BTO RESEARCH REPORT 794

Assessing the extent and effects of disturbance on wintering waterbirds in Northern Ireland's sea loughs

El Haddad, H., Pickett, S., O'Connell, P., Burton, N. & Booth Jones, K.

Birds Science People
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Contents

1. Introduction

The key responsibility of the Department of Agriculture, Environment and Rural Affairs' (DAERA's) Marine and Fisheries Division (MFD) is to ensure the protection of Northern Ireland's marine and coastal areas while, where appropriate, promoting their sustainable use. The sea loughs of Northern Ireland all contain Areas of Special Scientific Interest (ASSIs) — protected areas that aim to preserve the best of Northern Ireland's wildlife and geology and that are safeguarded under The Environment (Northern Ireland) Order 2002 (Part IV). In addition, all the five sea loughs also hold Special Protection Area (SPA) and Ramsar Convention designations for their importance to birds, wetland habitats, and biodiversity. Dundrum Bay, which is not protected by SPA designations, also provides important feeding and roosting places for wintering waterbirds as part of the Dundrum Bay and Murlough ASSI.

Human-related disturbances to foraging or resting waterbirds during the winter can come from a range of sources, from people on foot or using machines or vehicles, and from industrial or recreational sources (Davidson & Rothwell 1993, Robinson & Pollitt 2002). Anthropogenic disturbances may cause birds to fly away to alternate areas or cause non-fleeing responses like increased vigilance if there is a lack of alternative habitat to flee to (Goss-Custard et al. 2006, Gittings & O'Donoghue 2016 Jarrett et al. 2018, Jarrett et al. 2020), although this may not be the case in all situations (Gill et al. 2001, Collop et al. 2016, Maslo et al. 2020). Sporting and leisure activities are common at the Northern Irish sea loughs. Furthermore, the habitat of these birds can be affected by industrial activities carried out in these areas. One of the most commercially important uses of Northern Ireland's sea loughs is aquaculture.

The Northern Irish shellfish aquaculture industry produces mussels, oysters, and to a lesser extent, clams (DAERA Marine Map Viewer). Of these industries, activities associated with intertidal oyster trestles have the greatest potential to cause disturbance to birds. This is because activities are targeted around low tides, when the trestles are exposed, which is also when wintering waterbirds are most likely to be foraging in the intertidal area (Clarke et al. 2017). However, aside from an impact assessment carried out on the aquaculture disturbance in Mill Bay (Boyd 2023) and an unpublished dissertation produced by Queen's University Belfast and the Loughs Agency (Morrisson 2017), little research has been produced on its effects on the interest features of the sea loughs in Northern Ireland.

This pilot project builds on the findings of an analysis of within-site wintering waterbird trends (Booth Jones et al. 2019, Booth Jones et al. 2023), based on BTO/RSPB/JNCC Wetland Bird Survey (WeBS) data, supported by the Northern Ireland Environment Agency (NIEA) and the MFD. The project provides a more targeted field-based study that directly assesses the potential responses of waterbirds to disturbance, particularly disturbance associated with intertidal aquaculture activities at active sites across Northern Ireland and to set these in the context of disturbance events caused by other activities.

Here we define disturbance as any event that disrupts the behaviour of bird communities or individual birds and has the potential to impact individual energy budgets, e.g. when it affects either roosting or feeding behaviour (Collop et al. 2016), and thus individual fitness (body condition, survival).

Table 1. Examples of activities that may cause disturbance responses and impacts.

Activity	Potential impact
Walking/jogging/running and dog walking	Very common in some areas around sea loughs and sheltered bays, particularly when close to inhabited areas and easily accessible. Dogs off leads can be a particularly significant issue (Davidson & Rothwell 1993). These activities often cause minor disturbance but regularity in some areas may be cumulative. Causes birds to be on alert, feeding less or affecting roosting sites. Can also lead to displacement of birds away from optimal feeding/roosting areas or force them to feed more at night (Burger & Gochfeld 1991, Melon & Allen 2015).
Water-based disturbance	Areas with easy access to the water, with harbours or piers or popular beaches can see a significant amount of water-based activity, although recreation use will often be less in winter than in for the rest of the year. This may also affect foraging by disturbing birds on the water and/or shorebirds. Species show different sensitivities to disturbance, often influenced by speed of approach (Ronconi & Clair 2002, Larsen & Laubeck 2005). Smaller craft including kayaks, windsurfers, jet ski etc. can cause disturbance to birds feeding or roosting on shore due to their ability to come close into shore and in some cases the need to launch from and return to shore.
Aircraft	Low flying aircraft, including those moving at slower speeds like helicopters or very fast speeds like jet fighters, can cause significant disturbance to feeding or roosting waterbirds (Davidson & Rothwell 1993). Unmanned drones may also cause disturbance to waterbirds (Jarrett et al. 2020).
Wildfowling	Wildfowling can cause direct mortality but may also cause significant disturbance (Hirons and Thomas 1993). The reported disturbance effects associated with wildfowling vary and may depend on the species involved and the local conditions, but at least in some areas it appears to have an impact (Madsen 1995, Holloway 1997). Displacement due to hunting has also been reported (Webb et al. 2011).
Aquaculture	The primary forms of aquaculture likely to cause disturbance to wintering waterbirds within sea loughs and bays can be separated into offshore and intertidal aquaculture. Disturbance due to offshore aquaculture may arise due to regular boat journeys to and from the site and targeted scaring techniques to keep predators away from the fish/shellfish being farmed (Kaiser et al. 1998). On the foreshore, the primary aquaculture is for trestle-grown oysters. Disturbance may arise from the regular site visits to inspect/work the trestles, and displacement may occur where the presence of the trestles affects a species' ability to feed (Kaiser et al. 1998).
Bait digging and foraging	Bait digging and foraging for e.g. seaweed or molluscs, may cause disturbance as it requires one or more people to be on site for a period of time with someone in potentially close proximity to the feeding areas of waterbirds (Kaiser et al. 1998). The extent of disturbance caused is likely related to the number of people present, the length of time they are present for and the nature of the site. Weather conditions may also be important. As this activity normally only occurs on a low tide there is less likelihood of disturbing roosting birds.
Other	Construction work, noise, light, transport links.

2. Aims

This pilot project aimed to investigate the impact of disturbance to wintering waterbirds within Northern Ireland's sea loughs and bays which contain licenced and active oyster-trestle aquaculture. To achieve this aim three key objectives were set out:

1. to describe how the numbers and behaviours (feeding/roosting/resting) of waterbirds vary between sites and with environmental factors, including tidal phase;
2. to identify the presence of activities that might cause disturbance and to use these to grade the sites from most to least disturbed;
3. to assess responses of waterbirds to different forms of disturbance, their foraging 'guild' and tidal cycle.

3. Methods

The original project proposal aimed to survey paired sites within five loughs, one site with active aquaculture and a control. However it was decided that true counterfactuals would be impossible to match and would never be independent, particularly on smaller sites such as Killough and Dundrum (Figure 1). An alternative to counterfactuals was to compare changes in numbers and behaviours between sites with a gradient approach. This would potentially require measuring variables such as the size of aquaculture sites, their yield, and their activity levels to get a gradient of potential disturbance. However, it was not possible to get this information in time for the surveys. Therefore, the aim of the fieldwork was expanded to try and identify a gradient of activity in relation to aquaculture but also record other disturbance events such as recreational activity at each site. Five sites were selected where licenced aquaculture of oysters was taking place on the foreshore. The survey was planned to run between November and February but, due to a delay in receiving information to inform fieldwork planning, the survey period instead ran from December to February with a reconnaissance visit conducted by fieldworkers in November.

3.1. Study sites

Figure 1 shows the five sea loughs and bays — Larne Lough, Carlingford Lough, Strangford Lough, Killough Harbour and Dundrum Bay — where licenced oyster-trestle aquaculture takes place in Northern Ireland, and the locations of these activities in these sites relative to WeBS Core Count sectors. Each of these locations was matched with the corresponding WeBS sector(s), to allow future comparisons of trends of waterbird populations (where sufficient data are available) within these from before and after aquaculture was licenced. However, field surveys were only conducted within the defined areas during this study. Four of these sites were surveyed on two days a month between December 2021 and February 2022, but due to poor weather and staff illness only one survey day was completed at Dundrum Bay in February and Larne Lough in January. An additional site at Greencastle in Carlingford Lough was also surveyed by DAERA MFD staff once during December and twice in January, and three times by BTO staff in February. Survey days were broken up into intervals called visits that were normally two hours apart. Table 2 shows the number of days each lough was surveyed and the number of visit intervals during which environmental variables and disturbance events were recorded. Results will be presented for all these sites based on which lough they are in except for Greencastle at Carlingford Lough which will be reported separately under the name Greencastle.

Figure 1. Locations of active* aquaculture licenced areas in NI sea loughs: (a) Larne, (b) Carlingford, (c) Strangford, (d) Killough, (e) Dundrum (aka Murlough). Turquoise highlighted purple polygons are specifically oyster-trestle sites, red polygons are WeBS sectors. *All licenced as of 2019, with the exception of one of the two Strangford areas (Ringneill, the southern of the two), for which the licence was pending in 2019.

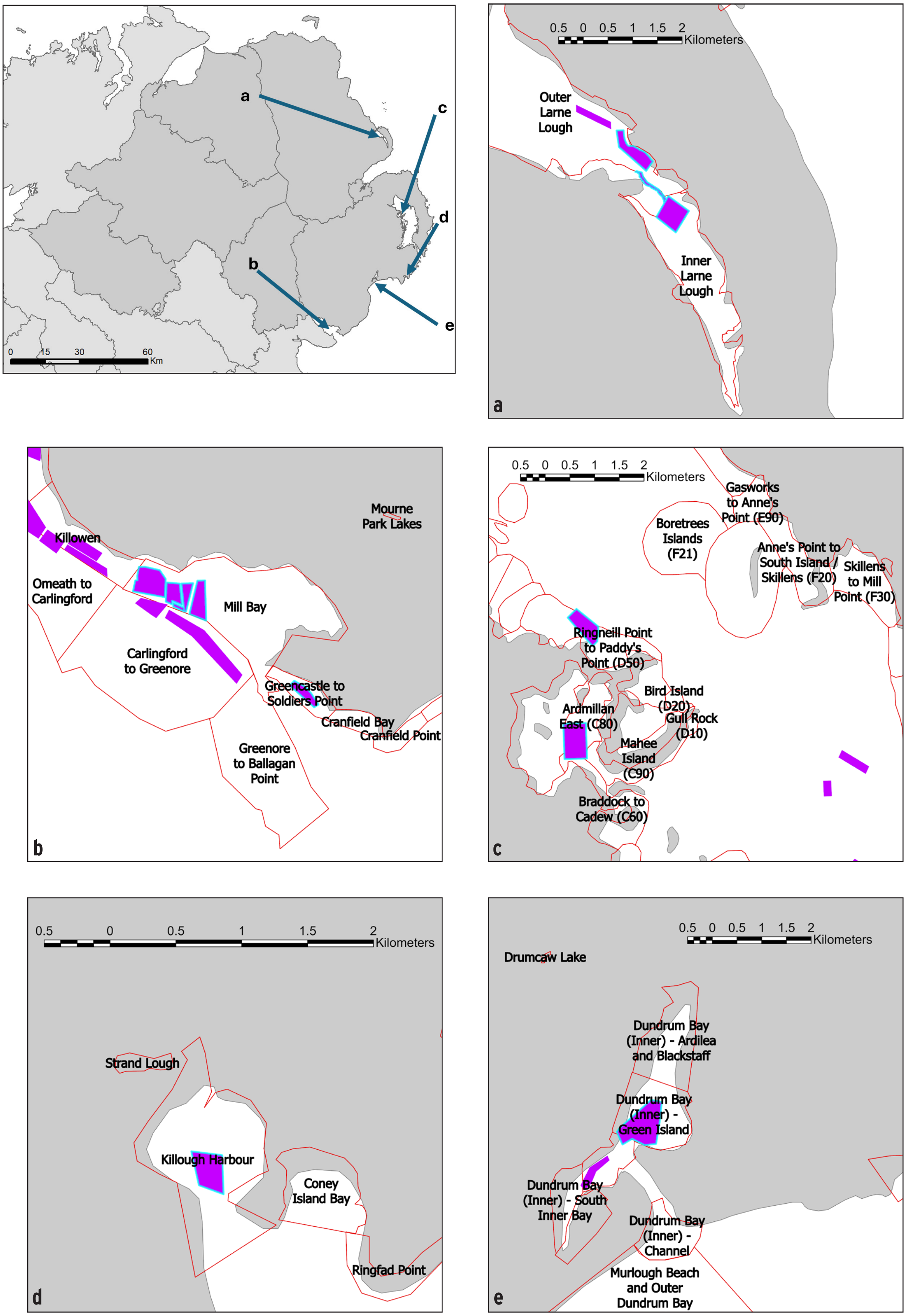


Figure 2. The vantage point location (red pin) for Larne Lough, including the estimated survey area (red box) and the location of active oyster trestles within the survey area (purple box). Map courtesy of the Northern Ireland Marine Mapviewer, DAERA.

Figure 3. The vantage point locations (red pin) for Strangford Lough, including the estimated survey area (red box) and the location of active oyster trestles within the survey area (purple box). Map courtesy of the Northern Ireland Marine Mapviewer, DAERA.

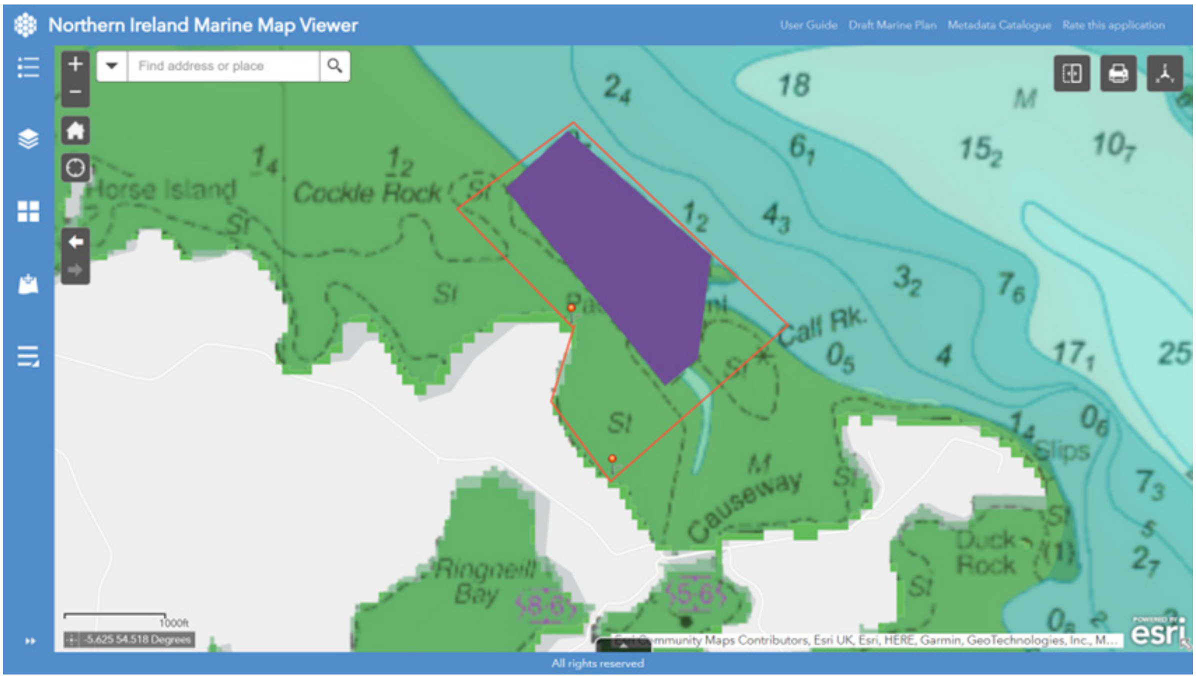


Figure 4. The vantage point location (red pin) for Killough Harbour, including the estimated survey area (red box) and the location of active oyster trestles within the survey area (purple box). Map courtesy of the Northern Ireland Marine Mapviewer, DAERA.

