How are sea surface temperatures affecting populations of wetland birds on Millport?

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1. Introduction

1.1 Wetlands

1.1.1 Ecology and Conservation of Wetlands

Wetlands are areas that are saturated by surface or ground water, and support vegetation that is adapted to saturated soil (Batzer and Sharitz 2014). Wetlands provide habitat for a variety of species, often with high biodiversity relative to their geographical size. For example, the UK's wetlands take up 3% of its area while sustaining 10% of its species. Wetlands are not only key in supporting wildlife globally, they also provide direct benefits to humans, by helping to prevent flooding as well as supporting livelihoods such as farming (Belden et al. 2012).

The importance of wetlands to the planet cannot be overstated. Despite this, almost 35% of the world's wetlands were lost between 1970 and 2015; which has placed almost 25% of species at risk of extinction (Ramsar Convention on Wetlands, 2018). Not only are wetlands being lost in their entirety, the quality of remaining wetlands is diminishing due to lack of sustainable use and poor management.

Steps must be taken to conserve and restore wetlands. Any site specific management strategies will stand the best chance of success if they are appropriately and effectively communicated to all stakeholders.

1.1.2 Wetland Birds

One clear function of wetlands is to provide habitat for birds. Birds rely on wetlands to fulfil a wide range of behavioural and fitness-critical needs, including food sources, shelter, water, social behaviours, reproduction, and rearing young (Stewart 2016). Some species of birds rely on certain types of wetlands and would become extinct without them. Other species only use wetlands for part of their lives.

Figure 1.1.3, Map of Scotland, highlighting the Firth of Clyde (red circle)

1.1.3 Wetlands and Wetland Birds of Clyde

The Firth of Clyde is located on the West coast of Scotland. The Clyde River flows through Glasgow and the Clyde Estuary is around 10km North West of Glasgow; the inner Firth of Clyde is around 30km West of Glasgow. The Clyde Marine Region (CMR) has several Sites of Special Scientific Interest, including one on the island of Great Cumbrae; which is the site of focus in this report.

Figure 1.1.4, Eurasian oystercatcher (Haematopus ostralegus; left) and Eurasian curlew (Numenius arquata; right). Both species are listed as 'near threatened' on the IUCN Red List.

The populations of wetland birds in the CMR are considered internationally important as they represent a significant proportion of the global population of some species. The intertidal mudflats of the inner estuary alone regularly support a wintering population of 20,000 waterfowl (Mills et al 2017). Wading birds make use of the large area of mudflats exposed at low tide, where they forage for small invertebrates burrowing in the mud. The mudflats support a number of bird species, notably the 'near threatened' curlew and oystercatcher (IUCN 2020). Wading birds are the group of species of interest in this report.

1.2 Changing Sea Surface Temperature

1.2.1 SST and Climate Change in the UK

Sea surface temperature (SST) is a useful measurement for quantifying marine change over many decades (Merchant et al. 2014). The quantification of marine change is especially relevant for monitoring climate change. Changes to the temperature of seas can alter entire ecosystems, due to the sensitivity of key species to temperature. Poikilotherms (animals unable to regulate their own body temperature), make up some key marine animal groups fish and most invertebrates, and are particularly sensitive to changes in temperature. Significant changes to the population sizes of these species could have knock-on effects in other species in the ecosystem, for example wading birds feeding on invertebrates.

1.3 Objectives

1. Investigate data from the mini-logger located off Millport, Great Cumbrae to investigate how SST has changed between 1997-2013.
2. Investigate data recorded and compiled by the Wetland Bird Survey to investigate how the population of wading birds in Largs and Great Cumbrae has changed between 1997-2013.
3. To analyse any correlation between SST change and wading bird population size change between 1997-2013 in Largs and Great Cumbrae, and assess other factors contributing to changes in wading bird population sizes.

2. Materials and Methods

2.1 Study Area and Animals

Figure 2.1, map showing the Firth of Clyde; with sites of interest for this study, Millport (Great Cumbrae) and Largs.

The 500m (approx.) stretch between Farland Point, Great Cumbrae and the Ferry Terminal at FSC Millport, Great Cumbrae is where some of the Wetland Bird Survey data used in this report was collected (years 1997 -2000). The remainder of the data (2001-2013) was collected at a 2km (approx.) stretch of coast between Largs and Fairlie. Sea surface temperature data was recorded at a drifting buoy off Millport, Great Cumbrae.

This report focuses on the wetland birds of the Clyde Marine Region (CMR), specifically wading bird species found on Great Cumbrae between 1997-2013. The various species of wading birds cannot be classified under any one taxonomic group. Therefore, a list of wading birds was compiled from a list of all known wetland birds that inhabit the CMR.

Figure 2.2.1, a biologist recording data for a wading bird census Stratton Island, Maine.

