G. & Tierney, D. (2018) Estimates of waterbird numbers wintering in Ireland, 2011/12 – 2015/16. *Irish Birds* 11: 1-12.

[7] NPWS (2012) Conservation Objectives: Wexford Harbour and Slobs SPA 004076. Version 1.0. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht.

Population trends at the site

The primary metric for assessment of the condition of populations (which form the basis of the QI species conservation objectives and contribute to the overall SSCOs) are the trends in populations - the long-term trend for each waterbird SCI should be stable or increasing, species being classified as being in unfavourable status when they have declined by 25% or more as assessed by the most recent trend analysis[8]. Population trends for the site are primarily based on trends for a ~15 year period from 1994/95 to 2008/09, the exact range being dependent on the species (full details on Page 17 of the NPWS SSCOs supporting document). Inadequacies in data have meant that I-WeBS has not produced site trends for Wexford Harbour & Slobs and thus the most recent evaluations are that up to 2008/09 by NPWS (16 years old) and an updated (but rather crude) analysis we undertook based on all available data up to and including the 2021/21, published as Table 2 in the KRC June 2023 report. The absence of a statistically robust and up to date understanding of population trends within Wexford Harbour & Slobs clearly inhibits making sound judgements on attaining conservation objective targets and conservation planning, including with respect to future aquaculture development within Wexford Harbour.

The non-breeding SCI species trends were classified by NPWS as highly unfavourable for two species, unfavourable for six, intermediate (unfavourable) for 11 and favourable for 11, with two unassessed (Table 2). The rudimentary analysis (based on all available I-WeBS summary data and in lieu of modelled site alerts being available for this site) shown in the KRC June 2023 report updates the values from those presented by NPWS[9], showed a generally much more negative long-term picture for non-breeding waterbird populations.

Whilst the short-term (12-year) trend showed 25-50% declines (*Unfavourable*) and >50%

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[8] https://www.npws.ie/sites/default/files/publications/pdf/4076_4019_Wexford%20Harbour%20and%20Slobs%20&%20The%20Raven%20SPAs%20Supporting%20Doc_V1.pdf

[9] Note that this analysis cannot be considered statistically robust and based only on comparison of population counts through time. More rigorous analysis should be undertaken

declines (*Highly Unfavourable*) for six and two species respectively, the long-term trends classify a total of 22 species to unfavourable or highly unfavourable status - five species as *Unfavourable* and 17 species as *Highly Unfavourable*. As described in our June 2023 report "Note that the counts shown here do not account for missing subsectors and/or poor-quality counts and caution is required to interpret them". Compared to national trends, our observations from the June 2023 were that:

Of the declining/unfavourable species in Wexford Hbr & Slobs, 11 are also declining nationally at similar rates/levels.

For 12 species the Wexford Hbr & Slobs trend is more negative (worse) than at the national level – this is the case for Shelduck, Teal, Cormorant, Oystercatcher, Sanderling, Bar-tailed Godwit, Wigeon, Mallard, Little Grebe, Grey Heron, Coot and Redshank

Populations of 5 species in Wexford Hbr & Slobs show a similar or better trend than is the case nationally – Whooper Swan, Light-bellied Brent Goose, Golden Plover, Black-tailed Godwit and Dunlin.

In summary (the previous reports referred to prepared by NPWS and KRC Ecological should be referred to) the overall status of waterbird populations at Wexford Harbour & Slobs appears to be generally negative and exhibit more negative trends than are the case nationally.

The Atkins AA (2016): key findings

The Wexford Harbour, the Raven and Rosslare Bay Appropriate Assessment Report (2016) concluded that (a) disturbance from bottom mussel-related boat activity may cause significant displacement impacts to Red-breasted Merganser, and (b) there was insufficient evidence to rule out significant impacts beyond reasonable scientific doubt in relation to bottom mussel culture impacts on the following species - Greenland-white-fronted Goose, Scaup, Goldeneye, Red-breasted Merganser, Great Crested Grebe, Golden Plover, Grey Plover, Knot, Sanderling, Bar-tailed Godwit and Little Tern.

