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Displacement and habituation of seabirds in response to marine activities (MMO 1139)

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Displacement and habituation of seabirds in response to marine activities (MMO 1139)
May 2018

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Project funded by: Marine Management Organisation

Version	Authors	Note
0.1	G Cook (Natural Power)	Iteration
0.2	C Sweeting (MMO)	Iteration comments
1.0	G Cook (Natural Power)	Draft report
1.1	C Sweeting (MMO)	Draft report comments
1.2	E Nelson (Natural Power)	Natural Power internal comments
2.0	G Cook (Natural Power)	Final report
-.-	C Graham (MMO)	MMO Quality Assurance

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This report should be cited as

MMO (2018). Displacement and habituation of seabirds in response to marine activities. A report produced for the Marine Management Organisation,. MMO Project No: 1139, May 2018, 69pp

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Executive Summary

This report aims to provide a high-level overview of current knowledge of potential disturbance impacts associated with anthropogenic marine activities upon seabird species in English territorial waters and subsequent habituation to such activities.

The two main objectives of this report are to inform:

1. The Marine Licence consenting process
2. The management of Natura 2000 sites

Activity classes and species groups included in this report are:

Activity classes	Species groups
Coastal management	Seaducks
Waste management	Divers
Extraction (living resources)	Tubenoses
Extraction (non-living resources)	Cormorants
Energy generation	Grebes
Traffic and transport	Skuas
Other activities (primarily recreation and tourism)	Auks
	Terns
	Gulls

To locate available information about displacement impacts associated with each activity class and species group, a systematic open source literature search was undertaken. To summarise the resultant aggregations of data into a useable format form, outputs from this literature search were used to compile matrices of displacement indices. Information on habitation was also extracted from the sources identified in the systematic literature search in order to compile a habituation matrix for species groups in response to each activity class.

The amount of information available relating to disturbance impacts varied considerably between activity classes and species groups. For many activity classes and for some species groups very little (or no) data were available relating to displacement. Where data were available to quantify displacement, responses were highly variable within and between activity classes and species groups.

Activity classes associated with highest displacement impacts were traffic and transport, energy generation, extraction (non-living resources) and other activities (recreation and tourism). Species groups which were generally observed to display the greatest displacement responses were divers, seaducks, grebes and cormorants.

Activity classes associated with lowest displacement impacts were coastal management, waste management and extraction (living resources). Species groups which were generally observed to display the lowest displacement responses were skuas and gulls.

The amount of information available relating to habituation responses was extremely limited for activity classes and species groups, and for most no information was available. What little data was found related to the energy generation, traffic and transport and other activities (recreation and tourism) activity classes, and the seaduck, diver, cormorant and grebe species groups.

By comparing displacement impacts with habituation, overall sensitivities of seabird species groups, to marine activity classes were determined in order to understand the potential for long-term displacement in response to these activities. Data gaps were also identified and, where possible, their priority was assessed.

Overall sensitivity values, accounting for displacement impact and potential subsequent habituation, were produced for 24 of the 63 species group/activity class combinations, with data gaps identified for the remainder.

These overall sensitivity values represent a tool for regulators to begin to consider the amount of caution to apply in decision making processes in relation to particular species and activities. The methodology presented here and the associated database provided to the MMO will allow ongoing development of this tool to incorporate new data as it becomes available whilst providing a snapshot of the current state of knowledge and an evidence-base that is widely relevant to a range of stakeholders in the offshore industry.

1. Introduction

This report aims to provide a high-level overview of current knowledge of potential disturbance impacts associated with anthropogenic marine activities upon seabird species in English territorial waters and subsequent habituation to such activities. It will also act as a conduit to the extensive underpinning literature.

The intended uses of this report include informing the Marine Licence consenting process, and also the management of Natura 2000 sites.

A wide range of marine activities occur in English territorial waters which seabird species may respond to. These activities and their specific pressures on the marine environment are considered within the Joint Nature Conservation Committee (JNCC) Activities/Pressures Matrix. This matrix has formed the foundation of this report. Through consultation with the Marine Management Organisation (MMO), a shortlist of marine activities was selected for consideration. Broadly, those activities which require Marine Licences and / or are considered within site assessments for Natura 2000 sites have been considered further within this report. These are shown in Table 1 along with their selection criteria. Activities from the JNCC Activities/Pressure Matrix which were not considered further in this report, and rationales for their exclusion, are shown in Table 24 (Annex). This report focuses upon responses to the activities component of the JNCC Activities/Pressures Matrix, but, where possible, consideration has also been given to pressures.

Table 1: Scoped in activities

Activity class	Sub-activity	Rationale for inclusion
Coastal management	Coastal defence	Elements associated with these activities may require a Marine Licence
	Coastal docks (including ports, harbours and marinas)	
Waste management	Industrial and agricultural liquid discharges	Whilst not a licensable activity the MMO may need to consider wider impacts of a project for cases falling under Environmental Impact Assessment (EIA).
	Sewage	
	Power stations (thermal and nuclear discharge)	The MMO advise the Planning Inspectorate on applications for power stations. Outflows from power stations require a Marine Licence The MMO also issue Marine Licences for maintenance and new infrastructure for projects that were consented prior to the Planning Act, 2009.
Extraction of living resources	Demersal trawling	Required to inform site assessments for Special Protection Areas (SPAs).
	Dredging	
	Pelagic trawling	

Activity class	Sub-activity	Rationale for inclusion
	Traps	
	Recreational	
	Nets (static)	
	Lines	
	Seines	
	Other	
	Harvesting – seaweed and other food	
Extraction (and disposal) of non-living resources	Aggregate extraction (sand and gravel)	Licensable activities
	Navigational dredging	
	Dredge and spoil disposal	
Energy generation (excluding cables and pipelines)	Wind	Licensable activities and the MMO provide advice to the Planning Inspectorate for developments with outputs of greater than 100MW
	Wave	
	Tidal	
	Hydrocarbon extraction	Licenced by Department for Business, Energy & Industrial Strategy. Can result in extensive activity offshore.
Transport	Shipping (at sea)	Required to inform site assessments for SPAs.
Other activities	Macro-algae production	Licensable activity
	Recreational and tourism	Required to inform site assessments for SPAs.
	Marine research	Licensable activity, except where relevant exemptions apply
	Cables and pipelines	Licensable activities, except where relevant exemptions apply (i.e. some cables do not require a Marine Licence beyond 12nm from the coast)
	Gas storage	
	Artificial reefs	
	Other man-made marine structures	

Species assessed within this report are limited to seabirds which frequently occur in English territorial waters (

Table 2). Species which frequent tidal estuarine sites (for example waders and wildfowl) are not considered in this report, nor are non-seabird species listed as designated features of coastal protected SPAs (for example bittern, *Botaurus stellaris*, or marsh harrier, *Circus aeruginosus*).

Where it was deemed relevant (i.e. particularly for sub-activities and species groups for which few references were located), consideration was also given to closely related species (such as other British *Aythya* duck species), ecologically similar species (for example, goldeneye, *Bucephala clangula* – seaduck, Leach's petrel, *Oceanodroma leucorhoa* – tubenose and little auk, *Alle alle* – auk), and similar species from outside the north-east Atlantic (such as double-crested cormorant, *Phalacrocorax auritus*, and white winged scoter, *Melanitta deglandi*).

Table 2: Scoped in species

Conservation designations: Ann I – Annex I of the Birds Directive 2009/147/EC, Sch 1.1 – Schedule 1.1 of the Wildlife and Countryside Act (1981), BoCC Red / Amber – Red / Amber list species in Birds of Conservation Concern 4 (Eaton *et al*., 2015)

Species	Latin name	Conservation designations	UK Status (Svensson, 2009)
Seaducks			
Scaup	*Aythya marila*	Sch 1.1, BoCC Red	Local **winter visitor**
Eider	*Somateria mollissima*	BoCC Amber	Fairly abundant **resident breeder**
Long-tailed duck	*Clangula hyemalis*	Sch 1.1, BoCC Red	Fairly abundant **winter visitor**
Velvet scoter	*Melanitta perspicillata*	Sch 1.1, BoCC Red	Local **winter visitor**
Common scoter	*Melanitta nigra*	Sch 1.1, BoCC Red	Rare breeder, fairly abundant **winter visitor**
Red-breasted merganser	*Mergus serrator*	-	Local breeder, fairly abundant **winter visitor**
Divers			
Red-throated diver	*Gavia stellata*	Ann I, Sch 1.1	Local breeder, fairly abundant **winter visitor**
Black-throated diver	*Gavia arctica*	Ann I, Sch 1.1, BoCC Amber	Local breeder, local **winter visitor**
Great northern diver	*Gavia immer*	Ann I, Sch 1.1, BoCC Amber	**Passage migrant** and local **winter visitor**
Tubenoses			
Fulmar	*Fulmarus glacialis*	BoCC Amber	Abundant **resident breeder**
Manx shearwater	*Puffinus puffinus*	BoCC Amber	Abundant **migrant breeder**
Balearic shearwater	*Puffinus mauretanicus*	BoCC Red	Local **passage migrant**
Storm petrel	*Hydrobates pelagicus*	Ann I, BoCC Amber	**Passage migrant** and fairly abundant **migrant breeder**
Gannet	*Morus bassanus*	BoCC Amber	Abundant **resident and migrant breeder**
Cormorants			
Cormorant	*Phalacrocorax carbo*	-	Local **resident breeder**, **passage migrant** and common **winter visitor**
Shag	*Phalacrocorax aristotelis*	BoCC Red	Fairly abundant **resident breeder**
Grebes			

Species	Latin name	Conservation designations	UK Status (Svensson, 2009)
Great crested grebe	*Podiceps cristatus*	-	Local **resident breeder**, fairly abundant **winter visitor**
Red-necked grebe	*Podiceps grisegena*	BoCC Red	Local **winter visitor**
Slavonian grebe	*Podiceps auritus*	Ann I, Sch 1.1, BoCC Amber	Rare breeder, local **winter visitor**
Black-necked grebe	*Podiceps nigricollis*	Sch 1.1, BoCC Amber	Rare breeder, local **winter visitor**
Skuas			
Arctic skua	*Stercorarius parasiticus*	BoCC Red	Local **migrant breeder** and **passage migrant**
Great skua	*Stercorarius skua*	BoCC Amber	Local **migrant breeder** and **passage migrant**
Auks			
Puffin	*Fratercula arctica*	BoCC Red	Abundant **migrant breeder**
Black guillemot	*Cepphus grylle*	BoCC Amber	Fairly abundant **resident breeder**
Razorbill	*Alca torda*	BoCC Amber	Abundant **migrant breeder**
Guillemot	*Uria aalge*	BoCC Amber	Very abundant **resident and migrant breeder**
Terns			
Little tern	*Sternula albifrons*	Ann I, Sch 1.1, BoCC Amber	Local **migrant breeder**
Sandwich tern	*Sterna sandvicensis*	Ann I, BoCC Amber	Fairly abundant **migrant breeder** and **passage migrant**
Common tern	*Sterna hirundo*	Ann I, BoCC Amber	Fairly abundant **migrant breeder** and **passage migrant**
Roseate tern	*Sterna dougalli*	Ann I, Sch 1.1, BoCC Red	Local **migrant breeder**
Arctic tern	*Sterna paradisaea*	Ann I, BoCC Amber	Fairly abundant **migrant breeder** and **passage migrant**
Gulls			
Kittiwake	*Rissa tridactyla*	BoCC Red	Abundant **migrant breeder** and **passage migrant**
Black-headed gull	*Chroicocephalus ridibundus*	BoCC Amber	Abundant **resident breeder** and very abundant **winter visitor**
Little gull	*Hydrocoloeus minutus*	Ann I, Sch 1.1,	Local **passage migrant** and **winter visitor**
Common gull	*Larus canus*	BoCC Amber	Fairly abundant **resident breeder** and abundant **winter visitor**
Lesser black-backed gull	*Larus fuscus*	BoCC Amber	Abundant breeder, **passage migrant** and **winter visitor**
Herring gull	*Larus argentatus*	BoCC Red	Abundant **resident breeder** and **winter visitor**
Great black-backed gull	*Larus marinus*	BoCC Amber	Fairly abundant **resident breeder**

To determine the amount of information available about displacement impacts associated with each activity class and sub activity for each species and species group, and to compare the relative scale of each impact, a systematic open source literature search was undertaken. To summarise the resultant, typically large, aggregations of data into a useable format form, outputs from this literature search were used to compile matrices of displacement indices. Information on habitation was also extracted from the sources identified in the systematic literature search in order to compile a habituation matrix for species groups in response to each activity class.

By comparing displacement impacts with habituation, overall sensitivities of seabird species groups, to marine activities were determined in order to understand the potential for long-term displacement in response to these activities. Data gaps were also identified and, where possible, their priority was assessed. These overall sensitivity values may be utilised by regulators to begin to consider the amount of caution to apply in decision making processes in relation to particular species and activities.

Definitions

This project uses the following definitions of critical terms:

- **Displacement:** A reduced number of birds occurring within or immediately adjacent to an area in which an anthropogenic activity is occurring or has occurred.
- **Disturbance:** Birds spending extra time and/or energy to avoid anthropogenic structures, human activity or direct outputs from human activities.
- **Avoidance**: Birds may show multiple kinds of behaviour to reduce their exposure to disturbance inducing activities. These include 'macro-avoidance' and 'micro-avoidance'. Macro-avoidance describes when birds alter their distributions and movement patterns to keep clear of the whole area in which the activity is occurring (or has occurred). Micro-avoidance describes when birds enter the area in which an activity is occurring (or has occurred) but take evasive action to avoid particular disturbance-inducing parts of that area.