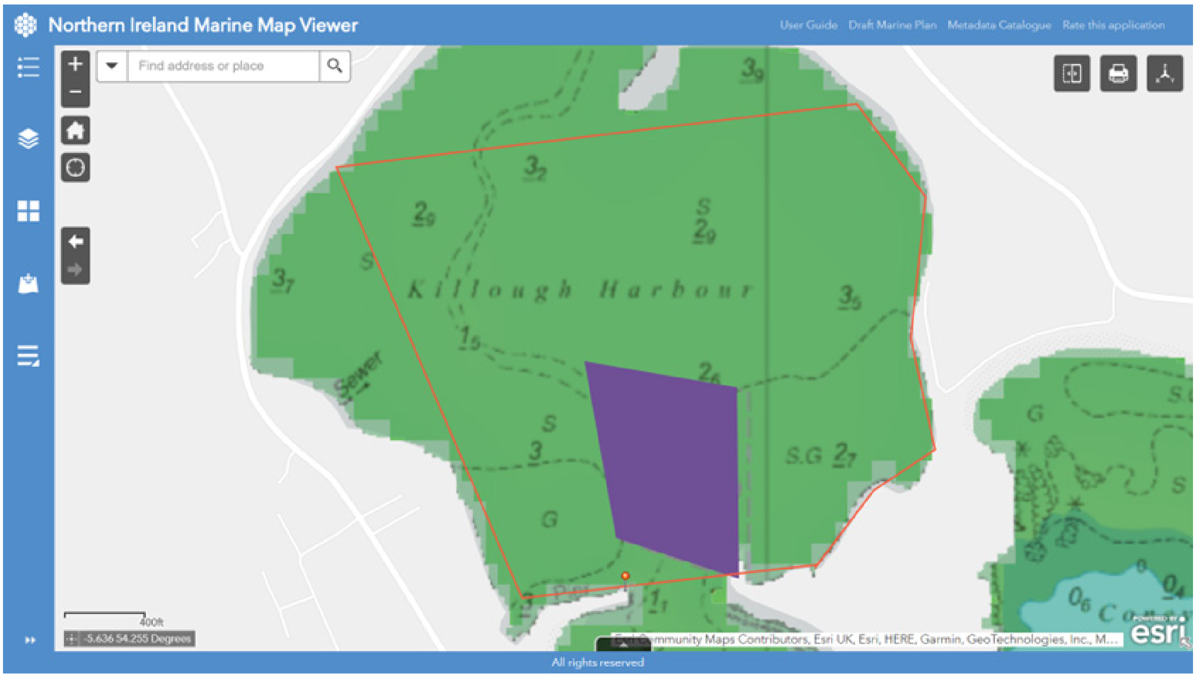


Figure 5. The vantage point location (red pin) for Dundrum Bay, including the estimated survey area (red box) and the location of active oyster trestles within the survey area (purple box). Map courtesy of the Northern Ireland Marine Mapviewer, DAERA.

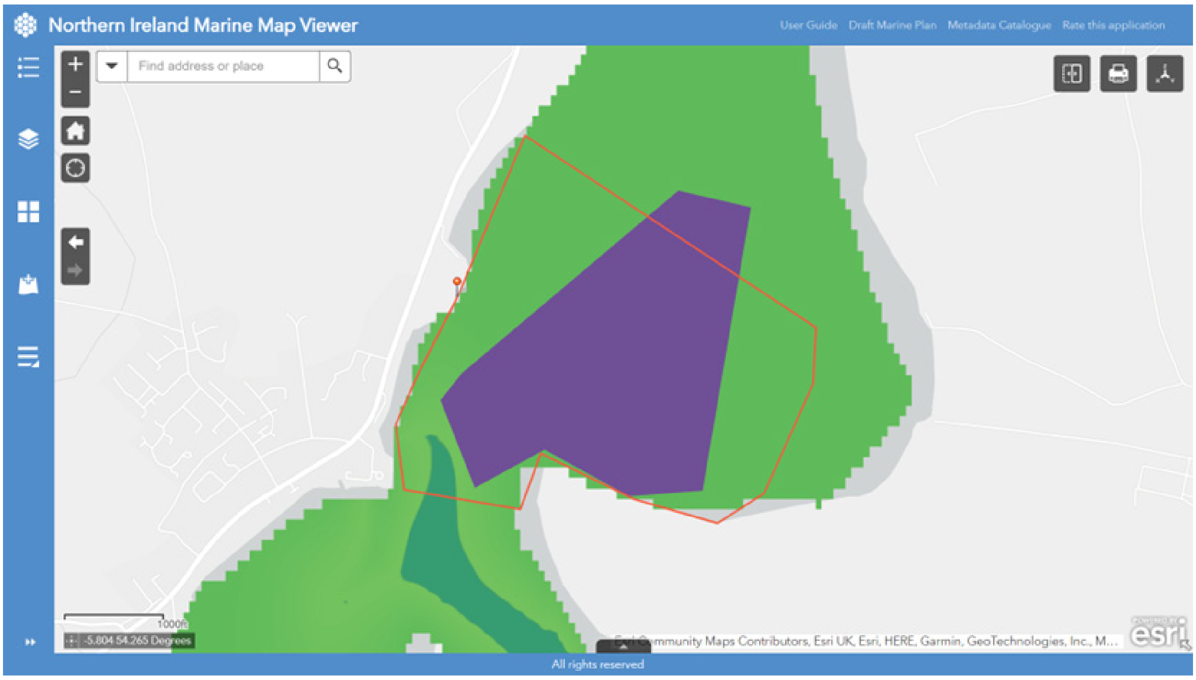


Figure 6. The vantage point location (red pin) for Carlingford Lough (Mill Bay), including the estimated survey area (red box) and the location of active oyster trestles within the survey area (purple box). Map courtesy of the Northern Ireland Marine Mapviewer, DAERA.

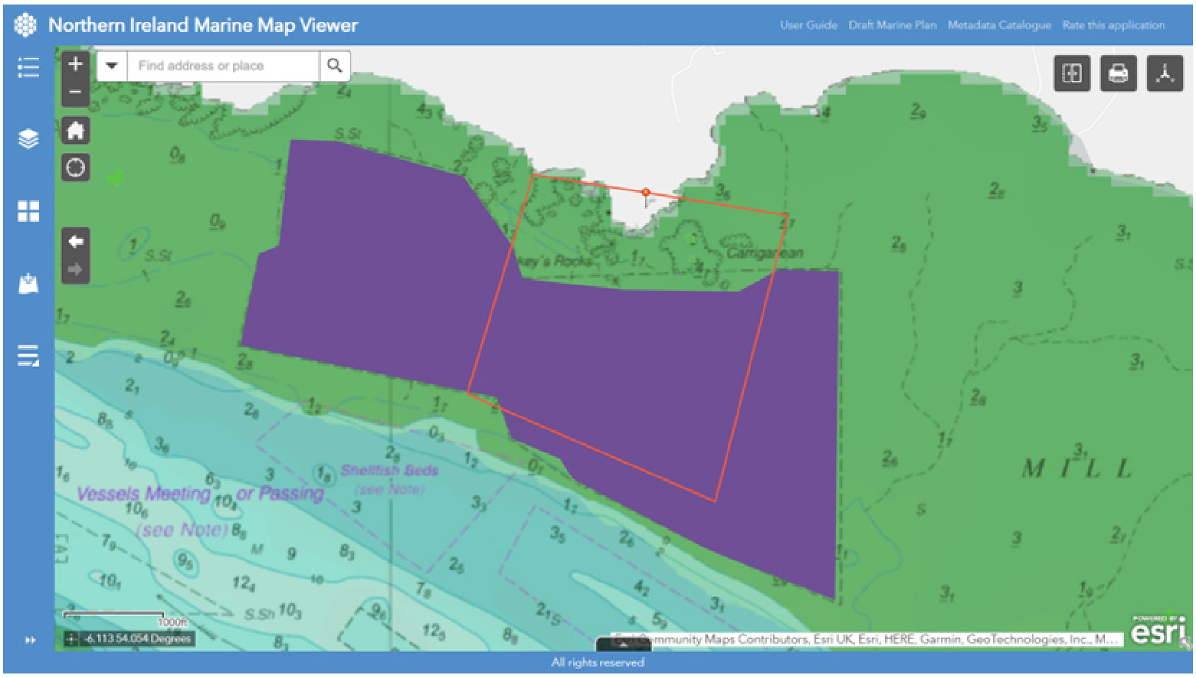


Figure 7. The vantage point location (red pin) for Carlingford Lough (Greencastle), including the estimated survey area (red box) and the location of active oyster trestles within the survey area (purple box). Map courtesy of the Northern Ireland Marine Mapviewer, DAERA.

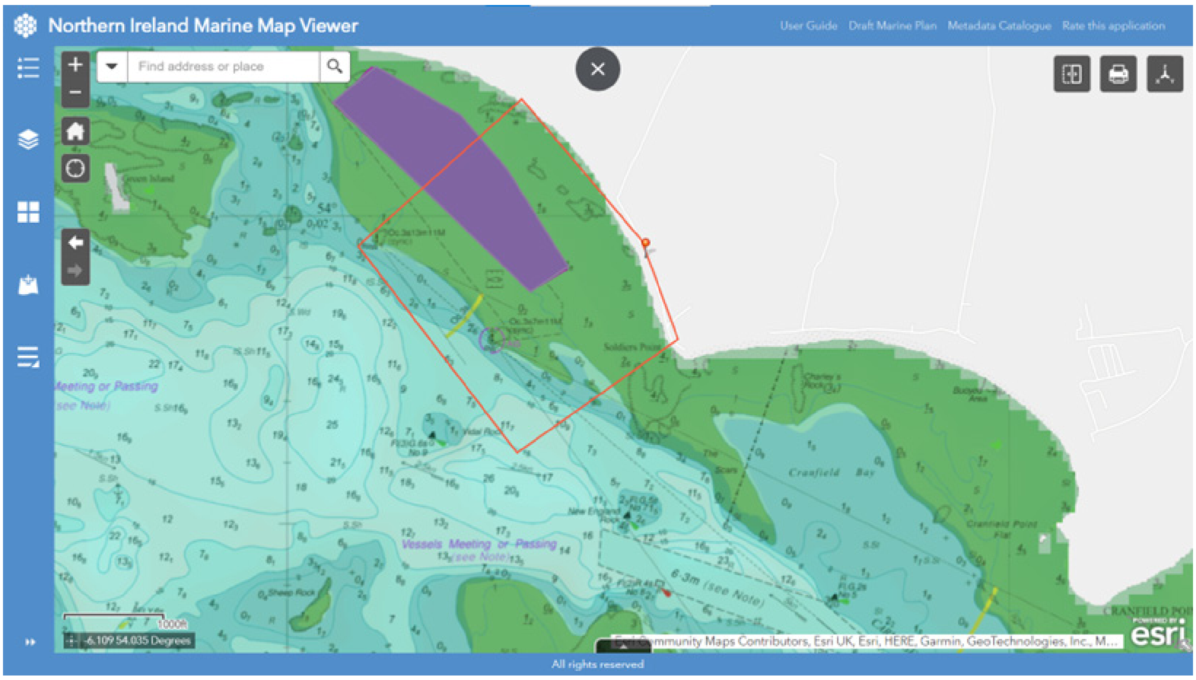


Table 2. Survey effort represented by the number of days the lough was visited and the number of recording intervals at each lough or bay. Site names of the survey areas in loughs are also added in parentheses.

Lough or Bay (Sites of Loughs)	Survey Days	Visit Intervals
Carlingford Lough (Mill Bay and Dickey's Rock)	6	18
Dundrum Bay	7	21
Greencastle	6	12
Killough Harbour	7	21
Larne Lough (Millbay)	5	15
Strangford Lough (Paddy's Point)	6	19

3.2. Bird counts and behaviour

Fieldworkers conducted monthly Through the Tide Counts (TTTCs) from a vantage point, surveying a defined area at intervals across the tidal cycle, followed by a period of disturbance monitoring. The plan was that each site would be visited at least twice a month to cover the six-hour period between each tide, one visit starting at low tide and the other at high tide. Each visit was broken down into three counts and three disturbance monitoring sessions as follows:

Table 3. Breakdown of visit survey sessions.

Hours from low/ high tide	Count
0.0–0.5	**Count 1:** 30 mins (low or high tide)
0.5–1.5	Record marine activity and target species' disturbance activity (60 minutes duration)
1.5–2.0	BREAK
2.0–2.5	**Count 2:** 30 mins (incoming or outgoing tide)
2.5–3.5	Record marine activity and target species' disturbance activity (60 minutes duration)
3.5–4.0	BREAK
4.0–4.5	**Count 3:** 30 mins (low or high tide)
4.5–5.5	Record marine activity and target species' disturbance activity (60 minutes duration)

Due to the short days (particularly in December and January) the number of potential survey days was limited. It was necessary to identify a range of key count dates where a six-hour daylight window was available beginning at a low or high tide. Due to the tidal cycle on the east coast, the lowest spring tides occurred during the hours of darkness or during the afternoon/evening. Therefore, surveys starting on a low tide tended not to take place on the lowest tides. This affected the likelihood of picking up on routine aquaculture activity. The tides at Strangford Lough are approximately two hours later than the rest of the survey sites and so different key count dates were chosen to reflect this.

Ideally, each site would have been visited on one day within the range of dates for the relevant tide. Where the conditions did not allow this (e.g. due to poor weather), the survey was spread across two days (i.e. a two-hour session one day and a four hour another) on consecutive days within the key count dates to fully encompass the tidal period.

The vantage point and the survey area were defined on the first day. Oyster trestles were present on all count sites and informed the area over which the surveys took place. Some locations such as Dundrum and Carlingford Lough had extensive areas of oyster trestles, so a discrete location was chosen based on the distance to the surveyor and the best view over the trestles.

Table 4. Key count dates for Carlingford, Dundrum, Killough, and Larne in the winter of 2021/22.

Month	Tide (at start of survey)	Key count dates
December	Low	Between 9th and 11th or 25th and 27th
	High	Between 1st and 4th or 15th and 18th
January	Low	Between 7th and 9th or 22nd and 25th
	High	1st, or between 13th and 16th or 29th and 31st
February	Low	Between 5th and 8th or 21st and 24th (extended to 25th due to stormy weather)
	High	Between 12th and 15th or 27th and 28th

Table 5. Key count dates for Strangford Lough in the winter of 2021/22.

Month	Tide (at start of survey)	Key count dates
December	Low	Between 7th and 9th or 22th and 24th
	High	1st, or between 13th and 15th or 29th and 31st
January	Low	Between 5th and 7th or 20th and 23rd
	High	Between 12th and 13th or 28th and 31st
February	Low	Between 3rd and 6th or 18th and 22nd
	High	Between 10th and 13th or 26th and 28th

The survey area needed to be sufficiently large to encompass oyster trestle and bird foraging activity but not so large that it was not possible to record disturbance events and their effects accurately using binoculars. The survey areas varied between 250 m and 500 m either side of the vantage point and between 500 m to 1 km in front of the vantage point.

There were three 30-minute bird counts within the survey area per visit (see Table 3). The total number of each waterbird species present within the survey section and the number feeding were counted. Gulls were not counted unless there was sufficient time to do so. There were sufficient gull counts to include in the analysis.

During surveys, fieldworkers were also asked to record environmental conditions that, in addition to tidal state and disturbance, might also affect the number of birds present on survey sites and the accuracy of counts. Wind speed was recorded using the Beaufort Scale, and temperature was recorded in degrees Celsius. Visibility and precipitation were measured in subjective scales from 1 to 3. For visibility, 1 indicated 'Good', 2 indicated 'Moderate', and 3 indicated 'Poor'. For precipitation, 1 indicated 'Good', 2 indicated 'Wet', and 3 indicated 'Very Wet'.

3.3. Monitoring disturbance events

It was not possible to develop a gradient of sites based on prior knowledge of aquaculture operations (e.g. activity patterns), nor a proxy (e.g. tonnage) so instead a simple summary was produced for each survey site of the number of active licenced aquaculture blocks and presence (within 500 m of the survey area boundary) of other sources of potential disturbance. This aimed to provide a baseline to which field-based surveys could be compared. Sources of potential disturbance considered were roads; railway lines; paths; towns/cities; villages/houses; slips/piers; industry (including harbours, power stations and active quarries); caravan parks and accessible sandy beaches. A disturbance event is therefore defined as the time a source for potential disturbance entered the survey area.

Table 6. A desk-based review of the number of active licenced aquaculture blocks and presence of other sources of potential disturbance at each survey site with licenced oyster-trestle aquaculture. *Active licenced aquaculture blocks in 2019, the latest available data at the time of the study.