The authors stated that significant additional information for the AA was required including:

(i) Research into impact of bottom mussel culture on several species to assess the impacts of aquaculture on habitat quality

(ii) Further research on Red-breasted Merganser (in addition to that already published from the site)

(iii) Examining displacement impacts on other species including Great Crested Grebe, Goldeneye and Scaup

(iv) Surveys of high-tide tern and wader roosts (to assess potential impacts of boat-based activity)

(v) Surveys of the low-tide distribution of waterbirds

(vi) Research into Little Tern ecology

Addressing information gaps – possible approaches

The following section identifies ten information gaps, which I believe, need to be addressed in order that a revised AA can be developed for Wexford Hbr. In the main these gaps were already identified in the Atkins (2016) report and are explained more fully here. In addition, a number (three) of other approaches are identified to address information gaps – firstly a detailed review of all available information (with analysis is data is available); secondly use of technological approaches to provide valuable information for multiple projects outlined, and thirdly, a modelling approach which should be an overall goal of components of the work. These are summarised as follows

Information gap	Identified in Atkins 2016?	Identified here	Rationale
1. Analysis/Desk review	No	Yes	Enables comprehensive review of information available since 2016 and possible analysis of any data as appropriate
2. Low-tide count programme (includes some annual high tide 'core counts')	Yes; identified as of importance for both bottom mussel and intertidal oyster cultivation		This is fundamental and possible approaches are outlined. Requires a minimum of 2, ideally 3 winter periods
3. Wader roost surveys	Yes; of particular relevance due to potential impacts of boat-based activity associated with bottom mussel cultivation		Can be undertaken as part of the above
4. Tern Roost surveys	Yes; of particular relevance due to potential impacts of boat-based activity associated with bottom mussel cultivation		Focussed on late summer (post-breeding)
5. Displacement studies	Yes; particularly in relation to bottom mussel cultivation and potential impacts on a variety of species		Undertaken as part of the range of other projects (a product of them)
6. Impacts on Little Terns	Yes; though mitigation is already proposed		Some more research may be required
7. Impacts on GWF Geese	Yes		
8. Movement/behaviour study	No	Yes	This has the potential to contribute to understanding of usage and would supplement (for selected species) studies 2, 3, 5, 9 and 10
9. Studying the effects of aquaculture operations on native mussel beds	Yes		
10. Development of a predictive model (for waders)	No	Yes	An overarching objective integrating much of the above information and can be developed to underpin site decision-making

1. Detailed analysis of waterbird population trends using existing data sources and increasing the frequency of high water 'core' counts

Since the apparent negative trends is materially important as a motivation for future action and planning at the site, including determining what the research and information needs, we recommend an initial and up-to-date statistically robust analysis of waterbird trends be undertaken at the site to document the short-medium and long-term trends in non-breeding and breeding populations of SCI species at the site. That analysis may be imperfect due to a paucity of data but needs to use Underhill-type linear models to account for variability in coverage in a statistically robust way but should be undertaken insofar as possible. This will inform the magnitude and direction of more intensive desk/fieldwork.

National and site-level trends are currently carried out by BirdWatch Ireland as part of the I-WeBS contract. Periodic revisions of site trends are undertaken as the volume of data increases and in order to keep the trend information assessment as up to date as possible. Due to the time lag between data being collected in the field, processed, checked, analysed and reported site, alerts/trends are typically available utilising data 3+ years retrospectively. For example, the current site trends[10] are available up to and including the 2019/20 season and omit already in-hand data covering four seasons (2020/21 – 2023/24 inclusive). The derivation of these trends is based on well-established statistical modelling techniques (Generalised Additive Model smoothing of annual indices) as used by the UK-WeBS scheme and similar to other approaches used elsewhere.

As coverage is variable (not every species is counted at every site in every month in every year), the approach models 'missing' counts through imputation, modelling these using the 'Underhill process'[11] whereby a Generalised Linear Model (GLM) generates values which are missing or of poor quality using information from counts in other sites in the same year, from other months in the same year at that site and from other years at the site. The outcome is a complete matrix of count data (all months/years/sites) for each

[10] https://birdwatchireland.ie/app/uploads/2023/08/iwebs_trends_report.html

[11] Underhill & Prys-Jones (1994)

species which comprise both high quality actual counts and imputed counts. The reliability of imputed counts is clearly reduced if the amount of actual data is limited, and as a consequence, a general threshold of a minimum of 50% actual count data is set in order that site trends can be calculated. Full details of the approach taken by I-WeBS are provided by Kennedy *et al*. (2023[12]). At sites such as, in this case Wexford Harbour & Slobs, the number of counts in the year/month/subsites matrix (complete counts would be up to seven counts in all subsites in each year) falls below this threshold. A number of factors lead to this, amongst which the availability of local counters and the scale of the site are probably the greatest contributors.