2.2 Methodology

2.2.1 Data Acquisition

The data for bird counts used in this study was recorded through the Wetland Bird Survey (WeBS), which is run by the British Trust for Ornithology (BTO). The WeBS is a monitoring scheme aimed at providing data for the conservation of waterbirds and their habitats. Data is recorded by around 3,000 volunteers during synchronised monthly counts at wetlands. The data provided by the WeBS is used in reports, such as this, to determine the historical, present, and future prosperity of wetland bird populations and habitats.

The data for SST used in this study was provided by FSC Millport. Temperature was recorded as monthly averages.

2.3 Statistics

2.3.1 Preliminary Observations

The raw data for the counts of individual species of wading birds was initially combined to produce a single 'wading bird' count for each month. This provided an idea of the general trend of wading birds at the site on Great Cumbrae.

The raw data for SST was initially graphically illustrated to plot each month and its corresponding temperature reading. In addition to this, each year's yearly average was calculated by finding the mean average across all 12 months of each year. This was done to more clearly show the general trend in SST over the 13-year period.

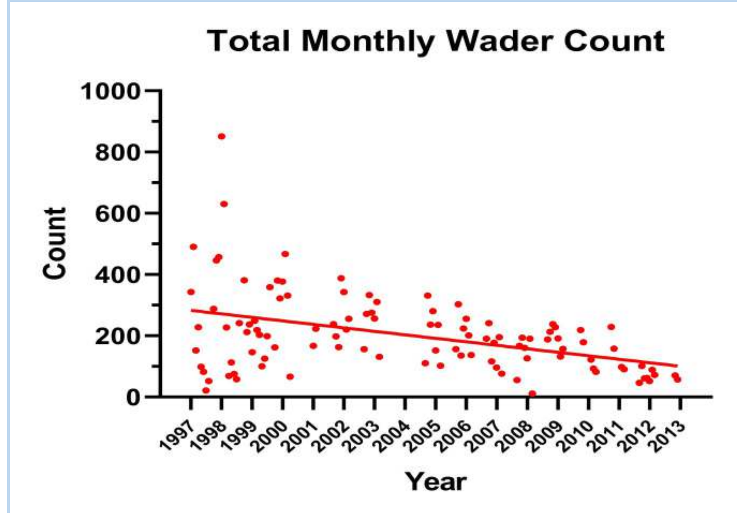
2.3.2 Final Statistical Tests and Data Analysis

The combined 'wading bird' count was tested for statistical significance by calculating a Pearson's correlation coefficient (r). To gain a more detailed insight into the population trend of specific wading bird species at Great Cumbrae, Pearson's correlation coefficients (r) were calculated for all 10 species.

To understand if any observed trends in SST were statistically significant, a Pearson's correlation coefficient (r) was calculated for the datasets. SST trends in the same month over the years were also investigated and Pearson's correlation coefficients (r) were calculated.

With the results of the statistical tests of both wading bird counts and SST, it was then possible to analyse the data for any potential links between the two variables. Other factors were also considered to help answer the question: how are sea surface temperatures affecting populations of wetland birds on Millport?

3. Results



3.1 Preliminary Observations

The count of all wader species combined was found to decrease with statistical significance between 1997-2013, a moderate correlation was found (r=-0.4288; P<0.0001; figure 3.1.1).

Figure 3.1.1, monthly total wader count recorded at Clyde Estuary, 1997-2013

Monthly SST cycles shows consistent peaks at around July and August, and troughs each year at around February and March (figure 3.1.2). There was no significant correlation between temperature and date. Average annual SST is decreasing with statistical significance, a moderate correlation was found (r=-0.6152; P=0.0112; figure 3.1.3).