These definitions are analogous to those used by Furness *et al.* (2013), but widened to incorporate all of the scoped in anthropogenic marine activities included in this review.

- **Habituation:** A reduction (or cessation) of response by birds to disturbance inducing activities; specifically (for the purpose of this review) a reduction in displacement / avoidance response.
- **Attraction:** An increased number of birds occurring within or immediately adjacent to an area in which an anthropogenic activity is occurring or has occurred.

2. Methods

Step 1 - Systematic literature search

Google Scholar was used to search for peer-reviewed published literature and 'grey' literature relating to potential displacement impacts of marine activities upon seabirds. Sixty-three standardised searches were conducted using compound search terms designed to capture literature relating to each combination of the seven activity classes (Table 1) and nine species groups (

Table 2) identified for inclusion in the report.

Each search term comprised three parts, each part separated by the Boolean operator 'AND', as shown below. Within each part, phrases were separated by the Boolean operator 'OR'. Exact search terms used are presented in Table 25 (Annex).

Impact terms	AND	Species group terms	AND	Activity class terms

Impact terms relate to the impact of interest. In all cases the words 'disturbance', 'displacement' and 'avoidance' were used. It was initially intended that separate searches would be conducted using terms relating to habituation. However, since habituation can only take place where there is prior avoidance behaviour, it was decided that this would likely yield a subset of the literature identified in the initial searches and would not provide sufficient new information to warrant the additional effort required.

Species group terms relate to the species group of interest. This part included the name of the species group (for example, 'seaduck') and the Latin family names of all of the scoped in species within that group (for example, '*Aythya*', '*Somateria*', '*Clangula*', '*Melanitta*' and '*Mergus*';

Table 2).

Activity class terms relate to the activity class of interest. This part included words or phrases relating to the activity class, including specific activities (for example, 'aggregate extraction', 'sand extraction', 'gravel extraction' and 'spoil disposal'; Table 1).

An example full search term is provided below.

disturbance OR displacement OR avoidance AND seaduck OR Aythya OR Somateria OR Clangula OR Melanitta OR Mergus AND "aggregate extraction" OR "sand extraction" OR "gravel extraction" OR "spoil disposal" OR "navigational dredging"

In order to prevent truncation of search terms by the search engine, full search terms were restricted to 260 or fewer characters.

Due to the algorithms used by Google Scholar, search terms were trialled and revised in order to minimise the number of spurious records returned, while still capturing literature of interest. Generic words and phrases were omitted where possible, and specific terms were used in their place, for example, 'sand extraction' was used instead of 'sand' OR 'extraction'. Specific alterations made to search terms during this process are listed below.

1. The term 'diver' was not used as a species group term as this term dramatically increased the number of spurious returns mostly relating to human diver surveys. In this case, the genus name *Gavia* within the compound term was assumed to capture the relevant literature.
2. The term *'Catharacta'* was added to the skua species group terms. This latin genus name was formerly used in reference to great skua, which has subsequently been reclassified to *Stercorarius* (as per BOU, 2018).
3. The term 'auk' was not used as a species group term as there is an ornithological scientific journal of that name, and consequently a great many spurious results were returned. Instead the term 'alcid' was utilised.
4. For terms used in the tern species group, the terms 'tern' and 'Sterna' were placed in quotation marks to minimise the search engine returning documents relating to similarly spelled words such as 'term' and 'turn'. Furthermore 'term' and 'turn' were included in the relevant search terms with the Boolean operator '-' used as a prefix to try to exclude any results relating to these terms.

Since Google Scholar can use user information to tailor search results, user history was cleared prior to conducting searches and repeatability of search outputs was tested across multiple users.

For each of the 63 searches, the first 100 returns were saved, except for three compound search term, for which only 73, 50 and 91 returns occurred (all of which were saved). Therefore, in total, 6,214 returns were saved.

Step 2 - Literature filtering

Once searches had been conducted, a multi-stage literature filtering process was used to select information to contribute to the assessment. The **first stage** was to review the titles of each hit to allow exclusion of any results that were unrelated to the topic area. As each search was carried out, a master list was generated and used to identify any results that had been returned from previous searches, in order to avoid future duplication of review effort. Of the 6,214 saved returns, a total of 3,577 (57.6%) unique entries were identified on the initial master list (i.e. 2,637 of the saved returns were duplicates). Of these non-duplicate entries, 528 (14.8%) were considered potentially relevant from their title.

The **second stage** of the literature filtering process was an abstract level review. Abstracts of all entries identified as having relevant titles during the first stage were reviewed in order to remove any references (such as methods papers) that would not yield useful information. For grey literature, and other items which did not contain an abstract, equivalent segments of overview text were assessed (executive summaries for example). A total of 198 entries (5.5% of non-duplicate entries) were considered potentially relevant from their abstract.

For all entries considered to have a potentially relevant abstract (or equivalent), some initial information was recorded. This included the species and activities studied, the year of publication and the geographic region covered. Where possible literature was saved to be read during the next stage of the filtering process. Where the full text was not available the reference was added to a list provided to the MMO to be obtained by them if possible

The **third stage** of the literature filtering process was to review the full text of each available entry identified as having a relevant abstract (or equivalent). This stage filtered out references that referred generally to the topic of interest but provided no information regarding the level of detail or relevance required to contribute to the assessment. A total of 58 entries (1.6% of non-duplicate entries) were found to contain extractable information when their full text was reviewed.

Step 3 - Literature scoring

For all references selected for inclusion within the assessment, relevant data were extracted and used to populate a response score database. Each reference was given a unique reference ID and the authors, publication date and title of the work were recorded. The reference was classified as a paper (i.e. peer-reviewed with original data), a review, a meta-analysis, a report or one of a number of other niche classifications such as conference proceedings. A separate field of the database was used to clarify whether or not the findings of the reference were based on primary data or were derived from a secondary source.

For each reference, a separate row of data was entered into the database for each species, sub-activity and impact (i.e. displacement or habituation) combination covered. For each row, the species, species group, activity, and sub-activity was recorded.

A response score between 0 and 2 was assigned, where 0 was used to indicate no evidence of displacement/habituation, 1 was used to indicate evidence of weak displacement or weak habituation and 2 was used to indicate evidence of strong displacement or strong habituation. Scores were based on review of any data presented in the source as well as the authors own interpretation of the magnitude of the impact.

A confidence score of between 0 and 2 was also assigned to each row and was based on the methods used to detect the impact (or lack of impact) as well as the confidence the authors convey in their own findings. For example, anecdotal comments were scored as 0 while identification of impacts with strong statistical support were scored as 2 unless the authors suggested that the results may be confounded by some other factors in which case the confidence would be scored as 1.

Where studies reported attraction of birds to activities, this was taken as evidence of no avoidance. For each row of data in the response score database, evidence of attraction was recorded as a 0 (no attraction) or a 1 (evidence of attraction).

The majority of the literature was scored by the same reviewer (approximately 88% of entries into the response score database). The remaining references were assessed by one other reviewer (approximately 12% of entries into the response score database), and where this secondary reviewer assessed references, a subset of their scores were double-checked by the primary reviewer to ensure scoring consistency.

Additional information relating to displacement or habituation was also extracted from each reference in order to contextualise identified impacts. Where information was available, data were recorded relating to conditions under which impacts occurred. These included details such as: distances from activities, seasonal effects, geographic locations where impacts did or did not occur and timescales relating to impacts (and particularly to subsequent habituation). Further details of additional information extracted and its integration into the results of the report are detailed in Step 5, below.

Step 4 - Calculation of displacement, habituation and overall sensitivity indices

Displacement and habituation indices were generated by calculating the mean of the response scores for particular species group/species and activity class/sub-activity combinations.

For **displacement indices** assessment levels were attributed based on equally spaced classes following mean value ranges:

- 0.00-0.39 – Very low (marked green)
- 0.40-0.79 – Low (marked yellow)
- 0.80-1.19 – Moderate (marked orange)
- 1.20-1.59 – High (marked red)
- 1.60-2.00 – Very high (marked dark red)

Habituation indices assessment levels were attributed on the same scale to that used for displacement. However, as a habituation response is assumed to be a beneficial/positive the colours associated with each assessment were inverted namely:

- 0.00-0.39 – Very low (marked dark red)
- 0.40-0.79 – Low (marked red)
- 0.80-1.19 – Moderate (marked orange)
- 1.20-1.59 – High (marked yellow)
- 1.60-2.00 – Very high (marked green)

Where displacement indices were assessed to be very low (or zero), the potential for subsequent habituation was assessed as NA (marked black). The rationale for this is that where there is no displacement impact, habituation cannot occur and also where impacts are very limited the ability of observers to measure subsequent habituation is very limited (this assumption was supported by the reviewed literature insofar that no references to habituation were found in relation to activities for which displacement impacts were assessed as very low).

For indices associated with species groups and activity classes (Table 6 and Table 8, below), overall confidence in the scores were calculated by summing the confidence scores for each row of data contributing the index. In this way the confidence score associated with each index reflects the confidence in each piece of data assessed, as well as the overall volume of data contributing to index value. For each index the following **confidence levels** were attributed based on summed confidence scores:

- Summed confidence scores = 0-1 – Low confidence (marked *)
- Summed confidence scores = 2-4 – Moderate confidence (marked **)
- Summed confidence scores > 4 – High confidence (marked ***)

For each index a measure of variance (one standard error of the mean) was also calculated to give an indication of the range of responses observed within the literature reviewed.

Overall sensitivity indices (Table 9, below) were calculated by combining the results of the displacement and habituation assessments as shown in Table 3.

Table 3: Conversion of Displacement and Habituation Indices into Overall Sensitivity Indices

Displacement Index	Habituation Index	Overall Sensitivity Index
No data	No data	Data gap – Unknown priority
V. low	NA	V. low
Low	No data	Data gap – Low priority (?)
	V. high	Low
	High	Low
	Moderate	Moderate
	Low	Moderate
	V. Low	High
Moderate	No data	Data gap – Moderate priority (??)
	V. high	Low
	High	Moderate
	Moderate	Moderate
	Low	High
	V. Low	High
High	No data	Data gap – High priority (???)
	V. high	Moderate
	High	Moderate
	Moderate	High
	Low	High
	V. Low	V. high
V. high	No data	Data gap – High priority (???)
	V. high	Moderate
	High	High
	Moderate	High
	Low	V. high
	V. Low	V. high

An incidental consequence of collecting information on displacement impacts was that many references to attraction were also identified. Although attraction was not included in the impact component of the search terms, these data are considered to provide useful context about non-avoidance. Attraction indices were calculated in a similar way to those for displacement and habituation, in that for given species group and activity class combinations the mean of all attraction scores were calculated however, in this case the maximum score was 1 (i.e. 1 = attraction, 0 = no attraction) (Table 7).

Step 5 – Extraction of additional information

Any data relating to spatial and temporal scales including displacement distances and seasonal effects and data relating to individual pressures were extracted from references and discussed in the text associated with the relevant activity.

Additional information extracted include further information on displacement, attraction and / or habituation for each activity class. For example:

- Displacement
    - Areas in which displacement impacts (or non-impacts) were recorded (i.e. North Sea, Baltic, Irish Sea, etc.)
    - Spatial scales at which displacement impacts occur (i.e. flushing distances, avoidance distances, areas surrounding activities in which densities are reduced, etc.)
    - Pressures resulting from activities which may lead to displacement (i.e. direct visual disturbance, indirect effects through impacts upon prey species, etc.)
    - Temporal scales at which displacement impacts occur.

- Attraction (and non-avoidance)
    - Areas and situations in which attraction was recorded (i.e. attraction of seaduck to sewage discharge in east coast UK estuaries, or various sources of information relating to attraction to fishing activities, etc.)
    - Evidence considered to constitute non-avoidance.

- Habituation
    - Temporal scales at which habituation has been recorded (or not recorded).
    - Changes in response to potential displacement inducing activities.

3. Results

Conducting systematic searches using Google Scholar was found to return a very large amount of information, however, through literature filtering, a large majority was found not to be relevant (Table 4).

Table 4: Systematic literature search returns

(n) = total number of entries considered for activity class. Typically first 100 returns extracted for each of the 9 species groups for each activity.

	Activity class						
	Coastal management	Waste management	Extraction (living resources)	Extraction (non-living resources)	Energy generation	Transport and traffic	Other activities
Initial search returns using compound search terms (total number of entries saved)	53,860 (900)	35,634 (900)	49,960 (900)	1,870 (814)	13,636 (900)	65,300 (900)	43,330 (900)
Non-duplicate titles	519	643	548	415	515	605	332
Potentially useful from titles (of non-duplicates)	33	29	109	12	218	103	24
Potentially useful from abstracts (of non-duplicates)	9	5	30	3	108	40	3
Extractable information in document text (of non-duplicates)	2	2	13	1	35	4	1

The volume (and quality) of available data relating to anthropogenic disturbance to seabirds resulting from each of the scoped in activities varied dramatically (Table 5). The activity class for which most information was available was energy generation (particularly the wind energy sub-activity), followed by transport and traffic, and, to a lesser extent, the extraction of living resources. Very few data were available in relation to other activity classes (coastal management, waste management, extraction of non-living resources), and no information was available for many of the sub-activities.

Overall, very little information was available about habituation by seabirds to human activities, and for four of the seven activity classes assessed, no information was found.

