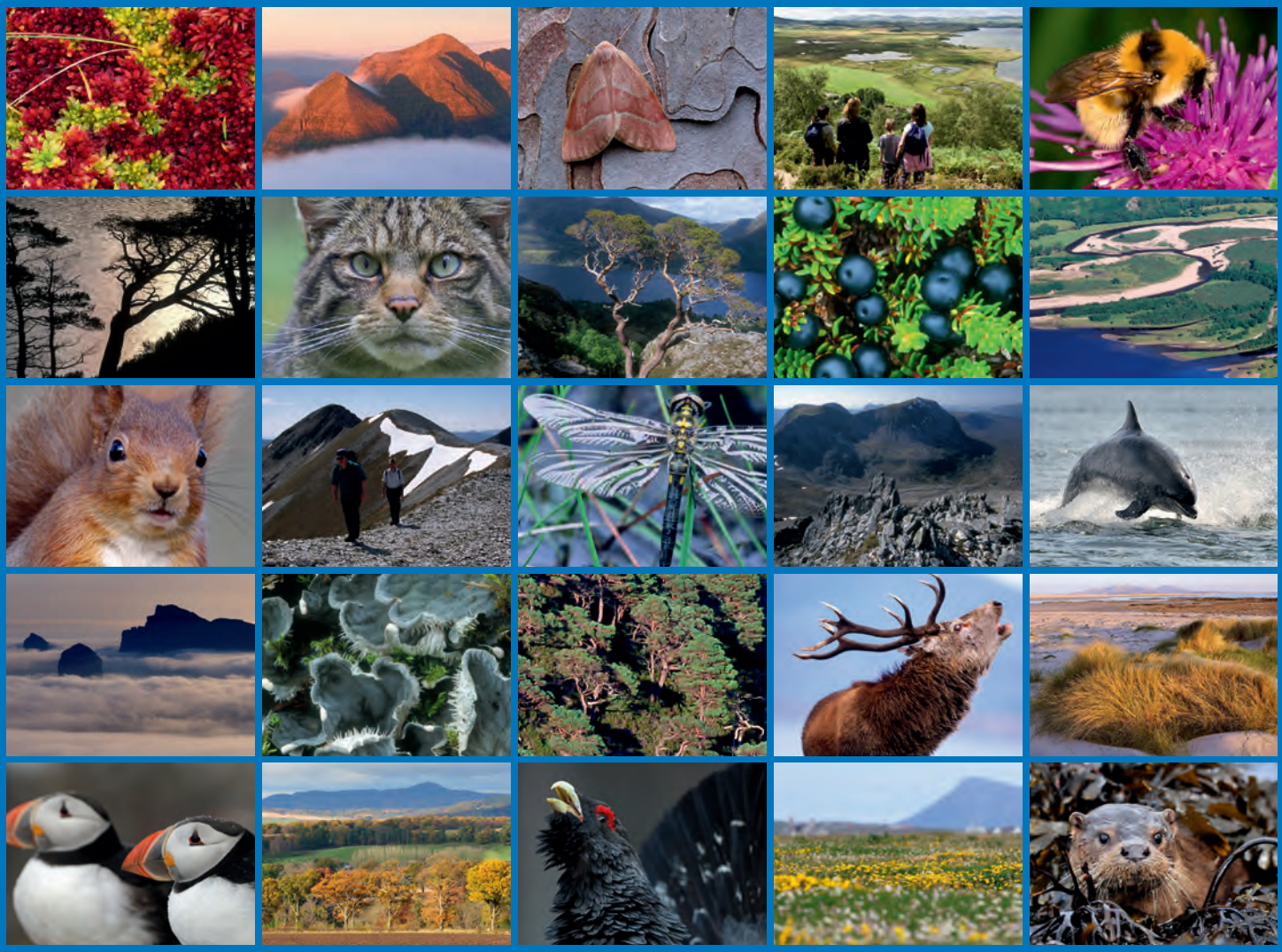
Scottish Natural Heritage
Commissioned Report No. 804

A review of literature on the qualifying interest species of Special Protection Areas (SPAs) in the Firth of Forth and development related influences



Scottish Natural Heritage
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COMMISSIONED REPORT

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A review of literature on the qualifying interest species of Special Protection Areas (SPAs) in the Firth of Forth and development related influences

For further information on this report please contact:

Darren Hemsley
Scottish Natural Heritage
Strathallan House
Castle Business Park
STIRLING
FK9 4TZ
Telephone: 01786 435364
E-mail: darren.hemsley@snh.gov.uk

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COMMISSIONED REPORT

Summary

A review of literature on the qualifying interest species of Special Protection Areas (SPAs) in the Firth of Forth and development related influences

Commissioned Report No. 804
Project No: 15172
Contractor: British Trust for Ornithology
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Keywords

Natura; Firth of Forth; Planning; Development; birds; HRA.

Background

Potential developments within, or otherwise affecting, designated Natura sites require Habitat Regulation Assessments (HRAs) that describe likely impacts on the features of interest ('qualifying interests') and the mediation action taken to prevent or that will be taken to mitigate against any losses. This requires knowledge of those features and how developments might interact with their ecological integrity. This review of literature summarises the ecology, distributions and status of 43 qualifying bird species of the Firth of Forth Special Protection Area (SPA), Forth Islands SPA, Imperial Dock Lock, Leith SPA and the draft Outer Firth of Forth and Tay Bay Complex dSPA. Also presented is a review of factors that affect estuarine birds. The reviews intend to provide those involved with HRAs in the Forth area (including developers, planners and others assessing applications for developments and otherwise advising on developments) with basic information on the ecology of qualifying bird species and factors that can affect birds within the estuary. The review is presented in two sections:

Part 1 Species accounts

A review of the ecology of each of the 43 qualifying species of the named SPAs and dSPA to provide synopses of their reliance on particular habitats and seasonality with particular relevance to the impact of prospective developments. Qualifying species (in alphabetical order) are:

- Arctic tern *Sterna paradisaea*;
- Bar-tailed godwit *Limosa lapponica*;
- Black-headed gull *Larus ridibundus*;
- Common gull *Larus canus*;
- Common scoter *Melanitta nigra*;
- Common tern *Sterna hirundo*;
- Cormorant *Phalacrocorax carbo*;
- Curlew *Numenius arquata*;
- Dunlin *Calidris alpina*;
- Eider *Somateria mollissima*;
- Fulmar *Fulmarus glacialis*;
- Gannet *Morus bassanus*;
- Goldeneye *Bucephala clangula*;
- Golden plover *Pluvialis apricaria*;
- Great crested grebe *Podiceps cristatus*;
- Grey plover *Pluvialis squatarola*;
- Guillemot *Uria aalge*;

- Herring gull *Larus argentatus*;
- Kittiwake *Rissa tridactyla* ;
- Knot *Calidris canutus*;
- Lapwing *Vanellus vanellus*;
- Lesser black-backed gull *Larus fuscus*;
- Little gull *Larus minutus*;
- Long-tailed duck *Clangula hyemalis*;
- Mallard *Anas platyrhynchos*;
- Manx shearwater *Puffinus puffinus*;
- Oystercatcher *Haematopus ostralegus*;
- Pink-footed goose *Anser brachyrhynchus*;
- Puffin *Fratercula arctica*;
- Razorbill *Alca torda*;
- Red-breasted merganser *Mergus serrator*;
- Redshank *Tringa totanus*;
- Red-throated diver *Gavia stellata*;
- Ringed plover *Charadrius hiaticula*;
- Roseate tern *Sterna dougallii*;
- Sandwich tern *Sterna sandvicensis*;
- Scaup *Aythya marila*;
- Shag *Phalacrocorax aristotelis*;
- Shelduck *Tadorna tadorna*;
- Slavonian grebe *Podiceps auritus*;
- Turnstone *Arenaria interpres*;
- Velvet scoter *Melanitta fusca*;
- Wigeon *Anas penelope*.

Their ecology is summarised under the headings:

- Conservation status;
- Origin;
- Behaviour;
- Diet;
- Habitat;
- Distribution;
- Seasonality;
- Pressures;
- Population trends.

Part 2 Factors affecting estuarine birds

This is a review of current scientific knowledge on factors affecting estuarine birds which are of 'qualifying interests' of the SPAs within the Forth estuary. This is presented under the headings:

- Ecological relationships, natural processes and pollution – this section considers the habitat requirements of birds, how processes and species interaction may affect birds and influences of altered sediment deposition and sediment flows, pollution and nutrient enrichment and of invasive non-native species;
- Management of the physical environment – this section considers land claim and development, managed realignment and habitat creation, dredging for navigation purposes and fishing, tide wrack removal and renewable energy;
- Disturbance – this section considers the activities that may cause disturbance, the effects of disturbance, species' response and habituation to disturbance, which activities cause the most disturbance and reducing the impacts of disturbance.

For further information on this project contact:
Darren Hemsley, Scottish Natural Heritage, Strathallan House, Castle Business Park, Stirling, FK9 4TZ.
Tel: 01786 435364 or darren.hemsley@snh.gov.uk
For further information on the SNH Research & Technical Support Programme contact:
Knowledge & Information Unit, Scottish Natural Heritage, Great Glen House, Inverness, IV3 8NW.
Tel: 01463 725000 or research@snh.gov.uk

Acknowledgements

The species accounts include data from the Wetland Bird Survey (a partnership of the British Trust for Ornithology (BTO), Royal Society for the Protection of Birds (RSPB), Joint Nature Conservation Committee (JNCC) and in association with the Wildfowl and Wetlands Trust (WWT)) and the Seabird Monitoring Programme (coordinated by JNCC). We are grateful to all volunteers who contributed to both surveys and to Roddy Mavor (JNCC) for providing data on breeding seabirds. We are also grateful to all the photographers who have allowed us to use their images and to Anne Cotton (BTO Scotland) for their collation. Although the copyright of photographs remains with the photographers, all have given their permission for their images to be used in this document and any subsequent derivations.

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PART 1: SPECIES ACCOUNTS

KEY TO SPECIES ACCOUNTS

At the head of each account is the common English name, scientific name and a photograph. The remaining sections summarise the basic ecology of the species, its status and distribution within the Firth of Forth area under the following headings:

CONSERVATION STATUS

This includes:

(a) The estimated population size of each species used in the SPA citations. For most cases (the Firth of Forth and Forth Islands SPAs) classification as SPA was in October 2001 and the cited population baselines vary in origin between 1986 and 1998 dependent on the species involved ;

(b) UK conservation status - The conservation status of 246 regularly occurring birds in the UK has been reviewed by the leading governmental and non-governmental conservation organisations (Eaton, M.A. *et al*., 2009). This resulted in each species being placed on one of three lists; Red, Amber or Green. *Red listing* is for a species that have undergone severe breeding or wintering population declines in the UK of more than 50% over 25 years or have undergone a severe breeding range decline of more than 50% in the past 25 years or else are listed by BirdLife International as being Globally Threatened using IUCN criteria. *Amber listing* is for species that have undergone moderate breeding or wintering population declines in the UK of between 25% and 50% over 25 years or at least 50% of the UK breeding or non-breeding population found in 10 or fewer sites or the UK breeding population is estimated at less than 300 pairs, or non-breeding population less than 900 individuals or have undergone a breeding range decline of between 25% and 50% in the past 25 years. *Green listing* is for all regularly occurring species that do not qualify under any of the red or amber criteria. In some cases this might be a result of insufficient data.

(c) European conservation status – The conservation status of birds in Europe has been assessed with species placed into categories, with first three representing Species of Conservation Concern (SPEC) (Burfield & van Bommel, 2004). *SPEC 1* species are those which are of global conservation concern. *SPEC 2* species are those which have an unfavourable conservation status in Europe (if the population is threatened, declining, depleted from historical levels or is found only in a few locations) and are concentrated in Europe (i.e. more than 50% of the global population occurs in Europe). *SPEC 3* species are which have an unfavourable conservation status in Europe (see above), but which are not concentrated in Europe. A *non-SPEC* category includes species that are not known to qualify for the above European conservation status which will include widespread, stable and increasing species but also some for which data is insufficient to classify into one of the other categories.

(d) Global - Species of global conservation concern are assessed by the International Union for Conservation of Nature and Natural Resources (IUCN) and placed in a series of categories based on their global status (IUCN 2001). The primary categories, with an indication of the qualifying criteria, are: *Critically Endangered* species have either undergone a rapid population decline in the last 10 years, an extremely restricted range or very low population size and so faces an extremely high risk of extinction in the wild. *Endangered* species have undergone population decline of >50%, have a restricted range or low population size and so faces a very high risk of extinction in the wild. *Vulnerable* species have undergone a population decline of >30%, have a limited range or small population size, so the population faces a high risk of extinction in the wild. *Near Threatened* species do not qualify for the above three categories, but are considered as close to doing so, or to do so in the near

future. Species which do not fulfil these criteria are considered of *Least Concern*, though some for which information is relatively limited and could be included as *Data Deficient*.

ORIGIN

This section describes whether the species is a resident within the geographical area covered by this review, or migratory. For non-resident species, it describes briefly their origins.

BEHAVIOUR

Key information on each species' feeding, roosting and breeding behaviour.

DIET

Key information on the diet of each species when they are present within the Forth SPAs.

HABITAT

This section summarises information on the principle habitats that species use within the geographical area covered by this review. Habitat use is described for both high and low tides as some species' presence in a particular habitat can be dependent on the state of the tide.

DISTRIBUTION

This section summarises the occurrence and abundance of the species within: (a) the 'Inner Forth', defined as the largely estuarine area up river from the Queensferry Bridges; and (b) the 'Outer areas' that includes the Firth of Forth below the Queensferry Bridges, the Forth Islands and outer Tay areas. Within each area, the distribution and abundance of species are described using the terms:

a) Widespread – species found in most areas of suitable habitat within the site;
b) Local(ly) – species found in a few (often specific) areas of the site;
c) Absent, rare, scarce, uncommon, common, numerous – six subjective categories are used to indicate relative in increasing order of magnitude. These categories are based on data from the Wetland Bird Survey (WeBS), the Seabird Monitoring Programme, local bird reports and the authors' personal experiences. Numerical data for each species are presented in the population trends section.

SEASONALITY

Periods of presence and relative abundance are presented graphically using data from the WeBS where applicable or are otherwise summarised by a brief text. Where presented, the figures show mean monthly counts for five recent years.

PRESSURES

The accompanying review of factors affecting estuarine birds (Part 2 of this report) describes threats and other factors influencing estuarine birds. This section, within Part 1, provides a short summary of some pertinent threats and issues particular to each species, both within the SPAs and further afield. It should be emphasised that some pressures will apply to all species (for example oil pollution or recreational disturbance) and to prevent repetition, these are largely excluded from the species accounts (but included in Part 2). In some instances,

specific pertinent pressures have been identified for some species and although they could well influence others, specific examples have not been cited in the literature. An example that is especially relevant to the Firth of Forth is the interaction between scaup, molluscs and water quality (reduced sewage outputs leading to reduced mollusc abundance which supported less scaup). Although it is likely that other seaduck will have similar interactions, they may not be as marked, not investigated or the details remain unpublished. Therefore the list of pressures should not be considered comprehensive but rather an indication of current knowledge about them.

POPULATION TRENDS

Where data are available, this section details whether the site population for each species has increased, declined or remained stable, with comparisons being made with the wider Scottish trend. The comparisons are made to illustrate that a decline or increase within the Forth area does not always indicate a change in the conditions of that area. In some cases, a change in the Forth may simply reflect wider scale changes occurring in Scotland and further afield. Data have been sourced from the Wetland Bird Survey (WeBS, which is largely for the Firth of Forth) and the Seabird Monitoring Programme (which is largely for the Forth Islands, or else for specific islands).

Note that population trends are determined from data that are not necessarily restricted the SPA boundaries. This will lead to some apparent discrepancy between baseline population estimates given under the 'Conservation Status' heading; however the trends are expected to be representative of the patterns of change within the SPAs.

Figures derived from WeBS show relative changes in peak counts over the period covered (generally over three decades) with the baseline year (index = 100) taken as the 2010/11 winter. WeBS figures illustrate both the raw maximum indices (joined by a dotted line) and also the smoothed trend (shown by a solid line) derived from those counts.

Population changes for pink-footed goose are based on winter roost counts and those for breeding seabirds on counts of apparently occupied nest sites. Breeding seabird trends are shown for years when most (and a constant sample of) island colonies have been counted. Longer runs of seabird data than presented are available from single colonies, notably for the Isle of May.

BIBLIOGRAPHY

Sources of information used in compilation of the species accounts are presented in single bibliography after the accounts.

PINK-FOOTED GOOSE
Anser brachyrhynchus

CONSERVATION STATUS
SPA Population at Classification: 10,852
UK: AMBER (localised and important non-breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Winter visitors to Scotland, breed in Iceland and E. Greenland. Many birds that winter in England stage in Scotland in the spring and autumn.

BEHAVIOUR – Highly gregarious, roosting and feeding in large flocks. Persistent use of favoured feeding sites within and between winters, especially when little disturbed.

DIET – Herbivorous. Outside the breeding season feeds on improved grasslands, cereal stubbles and vegetables (e.g. potatoes, sugar beet, carrots).

HABITAT – Feeds on farmland, and usually roosts on estuaries at night. Foraging areas are normally within 20 km of roost sites.

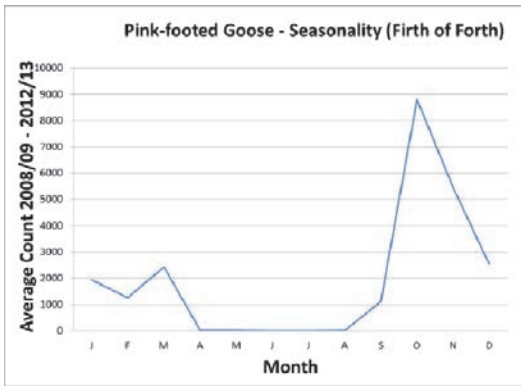
	Low tide	High tide
Open water	✓	✓
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	-	-
Coastal fields	✓	✓
Inland fields	✓	✓

DISTRIBUTION

INNER FORTH	Locally numerous
OUTER AREAS	Locally numerous

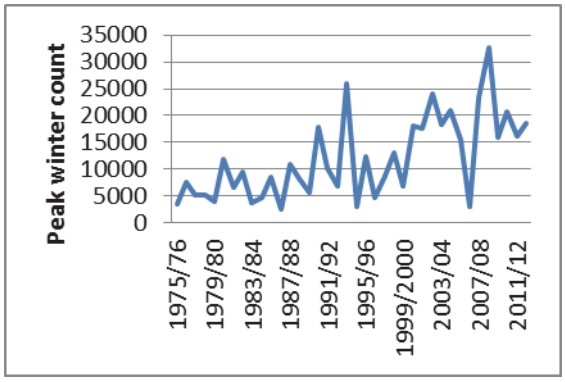
Anne Cotton

SEASONALITY – Mainly a passage migrant with more modest numbers through the winter.



PRESSURES – Conflict with farmers may grow especially if numbers continue to increase. Changes in agricultural practice could affect food availability. Disturbance to roosts. A major quarry species for hunters.

POPULATION TRENDS – Winter numbers in the (and around) the Firth of Forth have increased in line with national trends.



SHELDUCK
Tadorna tadorna

CONSERVATION STATUS
SPA Population at Classification: 4,509
UK: AMBER (localised and important non-breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Undertakes short migrations to moulting sites in late summer when most adults leave the UK for a month or two. Small number of birds moult in British estuaries, notably including the Forth.

BEHAVIOUR – Feeds by digging, and dabbling in intertidal areas, feeding during both day and night according to the tide. The late summer moulting flock around Grangemouth is one of the three largest in Britain.

DIET – Various tiny invertebrates, with small molluscs predominant in N. and W. Europe, especially *Hydrobia* snails.

HABITAT – Prefers saline habitats including muddy and sandy estuaries.

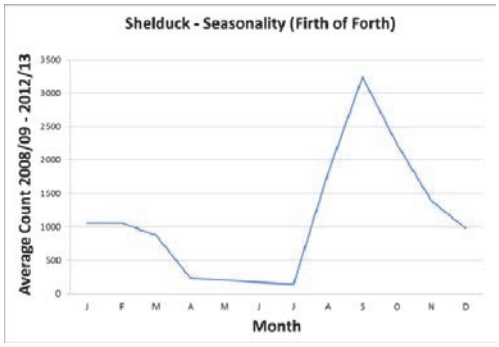
	Low tide	High tide
Open water	✓	✓
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	-	-
Coastal fields	✓	✓
Inland fields	✓	✓

DISTRIBUTION

INNER FORTH	Widespread, numerous
OUTER AREAS	Locally common

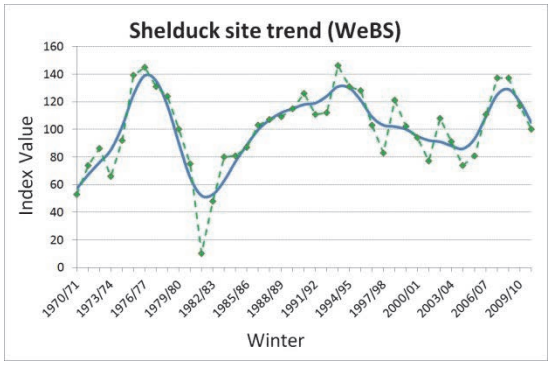
Anne Cotton

SEASONALITY – Mainly an autumn/winter visitor, with peak numbers occuring during the autumn moult in August/September. The breeding population on low ground around the estuary is important in a Scottish context.



PRESSURES – Disturbance to potentially flightless moulting birds. Across UK estuary sites, counts were significantly lower in areas close to footpaths. The abundance of *Hydrobia* is influenced by water quality and may affect the numbers of shelduck and their duration of stay.

POPULATION TRENDS – Numbers appear reasonably stable, at least in recent years.



WIGEON
Anas penelope

CONSERVATION STATUS
SPA Population at Classification: 2,139
UK: AMBER (localised and important non-breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Birds wintering in UK breed mainly in northern Russia, though some Icelandic-bred birds also occur in Scotland.

BEHAVIOUR – Gregarious, forming large flocks, often grazing in grassy fields. Can feed at night especially in marine habitats where affected by disturbance and tides.

DIET – Plant material from both above and below surface level (leaves, stems, stolons, bulbils and rhizomes).

HABITAT – Salt marshes, lagoons, estuaries, intertidal mudflats and sheltered marine habitats.

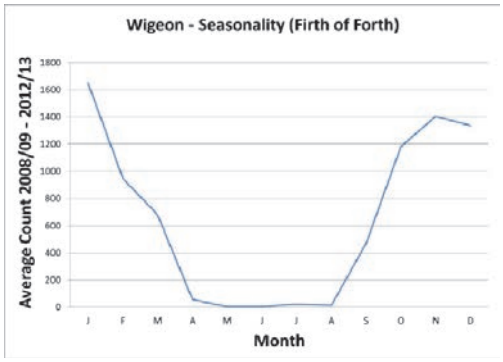
	Low tide	High tide
Open Water	✓	✓
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	-	-
Coastal fields	✓	✓
Inland fields	✓	✓

DISTRIBUTION

INNER FORTH	Widespread, common
OUTER AREAS	Locally common

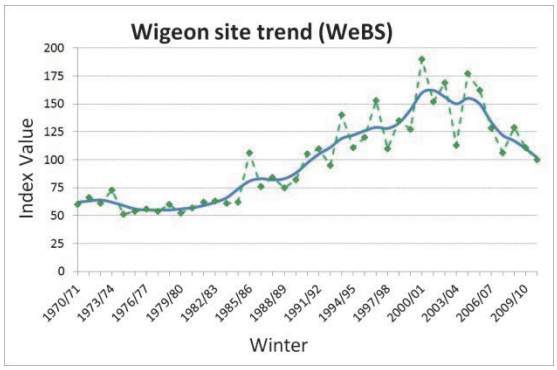
Edmund Fellowes

SEASONALITY – Winter visitor, from September to March.



PRESSURES – Wigeon flocks feed close to the water's edge. When disturbed, flocks fly to the safety of open water and water and take a while to come back to feed after a disturbance occurs, affecting their ability to forage if ongoing disturbance occurs.

POPULATION TRENDS – The Forth trend is tracking the Scottish trend, and the proportion of Scottish wintering birds using the site is stable. This suggests the site remains relatively favourable to this species.



