Effects of disturbance on foraging shorebirds on the coast of CO. Cleveland

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EFFECTS OF DISTURBANCE ON FORAGING SHOREBIRDS ON THE COAST OF CO. CLEVELAND.

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ABSTRACT.

This project studied the disturbances caused to four species of shorebird at several different sites along the Cleveland coast. It found that the most common cause of disturbance were people exercising their dogs. Studies on a large sandy beach showed that most of the disturbances were caused by people walking their dogs there in the evening. Disturbance rates at a beach composed of sandy, rocky and shingle areas showed a wider variety of disturbance sources with dog-walking at high tide, and children and families visiting the rocky part of the beach at low tide, both causing substantial disturbance.

No significant difference was found in different species reactions to dogs as opposed to people, neither was there a significant difference in their reaction to tall, easy to spot sources as compared to low, relatively inconspicuous disturbances.

The disturbances observed were responsible for a loss of potential feeding time between 0.36% and 0.56%. The project concluded that this was unlikely to cause serious curtailment of the birds feeding activity and that restrictions on any of the activities discussed by the project were not justified.

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INTRODUCTION.

The aim of this project was to study the effects of disturbance resulting from human use of coastal habitats on four species of shorebird, the Turnstone *Arenaria interpres*, Ringed Plover *Charadrius hiaticula*, Oystercatcher *Haematopus ostralegus* and Sanderling *Calidris alba*. The work was carried out at four main sites along the Cleveland coast, sites which vary in substrate, intensity of human use and the distribution of the above species.

The stretches of beach covered by the project are used by humans in a variety of ways. Some of most common are their use as a recreational facility by dog owners, horse riders, walkers and windsurfers. Many of the small coastal towns are popular seaside resorts, serving the larger towns like Hartlepool and Middlesborough, and the income from tourists and visitors is a valuable part of the local economy.

Some of the beaches also serve a limited economic function. Redcar supports a small fishing industry and most of the small boats used are launched directly from the beach. The beaches are also used by people digging for fishing bait and collecting coal dust (sea coal) washed on to the shore.

Over the last few decades human impact on shoreline habitats has grown considerably (Davidson and Rothwell 1993 ,Burger and Gochfeld 1991). Such growth includes increases in the number of areas suffering disturbance and an increase in the proportion of the year to which the disturbance applies. As well as the effects of development and pollution one of the biggest problems facing birds feeding in these habitats is human disturbance. Limited research has been done to examine its effects, on both breeding and feeding sites. Studies into disturbances on feeding grounds have looked at both the effects of aerial disturbances (Koolhaas, Dekinga &

Piersma. 1993) and land based disturbances such as dogs (Goss-Custard and Verboven 1993).

Disturbances caused by recreational use of beaches have been described by Kirby et. al.(1993). Their studies showed that although the actual levels of disturbance did not increase significantly over the five years of the study (1986-1991) the sources of disturbance had become more varied, with recent increases in the amount of disturbance caused by horse riders, windsurfers and bird watchers. Other sources of disturbance which had an effect only towards the end of the project were cyclists, boats and jet-skis. The lack of a significant increase in the overall levels of disturbance suffered by the birds was in marked contrast to the substantial increase in beach usage over the five years. The majority of the disturbances recorded were caused by walkers and by dogs and their owners using the beach. The effects of disturbance were also found to vary between species.

Work by Scott (1989) examined the effects of walkers, dogs, bait-diggers and fishermen on wading birds, concentrating on the distance at which the birds react by taking flight. This was found to vary both with the species of bird and the kind of disturbance. All sources of disturbance produced an average disturbance distance for Oystercatchers of 10m and 7m for Turnstone. For disturbances caused only by sea-anglers working from the shore reaction distances were higher, 50m for oystercatchers. In general the shorebirds studied were disturbed more often by fishermen than bait-diggers. Many bird species were found to be reasonably tolerant of the presence of nearby bait-diggers.

Another potential source of significant disturbance is the effect of bird catching by cannon netting (Zegers 1973.). The disturbance caused by this work could last for between five days and two weeks, this being the time taken for the bird numbers in that site to reach their original levels. When the activities of cannon netters was spread out more, with a greater interval between catches, the effects of the disturbance were reduced.

Work by Burger (1981) also found that birds react differently to different causes of disturbance. In her study joggers were found to cause greater disturbance than walkers, birdwatchers and shellfish collectors, who caused very little disturbance to shorebirds.

According to Cayford (1993) the nature of the disturbances themselves varies considerably. Variation occurs in the number of people involved and the activity in which they are involved, in the duration of the disturbance, the frequency with which such disturbances occur, their regularity (birds may be more tolerant of disturbances which are in some way predictable) and the area over which the disturbance has an effect (c.f. mobile and static disturbance sources).

Human activities on the coast are bound to have some effect on the shorebirds which also live there because the approach of humans, dogs, etc poses a potential threat to any feeding bird. Roberts and Evans(1993) concluded that the birds' reaction is a compromise between two conflicting factors. On the one hand the bird wants to remain feeding for as long as possible. The sooner the bird takes off and the longer it is in the air, the more feeding time and so potential energy, is lost. On the other hand the bird wants to avoid the risk of predation or injury which the threat poses. The sooner the bird ceases feeding and reacts to the disturbance, the greater its chances of avoiding injury. It is the balance between these two conflicting pressures which will determine the distance at which birds eventually react to activity on the beach.

Much of the work looking at disturbance (Davidson and Rothwell 1993) has concentrated on the effects of disturbance during the winter months, when energy budgets become far more precarious. In winter, birds expend more energy per day maintaining a constant internal body temperature. The birds food supply has not increased, and is often lower at this time of year. As a result birds need to change their behaviour during winter, either by migrating to sites with better food sources or by increasing their time spent feeding. So during winter losses in feeding time have a more serious effect on the birds' energy budget and are more likely to reduce the birds' food intake to the extent that they suffers ill-health or even starvation. Belanger and Bedard (1990) have shown that human disturbance can have a significant adverse effect on the rate of energy intake. If the birds require protection from human disturbance then it is during winter that such protection would need to be established.

In my project I attempted to quantify the effects of disturbance by measuring the reaction of different species to various human activities on the beach, and estimating the potential feeding time lost to the bird as a result of each human disturbance. Some work has already been done by examining the effects of deliberate disturbances (Roberts & Evans 1993, Koolhasss et.al. 1993 and Fox et. al. 1993.). The advantage of such methods is that, by creating the disturbance, the researcher can more carefully control the type of disturbance and, for example, can vary the nature of disturbance according to their own criteria.

Examining uncontrived disturbances is far more problematic due to the irregular and unpredictable nature of the disturbances. Nevertheless I decided to make direct observations of disturbances which occurred in the "natural course of events". This meant that many disturbances which a single researcher would be unable to create could be recorded.

The information so gathered is used to address the following questions:

Which disturbances are most common?

How does the frequency of various disturbances at the different sites along the Cleveland coast vary?

How do the disturbances affecting the shorebirds vary over the course of the day?

Does the state of the tide have an effect on the frequency of different causes of disturbance?

Which disturbances cause the greatest loss of feeding time?

What is the impact of various disturbances?

Which sources of disturbance have the greatest reaction distances for each species?

How do different species react to similar disturbances?

How does each species vary in its reaction to different disturbances?

Projects on disturbance have taken three different approaches.

1. To look at the effects of potential disturbances by studying their effects on a single behavioural trait such as feeding rate.