Table 5: Reference documents located per activity

Activity class	Sub-activity	Documents used for assessment for each activity (documents relating to habituation)	
Coastal management	Coastal defence	2 (0)	0
	Coastal docks		2
Waste management	Industrial and agricultural liquid discharges	4 (0)	1
	Sewage		4
	Power stations (thermal and nuclear discharge)		0
Extraction of living resources	Demersal trawling	9 (0)	NA – not possible to differentiate between sub-activities. References generic to fishery impacts.
	Dredging		
	Pelagic trawling		
	Traps		
	Recreational		
	Nets (static)		
	Lines		
	Seines		
	Other		
	Harvesting – seaweed and other food		
Extraction (and disposal) of non-living resources	Aggregate extraction (sand and gravel)	6* (0)	6*
	Navigational dredging		1
	Dredge and spoil disposal		1
	* Includes one important reference which was not located in Google Scholar searches (Cook and Burton, 2010)		
Energy generation (excluding cables and pipelines)	Wind	29 (4)	24 (4)
	Wave		3 (0)
	Tidal		2 (0)
	Hydrocarbon extraction		3 (0)
Transport and traffic	Shipping (at sea)	18 (2)	
Other activities	Macro-algae production	6 (3)	0
	Recreational and tourism		6 (3)
	Marine research		0
	Cables and pipelines		0
	Gas storage		0
	Artificial reefs		0
	Other man-made marine structures		0

Displacement indices for each species group associated with each activity class are provided in Table 6. An incidental consequence of collecting information on displacement impacts was that many references to attraction were also identified. These data are considered to provide useful context about non-avoidance and are summarised in Table 7.

Table 8 shows habituation indices for each species group in relation to each activity class.

Table 9 shows overall sensitivity indices for each species group in relation to each activity class.

Table 6: Displacement index - Species group vs Activity class

Species group		Activity class: Coastal management	Waste management	Extraction (living resources)	Extraction (non-living resources)	Energy generation	Transport and traffic	Other activities
	Seaduck	0.00* (0.00 - 0.00)	0.00** (0.00 - 0.00)	0.22*** (0.08 - 0.37)	1.38*** (1.22 – 1.53)	1.03*** (0.90 – 1.16)	1.59*** (1.51 – 1.67)	1.33*** (1.04 - 1.62)
	Diver			0.00*	1.67** (1.33 – 2.00)	1.55*** (1.42 – 1.67)	1.82*** (1.70 – 1.95)	1.00**
	Tubenose			0.00*** (0.00 - 0.00)	0.50*** (0.28 – 0.72)	1.08*** (0.94 – 1.21)	0.35*** (0.23 – 0.47)	
	Cormorant			0.00*	1.50** (1.21 – 1.79)	0.58*** (0.35 – 0.81)	1.70*** (1.55 – 1.85)	1.00*
	Grebe			0.00*	0.50** (0.00 – 1.00)	1.00*** (0.69 – 1.31)	1.21*** (1.10 – 1.33)	2.00*
	Skua			0.00*		0.27*** (0.08 – 0.47)	0.20*** (0.07 – 0.33)	
	Auk	0.00*		0.08*** (0.00 - 0.17)	1.00*** (1.00 – 1.00)	1.17*** (1.06 – 1.28)	1.04*** (1.00 – 1.08)	
	Tern			0.00** (0.00 - 0.00)	1.62*** (1.47 – 1.76)	0.42*** (0.31 – 0.54)	0.70*** (0.61 – 0.79)	
	Gull			0.00*** (0.00 - 0.00)	0.70*** (0.55 – 0.85)	0.20*** (0.15 – 0.25)	0.73*** (0.65 – 0.81)	

Impact level: No data | V. low | Low | Moderate | High | V. high

Confidence in assessment: * Low | ** Moderate | *** High

Table 7: Attraction index - Species group vs Activity class
(n) = no of references mentioning group in relation to activity

		Activity class						
		Coastal management	Waste management	Extraction (living resources)	Extraction (non-living resources)	Energy generation	Transport and traffic	Other activities
Species group	Seaduck	1.00 (2)	1.00 (6)	0.00 (9)	0.00 (8)	0.06 (35)	0.00 (36)	0.00 (9)
	Diver			0.00 (1)	0.00 (1)	0.00 (19)	0.00 (16)	0.00 (1)
	Tubenose			0.71 (7)		0.03 (37)	0.00 (14)	
	Cormorant			0.00 (1)		0.50 (12)	0.00 (8)	0.00 (1)
	Grebe			0.00 (1)		0.00 (7)	0.00 (13)	0.00 (1)
	Skua			1.00 (1)		0.18 (11)	0.00 (10)	
	Auk	0.00 (1)		0.00 (12)		0.09 (45)	0.00 (22)	
	Tern			1.00 (3)	0.00 (3)	0.23 (31)	0.00 (22)	
	Gull			1.00 (17)		0.44 (100)	0.04 (28)	

Attraction level:	No data	V. low	Low	Moderate	High	V. high

Table 8: Habituation index - Species group vs Activity class

Species group		Coastal management	Waste management	Extraction (living resources)	Extraction (non-living resources)	Energy generation	Transport and traffic	Other activities
		Activity class						
Species group	Seaduck	NA	NA	NA		0.67**	1.00**	
	Diver			NA		0.00**	0.00**	1.00*
	Tubenose			NA			NA	
	Cormorant			NA				1.00*
	Grebe			NA			1.00*	1.00*
	Skua			NA		NA	NA	
	Auk	NA		NA				
	Tern			NA				
	Gull			NA		NA		

Habituation ability:	No data	NA	V. high	High	Moderate	Low	V. low

Confidence in assessment:	* Low	** Moderate	*** High

Table 9: Overall sensitivity index - Species group vs Activity class

Species group	Coastal management	Waste management	Extraction (living resources)	Extraction (non-living resources)	Energy generation	Transport and traffic	Other activities
Seaduck	V. low	V. low	V. low	Unknown ???	High	High	Unknown ???
Diver	Unknown	Unknown	V. low	Unknown ???	V. high	V. high	Moderate
Tubenose	Unknown	Unknown	V. low	Unknown ?	Unknown ??	V. low	Unknown
Cormorant	Unknown	Unknown	V. low	Unknown ???	Unknown ?	Unknown ???	Moderate
Grebe	Unknown	Unknown	V. low	Unknown ?	Unknown ??	High	High
Skua	Unknown	Unknown	V. low	Unknown	V. low	V. low	Unknown
Auk	V. low	Unknown	V. low	Unknown ??	Unknown ??	Unknown ??	Unknown
Tern	Unknown	Unknown	V. low	Unknown ???	Unknown ?	Unknown ?	Unknown
Gull	Unknown	Unknown	V. low	Unknown ?	V. low	Unknown ?	Unknown

Sensitivity level: V. low | low | Moderate | High | V. high

Data gap priority: Unknown | ? low | ?? Moderate | ??? High

As regulatory decisions are usually applied at activity class or sub-activity level a more detailed consideration including wider contextual information is provided in the following sections for each activity class.

Coastal management

Displacement, attraction and non-avoidance

Very few data were available relating to the displacement impacts of coastal management activities on seabirds. Data which were available related to seaduck and auk, both of which were not considered to be displaced by coastal management activities. However, confidence in these assessments is low (Table 6). In fact, there was evidence that seaduck are attracted to coastal management activities but no such behaviour was detected for auks (Table 7).

All available data related to the coastal docks sub-activity (this includes ports, harbours and marinas), and no information describing displacement impacts on target seabird species associated with coastal defence works was found (Table 5). Species identified in relevant literature were black guillemot, pochard, *Ayatha farina*, and tufted duck, *A. fuligula*. Whilst the latter two species are not scoped in species (

Table 2), both are in the same genus as scaup (
Table 10).

As many seabird species distributions are primarily pelagic outside of periods in their breeding seasons, it is unsurprising that limited information is available about the interactions of these species with coastal activities. Such species include tubenoses, skuas, auks (excluding black guillemot) and kittiwake.

Further information on attraction

Marsden and Bellamy (2000) reported on the attraction of wintering pochard and tufted duck to a very polluted and busy dockland in western England (Manchester), though attraction to such habitats may be considered a consequence of the presence of foraging resources (such as sewage and other waste discharges) at those sites.

Black guillemots are known to nest in areas with high and predictable levels of anthropogenic disturbance such as ports and ferry terminals (Greenwood, 2002 – mentioned in Johnston *et al*., 2018). This was considered to be non-avoidance of such coastal management activities.

Habituation

There were no data available regarding habituation of seabirds to coastal defence activities (Table 8). For seaduck and auk, this may be due to the lack of displacement effect, but this area is generally understudied and may require further investigation.

Overall sensitivity

Overall sensitivities to coastal defence were classified as very low for seaduck and auk (Table 9). In both cases the lack of information relating to habituation was considered unlikely to influence the sensitivity assessment (the potential for habituation is very limited where there is a very low displacement impact). For all other species groups sensitivities could not be calculated, and information gaps of unknown priority were identified.

Table 10: Coastal management displacement index - Species vs Sub-activity

Species group	Species	Coastal management			
		Coastal defence		Docks	
Seaduck	Scaup				
	Eider				
	Long-tailed duck				
	Common scoter				
	Velvet scoter				
	Red-breasted merganser			0.00	
Diver	Red-throated diver				
	Black-throated diver				
	Great northern diver				
Tubenose	Fulmar				
	Manx shearwater				
	Balearic shearwater				
	Storm petrel				
	Gannet				
Cormorant	Cormorant				
	Shag				
Grebe	Great crested grebe				
	Red-necked grebe				
	Slavonian grebe				
	Black-necked grebe				
Skua	Arctic skua				
	Great skua				
Auk	Puffin				
	Black guillemot				0.00
	Razorbill				
	Guillemot			0.00	
Tern	Little tern				
	Sandwich tern				
	Common tern				
	Roseate tern				
	Arctic tern				
Gull	Kittiwake				
	Black-headed gull				
	Little gull				
	Common gull				
	Lesser black-backed gull				
	Herring gull				
	Great black-backed gull				

Impact level:	No data	V. low	Low	Moderate	High	V. high

Waste management

Displacement, attraction and non-avoidance

Very few data were available relating to displacement impacts of waste management activities on seabirds. Data which were available related to seaduck, which were not considered to be displaced by waste management activities, and confidence in this assessment is moderate (Table 6). In fact, there was evidence that seaduck are attracted to waste management activities (Table 7).

Most available data related to the sewage discharge sub-activity, and one related to the industrial and agricultural liquid discharge sub-activity (Table 5). No information describing displacement impacts on target seabird species associated with power station discharges was found. Species identified in relevant literature were pochard, tufted duck, goldeneye, a coastally occurring diving duck species and Scaup (Table 11).

Further information on attraction

Marsden and Bellamy (2000) reported on the attraction of wintering pochard and tufted duck to a very polluted and busy dockland in western England (Manchester), and attraction to such habitats is considered a consequence of the presence of foraging resources (such as sewage and other waste discharges) at those sites.

Several of the references identified also mentioned wintering seaduck (specifically scaup and goldeneye) associating with sewage and/or other waste discharges in North Sea estuaries (Kalejta-Summers and Butterfield, 2013; Campbell and Milne, 1977; Pounder, 1976).

Habituation

There were no data available regarding habituation of seabirds to waste management (Table 8). For seaduck, this may be due to the lack of displacement effect, but this area is generally understudied and may require further research.

Overall sensitivity

Overall sensitivities to waste management were classified as very low for seaduck (Table 9). In this case the lack of information relating to habituation was considered unlikely to influence the sensitivity assessment (the potential for habituation is very limited where there is a very low displacement impact). For all other species groups sensitivities could not be calculated, and information gaps of unknown priority were identified.

Table 11: Waste management displacement index - Species vs Sub-activity

Species group	Species	Waste management					
		Industrial and agricultural liquid discharges		Sewage		Power stations (thermal and nuclear discharge)	
Seaduck	Scaup	0.00	0.00	0.00	0.00		
	Eider						
	Long-tailed duck						
	Common scoter						
	Velvet scoter						
	Red-breasted merganser						
Diver	Red-throated diver						
	Black-throated diver						
	Great northern diver						
Tubenose	Fulmar						
	Manx shearwater						
	Balearic shearwater						
	Storm petrel						
	Gannet						
Cormorant	Cormorant						
	Shag						
Grebe	Great crested grebe						
	Red-necked grebe						
	Slavonian grebe						
	Black-necked grebe						
Skua	Arctic skua						
	Great skua						
Auk	Puffin						
	Black guillemot						
	Razorbill						
	Guillemot						
Tern	Little tern						
	Sandwich tern						
	Common tern						
	Roseate tern						
	Arctic tern						
Gull	Kittiwake						
	Black-headed gull						
	Little gull						
	Common gull						
	Lesser black-backed gull						
	Herring gull						
	Great black-backed gull						

Impact level:	No data	V. low	Low	Moderate	High	V. high

Extraction (living resources)

Displacement, attraction and non-avoidance

A moderate amount of data (compared to other activity classes) were available relating to the displacement impacts of extraction of living resources (fishing activities – no data were identified relating to other forms of harvesting) on seabirds. Data were available for all species groups, and displacement impacts were, in all cases, considered to be very low or zero (Table 6). Confidence in these assessments varied between groups: low for divers, cormorants, grebes and skuas, moderate for terns, and high for seaduck, tubenoses, auks and gulls.