MALLARD
Anas platyrhynchos

CONSERVATION STATUS
SPA Population at Classification: 2,564
UK: AMBER (recent non-breeding population decline).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Many are local but up to three-quarters of the birds wintering in the UK may be winter visitors from NW Europe.

BEHAVIOUR – Feeds predominantly by dabbling in shallows, or upending in slightly deeper water. May also feed ashore and occasionally graze. May feed at night. Often tolerant of humans, especially in urban areas.

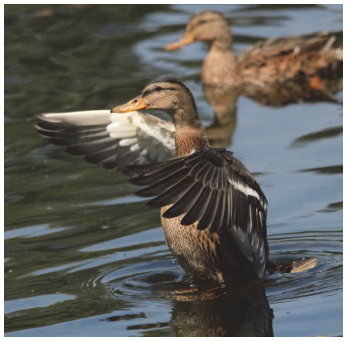
DIET – Omnivorous, including both plant and animal matter.

HABITAT – All wetland types, though prefers sites with shallow water and cover. Will feed and roost on the sea and in brackish waters.

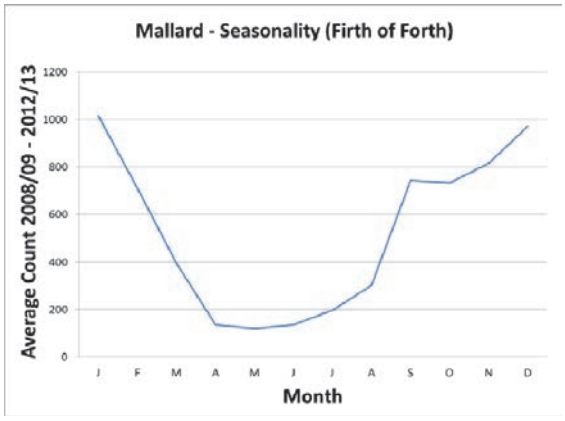
	Low tide	High tide
Open water	✓	✓
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	-	-
Coastal fields	✓	✓
Inland fields	✓	✓

DISTRIBUTION

INNER FORTH	Widespread, common
OUTER AREAS	Widespread, common

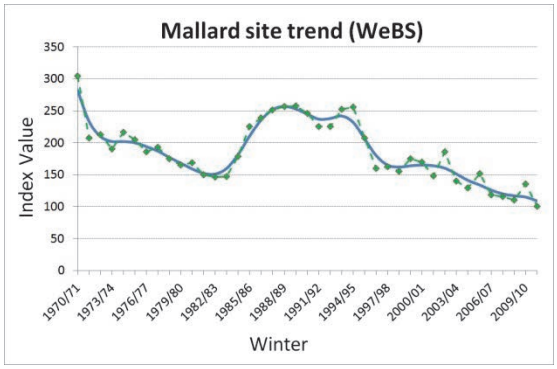

Anne Cotton

SEASONALITY – Mainly a winter visitor but with substantial numbers resident and breeding.



PRESSURES – The decline in the wintering population in the UK is thought to be caused by a reduction in long-distance movement by European mallards, perhaps because of milder winters in mainland Europe.

POPULATION TRENDS – The Forth trend is tracking the Scottish trend, and the proportion of Scottish wintering birds using the site is stable. This suggests conditions on the site remain favourable for this particular species.



SCAUP
Aythya marila

CONSERVATION STATUS
SPA Population at Classification: 437
UK: **RED** (recent non-breeding population decline).
Europe: Concern. SPEC Category 3. Endangered.
Global: Least Concern.

ORIGIN – Birds wintering in Britain & Ireland come from Iceland, the Baltic, Scandinavia and Russia.

BEHAVIOUR – Gregarious outside breeding season, feeding by diving in shallow waters.

DIET – Omnivorous, but mostly molluscs in winter, especially mussels *Mytilus* species. Also cockles *Cardium* species and clams *Macoma* species in estuaries and *Hydrobia* species in brackish waters.

HABITAT – Winters in sheltered coastal waters, e.g. estuaries.

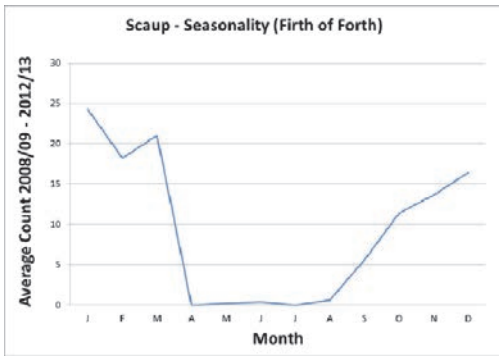
	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Scarce
OUTER AREAS	Scarce

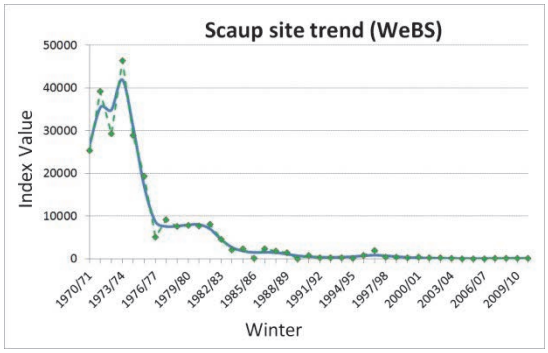
Graham Catley

SEASONALITY – Winter visitor, mainly October to March.



PRESSURES – Cleaner water can support fewer molluscs (see below).

POPULATION TRENDS – Numbers using the site declined sharply, from >60% of Scottish wintering birds in the late 1970s to less than 5% in recent years. Declines linked to reduction in sewage inputs.



EIDER
Somateria mollissima

CONSERVATION STATUS
SPA Population at Classification: 2,400 pairs
UK: AMBER (recent non-breeding population decline).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – In Scotland mainly a resident species with only a few birds making short-distance movements.

BEHAVIOUR – Eider feed either by diving in deep water or upending in shallow water. Frequent flights are made between roost and feeding sites. Eider form large flocks during July and August when birds undergo a moult and are flightless for several weeks. After hatching, young will join together to form large creches which can disperse several km (e.g. from islands to mainland coast).

DIET – Molluscs and Crustaceans, blue mussels *Mytilus edulis* are the main prey species.

HABITAT – Eiders are a marine species concentrated in sheltered waters, and feeding on blue mussels. Eider nest on the ground mainly on mammal-free offshore islands and on quieter areas of mainland coast.

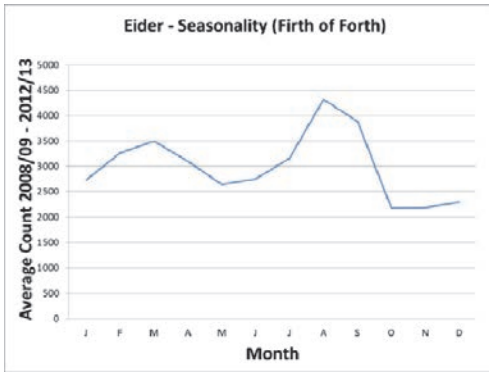
	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Uncommon
OUTER AREAS	Common

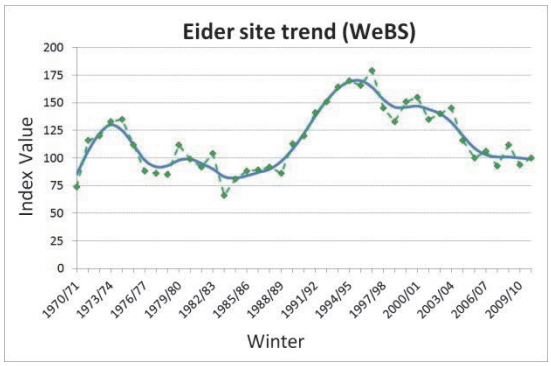
Anne Cotton

SEASONALITY – Present year-round in the Firth of Forth with a peak in late summer /early autumn as numbers are supplemented by young birds.



PRESSURES – Nest predation, especially by mammals. Recreational disturbance by walkers and dogs.

POPULATION TRENDS – Winter counts of eider have declined in recent years at a more rapid rate than for Scotland as a whole; the proportion of the Scottish population supported by the area is therefore declining.



LONG-TAILED DUCK
Clangula hyemalis

CONSERVATION STATUS
SPA Population at Classification: 1,045
UK: **GREEN**
Europe: Not a species of concern.
Global: Vulnerable (recent non-breeding decline).

ORIGIN – Breeds around Arctic Circle. Those wintering in Britain may originate from Fennoscandinavia and NW Russia.

BEHAVIOUR – Highly gregarious outside the breeding season, roosting and feeding in inshore and offshore waters. Diurnal, feeding by diving, regularly at depths of 3–10m, but to maximum depth of 50–60m.

DIET – Predominantly animal matter, including crustaceans, molluscs, other marine invertebrates and fish.

HABITAT – At sea, often far offshore, but also in estuarine waters.

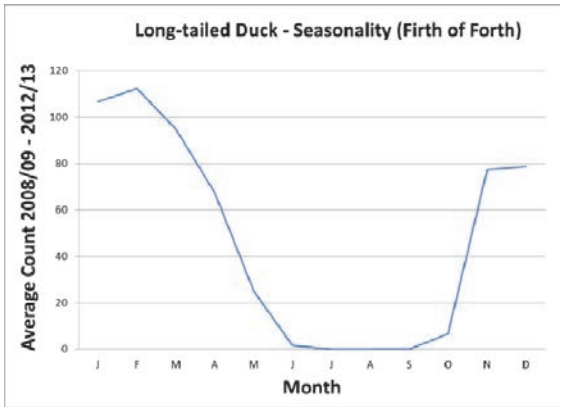
	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Rare
OUTER AREAS	Locally uncommon

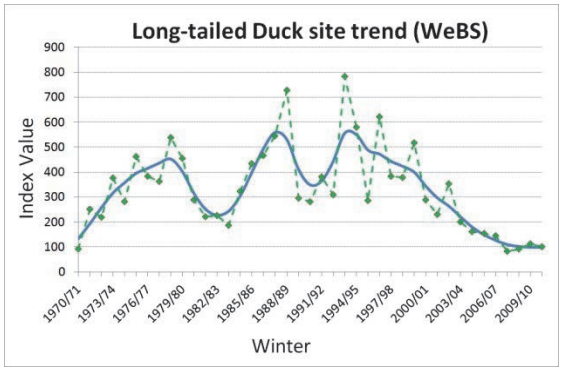
Dave King

SEASONALITY – Winter visitor, mainly November to April, peaking in February.



PRESSURES – Reduced breeding success (away from Scotland) in recent years.

POPULATION TRENDS – The Forth trend is lower than the Scottish trend. A declining proportion of Scottish wintering birds have been supported by this site since the turn of the century.



COMMON SCOTER
Melanitta nigra

CONSERVATION STATUS
SPA Population at Classification: 2,125 individuals
UK: **RED** (recent breeding population decline).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Mostly a winter visitor from Iceland and Fennoscandinavia, although small numbers of non-breeding birds are present in the Firth of Forth throughout the year.

BEHAVIOUR – Feeds and roosts in small to large flocks sometimes quite far offshore. Frequent flights are made between favoured feeding areas.

DIET – A range of mollusc species caught by diving and foraging in mostly sandy substrates.

HABITAT – Away from their breeding grounds Common Scoters spend most of their time on the sea. They forage for food by diving in inshore waters that are up to 20 m deep.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-

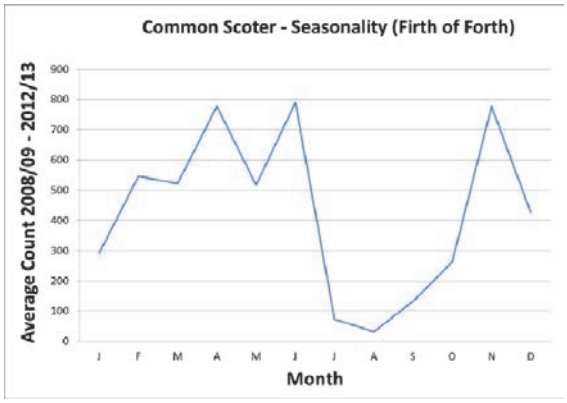
DISTRIBUTION

INNER FORTH	Rare
OUTER AREAS	Locally common

Large flocks found between Musselburgh and North Berwick on the south side of the Forth, in Largo Bay and St Andrews Bay in Fife.

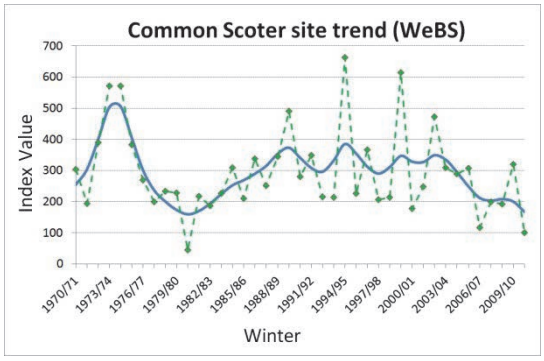
Graham Catley

SEASONALITY – Numbers are highest in November and during April to June.



PRESSURES – None specifically recognised but in common with other seaduck likely to include recreational water use and interactions with water quality and sediments.

POPULATION TRENDS – Declining but tracking the Scottish trend. The proportion of the Scottish population supported by this site is stable. This suggests that despite the on-going decline in numbers, the conditions on the site remain relatively favourable for this particular species.



VELVET SCOTER
Melanitta fusca

CONSERVATION STATUS
SPA Population at Classification: 612
UK: AMBER (species of European Concern, localised non-breeding population).
Europe: Concern. SPEC Category 3. Declining.
Global: Endangered.

ORIGIN – A winter visitor from Fennoscandinavia and Russia, although small numbers of non-breeding birds are present in the Forth through the year.

BEHAVIOUR – Feeds and roosts in flocks, often mixed with common scoter, although velvet scoter often forage closer to shore. Frequent flights are made between favoured feeding areas.

DIET – A high proportion of Velvet Scoter's diet consists of molluscs, caught by diving underwater and foraging in mostly sandy substrates.

HABITAT – Away from their breeding grounds, velvet scoters spend most of their time on the sea. They forage for food by diving in inshore waters that are up to 20 m deep.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-

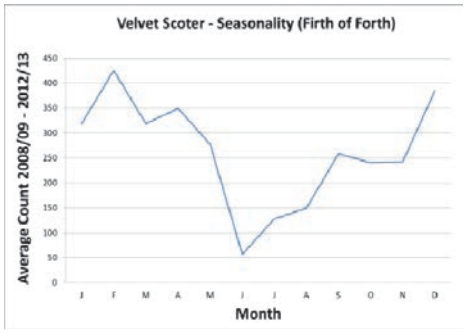
DISTRIBUTION

INNER FORTH	Rare
OUTER AREAS	Locally common

Large flocks found between Musselburgh and Gullane on the south side of the Forth, and in Largo Bay and St Andrews Bay in Fife.

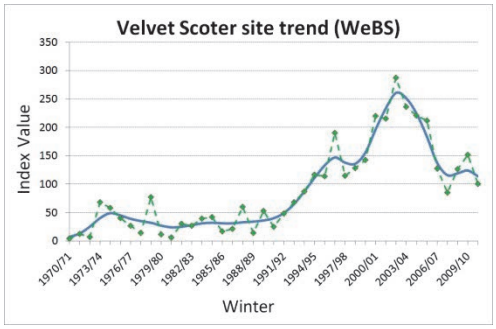
Peter Walkden

SEASONALITY – Numbers increase from late summer with a peak in late winter.



PRESSURES – None specifically recognised but in common with other seaduck likely to include recreational water use and interactions with water quality and sediments.

POPULATION TRENDS – Although numbers fluctuate over time, approximately two-thirds of the UK's velvet scoters were in the Firth of Forth during the winter of 2012/13. A greater rate of decline elsewhere leads to the Firth of Forth of supporting an increasing proportion of the UK's population of velvet scoter.



GOLDENEYE
Bucephala clangula

CONSERVATION STATUS
SPA Population at Classification: 2,465
UK: AMBER (small breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – A small number of birds nest in the north of the UK but most wintering birds in Scotland are thought to be from Norway and northern Sweden.

BEHAVIOUR – Principally a diurnal feeder. Feeds by diving.

DIET – Mostly aquatic insects, molluscs and crustaceans. Occasionally fish, plant material generally less than 25% of diet.

HABITAT – Mainly shallow estuaries, bays and harbours; also larger lakes and rivers and in the vicinity of sewage outfalls.

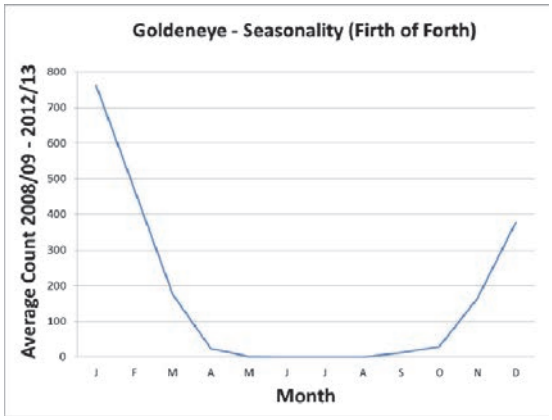
	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Widespread, uncommon
OUTER AREAS	Widespread, uncommon

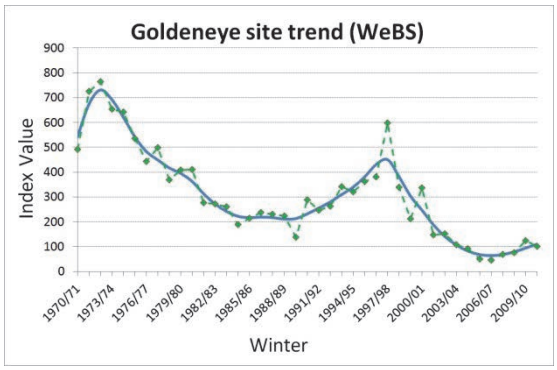
Anne Cotton

SEASONALITY – Winter visitor (mainly November to March).



PRESSURES – None specifically recognised but in common with other seaduck likely to include recreational water use and interactions with water quality and sediments. Note declining status in Forth.

POPULATION TRENDS – A declining proportion of Scottish wintering birds are being supported by the Forth. This suggests that conditions on the site are deteriorating for this particular species.



RED-BREASTED MERGANSER
Mergus serrator

CONSERVATION STATUS
SPA Population at Classification: 670
UK: **GREEN**
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Wintering birds include some local breeders and probably some from C. Europe, but most are from Iceland and possibly E. Greenland.

BEHAVIOUR – Gregarious during winter. Feeds by diving.

DIET – Mainly fish and crustaceans; also worms, insects and amphibians.

HABITAT – Winters mainly at sea on secluded bays or estuaries. Shows a preference for clear, shallow waters not affected by heavy wave action.

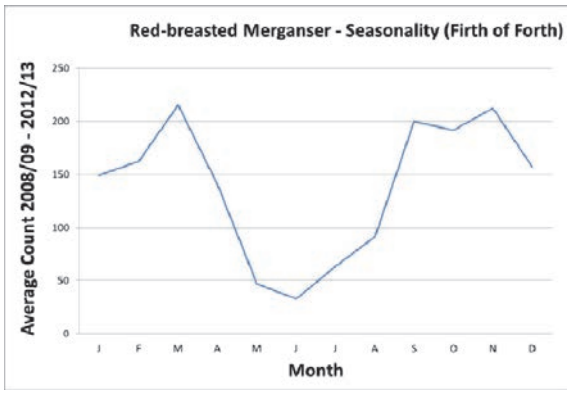
	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Widespread, uncommon
OUTER AREAS	Widespread, uncommon

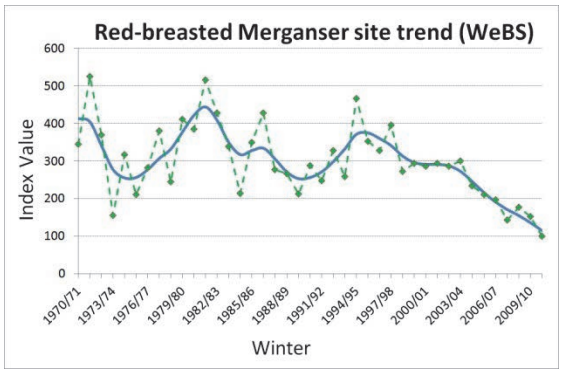
Anne Cotton

SEASONALITY – Mainly a winter visitor, but birds start returning in late summer to moult in the Firth of Forth.



PRESSURES – This species is shot under licence at fisheries throughout Scotland. Otherwise, none specific, but note declining status in Forth.

POPULATION TRENDS – A declining proportion of Scottish wintering birds are being supported by the Forth. This suggests conditions on the site are deteriorating relative to other sites for this particular species.



RED-THROATED DIVER
Gavia stellata

CONSERVATION STATUS
SPA Population at Classification: 104 individuals
UK: AMBER
Europe: Concern. SPEC Category 3. Depleted.
Global: Least Concern.

ORIGIN – Circumpolar species with Scotland at the southern edge of the breeding range. Wintering birds are a mixture of Scottish breeders and migrants from Fennoscandinavia, Iceland and Greenland.

BEHAVIOUR – Feeds by diving,usually solitary or in small groups. Occasionally in large flocks further offshore. Often flies between feeding areas on wintering areas.

DIET – Primarily fish.

HABITAT – Principally a marine species in winter, occuring on sheltered inshore waters above soft substrates and sometimes also in large numbers further offshore. Offshore occurrence maybe more frequent than is recorded but difficult to monitor.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-
Offshore islands	-	-

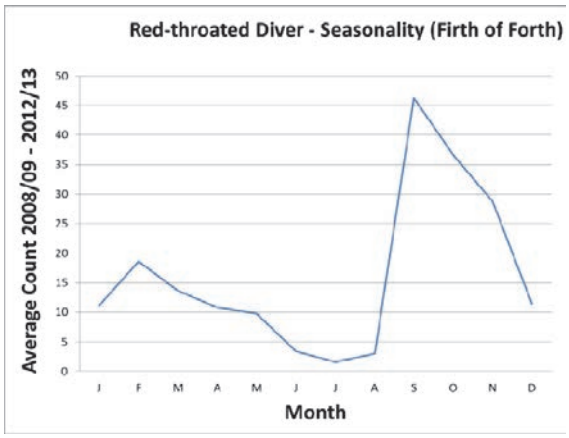
DISTRIBUTION

INNER FORTH	Scarce
OUTER AREAS	Widespread, scarce

The largest numbers are in the outer Firth of Forth and St Andrews Bay.

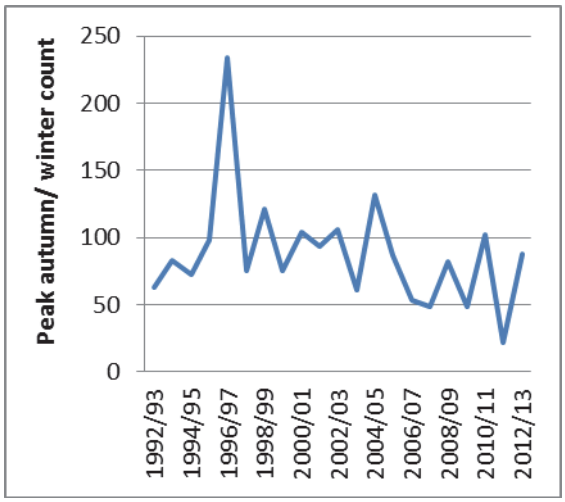
Dave King

SEASONALITY – Numbers peak in autumn with low numbers present all year.



PRESSUES – None specific.

POPULATION TRENDS – Appears relatively stable but data should be treated with caution as this species is difficult to survey comprehensively from the shore. Birds spend much of their time too far from land to count accurately.



FULMAR
Fulmarus glacialis

CONSERVATION STATUS
SPA Population at Classification: 798 Pairs
UK: AMBER (recent breeding population decline).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Fulmars colonised Scotland in the late 1800s from Iceland and the Faroes with birds reaching SE Scotland in the 1920s. They are now a common breeding bird. Adult birds spend the winter offshore in Scottish waters, with immatures wandering more widely around the North Atlantic.