Whilst a minimum of 50% coverage is recommended, analysis is feasible below this threshold and the modelled trends would arguably be better than a rudimentary analysis of raw count data.

Recommendation

We recommend such analysis should be done using index numbers for Wexford Harbour & Slobs supplied by I-WeBS for all available species/years/months/subsites as up-to-date as possible. Data curation, analysis and reporting is likely an exercise for an experienced statistical modeller, familiar with this type of data, over several months.

This exercise is purely a desk exercise and can be undertaken relatively quickly and easily.

Increasing the number and frequency of I-WeBS Core Counts should remain an important objective for this site such that annual indices and site trends can be generated – as the computation is carried out on a moving window improving coverage (more frequent actual counts) can enable such analyses if the >=50% coverage target is attained.

2. Low-tide waterbird counts

As recommended via the AA, surveys of the distribution of waterbirds at low-tide should be undertaken. Low-tide counts differ from typical I-WeBS counts in a number of ways, guided by their differing aims and objectives.

Critically, the objective of I-WeBS 'core counts' is to derive site total counts for species in

[12] https://birdwatchireland.ie/app/uploads/2023/08/iwebs_trends_methodology_2023.pdf

the months and years that they are undertaken. Aggregated, these counts give detail on the phenology of site usage, mean and peak usage within and between years , contribute to periodic national and international assessments of population sizes, understanding the relative importance of sites at local, regional, national populations and changes in populations through time at sites (see trends above) and larger spatial scales including nationally. 'Core counts' are often undertaken at or near high tide when birds are usually closer to observers, more concentrated and easier to count accurately. Information on the relative importance of areas within a site usually arises as a consequence of the fact that it is easier to implement counts by sub-dividing areas into smaller 'manageable' count sectors/subsites using geographical features, thereby limiting the scale such that observers are able to identify and count all that they are seeing. Such subdivision is essential at large sites (such as Wexford Harbour & Slobs) but less critical as sites get smaller. As these counts are often taken at or close to high tide (when birds may not be feeding) then such data is of limited value for an accurate understanding of the importance of areas for foraging birds. Resting and maintenance activity (preening etc) are also important so separate counts and mapping of roosts and other non-feeding sites is also important.

The primary objective of low-tide counts is to understand how coastal (tidal) wetland sites are utilised by foraging waterbirds. As such they provide crucial information for the assessment of potential impacts via developments. Birds are counted, mapped and their behaviour described for all species in one or more time windows either side of low water, and they key information is the relative density of species within the site – this is a measure of importance and, as birds shift with the tide within sites, it does not matter if birds are 'double-counted' within sites as if they use more than one area that needs to be documented. The count methods were initially developed by the BTO[13] for that Low-Tide Count scheme which has run in the UK since 1992 and a similar and widely adopted methodology developed for Ireland by NPWS[14].

[13] https://www.bto.org/sites/default/files/u18/downloads/counter_resources/lowtide_methods.pdf

[14] https://www.npws.ie/sites/default/files/publications/pdf/IWM80.pdf

Aside from specially commissioned surveys undertaken as part of development projects, or for example commissioned by the Marine Institute to aid decision-making in relation to aquaculture, low-tide counts are infrequently carried out in Ireland. Unlike the case in the UK, there is no low-tide count scheme in Ireland and the focus has and will likely continue to be the I-WeBS Core Count scheme.

There was, however, a national project run by NPWS which collected low-tide count data across thirty-three coastal sites over the consecutive winters of 2009/10 - 2011/12 inclusive. In many cases this formed the most authoritative understanding of the spatial usage of coastal wetlands by waterbirds for foraging and has not been repeated on the same scale since. The primary exception has been a number of sites including *inter alia* Poulnasherry Bay (Clare), Castlemaine Harbour (Kerry), Dungarvan Harbour (Waterford) and Bannow Bay (Wexford) where a large number of surveys have been undertaken commissioned by The Marine Institute over multiple years. Consequently the information on the relative importance of parts of these sites in unrivalled in an Irish context.

The results of the 2009/10 NPWS waterbird surveys were presented in the Annex to the SSCOs [8], summarising a series of counts which were undertaken in the Wexford Harbour & Slobs SPA and the adjacent The Raven SPA on four occasions between October 2009 and February 2010. Across nine subsites the relative importance of each for each of ~30 species counted was assessed.