Most references within this activity class did not specify a sub-activity (reference was made to fishing activity, but not necessarily which type of fishing activity; Table 5). Only for two species groups were any (non-zero) impacts identified; namely seaduck and auk (

Table 14).

Many of the references within this activity class related to attraction (i.e. utilisation of fishery discards or longline fishery bycatch; Table 7 and

Table **12**). Species groups considered to show high or very high levels of attraction to fishing activities were tubenoses, skuas, terns and particularly gulls. No evidence of attraction to fishing activities was noted for any of the other species groups, however many species are regularly reported as bycatch in fishing activities, and this was considered to constitute evidence of non-avoidance (

Table **13**).

Further information on displacement

The presence of fishing vessels may have resulted in some displacement of wintering common scoter and velvet scoter flocks in the southern North Sea (Tasker *et al*., 2000), and more guillemots were located in areas which were not being utilised by sandeel fisheries in the North Sea (Wright and Begg, 1997). One study from the Irish Sea noted that, although common scoter appeared to have been displaced from areas of apparently suitable habitat experiencing high levels of shipping activity, such effects were not noted for areas with high levels of fishing activity (Kaiser *et al*., 2006).

Further information on attraction and non-avoidance

The primary reference identified relating to seabird attraction to (and non-avoidance of) marine fishing activities was a review by Tasker *et al*. (2000). Further information on attraction and non-avoidance is provided in Table 12 and Table 13.

Table 12: Incidental evidence of attraction to fishing activities (Extraction - living resources)

Species	Fishery	Reference
Fulmar	Primary avian bycatch in north-east Atlantic longline fishery - i.e. attraction to longline bait necessary for birds to be caught	Tasker *et al*. (2000)
Fulmar, gannet, great skua, kittiwake, black-headed gull, common gull, lesser black-backed gull, herring gull, great black-backed gull	Primary species reported as attracted to fishery discards in the North Sea	Tasker *et al*. (2000)
Black headed gull, common gull, herring gull and great black-backed gull	Primary species reported as attracted to fishery discards in the Baltic Sea	Tasker *et al*. (2000)
Balearic shearwater	Reported as attracted to fishery discards in the Mediterranean Sea	Bartumeus *et al*. (2010)
Gannet	Satellite tracking studies show strong interaction with fishing vessels	Bodey *et al*. (2014)
Lesser black-backed gull, herring gull	Reported as attracted to fishery discards in the North Sea	Camphuysen (1995)
Common tern	Attracted to trawl fishery discards in coastal waters in south-west Atlantic (Brazil)	Traversi and Vooren (2010)
Sandwich tern, common tern	Reported to extensively exploit discards in the Mediterranean Sea	Bicknell *et al*. (2013)
Lesser black-backed gull	Satellite tracking study – extent of use of discards varies between individuals	Tyson *et al*. (2015)
Common gull, herring gull, great black-backed gull	Reported to commonly take discards from fishery vessels in the Baltic Sea.	Skov *et al.* (2011)

Table 13: Incidental evidence of non-avoidance of (but not attraction to) fishing activities (Extraction - living resources)

Species	Fishery	Reference
Gannet, guillemot, razorbill, black guillemot, puffin	Frequent avian bycatch in north-west Atlantic gillnet fishery	Tasker *et al*. (2000)
Guillemot	Frequent bycatch in Norwegian gillnet fishery	Tasker *et al*. (2000)
Eider, common scoter, velvet scoter, long-tailed duck, guillemot, razorbill	Frequent bycatch in Baltic fixed net fishery	Tasker *et al*. (2000)
Guillemot, razorbill	Frequent bycatch in British gillnet fishery	Tasker *et al*. (2000)
Guillemot	Frequent bycatch in British sandeel trawl fishery	Tasker *et al*. (2000)
Gannet, cormorant	Very frequently entangled in / carrying fisheries paraphernalia (non-avoidance)	Tasker *et al*. (2000)
Seaducks (particularly long-tailed duck), divers, grebes and auks	Frequent bycatch in Baltic gillnet fishery	Skov *et al*. (2011)

Habituation

There were no data available regarding habituation of seabirds to the extraction of living resources (Table 8).

Overall sensitivity

Lack of information relating to habituation was, however, considered unlikely to influence the sensitivity assessment (the potential for habituation is very limited where there is a very low displacement impact or attraction) and, consequently, overall sensitivities to the extraction of living resources were classified as very low for all species groups (Table 9).

Notes on extraction (living resources)

Overlap with other activities

As activities involving the extraction of living resources typically are conducted from vessels (i.e. fishing from fishing boats), it was not possible to entirely separate the impacts associated with these extraction activities from impacts resulting from vessel activity (i.e. traffic and transport).

Displacement effects attributed to the extraction (living resources) activity class, where possible, primarily relate to impacts associated with the extraction process (i.e. the fishing activities) rather than the transit of fishing vessels as they move to, from and about fishing sites. A more complete impression of the displacement associated with the extraction of living resources may be obtained by additively considering extraction (living resources) impacts with traffic and transport impacts.

Impacts not considered

The potentially very-long term trophic consequences of the extraction of living resources is not addressed in this document. How human removal of prey species (or predators, prey or competitors etc. of prey species) is linked with the distribution of avian predators was considered outside the scope of this report.

Table 14: Extraction (living resources) displacement index - Species vs Sub-activity

Species group	Species	Extraction (living resources)	
Seaduck	Scaup		
	Eider		0.00
	Long-tailed duck		0.00
	Common scoter		0.33
	Velvet scoter		0.50
	Red-breasted merganser	0.22	
Diver	Red-throated diver		
	Black-throated diver		
	Great northern diver	0.00	
Tubenose	Fulmar		0.00
	Manx shearwater		
	Balearic shearwater		0.00
	Storm petrel		
	Gannet	0.00	0.00
Cormorant	Cormorant		0.00
	Shag	0.00	
Grebe	Great crested grebe		
	Red-necked grebe		
	Slavonian grebe		
	Black-necked grebe	0.00	
Skua	Arctic skua		
	Great skua	0.00	0.00
Auk	Puffin		0.00
	Black guillemot		0.00
	Razorbill		0.00
	Guillemot	0.08	0.17
Tern	Little tern		
	Sandwich tern		0.00
	Common tern		0.00
	Roseate tern		
	Arctic tern	0.00	
Gull	Kittiwake		0.00
	Black-headed gull		0.00
	Little gull		
	Common gull		0.00
	Lesser black-backed gull		0.00
	Herring gull		0.00
	Great black-backed gull	0.00	0.00

Impact level:	No data	V. low	Low	Moderate	High	V. high

Extraction (non-living resources)

Displacement, attraction and non-avoidance

A moderate amount of data (compared to other activity classes) were available relating to the displacement impacts of extraction of non-living resources (aggregate removal, dredging and spoil disposal) on seabirds. Data which were available related to all species groups except skuas. Divers and terns were assessed as experiencing very high displacement impacts from these extraction activities; seaducks and cormorants high impacts, auks moderate impacts, and tubenoses, grebes and gulls low impacts (Table 6). Confidence in these assessments was high for seaducks, tubenoses, auks, terns and gulls, and moderate for divers, cormorants and grebes.

There were no specific references to attraction relating to these extraction activities (Table 7). However Cook and Burton (2010) state that "It is conceivable that dredging activity may, at least initially, attract some seabirds to an area".

Most available data identified by the systematic literature search related to the aggregate extraction sub-activity, one related to the navigational dredging sub-activity, and one related to the spoil disposal sub-activity (Table 5). Species identified in relevant literature were common scoter, long-tailed duck, red-breasted merganser, red-throated diver, sandwich tern, common tern and arctic tern. However, one highly relevant grey literature reference (of which the authors were previously aware) relating to the aggregate extraction sub-activity, was not captured during the systematic literature search process. Indeed the report in question (Cook and Burton, 2010), was not found in Google Scholar when its exact title was entered as a single search term. Given the large volume of relevant extractable data about displacement impacts contained within this report, it was decided to incorporate this reference when calculating displacement indices (Table 6) and overall sensitivity indices (Table 9). Cook and Burton (2010) provides a very thorough review of impacts of aggregate extraction on seabirds in a UK context, and contains information relating to a wide range of species (included in

Table 16).

Further information on displacement

Long-tailed duck in the Baltic were identified as being susceptible to experiencing displacement as a consequence of aggregate extraction, navigational dredging and spoil disposal (all of the sub-activities within the extraction of non-living resources activity class; Hearn *et al.*, 2015). Aggregate extraction activities were also identified as resulting in displacement impacts upon *Aythya* ducks (scaup and tufted duck) during the breeding and moulting seasons on an Icelandic large freshwater lake (Einarsson and Magnusdottir, 1992). The same study identified no such displacement impacts upon red-breasted merganser. Another *Aythya* species (pochard) was noted not to occur in winter on waterbodies at which gravel extraction was actively occurring during a study at a gravel pit complex in southern England.

No data relating to **spatial scales** associated with displacement impacts on particular species or species groups were identified in the reviewed literature. Cook and Burton (2010), however, hypothesise that although some aspects associated with displacement may be relatively local in their effects (i.e. direct disturbance and on-site seabed changes), the moderate term trophic consequences resulting from sediment plumes generated by extraction activities could result in displacement impacts for distances up to 10km.

Cook and Burton (2010) also estimate sensitivities of species to displacement by aspects of extraction activities which may act at different **temporal scales**. Namely short-term direct displacement consequences associated with avoidance of extraction activities, and longer-term (often years) indirect displacement consequences associated with trophic changes. The estimated importance of each aspect for each species is shown in Table 15.

Table 15: Species sensitivities of two components of potential displacement impacts associated with aggregate extraction activities (Cook and Burton, 2010)

Species	Sensitivity to displacement impact	
	Direct disturbance associated with dredging activities	Indirect impacts on fish and benthic communities
Eider	Moderate	Low
Long-tailed duck	Moderate	Low
Common Scoter	Very high	High
Velvet scoter	Very high	High
Red-throated diver	High	Moderate
Manx shearwater	Low	Very low
Storm petrel	Low	Very low
Gannet	Low	Very low
Cormorant	High	Low
Shag	High	Moderate
Slavonian grebe	Moderate	Very low
Black-headed gull	Low	Low
Lesser black-backed gull	Low	Very low
Herring gull	Low	Very low
Great black-backed gull	Low	Very low

Species	Sensitivity to displacement impact	
	Direct disturbance associated with dredging activities	Indirect impacts on fish and benthic communities
Kittiwake	Low	Low
Little tern	Low	High
Sandwich tern	Low	Very high
Common tern	Low	High
Roseate tern	Low	Very high
Arctic tern	Low	Very high
Guillemot	Moderate	Moderate
Razorbill	Moderate	Moderate
Puffin	Moderate	Moderate

Some species, such as terns, which are assumed to have relatively low sensitivities to short-term, direct disturbance impacts, are considered to be particularly sensitive to potentially longer term indirect impacts on fish and benthic communities. Conversely other species, such as cormorants, which are considered relatively sensitive to short-term direct displacement impacts, may have relatively low sensitivities to longer-term indirect impacts.

Habituation

There were no data available regarding habituation of seabirds to the extraction of non-living resources (Table 8).

Overall sensitivity

Sensitivity indices could not be attributed to any of the species groups. As displacement impacts were considered to be high or very high for seaduck, divers, cormorants and terns these species groups were considered to represent information gaps of high priority (Table 9). As displacement impacts on auks were assessed as moderate, this species group was identified as an information gap of moderate priority. Tubenoses, grebes and gulls (low displacement impacts) were identified as low priority information gaps. For skuas an information gap of unknown priority was identified.

Table 16: Extraction (non-living resources) displacement index - Species vs Sub-activity

Species group	Species	Extraction (non-living resources)					
		Aggregate extraction (sand and gravel)		Navigational dredging		Dredge and spoil disposal	
Seaduck	Scaup					1.00	
	Eider		1.00				
	Long-tailed duck		1.00		1.00		1.00
	Common scoter		2.00				
	Velvet scoter		2.00				
	Red-breasted merganser	1.43	0.00	1.00			
Diver	Red-throated diver		1.67				
	Black-throated diver						
	Great northern diver	1.67					
Tubenose	Fulmar						
	Manx shearwater		0.50				
	Balearic shearwater						
	Storm petrel		0.50				
	Gannet	0.50	0.50				
Cormorant	Cormorant		1.50				
	Shag	1.50	1.50				
Grebe	Great crested grebe						
	Red-necked grebe						
	Slavonian grebe		0.50				
	Black-necked grebe	0.50					
Skua	Arctic skua						
	Great skua						
Auk	Puffin		1.00				
	Black guillemot						
	Razorbill		1.00				
	Guillemot	1.00	1.00				
Tern	Little tern		1.50				
	Sandwich tern		1.67				
	Common tern		1.67				
	Roseate tern		1.50				
	Arctic tern	1.62	1.67				
Gull	Kittiwake		1.00				
	Black-headed gull		1.00				
	Little gull						
	Common gull						
	Lesser black-backed gull		0.50				
	Herring gull		0.50				
	Great black-backed gull	0.70	0.50				

Impact level:	No data	V. low	Low	Moderate	High	V. high

Energy generation

Displacement, attraction and non-avoidance

A large amount of data (compared to other activity classes) were available relating to the displacement impacts of energy generation activities on seabirds. Data were available for all species groups, and assessed overall displacement impacts varied markedly between groups (Table 6); very low for skuas and gulls, low for cormorants and terns, moderate for seaducks, tubenoses, grebes and auks, and high for divers. Confidence of assessed displacement impact levels was high for all species groups.