BEHAVIOUR – Can forage very long distances from breeding sites. Surface feeder, frequently following fishing vessels, also feeds on bioluminescent prey at night.

DIET – Fish, squid, crustaceans, other marine invertebrates, and material discarded from fishing vessels.

HABITAT – Fulmars are a marine species feeding out at sea during both day and night. In the Forth, most breed on cliffs and stacks on offshore islands. Small numbers also breed on suitable cliffs (and some man-made structures) around the Forth coast.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	-
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

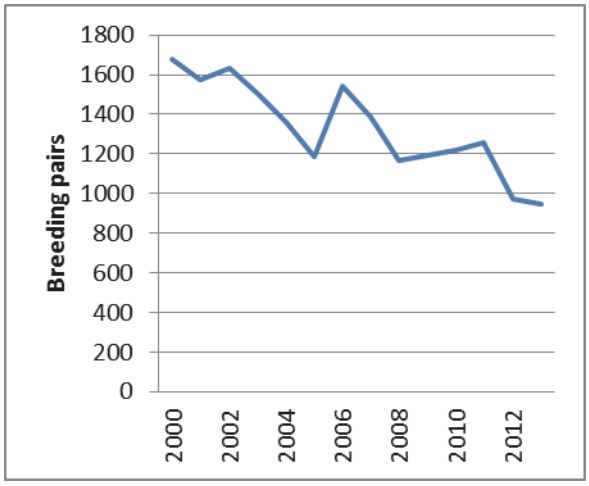
INNER FORTH	Rare
OUTER AREAS	Widespread, common


Anne Cotton

SEASONALITY – Most breeding birds are back at their nests in January. All birds have left breeding cliffs by September. Scarce at sea outside nest occupation period, especially in October.

PRESSURES – Has become dependent on the fishing industry for much of its food. Changes in treatment of fishing discards might have significant population effects on this species.

POPULATION TRENDS – Breeding numbers have declined on the Forth islands in recent years.



MANX SHEARWATER
Puffinus puffinus

CONSERVATION STATUS
SPA Population at Classification: ?
UK: AMBER (species of European Concern, recent breeding range decline).
Europe: Concern. SPEC Category 2. Localised.
Global: Least Concern.

ORIGIN – A North Atlantic species of which 80% nest on islands off the west coast of Britain and Ireland. Manx shearwaters are predominantly spring and autumn migrants off the east coast of Scotland. They winter in the south Atlantic off South America.

BEHAVIOUR – Manx shearwaters are a long-distance migrant, able to cover very large distances over the sea. This species feeds on the surface as well as underwater, where it actively pursues prey using its wings.

DIET – Manx shearwater's diet consists mainly of fish and squid.

HABITAT – Oceanic but mainly over the continental shelf, only coming ashore to breed on predator-free offshore islands.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	-
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

INNER FORTH	Absent
OUTER AREAS	Uncommon

Small or moderate numbers are intermittently recorded offshore from the Outer Forth areas during summer and early autumn.


Alex Barclay

SEASONALITY – Birds return from their wintering grounds in April with largest numbers reported between July and September.

PRESSURES – Breeding range is constrained by the presence of rats and other ground predators on otherwise suitable offshore islands.

POPULATION TRENDS – Manx shearwaters breed in burrows in the ground and only return to their colonies at night, so their populations are very difficult to monitor. The presence of single pair(s) breeding on the Isle of May has been proven in recent years but further birds may be present as the species can be difficult to detect and locate, especially when occuring at low densities.

GANNET
Morus bassanus

CONSERVATION STATUS
SPA Population at Classification:
21,600 pairs
UK: AMBER (important & localised breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Breeds throughout the North Atlantic with Scotland holding half the world population in 14 colonies. The Bass Rock in the Firth of Forth is the world's largest colony. Winter out at sea as far south as West Africa. As birds grow older they winter closer to the breeding grounds.

BEHAVIOUR – Large movements of birds occur between breeding sites and foraging areas. Can forage up to 500 km from colonies although large feeding flocks occur in the Forth. Gannets can catch prey at a wide range of depths. Prey is caught by plunge-diving from height or occasionally by diving from the surface.

DIET – A diverse range of fish and squid, including fisheries discards.

HABITAT – Gannets are a marine species that rarely come to land except to breed. They breed on sheer cliffs and stacks, but where conditions are right, as on Bass Rock, also on flat surfaces.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	-
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Scarce
OUTER AREAS	Locally numerous

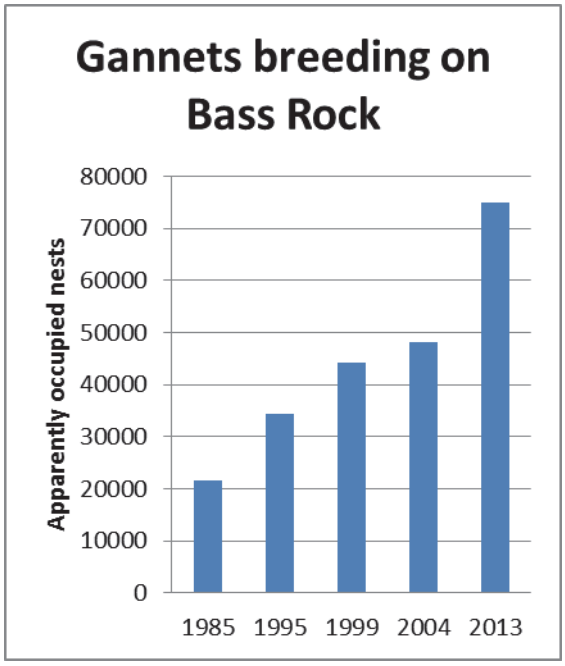
In the Forth only breeds on Bass Rock.

Jill Pakenham

SEASONALITY – Gannets are present all year but more numerous during the breeding season. They return to their nesting sites in January. Most egg laying takes place in April and fledging peaks in early to mid-September.

PRESSURES – Plastic debris floating in the sea can be ingested or cause entanglement, both potentially fatal. Flight heights of gannets could make them vulnerable to collision at wind farms. Changes to fisheries discard regulatuions may affect gannets.

POPULATION TRENDS – Bass Rock is now the largest gannetry in the N. Atlantic, following large increases in recent decades. A similar increase has been reported at other Scottish colonies.



GREAT CORMORANT
Phalacrocorax carbo

CONSERVATION STATUS
SPA Population at Classification: 200 Pairs
UK: **GREEN**
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Resident breeders supplemented by migrants in winter. Most Scottish Cormorants are of the sub-species *P.c. carbo*.

BEHAVIOUR – In the Forth breeds on cliffs and stacks on islands. Feeds by diving underwater from the surface.

DIET – A wide range of small fish (generally smaller than 20 cm in length) such as butterfish, sandeels, flatfish and eels.

HABITAT – Feeds in shallow water, generally less than 20 m deep. Foraging range up to 50 km. Roosts on man-made structures (e.g. buoys, jetties, harbour walls) as well as natural rocky headlands, islands, beaches and on estuaries at low tide.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

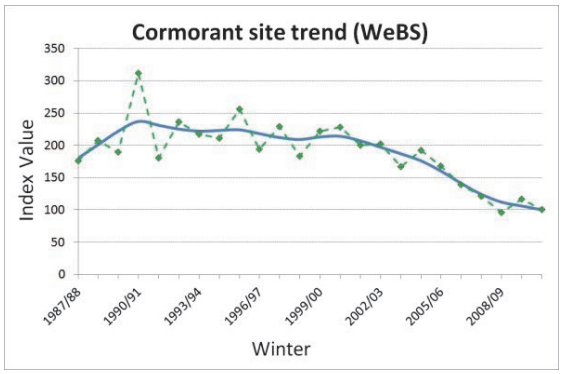
INNER FORTH	Widespread, common
OUTER AREAS	Widespread, common

Edmund Fellowes

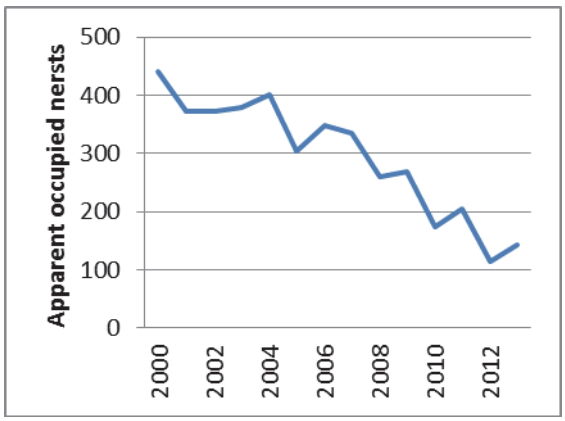
SEASONALITY – Numbers peak in autumn, bolstered by young birds.

PRESSURES – Cormorant are shot under licence at inland fisheries in Scotland.

POPULATION TRENDS – The winter population in the Firth of Forth is declining but tracking the Scottish trend.



The breeding population on the Forth islands is declining.



SHAG
Phalacrocorax aristotelis

CONSERVATION STATUS
SPA Population at Classification: 2,400 Pairs
UK: AMBER (recent breeding population decline, localised and important breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – A resident and dispersive species with interchanges of birds between the Forth and elsewhere in Scotland, England and Norway.

BEHAVIOUR – Shags dive from water surface pursuing fish underwater. Can form large flocks, both at roosting and feeding sites.

DIET – Small fish, most commonly sandeels, even in winter months. Young are fed almost exclusively on Lesser Sandeels *Ammodytes tobianus*.

HABITAT – Almost exclusively marine, breeding on most of the islands in the Forth. Shags are seldom seen far from shore and do not forage far from breeding colonies. Roosts on man-made structures (e.g. buoys, jetties, harbour walls) as well as natural features such as rocky headlands and islands.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

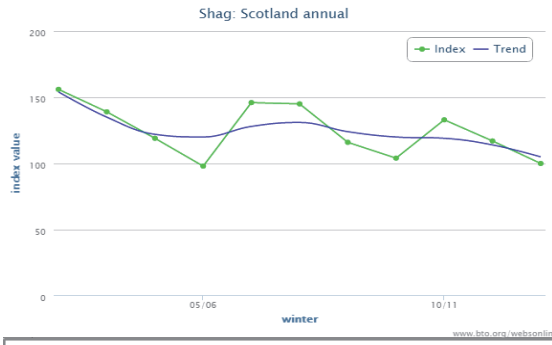
INNER FORTH	Rare
OUTER AREAS	Widespread, common

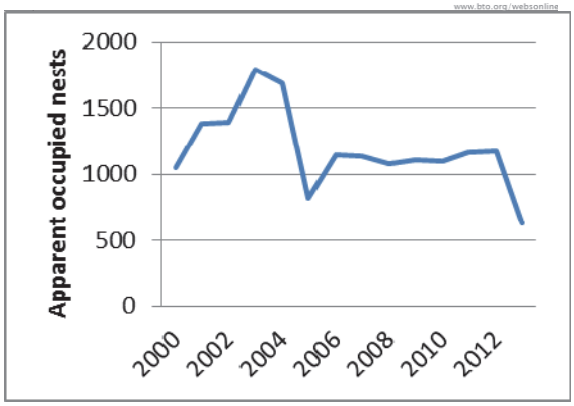
Hugh Insley

SEASONALITY – Numbers peak in autumn, bolstered by young birds.

PRESSURES – Sandeel shortages cause breeding failure; winter storms.

POPULATION TRENDS – Winter and breeding numbers fluctuate with some evidence of recent decline (in common with elsewhere in Scotland).





GREAT CRESTED GREBE
Podiceps cristatus

CONSERVATION STATUS
SPA Population at Classification: 646
UK: **GREEN**
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Most movements are thought to be fairly local, but there are few ring recoveries. Little is known about the amount of interchange between Britain and continental Europe.

BEHAVIOUR – Largely solitary during winter, though temporary aggregations may form.

DIET – Includes large fish, insects, crustaceans (e.g. crayfish and shrimps) and molluscs.

HABITAT – Overwinters on large lakes and reservoirs, and in inshore coastal waters especially during cold spells (when inland waters are frozen).

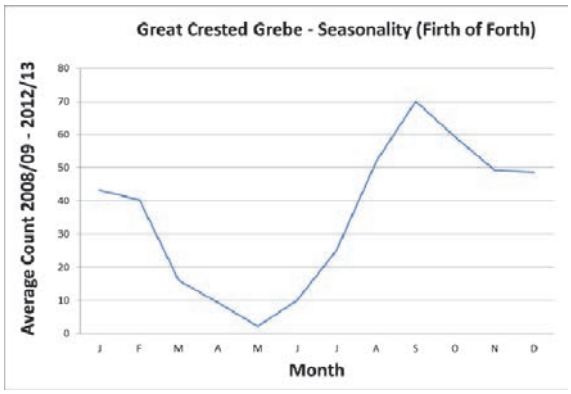
	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	✓
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Widespread, uncommon
OUTER AREAS	Widespread, uncommon

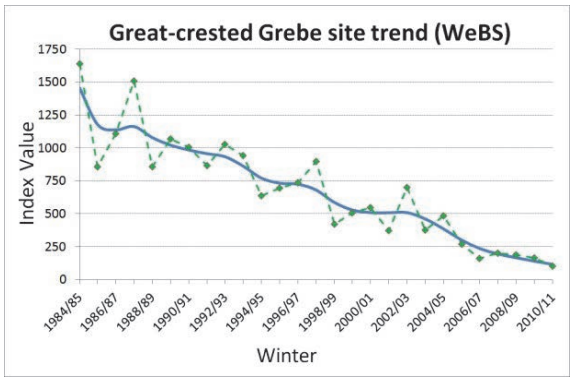
Amy Lewis

SEASONALITY – Mainly a winter visitor and passage migrant with peak in September. Many pairs breed on nearby lakes and reservoirs, especially in Fife.



PRESSURES – None specified but note the severe declining trend for this species**.**

POPULATION TRENDS – Severe decline. The trend for the Forth is broadly tracking the Scottish trend, although a declining proportion of Scottish wintering birds are being supported by the site. This suggests that conditions on the site are deteriorating for this particular species.



SLAVONIAN GREBE
Podiceps auritus

CONSERVATION STATUS
SPA Population at Classification: 84
UK: AMBER (species of European concern, recent breeding population decline).
Europe: Concern. SPEC Category 3. Declining.
Global: Least Concern.

ORIGIN – The origin of birds in the Firth of Forth is uncertain, but is likely to be Iceland and Norway.

BEHAVIOUR – Slavonian Grebes dive underwater from the surface to catch prey.

DIET – Mainly small fish and crustaceans.

HABITAT – In winter predominantly a marine species, preferring sheltered sites.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	-
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-

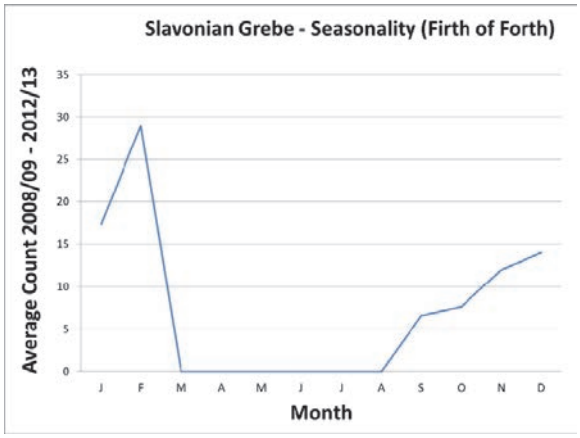
DISTRIBUTION

INNER FORTH	Rare
OUTER AREAS	Local and uncommon

Most regular between Musselburgh and Gullane on the south side of the Forth and in Largo Bay in Fife.

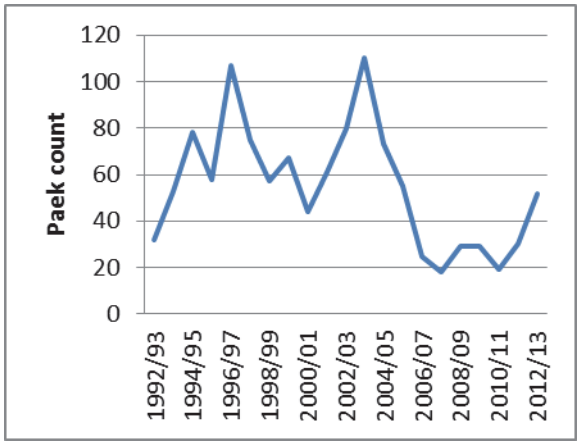
Adrian Dancy

SEASONALITY – Numbers increase from August onwards, peaking in late winter. Absent in summer.



PRESSURES – None specified.

POPULATION TRENDS – Peak counts are lower than they were in the 1990s which contrasts with the wider Scottish trend. Overall numbers are small and variable, and therefore difficult to interpret.



OYSTERCATCHER
Haematopus ostralegus

CONSERVATION STATUS
SPA Population at Classification: 7,846
UK: AMBER (localised and important non-breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Some wintering birds breed in Scotland. Large numbers also come from Iceland, the Faroes and Norway.

BEHAVIOUR – Prey is detected by both sight and touch and birds can feed by day and night. Many Oystercatchers are very site faithful, returning to the same shellfish beds, though others roam over a wider area. Less sensitive to disturbance than other species.

DIET – Predominantly shellfish, especially large cockles *Cerastoderma edule* and mussels *Mytilus edulis*. Also include ragworms *Nereis* species and lugworms *Arenicola* species on mudflats and earthworms from wet fields.

HABITAT – Mostly on shellfish beds on intertidal mudflats, using nearby mixed wader roost sites when feeding areas are covered by tides. Some also feed on earthworms in adjacent wet fields.

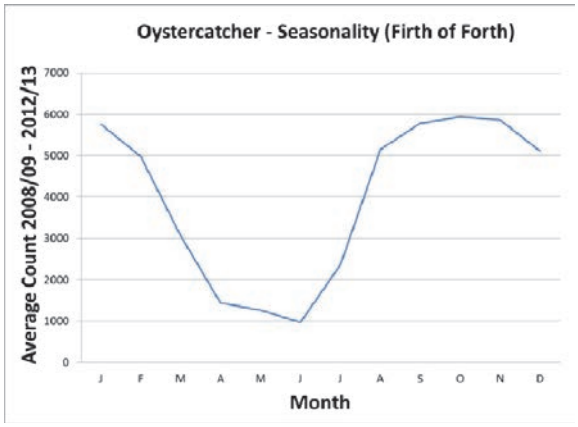
	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	✓	✓
Coastal fields	✓	✓
Inland fields	✓	✓

DISTRIBUTION

INNER FORTH	Widespread, numerous
OUTER AREAS	Widespread, numerous

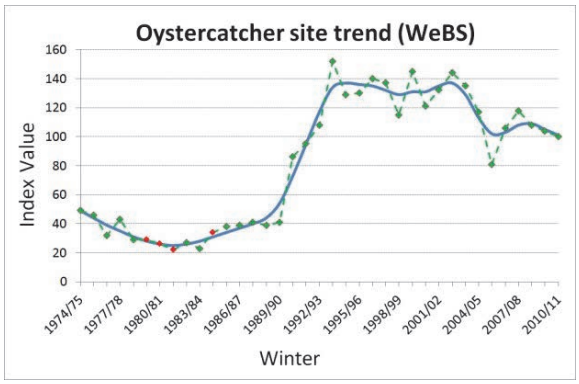
Jill Pakenham

SEASONALITY – Modest numbers breed along rocky coasts and in fields adjacent to the estuary and coasts. Highest numbers occur during autumn passage through to mid-winter, birds begin vacating the site early in the year.



PRESSURES – Dredging for shellfish.

POPULATION TRENDS – The proportion of Scottish wintering birds using the Forth has remained stable after an increase in the early 1990s. This suggests conditions on the site remain favourable for this particular species.



GOLDEN PLOVER
Pluvialis apricaria

CONSERVATION STATUS
SPA Population at Classification: 2,949
UK: AMBER (important non-breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Wintering birds on the Forth will breed in Britain, Fennoscandinavia and Iceland.

BEHAVIOUR – Birds forage by day and by night, returning to favoured sites in subsequent years. Tends to be more tolerant of disturbance than other waders, with flight distances of c.50m compared with almost 100m for Redshank and Curlew.

DIET – Mainly insects, especially beetles; also other invertebrates and some plant material.

HABITAT – Feeds mainly on pasture and arable farmland in winter with mudflats and saltmarshes mainly used for roosting.

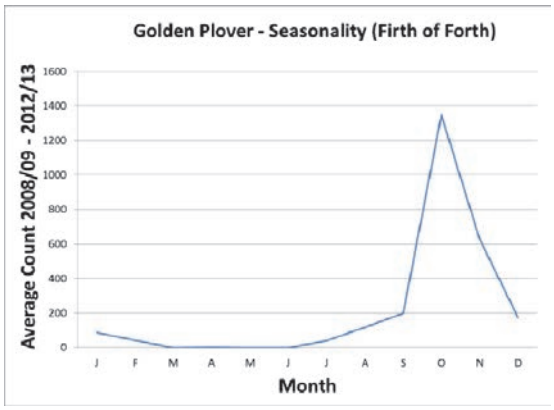
	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	-	-
Coastal fields	✓	✓
Inland fields	✓	✓

DISTRIBUTION

INNER FORTH	Locally common
OUTER AREAS	Locally common

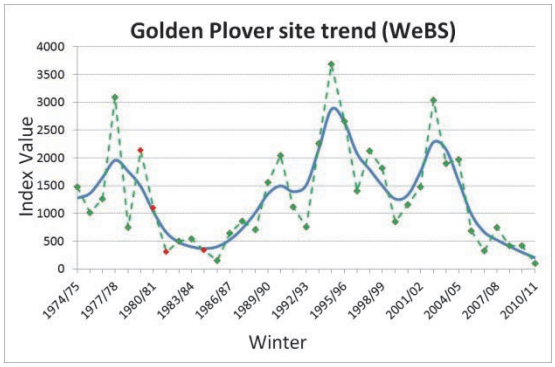
Jill Pakenham

SEASONALITY – Present during autumn passage and early winter (mainly Sept-Dec). Some breed in nearby uplands.



PRESSURES – Long term declines may be associated with changing conditions in breeding areas.

POPULATION TRENDS – The Forth trend is broadly tracking the Scottish trend, although a declining proportion of Scottish wintering birds are being supported by the site. This suggests that conditions on the site are deteriorating for this species.



GREY PLOVER
Pluvialis squatarola

CONSERVATION STATUS
SPA Population at Classification: 724
UK: AMBER (localised and important non-breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – All birds come from the population breeding in western Siberia.

BEHAVIOUR – Site faithful, defending individual feeding territories within and between winters. Feeds by sight but can forage by night as well as day. Sensitive to disturbance by walkers and dogs.

DIET – In winter, predominantly marine (polychaete) worms, molluscs and crustaceans.

HABITAT – Estuaries and lagoons, feeding on mudflats and joining mixed wader roosts. Roost sites may include man-made artefacts or occasionally adjacent fields.

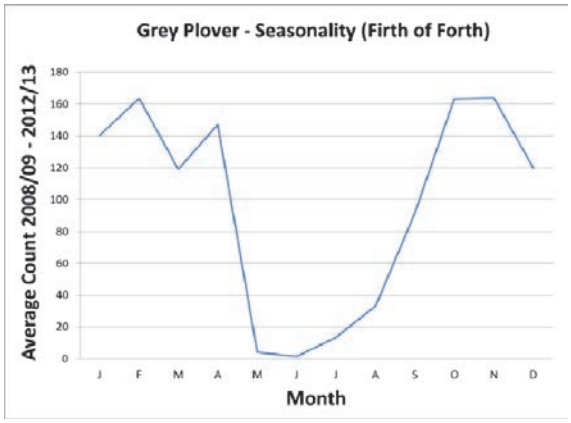
	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	-	-
Coastal fields	-	✓
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Scarce
OUTER AREAS	Widespread, uncommon

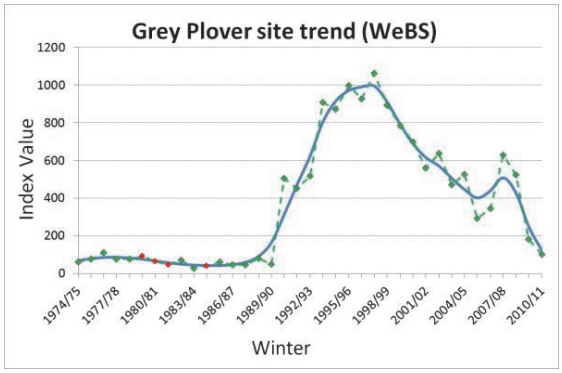
Jill Pakenham

SEASONALITY – Winter visitor, with first passage or returning birds as early as July.