	Carlingford Lough	Greencastle	Strangford Lough	Larne Lough	Killough Harbour	Dundrum Bay
Roads		X	X	X	X	X
Rail				X		
Path		X	X	X	X	X
Town/city					X	X
Village/houses	X	X	X	X	X	
Slip/pier		X	X	X	X	X
Industry (Power station, harbour, active quarry etc.)						
Caravan Park		X			X	
Sandy beach		X			X	X
No. licenced oyster aquaculture blocks*	4	1	1	2	1	1

Maps were provided along with recording forms. These maps were used to mark where disturbance events occurred within or adjacent to the survey area. Each mapped event was given an identical ID to the subsequent record in the disturbance form i.e. if there were bait diggers on the foreshore and one of them caused a disturbance event, this was marked on the map and disturbance form using the code 1BD to signify the first potential disturbance event caused by a bait digger; if another event occurred this was mapped and recorded as 2BD, then 3BD etc. See Appendix 2.

For some sites it was not possible to reach the vantage point without disturbing some waterbirds, particularly at high tide. Where this was likely, surveyors got into position 15 minutes early to allow birds to resettle. At one site, Strangford Lough, the vantage point area was located near to a roosting site at high tide so the high tide count for this location was moved to an area with a similar view away from the roost (Figure 3).

Five categories of disturbance responses were defined. From highest to lowest, they were 'Long flight', 'Short flight', 'Walking/swimming/diving away', 'Being alert', and 'No response'. The highest category of response for each species was recorded following a disturbance event and the distance to the furthest bird of each species affected also recorded using distance bands, if possible. For a full description of the methodology and the disturbance monitoring form see Appendix 2.

A descriptive analysis of the data was carried out. The cumulative number of each species present at each survey area per visit interval was calculated. This sum was then used to produce an average number for each species present, feeding, and disturbed. It was also used to and assess how those numbers changed when grouped by different variables. It should be noted that the total number of birds disturbed represents a cumulative total and could exceed the total number of birds recorded, if individual birds were repeatedly disturbed. To assess disturbance levels, three sums were calculated per visit interval: the number of disturbance events, the duration of disturbance events, and the number of individual birds disturbed. A disturbance index was calculated by multiplying the cumulative duration of disturbance events by the frequency of disturbance events based on different variable groupings. An average number of individual birds disturbed was also calculated and was grouped by different variables.

4. Results

Survey visits recorded a total of 42 species, excluding unidentifiable birds. The numbers of birds disturbed during the surveys were also summarised by species, and 18 species were disturbed during the survey period. The foraging guild with the highest number of individual birds present and disturbed was benthivores. Table 7 shows the species recorded and their corresponding number of records and foraging guild.

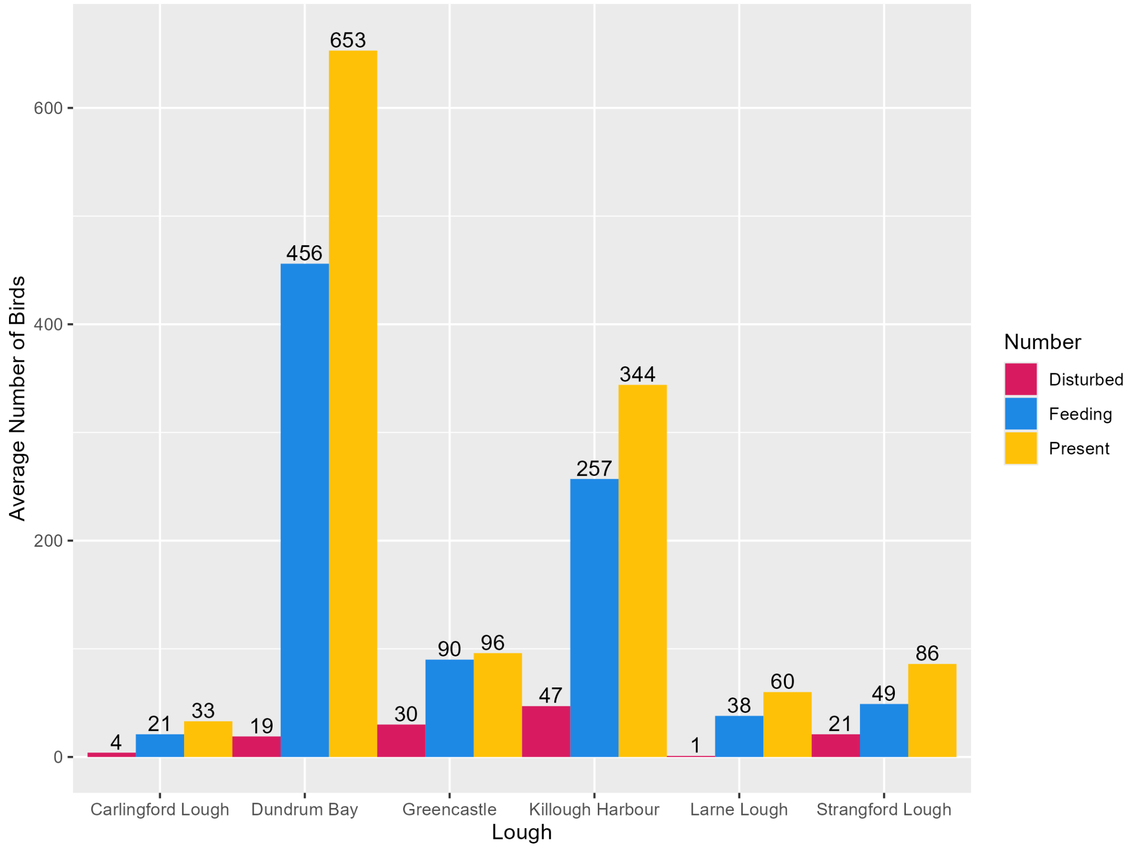
Table 7. Bird species recorded during count sessions, the number of times they were recorded and their foraging guild. The number in parentheses shows the total records of each guild in the count sessions. Species are listed from most to least recorded by guild. Species affected by disturbance are highlighted in yellow.

Species	Number of records	Guild (Total records)
Oystercatcher	81	Benthivores (432)
Redshank	75	
Curlew	66	
Turnstone	45	
Greenshank	33	
Dunlin	28	
Shelduck	28	
Knot	16	
Ringed Plover	16	
Black-tailed Godwit	9	
Eider	9	
Lapwing	8	
Golden Plover	7	
Sanderling	5	
Whimbrel	5	
Bar-tailed Godwit	1	
Light-bellied Brent Goose	54	Herbivores (70)
Wigeon	16	
Black-headed Gull	17	Omnivores (108)
Teal	16	
Herring Gull	14	
Common Gull	12	
Mallard	11	
Hooded Crow	9	
Goldeneye	8	
Great Black-backed Gull	5	
Lesser Black-backed Gull	5	
Rook	4	
Tufted Duck	4	
Jackdaw	2	
Magpie	1	

Grey Heron	44	Piscivores (176)
Cormorant	31	
Red-breasted Merganser	31	
Goosander	1	
Great Crested Grebe	19	
Little Egret	16	
Little Grebe	13	
Shag	11	
Red-throated Diver	9	
Slavonian Grebe	1	

4.1. Number of birds

Figure 8. The average number of birds present, feeding, and disturbed at each study site.



Among the six sites, Dundrum Bay had the highest average number of birds present across survey days, followed by Killough Harbour, Greencastle, Strangford Lough, Larne Lough, and Carlingford Lough respectively. The average number of feeding birds follows the same pattern. Killough Harbour had the highest average number of birds disturbed across survey days followed by Greencastle, Strangford Lough, Dundrum Bay, Carlingford Lough, and Larne Lough respectively. Only one disturbance event was recorded at Larne Lough, and it affected one Shag.

Figure 9. The average number of birds present in each foraging guild at each study site.

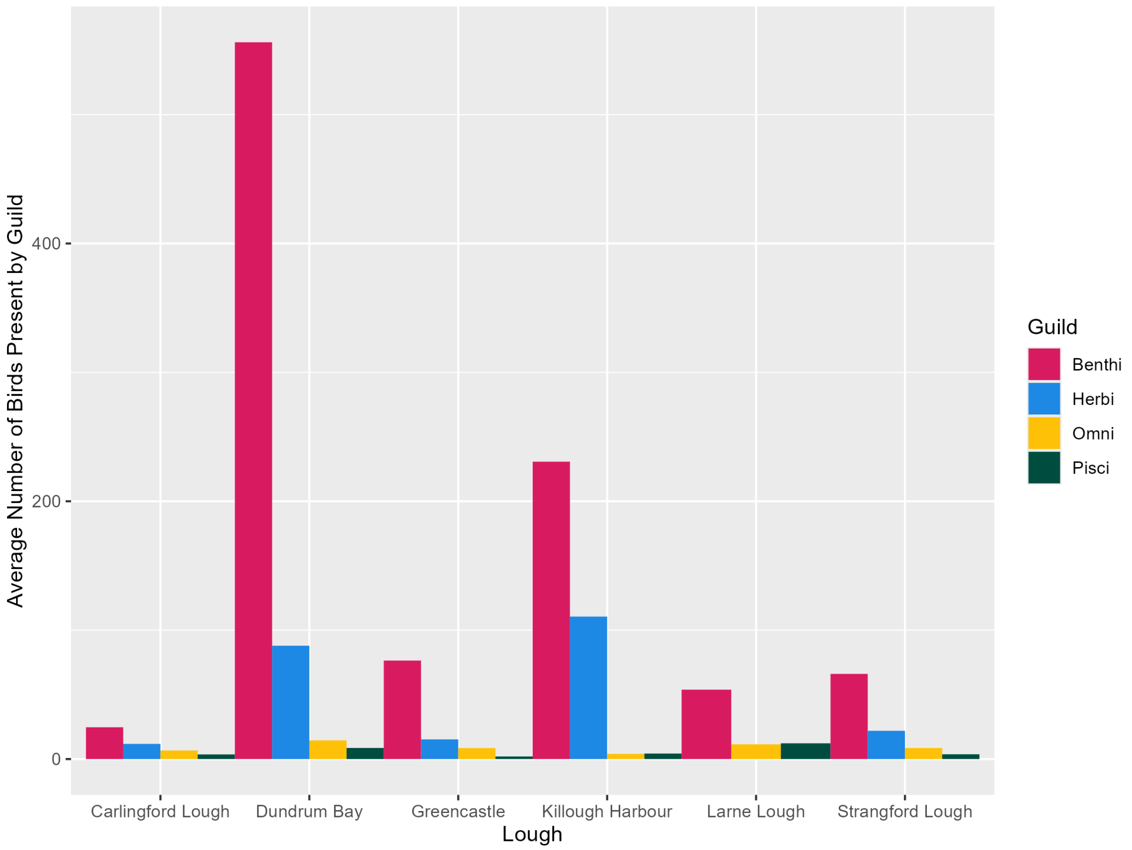
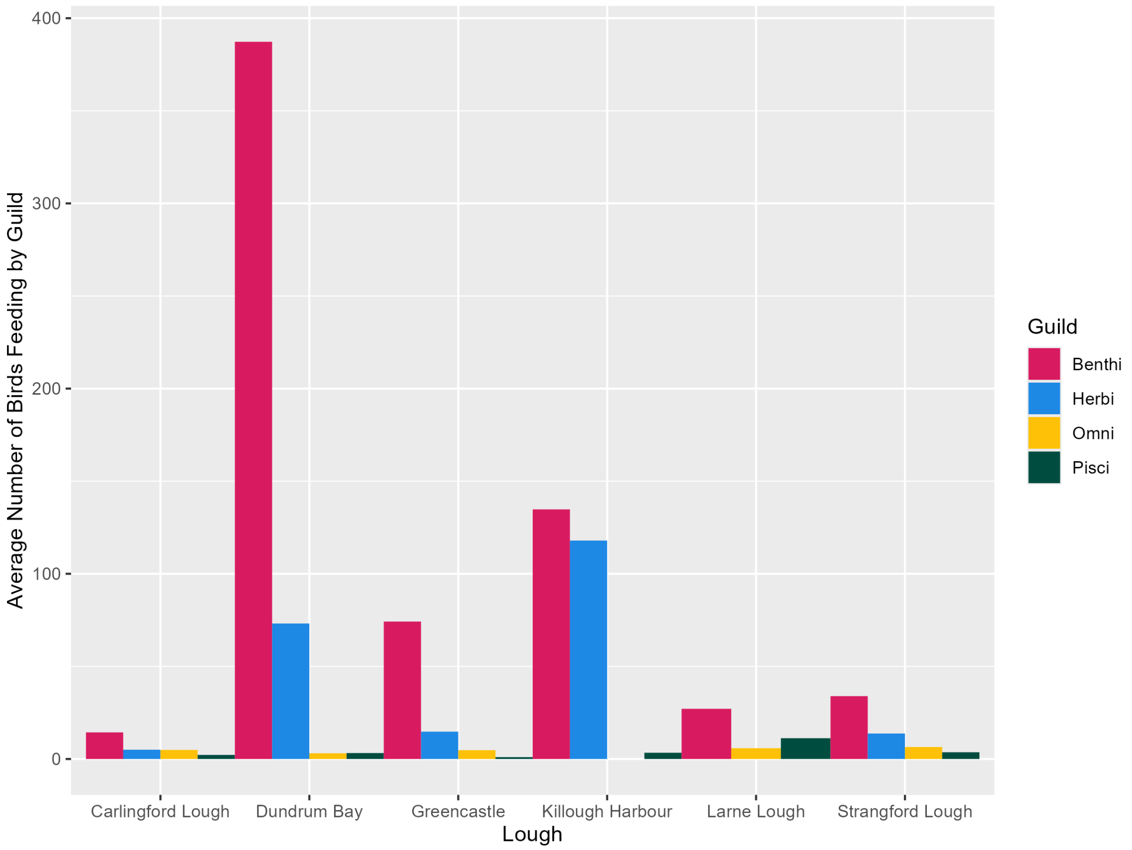
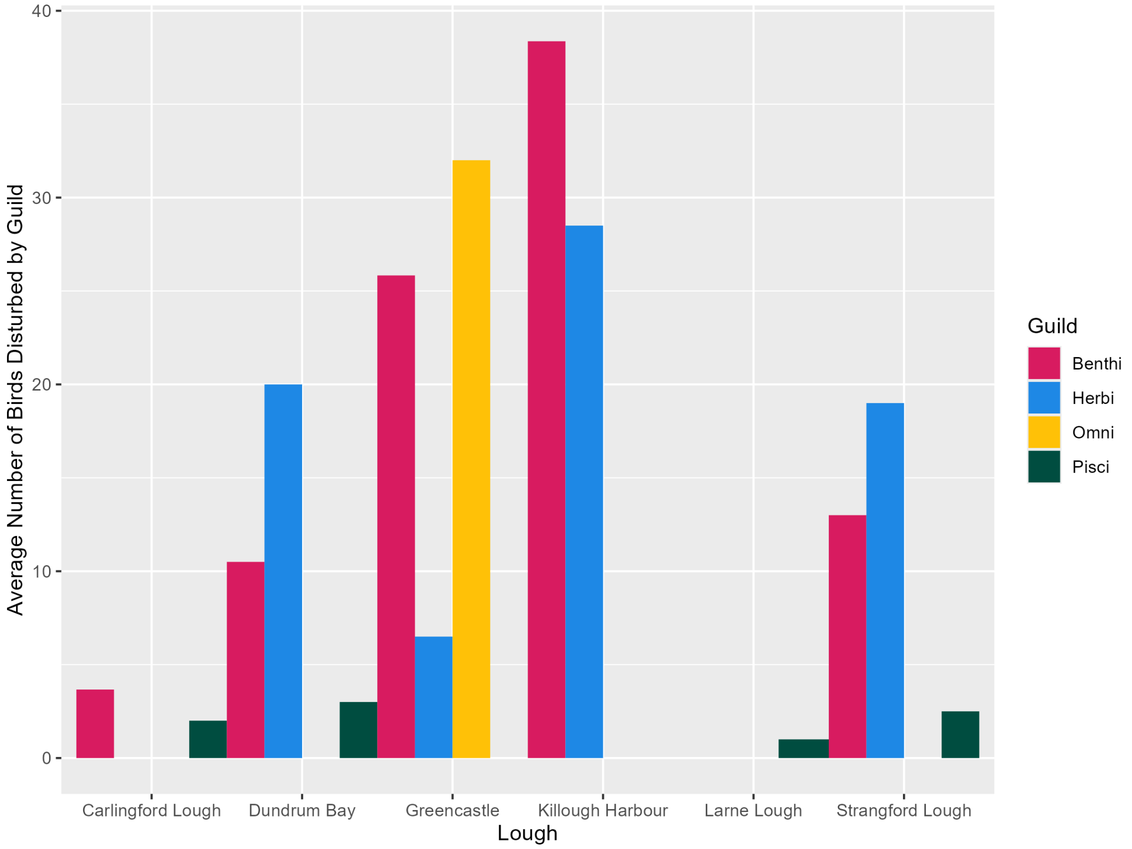


Figure 10. The average number of birds feeding in each foraging guild at each site.