Some of the references within this activity class related to attraction (Table 7). Species groups considered to moderate levels of attraction to energy generation activities were cormorants and gulls. Low levels of attraction were also noted for terns. No, or very low, evidence of attraction to energy generation activities was noted for the other species groups.

Most available data (74.2%) related to the wind energy sub-activity, with smaller proportions informing about potential displacement impacts associated with wave energy (11.5%), tidal energy (10.9%), and hydrocarbon extraction (3.4%) (Table 17). All of the target species identified in

Table 2, excluding red-necked grebe, black-necked grebe and Balearic shearwater, were referenced in identified literature relating to displacement impacts of energy generation activities (
Table 19). For wind, wave and tidal energy sub-activities all species groups were represented in the literature reviewed (Table 17). However for hydrocarbon extraction, the smaller amount of literature found related only to tubenoses, cormorants, auks and gulls (Table 17).

Table 17: Breakdown of data available for energy generation by sub-activity, and then by species group

	Proportion of data within activity class per sub-activity			
	Wind energy generation	Wave energy generation	Tidal energy generation	Hydrocarbon extraction
	74.2%	11.5%	10.9%	3.4%
Proportion of data within sub-activity per species group				
Seaduck	11.3%	13.5%	14.3%	-
Diver	7.1%	8.1%	8.6%	-
Tubenose	11.7%	10.9%	11.5%	36.3%
Cormorant	2.9%	5.4%	5.7%	9.1%
Grebe	1.3%	5.4%	5.7%	-
Skua	2.9%	5.4%	5.7%	-
Auk	13.4%	18.9%	17.1%	27.3%
Tern	9.6%	13.5%	14.3%	-
Gull	39.8%	18.9%	17.1%	27.3%

Further information on displacement

For species and species groups where displacement impacts were noted in response to offshore wind farms, several studies provided information relating to the **spatial scale of displacement** (Table 18). Displacement effect ranges of 1.5km (little gull) to 6km (divers – possibly up to 13km) were cited in the literature identified. However, impact scales may be site-specific for given species/species groups. For example, at two Danish offshore wind farms measurable displacement impacts out to 4km were recorded for guillemots/razorbills (Petersen *et al*. 2006), yet at a wind farm in an estuarine site on the west coast of the UK no displacement impacts were recorded at any of the spatial scales studied (Vallejo *et al*., 2017).

Table 18: Spatial scales of displacement in relation to offshore wind farms

Species/ species group	Area	Displacement impact range	Reference
Long-tailed duck	Nysted Wind Farm, south-west Baltic, Denmark	2km	Petersen *et al*., 2006
Common scoter	Horns Rev Wind Farm, south-east North Sea, Denmark	Not specified, but limited as large groups reportedly frequently recorded close to wind farm.	Petersen *et al*., 2006
Divers	Horns Rev Wind Farm, south-east North Sea, Denmark	2km	Petersen *et al*., 2006
Divers	Selected Baltic and North Sea wind farms	2-4km	Diershke and Garthe, 2006
Divers	Alpha Ventus Wind Farm, south-east North Sea, Germany	1.5-2km	Welcker and Nehls, 2016
Divers	Lincolnshire Wind Farm, south-west North Sea, UK	2-6km	Webb *et al*., 2015 – summarised by Welcker and Nehls, 2016
Divers	Horns Rev II Wind Farm, south-east North Sea, Denmark	Statistical effect up to 13km, authors suggest effect up to 5-6km	Petersen *et al*., 2014 – summarised by Welcker and Nehls, 2016
Divers	Thanet Wind Farm, , south-west North Sea, UK	0km	Percival, 2013 – summarised by Welcker and Nehls, 2016
Red-throated diver	Kentish Flats Wind Farm, south-west North Sea, UK	2km during construction and operation	Percival, 2010 – summarised by Petersen and Fox, 2013
Auks	Alpha Ventus Wind Farm, south-east North Sea, Germany	Displacement impacts out to 2.5km	Welcker and Nehls, 2016
Auks	Lincolnshire Wind Farm, south-west North Sea, UK	4km	Webb *et al*., 2015 – summarised by Welcker and Nehls, 2016

Species/ species group	Area	Displacement impact range	Reference
Guillemot/razorbill	Nysted Wind Farm, south-west Baltic, Denmark and Horns Rev Wind Farm, south-east North Sea, Denmark	Strong displacement impacts out to 4km	Petersen *et al*., 2006
Guillemot	Robin Rigg Wind Farm, Solway Firth, Irish Sea, UK	No displacement	Vallejo *et al*., 2017
Little gull	Alpha Ventus Wind Farm, south-east North Sea, Germany	Displacement impacts out to 1.5km	Welcker and Nehls, 2016

Several studies also made reference to pronounced **macro-avoidance** by seabird species in response to offshore wind farms. At Nysted Wind Farm, Denmark, radar tracking of eiders demonstrated strong avoidance of the turbine area (Desholm and Kahlert, 2005), and analogous barrier effects have also been noted for other seaduck species (common and velvet scoter – Dierschke and Garthe, 2006). Very strong macro-avoidance has also been noted for gannet around several operational wind farms in the Belgian North Sea (Thorntonbank and Bligh Bank; Vanermen *et al*., 2013), with birds appearing to avoid areas within 3km of the wind farm sites.

One identified reference (Larsen and Guillemette, 2007) concluded that visual impacts, rather than noise, associated with offshore wind farms may play an important role in causing displacement effects. In the case of this study, eider ducks at Tuno Knob Wind Farm, Denmark, were displaced by non-turning (silent) turbines to the same extent as by turning (non-silent) turbines.

Further information on attraction and non-avoidance

Wind energy

Most information relating to attraction to offshore wind farms was derived from monitoring construction and operation of those wind farms, and is incorporated into Table 7. An interesting source of additional information derives from satellite tracking studies of lesser black-backed gulls breeding in south-east England. Breeding adults were observed to display attraction to offshore wind farms, but the extent of this attraction was variable between individuals and years (Thaxter *et al*. 2014). More specifically, lesser black-backed gulls have been shown to preferentially utilise particular areas within offshore wind farms, potentially avoiding areas immediately adjacent to turbines (macro-scale attraction, but meso-scale avoidance; Thaxter *et al*., 2018).

Wave and tidal energy

Cameras attached to wave energy test devices in the Pentland Firth, Scotland, have recorded black guillemots and kittiwakes resting / perching on these structures (Lees *et al*., 2014). This is consistent with data from tracking studies of black guillemots showing them using man-made structures in tidal areas for resting between foraging bouts (Owen, 2015). Whether these studies constitute evidence of potential attraction to wave or tidal energy devices is debatable, however both provide support that those species are not avoiding the energy generation infrastructure.

Hydrocarbon extraction activities
No information was located relating to attraction to hydrocarbon extraction activities in the UK or European waters, or relating to any of the species scoped in to this report. One reference mentioned nocturnal attraction to oil rigs in the Canadian Arctic involving related species (Leach's storm petrel and little auk; Diershke and Garthe, 2006).

Habituation

Few data were available regarding habituation of seabirds to energy generation activities, all relating seaducks or divers (Table 8), and all to wind energy. Seaducks were assessed as displaying a low habituation response to energy generation activities, and divers as displaying a very low habituation response.

Further information on habituation

Evidence of habituation (and non-habituation) by seaducks to displacement by offshore wind farms comes from long-term monitoring studies at several Danish sites:

- Following a drop off in abundance around the constrauction period of Tuno Knob Wind Farm, eider numbers increased again within the windfarm area two years after construction (Drewitt and Langston, 2006). This may have been a consequence of habituation to the development, although population level effects may also be implicated in observed trends.
- Similarly, after an initial period of strong avoidance, common scoter densities increased within Horns Rev Wind Farm (to be equal with densities outside the wind farm) five years after its construction (Leonhard *et al.*, 2013).
- In contrast, when the distributions of long-tailed duck were studied around Nysted Wind Farm five years after its construction, no evidence of habituation was noted (Petersen et al., 2006).

Evidence of non-habituation by red throated divers was found at Kentish Flats Wind Farm in England (Percival, 2010 – summarised by Petersen and Fox, 2013).

Overall sensitivity

Due to their apparently high sensitivity to displacement by energy generation activities and low habitiuation ability to such activities, the overall sensitivities of seaduck to energy generation was assessed as high (Table 9). Similarly, divers, which were very sensitive to displacement and assessed as having very low habituation abilities were considered to have very high overall sensitivities. For skuas and gulls, a lack of information relating to habituation was considered unlikely to influence the overall sensitivity assessment (the potential for habituation is very limited where there is a very low displacement impact) and, consequently, overall sensitivities to energy generation activities were classified as very low for those species groups. Due to apparently low displacement impacts, and no available information relating to habituation, overall sensitivities for cormorants and terns were identified as low priority information gaps. Due to apparently moderate displacement impacts, and no available information relating to habituation, overall sensitivities for tubenoses, grebes and auks were identified as moderate priority information gaps.

Table 19: Energy generation displacement index - Species vs Sub-activity

Species group	Species	Energy generation							
		Wind		Wave		Tidal		Oil & Gas	
Seaduck	Scaup	1.17	0.00	0.80	1.00	0.60	0.00		0.00
	Eider		1.25		1.00		1.00		
	Long-tailed duck		1.60		0.00		0.00		
	Common scoter		1.25		1.00		1.00		
	Velvet scoter		1.00		1.00		1.00		
	Red-breasted merganser		0.50						
Diver	Red-throated diver	1.75	1.50	1.00	1.00	1.00	1.00		
	Black-throated diver		2.00		1.00		1.00		
	Great northern diver				1.00		1.00		
Tubenose	Fulmar	1.29	0.70	0.50	0.00	0.50	0.00	0.75	1.00
	Manx shearwater		1.00		1.00		1.00		
	Balearic shearwater								
	Storm petrel				0.00		0.00		1.00
	Gannet		1.60		1.00		1.00		
Cormorant	Cormorant	0.14	0.00	1.00	1.00	2.00	2.00	0.00	
	Shag		0.00		1.00		2.00		0.00
Grebe	Great crested grebe	1.33	1.33	0.50	0.00	1.00	1.00		
	Red-necked grebe								
	Slavonian grebe				1.00		1.00		
	Black-necked grebe								
Skua	Arctic skua	0.43	0.00	0.00	0.00	0.00	0.00		
	Great skua		0.60		0.00		0.00		
Auk	Puffin	1.34		0.57	1.00	1.33	1.00	0.33	1.00
	Black guillemot		1.00		0.33		1.00		
	Razorbill		1.11		1.00		2.00		
	Guillemot		1.36		1.00		2.00		
Tern	Little tern	0.30	0.00	1.00	1.00	0.40	1.00		
	Sandwich tern		0.11		1.00		1.00		
	Common tern		0.00		1.00		0.00		
	Roseate tern				1.00		0.00		
	Arctic tern		0.00		1.00		0.00		
Gull	Kittiwake	0.23	0.45	0.00	0.00	0.00	0.00	0.00	0.00
	Black-headed gull		0.00		0.00		0.00		
	Little gull		0.56						
	Common gull		0.21		0.00		0.00		
	Lesser black-backed gull		0.24		0.00		0.00		
	Herring gull		0.00		0.00		0.00		
	Great black-backed gull		0.00		0.00		0.00		

Impact level:	No data	V. low	Low	Moderate	High	V. high

Transport and traffic

Displacement, attraction and non-avoidance

A large amount of data (compared to other activity classes) were available relating to the displacement impacts of traffic and transport activities on seabirds. Displacement responses varied among species groups (Table 6), and confidence in assessment values was high for all species groups. Overall, there is strong support for a very high displacement impacts of traffic and transport on the diver and cormorant species groups. Seaducks and grebes display high displacement impacts in relation to transport and traffic activities, auks moderate impacts, gulls and terns low impacts, and tubenoses and skuas very low displacement impacts.

Much of the data identified in relation to displacement to seabirds by transport and traffic were sensitivity indices of species to disturbance by ship traffic. Indices from five reviews were incorporated. These indices (rescaled) are presented in Table 26, Annex.

None of the references identified related to attraction effects associated with transport and traffic, except one for gulls (Table 7).

Information relating to displacement impacts associated with transport and traffic was found for all species groups, and all species except black-necked grebe (Table 21).

Further information on displacement

For species and species groups where displacement impacts were noted in response to transport and traffic, several studies provided information relating to the **spatial scale of displacement** (Table 20). Displacement effect ranges of 0.2km (eider) to 2km (common scoter) were cited in the literature identified. However impact scales may be site-specific or variable within species or species groups. For example, great northern divers in a busy bay on the west coast of Ireland display very low flush response ranges (<100m) (Gittings *et al*., 2015), which were markedly different with estimates derived from other sites (>1,000m) (Topping and Petersen, 2011).