2. Measurement of the distribution and density of bird flocks. Use mathematical models to determine density in relation to certain environmental variables. Deviation from the model may indicate the effects of disturbance. The model used needs to precisely account for natural variation. This is a very difficult undertaking. There is a need to study a large number of individual bird populations covering a wide range of densities in order to produce an accurate model.

3. Experimentally controlled disturbance. The factors affecting the experiment can be more carefully controlled and such studies tend to experience less bias.

Studies in the Wadden Sea (Koolhass et. al. 1993) looking at the effects of disturbance on feeding shorebirds showed that there is considerable variation in behaviour and population density between different species. They also showed a difference in the response to low flying aircraft between birds with varying experiences of such disturbance. Flight distance was used to calculate the theoretical size of the area abandoned due to disturbance. The size of the area deserted was found to be relatively small for disturbances like bait digging, about 3 hectares, compared to an area of 20 hectares which was typical for disturbances caused by walkers.

Studies on Oystercatchers showed that displacement to new feeding grounds caused a substantial shift in behaviour and a reduction in the proportion of time spent feeding during the transition. The project concluded that the birds involved showed an ability to adapt to high levels of human disturbance but that certain combinations of disturbance types, such as windsurfers followed by low-flying aircraft, could be particularly detrimental, resulting in a more marked effect than either disturbance would have produced by itself.

Koolhass et. al.(1993) also considered it important to determine whether birds are acting territorially and also whether symptoms of stress e.g. increased heart rate, were being ignored due to the lack of an external indication.

Changes in bird behaviour caused by human disturbance have also been recorded in other projects. When disturbed, Oystercatchers spent less time feeding but they fed more intensively. This resulted in a reduced handling time and an increase in the risk of bill damage and parasitic infestation.

Madsen (1993) found that a reduction in the feeding time of Mute swans Cygnus olor when disturbed was overcome by increased night-feeding. Wigeon Anas peaelope, which were also being studied during the project, were unable to compensate for lost feeding time in this way. Work by Burger and Gochfeld (1991) also found that an increase in disturbance during the day was accompanied by an increase in night feeding by Sanderling.

A reduction in feeding time is not the only effect of disturbance. Studies by Stock (1993) and Goss-Custard and Verbovan (1993) showed that birds would shift their distribution within a local area from sites of high disturbance to more peaceful areas. Local population levels were also found to increase within reserves where disturbances such as wildfowling were absent (Madsen 1993 and Owen 1993.)

Changes in feeding location were also observed by Townshend and O'Connor(1993). Their studies into the effects of bait digging in the vicinity of Lindisfarne showed that when bait digging was banned from a particular part of the coast, populations of Wigeon, Bar-tailed Godwit Limosa lapponica and Redshank Tringa totanus in that area increased. Bait digging was eventually banned from that area and shifted to sites adjacent to a nearby causeway.

Work by Striata (1993) revealed that birds in large flocks, although theoretically safer from predators due to the advantages of neighbours' vigilance, were more susceptible to the effects of nervous individuals, which would take off far more readily and so cause the entire flock to take flight.

STUDY AREA AND METHOD.

This study was carried out at sites in and around the Tees estuary in Co. Cleveland. These are shown on Fig. 6A. The data was collected at four main sites, areas which had quite high levels of human activity and which were also regularly visited by feeding shorebirds.

Site A was the beach at Crimdon Dene (See Fig. 4.). This area was a sandy beach backed by small dunes and low cliffs towards the furthest extent of the site. It was a popular tourist site and received a large influx of visitors from the caravan site behind the beach. It was also a popular site of exercising horses. It was used mainly as a feeding site by sanderling.

Site B was an area of shingle and sand beach lying north of Seaton Carew (See Fig. 3.). Although not as busy as the sandy beaches further south it was popular with dog owners and was a regular site used for coal collection, removing the thin layers of fine coal waste washed up onto the beach. This beach was used by a wide variety of shorebird species.

Site C was Coatham sands, a large sandy beach to the north of Redcar, hereafter referred to as Redcar north beach (See Fig. 2.). This was a very popular beach for a wide variety of leisure activities, including dog walking, jogging and windsurfing. Sanderling are commonly found feeding here.

Site D was a beach at the south end of Redcar (See Fig. 1.). It is dominated by a rocky outcrop which extends out from the coast a short way. This beach does not attract as many tourists as Coatham sands and most of the people using it are local. It is also used by local fisherman who put out to sea at a nearby slipway. It is used by many shorebirds but dominated by oystercatchers.

Several other smaller sites were also visited. These were at South Gare, a breakwater to the south of the Tees estuary (See Figs. 5 and 6.) and Hartlepool marina. At

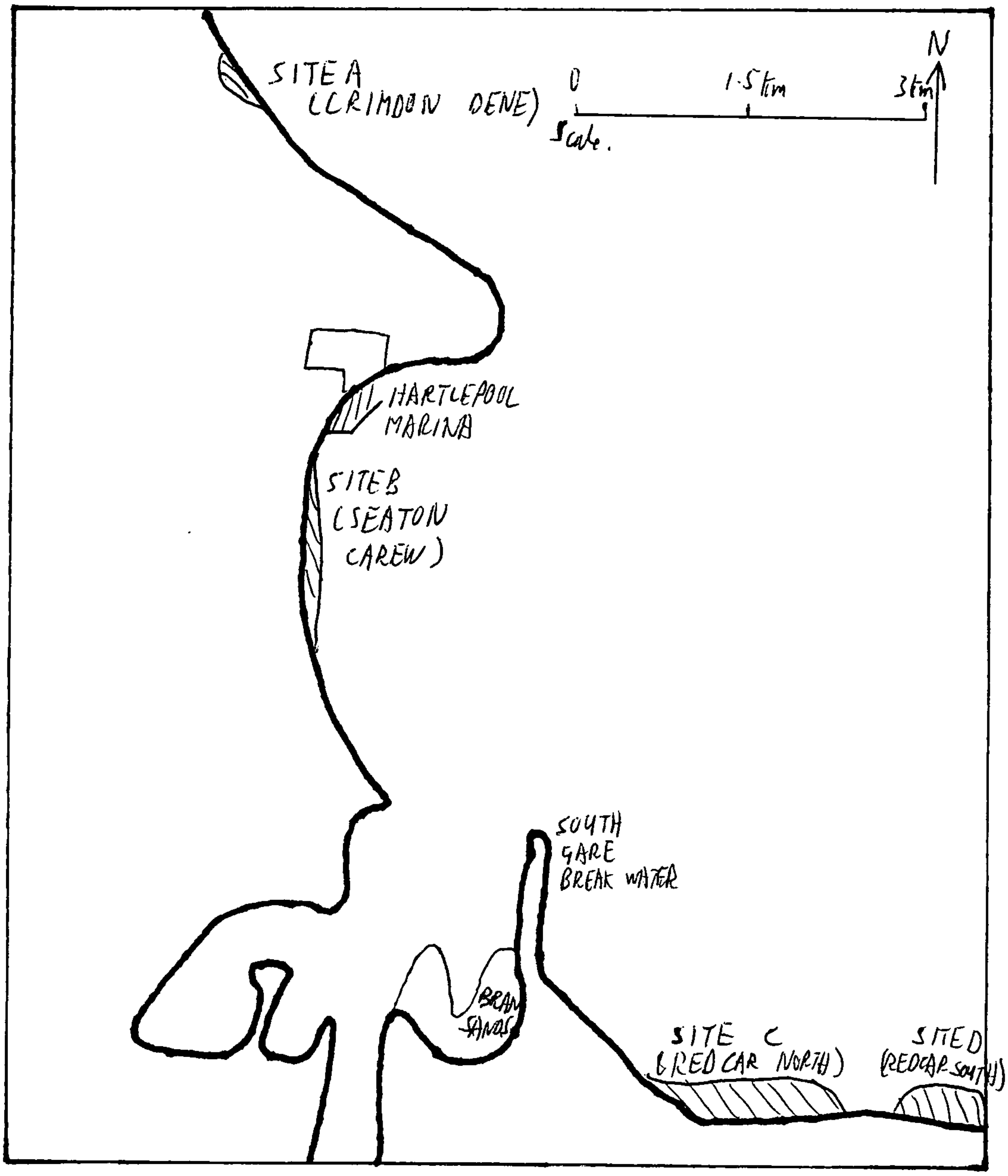

Fig. 6A. Co. Cleveland showing sites used during project.