Benthivores were the foraging guild with the highest average number of birds present and feeding across sites and survey days. Herbivores were second highest though there were none at Larne Lough. The average number of omnivores and piscivores were highest at Dundrum Bay and Larne Lough respectively although there was an average number of less than 15 birds at any site.

Figure 11. The average number of birds disturbed in each foraging guild at each study site.



Benthivores were the foraging guild with the highest number of birds disturbed at survey sites in Killough Harbour and Carlingford Lough. At Dundrum Bay and Strangford Lough sites, the highest average number of birds disturbed were herbivores, and at Greencastle, they were omnivores. Piscivores were the foraging guild with the lowest average number of birds disturbed across sites but were the only foraging guild disturbed at the Larne Lough site.

Table 8. The three species with the highest average number present, feeding, and disturbed at each survey site with their average numbers in parentheses.

	Carlingford Lough	**Dundrum Bay**	**Greencastle**	**Killough Harbour**	**Larne Lough**	**Strangford Lough**
Highest present	Black-tailed Godwit (17)	Oystercatcher (318)	Curlew (140)	Golden Plover (279)	Shelduck (65)	Knot (36)
Second highest present	Bar-tailed Godwit (15)	Knot (250)	Dunlin (25)	Light-bellied Brent Goose (85)	Goldeneye (13)	Oystercatcher (29)
Third highest present	Lapwing (14)	Light-bellied Brent Goose (88)	Ringed Plover (21)	Lapwing (52)	Teal (8)	Golden Plover (25)
Highest feeding	Black-tailed Godwit (12)	Oystercatcher (280)	Curlew (140)	Light-bellied Brent Goose (90)	Shelduck (31)	Oystercatcher (20)
Second highest feeding	Teal (6)	Light-bellied Brent Goose (73)	Dunlin (25)	Redshank (37)	Goldeneye (6)	Light-bellied Brent Goose (14)

Third highest feeding	Oystercatcher (5)	Knot (72)	Ringed Plover (21)	Wigeon (32)	Teal (6)	Redshank (10)
Highest disturbed	Oystercatcher (3)	Light-bellied Brent Goose (20)	Black-headed Gull (31)	Lapwing (90)	Shag (1)	Light-bellied Brent Goose (19)
Second highest disturbed	Greenshank (2)	Oystercatcher (12)	Dunlin (29)	Light-bellied Brent Goose (27)	-	Oystercatcher (10)
Third highest disturbed	Grey Heron (2)	Goosander (5)	Ringed Plover (25)	Dunlin (25)	-	Redshank (5)

WeBS trend analysis for Carlingford Lough (Booth Jones et al. 2019) showed decreases in numbers of Shelduck, intertidal waders, and diving waterbird populations between 2000/01 and 2015/16. Great Crested Grebe and Goldeneye especially decreased significantly. On the other hand, numbers of four waders – Golden Plover, Lapwing, Knot, and Black-Tailed Godwit – have increased. There are four active oyster-trestle aquaculture sites in Mill Bay. At a sector-level, Light-bellied Brent Goose, Grey Plover, Lapwing, Turnstone, and Curlew numbers have remained stable at Mill Bay despite showing increases over the lough as a whole. On the other hand, Shelduck and Dunlin populations have decreased over the lough as a whole but remained stable in Mill Bay. Redshank and Oystercatcher populations have increased at Mill Bay despite remaining stable on the lough. No waterbird populations were observed to have decreased at Mill Bay between 2001/02 and 2016/17; however, there were insufficient data to produce trends for 14 species (Booth Jones et al. 2019).

WeBS trend analysis for Dundrum Bay (Booth Jones et al. 2023) showed increases in numbers of Black-tailed Godwit, Light-Bellied Brent Goose, Wigeon, Mallard and Teal, stable numbers of Dunlin and Oystercatcher populations, and decreases in numbers of Shelduck, Ringed Plover, Golden Plover, Grey Plover, Lapwing, Knot, Turnstone and Curlew between 2000/01 and 2015/16. It is possible that Dunlin, Oystercatcher, Curlew and Knot numbers are affected by factors local to Dundrum Bay rather than regional factors affecting the whole of Northern Ireland (Booth Jones et al. 2023).

Despite Greencastle being a part of Carlingford Lough, its WeBS Core Count sector falls under the larger South Down Coast. A sector-level analysis of the South Down Coast has not been undertaken; however, it is recommended that this is done in the future as it recorded the second highest average number of birds disturbed.

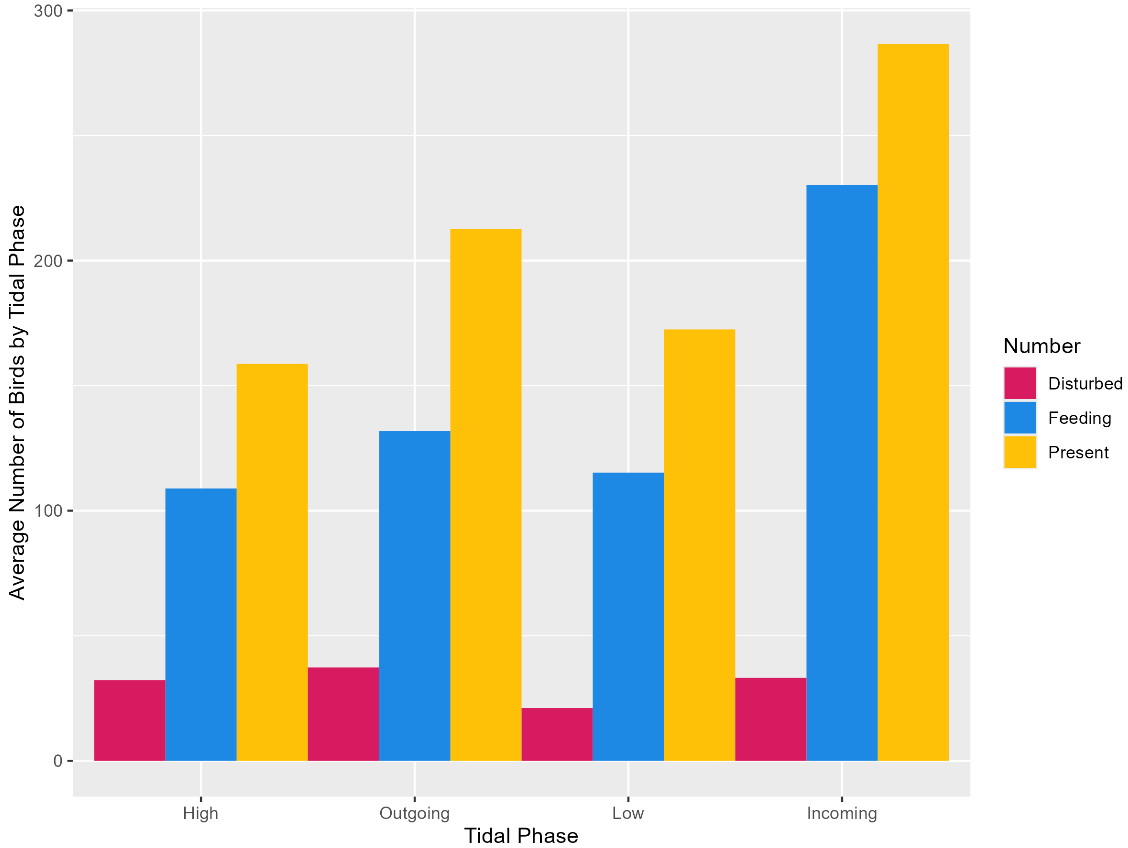
WeBS trend analysis for Killough Harbour (Booth Jones et al. 2023) showed increases in the numbers of Lapwing, Curlew, Redshank (Figures 8a, b, and c), Teal and Wigeon (Figures 9a and b) between 2000/01 and 2015/16, which suggests that conditions around the lough are favourable for these species. In contrast, numbers of Golden Plover and Dunlin showed declines over the 15 years between 2000/01 and 2015/16. Numbers of Oystercatcher in Killough Harbour remained stable over the 2000/01 to 2015/16 period (Booth Jones et al. 2023).

WeBS trend analysis for Larne Lough showed that numbers of Light-Bellied Brent Goose, waders, Goldeneye, Great Crested Grebe and Shelduck decreased between 2001/02 and 2016/17, that numbers of Teal and Eider increased, while numbers of Mallard, Wigeon and Red-Breasted Merganser remained stable (Booth Jones et al. 2023). Sector-level trends showed an increase in Redshank and Light-Bellied Brent Goose populations in Outer Larne Lough where the active oyster cultivation site is situated. There was also a slight decrease in Oystercatcher, Lapwing, Turnstone and Curlew populations in Outer Larne Lough. However, numbers of all the species showing decreases were low (Booth Jones et al. 2023).

WeBS trend analysis for Strangford Lough (Booth Jones et al. 2019) showed declines in the numbers of Shelduck, Turnstone, Great Crested Grebe and Goldeneye, increases in the numbers of Teal and Eider, but stable numbers of Mallard, Wigeon and Red-Breasted Merganser between 2000/01 and 2015/16. In areas with active oyster cultivation, numbers of Oystercatcher, Knot and Curlew showed negative trends, whereas numbers of Lapwing and Light-Bellied Brent Goose showed positive trends. Despite these trends, it is worth noting that the timing of negative trends contrasted with the timing of an increase in oyster cultivation activity, suggesting that it is unlikely that the changes in birds' numbers were directly linked to the aquaculture activity (Booth Jones et al. 2019). Redshank numbers remained stable in the two sectors with active oyster cultivation, suggesting that the aquaculture disturbance events did not significantly impact their distribution.

4.2. Environmental variables vs. number of birds

Figure 12. The average number of birds present, feeding, and disturbed during each tidal phase.



The average number of birds present, and feeding, was highest during incoming tide followed by outgoing tide, low tide, and high tide. The average number of disturbed birds was lowest at low tide, followed by high tide, incoming tide, and outgoing tide respectively.

More birds were feeding on wet survey days than dry survey days, but the average number of birds present and disturbed was higher on dry survey days. Fewer than 20 birds were present or feeding on very wet days and no disturbance events were recorded. There was a higher average number of birds present, feeding, and disturbed during visits with good visibility than moderate visibility. The average number of birds present and feeding per survey day fluctuated between high and low as wind speed increased. Specifically, the highest average number of birds present, and feeding, was recorded when wind speed was recorded as one, then two, four, three, and five respectively on the Beaufort Scale. On the other hand, the average number of birds disturbed was highest at wind speed two, then four, five, one, and three respectively. Similarly, the change in average number of birds did not consistently increase or decrease with the recorded temperature. There were also differences between the temperatures at which the average number of birds present were highest and those at which the average number of birds feeding or disturbed were highest.

Figure 13. The average number of birds present, feeding, and disturbed during good, wet, and very wet days.

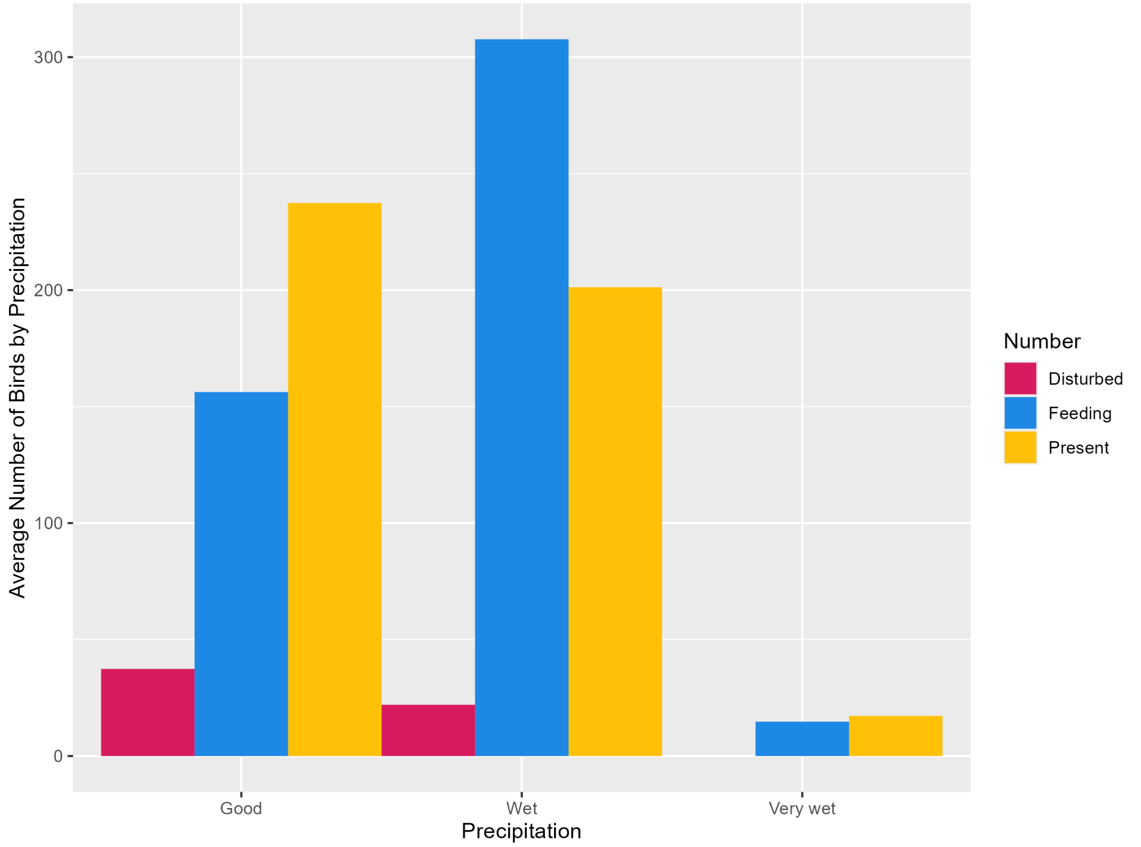


Figure 14. The average number of birds present, feeding, and disturbed during good and moderate visibility.

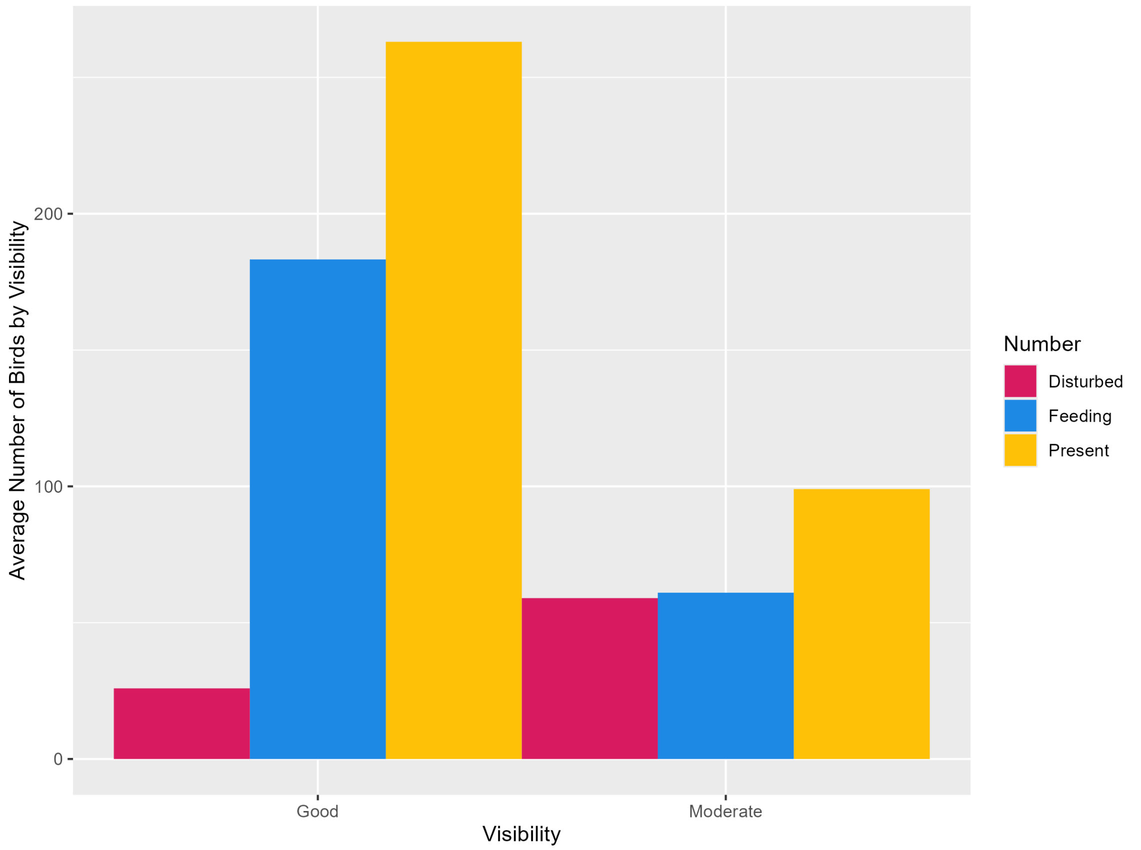


Figure 15. The average number of birds present, feeding, and disturbed at different wind speeds on the Beaufort Scale.