Table 20: Spatial scales of displacement in relation to transport and traffic

Species/ species group	Area	Displacement impact range	Reference
Eider	Regularly used high speed ferry route in the Baltic Sea	Displaced within 500 - 1,000m of ferry route	Larsen and Laubek, 2005
Common scoter	Regularly used high speed ferry route in the Baltic Sea	Displacement over 1,000m from ferry route	Larsen and Laubek, 2005
Common scoter	Irish Sea	Flushing distances 1,000 – 2,000m from vessels	Kaiser *et al*., 2006
Common scoter	German parts of North Sea and Baltic Sea	Median flushing distance 804m from vessels	Schwemmer et al., 2011
Velvet scoter	German parts of North Sea and Baltic Sea	Median flushing distance 404m from vessels	Schwemmer *et al*., 2011
Long-tailed duck	German parts of North Sea and Baltic Sea	Median flushing distance 293m from vessels	Schwemmer *et al*., 2011

Species/ species group	Area	Displacement impact range	Reference
Eider	German parts of North Sea and Baltic Sea	Median flushing distance 208m from vessels	Schwemmer *et al.*, 2011
Scaup	Two lakes in the Netherlands	Fly from boats up to 400m away	Platteeuw and Beekman, 1994
Divers	NA	Fly from boats more than 1,000m away.	Topping and Petersen, 2011
Great northern diver	Inner Galway Bay, western Ireland	No flushing response to medium sized craft at distances greater than 100m.	Gittings *et al.*, 2015
Guillemot, razorbill and black guillemot	NA	Fly from approaching boats hundreds of metres away	Furness and Wade, 2012

Although little information was available about the **temporal scale of displacement** impacts associated with traffic and transport activities it appears that repeated short-term responses to individual events (i.e. disturbance responses) may result in longer term avoidance of areas where exposure to these impacts may occur (displacement). For example, Skei *et al*. (2014), noted that, for eiders in the Baltic, birds which were displaced by a boat, typically returned to pre-disturbance behaviours and locations quite rapidly once the source of disturbance was removed (i.e. after 16.5 min, 91.8% of flocks had resumed original behaviours). However, where such disturbance events occurred consistently and repeatedly, such as around a high speed ferry route (Larsen and Laubek, 2005), eider duck were observed to consistently avoid such areas. Similar avoidance of shipping routes was also noted for common scoter in the Irish Sea (Kaiser *et al*., 2006).

One consistent finding in identified literature was that large flocks are more susceptible to disturbance by boat traffic that smaller groups (Schwemmer *et al*., 2011). A consequence of this is that, for certain species, particularly seaducks which typically aggregate outside the breeding season, birds may potentially experience greater disturbance, and consequent displacement impacts as a result of traffic and transport activities on their wintering grounds.

Further information on attraction

Diershke and Garthe (2006) refer to general attraction of gulls to vessels, a widely known phenomenon.

Habituation

Few data were available regarding habituation of seabirds to transport and traffic activities, and all of these related to seaducks, divers and grebes (Table 5). Divers were assessed as displaying a very low habituation response to transport and traffic (low confidence), and the habituation responses of seaducks and grebes were considered moderate (moderate and low confidences respectively). As displacement impacts on tubenoses and skuas were assessed as being very low, habitituation was considered to be not applicable.

Further information on habituation

By comparing general species specific flush distances to those of birds near shipping lanes, Schwemmer *et al*. (2011) concluded that eider displayed a high degree of habituation to boat traffic, long-tailed duck a moderate degree, and common scoter no/very little habituation. The same study considered habituation to passing ships 'unlikely to occur' for diver species. Schwemmer *et al*. (2011) also comment that, although for some species habituation responses are apparent in areas with channeled traffic (frequent/predictable disturbance), it is questionable if habituation to free ranging ships will occur (infrequent/unpredictible disturbance). One other study regarding habituation to boat traffic (and recreational activity, see below) was identified, where breeding great-crested grebes displayed a degree of habituation to recreational boating on a Swiss lake (Keller, 1989).

Overall sensitivity

Due to their apparently very high displacement indices in response to transport and traffic activities and moderate habitiuation indices to such activities, the overall sensitivities of seaducks and grebes to transport and traffic was assessed as high (Table 6). Similarly, divers, with a very high displacement index, and assessed as having a very low habituation index, were considered to have very high overall sensitivity to transport and traffic. For tubenoses and skuas, a lack of information relating to habituation was considered unlikely to influence the overall sensitivity assessment (the potential for habituation is very limited where there is a very low displacement impact) and, consequently, overall sensitivities to transport and traffic activities were classified as very low for those species groups. Due to apparently low displacement indices, and no available information relating to habituation, overall sensitivities for gulls and terns were identified as low priority information gaps. Due to apparently moderate displacement indices, and no available information relating to habituation, overall sensitivities for auks were identified as moderate priority information gaps.

Notes on transport and traffic

Transport and traffic activities, to varying degrees, occur concurrently with each of the other activity classes reviewed (with the general exception of waste management activities). In particular, impacts associated with transport and traffic activities overlap with impacts associated with extraction activities (living and non-living resources – but particularly fisheries).

Where possible, impacts associated transport and traffic were separated from those associated with other activity classes. However, when considering the full impacts of other activities it may be beneficial to also consider the additional impacts which may result from traffic and transport activities associated with those activities.

Table 21: Traffic and transport displacement index - Species vs Sub-activity

Species group	Species	Traffic and transport	
Seaduck	Scaup		2.00
	Eider		1.30
	Long-tailed duck		1.33
	Common scoter		2.00
	Velvet scoter		2.00
	Red-breasted merganser	1.59	1.00
Diver	Red-throated diver		1.83
	Black-throated diver		2.00
	Great northern diver	1.82	1.50
Tubenose	Fulmar		0.00
	Manx shearwater		0.33
	Balearic shearwater		0.00
	Storm petrel		0.33
	Gannet	0.35	0.67
Cormorant	Cormorant		1.83
	Shag	1.70	1.33
Grebe	Great crested grebe		1.17
	Red-necked grebe		1.33
	Slavonian grebe		1.20
	Black-necked grebe	1.21	
Skua	Arctic skua		0.20
	Great skua	0.20	0.25
Auk	Puffin		1.00
	Black guillemot		1.00
	Razorbill		1.00
	Guillemot	1.04	1.00
Tern	Little tern		0.80
	Sandwich tern		0.80
	Common tern		0.67
	Roseate tern		1.00
	Arctic tern	0.73	0.67
Gull	Kittiwake		0.80
	Black-headed gull		0.80
	Little gull		0.33
	Common gull		0.75
	Lesser black-backed gull		0.80
	Herring gull		0.80
	Great black-backed gull	0.71	0.80

Impact level:	No data	V. low	Low	Moderate	High	V. high

Other activities

Displacement, attraction and non-avoidance

For this disparate grouping of sub-activities (Table 1), data on displacement impacts were only available for recreation and tourism, and only for the seaducks, divers, cormorants and grebes (Table 5). Grebes were assessed as showing very high displacement in response to recreation and tourism (low confidence), seaducks high displacement response (high confidence), and divers and cormorants as moderate displacement response (moderate and low confidence respectively) (Table 6). No evidence was found of attraction to recreation and tourism activities for any of the species groups (Table 7).

Seaduck species (or related species) identified in relevant literature were pochard, tufted duck, goldeneye, eider and scaup. Great northern diver, cormorant and great crested grebe were also identified (Table 22).

Further information on displacement

Very little information about disturbance, avoidance or displacement of seabirds at sea was identified. Onshore recreational activities were shown to cause considerable disturbance and displacement to eider crèches at a Scottish estuarine site (Keller, 1991). However most studies identified related to freshwater environments, and to species related to the seabird species included in this review. For example, Fox *et al*. (1994) analysed pochard abundance and distribution on gravel pit lakes in England and noted that birds appeared to avoid lakes at which recreational boating activities took place.

Habituation

Few data were available regarding habituation of seabirds to other activities (again, all for recreation and tourism), and all of these related to divers, cormorants and grebes – all of which were considered to display moderate habituation responses (low confidence) (Table 8).

Further information on habituation

Three references to habituation by seabirds to recreational activities were located, all of these observations were, however, made in freshwater environments:

- One review of disturbance impacts mentioned habituation by great northern divers to recreational boating on freshwater lakes in North America (Platteeuw and Henkens, 1997)
- Iguchi *et al*. (2015) noted that cormorants from urban environments were less susceptible to human disturbance (recreational activity around waterways) than birds from rural environments, and suggested that this represented habituation to recreational activities.
- Keller (1989) noted apparent habituation by great crested grebes breeding on a Swiss lake to disturbance by recreational boating.

Overall sensitivity

Due to their apparent very high displacement index and moderate subsequent habituation response, grebes are asessessed as having high overall sensitivity to recreation and tourism activities (Table 9). Divers and cormorants are considered to have moderate overall sensitivities (moderate displacement indices and moderate habituation responses). For seaducks, where the displacement index was considered high, but no information was available relating to habituation, overall sensitivity was considered to be a high pripority data gap. For all other species groups, where there was no information about displacement impacts or habituation responses, information gaps of unknown priority were identified.

Table 22: Other activities displacement index - Species vs Sub-activity

Species group	Species	Other activities: Recreation and tourism		Other activities: Macro-algae production Marine research Cables and pipelines Gas storage Artificial reefs Other structures	
Seaduck	Scaup		2.00		
	Eider		2.00		
	Long-tailed duck				
	Common scoter				
	Velvet scoter				
	Red-breasted merganser	1.33			
Diver	Red-throated diver				
	Black-throated diver				
	Great northern diver	1.00	1.00		
Tubenose	Fulmar				
	Manx shearwater				
	Balearic shearwater				
	Storm petrel				
	Gannet				
Cormorant	Cormorant		1.00		
	Shag	1.00			
Grebe	Great crested grebe		2.00		
	Red-necked grebe				
	Slavonian grebe				
	Black-necked grebe	2.00			
Skua	Arctic skua				
	Great skua				
Auk	Puffin				
	Black guillemot				
	Razorbill				
	Guillemot				
Tern	Little tern				
	Sandwich tern				
	Common tern				
	Roseate tern				
	Arctic tern				
Gull	Kittiwake				
	Black-headed gull				
	Little gull				
	Common gull				
	Lesser black-backed gull				
	Herring gull				
	Great black-backed gull				

Impact level: No data | V. low | Low | Moderate | High | V. high

4. Discussion

General discussion on limitations/advantages of methods

The scope of this project was to produce a high-level overview of the extent and conditions under which birds may habituate to pressures (as defined according to the JNCC Activity/Pressures matrix) resulting from selected anthropogenic marine activities.

In this case an activity is defined as "a human social or economic action or endeavour that may create pressures on the marine environment, and a pressure as "the mechanism through which an activity has an effect on any part of the ecosystem".

This document provides an evidence-based tool to aid decisions by the MMO regarding marine licensing and site assessments for SPAs. Since studies tend to focus on activities themselves rather than pressures, and decisions and advice will likely relate to activities rather than individual pressures, the decision was made to conduct this study at the activity level, with reference to pressures where possible. However, it is acknowledged that birds will be responding to the underlying pressures rather than the activities themselves and therefore key patterns may not be as easily identified using this method.

In total, 38 seabird species and 30 activity sub-groups were identified for consideration in the study. Given the broad scope of the project, the methodology was devised with the aim of identification of general patterns and key data gaps rather than focusing on quantification of specific impacts relating to individual activities. Although more detailed information would be useful in the contexts described above, the reality is that most of the activities covered are so poorly studied that such assessments would not be possible. The methodology does provide an easy technique for reviewing relative sensitivities for better-studied species and activities and gives a clear picture of where uncertainties lie.

The standardised literature review methodology was developed to ensure that the process was transparent and repeatable. The same search terms could be used with any search tool to review, expand and/or update the database. Google Scholar was used for the literature search as it is open source and provides access to both peer-reviewed literature and certain grey literature including technical reports and conference proceedings. Disadvantages of the use of Google are mainly associated with the algorithms Google uses to search. Google uses advanced algorithms that optimise searches for the majority of users but reduce the level of control the user has over the results returned. Whilst searches undertaken here were designed as much as possible to avoid this, it was impossible to coerce Google to override these types of substitutions where relevant information was scarce. In addition, since the Google algorithms are based on a variety of data sources, prioritisation of returns will be different compared with, for example, the straightforward database query search methodology implemented by a databases of bibliographic information e.g. Web of Science, and altering the likelihood of finding specifc papers. Based on literature cited in sources that were identified by the searches, it appeared that most useful references were returned by one of the searches. However, as would be the case with any search methodology, there were known papers of high relevance to one or more topics that were omitted. Such references were incorporated into the sensitivity index calculation but were discussed separately.

The scoring methods used here are subjective, and therefore subject to interpretation by the individual assigning scores, however, consistency of the reviewer will reduce variation in scoring among similar reported impacts and reliabilities allowing comparisons to safely be made among species groups and activities. Although specific criteria could have been derived to generate these scores, this would tend to limit the number of studies that could be included based on provision of appropriate data, and would still require a degree of subjectivity, which would then be magnified due to the uncertainty around each of the measures used to calculate the overall index. It was therefore decided that this simple methodology would allow efficient, flexible, straightforward and comparable measures of sensitivity and confidence.

Data gaps

The main conclusion of this work is that there is a paucity of evidence relating to the long-term effects of marine activities on seabird groups. In terms of assessment of displacement impacts, certain activities such as energy generation and traffic and transport dominated the literature, whilst other activities including coastal activities and extraction of non-living resources were practically unstudied. These differences may stem from a range of different factors including the scale of the activity, the perceived importance of the activity in terms of the scientific community and the general public, differential monitoring requirements associated with different activities and the possible level of control over the impacts.

There were also differences among the species groups in terms of coverage in the literature. Gulls were the most widely studied groups along with seaducks and auks, whereas grebes, cormorants and skuas were less well represented. This is partly an artefact of the numbers of species considered under each group but it is also a result of the probability of the groups coming into contact with the activities in question and the abundance of the species in question. It is inevitable that rarer species are less well-studied, however, these species are likely the species that are most at risk.