Fig. 1. View east over Redcar south beach at low tide.

Fig. 2. View north over Redcar north beach at low tide.

Fig. 3. View north over Seaton Carew beach at low tide.

Fig. 4. View south over Crimdon Dene at low tide.

Fig. 5. View east from South Gare Breakwater.

Fig. 6. Bran sands at low tide.

the marina a small island has been constructed in the hope that it will be used as a roosting site for shorebirds. Data from this site will be used to examine the effects of disturbance on roosting birds.

At each site each potential disturbance was recorded using the following method (The type of disturber was categorised using the key described in Appendix B.). First the type of potential disturbance, species of bird involved, time and the substrate the bird was standing on was noted. If no reaction occurred then the closest distance achieved between the bird and the potential disturber was noted. If a reaction occurs then the distance between the bird and the disturber is noted. Two types of reaction were recognised. The bird could become alerted in which case it stopped feeding until it judged that the disturber has move far enough away. The duration of this period of alertness was recorded. The second type of disturbance is when the bird takes flight. In this case the duration of the flight is recorded, the straight line distance of the flight and the overall direction of the flight, start to finish, compared with the direction of movement of the disturber. This had three categories. Away flight meant that the bird flew away from the disturber in the same direction as the disturber was moving. Perpendicular flight meant that the bird flew away from the disturber in a direction at 90 degrees to the direction of movement of the disturber. Towards flight meant that the bird flew towards and behind the disturber.

By placing markers along a measuring tape the observer was able to improve their ability to estimate distances by familiarising themselves with distances of a known length. By doing this at various positions up the beach some compensation for the various distances away from the observer at which distances had to be measured could be made. Nevertheless the observer only attempted to estimate distance to the nearest 5m.

Times were measured using a stop watch. The data was record using a dictaphone. This enabled data to be recorded while an observation was taking place.

As well as recording disturbances the observer also recorded, at regular intervals throughout the data collection period, the number of birds of each species present on the beach.

At the end of each day the data recorded was transcribed onto a standard data collection sheet as shown in Appendix A. Subsequently the data was transcribed onto a spreadsheet for analysis.

RESULTS.

(i). Disturbance frequency.

One function of this project was to quantify the nature of human disturbances affecting the bird species under study. Approximately 99 hours and 15 minutes of observations at the four main sites were undertaken between May and August 1995. During this time 182 disturbances were observed. How these were spread out between the four sites is shown in Table 1.

The rate of disturbance (Number of observed disturbances/Number of hours of observation recorded) are minimum estimates because only one disturbance can be observed at a time. While the information on one disturbance is being recorded, other disturbances may occur which pass unrecorded.

Table 1. Hours of observations and the number of disturbances observed at each site.

Site.	Minutes of observations.	Number of disturbances observed.	Disturbance rate per hour.
Redcar north beach.	930 min.	41	2.65
Redcar south beach.	4335 min.	130	1.80
Seaton Carew.	420 min.	10	1.43
Crimdon dene.	270 min.	1	0.22

The level of disturbance at Crimdon Dene was particularly low although the main holiday season does not start until the Autumn after observations had ceased.

The number of occurrences of particular types of human disturbance are described in Table 2. The causes of disturbance were grouped together using the notation described previously (e.g. A+C+D3 describes all disturbances involving groups composed of adults, children and excited dogs.). The percentage of all the disturbances caused by that particular group are also given.

Table 2. Causes of disturbance at each site.

Site	Redcar north beach		Redcar south beach		Seaton Carew		Crimdon Dene		Total number of disturbances	
Cause of disturbance		%		%		%		%		%
A	7	17	22	17	2	20	0	0	31	17.03
D2	1	2	8	6	0	0	0	0	9	4.95
D3	1	2	2	2	0	0	0	0	3	1.65
D4	0	0	7	5	2	20	0	0	9	4.95
D5	0	0	6	5	0	0	0	0	6	3.30
C	0	0	12	9	0	0	1	100	13	7.14
A+C	0	0	14	11	1	10	0	0	15	8.24
A+D1	0	0	4	3	0	0	0	0	4	2.20
A+D2	6	15	18	14	0	0	0	0	24	13.19
A+D3	7	17	16	12	2	20	0	0	25	13.74
A+D4	8	20	4	3	0	0	0	0	17	9.34
A+D5	0	0	3	2	0	0	0	0	3	1.65
A+Mixed dogs	2	5	2	2	0	0	0	0	4	2.20

A+C+D2	0	0	4	3	0	0	0	0	4	2.20
A+C+D3	1	2	0	0	0	0	0	0	1	0.55
A+C+D4	2	5	0	0	2	20	0	0	4	2.20
C+D2	0	0	1	1	0	0	0	0	1	0.55
Joggers	3	7	0	0	0	0	0	0	3	1.65
Swimmers	0	0	2	2	0	0	0	0	2	1.10
Vehicles	0	0	1	1	1	10	0	0	2	1.10
Anglers	0	0	1	1	0	0	0	0	1	0.55
Windsurfers and surfers	3	7	1	1	0	0	0	0	4	2.20
Inflatable dingy	0	0	1	1	0	0	0	0	1	0.55
Scientific research.	0	0	1	1	0	0	0	0	1	0.55

These results show that overall the majority of disturbances were caused by one of two groups. The first group are people, both adults and children, walking along the beach. The second group are people using the beach to exercise their dogs. Disturbances caused by dogs alone were almost always the result of dogs travelling some distance from their owners.

Several disturbances were also caused by joggers, surfers and windsurfers using the beach. Other sources of disturbance occurred only as isolated incidents during the study period.

Looking at each site, the majority of disturbances at Redcar north beach were caused by dogs and such disturbances formed a greater percentage of the total disturbances than at the other sites. Other disturbances particularly associated with Redcar north beach were joggers and windsurfers. Disturbances involving children were far less frequent than at other sites.

In comparison the birds feeding at Redcar south beach suffered relatively less disturbance from dog walkers and relatively more disturbance from people using the beach. Furthermore the disturbances observed at this site also covered a wider variety of sources than at other sites. Of these the disturbances unique to this site were swimmers, sea fishermen, the use of an inflatable dingy and scientific research being carried out at the site.

The disturbances recorded at Seaton Carew did not vary markedly from the distribution of disturbances for all the sites, apart from the higher than normal occurrence of disturbances caused by vehicles.

Only one disturbance was observed at Crimdon dene.

(ii). Use of sites by shorebirds on days of observation during May to August.

The data for the number of birds present during the observations were used to produce a mean value for the number of birds at each site. These data are shown in Table 3.

Table 3. Mean number of birds observed at each site.

Species / Site	Sanderling	Turnstone	Ringed plover	Oyster-catcher
Redcar north beach	11.2	0	0	2
Redcar south beach	10.9	4.5	2.3	25.7
Seaton Carew	3	1	0	14

Crimdon dene	4	0	0	1

The results shown in Table 3. show that on Redcar south beach all four species are present and bird density is higher than at the other four sites.