PRESSURES – There is some evidence that the distribution of this species is shifting north-eastwards in response to climate change. Sensitive to disturbance by walkers and dogs.

POPULATION TRENDS – The trend for the Forth is broadly tracking the Scottish trend, although a declining proportion of Scottish wintering birds are being supported by the site. This suggests that conditions on the site are deteriorating for this species.



LAPWING
Vanellus vanellus

CONSERVATION STATUS
SPA Population at Classification: 4,148
UK: **RED** (recent breeding population decline).
Europe: Concern. SPEC Category 2. Vulnerable.
Global: Least Concern.

ORIGIN – The majority of wintering birds are from elsewhere, with most birds thought to come to the UK from central Europe and Russia.

BEHAVIOUR – Lapwings feed by sight, but have large eyes and so can feed at night, especially during brighter nights.

DIET – Wide range of invertebrates including beetles and earthworms.

HABITAT – Feeds mainly on pasture, wet meadows and arable farmland in winter. Roosts in fields or on saltmarsh. Estuarine sites can become important in cold weather when other sites freeze.

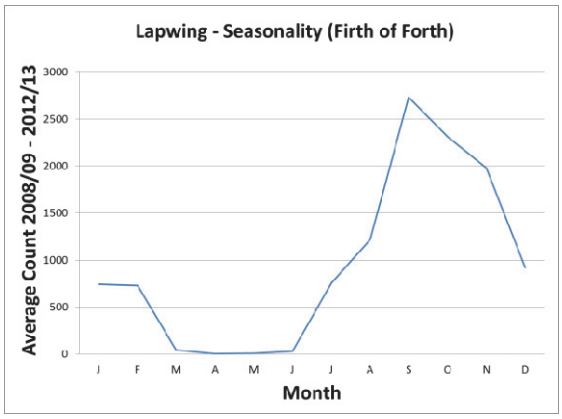
	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	-	-
Coastal fields	✓	✓
Inland fields	✓	✓

DISTRIBUTION

INNER FORTH	Locally common
OUTER AREAS	Locally common

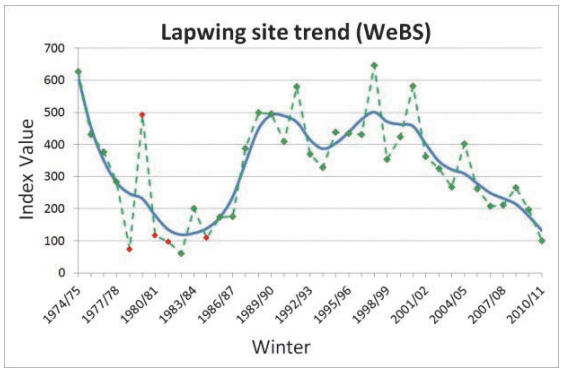
Adrian Dancy

SEASONALITY – Mainly a passage migrant with some birds wintering. Breeds inland in area around the estuary. The first continental birds return in July.



PRESSURES – Steep declines in western Europe have been linked to agricultural intensification. Climate change may further reduce the value of Scottish sites as a winter destination.

POPULATION TRENDS – The trend for the Forth is broadly tracking the Scottish trend, although with an increasing proportion of Scottish wintering birds being supported by the site. This suggests that, despite the ongoing decline in numbers, conditions on the site remain relatively favourable for this species.



RINGED PLOVER
Charadrius hiaticula

CONSERVATION STATUS
SPA Population at Classification: 328
UK: AMBER (recent breeding population decline; important non-breeding population).
Europe: Not a species of concern
Global: Least Concern.

ORIGIN – Movements are poorly understood. Some wintering birds may be local or from further north, others from populations around the North Sea. Birds from Fennoscandinavia, Iceland and Greenland probably occur mainly on passage.

BEHAVIOUR – Can occur in large flocks in winter. Feeds by sight using pause-travel approach, like other plovers.

DIET – In winter, mainly marine worms, crustaceans and molluscs.

HABITAT – Predominantly sand and shingle shores, sandbanks and mudflats, roosting close to the feeding sites on bare ground and in low vegetation. May also join mixed wader roosts including those on man-made artefacts.

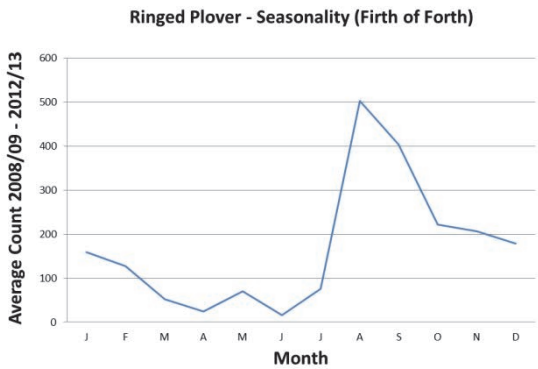
	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Widespread in small numbers
OUTER AREAS	Widespread in small numbers

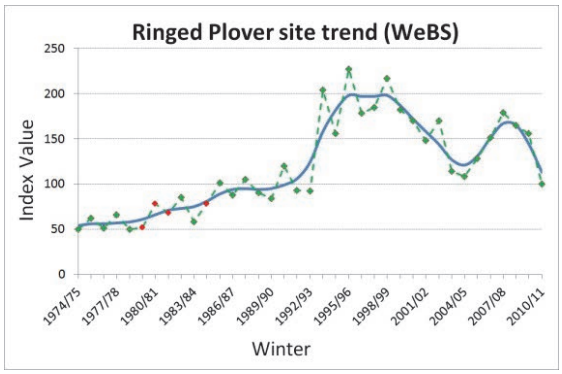
Jill Pakenham

SEASONALITY – Mainly a passage migrant and winter visitor with peak in autumn (August-September). Small numbers breed on shore and nearby 'broken' ground (including manmade surfaces and unvegetated patches in fields).



PRESSURES – Disturbance to breeding birds is a major threat to this species.

POPULATION TRENDS – Although numbers have been declining recently the decrease has been insufficient to have triggered a WeBS Alert. Despite the decrease in numbers on the site an increasing proportion of Scottish wintering birds are supported by the Firth of Forth, suggesting site conditions remain relatively favourable for this species.



CURLEW
Numenius arquata

CONSERVATION STATUS
SPA Population at Classification: 1,928
UK: AMBER (>20% of European breeding and wintering populations).
Europe: Concern. SPEC Category 2. Declining.
Global: Near Threatened.

ORIGIN – Curlews breeding in eastern Scotland mostly winter in Ireland. The vast majority of Curlews in eastern Scotland in winter are from Fennoscandinava.

BEHAVIOUR – Gregarious during winter, occurring in small to large flocks. Birds are thought to mostly be site faithful within and between winters. Sensitive to disturbance.

DIET – Invertebrates, including intertidal worms, crustaceans, molluscs and earthworms. Food located primarily by touch .

HABITAT – Mainly feeds along muddy shorelines of estuaries, lagoons, lakes and rivers, with some birds also using inland fields. Roosts at high tide, usually among mixed wader flocks. Roost sites can include man-made artefacts as well as more natural habitats.

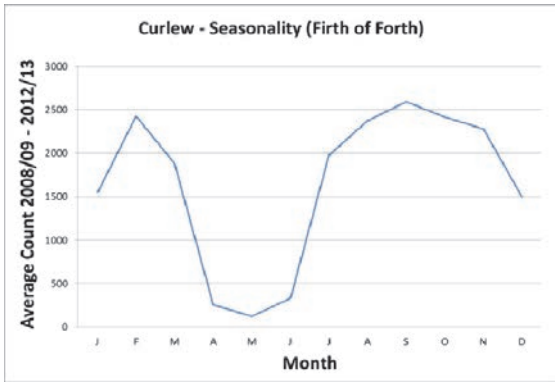
	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	✓	✓
Coastal fields	✓	✓
Inland fields	✓	✓

DISTRIBUTION

INNER FORTH	Widespread, numerous
OUTER AREAS	Widespread, numerous

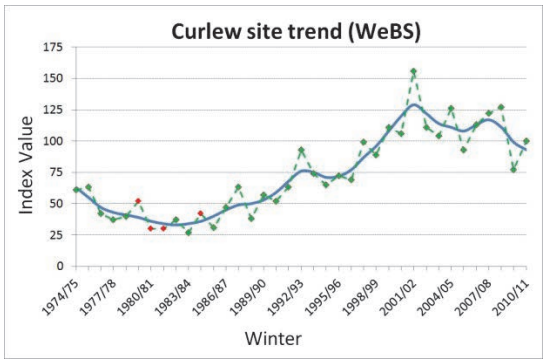
John Harding

SEASONALITY – Peaks occur in autumn and in late winter. A small (and declining) population breeds in fields adjacent to the estuary and coasts.



PRESSURES – Agricultural intensification, afforestation and predation threatens breeding birds. Disturbance at feeding and especially roost sites by walkers and dogs.

POPULATION TRENDS – Winter numbers are variable but increased to a maximum count of 2,582 in 2008/09 and have decreased slightly since to 1,777 in 2012/13. The Forth trend is similar to the Scottish trend. This suggests that conditions on the site remain relatively favourable for this species.



BAR-TAILED GODWIT
Limosa lapponica

CONSERVATION STATUS
SPA Population at Classification: 1,974
UK: AMBER (localised and important non-breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – All birds come from the population breeding in northern Europe and western Siberia (*lapponica* race).

BEHAVIOUR – Highly gregarious in winter, forming large flocks. Many birds are site faithful but small numbers do move sites within or between winters. Relatively sensitive to disturbance compared to other waders.

DIET – Mainly marine worms from mudflats.

HABITAT – Mostly feeds on mudflats in estuaries, preferring the outer parts of estuaries where substrates are generally most sandy. Joins mixed wader roosts at high tide.

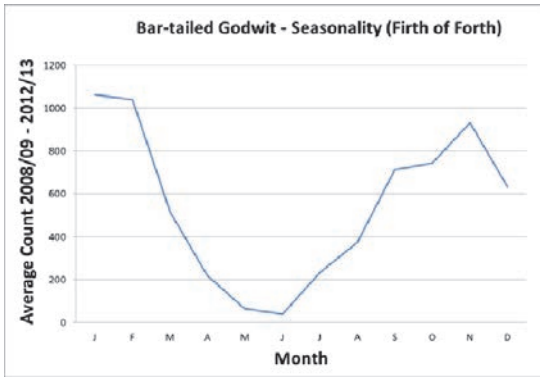
	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	✓	✓
Coastal fields	✓	✓
Inland fields	✓	✓

DISTRIBUTION

INNER FORTH	Local, common
OUTER AREAS	Local, numerous

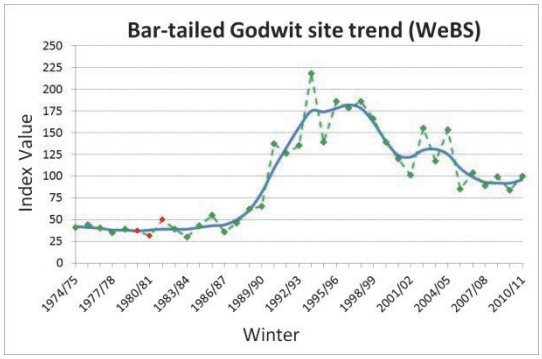
Al Downie

SEASONALITY – Mainly winter visitor but some spring passage migrants are present in May and return passage may begin in July.



PRESSURES – Disturbance of feeding flocks and especially roosts by walkers and dogs.

POPULATION TRENDS – The trend for the Forth is broadly tracking the Scottish trend, although an increasing proportion of the Scottish wintering birds are supported by the site. This suggests that despite the ongoing decline in numbers, conditions on the site remain relatively favourable for this species.



TURNSTONE
Arenaria interpres

CONSERVATION STATUS
SPA Population at Classification: 860
UK: AMBER (important non-breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – The vast majority of Turnstone wintering in the UK are from the Canada/Greenland population. Baltic birds occur on migration.

BEHAVIOUR – Locates food by sight, often by turning over pebbles or seaweed. Highly site faithful, both within and between winters, often remaining in flocks with the same membership. Not particularly sensitive to disturbance compared to other wader species.

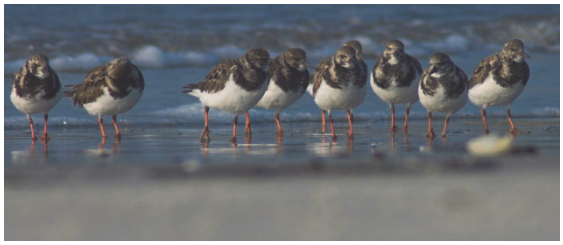
DIET – A very wide range of invertebrates and other material, including carrion.

HABITAT – Often along rocky or stony shores, but also on mudflats or sandy shores and especially on tide wrack. May join mixed wader roosts, including on man-made artefacts.

	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-

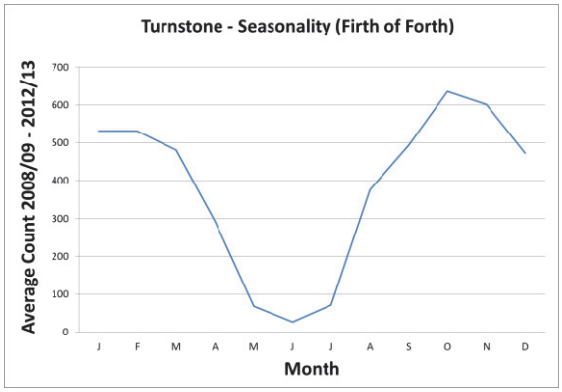
DISTRIBUTION

INNER FORTH	Local, scarce
OUTER AREAS	Locally common



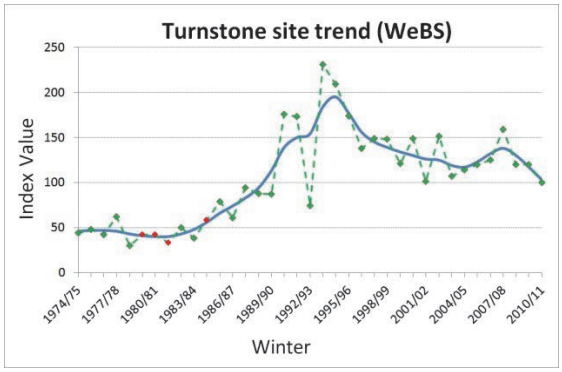
Rob Robinson

SEASONALITY – Wintering numbers are just exceeded by a passage peak in October. A few non-breeders spend the summer.



PRESSURES – Declines shown by the non-estuarine winter shorebird count are thought to have been caused by a northerly range shift brought about by climate change.

POPULATION TRENDS – The proportion of Scottish wintering birds using the Forth has remained stable after increasing in the early 1990s. This suggests the Forth area remains relatively favourable for this species.



KNOT
Calidris canutus

CONSERVATION STATUS
SPA Population at Classification: 9,258
UK: AMBER (localised and important non-breeding population, and species of European concern).
Europe: Concern. SPEC Category 3. Declining.
Global: Least Concern.

ORIGIN – Most birds wintering in Britain are from Greenland and Arctic Canada.

BEHAVIOUR – Knots feed in very large flocks on open mudflats, catching food mainly by touch. Flocks will move with the tide and may cover very extensive areas of mudflat. Sensitive to disturbance, especially at roost sites.

DIET – Mainly molluscs, including tellins *Macoma balthica*, mussels *Mytilus edulis*, cockles *Cerastoderma edulis* and mudsnails *Hydrobia ulvae*, the latter especially in early winter.

HABITAT – Feed in dense flocks on extensive intertidal mudflats. Sometimes fly many kilometres to roost sites, along undisturbed shorelines. Roost sites may include man-made artefacts and occasionally fields adjacent to the shore.

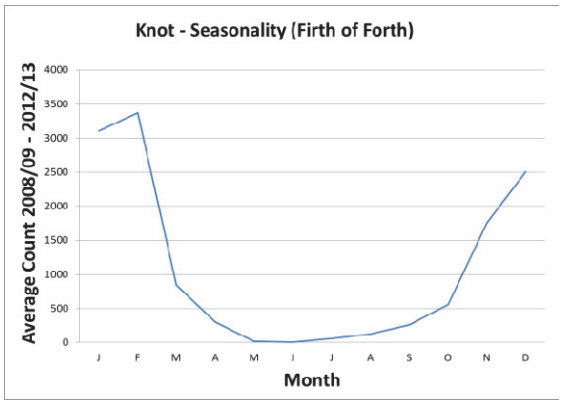
	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	-	-
Coastal fields	-	✓
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Widespread and numerous
OUTER AREAS	Locally numerous

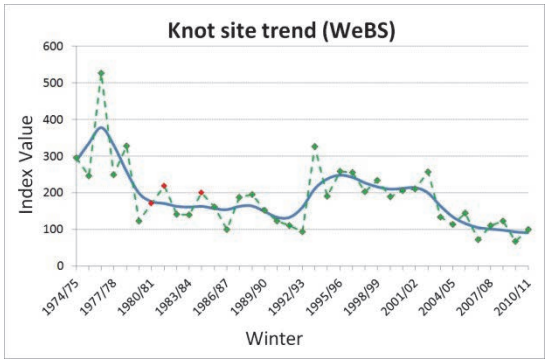
Neil Calbrade

SEASONALITY – Winter visitor. Mainly October to March, peak in January/February.



PRESSURES – There is evidence that an easterly shift in the wintering distribution of this species in Europe as a result of climate change.

POPULATION TRENDS – The trend for the Forth broadly tracks the Scottish trend, although a declining proportion of Scottish wintering birds are being supported by the site. This suggests that conditions on the site are deteriorating for this species.



DUNLIN
Calidris alpina

CONSERVATION STATUS
SPA Population at Classification: 9,514
UK: **RED** (recent non-breeding population decline).
Europe: Concern. SPEC Category 3. Depleted.
Global: Least Concern.

ORIGIN – The majority of wintering birds are from northern Fennoscandinavia and European Russia. Others from Iceland and SE Greenland are common on passage.

BEHAVIOUR – Feeds by touch and sight by day and night according to tides, remaining in large flocks during winter. Site faithful to winter roost sites both within and between winters.

DIET – Invertebrates, mainly marine worms and small gastropods during winter.

HABITAT – Feeds on estuarine and non-estuarine intertidal mudflats. Joins wader roosts near feeding areas; will roost on open fields during highest tides.

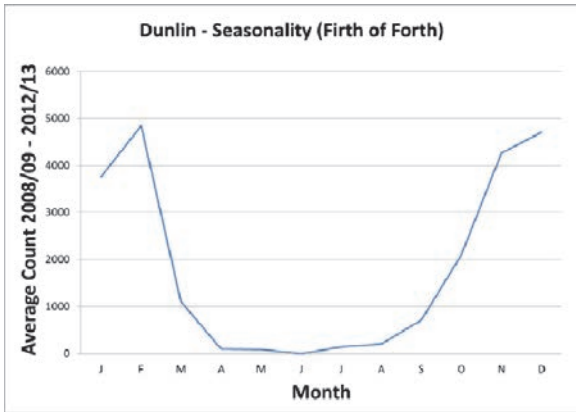
	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	✓	✓
Coastal fields	-	✓
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Widespread and numerous
OUTER AREAS	Widespread and numerous

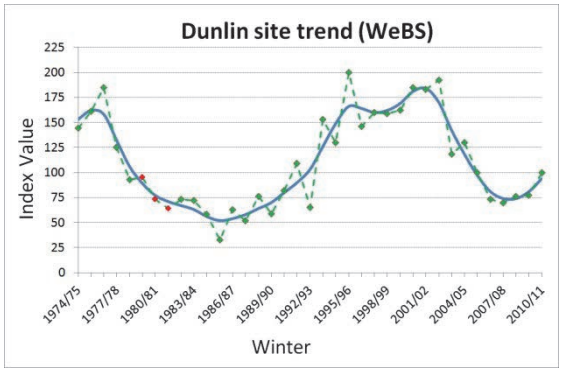
Anne Cotton

SEASONALITY – Winter visitor (September to March).



PRESSURES – There is evidence that an easterly shift in the wintering distribution of this species in Europe as a result of climate change.

POPULATION TRENDS – The trend for the Forth is broadly tracking the Scottish trend, although with an increasing proportion of Scottish wintering birds being supported by the site. This suggests that despite the recent decline in numbers, conditions on the site remain relatively favourable for this species.



REDSHANK
Tringa totanus

CONSERVATION STATUS
SPA Population at Classification: 4,341
UK: AMBER (recent breeding population decline; important non-breeding population, European concern).
Europe: Concern. SPEC Category 2. Declining.
Global: Least Concern.

ORIGIN – Large numbers from Iceland occur in winter, when many Scottish breeders head to England or further south.

BEHAVIOUR – Redshanks are usually site faithful in winter, though long-distance movement sometimes occurs, probably in response to cold weather. Redshanks are particularly susceptible to disturbance in severe weather. As they take small prey, they need to feed for longer periods during the tidal cycle than other species and have less scope for extending feeding time when necessary to meet their energy requirements.

DIET – Invertebrates, including insects, spiders, annelid worms, molluscs and crustaceans (especially amphipods).

HABITAT – Mainly coastal, including mudflats and tidal estuaries joining mixed wader roosts at high tide. Roost sites may be on man-made artefacts as well as natural sites.

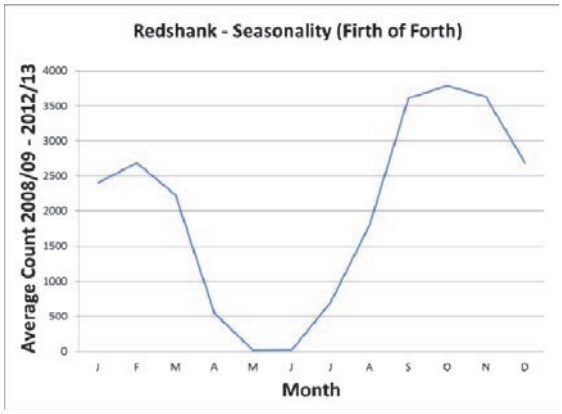
	Low tide	High tide
Open water	-	-
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	✓	✓
Coastal fields	✓	✓
Inland fields	-	-

DISTRIBUTION

INNER FORTH	Widespread and numerous
OUTER AREAS	Widespread and numerous

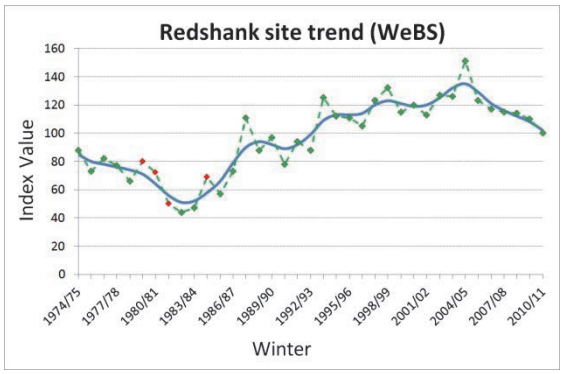
John Harding

SEASONALITY – Peak numbers occur in autumn, dropping slightly by mid winter. Small numbers breed nearby.



PRESSURES – Widespread declines in Britain and Europe have been attributed to agricultural intensification on the breeding grounds.

POPULATION TRENDS – The trend for the Forth broadly tracks the Scottish trend, although a declining proportion of Scottish wintering birds are being supported by the site. This suggests conditions on the site are are deteriorating relative to other sites for this species.



PUFFIN
Fratercula arctica

CONSERVATION STATUS
SPA Population at Classification: 14,000
UK: AMBER (species of European concern, localised breeding population).
Europe: SPEC Category 2. Depleted.
Global: Least Concern.

ORIGIN – Puffins breed on several of the islands in the Firth of Forth. Outside of the breeding season, movements at sea are poorly understood.

BEHAVIOUR – Breed in colonies of varying sizes mainly on offshore islands with no mammalian predators. Feed at sea, diving from surface.