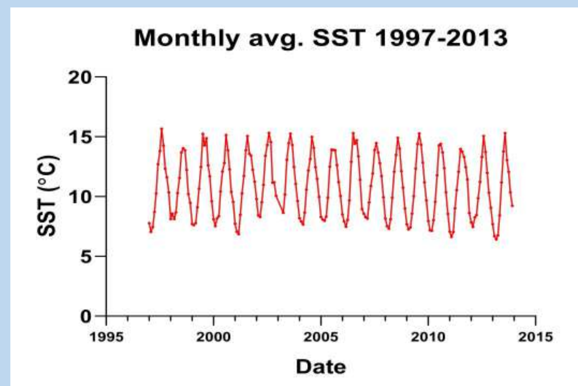


Figure 3.1.2 showing monthly average SST recorded at Millport between 1997-2013

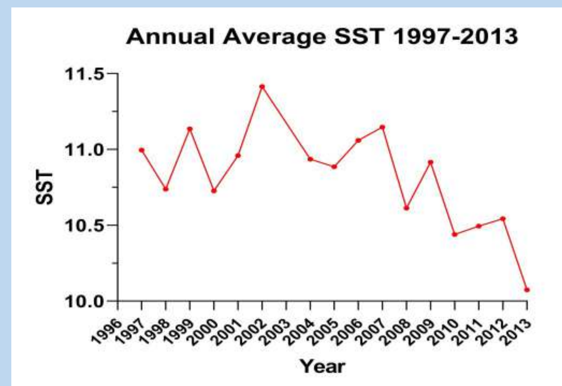


Figure 3.1.3, yearly average SST recorded at Millport between 1997-2013

3.2 Recorded Number of Waders between 1997-2013 at Cumbrae and Largs

There was a statistically significant decrease in the numbers of seven out of the ten wading bird species investigated in this report. This was found by conducting correlations between count and date, producing Pearson's correlation coefficients (r). Statistically significant population changes were found in the following species: common sandpiper (r=-0.3507; P=0.0029), curlew (r=-0.5849; P<0.0001; figure 3.2**b**), dunlin (r=-0.4350; P=0.0001), grey heron (r=-0.4488, P<0.0001), lapwing (r=-0.4134; P<0.0001), oystercatcher (r=-0.3086; P=0.0013; figure 3.2**a**), and turnstone (r=-0.3649; P=0.0009).

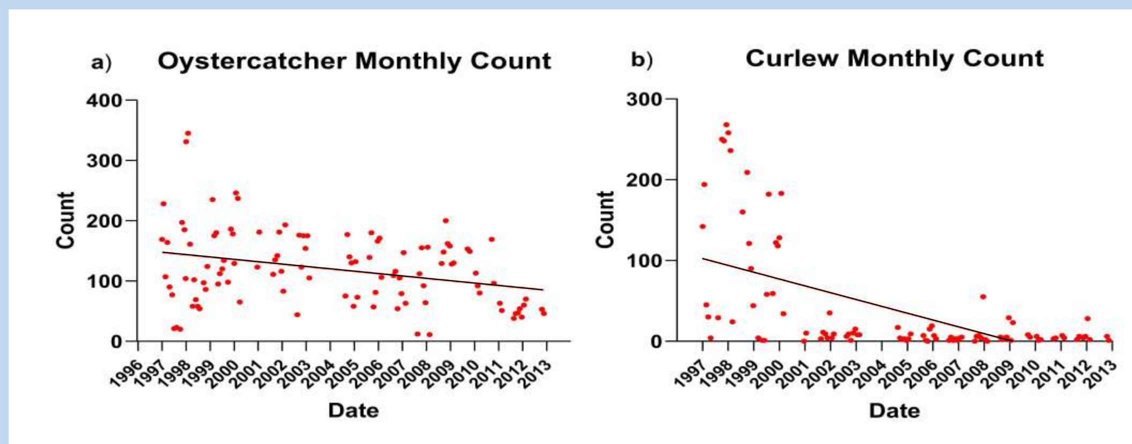


*Figure 3.2 showing the monthly count of **a** oystercatcher and **b** curlew, recorded at Great Cumbrae between 1997-2013. Line of best fit shown in black, depicting the statistically significant correlation.*

3.3 SST between 1997-2013 at Millport

In addition to the statistically significant decrease in SST shown in figure 3.1.3, there were significant decreases in SST between 1997-2013 in three months of the year. It was found that May had a negative correlation between SST and year (Pearson's r=-0.5485; P=0.0226), as well as September (r=-0.5227; P=0.0313; figure 3.3**a**) and December (r=-0.6043; P=0.0102; figure 3.3**b**).

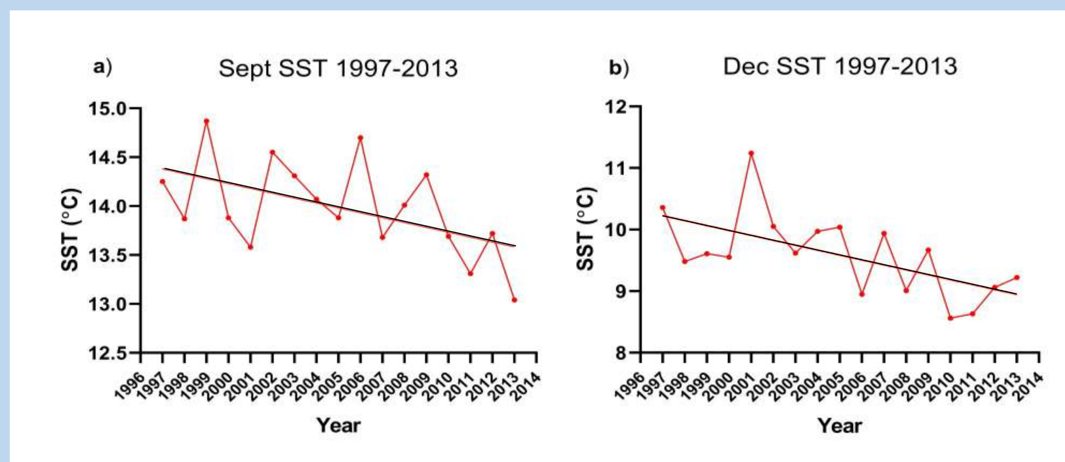


*Figure 3.3, showing the statistically significant decreases of SST in the months of **a** September and **b** December between the years 1997-2013. Line of best fit shown in black, depicting the statistically significant correlation.*