Given the very significant changes which have occurred in both the numbers of each species using Wexford Harbour & Slobs (Table 2) and nationally since 2009/10 (Lewis *et al.*, 2019[15]) it is highly likely that usage of this site has changed in the intervening period of 15 years. A contemporary assessment of site usage via low-tide counts is a basic and fundamentally important information requirement for conservation planning at this site.

[15] https://www.npws.ie/sites/default/files/publications/pdf/IWM_106_Irelands_Wintering_Waterbirds.pdf

Recommendation

We suggest a multi-year comprehensive series of low-water counts are carried out at Wexford Harbour & Slobs. Following the accepted methodology of Lewis & Tierney (2014), counts should be undertaken encompassing the range of months when numbers of most species peak (Oct/Nov to Feb/Mar), at least once (but ideally a minimum of twice) in the two hour period either side of low -tide. If resources (manpower/finance) permit 'through-the-tide ' counts at each sector will yield optimal utilisation data.

A minimum of five low-tide and two high tide (core) counts should be undertaken as a package of work, aligned to I-WeBS core counts (if they occur) and accessing all this data for analysis. These should be carried out over at least two, but ideally three winter seasons.

The Atkins 2016 AA indicates that though it is probable that displacement effects on [Golden Plover, Grey Plover, Knot, Sanderling and Bar-tailed Godwit] will be substantially less than 5%, the lack of low tide count data available for the analysis meant that there was considerable uncertainty. They advocated for "further data on the low tide distribution of these species across the whole of Wexford Hbr (not just the IWeBS / BWS subsites) to complete this assessment".

3 & 4 Surveys of high-tide roosts of 'wintering' waders and post-breeding terns

Waders

Eleven species of wader are qualifying interests in this SPA. At elevated tide levels these birds aggregate at one or more communal roosts, often starting to gather at traditional and preferred roost sites as the water level rises to high and dispersing again to feeding areas as the tide drops. The roosts are supratidal and typically occur just above the high water mark on slightly elevated sandspits, saltmarshes, embankments or wetland areas above most phases of tidal inundation. Relatively little is known about roosting behaviour, the selection of roosts and the factors underlying them but it is known that there is considerable variability and probably selection is driven by factors such as *inter alia* disturbance, water levels and prevailing weather conditions. As well as providing safe refuge from predators, allowing species to rest between foraging bouts that operate irrespective of daylight conditions, these act as information centres. Due to the high concentrations of birds in them and the relatively few suitable alternatives which may be

available, the negative energetic implications of disturbance at roosts are significant and their protection can play a key role in management and protection of protected sites. They are integral to site conservation management just as foraging areas are.

There is undoubtedly some information on the location of key roosts of waders at Wexford Harbour & Slobs but it is unlikely that this is well understood in lieu of a dedicated series of surveys of the location and composition of roosts. The I-WeBS scheme may have recorded roosts, as well as the NPWS low-tide counts (which also did one HW count as part of the programme). The availability and quality of this data needs reviewed in advance of any dedicated monitoring.

Recommendation

As seems likely (there are very few Irish sites at which roost location, stability, composition etc are well monitored and understood) we suggest that a specific monitoring programme occurs at of just after an increased frequency of high water counts (indicated in Sections 1 and 2 above). These should comprehensively survey all areas around Wexford Harbour & Slobs on a monthly basis for several years, recording parameters on each occasion including (a) abundance of each species present, (b) tide height, (c) weather parameters, and (d) date and time of day. The data acquisition programme needs to be hypothesis driven so that the influence of potential explanatory variables on roost persistence, significance, and composition – weather, disturbance, seasonality etc - can be understood. Recent work by Clausen et al. (2022[16]) in the Danish Wadden Sea describes how retrospective analysis of existing information has been used to map important roosts there.

Assessment of the response of roosting waders to disturbance activities caused by mussel dredging must form part of any study.

Terns

Ireland holds very significant populations of breeding terns, including a very large proportion of Roseate Terns but also important populations of some others including

[16] Clausen, P. & Bregnballe, T. (2022) Mapping important roost sites for waders to alleviate human-waterbird conflicts in the Dnish Wadden Sea. *Ocean and Coastal Management* 223: 15 May 2022, 106147.

Sandwich and Common Terns. These species often breed in discrete traditional locations, typically small islands/islets where disturbance from humans or predators is least. Areas adjacent to significant colonies (such as the multiple colonies around Dublin or Wexford) often hold large numbers of adults and young in the post-breeding period. Late summer tern flocks typically comprise breeding adults, young of the year and a proportion of pre-breeding birds. Disturbance-free roosing areas adjacent to high-quality foraging areas are likely critical to survival and future recruitment of these long distance migratory seabirds, the loss of which could have population-level consequences (Warnock, 2010).