The variation in bird density over the course of the study are shown in Figures 7 to 10. At Redcar north beach the numbers of sanderling were comparatively high in May but dropped when in June the birds migrated to the arctic to breed. Oystercatchers were observed only during the last month of the project.

At Redcar south beach the numbers of all species were low until August when the numbers of Sanderling and Oystercatchers increased substantially as the migrants returned from the breeding areas.

At Seaton Carew no birds were observed during June and July and in August only Oystercatchers were seen.

At Crimdon Dene Sanderling were observed only at the start of the project. At the end of the project small numbers of Oystercatcher were present.

<u>(iii). Variations in disturbance over the day.</u>

The way in which the sites investigated in this project were used was unlikely to remain constant throughout the day. In examining the variation over the day of the disturbance frequency, two sites were used, Redcar north beach and Redcar south beach. For each site the hours at which observations were made were split into time periods, each time period lasting three hours. The number of disturbances caused by particular groups within each time period is shown in Tables 4 and 6.

Fig. 7. Mean number of birds present at Crimdon dene.

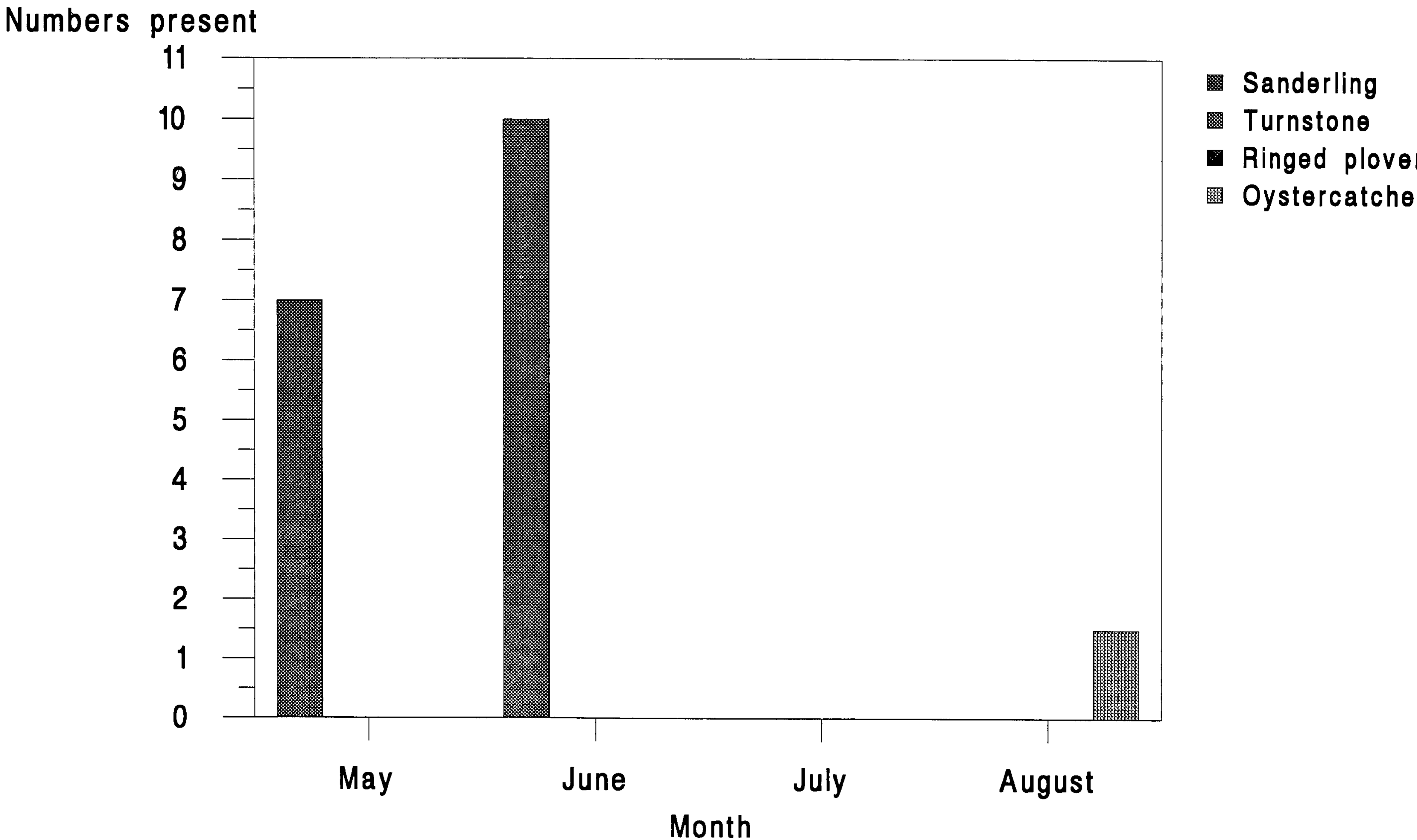

Fig. 8. Mean number of birds present at Redcar north beach.