DIET – Small fish, with sandeels being the main prey species fed to young during the breeding season.

HABITAT – Breed in burrows on offshore islands, birds on the Isle of May are known to forage up to 64km from the island (most < 40 km).

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	-
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

INNER FORTH	Rare
OUTER AREAS	Locally numerous

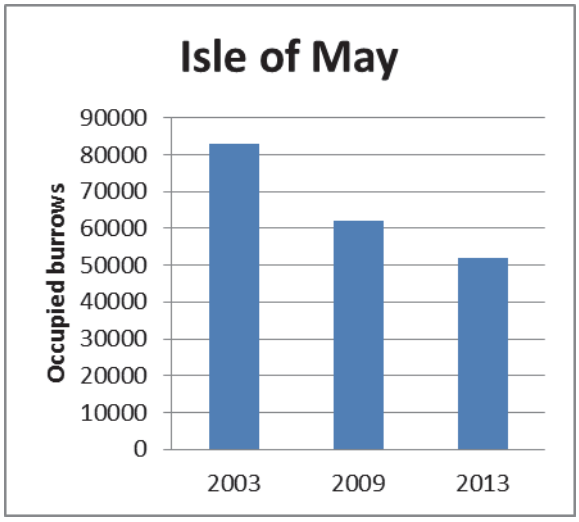
Breeds on islands in Forth Islands SPA.


Anne Cotton

SEASONALITY – Return to their colonies in late March-early April, though arrival dates have fluctuated over time. Most young fledge in July. This species is pelagic in winter and very rarely observed from land.

PRESSURES – Vulnerable to the availability of suitable size (age-class) fish. Also to mammalian predators such as rats in breeding colonies and to some invasive plant species (e.g. tree mallow *Lavatera arborea*).

POPULATION TRENDS – Monitoring on the Isle of May suggests a recent decline in breeding numbers following a period of increase during the 20th century. This is similar to trends in some, but not all parts of Scotland.



RAZORBILL
Alca torda

CONSERVATION STATUS
UK: AMBER (localised breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Razorbills nest on several of the islands in the Firth of Forth. Local breeders winter in shallow coastal waters, most in the North Sea with some moving south to the Bay of Biscay. Winter birds may include birds from Iceland, the Faroes and Scandinavia.

BEHAVIOUR – Breed in colonies of varying sizes mainly on cliffs and offshore islands. Feed at sea, diving from surface.

DIET – Predominantly small fish (sprats *Sprattus sprattus*, herring *Clupea harengus* and sandeels), with prey size being intermediate between those caught by Puffins and Guillemots.

HABITAT – In the Forth, Razorbills breed on cliffs and boulder-scree slopes on offshore islands.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	-	-
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

INNER FORTH	Scarce
OUTER AREAS	Locally numerous

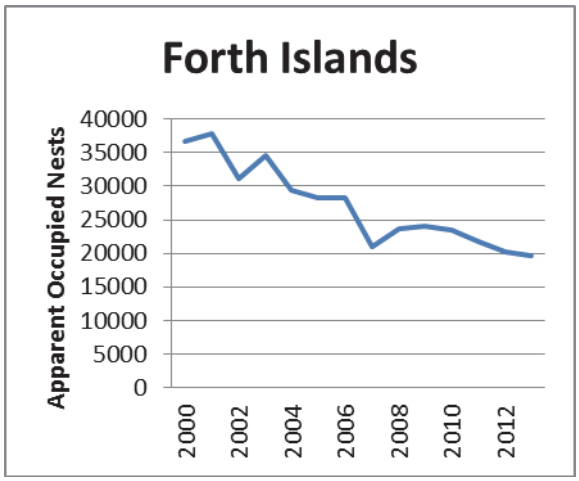
Breeds on a number of offshore islands in the outer Forth.

Anne Cotton

SEASONALITY – Birds are in the Forth all year round (lowest numbers in winter), with most returning to their colonies in late March. Chicks leave their nests during the first week of July when still flightless and are fed by the males for several weeks.

PRESSURES – Vulnerable to the availability of suitable size (age-class) fish.

POPULATION TRENDS – Numbers have been increased in the Firth of Forth during the 20th century but have declined considerably in the 21st century. This is in contrast to the UK population trend which has increased since 2000.



GUILLEMOT
Uria aalge

CONSERVATION STATUS
SPA Population at Classification:
16,000 pairs
UK: AMBER (important & localised breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Guillemots nest on several of the islands in the Firth of Forth. Large numbers of these birds winter off the east coast of Scotland with some moving as far west as Scandinavia, and as far south as the Bay of Biscay. Winter birds may include some from the Faroes and Norway and other British colonies.

BEHAVIOUR – Guillemots spend most of their time on the sea, catching their food by diving under the water from the surface. Guillemots, unlike the other two auks, only carry one item of prey back to their nest.

DIET – Predominantly small fish such as sandeels, herring and sprats.

HABITAT – Outside the breeding season Guillemots are a pelagic species, though a few make short visits to the nesting cliffs in clement weather. In the Forth, Guillemots breed at high densities on sheer cliffs on offshore islands.

	Low tide	High tide
Open Water	✓	✓
Intertidal mud	-	-
Saltmarsh	-	-
Rocky shore	-	-
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

INNER FORTH	Uncommon
OUTER AREAS	Locally numerous

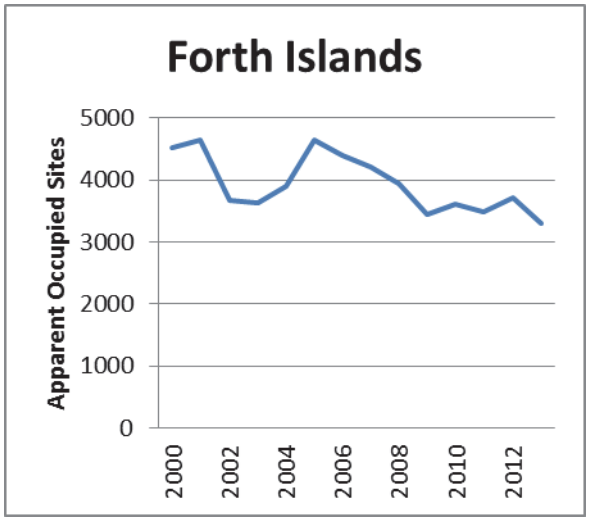
Breeds on a number of offshore islands in the outer Forth.

Stuart Newson

SEASONALITY – Breeding adults return to their colonies by late March. Chicks leave their nests during late June and early July when still flightless and are fed by the males for up to eight weeks.

PRESSURES – Vulnerable to the availability of suitable size (age-class) fish.

POPULATION TRENDS – Numbers increased in the Firth of Forth through the 1980s and 1990s, but have declined since 2003, particularly on the Isle of May, the largest colony in the Forth.



SANDWICH TERN
Sterna sandvicensis

CONSERVATION STATUS
SPA Population at Classification: 440 Pairs
UK: AMBER (species of European concern, recent breeding range decline, localised breeding population).
Europe: Concern. SPEC Category 2. Depleted.
Global: Least Concern.

ORIGIN – The site is designated as an SPA for the large numbers that congregate in the Forth post-breeding. Colour-ringed birds have originated from breeding sites in Scotland, England, Belgium and The Netherlands. Sandwich terns winter off west Africa, travelling as far as South Africa and the Indian Ocean.

BEHAVIOUR – Nests in colonies usually in association with other terns and gulls. Roosts communally in flocks often with other terns. Patrols coastal waters, often in groups, diving into the water to catch prey.

DIET – Small fish caught in surface waters.

HABITAT – Principally a marine species, but roosts on offshore islands, exposed rocks, estuaries at low tide, and on coastal lagoons. Nested on offshore islands, undisturbed beaches and sand dunes in the Forth.

	Low tide	High tide
Open Water	✓	✓
Intertidal mud	✓	✓
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

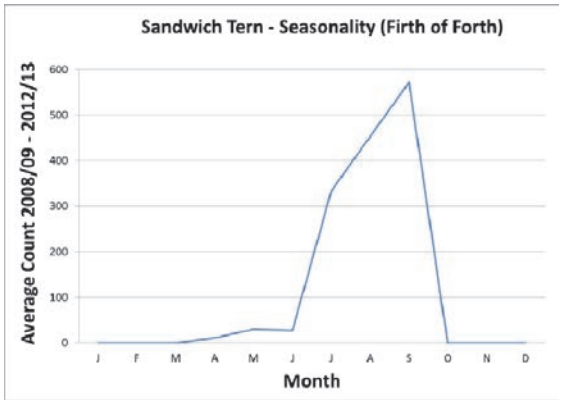
DISTRIBUTION

INNER FORTH	Uncommon
OUTER AREAS	Common and widespread

Large roosts found between Musselburgh and Aberlady Bay, and also in Tyninghame Bay. Occasionally found in the upper reaches of the estuary when terns follow large shoals of small fish moving upstream.

Jill Pakenham

SEASONALITY – Most Sandwich Terns arrive in Scottish waters in April and early May. In July and August, post-breeding, large numbers build up in the Forth (over 2000 in August 2014) with most birds leaving by the end of September.



PRESSURES – Potentially displaced from colonies by disturbance, predation and increasing gull colonies. Vulnerable to the availability of suitable size (age-class) fish.

POPULATION TRENDS – The number of colonies in Scotland has declined dramatically from up to 25 in the past to 7 in 2000, with the subsequent loss of all colonies in the Forth reflecting this.

COMMON TERN
Sterna hirundo

CONSERVATION STATUS
SPA Population at Classification: 558 Pairs
UK: AMBER (localised breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – British breeding birds winter off west Africa. Birds breeding in Iceland, Scandinavia and western Siberia occur on passage.

BEHAVIOUR – Nests in colonies on flat ground. Roosts communally often with other tern species on islands, exposed rocks, estuaries at low tide and coastal lagoons.

DIET – Small fish, principally sandeels in surface waters are caught from an aerial dive.

HABITAT – Mostly a marine species in Scotland. Nesting on offshore islands, and formerly on beaches along the Forth coast. Forages over both inshore and offshore waters.

	Low tide	High tide
Open Water	✓	✓
Intertidal mud	✓	✓
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

INNER FORTH	Common
OUTER AREAS	Widespread, common, locally numerous

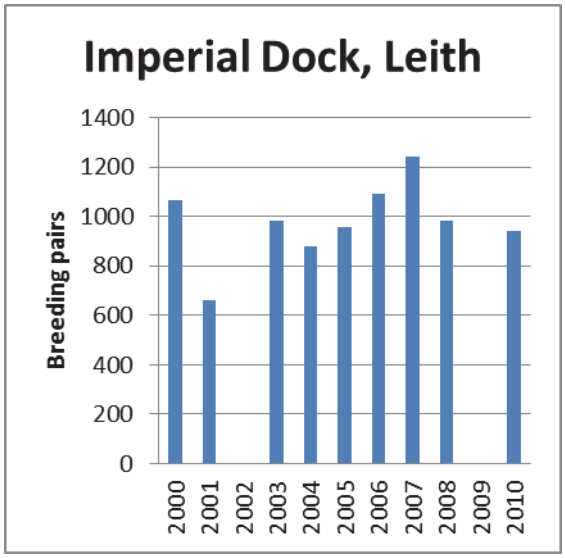
Important colonies are present at Imperial Dock Lock, Leith SPA, the Isle of May and Grangemouth docks.

Jill Pakenham

SEASONALITY – The first Common Terns arrive in the Forth in mid April with the majority back by early May. Most have left by the first week in September.

PRESSURES – Displaced from former colonies by human disturbance, predation and increasing gull colonies. Vulnerable to the availability of suitable size (age-class) fish.

POPULATION TRENDS – Typically for terns, colony numbers and distributions fluctuate with colonies being formed and deserted over time.



ROSEATE TERN
Sterna dougallii

CONSERVATION STATUS
SPA Population at Classification: 8 Pairs
UK: **RED** (recent breeding population decline).
Europe: Concern. SPEC Category 3. Rare.
Global: Least Concern.

ORIGIN – Now an irregular breeder, birds visiting the Firth of Forth area are likely to be from colonies in Northumberland. Roseate terns winter off west Africa.

BEHAVIOUR – Nests in colonies usually with other terns but often amongst rocks and under artificial cover. Roosts communally in flocks often with other tern species on offshore islands, exposed rocks, estuaries at low tide, and on coastal lagoons. Recently fledged young are dependent on their parents for a few weeks.

DIET – Small fish, principally sandeels in surface waters, which are caught from an aerial dive.

HABITAT – Away from their breeding grounds Roseate Terns are a highly marine species and feed further offshore than most other tern species.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	✓	✓
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

INNER FORTH	Rare
OUTER AREAS	Rare

Formerly a regular breeder, they are still seen annually, including amongst colonies of other terns.

Graham Catley

SEASONALITY – Roseate Terns arrive in Scottish waters between late April and early June. Post-breeding, occasional birds wander into the Forth in August and early September.

PRESSURES – Displaced from former colonies by human disturbance, predation and increasing gull colonies. Vulnerable to the availability of suitable size (age-class) fish.

POPULATION TRENDS – The UK and Irish population underwent a large decline in the 20th century, with only a few of the large colonies extant. Numbers at these colonies have been increasing since 2000. With an extant colony in Northumberland, and birds recorded annually in the Forth, re-establishment of breeding remains possible.

ARCTIC TERN
Sterna paradisaea

CONSERVATION STATUS
SPA Population at Classification: 540 Pairs
UK: AMBER (recent breeding range decline).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – A highly migratory species spending northern winters in the southern oceans, with some reaching Antarctic pack ice. Birds breeding elsewhere in northern Britain, Iceland, Scandinavia and western Siberia are likely to pass through.

BEHAVIOUR – Nests in colonies on flat ground. Roosts communally in flocks often with other tern species on offshore islands, exposed rocks, estuaries at low tide, and on coastal lagoons.

DIET – Small fish, principally sandeels in surface waters which are caught from an aerial dive.

HABITAT – Away from their breeding grounds Arctic Terns are a highly marine species. Feeds in inshore and offshore waters.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	✓	✓
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

INNER FORTH	Uncommon
OUTER AREAS	Widespread, common, locally numerous

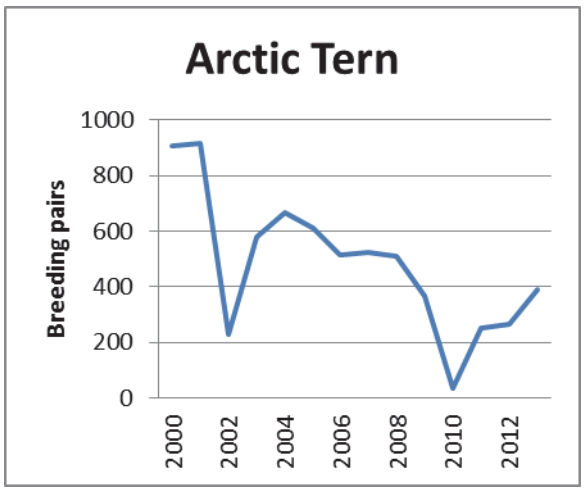
Nested historically on several of the islands in the Firth of Forth, although only on the Isle of May since 1998.

Anne Cotton

SEASONALITY – The first arctic terns arrive back in the Forth in mid April with the majority back by mid May. Most have left by early September.

PRESSURES – Displaced from former colonies by human disturbance, predation and increasing gull colonies. Vulnerable to the availability of suitable size (age-class) fish.

POPULATION TRENDS – Having been absent from the Isle of May since 1958, arctic terns recolonised the island in 1984 after which numbers increased to 916 pairs in 2001. Numbers have subsequently declined in line with the Scottish trend.



KITTIWAKE
Rissa tridactyla

CONSERVATION STATUS
SPA Population at Classification: 8,400 Pairs
UK: AMBER (recent breeding population decline).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – A marine species breeding in the North Atlantic and North Pacific. Scottish birds winter at sea and have been found as distant as Morocco and Newfoundland. Birds from Norway winter in the North Sea.

BEHAVIOUR – Breeds in colonies on cliffs or buildings. Food is caught through shallow plunge-dives or picked from the surface of the sea.

DIET – Sandeels are main prey species for both adults and young in the Forth. In winter, their diet consists mainly of marine invertebrates and small fish.

HABITAT – Most colonies are on the Forth islands with a few on mainland cliffs and man-made structures. Feeds typically in the open sea with The Banks (area of shallow sea 40 km east) important.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	✓	✓
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-
Offshore islands	✓	✓

DISTRIBUTION

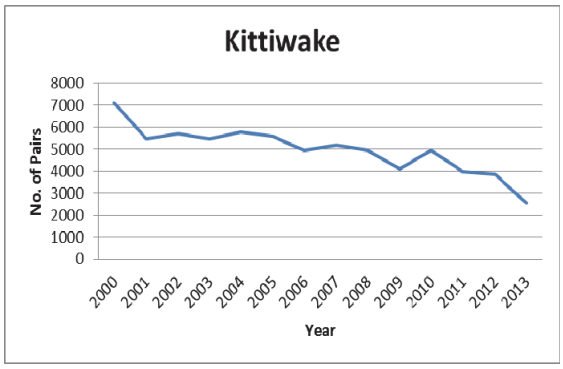
INNER FORTH	Rare
OUTER AREAS	Widespread and locally numerous

Jill Pakenham

SEASONALITY – Kittiwakes return to their colonies in late February or March. The timing of egg-laying depends on weather and feeding conditions. Nesting colonies are deserted by late August, but large feeding concentrations and passage along the east coast occur late into autumn. Some Kittiwakes do winter in the North Sea, but only come close to the coast in inclement weather.

PRESSURES – Vulnerable to the availability of suitable size (age-class) fish.

POPULATION TRENDS – The breeding population of Kittiwakes in the UK declined by 61% between 2000 and 2013 with a similar decline being recorded in the Firth of Forth.



BLACK-HEADED GULL
Chroicocephalus ridibundus

CONSERVATION STATUS
SPA Population at Classification: Not recorded
UK: AMBER (recent non-breeding population decline and important non-breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – Some winter birds may be resident or local; many others breed in northern Europe especially Fennoscandinavia and the Baltic States.

BEHAVIOUR – Gregarious throughout the year. Roosts at night in large flocks in winter on the sea, estuary or inland reservoirs, often feeding inland. Often tolerant of humans.

DIET – Omnivorous but mainly aquatic and terrestrial invertebrates. Also artificial food sources provided by humans.

HABITAT – Most common in winter in coastal habitats though generally avoiding rocky coastlines and occurring inland in many different natural and urban habitats.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	✓	✓
Coastal fields	✓	✓
Inland fields	✓	✓

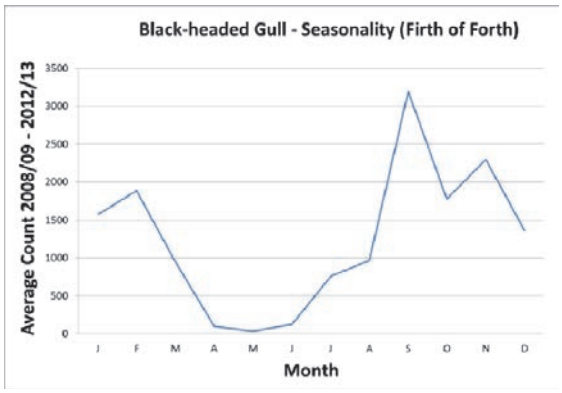
DISTRIBUTION

INNER FORTH	Widespread and nuumerous
OUTER AREAS	Widespread and numerous

Small numbers breed close to the SPAs.

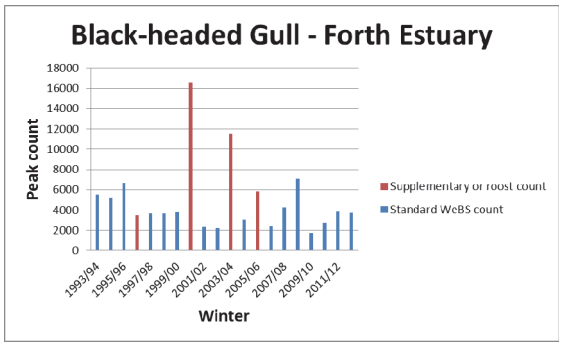
Anne Cotton

SEASONALITY – Mostly a winter visitor. Failed breeders or post-breeding birds start returning from late June. Peak in September.



PRESSURES – Breeding numbers have declined in Britain, the reasons for which are unclear.

POPULATION TRENDS – Peak winter counts suggest relative stability.



LITTLE GULL
Hydrocoloeus minutus

CONSERVATION STATUS
SPA Population at Classification: N/A (dSPA)
UK: AMBER
Europe: Concern. SPEC Category 3. Depleted.
Global: Least Concern.

ORIGIN – A spring and autumn passage bird in eastern Scotland. The main breeding range is in northwest Russia, the Baltic and in Siberia. Most winter along the coasts of western Europe, although several hundred remain in the North Sea.

BEHAVIOUR – Feeds by picking food items off the surface of water, sometimes in large flocks.

DIET – When away from its breeding grounds in Scottish waters mostly small fish and invertebrates.

HABITAT – Roosts on sheltered water, estuaries and beaches, feeding offshore during the day.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	✓	-
Saltmarsh	-	-
Rocky shore	✓	✓
Coastal fields	-	-
Inland fields	-	-
Offshore islands	-	-

DISTRIBUTION

INNER FORTH	Rare
OUTER AREAS	Scarce

Largest numbers in eastern Scotland are found in the Tay Bay, but flocks of several hundred have been recorded in the Forth.

Dave King

SEASONALITY – Two peaks of birds occur in autumn with young birds and adults migrating at different times. Smaller numbers remain in the North Sea in winter when strong easterly winds can push birds close to the coast.

PRESSURES – Little Gull numbers in the outer Tay have fluctuated, and the sites that they use have been abandoned and others occupied for unknown reasons. Occurrence will be linked to conditions in breeding areas and weather at the migration times.

POPULATION TRENDS – Increased presence off the east coast of Scotland was possibly due to a western range expansion of their breeding grounds.

COMMON GULL
Larus canus

CONSERVATION STATUS
SPA Population at Classification: ?
UK: AMBER (species of European concern and important non-breeding population).
Europe: Concern. SPEC Category 2. Depleted.
Global: Least Concern.

ORIGIN – Some winter birds are resident in Scotland; many others breed in northern Europe especially Fennoscandinavia.

BEHAVIOUR – Gregarious in winter with flocks sizes depending on habitat and conditions. Joins mixed gull roosts at night.

DIET – Omnivorous but mainly earthworms, insects, aquatic and terrestrial invertebrates and small fish.

HABITAT – Uses both inland and coastal habitats, including farmland and urban habitats. Large night-time roosts form along the coast.

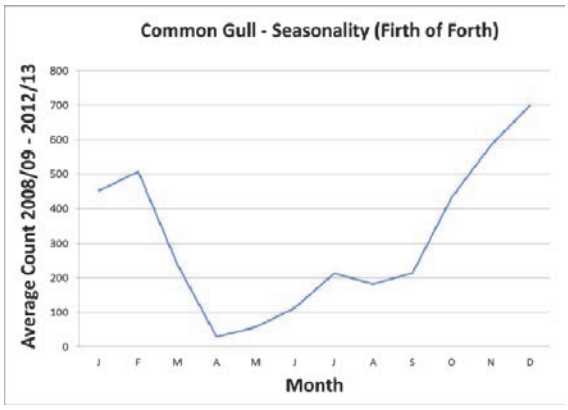
	Low tide	High tide
Open water	✓	✓
Intertidal mud	✓	-
Saltmarsh	✓	✓
Rocky shore	✓	✓
Coastal fields	✓	✓
Inland fields	✓	✓

DISTRIBUTION

INNER FORTH	Widespread and numerous
OUTER AREAS	Widespread and numerous

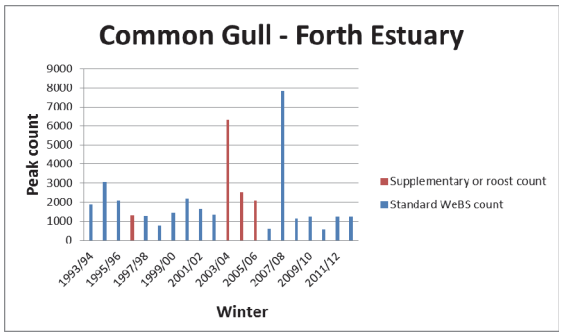
Anne Cotton

SEASONALITY – Winter visitor mainly present September to March. Small numbers breed close to the Forth (including urban nesting).