The extent to which these post-breeding aggregations is monitored is unknown at present but studies in Dublin (Merne *et* al., 2008; Tierney *et al*., 2016) and across other areas of Ireland including Wexford (Burke *et al*., 2020) have considerably increased knowledge. In Wexford in the period 2016-18 this latter study showed that very large aggregations of especially Common/Arctic Terns occurred (peaking at 1,500) but also significant numbers of Roseate Terns.

Any assessment of potential disturbance impacts at Wexford Harbour & Slobs must consider tern roosting behaviour. A first step would be to compile the detailed information collected for the site (likely available from regional NPWS staff) collected during the period 2016-18, together with any that may have been collected since.

Recommendation

We would also recommend frequent systematic surveys be undertaken within Wexford Harbour & Slobs between mid-August and mid-September over multiple years, ideally making multiple surveys per day outwith the high tide period, identifying the numbers, species, and location of flocks. In particular the sensitivity of terns to aquaculture activity (see Lewis & Tierney, 2014 for methods of recording disturbance and reactions to it).

5. Assessment of the displacement effects of aquaculture and associated activities (esp disturbance) on selected SCI species including Red-breasted Merganser, Great Crested Grebe, Goldeneye and Scaup

The Atkins AA (2016) identified a potential highly likely significant impact of bottom mussel culture on Red breasted Merganser, stating that "the mean area potentially

disturbed could be 19-27% of the total area of available habitat" and that "high levels of impact could occur on around 80% of days in the October-December period". They also identified the potential for night-time dredging to cause disturbance to nocturnal roosts of Red-breasted Merganser, Scaup, Goldeneye and Great Crested Grebe.

Gittings & O'Donoghue (2016[17]) published some preliminary findings in this regard, which found that of 45 interactions between Red-breasted Mergansers and boat traffic, 71% showed a disturbance response and almost half a flush response. A more intensive multi-species study by Jarrett *et al*. (2022[18]) showed particular sensitivity of some species including divers and Slavonian Grebes.

Recommendation

A study should be initiated to investigate the disturbance sensitivity of this variety of species (especially Red-breasted Merganser) to boat-traffic (in particular mussel dredgers) in Wexford Harbour. Such a study should be carried over at least one season, be hypothesis-driven and designed in such a way to enable robust analyses of disturbance responses and effects (including for example energetic consequences). Observations should take place (ideally) on vessels as well as from land and need to be carried out across day and night periods – the use of telemetry, thermal imaging etc should be considered in this respect.

6. Understanding the behaviour of breeding and foraging Little Terns

The Atkins AA (2016) identified the potential for significant disturbance of both bottom mussel and oyster trestle culture to the Little Tern breeding colony which could be avoided through an appropriate adaptive management strategy.

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[17] Gittings, T. & O'Donoghue, P. (2016) Disturbance response of Red-breasted Mergansers to boat traffic in Wexford Harbour. *Irish Birds* 10: 329-334.

[18] Jarrett, D., Calladine, J., Cook, A.S.C.P., Upton, A., Williams, J., Williams, S., Wilson, J.M., Wilson, M.W., Woodward, I. & Humphreys, E.M. (2022). Behavioural responses of non-breeding waterbirds to marine traffic in the near-shore environment. *Bird Study* 68: 443-454.

Recommendation

If Little Terns are breeding on the site the potential effects of aquaculture needs further investigation and may require a study to be carried out to quantify the effects of activities on behaviour, possibly through observation and/or a telemetry study.

7. Assessment of the potential effect of bottom mussel culture on roosting and feeding Greenland White-fronted Geese

Wexford Harbour & Slobs holds the vast majority of the wintering population of this species which occur between October and March/April. The site is of very high significance internationally. The species mainly forages on terrestrial land – mostly farmland adjacent to Harbour (on the Slobs), roosting within Wexford Harbour. GPS telemetry has shown the importance of the shallow banks of Wexford Harbour as the only safe roosting area for this species in this area (Fox *et al*., 2018[19]).

As reported in the 2016 AA, NPWS raised concerns about the potential disturbance impact of dredger activity adjacent to foraging geese on the Slobs.