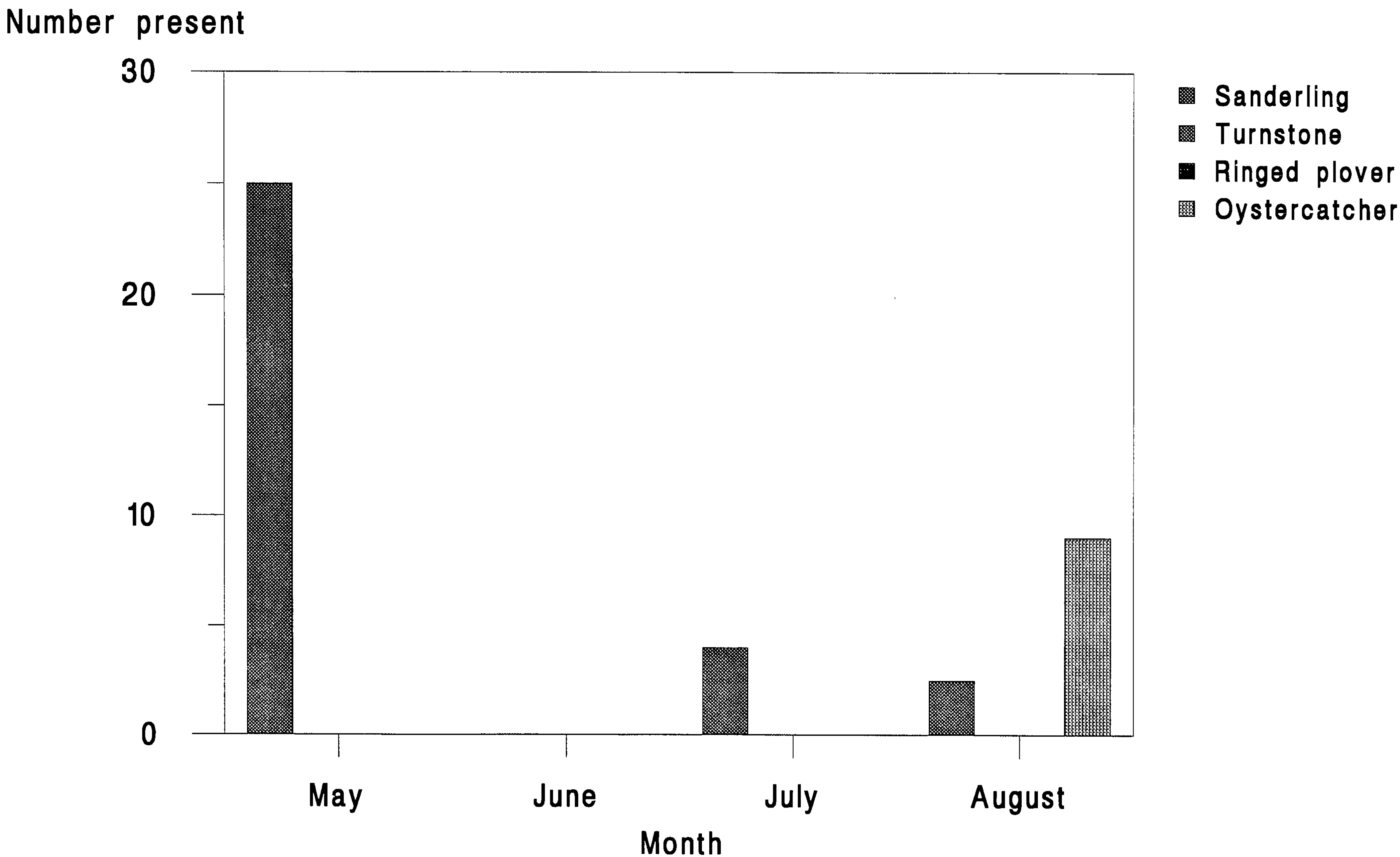

Fig 9. Mean number of birds observed at Seaton Carew

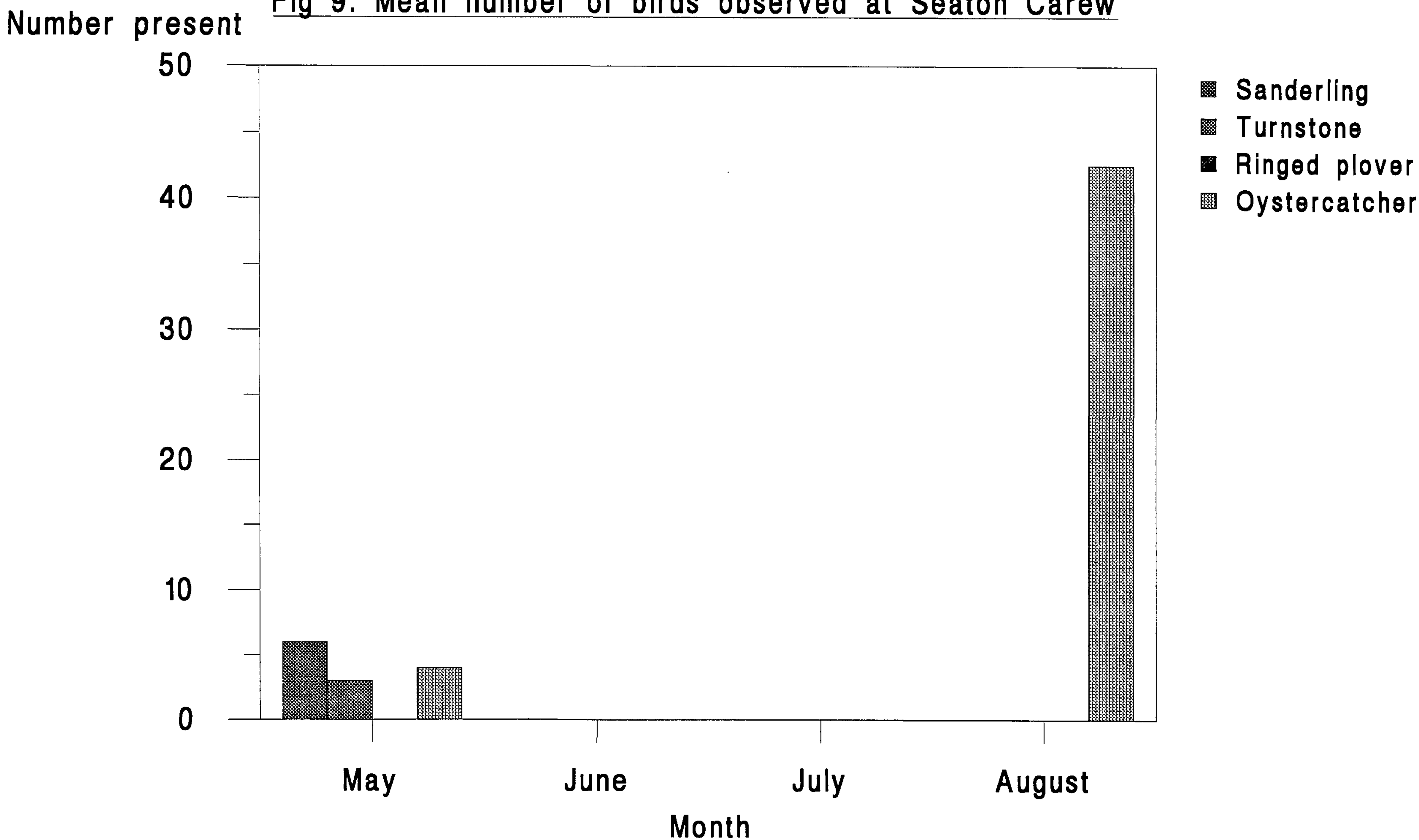

Fig. 10. Mean number of birds observed at Redcar south beach.