PRESSURES – None specified.

POPULATION TRENDS – Peak winter counts suggest relative stability.



LESSER BLACK-BACKED GULL
Larus fuscus

CONSERVATION STATUS
SPA Population at Classification: 6,600 pairs
UK: AMBER (important & localised breeding population).
Europe: Not a species of concern.
Global: Least Concern.

ORIGIN – A common and widespread local breeder. Scottish birds can travel in winter to Spain and north Africa although increasing numbers winter in the UK.

BEHAVIOUR – Adaptable species, exploiting a range of habitats and food resources. At sea it is a surface feeder, foraging behind fishing boats or catching fish and invertebrates. It also readily forages in urban areas.

DIET – An omnivore that eats a wide range of fish, invertebrates, carrion, live prey and human waste.

HABITAT – Tends to forage further out to sea than other large gulls. Also forage in agricultural and use of urban areas, rubbish dumps and sewage plants. Away from breeding sites this species forms large roosts with other gulls on sheltered open water, inland or in bays in the Forth.

	Low tide	High tide
Open Water	✓	✓
Intertidal mud	✓	✓
Saltmarsh	✓	✓
Rocky shore	✓	✓
Coastal fields	✓	✓
Inland fields	✓	✓
Offshore islands	✓	✓

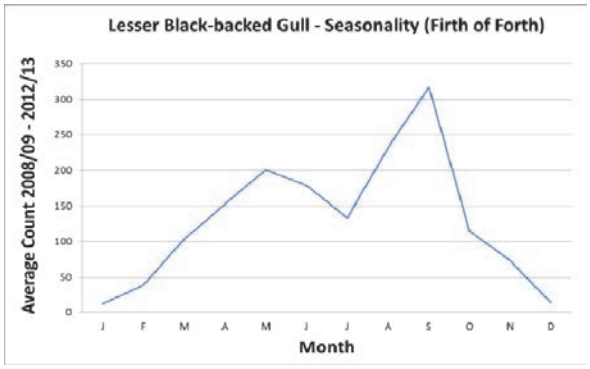
DISTRIBUTION

INNER FORTH	Widespread and numerous
OUTER FORTH	Widespread and numerous

Breeds in large colonies on Forth islands and also in urban areas (rooftops).

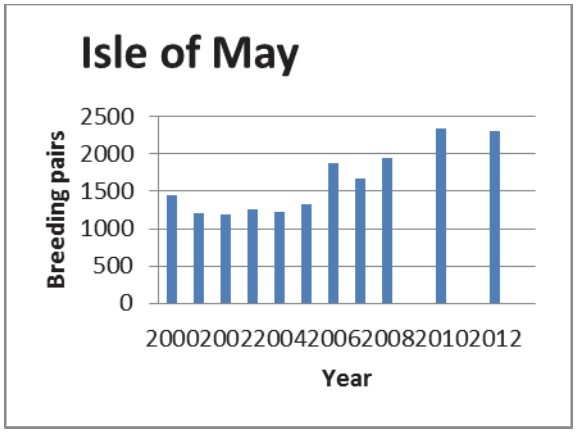
Anne Cotton

SEASONALITY – Migrants return to the Forth in February and March with birds passing through on their way north at this time as well.



PRESSURES – Abundance and distribution influenced by availability of human food and fishery discards as well as natural food sources. Urban nesting is perceived a major issue for some areas.

POPULATION TRENDS – Increased through much of 20th century. Regular counts on the Isle of May suggest a recent increase in population which is counter to the national 48% decline for breeding birds between 2002 and 2012. Increased incidence of urban nesting contrasts with a wider decline.



HERRING GULL
Larus argentatus

CONSERVATION STATUS
SPA Population at Classification: 6,600 Pairs
UK: RED (recent breeding population decline).
Europe: Not a species of concern.
Global: Least concern.

ORIGIN – Local breeders can remain through the year but some move south in winter including to mainland Europe. Winter population also includes by birds from northern Scotland, Iceland and Scandanavia.

BEHAVIOUR – Adaptable species, exploiting a range of habitats and food resources.

DIET – An omnivore that eats a wide range of fish, invertebrates, carrion, live prey and human waste.

HABITAT – Breeds on offshore islands, coastal cliffs and buildings. Forages in the intertidal zone, agricultural and urban areas, rubbish dumps and sewage plants.

	Low tide	High tide
Open water	✓	✓
Intertidal mud	✓	✓
Saltmarsh	✓	✓
Rocky shore	✓	✓
Coastal fields	✓	✓
Inland fields	✓	✓
Offshore islands	✓	✓

DISTRIBUTION

INNER FORTH	Widespread and numerous
OUTER AREAS	Widespread and numerous

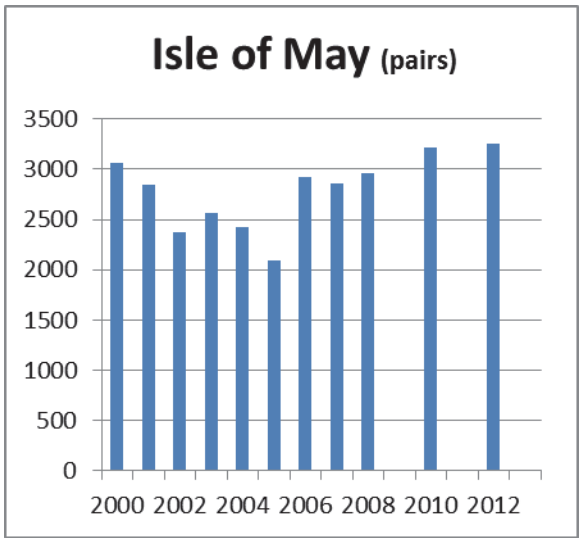
Breeds in large colonies on Forth islands and also in urban areas (rooftops).

Anne Cotton

SEASONALITY – Large numbers of birds are present in the Forth year-round. Adult males tend to stay near their breeding colonies year-round. Egg-laying takes place from late April and young fledge from early July onwards.

PRESSURES – Abundance and distribution influenced by availability of human food and fishery discards as well as natural food sources. Urban nesting is perceived a major issue for some areas.

POPULATION TRENDS – Increased through much of 20th century and subject to control in 70s-80s. Regular counts on the Isle of May suggest a recently stable population which is counter to the national 30% decline for breeding birds between 2002 and 2012.



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PART 2 FACTORS AFFECTING ESTUARINE BIRDS

1. INTRODUCTION

Britain holds many species of estuarine birds. Some populations visit for the winter, mainly from breeding grounds in various parts of the Arctic; others pass through, often *en route* between Arctic breeding grounds and wintering zones in southern Europe or Africa; and others breed locally in Britain, either on the estuaries themselves or short distances inland.
Britain has many estuaries, a relatively large tidal range and a maritime climate. It lies on major flyways (migration routes) that birds follow on journeys between the eastern Nearctic (Canada and Greenland) and Africa, and between northern Eurasia and Africa. Britain's estuaries are often winter destinations for some populations and essential stepping stones for others on longer migratory journeys. In many cases, the numbers of birds involved are recognised as being of international importance.

For these reasons, it is especially important that the UK honours its international responsibilities for the conservation of estuarine birds. Special Protection Area (SPA) designation is part of this process. Estuarine birds are under considerable threat from a wide range of factors, however, and these are discussed in this section of the report.

Estuarine birds can be affected directly by changes occurring within the estuary which lead to immediate loss of habitat (e.g. land claim or development). They can also be affected indirectly by factors that may change the quality or the extent of habitat over time (e.g. altered sediment deposition), or may have an impact on the bird's behaviour (e.g. disturbance). Many of these factors are caused by human activity, although some factors may also occur as a result of natural processes (e.g. some changes to sediment and water flow).

This report assesses the current knowledge of the most important factors affecting estuarine birds, through a review of papers published in peer-reviewed scientific journals. It is primarily aimed at groups, organisations, individuals and authorities that will or are likely to be required to make Habitat Regulation Assessments (HRA) associated with active and potential developments affecting the Firth of Forth SPA. The Firth of Forth occupies a large proportion of the coast of south-east Scotland. The inner parts of the estuary (upstream of the Forth Bridges) have extensive intertidal flats but much of the shore further downstream is essentially non-estuarine in character, with more isolated areas of flats, especially at Aberlady and Gosford Bays, Drum Sands and Musselburgh. Saltmarsh occurs in places around the site, notably between Alloa and Grangemouth and at Aberlady Bay. With such a large site, almost all types of possible human-related activities and disturbance occur, including leisure (onshore and offshore), industry (harbours, an offshore oil terminal, an oil rig repair site, etc.), dredging of sea-bed sand and exploitation of natural resources, whilst there is a history of reclamation for industrial uses.

We discuss these broad topics under the following main headings:

> **Ecological relationships, natural processes and pollution**: Habitat requirements; predator–prey interactions and competition; sediment deposition and water flows; pollution and nutrient enrichment.
>
> **Management of the physical environment**: Land claim and development; ongoing management activities (e.g. dredging and tide wrack removal); renewable energy (excluding offshore wind farms).
>
> **Disturbance and other human activities**: Recreational activities and resource management that may impact on bird populations.

In many cases, these factors do not act independently. For example, land claim and dredging may lead to changes to sediment deposition and water flows. The most important interactions between different factors are also discussed.

2. ECOLOGICAL RELATIONSHIPS, NATURAL PROCESSES AND POLLUTION

2.1 Habitat requirements for birds

Like all species, birds require energy to survive and to breed. Different species are adapted to feed on different resources and therefore favour different habitats. For example: wigeon *Anas penelope* graze mainly on grass and similar plants and can be found on saltmarsh or coastal fields (Kear 2005); lapwing *Vanellus vanellus* and golden plover *Pluvialis apricaria* feed on invertebrates in arable farmland and grassland (Delany *et al.,* 2009); many other waders feed on benthic invertebrates on mudflats (e.g. van de Kam *et al.,* 2004; Delany *et al*., 2009); gannet *Morus bassanus* dive for fish in open water (Nelson, 1978); and velvet scoter *Melanitta fusca* dive for molluscs in inshore waters (Fox, 2003).

Even within the same habitat, different species may be using different food resources, each having evolved to exploit particular niches. A niche is the role and position a species has in its environment - how it meets its needs for food and shelter, how it survives, and how it reproduces. For example, many waders and other long-billed birds typically forage by touch or a combination of sight and touch, and have touch-sensitive bill tips which can detect prey whilst probing, whereas the short-billed plovers forage mainly by sight (van de Kam *et al*., 2004). The bill length and shape vary, particularly among the tactile and mixed foragers, and thus influence the prey choices of different species (van de Kam *et al*., 2004).

The particle size of sediments varies throughout an estuary, with the settlement patterns of particles of different sizes determined by currents, tides and weather. Whether a substrate is rocky, shingly, sandy or muddy is a key determinant of which prey animals and food-plants are abundant in which parts of an estuary and of which are available as food to the various species of estuarine bird.

As well as foraging habitat, some birds use different habitats for other purposes. In the estuarine environment, the tidal cycle has a strong effect on bird behaviour, as it means that intertidal habitats and their associated food resources become unavailable on a regular cycle. When intertidal mudflats are covered by the tide, many waders and wildfowl often move to a safe resting area where they roost and wait for the tide to turn (van de Kam *et al*., 2004), whilst some may seek alternative feeding sites such as coastal fields or lagoons adjacent to the estuary (e.g. Townshend, 1981). Roosting minimises unnecessary and wasteful energy expenditure and so roosting sites need to be safe from predators and disturbance, for example a saltmarsh or an island or mudflat. Man-made objects such as concrete islands and jetties sometimes provide a suitable roosting location. This reliance on the tidal cycle means that many estuarine birds sometimes need to feed at night, particularly in winter when the mudflats may be available for only a few hours during daytime (van de Kam *et al*., 2004). Visual feeders (e.g. plovers) have large eyes which enable them to feed at night alongside tactile feeders, especially on moonlit nights (Shrubb, 2007).

Some bird species also have different habitats requirements in different seasons. An obvious example is seabirds, many of which spend most of their lives at sea, but cannot nest on the open water and so move to land to breed. For example guillemots *Uria aalge* and razorbills *Alca torda* move to colonial nesting sites on cliffs. For many wader species, the birds overwintering on British estuaries breed at higher latitudes. For some species, including oystercatcher *Haematopus ostralegus*, curlew *Numenius arquata* and redshank *Tringa totanus*, a proportion of birds remain within Britain but many of them move inland to breed and only small numbers breed within the Firth of Forth and its immediate vicinity (Wernham *et al*., 2002)

The species accounts (Part 1) give further details of the variety of diets and habitats used by the species considered in this report, and of the seasonal movement of birds that use the

Firth of Forth. More detailed summaries of influences on bird use of estuarine environments include van de Kam *et al.* (2004) and Gill (2012).

2.2 How natural processes and species interactions may affect birds

Habitats and food resources do not necessarily remain static, even where they are unaffected by human activity. The estuarine environment is dynamic. River flows, tidal forces and wave action may cause sediments to move to, from and within the estuary, and are affected by other factors such as the location of creeks (Little, 2000). At high tide, particles of sediment in the intertidal zone are redistributed and sorted for size by wave action, currents and tidal flow. All of these are influenced by the height of a particular tide, weather conditions and the strength of local currents. When the tide is out, the intertidal zone, like the area above the tidemark, is open to the weather, though flows in creeks and permanent channels also alter sediment patterns. Mid tide, there are constantly changing influences of all these factors across all zones of the shore. In general, changes to sediment distribution brought about by these natural processes are quite slow. Storms and tidal surges, however, can cause large-scale changes within a very short time.

Changes to water flows and sediment deposition may cause erosion and accretion leading to obvious and visible changes to intertidal habitats. In other cases, changes may be more subtle. For example, the composition of sandy and muddy sediments may change as water flows change, or the salinity levels may change in different parts of the estuary (Little, 2000). Changes to factors such as water flow, salinity and sediment deposition within an estuary may lead to changes in the habitats, plants, benthic (bottom-living) invertebrates and other organisms and hence to changes in the abundance of the bird species that rely on them to survive. However, this is not a one-way process and plants and organisms may also affect the sedimentary regime, e.g. plants may bind sediments together, as may some benthic animals, whereas other benthic organisms may loosen sediment structure (Little, 2000). Some changes will also be continuous or cyclic. For example, river flows and wave action can change with seasons on an annual cycle and the magnitudes of tides vary on a lunar cycle.

As well as changes to the natural environment, individual birds may also be affected by predation from other animals, or from competition from members of the same or other species competing for similar food resources. These interactions will not always have a measurable effect on the population of a particular species, however they may become significant. For example, survival models have predicted that in order to maintain oystercatcher populations, the volume of bivalves molluscs available in autumn needs to be 2.5-8 times the amount they will consume during the winter. This is because intraspecific competition increases when food supplies are low and sub-dominant birds are excluded from much of the food supply (Goss-Custard *et al.*, 2004).

Minor changes to sediment deposition, water flows, habitats, availability of food resources and predator/prey relationships are constantly occurring in natural environments. Their impact can be extremely complicated and, in some cases, small incremental changes may lead to a substantial overall effect. Apparently minor changes to the environment therefore need to be assessed carefully when considering factors that have caused declines in bird numbers, whether these change occur as a result of natural processes or human activities.
Some natural processes may have a substantial effect on estuarine habitats and these are considered below.

2.3 Altered sediment deposition and water flows

Changes to water flow and sediment deposition occur naturally (see above). However, they can be affected substantially by human activities (discussed under the relevant sections

below). Changes to water flows and to patterns of sediment deposition, accretion or erosion may lead to changes in intertidal and sub-tidal habitats and hence changes to the food resources that are available to birds.

The movement of sediments within the estuary is extremely complicated and may be affected by many factors including variation to the flow rate of rivers entering the estuary, the shape of the estuary and presence of other features such as islands and man-made objects, wave movements, the variation in tidal range and tidal velocity, the size of the sediments, and even the actions of benthic invertebrates themselves (Little 2000). Depending on tidal flows, sediments may also be brought into the estuary as a result of erosion occurring elsewhere along the coast, or there may be a net loss of sediment from the estuary to other coastal areas.

At a very simple level, major alterations to water flows within an estuary can lead to erosion and/or accretion of sediments within the estuary. Where erosion occurs, some habitat and food resources may be permanently lost to birds, but accretion in subtidal areas may create new areas of intertidal mudflat in other areas. In other instances, accretion may occur in areas where intertidal mudflat and saltmarsh already exist, thus increasing their height. Over time, these areas are likely to be covered by the tide less frequently, allowing the development of a saltmarsh community on areas formerly covered by mudflat. In an estuary, intertidal habitats can also move further inland following sea level rise or tidal surges. However, in many estuaries (including the Firth of Forth), the development of saltmarsh is now restricted by seawalls constructed to protect or claim the land behind them. With no opportunity to move inland, areas of saltmarsh, wetland and mudflats are expected to disappear through ‘coastal squeeze’ as a result of sea level rise (e.g. Clausen & Clausen, 2013; Torio & Chmura, 2013); changes in sea level (a rise induced by climate change) and land level (post-glacial isostatic rise) predict a net rise in sea level of 5 – 54 cm between 1990 and 2095 (Marine Scotland, 2011).

The size of sediment is very important when considering habitat for benthic invertebrates and birds that prey on them. In descending size order, the sediment types are boulders, cobbles, pebbles, granules, sands, silts and clays, with 'mud' including both silts and clays (Little 2000). Different benthic invertebrates may be present in different sediment types, and bird species may prefer different sediments depending on their preferred prey, for example bar-tailed godwits *Limosa lapponica* prefer the outer parts of estuaries which are sandier (Musgrove *et al*., 2003, Scheiffarth, 2001). In estuaries, changes to the direction and velocity of currents may cause different sediment types to be laid down in different areas, so sometimes changes to sediment types may occur, or different layers of sediment may be laid down in areas where changes to the currents occur frequently (Little, 2000). Changes to the sedimentary regime may take place slowly over a long time period but may also occur suddenly as a result of extreme weather events such as tidal surges (which may then subsequently affect the movements of water and sediment leading to further changes).

Over time, a state of equilibrium may develop in an estuarine environment. If no significant changes occur, the major currents (i.e. the river flows and tides) become relatively predictable over the course of a year or number of years. Some minor changes may continue to occur as a result of the natural variability in the water flow caused by factors such as the weather, but these will not have a significant effect on the sedimentary regime of the estuary unless a significant event occurs that changes the equilibrium status. This could be a natural event such as a tidal surge that causes a substantial change to the estuary (e.g. through erosion). However, in recent times, major changes to the state of equilibrium in estuaries have often been anthropogenic, in particular land claim (Section 3.1)

2.4 Pollution and nutrient enrichment

A wide range of anthropogenic additions to the estuarine environment come under the heading of pollution and nutrient enrichment, from items on the seabed or in the water column to chemicals as coatings on surfaces or dispersed in the water or sediment. These may affect wildlife in various ways. Underwater objects, most notably shipwrecks, may create new habitat for many plants and animals. Items in the water column or floating at the surface can cause problems to animals that ingest them or get themselves tangled, and may be lethal. Chemical coatings, such as from an oil spill are usually lethal to all wildlife affected. Chemicals diffused in the water or sediment may also kill wildlife, or have sublethal effects on an individual's health or reproduction. Nutrient enrichment disturbs the natural ecological balance of an estuary by promoting the few species best suited to a high-nutrient environment, often to the detriment of others.

At its most extreme, pollution can have a direct and highly visible effect on estuarine wildlife, and can kill birds directly, for example oil spills. However, significant and highly polluting events are rare. Pollution occurs more commonly as a result of low-level inputs coming into the estuarine system from many diffuse sources, including shipping, industry, agriculture and residential properties. In most cases, these pollutants are invisible to the human eye. Diffuse pollution is discussed under three separate categories: heavy metals; organic pollutants; and nutrients.

2.4.1 Oil spills

Major oil spills are often well publicised events, and may cause significant mortality of birds. Recent major spills which have killed substantial numbers of birds have included the Sea Empress at Milford Haven in 1996 (Banks *et al*., 2008; Armitage *et al*.. 2000), the Prestige off the Iberian coast in 2002/03 (Munilla *et al*., 2011), and the Deepwater Horizon oil spill in the Gulf of Mexico in 2010 (Barron, 2012). The impact of a major oil spill may extend beyond the area where the spill occurs. For example, Montevecchio *et al.* (2012) calculated from tracking data that around 25% of the population of Northern Gannets from four colonies in eastern Canada migrated to the area of the Deepwater Horizon spill in winter (though this proportion was higher than that suggested by ringing data). In this instance the oil spill occurred in April when most adults had already returned to the colonies so most of the Gannets affected were juveniles, and no immediate effect on breeding numbers was apparent.

Although the visible effects of significant pollution events sometimes can be cleaned up relatively quickly, the environmental effects may last longer. In Milford Haven, following the Sea Empress spill, common scoter *Melanitta nigra* were affected by direct mortality and probable pollution of food resources; distribution changes were observed and it was thought that the common scoters were using potentially sub-optimal feeding areas after the pollution incident, though a rapid recovery occurred in this instance and numbers returned to pre-spill levels within three years (Banks *et al*., 2008). At nearby estuaries following the Sea Empress spill, redshank and shelduck *Tadorna tadorna* numbers recovered after one year, but oystercatcher and curlew numbers took longer; it was believed that these differences were caused by the different rates of recovery of food resources (Armitage *et al*., 2000). Other studies have also reported differences in rates of recovery between species, for example a study at an estuary on the eastern coast of USA found that some species had returned to previous abundance levels seven years after an oil spill, but that others had shifted their distribution, either in response to colony/site dynamics, or because the spill was still having an effect on the environment (Maccarone & Brzorad, 1998).

2.4.2 Heavy metal and organic pollutants

Heavy metals arising from industrial activity accumulate in the sediment, and can be taken up into the food chain. Metals occur naturally within the soil but higher concentrations have resulted from the industrial era. For example, in the Humber estuary, sediment quality is currently 'far from its background state' (Cave *et al.*, 2005) in relation to trace metals such as arsenic, copper, lead and zinc. Pollution reached its peak from 1950 to 1970, and has declined since the 1970s, but the industrial legacy continues to drive water quality below desired standards (Cave *et al*., 2005). Another source of lead in the estuarine environment is from lead shot used in wildfowling (Thomas, 1997; Quy, 2010).

Metals can be transported by currents and sediment flow long distances from the original source, for example in south-western Spain where partial transport of heavy metals was carried by currents up to some 40 km from the original source (Ruiz *et al*., 2014). Metals can also be taken up by the food chain and concentrations of heavy metals have been found in benthic invertebrates and fish (e.g. Thompson *et al*. 2007), both of which are food resources for estuarine birds. Bryan & Langston (1992) stated that experimental studies had found that several metals (silver, cadmium, chromium, copper, mercury and zinc) were toxic to benthic invertebrates at levels that could occur environmentally, and found high concentrations of cadmium and silver in benthic invertebrates in the Severn Estuary, but did not find any unequivocal evidence that these metals had affected those invertebrates. García-Alonso *et al*. (2011) found responses to toxicity in ragworms *Hediste diversicolor* in some areas in the Humber estuary, which they related to metals such as copper. However, higher-level biological responses (for example changes in populations of waders) could not be predicted.

High concentrations of heavy metals have been detected in birds or their eggshells in several studies, including Dunlin in the Bristol Channel (Ferns & Anderson, 1997), herons (and other species) in Japan (Horai *et al.* 2007), Canada geese *Branta Canadensis* in New Jersey (Tsipoura *et al*., 2011), and little egrets *Egretta garzetta* and Chinese pond herons *Ardeola bacchus* in Korea (Kwok *et al.*, 2014). In several of these cases it was suspected that the levels could have a negative effect on the health of birds. However, such effects can be difficult to prove in wild birds as toxins may cause only subtle pathological changes or none at all (Degernes, 2008). A study of dead wild birds in Korea found evidence of lead shot in the gizzard of some birds, and lead concentrations in the liver at levels known to be potentially lethal (Nam & Lee, 2011). In the Coeur d'Alene River Basin in Idaho, USA, lead contamination in the sediment was also suspected as a cause of mortality in waterfowl; subsequent experimental feeding of lead-contaminated sediment to mallard *Anas platyrhynchos* resulted in the mortality of some birds (Heinz *et al.*, 1999).