Recommendation

We recommend that a simple disturbance study should be carried out to investigate the disturbance responses of Greenland White-fronted Geese to dredger activity on Wexford Harbour – this would require monitoring the behaviour and/or movements of geese in relation to the proximity, scale and type (scale) of dredger disturbance.

8. Understanding the general movements and behaviour of waterbirds in Wexford Harbour

A comprehensive dataset of counts of waterbirds at sites such as this is an essential step towards being able to understand the potential impacts of anthropogenic activities, threats and pressures. If implemented they give essential data on the within- and

[19] Fox, A.D., Walsh, A.J. & Weegman, M.D. (2018). Effects of the Wexford Opera Festival firework display on roosting Greenland White-fronted Geese *Anser albifrons flavirostris*. *Irish Birds* 11: 96-99

between-year abundance and distribution of waterbirds within the site, trends and total numbers, and the usage and significance of roosting areas. In parallel, knowledge of the movements of individual birds, either through telemetry and/or colour-ring observations, adds a layer of complimentary information which is hugely informative, overcoming biases caused, for example, by the near instantaneous 'snapshot' nature of periodic counts and, for example, understanding how such sites are utilised after dark.

Recommendation

To supplement the data gathered via surveys of foraging and roosting areas described above we suggest a large-scale tracking study be undertaken across a selection of species. In combination with the survey data, we suggest that such a study would significantly improve understanding of movements, behaviour, selection of foraging and roosting areas. Whilst relatively expensive, the value of such work can be very high indeed, contributing information across the tidal cycle on foraging and roosting in relation to variables such as disturbance, weather etc via near-continuous monitoring of some species. Automatic tracking of dredgers (equivalent to VMS type information) in parallel would be hugely informative.

Through capture-release, fitting temporary telemetry devices and colour-rings to individuals across a range of SCI species is recommended, providing data across at least part of one winter season but potentially multiple seasons. Examples of equivalent work elsewhere in Ireland include waders in N Dublin, Grey Plover in Dungarvan, Brent Geese in Trawbreaga (Donegal) and a variety of species across multiple coastal wetlands in N Ireland. Such work would be highly suitable for a PhD project with collaborators with the experience and skills to manage practical aspects of the project.

9. Assessment of the impacts of bottom mussel culture on inter-tidal mussel beds

The Atkins (2016) AA suggests that there is a potential long-term effect of seed collection on the regeneration of existing mussel beds. This could impact the "quality of the habitat for Oystercatcher, Know, Curlew and Redshank". What is currently unknown is the importance of existing mussel beds for the range of bird species, detail on their location

and the impact of seed collection. It is not possible to evaluate the potential impact without gathering this information.

Recommendation

This information gap i.e. impact on inter-tidal mussel beds could be addressed via the low tide count surveys described, a telemetry survey (focussing at least in part on species most likely to exploit mussel beds – such as Oystercatcher), a baseline benthic survey of mussel beds (see later) and some autecology/experimental study.

10. Modelling the effects of environmental change within Wexford Harbour including expansion of aquaculture

To assess the impact of the range of environmental changes that might naturally occur at this site or via anthropogenic-induced changes – such as aquaculture expansion - an ultimate goal of a monitoring and research programme should be to be able to predict the impact of new conditions. This has been done in this context at a number of sites around the world including UK and continental Europe but not as yet within Ireland. The Individuals Based Models (IBMs) developed by Richard Stillman and colleagues at Bournemouth were specifically created with this in mind – for coastal waterbirds at coastal sites. These IBMs overcome some limitations of demographic models in a number of ways including the fact that they require less historical data and the basis of model predictions – fitness maximisation of individual animals within populations – is more likely to remain constant in new conditions than the empirical relationships of traditional methods (Goss-Custard & Sutherland, 1997).

The data required to parameterise such models include: (a) site-specific data which must be gathered locally on the food (prey) supply, the abundance and distribution of consumers, and a range of published parameters on bird energetics, functional and interference functions.

Recommendation

Building and implementing such an Individuals Based Model (IBM) should be seen as a goal of much of the previously described work packages which could, therefore, be used to inform their design and implementation. In addition to the variety of waterbird surveys proposed, data on the abundance and distribution, and how food quality and abundance changes through time is the primary additional data which needs to be gathered to parameterise such an IBM. This required at least two comprehensive surveys of benthic invertebrates to be carried out on the site in a single year. Similar IBMs could be considered for other non-wader species where deemed important and where feasible.