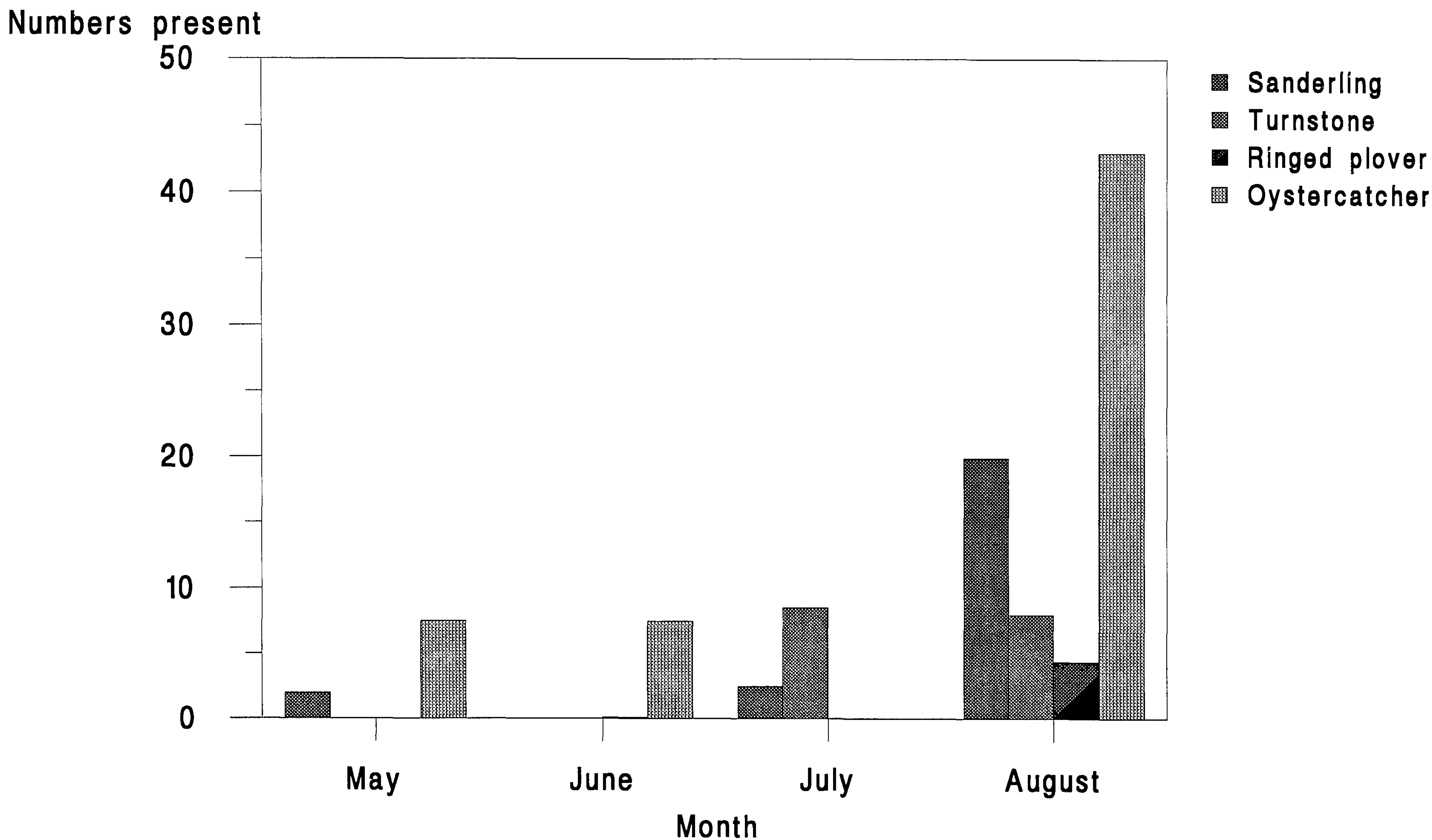

Table 4. Disturbance frequency throughout day at Redcar north beach.

Time period.	1100-1400	1400-1700	1700-2000
Duration of observations.	1 hour 45 mins.	4 hours.	9 hours 45 mins.
Number of disturbances caused by adults (A).	0	1	6
Number of disturbances caused by adults and children (A+C).	0	0	0
Number of disturbances caused by children (C).	0	0	0
Number of disturbances caused by dog-walkers.	0	2	25
Number of disturbances caused by other sources.	0	1 Windsurfer	3 Joggers 2 Windsurfers

To compare these values estimates of the rate of disturbance were calculated using the information in table 4. The values for the rates of disturbance are shown in Table 5.

Table 5. Variation in rates of disturbance at different time periods at Redcar north beach.

Time period.	1100-1400	1400-1700	1700-2000
Rate of disturbance caused by adults (A).	0/hour	0.25/hour	0.62/hour
Rate of disturbance caused by dog-walkers.	0/hour	0.5/hour	2.56/hour
Rate of disturbance caused by other sources.	0/hour	0.25/hour Windsurfer	0.31/hour Jogger 0.21/hour Windsurfer

The rates of disturbance recorded around midday were zero and the bulk of the disturbances affecting Redcar north beach occurred in the late afternoon and evening. The rates of disturbance recorded form dog-walkers increased substantially in the evening to the extent that they were the main cause of disturbance at that time of day.

Table 6. Disturbance frequency throughout the day at Redcar south beach.

Time period	0900-1200	1200-1500	1500-1800	1800-2100
Duration of observations	8 hours 45 mins.	21 hours 30 mins.	36 hours 30 mins.	9 hours 45 mins.
Number of disturbances caused by adults.	1	10	9	2
Number of disturbances caused by adults and children.	6	2	6	0
Number of disturbances caused by children.	0	0	7	6
Number of disturbances caused by dog-walkers.	15	18	37	5
Number of disturbances caused by another source.	1 Researcher	1 Vehicle	2 swimmers 1 Angler 1 Dingy 1 Surfer	0

The data for Redcar south beach (Table 6.) have also been used to calculate the rates of disturbance of birds at various times of day. The results are shown in Table 7.

Table 7. Variation in rates of disturbance at different times on Redcar south beach.

Time period.	0900-1200	1200-1500	1500-1800	1800-2100
Rate of disturbance called by adults.	0.11/hour	0.47/hour	0.25/hour	0.21/hour
Rate of disturbance caused by adults and children.	0.69/hour	0.09/hour	0.16/hour	0/hour
Rate of disturbance caused by children.	0/hour	0/hour	0.19/hour	0.62/hour
Rate of disturbance caused by dog-walkers.	1.71/hour	0.84/hour	1.01/hour	0.51/hour
Rate of disturbance caused by other sources.	0.11/hour Researcher	0.05/hour Vehicle	0.05/hour Swimmers 0.03/hour Angler 0.03/hour Dingy 0.03/hour Surfer	0/hour

As with Redcar north beach the rates of disturbance caused by adults did not vary greatly over the course of the day. Rates of disturbance caused by families were higher in the morning while the rate of disturbance caused by children alone was highest in late evening. Dog-walkers were the major source of disturbance throughout the day apart from during late evening when children were the major cause of disturbance to feeding birds during the period of study.

(iv). The effects of tide level on disturbance patterns.

It has already been shown that the patterns of disturbance affecting the species under study vary over the course of the day. The change in tide levels during the course of the day may also cause differences in the pattern of disturbance recorded. To investigate this the tide was separated into three states.

1. Low tide. The time period incorporating the lowest point of the tide and one and a half hours either side.

2. High tide. The time period incorporating the highest point of the tide and one and a half hours either side.

3. Mid tide. This is the transitional state between the above two and covers the times when the tide is ebbing and flowing. Each mid tide lasts roughly three hours.

So the whole tide is split into four equal times: high tide, mid tide(ebb), low tide and mid tide(flow).

As before the sites investigated were Redcar north beach and Redcar south beach.

The number of disturbances recorded on Redcar north beach at different tide conditions are shown in Table 8.

Table 8. Number of disturbances caused at Redcar north beach at different tide conditions.

Tide position	Low tide	Mid tide	High tide
Duration of observation.	3 hours	10 hours 15 mins.	2 hours 45 mins.
Number of disturbances caused by adults.	0	7	0
Number of disturbances caused by adults and children.	0	0	0
Number of disturbances caused by children.	0	0	0
Number of disturbances caused by dog-walkers.	1	25	1
Number of disturbances caused by other sources.	0	3 joggers 3 Windsurfers	0

The rates of disturbance for these results were calculated and are shown in Table 9.

Table 9. Rates of disturbance occurring at Redcar north beach during different tide conditions.

Tide position	Low tide	Mid tide	High tide
Rate of disturbance caused by adults.	0/hour	0.68/hour	0/hour
Rate of disturbance caused by dog-walkers.	0.33/hour	2.44/hour	0.36/hour
Rate of disturbance caused by other sources.	0/hour	0.29/hour Joggers 0.29/hour Windsurfer	0/hour

These results show that the majority of disturbances occur during mid tide levels and that the rates of disturbance at extremes of tide were comparatively low for all types of disturbance.

Table 10. Number of disturbances recorded at Redcar south beach during different tide conditions.

Tide position	Low tide	Mid tide	High tide
Duration of observations	16 hours 15 mins.	41 hours 30 mins.	13 hours 15 mins.
Number of disturbances caused by adults	7	5	10
Number of disturbances caused by adults and children	9	5	0
Number of disturbances caused by children	4	10	1

Number of disturbances caused by dog-walkers	11	40	22
Number of disturbances caused by other sources	1 Researcher	2 swimmer 1 angler 1 vehicle	1 dingy 1 surfer

These results were used to calculate values for the rates of disturbance which are shown in table 11.