In terms of habituation, very few data were available at all, demonstrating the urgent need for long-term studies and synthesis of data collected during long-term monitoring schemes. Having said that, for many of the activities it was quite difficult to disentangle displacement and habituation, for example, for traffic and recreation, studies tended to compare areas where the activities were taking place and weren’t taking place but with no indication of how long these activities had been taking place for prior to the study. These findings will have been scored as displacement but in reality may reflect lack of habituation. Conversely, these studies may suggest a lack of displacement where habituation had taken place leading to underestimation of the strength of the initial displacement impact.

Use of overall sensitivity values and interpretation of data gaps

The primary use of overall sensitivity values (Table 9) are as indices by which regulators may begin to consider the amount of caution to apply in decision making processes in relation to particular species and activities.

Where overall sensitivity levels have been attributed, for 24 of the 63 species group/activity class combinations which were assessed – 38.1%, decisions may be informed as follows:

Overall sensitivity:	Very low	Low	Moderate	High	Very high
Caution applied:	Least ←				→ Most

But, due to lack of available data, it was not possible to attribute overall sensitivity values to the remaining species group/activity class combinations (a total of 39 of the 63 combinations were classed as data gaps – 69.1%).

So, how should regulators proceed where data gaps have been identified?

- **Where information regarding displacement impacts is available.**
  There was at least some information for 18 (28.6%) of species group/activity class combinations regarding displacement impacts, and these data gaps were attributed priority levels on that basis (Table 9). If **low habituation indices** are attributed for these species group/activity class combinations (considered precautionary) then overall sensitivity indices may be calculated (as per Table 3). This adjusted overall sensitivity matrix is shown in Table 23, and may inform regulators on the application of caution in these instances.

- **Where no information regarding displacement impact or subsequent habituation is available.**
  No information relating to displacement impacts or subsequent habituation was available for 21 (30.4%) of the species group/activity class combinations (data gaps of unknown priority in Table 9). For these data gaps a matrix based classification to inform about the application of caution in decision making processes is not viable.

  In accordance with the precautionary principle, where no data is available it is most appropriate to apply a reasonable degree of caution. As other activity classes may cause similar pressures, or other species groups may respond similarly to an activity, it may be more appropriate to consider these activities and/or species groups when considering the application of caution.
    - For example, no information is available in relation to gulls and coastal management activities (Table 9). Where information is available about this activity class, overall sensitivities are considered very low, and for this species group, overall sensitivities to other activity classes are very low. Therefore applying the greatest degree of caution for decisions relating to gulls/coastal management may be inappropriate. An assessment as if overall sensitivity was moderate may be considered precautionary.

Table 23: Adjusted overall sensitivity index - Species group vs Activity class
Sensitivity indices if low habituation index values are attributed where no information is available.

Species group	Coastal management	Waste management	Extraction (living resources)	Extraction (non-living resources)	Energy generation	Transport and traffic	Other activities
Seaduck	V. low	V. low	V. low	High ???	High	High	High ???
Diver	Unknown	Unknown	V. low	V. high ???	V. high	V. high	Moderate
Tubenose	Unknown	Unknown	V. low	Moderate ?	High ??	V. low	Unknown
Cormorant	Unknown	Unknown	V. low	High ???	Moderate ?	V. high ???	Moderate
Grebe	Unknown	Unknown	V. low	Moderate ?	High ??	High	High
Skua	Unknown	Unknown	V. low	Unknown	V. low	V. low	Unknown
Auk	V. low	Unknown	V. low	High ??	High ??	High ??	Unknown
Tern	Unknown	Unknown	V. low	V. high ???	Moderate ?	Moderate ?	Unknown
Gull	Unknown	Unknown	V. low	Moderate ?	V. low	Moderate ?	Unknown

Sensitivity level: V. low | low | Moderate | High | V. high   Data gap priority: Unknown | ? low | ?? Moderate | ??? High

When applying caution to regulatory processes, considered use of the precautionary principle should always be used and professional judgement applied. Consideration should be given to species specific responses to disturbance (or, in the limited cases where information is available, habituation), as these may differ from those of the wider species group. Similarly, consideration should also be given to the specific sub-activities, as pressures exerted by (and subsequent responses to) sub-activities may differ from those of the wider activity class.

It should also be noted that, in many cases, assessments of overall sensitivity are based on limited data, and confidence in these outputs should be treated accordingly.

Furthermore, some of the data gaps identified may be a consequence of a lack of potential interaction between particular species groups and activity classes. For example, no information is available for tubenoses (a highly pelagic group) in relation to coastal management.

Limitations (discussion) of each activity

Converting sensitivities to activities into sensitivities to pressures is not easy as all activities impose a wide range of pressures and the range of pressures imposed by each activity are similar even if the extant of that pressure are not. In addition, the range of activities for which data on disturbance or habituation are available is small further complicating such generalisations.

Another issue that came to light during the course of the study was the difficulty in differentiating sources of disturbance even at the activity level. There is a high degree of overlap among certain activities, particularly boat transport and extraction of living resources and recreational activity. Where possible, different sources of disturbance were separated out so it is envisaged that from the user point of view, an assessment will be made separately for the activity in question and for any associated activities such as transport.

Although the methodology was designed to make sensitivity indices as comparable as possible among activities, the scale of their impacts and the time-scales upon which they operate may be very different and therefore importance to the receptors of interest may vary simply due to these differences. For example, a long-term shipping route could impact upon populations for many generations whereas dock development may only impact a single generation. However, the scope for habituation to the former might be greater than to the latter. Similarly, some activities only represent temporary or intermittent sources of disturbance such as marine research and fishing, whereas structures such as oil platforms and renewable energy installations represent a continuous source of disturbance. And the scale of the impacts caused by large-scale activities such as offshore wind farms will result in a greater number of animals exposed to the associated pressures than something very localised like harvesting seaweed by hand. The study makes no attempt to take this to the next level and look at likely population level impacts, but these kinds of considerations will be important when making that step.

It is certain that part of the reason for the scarcity of solid data regarding the impacts of marine activities is the difficulty in satisfactorily demonstrating an impact or lack of impact. There is an enormous degree of interannual variation in underlying determinants of seabird distribution including climatic variables and prey location. Since most studies focus on a single source of disturbance (e.g. a single wind farm), it is almost impossible to distinguish short-term effects of the source from natural background variation. The probability of detecting displacement can be maximised by surveying over many years, but in practise few studies are conducted over these timescales, probably due to the short-term nature of most research contracts. Of those that are, it then becomes almost impossible to distinguish evidence of no disturbance from short-term disturbance followed by habituation. Whether or not this distinction is important will likely depend on the species or species group in question and how robust local populations are to short-term perturbations as well as the context within which the activity is taking place in terms of other pressures. This report revealed the need for longer-term studies of the impacts of the activities studied and/or collaboration and data sharing among groups collecting data at different sites to allow patterns to be generalised across sites.

There is also likely to be biased reporting, where publications describing impacts may be more likely to be written up, published and well cited than results describing no impact. In addition, empirical evidence is rarely reported where responses are ‘well-known’ meaning that it can be difficult to find support for some apparently obvious potential impacts. For example, several gull species are ‘well-known’ to be attracted to vessels in general (not specifically fishing vessels), however little empirical evidence of this was uncovered by this review (Table 7).

5. Conclusions

This document represents a tool which can be used by regulatory bodies to undertake appropriate site-specific assessments for SPAs and to aid decision making regarding marine licensing with regard to the sensitivity of seabirds to different anthropogenic activities. Whilst good data are available to support this for certain activities and species, several remain poorly studied and there is a requirement for further investigation and/or data sharing and dissemination to bridge these gaps. However, generalizable patterns identified during this study will provide a method of assessing likely impacts of activities where data is currently scarce. The methodology presented here and the associated database provided to the MMO will allow ongoing development of this tool to incorporate new data as it becomes available whilst providing a snapshot of the current state of knowledge and an evidence-base that is widely relevant to a range of stakeholders in the offshore industry.

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Annex

Table 24: Annex 1 - Scoped out activities (non-licensable and not required to inform site assessments for SPAs)

Activity class	Sub-activity
Waste management	Waste gas emissions
	Munitions
Extraction of living resources	Extraction of genetic resources
Production of living resources (aquaculture)	Fin fish
	Shellfish
Extraction (and disposal) of non-living resources	Rock / mineral (coastal quarrying)
	Water (abstraction)
Transport	Shipping (port operations)
Defence	Military activities
Other man-made structures	Cultural heritage sites

Table 25: Annex 2 - Terms used in systematic literature search

Species group	Activity class	Returns (raw)	Exact search term for Google Scholar
Seaducks	Coastal management	4,040	disturbance OR displacement OR avoidance AND seaduck OR Aythya OR Somateria OR Clangula OR Melanitta OR Mergus AND "coastal management" OR "coastal defence" OR "sea wall" OR seawall OR port OR harbour OR dock
	Waste management	2,370	disturbance OR displacement OR avoidance AND seaduck OR Aythya OR Somateria OR Clangula OR Melanitta OR Mergus AND "waste management" OR "agricultural discharge" OR "agricultural waste" OR "industrial waste" OR sewage OR "thermal discharge" OR nuclear
	Extraction (living resources)	5,300	disturbance OR displacement OR avoidance AND seaduck OR Aythya OR Somateria OR Clangula OR Melanitta OR Mergus AND fishing OR fishery OR dredging OR trawling OR "seaweed harvesting"
	Extraction	274	disturbance OR displacement OR avoidance AND seaduck OR Aythya OR Somateria OR Clangula OR Melanitta OR Mergus AND "aggregate extraction" OR "sand extraction" OR "gravel extraction" OR "spoil disposal" OR "navigational dredging"
	Energy generation	1,560	disturbance OR displacement OR avoidance AND seaduck OR Aythya OR Somateria OR Clangula OR Melanitta OR Mergus AND "wind farm" OR "tidal energy" OR "wave energy" OR "renewable energy" OR "oil and gas"
	Transport	4,880	disturbance OR displacement OR avoidance AND seaduck OR Aythya OR Somateria OR Clangula OR Melanitta OR Mergus AND transport OR traffic OR shipping
	Other activities	3,880	disturbance OR displacement OR avoidance AND seaduck OR Aythya OR Somateria OR Clangula OR Melanitta OR Mergus AND cable OR pipeline OR "gas storage" OR "artificial reef" OR "marine research" OR tourism OR recreation OR "seaweed production"
Divers	Coastal management	1,480	disturbance OR displacement OR avoidance AND Gavia AND "coastal management" OR "coastal defence" OR "sea wall" OR seawall OR port OR harbour OR dock
	Waste management	794	disturbance OR displacement OR avoidance AND Gavia AND "waste management" OR "agricultural discharge" OR "agricultural waste" OR "industrial waste" OR sewage OR "thermal discharge" OR nuclear
	Extraction (living resources)	1,850	disturbance OR displacement OR avoidance AND Gavia AND fishing OR fishery OR dredging OR trawling OR "seaweed harvesting"
	Extraction	73	disturbance OR displacement OR avoidance AND Gavia AND "aggregate extraction" OR "sand extraction" OR "gravel extraction" OR "spoil disposal" OR "navigational dredging"
	Energy generation	668	disturbance OR displacement OR avoidance AND Gavia AND "wind farm" OR "tidal energy" OR "wave energy" OR "renewable energy" OR "oil and gas"
	Transport	1,830	disturbance OR displacement OR avoidance AND Gavia AND transport OR traffic OR shipping
	Other activities	1,370	disturbance OR displacement OR avoidance AND Gavia AND recreation OR cable OR pipeline OR "gas storage" OR "artificial reef" OR "marine research" OR tourism OR recreation OR "seaweed production"
Tubenoses	Coastal management	4,850	disturbance OR displacement OR avoidance AND tubenose OR Fulmarus OR Puffinus OR Hydrobates OR Morus AND "coastal management" OR "coastal defence" OR "sea wall" OR seawall OR port OR harbour OR dock
	Waste management	3,090	disturbance OR displacement OR avoidance AND tubenose OR Fulmarus OR Puffinus OR Hydrobates OR Morus AND "waste management" OR "agricultural discharge" OR "agricultural waste" OR "industrial waste" OR sewage OR "thermal discharge" OR nuclear
	Extraction (living resources)	4,730	disturbance OR displacement OR avoidance AND tubenose OR Fulmarus OR Puffinus OR Hydrobates OR Morus AND fishing OR fishery OR dredging OR trawling OR "seaweed harvesting"
	Extraction	156	disturbance OR displacement OR avoidance AND tubenose OR Fulmarus OR Puffinus OR Hydrobates OR Morus AND "aggregate extraction" OR "sand extraction" OR "gravel extraction" OR "spoil disposal" OR "navigational dredging"
	Energy generation	1,210	disturbance OR displacement OR avoidance AND tubenose OR Fulmarus OR Puffinus OR Hydrobates OR Morus AND "wind farm" OR "tidal energy" OR "wave energy" OR "renewable energy" OR "oil and gas"
	Transport	6,360	disturbance OR displacement OR avoidance AND tubenose OR Fulmarus OR Puffinus OR Hydrobates OR Morus AND transport OR traffic OR shipping
	Other activities	2,250	disturbance OR displacement OR avoidance AND tubenose OR Fulmarus OR Puffinus OR Hydrobates OR Morus AND cable OR pipeline OR "gas storage" OR "artificial reef" OR "marine research" OR tourism OR recreation OR "seaweed production"