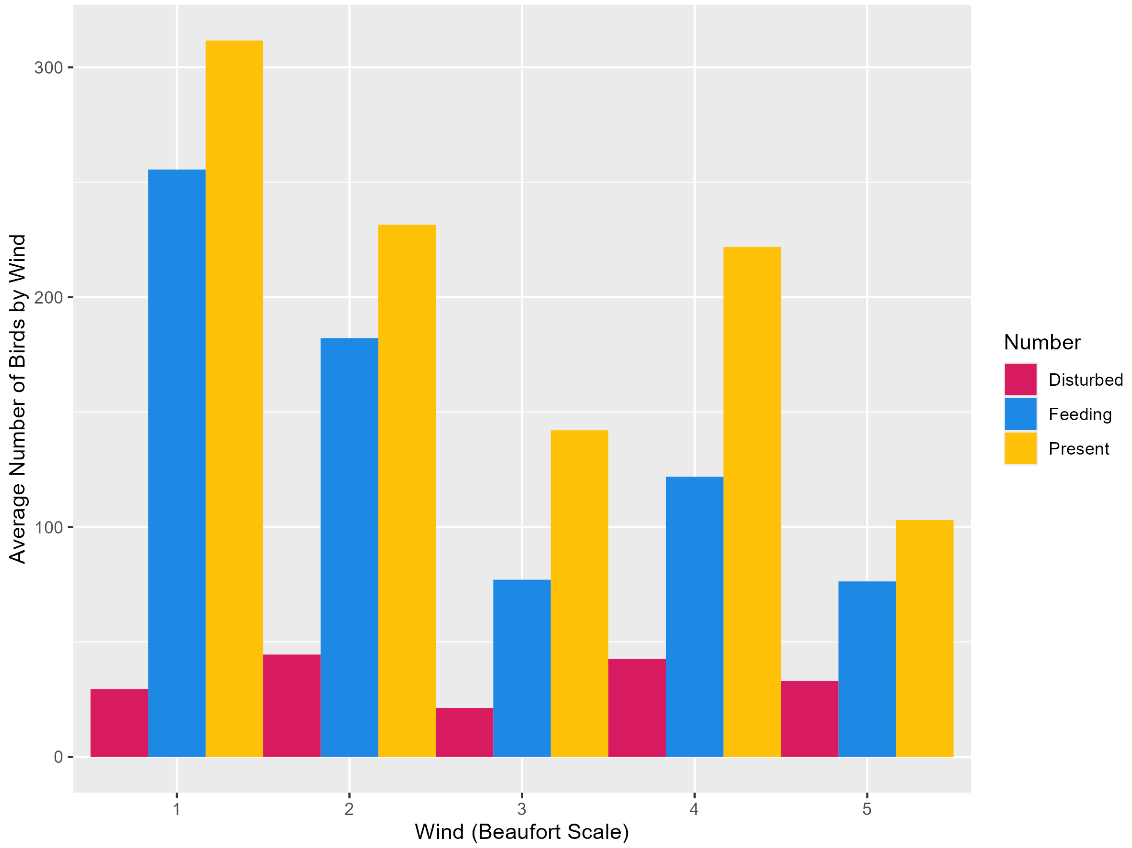
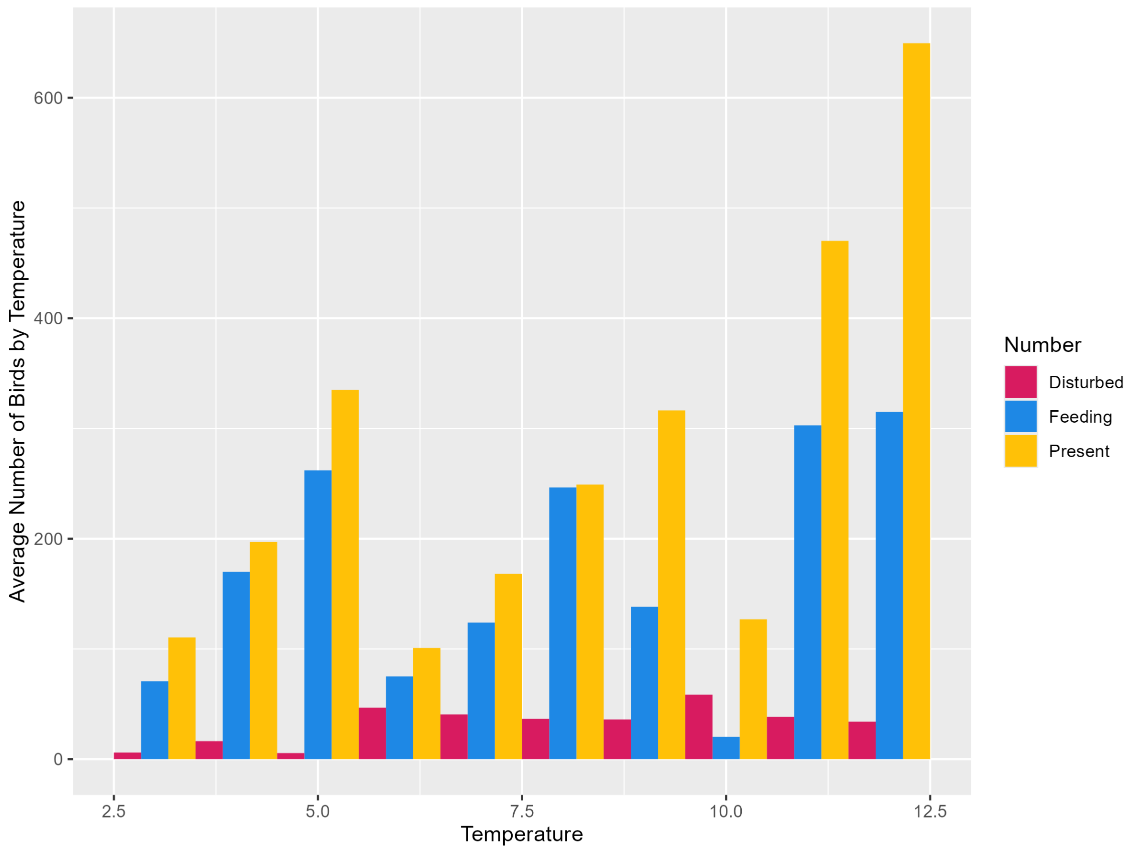


Figure 16. The average number of birds present, feeding, and disturbed at different temperatures.



4.3. Disturbance levels

The following information was sourced from a combination of observations from fieldworkers, desk-based research, interactions with aquaculture workers and discussion with an operator. Although not exhaustive it provides an indication of the amount of activity associated with oyster-trestle aquaculture.

Based on fieldwork, activity varies between sites, but it is reliant on suitably low tides. According to an operator of an aquaculture business in Carlingford Lough they would have workers on site approximately 10 to 12 times a month for a period of two to four hours whenever the tides allowed. They used the tidal times for Liverpool to plan their work year and, except for exceptionally bad weather or strong onshore winds causing the low tide to be higher than expected, they would be on site. The trestles in the location where they worked were often inaccessible during neap tides so the necessity to be on site whenever possible was probably more urgent than for a site like Dundrum where the trestles were more often exposed. Operators also sometimes visit trestles during the hours of darkness using high powered lights on tractors. Generally, in areas with nearby houses, it is likely that times will be chosen that cause the least amount of disturbance (i.e. 4 p.m. instead of 4 a.m.). The amount of activity within an area of active trestles will largely depend on the size of the operation and the number of operators within the same site, e.g. Mill Bay in Carlingford currently has four licenced trestle plots, if each of those has one to three tractors on site that would result in up to 12 tractors and associated workers using the area for a period of two to four hours.

Activity around oyster trestles generally involves one to three tractors with two to eight workers slowly moving up and down the lanes between trestles. Following the initial disturbance upon arrival of the workers and tractors, any disturbed birds tend to resettle or move away except for gulls which are more likely to fly in and out of the area and land nearby. There were times where workers may be up to 300 m from the tractors but still largely concentrated within the same area of trestles.

Figure 17. The average disturbance index at each study site.

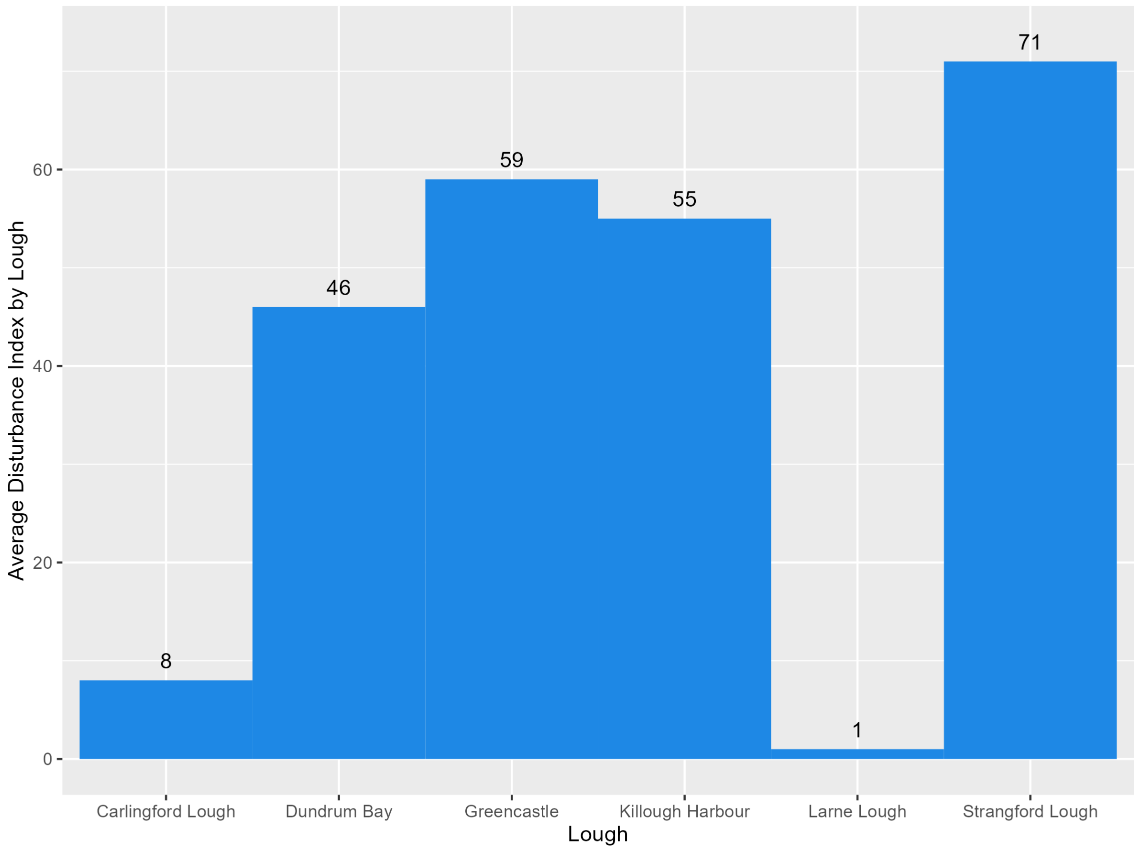
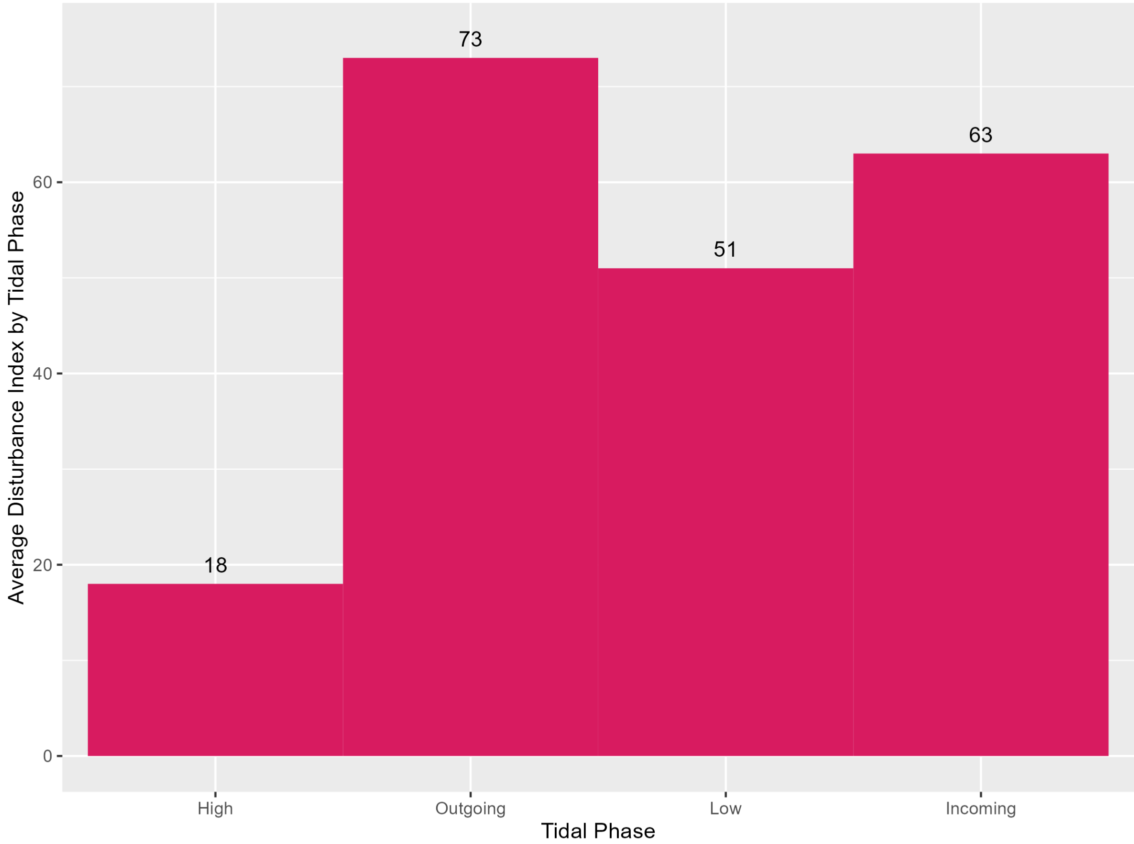


Figure 18. The average disturbance index at each tidal phase.



The average disturbance index per survey day was highest at the sites at Strangford Lough, followed by Greencastle, Killough Harbour, Dundrum Bay, Carlingford Lough and Larne Lough. Between tidal phases, outgoing tide had the highest average disturbance index followed by incoming tide, low tide, and high tide.

Figure 19. The average disturbance index of aquaculture-related activities versus non-aquaculture related activities at each study site.