Lead concentrations found in Dunlin in the Bristol Channel increased during the winter, but birds were apparently able to get rid of a substantial proportion of the body lead burdens, probably during the autumn moult (Ferns & Anderson, 1997). An impact cannot be ruled out, however, and models using Dunlins from the Severn and from Poole Harbour, suggested that lead and mercury may indeed pose a toxic risk (Smith *et al*., 2009).

Like heavy metals, man-made organic compounds can also accumulate within sediments and be taken up in the food chain, causing potential harm in birds and other wildlife. A well-documented example of this is the build-up of organochlorine pesticides including DDT in birds in prey, which was linked to the thinning of their eggshells and severe declines in their populations during the 1960s (e.g. Ratcliffe, 1970). Recovery quickly followed after the pesticides were banned (e.g. Opdam *et al.*, 1987; Newton & Wyllie, 1992). In the estuarine environment, man-made compounds have been found in several studies, for example: in both migrant and resident birds in northern Vietnam (Minh *et al*., 2002); in the egg-shells of oystercatcher, common tern *Sterna hirundo* and arctic tern *Sterna paradisaea* in countries

around the North Sea (Dittmann *et al*., 2012); in four waterbirds in the Buyuk Menderes River in Turkey (Kocagoz *et al*., 2014); and in birds' eggs and tissues in Chesapeake Bay (Rattner & McGowan, 2007), and San Francisco Bay (Thompson *et al*., 2007), on the Atlantic and Pacific coasts respectively of North America.

Heavy metal and organic pollutants in birds and their eggs does not necessarily indicate measurable impacts on the populations and fecundity of birds, as individuals may still be able to survive and breed (Kocagoz *et al.* 2014). However bird mortality, including major 'die-off events' have been attributed to alkyl lead poisoning (Bryan & Langston, 1992) and to organophosphorous and carbamate pesticides (Rattner & McGowan, 2007). The effects of pollution can be subtle, and it can be difficult to detect and confirm problems caused by contamination, as numerous other environmental and ecological factors may also be affecting communities (Thompson *et al*. 2007). In their review of pollution studies in San Francisco Bay, Thompson *et al*. (2007) found only a small number of studies that demonstrated a proven link between population declines and contamination, including one example affecting birds (decreased hatching ability of clapper rails *Rallus crepitans* caused by exposure to mercury). Environmental pollution can also affect birds indirectly by affecting other organisms and thus changing food resources and/or habitats (Fleeger *et al*., 2003).

Disturbing sediments is always likely to release further contaminants for potential take-up into the food web. Potential sources of such disturbance include dredging, either for navigation or for shell-fishing, and major construction works. Whilst action to prevent pollution from point sources may be possible, preventing pollution from more diffuse sources can be more difficult. Although measures are (and can be put) in place to prevent new contamination, background levels within sediments will still remain high in many estuaries as a result of previous inputs (Cave *et al.*, 2005). Some recent research has focused on 'phytoremediation', which aims to reduce concentrations of heavy metal in the soil through the take up by some plants of contaminants (Singh & Prasad, 2011; Ali *et al*., 2013). Weis & Weis (2004) reviewed studies investigating how metals affected plants in wetlands, and discussed the slightly different ways that different plant species store and deal with heavy metals and review the potential of phytoremediation. They caution that whilst marshes can store heavy metals, some studies have suggested that they may also release metals into the food chain. However, Teuchies *et al.* (2013) found that intertidal marshes could remove some metal inputs, and suggested that tidal marsh restoration projects would increase the metal storage capacity of marshes within the estuary.

2.4.3 Nutrient enrichment

Another form of pollution comes in the form of enhanced levels of nutrients, such as nitrogen and phosphorus, within the estuarine ecosystem. Nutrients are a natural and essential component of the estuary ecosystem, provided by the breakdown of plants within saltmarshes and further upriver, and provide energy inputs to promote growth of phytoplankton and other plants, and hence supporting other life forms within the food chain. Although nutrients occur naturally in estuaries, many estuaries experienced enhanced nutrient input during the twentieth century as a result of human activities, in particular agricultural run-off, and sewage (e.g. Balls, 1994). As a result of previous improvements to sewage treatment and the implementation of the Water Framework Directive in 2000, the water quality has improved in many estuaries. However, historical enhanced nutrient inputs may have contributed to high levels of some bird populations in estuaries. This occurs because the extra nutrient loading and organic content in sediments leads to increases the abundance, and biomass of invertebrates. Some species of invertebrates are able to tolerate high levels of organic and nutrient loading close to the source of the discharge, while others benefit from more moderate enrichment occurring over a wider area, including *Corophium*, *Eteone longa*, *Macoma balthica*, *Scolelepsis fuliginosa* and *Mytilus edulis* (Burton *et al*., 2002b). Higher abundances of invertebrates may support higher numbers of

birds. Therefore, bird species which feed on benthic invertebrates may be affected by reductions in food abundance following improvements to water quality. These include brent goose *Branta bernicla*, shelduck, wigeon, teal *Anas crecca*, oystercatcher, grey plover *Pluvialis squatarola*, lapwing, knot *Calidris canutus*, dunlin, black-tailed godwit *Limosa limosa*, bar-tailed godwit , curlew, redshank and turnstone *Arenaria interpres* (Burton *et al.*, 2002b). Additionally, some bird species may feed directly on waste matter from the discharge.

In Scotland, reductions in food discharged from waste water outfalls have been associated with declines in duck species such as scaup *Aythya marila*, goldeneye *Bucephala clangula* and pochard *Aythya ferina* (Campbell, 1984; Fox & Salmon, 1988; Burton *et al.*, 2002b). The substantial declines in scaup and goldeneye occurring on the Firth of Forth during the late 1970s and early 1980s being directly linked to sewage treatment and feeding flocks only persisting at outfalls where large quantities of sewage was still being discharged (Campbell, 1984). Scaup is now only recorded in very small numbers in winter (Cook *et al*. 2013).

2.5 Invasive non-native species

Coastal waters are at high risk from invasive organisms spread for example by ballast water transport by the global shipping industry. The invasive non-native plant, Japanese knotweed *Fallopia japonica* and the crustacean, Chinese mitten crab *Eriocheir sinensis* can cause major problems for waterways upstream of estuaries, however the Forth estuary itself has suffered few problems so far. Scottish saltmarshes have not been as greatly affected by the introduction of hybrid cord grass species, *Spartina anglica* as some estuaries in England where its dominance has reduced feeding areas available to birds. However, it has been present in the Eden Estuary in Fife (Morris 2005) and therefore its future presence in Firth of Forth remains possible.

On the islands of Craigleith and Fidra (both within the Forth Islands SPA), areas colonised by the non-native plant, tree mallow *Lavatera arborea* hindered access by puffins to nest burrows, and effectively limited the numbers breeding on those islands (Fischer & van der Wal, 2007; van der Wal *et al.*, 2008). Similarly it is likely eider, herring gull and lesser black-backed gull numbers were also being limited. Factors facilitating the spread of tree mallow on those islands included reduced grazing pressure (rabbits *Oryctolagus cuniculus* decimated by the disease myxomatosis) and a warming climate (van der Wal *et al.*, 2008). It is important to recognise that risks presented by invasive species are potentially severe and their likelihood can be determined combinations of factors which can often be of anthropogenic origin.

3. MANAGEMENT OF THE PHYSICAL ENVIRONMENT

3.1 Land claim (and development)

Land claim (often also referred to as 'land reclamation') involves changing the use of an area of estuary, often by constructing a barrier such as a seawall to prevent the tide from reaching that area. Historically, much tidal habitat has been converted to agricultural, urban and industrial uses in this way (Bromberg Gedan *et al*., 2009). Parts of the Forth estuary have been claimed and converted for use as industrial sites (e.g. the Grangemouth industrial complex), used for dumping mining waste, ash from coal-fired power stations and general waste (e.g. at Bo'ness, Longannet and Kinneil) with most losses of estuarine habitat to such uses occurring in the 20th century. In addition there has been longer term and progressive claims for agriculture. It is estimated that 50% of the intertidal of the Firth of Forth has been lost for a variety of reasons including agriculture, harbours and industrial development (Mclusky *et al.*, 1992). The most obvious impact of land claim or major developments on birds is the loss of natural habitats that have been claimed from the sea and intertidal areas. In time, some of the areas claimed from the estuary develop into different habitats, some of which, perhaps ironically, become valued as wildlife habitats and local nature reserves in their own right (e.g. the old bing at Bo'ness, Kinneil lagoon and the Musselburgh lagoons).

The ability of birds to find new sites following land claim or major development will depend on the quality of nearby sites and also whether these sites have any capacity to support extra birds. A study of birds displaced by the construction of Cardiff Bay barrage highlighted that displaced birds will not necessarily be able to find suitable alternative long-term habitat elsewhere (Burton *et al.*, 2003; Burton, 2006; Burton *et al.*, 2006). The barrage caused the displacement of almost all of the shelduck, oystercatcher, dunlin, curlew and redshank that had previously used the area. It was not possible to assess the impact on dunlin due to an ongoing local population decline, but some displaced shelduck, oystercatcher and curlew moved initially to nearby sites. However the increases at these sites were not sustained in subsequent winters (Burton *et al*., 2003; Burton, 2006). Redshanks had been the subject of a colour-ringing scheme prior to the development, which had confirmed that they were largely faithful to the bay (Burton, 2000). Continuation of the colour-ring study in Cardiff Bay confirmed that the displaced birds moved to nearby sites where they joined other redshank that previously used these sites. However, during the first year the displaced birds at one site (Rhymney) were significantly lighter than those which had previously been using the site, and suffered significantly higher winter mortality. The survival rate for Rhymney birds remained unchanged, indicating that the displacement caused the reduced survival rate of the Cardiff Bay birds (Burton *et al*., 2006)

Land claim may have indirect effects on an estuary as well as the direct impact caused by lost habitat. The construction of sea walls, barrages or drainage ditches alters the geomorphology of the estuary, and may therefore affect the equilibrium status of an estuary, causing changes to sediment deposition and erosion within the estuary and therefore potentially affecting the extent and type of intertidal habitat available to birds (see Section 2). Land claim also has the potential to create narrower estuaries and 'coastal squeeze', making habitats more vulnerable to future sea-level rise brought.

Relatively small-scale developments with relatively minor direct loss of estuarine habitat may not appear significant in isolation but planners will need to bear in mind the potential cumulative effect of several small-scale developments. Similarly, the extent of the impact may extend beyond that of the direct footprint of the development. A small development could have impacts on the wider morphology of the estuary, and that subsequent changes to water flows and sediment deposition may occur, which could in turn affect benthic invertebrate abundance and hence bird populations. For example, the creation of outflows into the estuary may affect nutrient input, and the creation of jetties may create a barrier

which can cause additional accretion to occur one side of the jetty and reduced accretion on the other.

Even where development has minimal or no physical impact on intertidal habitat, birds may still be affected. Some developments adjacent to the estuary may not directly affect estuarine habitats but result in loss of inland habitat used by estuarine birds that can be particularly important at certain times (e.g. feeding areas for pink-footed geese, wigeons lapwings, golden plovers, curlews and roost sites for a variety of species). Adjacent development may also displace birds from intertidal habitats even when this habitat is unaffected, as a result of disturbance during and after construction (discussed in Section 4). Therefore, it is important that, even for small-scale developments, planning assessment takes into account not only the direct impact of loss of intertidal and inland habitat, but also any potential indirect effects that may occur through changes to the water and sediment flows and through disturbance as well as cumulative impacts.

3.2 Managed realignment and habitat creation (mitigation for land claim and flood defence)

In recent years, managed realignment has been increasingly used as a method of flood defence management, and also to provide compensation for intertidal habitats lost as a result of development, and is expected to continue to be used as an important management tool in the future (e.g. Esteves, 2013; Esteves & Thomas, 2014). Managed realignment involves moving back the flood defences and breaching the old flood defences in order to allow an area to be inundated by the tide. Over time, this area will develop into intertidal mudflats, salt marsh or other habitats. Other management to mitigate against habitat loss (or simply to increase habitat for estuarine birds) can include the re-grading of substrates to create new mudflats and saltmarsh (an example was associated construction of the new upper Forth crossing, the Clackmannanshire Bridge) and also the creation of new tidal lagoons (as constructed at Powfoulis as part of the RSPB Skinflats nature reserve).

Assessment of the success of managed realignment (and other habitat (re-)creation) projects can be difficult due to their multiple aims and the fact that they often do not have well-defined targets (Esteves, 2013). One aim that is often assessed is compensatory habitat creation, which can occur to mitigate losses of habitat associated with a new development, or to mitigate predicted habitat losses which are expected to occur as a result of sea level rise. A number of studies have been carried out to monitor changes to habitats, benthic invertebrates and birds in managed realignment sites. Although sites are often colonised relatively quickly by intertidal communities, studies from several years after breaching suggest that the benthic communities are not yet equivalent to those on adjacent comparable (established estuarine) sites (e.g. Mander *et al*., 2013; Mazik *et al*., 2010; Petillon *et al*., 2014). The usefulness of realignment as a management tool may also be constrained by the fact that it is often limited to small scale sites (Esteves, 2013) whereas sites may need to be considerably bigger in order for managed realignment to achieve their complete habitat replacement targets (Morris, 2013). For example, realignment sites have often developed into saltmarsh (Morris, 2013), even in situations where the aim included the creation of mudflats (Mazik *et al*., 2010).

Although knowledge continues to improve, these studies highlight the fact that further research is needed before managed realignment (and habitat re-creation) can achieve its strategic objectives reliably (Esteves, 2013; Morris, 2013). Of particular importance is a better understanding of the long-term evolution of sites and how managed realignment affects sedimentation and biogeochemical processes within estuaries (Esteves, 2013; Esteves & Thomas, 2014). Further research may also help identify how longer term mudflat habitats can be created through realignment projects, for example Pontee (2014) discussed

some potential options including removing longer lengths of the old seawall, lowering site elevations and creating creek networks.

3.3 Ongoing maintenance activities

3.3.1 Dredging for navigation purposes

New sediment is constantly arriving in estuaries and coastal waters, mainly through the erosion caused by rainfall and rivers inland. Water and sediment movement causes sediment deposition to occur in particular parts of estuaries, according to particle size (Section 2). This may mean that dredging is required in order to keep shipping lanes open. For example, the channel for the port at Grangemouth is regularly dredged to retain access for ships. Dredged material is typically removed from the site but the act of dredging sparks a redistribution of the remaining sediment that may affect a much wider area. Many living organisms are removed and habitats for others are destroyed or redistributed.

Some studies have documented changes in sediments and/or lower level life forms (e.g. phytoplankton and benthic macroinvertebrates) caused by dredging. Ceia *et al*. (2013) found that sediments became sandier as a result of dredging, and several studies have found that the abundance and diversity of benthic invertebrates was affected in the area where dredging takes place, with substantial changes being noted in some cases (e.g. Skilleter *et al*., 2006; Taupp & Wetzel, 2013); changes in abundance included both increases or decreases but there was a general trend for diversity to decrease following dredging suggesting that generalist species tended to be the beneficiaries associated with a general reduction in habitat (sediment) diversity or heterogeneity. Quigley & Hall (1999) also recorded impacts on macroinvertebrates at their control site 500 metres away from the dredging site, which they suggested were caused by the dredging activity, indicating that the effects of dredging can be detected at considerable distances from the actual activity.

How long it takes for a site to ‘recover’ (revert to close to original sediment structure and benthic fauna) appears to vary, presumably according to individual site characteristics and the nature of dredging activities. Recorded recovery periods include two months (Ceia *et al*., 2013) and 6-8 months (Newell *et al.*, 1998), although some differences still existed after a year. It is suggested that muddy habitats can recover in relatively short periods (measured in months) as they are frequently disturbed by natural processes and therefore home to short-lived organisms that can colonise newly disturbed areas relatively quickly; however, they suggest that sand and gravel communities may take 2-3 years or longer to recover from dredging (Newell *et al*., 1998). Mechanical activities such as dredging can lead to a shift in the invertebrate fauna from bivalves (becoming less abundant) to worms (becoming more dominant within the invertebrate community) with subsequent effects on the bird assemblages that feed on them (Piersma *et al.*, 2001). Dredging for navigation purposes tends to be a near-continuous process however, and opportunities for ‘recovery’ will be small and short-lived. Therefore changes in sediment structure and invertebrate communities will tend to operate on the longer term. However, the bird assemblages associated with such continuously dredged area could potentially achieve some sort of stable equilibrium. It is likely that new ‘capital dredging’ events could have a greater impact on current and established bird use of an area.

Dredging may also increase the levels of metals and organic pollutants in the estuary, by releasing contaminants that have been trapped within the sediments (Hedge *et al.*, 2009; Martins *et al.*, 2012; Cabrita, 2014). In some cases, it has also been suggested that nutrients have also been released during dredging operations (e.g. Sangita *et al.*, 2014).

Although dredging may affect the sediments, benthic invertebrates and pollution levels, dredging to maintain existing shipping lanes and harbour entrances may have relatively low

impact on estuarine mudflats and their associated bird life. Burton & Clark (2002) stated that dredging in Cardiff Bay should not affect waders provided it does not affect the overall area of adjacent mudflats, though they also concluded that wildfowl and gulls may be affected by short-term loss of feeding opportunities along the channel edge following dredging. In the Tamar estuary, a study looking at changes caused by dredging between 1875 and 2001 had only a small impact on the area of intertidal mud and on the hydrodynamics of the estuary (Bale *et al*., 2007). Another study in the same estuary found no significant correlation between dredging activity and the overwintering numbers of ten species of wildfowl and waders (Widdows *et al.*, 2007). Other studies, however, that have investigated the long term sedimentary regimes and morphology of estuaries have attributed substantial changes to dredging in the Elbe (Li *et al.*, 2014) and in the Lower Oka estuary in the Bay of Biscay (Monge-Ganuzas *et al*., 2013). The variable findings between different studies suggests that the impact of dredging can differ markedly between sites and therefore that potential changes to the water and sediment flows of an estuary should be carefully assessed and tested through models specific to that site. Again the potential greater impact of new dredging in areas where it has not previously been undertaken should be emphasised.

3.3.2 Dredging for fishing or shellfishing

Shellfish harvesting in estuarine environments by humans can lead to direct conflicts with bird populations (Gill, 2012). Activities include disturbance of feeding birds (see Section 4), disturbance of substrates which harbour the shellfish (with some similarities to dredging, Section 3.3.1) and the removal of shellfish (leading to direct completion with birds for a resource; Goss-Custard, 1996; Atkinson *et al.*, 2003). Shellfisheries (oyster *Ostrea edulis*, queen scallop *Aequipecten opercularis* and horse mussels *Modiolus modiolus*) were once important in the Firth of Forth but long-term exploitation and, in particular, bottom-dredging activities during the 19th and 20th centuries have led to overall declines in the abundance and species richness of molluscs and increased dominance by soft-sediment communities (Thurstan *et al.*, 2013). Shell-fishing activities are now concentrated in the more marine outer Forth area and outside the scope of this review but the above influences, including long-term impacts on the populations of shell-fish themselves, should be considered in the event of re-establishment of a large fishery in the Forth estuary.

3.3.3 Tide wrack removal

The main component of tide wrack is marine algae torn from their attachments and washed up on the beach. Currents produce large amounts of tide wrack in certain bays and backwaters, where they provides habitat for invertebrates used as a resource by feeding birds (Dugan *et al.*, 2003). However it is also perceived by people as a nuisance through preventing human access or through the unpleasant smell created as the material rots away. Tide wrack is periodically removed by local councils for amenity reasons at some sites, in a process termed ‘beach grooming’. There have been relatively few studies, but those that have been carried out have confirmed that macroinvertebrate biodiversity is lower on 'groomed' beaches (Dugan *et al*., 2003; Deidun *et al*., 2009), including one study of Scottish beaches, including the outer Firth of Forth (Gilburn, 2012). In one of these studies, in California, the abundance of two plover species was positively correlated with the amount of tide wrack and tide wrack associated invertebrates (Dugan *et al.* 2003). In Scotland, regulations state that tide wrack should only be removed if it constitutes a nuisance. However, Gilburn (2012) found that wrack removal was much more likely on beaches receiving an award status and concluded that the achievement of award status was in fact the main driver behind wrack removal. Another reason that may be put forward to justify wrack removal is the improvement of microbial water quality, however clearing tide wrack does not always reduce the abundance of microbial bacteria in the water (Russell *et al*., 2014). The number of studies on the associations of tide wrack with birds and the impact of

tide wrack management is small and so further work is needed to confirm that their findings can be applied more generally.

3.4 Climate change and renewable energy

3.4.1 Climate change

Climate change is one of the major issues that are expected to affect estuarine and other ecosystems during the twenty-first century and beyond, and some of its effects are expected to be irreversible as a result of historic emissions, even if emissions are stopped (IPCC, 2014). In estuarine ecosystems, the effect of sea-level rise is of particular concern, as it may lead to the loss of intertidal habitat used by birds, such as mudflats and saltmarsh (IPCC, 2014). This loss may be exacerbated as a result of coastal squeeze in areas where land claim has occurred and sea walls have been constructed to protect the land behind them (discussed above in Section 3.1).

Climate change is also predicted to increase the unpredictability of weather events, meaning that severe weather events may occur on a more frequent basis (IPCC, 2014). The potential impacts on estuaries are numerous, complex and often inter-related. These could include more variability in water flows into the estuary as a result of extreme precipitation events, and the occurrence of tidal surges which could potentially cause substantial damage to habitats, and longer-term changes to sediment and water flows within the estuary (IPCC, 2014). Another predicted outcome of climate change is increased temperatures, though the strength of the increase is expected to vary around the world. Changing sea temperatures (which have already been documented) and possible associated changes to ocean acidification and salinity may lead to changes in the productivity of both plants and invertebrates, and hence to changes to food resources in the estuary. The effects of such multiple changes on birds are likely to be different between species and between estuaries. Conditions for some species on some sites may actually improve while for others there may be negative effects. For example, changing conditions may allow some birds to overwinter in areas that were previously unsuitable, which may affect abundance at other sites. For example, the wintering distribution of grey plover is thought to be shifting north-eastwards in response to climate induced changes (Maclean *et al.*, 2008). This general change may be driving the recent decline in numbers in the Firth of Forth even if other conditions remain unchanged. There is some evidence that such changes have already happened for a number of bird species in the UK (Maclean *et al.* 2008).

3.4.2 Renewable energy

One of the main causes of climate change is increased carbon dioxide (CO_2) levels in the atmosphere caused by the burning of fossil fuels (IPCC, 2014). Renewable energy is one of the tools which can be used to help bring a stop to increases in anthropogenic CO_2 levels. The two main types of renewable energy affecting estuarine environments are wind power and tidal energy.

Windfarms (including single turbines) can be constructed at inland locations, and also at offshore and coastal locations. Like other developments, windfarms may affect birds during construction, operation or decommissioning. As well as causing disturbance and displacement, windfarms may also affect bird populations by causing direct mortality through collision with the blades. The risk from windfarms is thought to vary for different groups and species of birds, and may be low for many smaller species such as passerines (e.g. Devereux *et al.*, 2008; Farfan *et al.*, 2009; Pearce-Higgins *et al.*, 2012). Larger species, including geese, raptors and large waders (e.g. curlew), may be more vulnerable to displacement from windfarms and to collision with turbines (Larsen & Madsen, 2000; Farfan *et al.*, 2009; Dahl *et al.*, 2012; Pearce-Higgins *et al.*, 2012; Stewart *et al.*, 2007; Jana & Pogacnik, 2008). In some cases, high collision rates have been linked to the positioning of

windfarms, or as a result of particular topographic factors that may make some species, such as birds of prey, more prone to collision (e.g. de Lucas *et al.*, 2008).