Species group	Activity class	Returns (raw)	Exact search term for Google Scholar
Cormorants	Coastal management	9,140	disturbance OR displacement OR avoidance AND cormorant OR Phalacrocorax AND "coastal management" OR "coastal defence" OR "sea wall" OR seawall OR port OR harbour OR dock
	Waste management	4,990	disturbance OR displacement OR avoidance AND cormorant OR Phalacrocorax AND "waste management" OR "agricultural discharge" OR "agricultural waste" OR "industrial waste" OR sewage OR "thermal discharge" OR nuclear
	Extraction (living resources)	11,800	disturbance OR displacement OR avoidance AND cormorant OR Phalacrocorax AND fishing OR fishery OR dredging OR trawling OR "seaweed harvesting"
	Extraction	390	disturbance OR displacement OR avoidance AND cormorant OR Phalacrocorax AND "aggregate extraction" OR "sand extraction" OR "gravel extraction" OR "spoil disposal" OR "navigational dredging"
	Energy generation	2,460	disturbance OR displacement OR avoidance AND cormorant OR Phalacrocorax AND "wind farm" OR "tidal energy" OR "wave energy" OR "renewable energy" OR "oil and gas"
	Transport	10,400	disturbance OR displacement OR avoidance AND cormorant OR Phalacrocorax AND transport OR traffic OR shipping
	Other activities	8,300	disturbance OR displacement OR avoidance AND cormorant OR Phalacrocorax AND cable OR pipeline OR "gas storage" OR "artificial reef" OR "marine research" OR tourism OR recreation OR "seaweed production"
Grebes	Coastal management	3,630	disturbance OR displacement OR avoidance AND grebe OR Podiceps AND "coastal management" OR "coastal defence" OR "sea wall" OR seawall OR port OR harbour OR dock
	Waste management	3,250	disturbance OR displacement OR avoidance AND grebe OR Podiceps AND "waste management" OR "agricultural discharge" OR "agricultural waste" OR "industrial waste" OR sewage OR "thermal discharge" OR nuclear
	Extraction (living resources)	3,820	disturbance OR displacement OR avoidance AND grebe OR Podiceps AND fishing OR fishery OR dredging OR trawling OR "seaweed harvesting"
	Extraction	209	disturbance OR displacement OR avoidance AND grebe OR Podiceps AND "aggregate extraction" OR "sand extraction" OR "gravel extraction" OR "spoil disposal" OR "navigational dredging"
	Energy generation	1,010	disturbance OR displacement OR avoidance AND grebe OR Podiceps AND "wind farm" OR "tidal energy" OR "wave energy" OR "renewable energy" OR "oil and gas"
	Transport	4,950	disturbance OR displacement OR avoidance AND grebe OR Podiceps AND transport OR traffic OR shipping
	Other activities	3,790	disturbance OR displacement OR avoidance AND grebe OR Podiceps AND cable OR pipeline OR "gas storage" OR "artificial reef" OR "marine research" OR tourism OR recreation OR "seaweed production"
Skuas	Coastal management	2,520	disturbance OR displacement OR avoidance AND skua OR Stercorarius OR Catharacta AND "coastal management" OR "coastal defence" OR "sea wall" OR seawall OR port OR harbour OR dock
	Waste management	1,240	disturbance OR displacement OR avoidance AND skua OR Stercorarius OR Catharacta AND "waste management" OR "agricultural discharge" OR "agricultural waste" OR "industrial waste" OR sewage OR "thermal discharge" OR nuclear
	Extraction (living resources)	2,600	disturbance OR displacement OR avoidance AND skua OR Stercorarius OR Catharacta AND fishing OR fishery OR dredging OR trawling OR "seaweed harvesting"
	Extraction	91	disturbance OR displacement OR avoidance AND skua OR Stercorarius OR Catharacta AND "aggregate extraction" OR "sand extraction" OR "gravel extraction" OR "spoil disposal" OR "navigational dredging"
	Energy generation	818	disturbance OR displacement OR avoidance AND skua OR Stercorarius OR Catharacta AND "wind farm" OR "tidal energy" OR "wave energy" OR "renewable energy" OR "oil and gas"
	Transport	2,670	disturbance OR displacement OR avoidance AND skua OR Stercorarius OR Catharacta AND transport OR traffic OR shipping
	Other activities	1,980	disturbance OR displacement OR avoidance AND skua OR Stercorarius OR Catharacta AND cable OR pipeline OR "gas storage" OR "artificial reef" OR "marine research" OR tourism OR recreation OR "seaweed production"
Auks	Coastal management	4,440	disturbance OR displacement OR avoidance AND alcid OR Fratercula OR Cepphus OR Alca OR Uria AND "coastal management" OR "coastal defence" OR "sea wall" OR seawall OR port OR harbour OR dock
	Waste management	3,590	disturbance OR displacement OR avoidance AND alcid OR Fratercula OR Cepphus OR Alca OR Uria AND "waste management" OR "agricultural discharge" OR "agricultural waste" OR "industrial waste" OR sewage OR "thermal discharge" OR nuclear

Species group	Activity class	Returns (raw)	Exact search term for Google Scholar
	Extraction (living resources)	3,710	disturbance OR displacement OR avoidance AND alcid OR Fratercula OR Cepphus OR Alca OR Uria AND fishing OR fishery OR dredging OR trawling OR "seaweed harvesting"
	Extraction	119	disturbance OR displacement OR avoidance AND alcid OR Fratercula OR Cepphus OR Alca OR Uria AND "aggregate extraction" OR "sand extraction" OR "gravel extraction" OR "spoil disposal" OR "navigational dredging"
	Energy generation	1,300	disturbance OR displacement OR avoidance AND alcid OR Fratercula OR Cepphus OR Alca OR Uria AND "wind farm" OR "tidal energy" OR "wave energy" OR "renewable energy" OR "oil and gas"
	Transport	6,580	disturbance OR displacement OR avoidance AND alcid OR Fratercula OR Cepphus OR Alca OR Uria AND transport OR traffic OR shipping
	Other activities	2,990	disturbance OR displacement OR avoidance AND alcid OR Fratercula OR Cepphus OR Alca OR Uria AND cable OR pipeline OR "gas storage" OR "artificial reef" OR "marine research" OR tourism OR recreation OR "seaweed production"
Terns	Coastal management	8,260	disturbance OR displacement OR avoidance AND "tern" OR "Sterna" OR Sternula AND "coastal management" OR "coastal defence" OR "sea wall" OR seawall OR port OR harbour OR dock -term -turn
	Waste management	6,540	disturbance OR displacement OR avoidance AND "tern" OR "Sterna" OR Sternula AND "waste management" OR "agricultural discharge" OR "agricultural waste" OR "industrial waste" OR sewage OR "thermal discharge" OR nuclear -term -turn
	Extraction (living resources)	2,510	disturbance OR displacement OR avoidance AND "tern" OR "Sterna" OR Sternula AND fishing OR fishery OR dredging OR trawling OR "seaweed harvesting" -term -turn
	Extraction	50	disturbance OR displacement OR avoidance AND "tern" OR "Sterna" OR Sternula AND "aggregate extraction" OR "sand extraction" OR "gravel extraction" OR "spoil disposal" OR "navigational dredging" -term -turn
	Energy generation	1,180	disturbance OR displacement OR avoidance AND "tern" OR "Sterna" OR Sternula AND "wind farm" OR "tidal energy" OR "wave energy" OR "renewable energy" OR "oil and gas" -term -turn
	Transport	9,730	disturbance OR displacement OR avoidance AND "tern" OR "Sterna" OR Sternula AND transport OR traffic OR shipping -term -turn
	Other activities	4,170	disturbance OR displacement OR avoidance AND "tern" OR "Sterna" OR Sternula AND cable OR pipeline OR "gas storage" OR "artificial reef" OR "marine research" OR tourism OR recreation OR "seaweed production" -term -turn
Gulls	Coastal management	15,500	disturbance OR displacement OR avoidance AND "gull" OR Larus OR Rissa OR Chroicocephalus OR Hydrocoloeus AND "coastal management" OR "coastal defence" OR "sea wall" OR seawall OR port OR harbour OR dock
	Waste management	9,770	disturbance OR displacement OR avoidance AND "gull" OR Larus OR Rissa OR Chroicocephalus OR Hydrocoloeus AND "waste management" OR "agricultural discharge" OR "agricultural waste" OR "industrial waste" OR sewage OR "thermal discharge" OR nuclear
	Extraction (living resources)	13,500	disturbance OR displacement OR avoidance AND "gull" OR Larus OR Rissa OR Chroicocephalus OR Hydrocoloeus AND fishing OR fishery OR dredging OR trawling OR "seaweed harvesting"
	Extraction	508	disturbance OR displacement OR avoidance AND "gull" OR Larus OR Rissa OR Chroicocephalus OR Hydrocoloeus AND "aggregate extraction" OR "sand extraction" OR "gravel extraction" OR "spoil disposal" OR "navigational dredging"
	Energy generation	3,430	disturbance OR displacement OR avoidance AND "gull" OR Larus OR Rissa OR Chroicocephalus OR Hydrocoloeus AND "wind farm" OR "tidal energy" OR "wave energy" OR "renewable energy" OR "oil and gas"
	Transport	17,900	disturbance OR displacement OR avoidance AND "gull" OR Larus OR Rissa OR Chroicocephalus OR Hydrocoloeus AND transport OR traffic OR shipping
	Other activities	12,600	disturbance OR displacement OR avoidance AND "gull" OR Larus OR Rissa OR Chroicocephalus OR Hydrocoloeus AND cable OR pipeline OR "gas storage" OR "artificial reef" OR "marine research" OR tourism OR recreation OR "seaweed production"

Table 26: Annex 3 - Sensitivity indices included in relation to transport and traffic

Species group	Species	Response score to disturbance by ship traffic*				
		Garthe and Huppop	Leopold and Dijkman	Cook and Burton	Furness and Wade	Bradbury *et al.*
		(2004)	(2010)	(2010)	(2012)	(2014)
		North Sea	North Sea (Dutch part)	UK territorial waters	Scottish waters	English territorial waters
Seaduck	Scaup		2		2	2
	Eider	1	2	1	1	1
	Long-tailed duck		2	1	1	1
	Common scoter	2	2	2	2	2
	Velvet scoter	2	2	2	2	2
	Red-breasted merganser		2			1
Diver	Red-throated diver	2	2	2	2	2
	Black-throated diver	2	2		2	2
	Great northern diver		2		2	2
Tubenose	Fulmar	0	0		0	0
	Manx shearwater			1	0	0
	Balearic shearwater					0
	Storm petrel			1	0	0
	Gannet	1	0	1	1	1
Cormorant	Cormorant	2	1	2	2	2
	Shag			2	1	1
Grebe	Great crested grebe	1	1		1	1
	Red-necked grebe	1	2			
	Slavonian grebe			1	1	1
	Black-necked grebe	No data				
Skua	Arctic skua	0	1		0	0
	Great skua	0	1		0	0
Auk	Puffin	1	1	1	1	1
	Black guillemot		1		1	1
	Razorbill	1	1	1	1	1
	Guillemot	1	1	1	1	1
Tern	Little tern		1	1	1	1
	Sandwich tern	1	0	1	1	1
	Common tern	1	0	1	1	1

Species group	Species	Response score to disturbance by ship traffic*				
		Garthe and Huppop	Leopold and Dijkman	Cook and Burton	Furness and Wade	Bradbury *et al.*
		(2004)	(2010)	(2010)	(2012)	(2014)
		North Sea	North Sea (Dutch part)	UK territorial waters	Scottish waters	English territorial waters
	Roseate tern			1	1	1
	Arctic tern	1	0	1	1	1
Gull	Kittiwake	1	0	1	1	1
	Black-headed gull	1	0	1	1	1
	Little gull	0	1			0
	Common gull	1	0		1	1
	Lesser black-backed gull	1	0	1	1	1
	Herring gull	1	0	1	1	1
	Great black-backed gull	1	0	1	1	1

Table 27: Annex 4 - Sensitivity indices included in relation to wave and tidal energy generation

		Garthe et al. (2012) UK waters	
Species group	**Species**	**Response scores to disturbance by…**	
		Wave energy devices	Tidal energy devices
Seaduck	Scaup	1	0
	Eider	1	1
	Long-tailed duck	0	0
	Common scoter	1	1
	Velvet scoter	1	1
	Red-breasted merganser	No data	
Diver	Red-throated diver	1	1
	Black-throated diver	1	1
	Great northern diver	1	1
Tubenose	Fulmar	1	1
	Manx shearwater	1	1
	Balearic shearwater	No data	
	Storm petrel	0	0
	Gannet	0	0
Cormorant	Cormorant	1	2
	Shag	1	2
Grebe	Great crested grebe	0	1
	Red-necked grebe		
	Slavonian grebe	1	1
	Black-necked grebe	No data	
Skua	Arctic skua	0	0
	Great skua	0	0
Auk	Puffin	1	1
	Black guillemot	1	2
	Razorbill	1	2
	Guillemot	1	2
Tern	Little tern	1	0
	Sandwich tern	1	1
	Common tern	1	0
	Roseate tern	1	0
	Arctic tern	1	1
Gull	Kittiwake	0	0
	Black-headed gull	0	0
	Little gull	No data	
	Common gull	0	0
	Lesser black-backed gull	0	0
	Herring gull	0	0
	Great black-backed gull	0	0