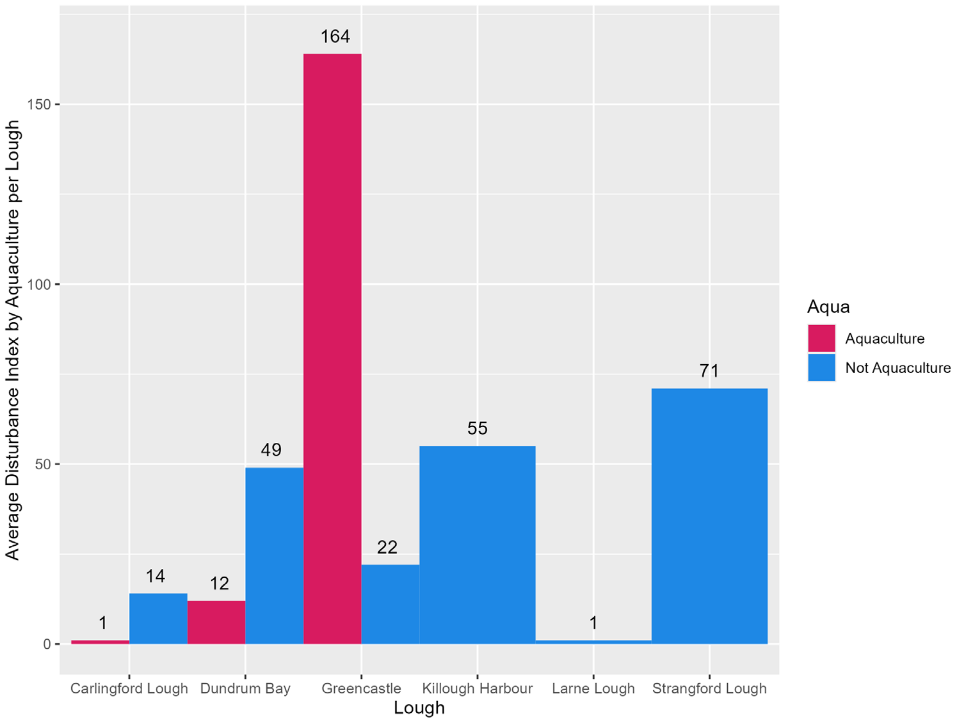


Figure 20. The average disturbance index of each disturbance groups at each study site.

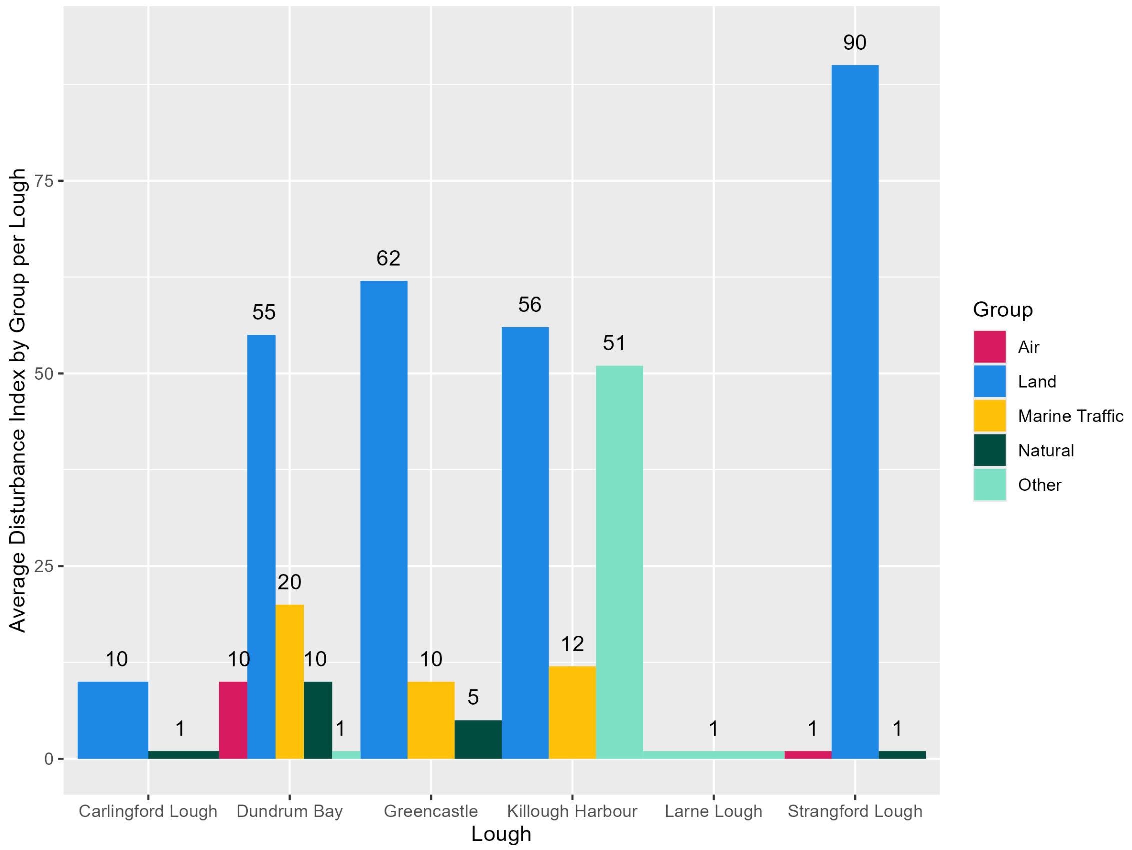
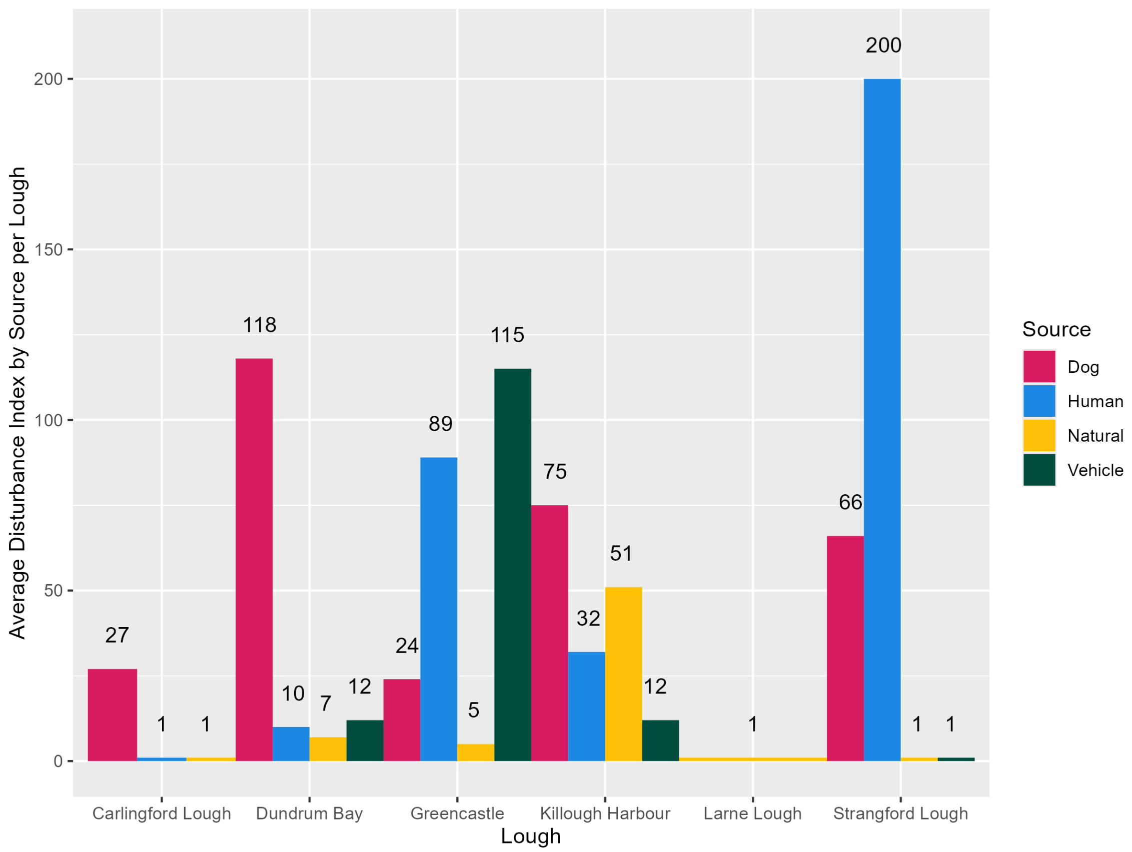


Figure 21. The average disturbance index of each source of disturbance at each study site.



Greencastle had the highest average disturbance index caused by aquaculture-related activities among all sites. At all other sites, the average disturbance index caused by aquaculture-related activities was less than that caused by non-aquaculture-related activities. Larne Lough, Killough Harbour, and Strangford Lough sites did not have any aquaculture-related disturbance events recorded which is likely due to the lack of coordination of survey dates with aquaculture workers. The overall average disturbance index was 125 for aquaculture-related events and 49 for non-aquaculture-related events.

Across all sites except Larne Lough, the average disturbance index caused by land-based events was higher than any other group. The Larne Lough disturbance event was a large flock of Teal flying overhead which caused the Shag to take flight. At Dundrum Bay, no notes were taken about the 'Other' disturbance event and for Killough Harbour, the 'Other' events that had notes were either cyclists or horse-riders. Of the three types of aquaculture-related disturbance ('Shellfish boat', 'Shellfishers/oyster-trestle workers', and 'Shellfish tractors'), two were in the 'Land' group and one in the 'Marine Traffic' group. No 'Shellfish boat' disturbance events were recorded at any sites. All 'Marine Traffic' events involved either powered or other boats. 'Air' events included a helicopter flying over Dundrum Bay and multiple aeroplanes flying over Strangford Lough. 'Natural disturbance' events were all caused by predators or competitors including Sparrowhawks, Buzzards, Peregrines and Common Gulls. The overall average disturbance index was highest for 'Land,' 'Other', 'Marine Traffic', 'Natural', then 'Air' respectively. The source of disturbance events with the highest average index at Carlingford Lough, Killough Harbour, and Dundrum Bay is dogs, at Strangford Lough it is humans, and at Greencastle it is vehicles. Disturbance events classified as 'Other' were assumed to be natural, which is why Larne Lough and Killough Harbour show the same average disturbance index caused by natural sources as that caused by 'Other' in the grouping graph. Of the 14 disturbance events caused by vehicles at Greencastle, 12 were caused by shellfish tractors, one by a car, and one by a powered boat. Of the 203 disturbance events caused by dogs across all sites, 144 were by dogs off leads and 59 were by dogs on leads. The overall average disturbance index was highest for events caused by dogs, then vehicles, humans, and finally natural sources.

Figure 22. The average number of birds disturbed and disturbance events which elicited each response type.

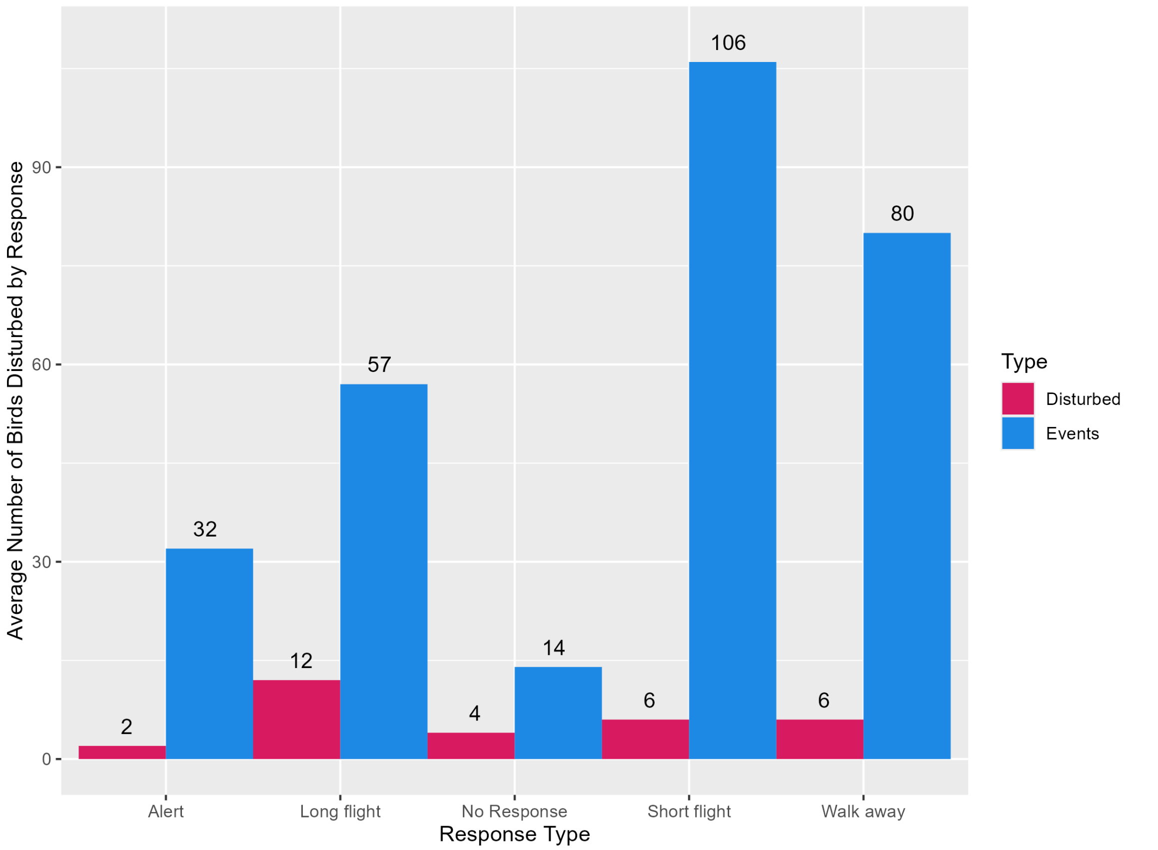
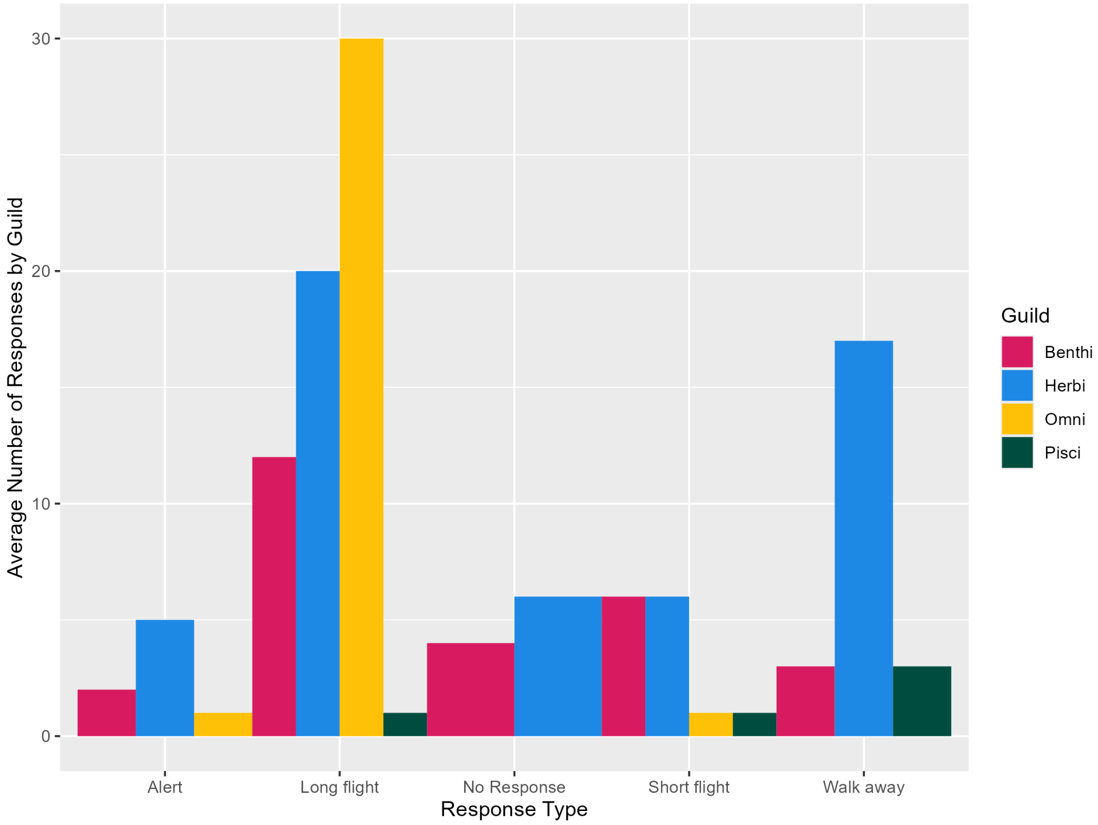


Figure 23. The average number of each response type by foraging guild.