<u>Table 11. Rates of disturbance at different tide positions at Redcar south beach.</u>

Tide position	Low tide	Mid tide	High tide
Rate of disturbance caused by adults	0.43/hour	0.12/hour	0.75/hour
Rate of disturbance caused by adults and children	0.55/hour	0.12/hour	0/hour
Rate of disturbance caused by children	0.25/hour	0.24/hour	0.08/hour
Rate of disturbance caused by dog-walkers	0.68/hour	0.96/hour	1.66/hour
Rate of disturbance caused by other sources	0.06/hour Researcher	0.05/hour Swimmers 0.02/hour Angler 0.02/hour Vehicle	0.08/hour Dingy 0.08/hour Surfer

These results show that the Redcar south beach was used by different groups depending on the state of the tide. On their own, adults caused disturbance mainly during low and high tide. Families tended not to cause disturbance at high tide. The rates of disturbance caused by dog-walkers increased as the tide rises. During low tide the major sources of disturbance were adults, families and dog-walkers. At other times dog-walkers continued to dominate as the major source of disturbance.

(v). Loss of feeding time.

The observations made during this project showed that the birds which were disturbed reacted in one of two ways. They either took flight and flew a certain distance before landing again or they adopted and alert posture until the disturbance had passed. Both of these reactions result in a loss of potential feeding time. The values for the duration of the loss of feeding time for individual disturbances were used to calculate the total potential feeding time lost for each cause of disturbance. The number of disturbances caused by each group were then used to calculate a mean value for the length of each disturbance caused by each human activity. These value were calculated for each of the main species under study, sanderling, turnstone and oystercatchers. The results are shown in Tables 12, 13 and 14.

Table 12. Loss of feeding time suffered by sanderling.

Cause of disturbance	Number of observations	Total loss of feeding time (sec)	Mean loss of feeding time (sec)
Dog-walkers (Dogs type 2.)	6	121	20
Dog-walkers (Dogs type 3.)	11	272	25

Dog-walkers (Dogs type 4.)	13	301	23
Dog-walkers (Dogs type 5.)	2	57	29
Children	3	23	7
Adults	12	227	19
Jogger	3	78	26
Windsurfer/surfer	3	40	13
Total for all sources of disturbance.	53	1119	21

Active dogs and adults caused the greatest loss of feeding time over the course of the project. The mean loss of feeding time per disturbance can be thought of as an indicator of the intensity of the disturbances caused by the various different causes. Children caused low intensity disturbances which resulted in little loss of potential feeding time. Among the most intense disturbances were those caused by very energetic dogs and joggers.

Table 13. Loss of feeding time suffered by Turnstone.

Cause of disturbance	Number of observations	Total loss of feeding time (sec)	Mean loss of feeding time (sec)
Dog walkers (Dogs type 1.)	2	23	12
Dog walkers (Dogs type 2.)	8	154	19
Dog walkers (Dogs type 3.)	3	166	55

Dog walkers (Dogs type 4.)	1	15	15
Dog walkers (Dogs type 5.)	1	60	60
Children	2	41	21
Adults and children	2	11	6
Adults	4	70	18
Scientific researcher	1	30	30
Total	24	570	24

Dog walkers caused the greatest loss of potential feeding time for turnstone, particularly the activities of calm and active dogs. Dogs chasing the birds caused more intense disturbances but such disturbances were less frequent and so their overall affect on the birds were less than the effects caused by better behaved dogs. The potential feeding time lost due to disturbances caused by families were lower than for any other source, as was the intensity of such disturbance. The disturbances caused by adults and children were similar in their effect but those caused by adults were twice as frequent. It is notable that the intensity of disturbances caused by scientific research being carried out in the vicinity of the turnstone was double that caused by other adults!

Table 14. Loss of feeding time suffered by Oystercatchers.

Cause of disturbance	Number of observations	Total loss of feeding time (sec.)	Mean loss of feeding time (sec.)
Dog-walkers (Dogs type 1.)	2	16	8
Dog-walkers (Dogs type 2.)	4	89	22
Dog-walkers (Dogs type 3.)	6	113	19
Dog-walkers (Dogs type 4.)	3	83	26
Dog-walkers (Dogs type 5.)	4	229	57
Children	3	249	83
Adults and children	5	52	10
Adults	6	90	15
Total	33	921	28

The greatest loss of potential feeding time amongst oystercatcher was caused by children and dogs running through flocks of birds. As with turnstone the effects of families on Oystercatchers was comparatively low. Dogs on leads caused the lowest intensity of disturbances of all the possible sources of disturbance.

(vi). Impact of disturbance on feeding.

The previous section considered the total amount of potential feeding time lost due to disturbances from human activities. To attempt to gauge their impacts on the birds' overall feeding strategy, the proportion of the birds' available feeding time this loss constituted was calculated. Over the course of the project the amount of time each of the different species were under observation represents the potential time available for each species to feed. Although individuals within a species do not feed for the entire time they are under observation they have the potential for doing so. This potential is not available during the periods when the birds are being disturbed. The values for potential feeding time available and potential feeding time lost were used to calculate the figures shown in Table 15.

Table 15. % loss of available feeding time due to disturbance.

Species	Potential feeding time	Feeding time lost due to disturbances.	% loss of potential feeding time.
Sanderling	55 hours 30 mins.	18 mins. 39 seconds	0.56%
Turnstone	44 hours	9 mins. 30 seconds	0.36%
Oystercatchers	59 hours 15 mins.	15 mins. 21 seconds	0.43%

These results show that the impact of human disturbances on Turnstone was the least severe whereas the sanderling suffered the greatest impact on their available feeding time due to human disturbance.

(vii). Variations in disturbance.

One of the aims of this project was to examine the differences in species' attraction to different sources of disturbance. This was done by comparing the different distances at which bird species are disturbed. Table 16 shows the average disturbance distance caused by various human activities.

Table 16. Mean disturbance distances for Sanderling, Turnstone and Oystercatcher.

Cause of disturbance	Sanderling	Turnstone	Oystercatcher
A	16.6m	20m	19.2m
D2	20m	19m	13.3m
D3	10m	15m	15m
D4	15m	20m	13.8m
D5	15m	N\A	20m
C	16.7m	12.5m	15.8m
A+C	22m	20m	22.1m
A+D1	N\A	25m	30m
A+D2	22.9m	20m	21.7m
A+D3	15m	15m	16.9m
A+D4	15.6m	N\A	18.8m
A+D5	20m	25m	10m
A+Mixed D	15m	15m	N\A
A+C+D2	N\A	15m	17.5m
A+C+D3	10m	N\A	N\A
A+C+D4	20m	30m	N\A

C+D2	N\A	10m	N\A
Jogger	10m	N\A	N\A
Windsurfer/ surfer	13.3m	10m	N\A
Swimmer	15m	N\A	15m
Vehicle	N\A	60m	180m
Angler	N\A	35m	N\A
Researcher	N\A	25m	N\A
Dingy	N\A	40m	N\A

Differences between each species' reaction to a given disturbance type and differences within each species in their reactions to different disturbances were analyzed using two methods. The first method examined the variance in the distances at which each species was disturbed. The number of times each species was disturbed at each of five metre increments (5m, 10m, 15m, etc) was recorded for each source of disturbance. This gives a distribution of the number of times a particular human activity causes a disturbance at 5m, 10m, 15m etc. These distributions were then compared using the Wilcoxon two-sample non-parametric test to see if there is a significant difference between them.

This method was used to test whether the disturbances caused by dogs differed from those which are not. The causes of disturbance were split into two groups.

First group (Dogs): All causes of disturbance which include at least one dog.

Second group (Non dogs): Disturbances caused by adults and/or children.

Each species was tested to see if there was a difference in their reactions to the two groups. The three species, Sanderling, Turnstone and Oystercatchers were also tested to see if there were differences between the species when disturbed by one of the two groups.

The results of these statistical test are listed below.