Summary of suggested research and monitoring work at Wexford Harbour

Work package	Task	Year 1	Year 2	Year 3	Year 4
1. Analysis/Desk review	Trend analysis and collation of existing information on other components; pilot/planning of the details of other projects as listed below	< 3 months			
2. Low-tide count programme (includes some annual high tide 'core counts')	Programme of annual low-water counts across Wex Hbr & Slobs over multiple years. Also include 1-2 high-water 'core' counts	Sep/Oct – Feb/Mar	Sep/Oct – Feb/Mar	Sep/Oct – Feb/Mar	
3. Wader roost surveys	Possibly co-incident with the above 'core counts' and/or I-WeBS 'core' counts – multiple surveys per winter season	Sep/Oct – Feb/Mar	Sep/Oct – Feb/Mar	Sep/Oct – Feb/Mar	
4. Tern Roost surveys	Mid-August to mid-September annual surveys with multiple surveys in each block	Mid-Aug to mid-Sep	Mid-Aug to mid-Sep	Mid-Aug to mid-Sep	
5. Displacement studies	Focussing on ducks and allies day and night observations of disturbance responses of waterbirds to boat traffic (including but not limited to Red-breasted Merganser)		Sep/Oct – Feb/Mar	Sep/Oct – Feb/Mar	
6. Impacts on Little Terns	April – June study to assess the effects of dredging/oyster trestle management on behaviour of Little Terns		Apr-June		
7. Impacts on GWF Geese	A study investigating the effects of dredging activity on terrestrial-foraging GWFG on the Slobs	Oct-Mar	Oct-Mar	Oct-Mar	
8. Movement/behaviour study	Telemetry study over 1+ winters of selected species – contributes to multiple objectives	Oct/Nov - Mar	Oct/Nov - Mar		
9. Studying the effects of aquaculture operations on native mussel beds	A baseline mapping study may be necessary and the importance of existing beds should be investigated. Impacts of seed on regeneration could be measured	?	?	?	
10. Development of a predictive model (for waders)	IBM implemented by ecological team incorporating data from some of the above projects but also requiring two comprehensive surveys of benthic invertebrate foods in the same season			Benthic surveys Sep/Oct and Mar/Apr	Modelling

Wexford Harbour & Slobs SPA Qualifying Interest Species including their relative ranking nationally, regionally and locally. SCI populations ranked within the top 5 in each category are highlighted. Source: NPWS (2011)

	Special Conservation Interests Species	National Importance Rank[20]	Regional Importance Rank[5]	County Importance Rank[5]
Site selection species	Bewick's Swan	2	2	2
	Whooper Swan	18	2	2
	Greenland White-fronted Goose	1	1	1
	Light-bellied Brent Goose	2	1	1
	Shelduck	4	1	1
	Teal	3	1	1
	Scaup	3	1	1
	Red-breasted Merganser	2	1	1
	Cormorant	2	1	1
	Oystercatcher	4	1	1
	Golden Plover	10	1	1
	Grey Plover	1	1	1
	Lapwing	2	1	1
	Sanderling	7	1	1
	Black-tailed Godwit	7	2	1
	Bar-tailed Godwit	2	1	1

[20] Ranking based on the relative position of the average maximum counts over the baseline period (1995/96 – 1999/00) relative to SPAs at *national* (all Irish wetland SPAs), *regional* (wetlands in the SE region as defined by the regions office) and *county* (Co. Wexford wetland SPAs) levels.

	Curlew	2	1	1
	Black-headed Gull	n/c	n/c	n/c
	Little Tern	n/c	n/c	n/c
Additional Special Conservation Interests	Wigeon	9	2	2
	Mallard	2	1	1
	Pintail	6	2	2
	Goldeneye	5	1	1
	Little Grebe	3	1	1
	Great Crested Grebe	6	1	1
	Grey Heron	4	1	1
	Hen Harrier	n/c	n/c	n/c
	Coot	8	2	2
	Knot	12	3	2
	Dunlin	13	3	2
	Redshank	14	3	1
	Lesser Black-backed Gull	n/c	n/c	n/c

Other conservation designations associated with the site	SAC	RAMSAR SITE	IMPORTANT BIRD AREA (IBA)	WILDFOWL SANCTUARY	OTHER
	Yes	Yes	Yes	Yes	