4.4. Response to disturbance

Five response types were recorded: 'Long flight', 'Short flight', 'Alertness', 'Walking away', and 'No response'. The sum of events that elicited each response type is presented in blue in Figure 24 and the bars in red represent the average number of birds disturbed within each response type. Overall, the highest average number of birds disturbed responded with a long flight, followed by a short flight and walking away, then no response, then alertness. 106 events elicited short flight responses, followed by 80 events for walking away, 57 for long flights, 32 for alertness, and 14 showing no response. When looking at the response types of the average number of birds disturbed by foraging guild, all guilds had the highest average number of birds respond with long flights, with omnivores having the highest average, followed by herbivores, benthivores, and piscivores. Benthivores then preferred short flights, no response, walking away, and alertness respectively. On the other hand, herbivores responded most with long flights, then walking away, short flights, no response, and alertness respectively. On average, three piscivores walked away from a disturbance event, and only one each responded with a long flight and a short flight. One omnivore each responded with a long flight and a short flight respectively.

The average number of birds disturbed that responded with long flight was highest at Killough Harbour, then Greencastle, Dundrum Bay, Strangford Lough, Carlingford Lough, and Larne Lough respectively. For short flights, the highest average number of birds disturbed was at Killough Harbour, then Dundrum Bay and Strangford Lough, Greencastle, and Carlingford Lough respectively. For walking away, the highest average number of birds disturbed was Strangford Lough, then Dundrum Bay, Killough Harbour, and Greencastle. Finally for alertness, Dundrum Bay had the highest average number of birds disturbed, then Greencastle, Killough Harbour, and Carlingford Lough. Only Greencastle had birds that showed no response. The average number of birds disturbed which responded with a long flight was higher than those that responded in any other way throughout the tidal phases. Specifically, more birds at high tide responded with a long flight than birds at outgoing tide, incoming tide, and low tide respectively. The same pattern was also true for birds that responded by walking away. More birds responded with a short flight during incoming tide than low tide, outgoing tide, and high tide respectively. An equal average number of birds responded with alertness during incoming as outgoing tide and during low tide as high tide. Birds only gave no response during disturbance events at incoming tide and low tide, with the average being six times higher during incoming tide than low tide.

Figure 24. The average number of each response type at each study site.

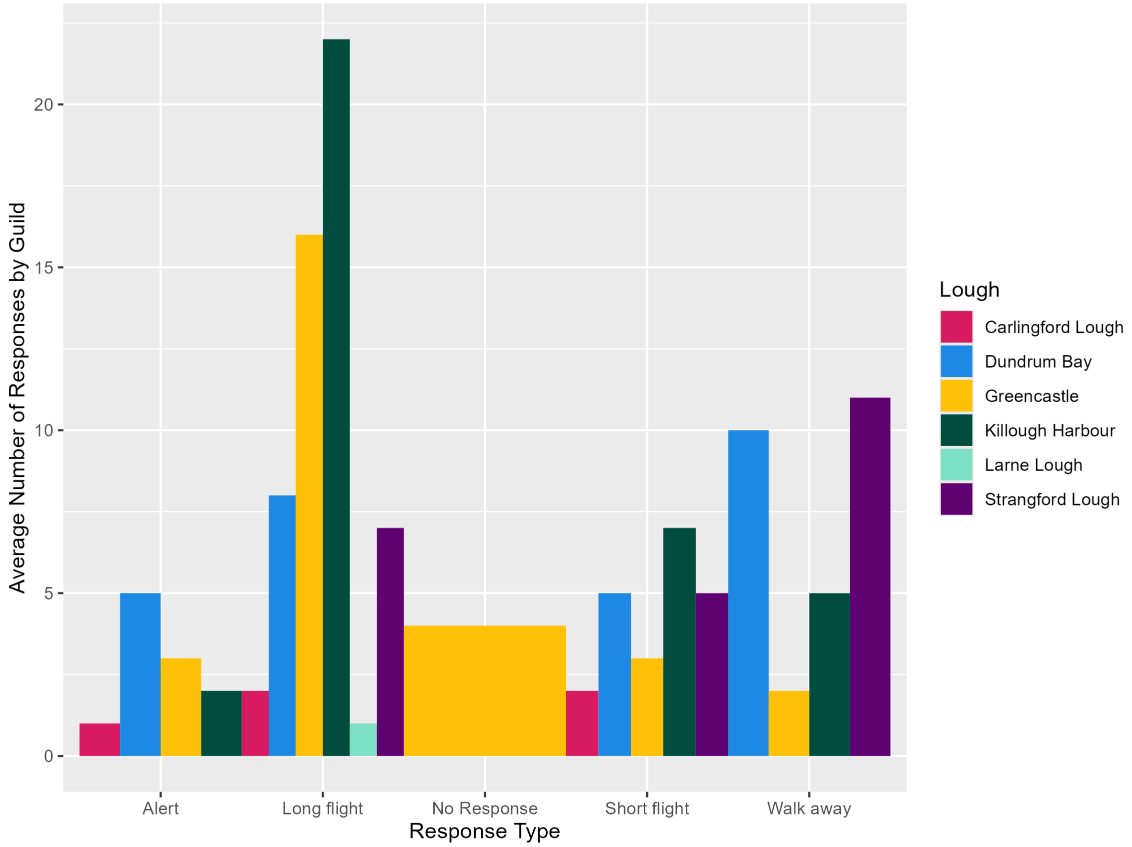


Figure 25. The average number of each response type during each tidal phase.

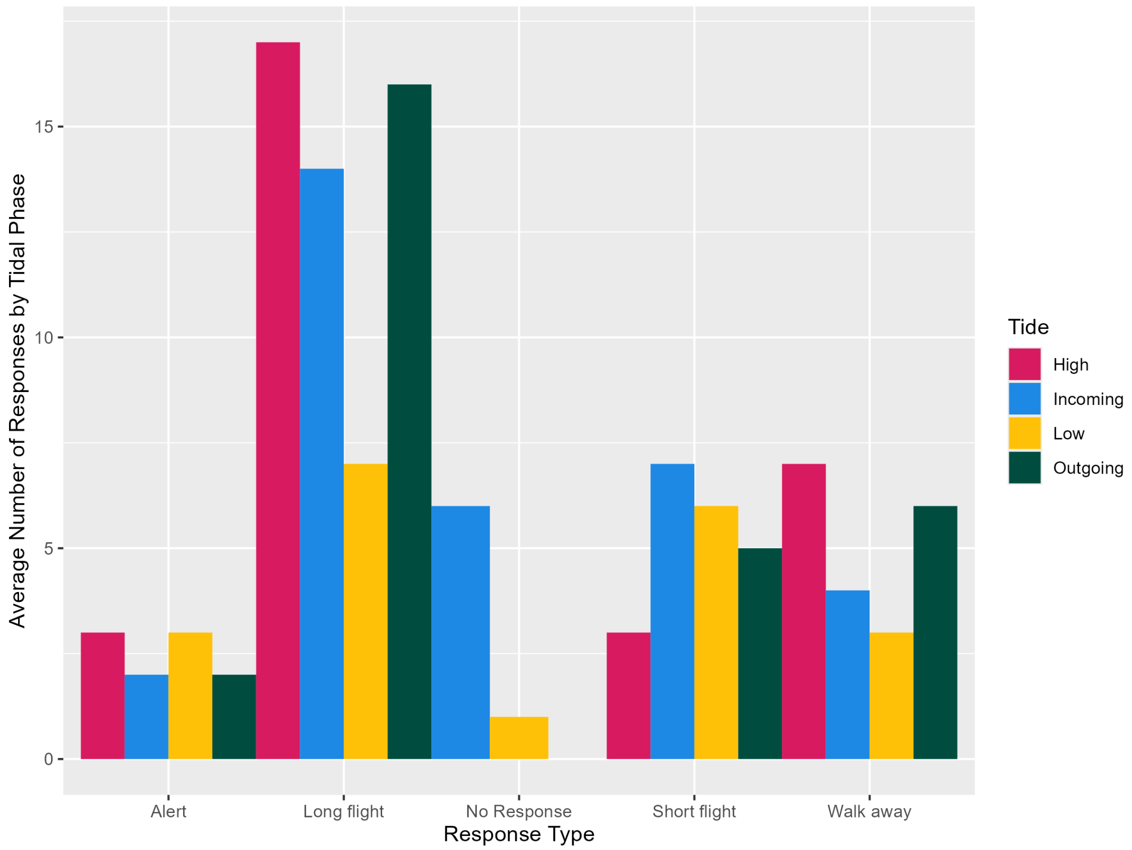


Figure 26. The average number of each response type to aquaculture-related activities versus non-aquaculture-related activities.

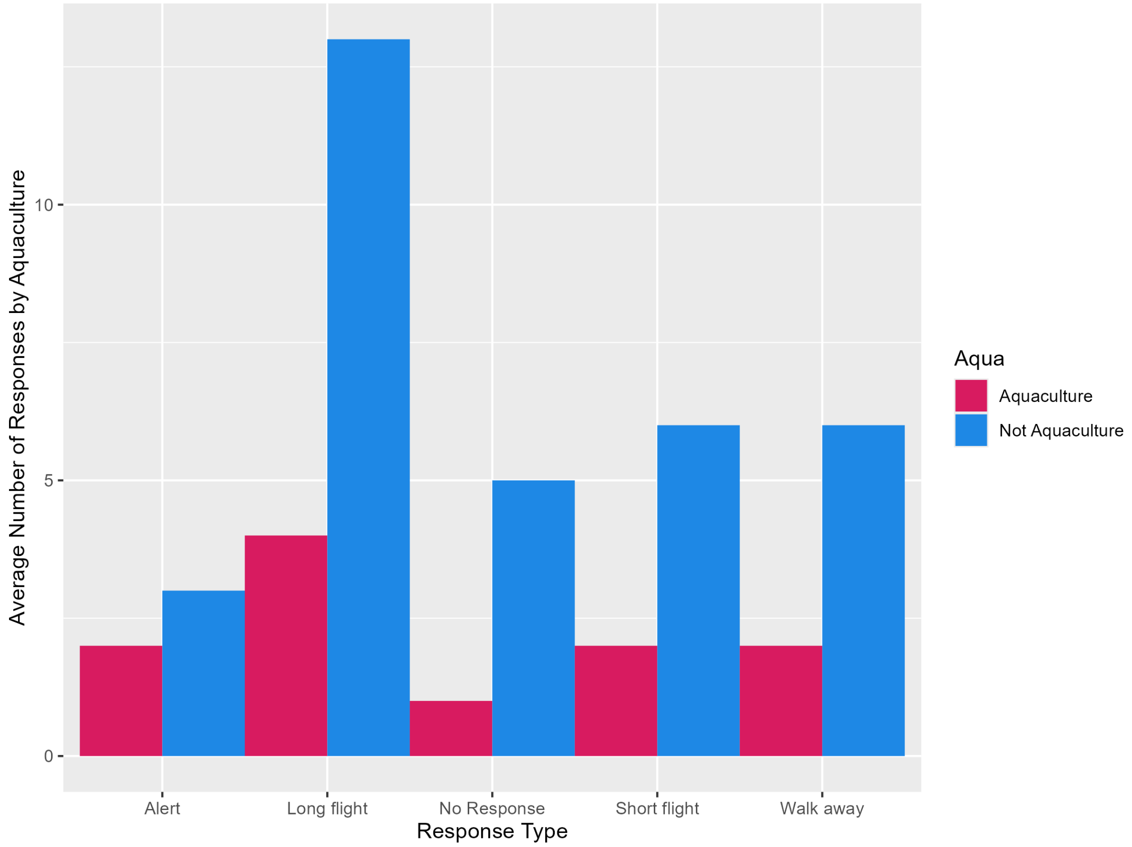


Figure 27. The average number of each response type by disturbance group.

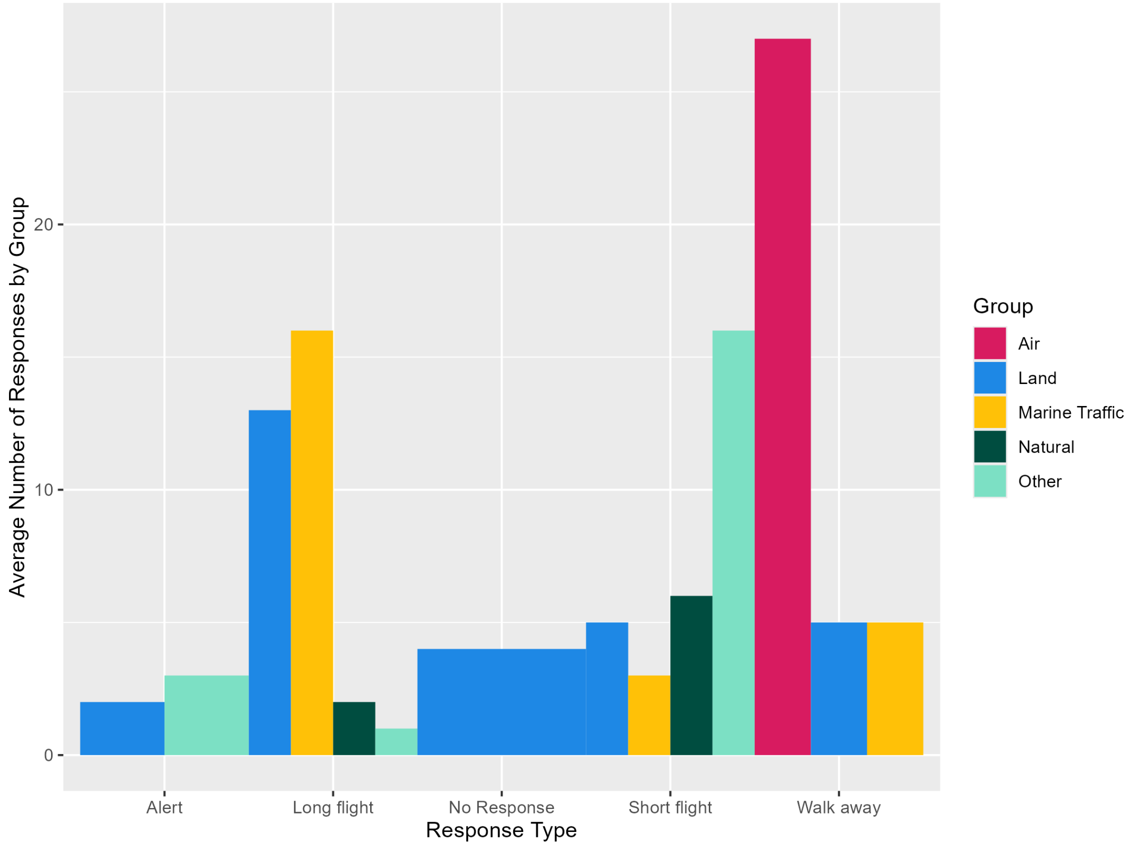
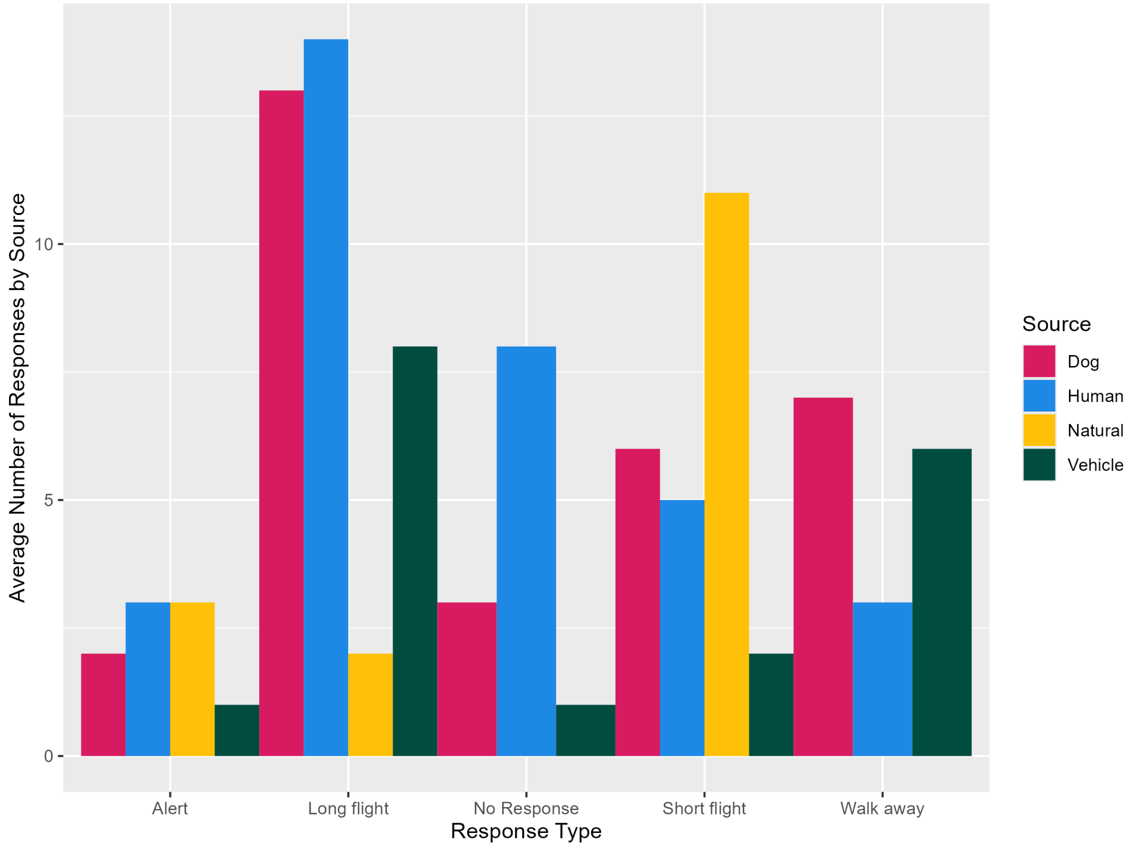


Figure 28. The average number of each response type by disturbance source.