4. Discussion

4.1 Preliminary Observations

The overall decreasing trend seen in the combined wader count (figure 3.1.1) is a change that is supported by Leech et al. (2004), where it is suggested that changing climate is causing shifts in the distribution of wader species. The decreasing trend is therefore not necessarily indicative of a reduction in the total number of wading birds worldwide, but may be evidence of changing site choice as a result of climate change.

The negative trend in yearly average SST between 1997 and 2013 identified in this report (figure 3.1.3) is supported by the decrease in SST observed between 2003 and 2013 in all regions of the UK's seas (Hughes et al. 2017). This period of decreasing SST is purported by Hughes et al. (2017) to be 'natural variability' in what had been a drastic increase in SST between around 1980 and the most recent data at the time of publication.

4.2 Wader Population at Great Cumbrae

The decline in seven wading bird species identified in this report is supported by findings from Sim et al. (2005), where it was observed that populations of curlew significantly declined by an average of 27% between 1992 and 2002 across six sites in the UK. It was also found in the same paper that lapwing populations significantly declined by 74% across four sites in the UK in the same time period; dunlin were also found to decline with significance.

Waders have been found to put on weight during periods of cold weather (Swann & Etheridge, 1989). This may mean that any subsets of individuals that are inefficient feeders (e.g. young) are less likely to put on the weigh necessary to survive the cold weather. The study by Swann & Etheridge (1989) highlights oystercatchers and redshank as having poor ability to regulate body weight with temperature, and these species were disproportionately affected by severe cold weather spells.

One suggestion for why wader numbers are declining in the UK is changes in populations of the invertebrates that wading birds forage for. Some invertebrates, including polychaete species which inhabit tidal flats and are the prey of some wading birds, have been found to be sensitive to low temperature to the extent that biomass after cold winters in the Wadden Sea decreased significantly (Beukema 1990). An investigation by Bowgen et al. (2015) found that invertebrate regime changes have different impacts on wading birds depending on the species of wader. More adaptable, generalist species are able to change prey species with little detectable change in population size. This means that changes in invertebrate distribution may not necessarily affect wading bird populations. However, it is a possible reason for the change seen at Great Cumbrae.

One potential source of inconsistency lies in the data recording method. As the counts are conducted by volunteers, there may be differing levels of skill and ability in bird surveying. This may produce statistically significant results, leading to inaccurate conclusions about the populations in question. The fact that the Wetland Bird Survey is volunteer-based does tend to mean that much more data can be collected than could have been by a small group of researchers alone. This means it is possible to gain a wider understanding of bird populations across the UK, in a shorter period of time, thanks to the voluntary nature of the scheme.

4.3 SST at Millport

The statistically significant year-on-year decreases in SST in the months of May, September, and December could be evidence of seasonal variation in climate. As previously stated in section 4.1, the decreasing trend over the time period in question contradicts the longer-term trend of increasing SST found in other studies (Hughes et al. 2017). The year-on-year unpredictability is evidenced by the numerous peaks and troughs in figure 3.3**a** and 3.3**b**.

Over a suitable time period, monitoring SST can be useful for measuring changing environmental conditions. However, natural fluctuations in SST can produce a trend for a number of years that contradicts the longer-term trend in SST. Reasons for these natural fluctuations are often due to unusual weather patterns. The data from the SST mini-logger at Millport is reliable because they buoy has remained in the same geographical position for more than a decade. This means there are relatively few possible confounding variables that could affect readings.

4.4 Conclusion and Future Work Arising

Sea surface temperatures (SST) are in a state of constant change, which is being accelerated by the anthropogenic causes of climate change. In this report it was found that, contradictory to the long-term trend, SST decreased with statistical significance between 1997 and 2013 at Millport, Great Cumbrae. In the same period of time, wader numbers at selected sites within 2km of Millport were also found to decrease with significance. This could be evidence of shifting geographical distribution of waders, and possibly of a decrease in overall wader population sizes.

It is not possible to state that changing SST is the reason for the changes in wader populations as there are numerous other factors that must be considered. Future work should look to solidify some of the suggestions made in this report, such as investigating population changes of the invertebrate species that waders feed on.