Environmental impact assessments prior to the construction of windfarms now routinely include bird surveys over the annual cycle to assess how many birds are likely to be at risk of collision or displacement, and should also assess the suitability of the topographical location of wind turbines based on current scientific knowledge. Although sensitivity maps have been produced to highlight areas that are particularly sensitive to the construction of windfarms in Scotland, based on the distribution of 16 species of conservation concern (Bright *et al.*, 2008), the sensitivity relates mainly to breeding species and consequently most of the area around the Firth of Forth is not identified as a high risk area. However, species that may be at higher risk around the Firth of Forth include pink-footed goose *Anser brachyrhynchus*, curlew, golden plover and lapwing, and therefore assessment of the estuarine and inland habitats used by these species may highlight particularly sensitive areas.

Tidal barrages have been used to generate electricity since the first constructed in France in 1967 (Rourke *et al*., 2010). Barrages may create substantial ecological impacts (Frid *et al*., 2012), for example, models predict that a barrage across the Severn would reduce the tidal currents and affect sediment movements (Goa *et al*., 2013). In recent years, research has focused on other ways to harness tidal stream energy and wave energy, such as tidal turbines. Although these potentially affect currents and hence sediment deposition and habitats (Frid *et al*., 2012), these devices can be placed so that they do not cover the whole estuary and therefore may not affect water and sediment flows to the same extent as barrages. For example, Sanchez *et al*. (2014) looked at the impact of both floating and bottom-fixed tidal stream turbines, and found that both caused slight reductions in flow up to several kilometres away from the device. However, as the technology is relatively new and in most cases is not yet operational, knowledge of their impacts is yet to be fully studied (Witt *et al*., 2012; Broadhurst and Orme, 2014). A number of peer-reviewed papers have aimed to assess the potential impacts of tidal and wave energy on birds and estuarine habitats (e.g. Inger *et al*., 2009; Grecian *et al.*, 2010; Broadhurst & Orme, 2014). Most of these studies agree that there will be some negative impacts including potential disturbance and displacement during construction, operation and decommissioning, and the risk of direct mortality from collision with the turbines or operational devices. However, there could also be positive impacts such as the creation of roosting sites, and a possible increase in prey abundance due to the creation of "*de facto* protected areas" around the sites (Grecian *et al*., 2010), and also because bottom-fixed devices may create an artificial reef structure (Inger *et al*., 2009; Broadhurst & Orme, 2014).

Several studies have also aimed to assess which birds are most likely to be vulnerable to tidal and wave devices in Scottish waters. Furness *et al*. (2012) suggested that wave energy devices presented lower risk to birds than tidal turbines, and that both presented a lower risk than offshore windfarms. Divers *Gavia* spp. were thought to be most vulnerable to wave energy devices, and black guillemot *Cepphus grylle*, razorbill *Alca torda*, shag *Phalacrocorax aristotelis*, guillemot *Uria aalge*, cormorant *Phalacrocorax carbo* and puffin *Fratercula arctica* most vulnerable to tidal turbines. Langton *et al*. (2011) suggested that the overall susceptibility of a species to impacts from tidal and wave energy was likely to be linked to their foraging behaviour, flight behaviour and their ability to buffer against environmental fluctuations. A further review assessing species' vulnerability from proposed tidal energy sites, based on whether they use the proposed area and their diving depths is given by Waggit & Scott (2014).

4. DISTURBANCE

Disturbance can be defined as any event that disrupts behaviour of bird communities or individual birds. Disturbance can occur naturally, for example when predators approach potential prey. However, this section focuses on anthropogenic disturbance. Disturbance may occur to both feeding and roosting birds, and may be caused by a wide variety of recreational and other human activities. In the environment of an open estuary, views are very long and sound carries well, especially over water. Thus both visual and aural disturbance on estuaries can have exceptionally long reach.

4.1 Activities that may cause disturbance

4.1.1 Walking and dog walking

Walking (including bird-watching) and dog-walking are among the most common and widespread activities carried out on British estuaries (Davidson & Rothwell, 1993). Most individual instances of disturbance from these activities may be relatively minor, however, the impact will potentially be greater when a larger number of disturbances occur. A study of sanderlings *(Calidris alba)* in Florida found that the number of people within 100 metres was the most important factor explaining the variability in time spent actively foraging, and that daylight foraging time decreased after the number of people increased dramatically, with more foraging taking place at night (Burger & Gochfeld, 1991). Dogs can be especially disturbing (Davidson & Rothwell, 1993), particularly free-running dogs which can cause substantial disturbance at both roost and feeding sites. For example, in a study of sanderlings in California they were found to be the most significant negative factor (Thomas *et al*., 2003).

4.1.2 Water-based recreation

Water based recreational activities may include sailing, water-skiing, jet-skis, motorboats, kayaking and windsurfing. Observational studies have found that, like walking, water-based activities may cause disturbance at high-tide roost sites (e.g. Burton *et al*., 1996; Holloway, 1997). Water-based activities may also cause more disturbance to feeding waders than approaches from land as many waders feed on the mud close to the tide-line (Davidson & Rothwell, 1993). Water-based activities also have the potential to affect species which normally forage at sea and are normally less prone to disturbance than birds using other habitats. For example, a study in Iberia found that tourist boats displaced shags from the best feeding areas and also affecting foraging time by provoking avoidance behaviour (Velando & Munilla, 2011).

4.1.3 Aircraft

Aircraft may have particularly strong effects on waterfowl (Davidson & Rothwell, 1993). In the Wadden Sea, knot were found to be strongly affected by the presence of both jet fighters and light aircraft. On days when aircraft were present, knot were rarely present in large numbers and were more likely to take flight at longer distances at the approach of human observers, or for no apparent reason (Koolhas *et al*., 1993). In another study, following radio-tagged redshank in the Cardiff Bay area, one site was entirely avoided by day, probably due to disturbance from an adjacent heliport, but was used by many birds at night when the heliport was inactive (Burton & Armitage, 2005).

Other studies have shown variable levels of response to aircraft which may depend in part on the altitude of the plane and also on differing levels of habituation (Smit & Visser, 1993). A different study on the Wadden Sea found that military jets had a relatively mild effect on roosting birds in spite of the associated high sound levels, and that helicopters caused more disturbance and caused birds to take flight at greater distances than military jets (Visser,

1986; Smit & Visser, 1993). Heinen (1986 in Smit & Visser 1993) also found that helicopters were the most disturbing aircraft type at a shorebird roost (causing disturbance in 100% of incidents), followed by jets (84%), small civil aircraft (56%) and motor gliders (50%).

4.1.4 Wildfowling (hunting)

Hunting can have an impact on bird populations through direct mortality, but the effect of disturbance caused by hunting may also be important (Hirons & Thomas, 1993). The scale of reported effects varies, presumably depending on hunting intensity and also individual attributes of the affected sites. An investigation into declines of 154 species of geese, ducks and swans found that hunting did not influence population trends (Long *et al*., 2007). At a more local scale, a review of wildfowling on the Stour estuary, south-east England, concluded that there was no evidence that the favourable conservation status of any species was being affected by hunting (Musgrove *et al*., 2001). However, a study in north Wales found that the estimated survival rate of curlews increased slightly after hunting was banned in 1982, and longevity increased by at least 40% (Taylor & Dodd, 2013). Similarly, Ebbinge (1991) attributed the increased populations of three goose species in western Europe to decreased mortality rates caused by reduced levels of shooting, and this study also suggests that spatial distribution is affected by shooting, with geese being concentrated on better protected areas rather than heavily hunted areas.

Displacement of birds away from hunted areas has also been noted by other studies. In Nebraska, a greater percentage of geese and ducks were recorded on wetlands closed to hunting than in hunted wetlands (Webb *et al*., 2011). In Findhorn Bay, Moray, waterfowl were disturbed by people at greater distances during the wildfowling season, and use of some areas by waterfowl increased after the end of the season (Holloway, 1997). In an experimental study in Denmark, the impact of hunting disturbance was tested by setting up two reserves: over five years, these became two of the most important staging areas for wildfowl (Madsen, 1995).

4.1.5 Construction work

Construction work on or adjacent to an estuary will also cause aural and visual disturbance. Major construction work can reduce densities, or exclude birds from some intertidal areas, during the construction phase (and sometimes after construction). At Cardiff Bay, construction work significantly reduced the densities of five species on the adjacent mudflat – teal, oystercatcher, curlew and redshank (Burton *et al*., 2002c). Disturbance from the construction of the a new bridge across the upper Forth estuary (the Clackmannanshire bridge) was associated with displacement of cormorants (probably as the result of disturbance of a low tide roost site) and redshanks that less frequently used some adjacent prey-rich mud flats (Dwyer, 2010).

4.1.6 Noise

The vast majority of research looking at anthropogenic noise and birds has focused on urban areas and how noise levels can cause songbirds to change their songs or the time at which they sing (e.g. Halfwerk & Slabbekoom, 2009; Fuller *et al*., 2007). Fewer studies have looked at the effect of noise on foraging and roosting birds. As might be expected, most studies have found that irregular and/or louder noises cause more disturbance than quiet and/or regular noises. Kusters & van Raden (1998) found that the impact of noise on a military shooting range depended on the order in which weapons were fired, with waterfowl and shorebirds showing less reaction if relatively quiet shooting occurred first. They also found that stronger reactions occurred when birds were closely grouped together in larger flocks, such as when they were roosting. An experimental study on the Humber also demonstrated stronger behavioural responses to increased noise levels for the four species studied (common gull, golden plover, lapwing and curlew) (Wright *et al*., 2010).

4.1.7 Artificial lighting

Artificial lighting has been found to affect the movements of migratory birds by attracting them, sometimes causing mortality (e.g. Longcore & Rich, 2004; Poot *et al*., 2008). However, artificial lighting may also have a positive effect on estuarine birds, with the extra light helping them forage at night. In a study of redshank on the inner Firth of Forth, using VHF transmitters and posture sensors, birds used sight based feeding methods on bright moonlit lights but fed by touch on darker nights when they spent more time feeding suggesting sight based feeding was more efficient. Artificial lighting, from the Grangemouth industrial complex, enabled them to feed by sight even on darker nights (Dwyer *et al*., 2013). Another study in the Tagus area, Portugal, looked at the habitat selection and foraging behaviour of six wader species (three visual feeders, one tactile feeder and two mixed feeders). During the night, visual feeders used areas illuminated by streetlights more than unlit areas, and mixed feeders fed by sight in illuminated areas. The authors suggest that artificial street lighting therefore has a positive effect, though they also point out that it brings waders close to degraded areas in urban areas, and may potentially also put them at risk from predators (Santos *et al.*, 2010).

4.1.8 Other activities causing disturbance

Other activities that have been observed causing disturbance include vehicles moving on roads and railway lines (Burton *et al*., 2002a), agricultural bird-scaring, bait-digging (Townshend & O'Connor, 1993); military activity (Kusters & van Raden, 1998); and horse-riding, angling and bathing/general beach use (Davidson & Rothwell, 1993).

4.2 The effects of disturbance

Disturbance can vary in magnitude, frequency, predictability, special range or duration (Cayford, 1993), and the impact on individual birds and species will therefore also vary accordingly (Blanc *et al.*, 2006).

4.2.1 Disturbance whilst foraging

Whilst it is clear from the literature that birds on estuaries are disturbed to some extent by human activity, it is more difficult to assess the actual impact that disturbance may have on individual birds or at a site or population level (e.g. Davidson & Rothwell, 1993; Hill *et al.*, 1997; Burton *et al*. 2002a).

Where disturbance is only temporary, it may not have any impact on the survival of species using the site. This will depend on how much foraging time is lost and how much extra energy expenditure occurs because of disturbance, and whether individual birds can compensate (Davidson & Rothwell, 1993). Where alternative habitat is available, or birds can quickly return to a feeding area after an episode of disturbance, most birds may be able to overcome the effect of disturbance by increasing food intake rates (Swennen *et al.*, 1989; Davidson & Rothwell, 1993), and/or extending the length of time that they feed (Davidson & Rothwell, 1993). In some instances, minor levels of disturbance may therefore have little long-term effect. A field study of oystercatchers found that they did not need to increase intake rates to make up for disturbances of 30-60 minutes, but instead spent longer feeding (Urfi *et al*., 1996). Similarly, Riddington *et al*. (1996) calculated that brent geese on the north Norfolk coast would need to feed for up to hour at night in midwinter to balance their energy budget as a result of disturbance.

However, the ability to extend feeding times may be limited. Many estuarine birds can feed only during low tide when mudflats are uncovered, and this limiting factor becomes more important in cold weather when birds need to feed for longer to meet their energy requirements. Some species need to feed for longer than others to meet their energy

requirements and so are more susceptible to the effects of disturbance during cold weather. The redshank is particularly susceptible to disturbance in severe weather as it feeds on very small prey relative to its size and therefore spends a high proportion of its time feeding (Mitchell *et al*., 2000). Like redshank, grey plover is also highly vulnerable to severe winters, and mortality rates also increase significantly for knot, dunlin and curlew (Clark, 2004). During periods of 'severe winter weather' (when average temperatures drop below a predetermined level for a minimum predetermined period), wildfowling bans are implemented in Britain as short-term mitigation against disturbance during particularly extreme conditions (Stroud *et al*., 2006).

Some species may overcome this limitation by using other habitats to find food. For example, fields adjacent to estuaries provide important feeding habitat for curlew over winter (Townshend, 1981).

4.2.2 Displacement from feeding sites

Sometimes birds leave the immediate area after disturbance. This will not necessarily have a significant effect on the overall numbers of birds using the site, if suitable habitat is available elsewhere for the duration of the disturbance. However, sustained disturbance may result in the effective long-term loss of an area of feeding habitat (Cayford 1993). Regular disturbance may therefore cause a reduction in the number of birds that an area can support, known as the 'carrying capacity' of a site. Where an area is close to its carrying capacity, the availability of prey may also become a limiting factor, leading to a need to increase feeding time and to more competition between individuals even when disturbance does not occur; hence the potential for disturbance to have more impact (Cayford 1993).
Burton *et al.* (2002a) used statistical modelling procedures to test whether the number of birds using different areas in six English estuaries varied according to a number of factors, including the proximity to the nearest footpath access point. Six of the nine species considered were found in significantly lower numbers where a footpath was close by (shelduck, knot, dunlin, black-tailed godwit, curlew and redshank). Count numbers were also reduced by the proximity of railway lines (brent goose, shelduck and grey plover) and roads (ringed plover, grey plover and curlew). This suggested that disturbance may be reducing the number of birds using particular areas within these estuaries.

4.2.3 Disturbance and displacement at roosting sites

Most recreational activity usually takes place at or close to the high-tide mark, and hence roosting birds are often more vulnerable to disturbance, as they are usually gathered in large flocks close to the high water mark, whereas foraging birds are often spread out over a wide area of mudflat, and further away from most human activities (e.g. Davidson & Rothwell, 1993; Holloway, 1997; Navedo & Herrera, 2012). Although disturbance at a high-tide roost site does not cause birds to stop feeding, it impacts upon them by causing increased energy expenditure. In some cases, the impact may be relatively minor and birds will return to the same roost after being disturbed; however in other cases disturbed birds have been observed flying to other roost sites several kilometres distant, or leaving a site altogether (e.g. Kirby *et al*., 1993; Burton *et al.*, 1996). Therefore, regular disturbance at secure roost sites may cause population declines even if sufficient food resources remain available in an area. In Portugal, declines in wintering populations of dunlin, grey plover and redshank on the Tagus estuary were linked to the loss and degradation of roost sites due to human activities (Catry *et al.*, 2011).

4.2.4 Predictive models

A number of studies have used predictive models to assess the effect of disturbance and other factors on species abundance. "Individual-based models" (IBMs) use information from behavioural studies to try to predict how individual birds respond to environmental changes

including disturbance, based on factors including their feeding rates, choice of prey and foraging area, and time spent foraging, and how these vary as a result of other factors including disturbance, changes in prey abundance and competition (e.g. Goss-Custard *et al*., 2006). Some IBMs suggest that the impact of disturbance may be substantial. A model predicting the effect of disturbance on breeding ringed plover along a 9-km stretch of coastline in the Wash predicted that the population would increase by 85% if there was a complete absence of human disturbance, but would decrease by 23% if human disturbance doubled from current levels (Liley & Sutherland, 2007).

Another behaviour-based model predicted that the impact of disturbance on oystercatchers on the Exe estuary was potentially more damaging than permanent habitat loss, with numerous small disturbances having greater impact than a few large disturbances (West *et al*., 2002). However, current levels of disturbance on this estuary were not expected to cause increased mortality, and preventing disturbance during late winter practically eliminated the impact of disturbance on the population (West *et al*., 2002).

In the Baie de Somme, France, where oystercatchers were again the subject of the research, modelling predicted a critical threshold of 1.0-1.5 disturbances per hour in good feeding and wintering conditions, with fitness expected to reduce at higher disturbance levels and some birds being at risk of dying of starvation. However, in severe weather or in instances where food resources were scarce, the critical threshold reduced to 0.2-0.5 disturbances per hour (Goss-Custard *et al.*, 2006)

4.3 Species' responses to disturbance

Species tend to differ in how they respond to instances of disturbance. For example, oystercatcher will often walk away from the source of disturbance, whereas redshank and curlew will stop feeding and fly away if the source approaches too closely (Fitzpatrick & Bouchez, 1998). Different species allow people to approach more closely before taking flight (Whitfield *et al.*, 2008). Some studies have attempted to quantify which species are more prone to disturbance relative to other species by measuring their reactions to disturbance or the 'escape distances' for different species when disturbed (i.e. the distance at which they take flight). Often, smaller species allow a closer approach than larger species (Laursen *et al*., 2005) but there are some exceptions, for example oystercatcher is usually less prone to take flight than redshank (Table 4.3.1).

Escape distances, however, may be extremely variable, and some commentators have therefore suggested that they may not be a good measure to use to assess the sensitivity of individuals or the vulnerability of a species to disturbance (e.g. Gill *et al*., 2001). Factors that influence the flight distance may include flock size, visibility and wind force as well as the type of disturbance (Laursen *et al*., 2005) and habituation to disturbance (Section 4.4).

Responses may also relate to the starvation risk of avoiding disturbance. A study by Stillman & Goss-Custard (2002) found that oystercatchers approach a disturbance source more closely and return to a site more quickly after disturbance during late winter, when food abundance is lower and they need to spend more time feeding to meet their energy requirements. They suggest that this may sometimes mean that species with stronger behavioural responses to disturbance may not always be particularly vulnerable, and that the most sensitive species are those with both long escape distances and a need to spend a high proportion of their time feeding.

Table 4.3.1: Relative responses to disturbance from several studies as examples of differing reactions between species.

FEATURE	**Level of tolerance when approached**		**Level of response to disturbance at roost****	**Tolerance to impulsive noise**	**Mean distances at which birds took flight when approached by people walking across tidal flat (m)**	**Approximate mean distances at which roosting birds took flight when approached by kayaks/windsurfers (m) #**
Reference	*Burton* et al., *2002a*	*Davidson & Rothwell, 1993*	*Kirby* et al., *1993*	*Wright* et al., *2010*	*van der Meer, 1985*	*Koepff & Dietrich, 1986*
Brent Goose		"more nervous"			105	
Shelduck					148	200/380
Oystercatcher		"less nervous"	Medium		85	50/140
Ringed Plover			Low		121	
Grey Plover			High		124	
Golden Plover				"middle tolerance"		
Lapwing				"least tolerant"		
Knot			High			275/210
Sanderling			Low			
Dunlin	"most tolerant"	"less nervous"	High		71	
Black-tailed Godwit	"most tolerant"					
Bar-tailed Godwit		"more nervous"	High		107	200/240
Curlew	"least tolerant"	"more nervous"	Medium	"most tolerant"	211	230/400
Redshank	"most tolerant"	"more nervous"	Low			190/280
Turnstone		"less nervous"			47	

** For Kirby *et al*. (1993): HIGH – species most likely to leave estuary when disturbed; MEDIUM – most likely to move to other roosts within the estuary but outside the study area; LOW – more likely to stay at the same roost or move to another roost within the study area.
# Distances are approximate as source report is in graphical form and exact distances are not stated

4.4 Habituation to disturbance

The impact of disturbance may be lower if it occurs regularly and is predictable (e.g. walkers staying on footpaths), especially if the intensity of the disturbing feature is not severe. In such cases, birds may show habituation to disturbance and allow a closer approach than birds which are not habituated. For example, Urfi *et al.* (1996) studied three sites with differing levels of disturbance and found evidence that oystercatchers reduce the distance at which they took flight when people were present more frequently, which they attributed to habituation. Nisbet (2000) even states that the impact of disturbance has been overstated and argues that there is little scientifically acceptable evidence of any harm to colonial waterbirds (terns, gulls and herons) from disturbance. He suggests that colonial waterbirds can become extremely tolerant of human disturbance, and therefore habituation should be deliberately promoted for research, education and recreation. This contradicts, however, many of the studies mentioned above which have identified strong behavioural responses to recreational activities and negative impacts. Habituation may be achievable only in certain specific locations. Some birds may not become habituated to disturbance, for example birds at a military range at Vlieland on the Dutch Wadden Sea did not habituate to shooting despite being exposed to it for 40 years, though this may have been due to particularly high sound levels in this case (Smit & Visser, 1993).

4.5 Which activities cause most disturbance?

As behavioural responses to disturbance vary due to a number of factors, it is difficult to assess which types of activity cause more disturbances, and in some instances the cumulative effect of multiple minor disturbances may be greater than a single large disturbance. As discussed above, recreational activities such as walking may have little effect on bird populations in the long term, if they are relatively infrequent so that birds can compensate or the disturbance, and/or if they occur in a predictable manner so that birds become habituated to the activity. Habituation is perhaps less likely where even a small proportion of walkers are accompanied by free-running dogs, fire guns, or otherwise disturb birds deliberately. However, some types of activity may cause higher levels of disturbance. Davidson & Rothwell (1993) considered aircraft as the most disturbing human activity, especially slow moving aircraft such as helicopters, microlights and other light aircraft. Other particularly disturbing activities that they refer to are moving people and animals on the intertidal area (especially dogs) and close approaches to mudflats from the water.

A study of wader roost sites at Hartlepool found that disturbances from helicopters, rats, raptors and boats were more likely than other factors (e.g. building work, people and gulls) to cause roosting birds to move to another roost site (Burton *et al*. 1996). The escape distances shown in Table 4.3.1 also suggest that water-based activities usually cause stronger responses than walkers, although the measurements are from different studies so are not necessarily directly comparable.

4.6 Reducing the impacts of disturbance

The most obvious method to reduce the impact of disturbance is to stop or substantially reduce access to a site or to key areas within a site. This was successful in Delaware Bay, where a combination of signs, education, the construction of viewing platforms and patrols on key beaches, helped to reduce the number of disturbances during spring migration (Burger *et al*. 2004). However, this is likely to be impractical at many sites, particularly for extended periods rather than the four-week migration period in the Delaware Bay example. Therefore, any attempt to reduce the impacts of disturbance needs to focus on where disturbance is likely to be having a significant long term impact at a species level, and to make an assessment of the most important habitats, the most important species, and the type and severity of disturbance events. Local, and often voluntary, exclusion zones are

widely implemented by, for example sailing clubs and other recreational organisations. Other widely practiced and advocated measures to reduce disturbance includes encouraging access to less sensitive parts of a site, for example through the creation of access points. The effectiveness of such measures appears to be poorly documented in the literature but anecdotal reports from site managers indicate that such actions can be successful in at least some cases.

At many estuaries, the provision of safe roost sites for waders is likely to be especially important, as studies have shown that this is where they are most likely to be disturbed (feeding areas such as mudflats are often rarely accessed). Roost use is highly variable according to conditions (e.g. wind direction), so the provision of a range of undisturbed natural and artificial roosts within an appropriate distance (for species involved) of feeding areas may be important (Peters & Otis, 2007). Similarly, measures to prevent disturbance in late winter also may be particularly important as this will be when many species are likely to be most at risk and less able to compensate for the effects of disturbance; declining temperatures and food quality combine to make survival more difficult in late winter (West *et al*., 2002). This is especially true during periods of severe weather, when birds may be at risk of starvation even without the added impact of disturbance. A formal process and set of criteria already exists in the UK to suspend shooting in severe weather (Stroud *et al*., 2006). Similar processes could be considered to mitigate other forms of disturbance when severe weather occurs.

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Policy and Advice Directorate, Great Glen House,
Leachkin Road, Inverness IV3 8NW
T: 01463 725000

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