On average, a long flight was the most common response type to aquaculture-related activities and no response was the least common response type. For non-aquaculture-related activities, the most common response type was long flight, then short flight and walking away, followed by no response and finally alertness respectively. Disturbance events that elicited no response were all land-based while those that elicited alertness were land-based or 'Other'. The highest average number of responses to land-based events was a long-flight, followed by walking away and short flights, no response, then alertness. Walking away was the only response type to air-based disturbance events. For marine traffic, the highest average number of birds responded with a long flight, then walking away then a short flight. Short flight was the most common response type for 'Other' disturbance events and natural disturbance events. When grouped by source, disturbance events caused by dogs were most often responded to by long flights, then walking away, short flights, no response, and alertness. Disturbance caused by humans were most often responded to by long flights, then no response, short flights, walking away, and alertness respectively. Natural disturbance events were most frequently responded to by short flights, alertness, and long flights. Finally, disturbance events caused by vehicles were most often responded to by long flights, then walking away, and short flights respectively, then equally by alertness and no response.

5. Discussion

This study had several limitations. During data collection, there were constraints like difficult weather and surveyor sickness which affected survey effort. Delayed responses also led to a lack of information on the operation mechanisms of specific aquaculture sites, which also caused a change in the methodology used for assessing disturbance. Staff turnover was another issue faced which caused difficulties during data analysis because of information being misplaced or no longer accessible. Nonetheless, the data collected has proven useful in understanding the behaviour of waterbirds at the six study sites.

Except at Larne Lough, four species – Curlew, Redshank, Oystercatcher, and Light-Bellied Brent Goose – were affected by disturbance at every study site. According to Gittings and O'Donoghue (2012), all four of these species produced a positive or neutral response to aquaculture disturbance during their study. Curlew, Redshank and Oystercatcher are all on the Birds of Conservation Concern Ireland Red List, while the Light-Bellied Brent Goose is on the Amber List (Gilbert et al. 2021). Killough Harbour is the only one of the five sites where there were positive trends in the numbers of waders between 2000/01 and 2015/16. Similarly, Dundrum Bay is the only site where numbers of Light-Bellied Brent Goose, have shown an increase over this period (Booth Jones et al. 2023).

Despite evidence in previous research suggesting that birds are most likely to feed during low tide (Clarke et al. 2017), the survey results show that the average number of birds and average number of feeding birds during low tidal phases was the lowest of all tidal phases. Preference for feeding at specific tidal phases varies by species depending on their ecology and prey resources (Burton et al. 2010). However, it is important to note that bird concentration might have decreased due to an increase in available feeding areas.

There were many differences between the survey sites including their size, footfall, and waterbird populations. Dogs off leads and walkers were the two most common disturbance events across all survey sites except Larne Lough. Both types of disturbance events are common in heavily residential areas and could impact bird feeding and roosting habits (Burger & Gochfeld 1991, Davidson & Rothwell 1993). According to Davidson and Rothwell (1993), airborne vehicles can significantly impact feeding or roosting waterbirds, however, in this study airborne-related events occurred during low or outgoing tidal phases and were exclusive to Dundrum Bay and Strangford Lough.

Mill Bay at Carlingford Lough had the highest number of active oyster-trestle cultivation sites. Despite that, it had the lowest disturbance index for aquaculture-related activity, possibly due to habituation. In contrast, Greencastle had the highest average disturbance index caused by aquaculture-related activities, with shellfish workers and shellfish tractors at Greencastle having the highest two average disturbance indices across all sites. Greencastle also had the second highest average number of birds disturbed. According to previous research Turnstone, Redshank, Curlew and Oystercatcher, all have a positive relationship with aquaculture activity (Gittings & O'Donoghue 2012). Therefore, conducting a sector-analysis of WeBS trends at the South Down Coast would be useful in confirming this.

Despite the average disturbance index of non-aquaculture-related activities being much higher than that of aquaculture-related activities at most sites, the average disturbance indices caused by oyster-trestle workers and shellfish tractors were the two highest among all types of disturbance across all sites. According to Kaiser et al. (1998), disturbance from trestle workers may arise when conducting visits to inspect the aquaculture activity. It should be noted that site visits were not coordinated with oyster trestle operators and thus were not timed to overlap between aquaculture activity. While this means that the relative frequency of (at least diurnal) disturbance events from different sources recorded may have been unbiased, this did mean that the absolute number of events associated with aquaculture that was recorded was relatively low and thus so was the evidence of the responses of birds to these events. Disturbance groupings with the highest average index were land-based events specifically events caused by dogs. Mitigation methods to reduce the number of disturbance events include increasing guidance and awareness for lough visitors regarding the effects of their actions on waterbird behaviour. Initiatives like Bird Aware implement this by focusing on community engagement and produce an annual report on the success of mitigation measures (birdaware.org).

When assessing waterbird responses to disturbance, the average number of responses to aquaculture-related activities was less than a third of non-aquaculture-related activities for all response types except alertness. Omnivores had the highest average number of responses between foraging guilds and response types despite benthivores having the highest average number of birds feeding and present. Between the five categories of response, 'Long flight' was the most frequent response type recorded across all guilds. The airborne disturbance events elicited the highest number of responses from birds but, they only elicited walking away as a response. Out of all disturbance sources, human-related disturbance events elicited the highest number of responses. Finally, the highest number of disturbance events which elicited no response occurred during incoming tide. This coincides with the findings above showing the highest average number of birds feed during incoming tide. It is possible that birds are less affected by disturbance while feeding to gather as much food as possible, especially considering that events with the second highest disturbance index occurred during incoming tide (Beale & Monaghan 2004).

6. Recommendations

Goss-Custard et al. (2019) conducted a study which found that assessing the impact of disturbance on waders requires determining the level of coincidence between human and bird spatial usage. Therefore, if further surveys are undertaken to assess the impacts on wintering waterbirds of oyster-trestle aquaculture then coordinating visits with oyster trestle operators' visits would be advised. A difficulty in the current survey was that activity patterns were unknown prior to the surveys commencing and it was hoped that some activity would be picked up by at least some fieldworkers on some visits. In many cases this did not prove to be the case and if future surveys occur on only one or two days a month then these should be coordinated to better understand species responses. Another potential issue was the availability of some fieldworkers to survey during the week, due to other commitments. Larne and Killough Harbour were almost exclusively surveyed during the weekend when activity at trestles may potentially be less regular (particularly at sites where operators are less restricted by tides). All surveyors noted that trestles were exposed during most low tides although trestles at Carlingford Lough were only partially exposed during surveys and access to these may be more reliant on spring or nearly spring tides. A conversation with an operator in Carlingford Lough revealed that they visited 10 to 12 times a month, whenever the tides allowed.

Planning surveys around when people will be working on the trestles could mean that six-hour visits (to accomplish a full through the tides count in two days) may not be realistic due to restricted daylight, so shorter, more targeted surveys may be more productive.

Visibility between trestles can be poor, thus for a more complete count of the birds using the area it may be necessary to conduct surveys by walking perpendicular to the trestles (from a far enough distance to avoid disturbance). However, this may not work in all cases where there are multiple rows of unaligned trestles down the shore i.e. at different angles from one another. Remote sensing opportunities might also be explored to capture counts from less visible areas of the trestles.

Observers also reported that some species like Light-bellied Brent Goose and Oystercatcher were seen apparently feeding on top of the trestles, and the trestles may be providing them with additional feeding opportunities as they remain above the waterline for longer. Redshank on Greencastle beach appeared to run from one trestle to the other apparently sheltering under the trestles to some extent, however other species such as Curlew appeared to keep a distance. These observations are from one site only over a period of three days and cannot be seen as a comprehensive assessment of the use of trestles. However, MFD staff confirmed that they observed similar behaviour from Brent Geese and Oystercatchers at many sites across the years (Morisson pers. comm.). This behaviour confirms the findings of Gittings & O'Donoghue (2012) on the foraging behaviour of widely spread flocks of waders at oyster cultivation sites.

As mentioned in the methodology, delays in receiving information led to a change in the study design, from surveying paired survey sites with and without aquaculture within sites, to comparing observations between sites. It would be interesting to see the original plan of this project come to fruition if future resources and time allowed for it. Furthermore, it is recommended to focus on a small number of species which can be used as indicators of sensitivity to disturbance. The species identified in this project — Light-Bellied Brent Goose, Curlew, Redshank and Oystercatcher — seemed especially sensitive to disturbance at most sites, and are designation features at multiple sites, and therefore could be a good starting point for future research. Finally, having a more comprehensive list of characteristics developed for each of the sea loughs would allow a more accurate comparison of the differences in disturbance events, responses to disturbance, and waterbird populations.

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Appendix 1.

Counting Form — Northern Ireland waterbird disturbance survey

Date: Date of the survey. **Surveyor:** Surveyors name. **Location:** Name of sea lough.

Visit count: Is this the first, second or third count for this visit. If you are covering the visit over two days, number the counts as if a single day 1–3.

Start time: Time count started. **Finish time:** Time count finished.

Tide: What state is the tide –

- Low (1 hour either side of low tide)
- Incoming (2–5 hours after low tide)
- High (1 hour either side of high tide)
- Outgoing (2–5 hours after low tide)

E.g. if low tide is predicted to be at 11:00 in the tide tables, 'Low' will be from 10:00–12:00, 'Incoming' will be from 12:01–15:00, 'High' will be from 15:01–18:00 and 'Outgoing' will be from 18:01–21:00.

Wind speed: If possible only survey on days where the wind speed is no higher than Beaufort force 4 (13–18 mph or moderate breeze).

Weather: Don't survey in heavy rain or snow.

Visibility: Don't survey if you cannot see the whole extent of your section to at least the tideline or 500 m from your vantage point if the tide is in.

Temp: Temperature in °C.

Count: The total count within the survey area for each species.

Count birds feeding: The total number of each species seen feeding within the survey area during the count period (not gulls). It may be helpful to use a clicker to record feeding birds whilst counting.

During the count please keep a track of any disturbances or potential disturbance events within the survey area or directly adjacent to it. Note these events in as much detail as you can whilst carrying out the count. When the count is complete begin the disturbance monitoring for at least one hour. Gulls should be counted only if there is sufficient time to do so during the count period. There is no need to record the impacts of disturbance on gulls.

Date:		**Location:**	
Surveyor:			

Visit count:		**Start time:**	
Tide:		**Finish time:**	

Wind speed (Beaufort 1,2,3,4,5)	**Weather** 1.Good, 2.Wet, 3.Very wet	**Visibility** 1.Good, 2.Moderate, 3.Poor	**Temp** (°C) if not sure estimate

Species:	**Count:**	**Count: Birds feeding**	**Notes**

Appendix 2.

Disturbance Form

Month: Month survey undertaken.

Visit: first or second visit of the month.

Disturbance monitoring session: Is it the first, second or third disturbance monitoring session of the day?

Tide: What state is the tide –

- Low (1 hour either side of low tide)
- Incoming (2-5 hours after low tide)
- High (1 hour either side of high tide)
- Outgoing (2-5 hours after low tide)

E.g. if low tide is predicted to be at 11:00 in the tide tables, 'Low' will be from 10:00–12:00, 'Incoming' will be from 12:01–15:00, 'High' will be from 15:01–18:00 and 'Outgoing' will be from 18:01–21:00.

Start time: When the disturbance monitoring session began.

End time: When the disturbance monitoring session ended.

ID: Disturbance event identifier. This number should correspond to the disturbance marked on the disturbance map. See worked example.

Disturbance type: Choose the appropriate code from Table 1 below. In brackets include the number of e.g. people/vehicles/dogs/etc. if relevant. Add additional detail in the notes if necessary.

Time of event: Record when the disturbance, or potential disturbance occurred. If there are multiple disturbances from the same event over a period of time record each separately.

Species affected: Use a new line for each of the waterbirds species affected by the disturbance event (don't include gulls).

Number disturbed: How many of that species reacted to the disturbance event (estimate if necessary).

Reaction: How the birds reacted to the disturbance:

1. Alert,
2. Walk/swim/dive away,
3. Short flight (landing <50 m from start position),
4. Long flight (landing >50 m from start position).

If a bird/flock displayed multiple reactions record the highest severity of the four options above i.e. Long flight > Short Flight > Walk/swim/dive > Alert.

Distance to (potential) disturbance: Record the distance between the potential disturbance event in the one of the following ways:

If birds reacted to a disturbance, what was the distance to the bird furthest away, that reacted, from the source of disturbance (for each species if possible)?

If birds did not react at all, what was the distance of the bird closest to the source of the disturbance (for each species if possible)?

Record distances in the following bands: 0–100 m, 100–200 m, 200–500 m, 500 m+

Duration of disturbance: How long is the cause of disturbance on site?

Disturbance codes

TYPE of DISTURBANCE	CATEGORY	CODE
LAND	1. Walkers	1. WK
	2. Joggers/runners	2. JG
	3. Birdwatchers/photographers	3. BW
	4. Anglers	4. AG
	5. Shellfishers (inc. oyster trestle workers)	5. SF
	6. Bait-diggers	6. BD
	7. Dogs on lead	7. DL
	8. Dogs off lead	8. DI
	9. Vehicles	9. VI
	10. Shellfish tractor	10. TR
AIR	11. Aeroplane	11. AR
	12. Helicopter	12. HE
	13. Drone	13. DR
NATURAL	14. Predator (e.g. bird of prey)	14. PR
MARINE TRAFFIC	15. Shellfish boat	15. SB
	16. Other powered boat	16. OB
	17. Jet-skis	17. JS
	18. Wind-surfer/surfer	18. WS
	19. Unpowered boat (e.g. canoe, rowboat, kayack, paddleboard)	19. UB
OTHER	20. Other disturbance, please specify in notes	20. OT

Disturbance monitoring

Month: **Visit:** **Disturbance monitoring session:** **Tide:**

Start time: **End time:**

ID	Disturbance type(no. where relevant)	Time of event	Species affected	Number disturbed	Reaction	Distance to disturbance /potential disturbance	Duration of disturbance (min) – time active on site	Notes

Front cover: Knot, by Allan Drewitt / BTO; Back cover: fishing boat, by David Tipling / birdphoto.co.uk

Assessing the extent and effects of disturbance on wintering waterbirds in Northern Ireland's sea loughs

Human-related disturbances to foraging or resting waterbirds can come from a range of sources, from people on foot or using machines or vehicles, and from industrial or recreational activities. Such disturbances may cause birds to fly away to alternate areas or cause non-fleeing responses like increased vigilance. Sporting and leisure activities are common at the Northern Irish sea loughs. Furthermore, the habitat of these birds can be affected by industrial activities carried out in these areas.

This pilot project builds on the findings of an analysis of within-site wintering waterbird trends, and provides a more targeted field-based study that directly assesses the potential responses of waterbirds to disturbance. A particular focus of the work is disturbance associated with intertidal aquaculture activities at sites across Northern Ireland, and the report seeks to set these in the context of disturbance events caused by other activities.

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