	Wexford Hbr & Slobs SCI Species	Average population size at baseline (1995/96 – 1999/00)[21]	Average population size (2004/05-2008/09)[22]	Average population size - recent (2016/17-2020/21)[23]	12-year Site trend (1995/96 - 2007/08)[24]	25-year site trend (1995/96 - 2020/21)[25]	Site Conservation Condition (1995/96 – 2007/08)	Site Conservation Condition (1995/96 – 2020/21)
Site selection species	Bewick's Swan	191	47	6	-79.7	-92.6[26]	Highly Unfavourable	Highly Unfavourable
	Whooper Swan	100	450*	425*	+193	+307	Favourable	Favourable
	Greenland White-fronted Goose	9,111*	8,703*	6,264*	-	-19.9	Intermediate (Unfavourable)	Intermediate (Unfavourable)

[21] * refers to species which occurred in internationally important numbers in Wexford at that time

[22] As per NPWS (2011), the exception being Greenland White-fronted Geese, figures for which are based on the period 2005/06 – 2009/10

[23] Latest I-WeBS site totals were accessed here: Site Summary Tables_S27 (caspio.com)

[24] From Table 4.2 NPWS (2011)

[25] Data derived from the 1995/96 baseline as shown; 2020/21 data from Site Summary Tables_S27 (caspio.com)

[26] No Bewick's Swans were recorded in 2020/21 so the latest count (for 2019/20) is used; the trend is thus for 24 years

	Light-bellied Brent Goose	1,496*	2,555*	2,078*	+50	+18.1	Favourable	Favourable
	Shelduck	753	489	425	-15.6	-47	Intermediate (Unfavourable)	Unfavourable
	Teal	1,538	1,153	438	+69.8	-81.5	Favourable	Highly Unfavourable
	Scaup	339	37	4	+14.8	-98.8	Favourable	Highly Unfavourable
	Red-breasted Merganser	209	95	131	-15	-17.7	Intermediate (Unfavourable)	Intermediate (Unfavourable)
	Cormorant	495	320	205	+45	-50.9	Favourable	Highly Unfavourable
	Oystercatcher	1,493	487	414	+5	-83.1	Favourable	Highly Unfavourable
	Golden Plover	5,013	10,915*	5,728	+39.7	-0.5	Favourable	Favourable
	Grey Plover	1,279	106	382	-45.5	-75.3	Unfavourable	Highly Unfavourable
	Lapwing	11,826	6,684	3,611	-31	-70.7	Unfavourable	Highly Unfavourable

	Sanderling	210	16	43	-2	-82.8	Intermediate (Unfavourable)	Highly Unfavourable
	Black-tailed Godwit	790*	1,379*	1,651*	+72.1	+190	Favourable	Favourable
	Bar-tailed Godwit	1,696*	967	898	-6	-67.9	Intermediate (Unfavourable)	Highly Unfavourable
	Curlew	1,771	800	883	-30.0	-48.2	Unfavourable	Unfavourable
	Black-headed Gull[27]	5,977	524	1,325	n/c	-45.5	-	-
	Little Tern	30 pairs	n/a	n/a	n/a	n/a	n/a	n/a
Additional Special Conservation Interests	Wigeon	2,752	4,067	1,190	-7.8	-64.8	Intermediate (Unfavourable)	Highly Unfavourable
	Mallard	3,290	1,255	670	-16.6	-68.3	Intermediate (Unfavourable)	Highly Unfavourable
	Pintail	66	113	24	+53	-12.1	Favourable	Intermediate (Unfavourable)

[27] Trends in gull populations need interpreted with caution as they may not be properly assessed during I-WeBS counts

	Goldeneye	182	69	43	-42.3	-87.3	Unfavourable	Highly Unfavourable
	Little Grebe	82	43	21	-13.1	-79.3	Intermediate (Unfavourable)	Highly Unfavourable
	Great Crested Grebe	117	63	113	-8.8	-49.6	Intermediate (Unfavourable)	Unfavourable
	Grey Heron	52	13	11	+45.4	-76.9	Favourable	Highly Unfavourable
	Hen Harrier	8 individuals	n/a	n/a	n/a	n/a	n/a	n/a
	Coot	351	40	3	-48	-99.4	Unfavourable	Highly Unfavourable
	Knot	453	21	83	-39.9	-44.8	Unfavourable	Unfavourable
	Dunlin	2,485	709	1,501	-61.7	+25.7	Highly Unfavourable	Favourable
	Redshank	555	298	454	+18.4	-57.6	Favourable	Highly Unfavourable
	Lesser Black-backed Gull[15]	1,086	13	5	n/c	-99.4	-	-