Is there a difference in the distribution of disturbance distances caused by dogs between sanderling and turnstone?

t=0.667 df=35 0.9>P>0.5 Not significant.

Is there a difference in the distribution of disturbance distances caused by dogs between turnstone and oystercatchers?

t=0.00629 df=35 0.9>P Not significant.

Is there a difference in the distribution of disturbances distances caused by dogs between sanderling and oystercatchers?

t=0.757 df=35 0.5>P>0.4 Not significant.

Is there a difference in the distribution of disturbance distances caused by non-dogs between Sanderling and oystercatchers?

t=1.0793 df=29 0.4>P>0.2 Not significant

Is there a difference in the distribution of disturbance distances caused by non-dogs between sanderling and turnstone?

t=1.168 df=19 0.9>P>0.5 Not significant.

Is there a difference in the distribution of disturbance distances caused by dogs and non-dogs against sanderling?

t=0.56 df=35 0.9>P>0.5 Not significant.

Is there a difference in the distribution of disturbance distances caused by dogs and non-dogs against turnstone?

t=0.357 df=30 0.9>P>0.5 Not significant.

Is there a difference in the distribution of disturbance distances caused by dogs and non-dogs against oystercatchers?

t=0.00855 df=35 0.9>P Not significant.

These results show that there is no significant difference in the disturbance distances within the dog/non-dog groups.

This analysis was also used to compare tall sources of disturbance, which have a greater impact on the birds visual field, to small disturbances which are closer to the ground and which may cause less stress to the birds. The two groups considered are tall disturbers (any group including adults) and short disturbers (disturbances caused by dogs on their own and children on their own).

The results of the statistical analysis are shown below.

The comparisons between the three species within each of the two groups are shown in Table 17.

Table 17. Comparisons within tall disturbance sources using Wilcoxon two-sample test.

Comparison	Tall disturbers
Sanderling and turnstone	t=1.87 df=59 0.1>P>0.05
Sanderling and oystercatchers	t=1.66 df=59 0.2>P>0.1
Turnstone and oystercatchers	t=0.281 df=38 0.9>P>0.5

The number of disturbances recorded for short disturbances caused by Sanderling and Turnstone was too low to be used for analysis.

The disturbances caused to Oystercatchers was analyzed to see if there was a difference in the distributions caused by tall and short disturbers. The statistical test shows a value of $t=1.789$, $df=35$ $0.1>P>0.05$. Although not significant this is very close to a P of 0.05 (as is the result when comparing the disturbances caused by tall disturbers to sanderling and turnstone).

These results indicate that there might be a slight difference in Oystercatchers reaction to Tall disturbers. Reactions to taller sources may occur at slightly longer distances than for short sources. Similarly Turnstone may react to tall disturbances at slightly longer distances than do Sanderling.

The second method of analysis used the data collected on disturbance distance, combined with data on the minimum distance without disturbance to provide a value for each 5m increment which is the % probability of a potential source of disturbance at that distance causing a disturbance. To produce this value the following procedure was used. The value for disturbance at each distance were cumulated (i.e. it is assumed that a disturbance at 15m would also have caused a disturbance at 10m and 5m). The number of additional non-disturbances at each 5m increment was also cumulated, so that if a potential disturber caused no disturbance at 25m, it also caused no disturbance at 30m, 35m etc. up to a maximum of 50m. The % disturbance was then calculated using the following equation.

$$\text{\% disturbance} = \frac{\text{Number of cumulative disturbances observed.}}{\text{Total number of disturbance observations made+cumulative non-disturbances observed.}} \times 100$$

distances to tall and short disturbances.

Comparison	Tall disturbers	Short disturbers
Sanderling and Turnstone.	Chi-squared=3.904 0.9>P>0.5	Chi-squared=0.078 0.9>P>0.5
Sanderling and Oystercatcher	Chi-squared=3.6 0.9>P>0.5	Chi-squared=0.027 0.9>P>0.5
Turnstone and Oystercatcher	Chi-squared=0.0397 0.9>P>0.5	Chi-squared=2.72 0.1>P>0.05

Table 21. Comparison of different species' reaction distances to tall and short disturbances.

Comparison	Comparison between tall and short.	
Sanderling	Chi-squared=0.000497	P>0.9
Turnstone	Chi-squared=1.92	0.5>P>0.1
Oystercatcher	Chi-squared=0.76	0.5>P>0.1

The results of the second analysis confirm the conclusions drawn from the first, i.e. that none of the statistical tests showed a significant difference both within and between species.

DISCUSSION.

(i) The nature of disturbance at different study sites.

The first question addressed by this project was which disturbances are the most common. The results show that they are those sources of disturbance to foraging shorebirds on the Cleveland coast caused by people exercising their dogs. The dog-walkers observed ranged from a single adult exercising one dog to large family groups exercising as many as five dogs. Beaches are popular sites for dog-walking for several reasons, but particularly because they are large open spaces with plenty of room for the dogs to run freely. The high rate of disturbance caused by dogs is not only due to their numbers but also because many, particularly large dogs off the lead, range over a large area while on the beach and often move very quickly, certainly when compared to their owners. This is the main reason why disturbances caused by a group containing dogs are a result of the birds reacting to the presence of the dog rather than the humans accompanying it.

Adults using the beach by themselves usually behave quite differently. Most people walking along the beach travel quite slowly and even when travelling with other people they stay close together. In comparison joggers, who travel faster and with greater distances between them, cause more intense disturbances (i.e. birds react at a greater distance) and cause a greater loss of potential feeding time.

Walkers, both adults and children, and dog owners were the only sources of disturbance which occurred regularly. All other sources of disturbance were observed only rarely. Some of these were intense, resulting in a high loss of feeding time but nevertheless did not have a significant effect on the shorebirds' total feeding time. As shown in Table 12. the total loss of feeding time caused by such disturbances were low, totalling less than two minutes. The work done by Zegers(1973) has shown that when highly disruptive disturbances are separated so that there is time between the disturbances for the birds to recover, the overall loss of feeding time is reduced.

The four sites studied varied in respect of the frequencies of disturbances, the variety of disturbance sources observed and in their use by different shorebird species. Much of this variation can be accounted for by their different locations and variation in substrate. Redcar south beach comprises areas of sand and rocky outcrops which become gradually more exposed as the tide recedes. This provides a varied habitat which attracts many bird species, including all four of the species studied in this project. Particularly common were Oystercatchers. This kind of beach is also particularly attractive to children and families, who often explore the rocky outcrop, searching for shellfish and investigating the rock pools and intertidal wildlife found there. This resulted in far higher disturbances caused by children and families than was observed at any of the other sites and these disturbances are almost always confined to low and mid tide when the rock outcrops are exposed (Table 11.).

In contrast the majority of disturbances on Redcar north beach were caused by people walking along the beach and dog-walkers. Redcar north beach is particularly suited to these activities. It is large, stretching from the start of Redcar promenade and stretching for about 2kms to the southern breakwater at the mouth of the Tees (South Gare). At high tide there is still a substantial width of sand between the dunes at the top of the beach and the waterline, unlike Redcar south beach where high tide leaves only a strip of shingle beach about 20m wide. Another difference which makes Redcar north beach attractive to dog-walkers is that the beach is separated from the main road by a car park whereas Redcar south beach lies immediately adjacent to the busy road which runs along Redcar promenade. (The potential danger this poses explains why Redcar south beach is the only location where some dogs were being walked on a lead (Table 2.)). The sandy nature of the north beach means that the diversity of birds at the site was less, with only Sanderling and Oystercatcher being observed.

One of the main reasons for the differences in disturbance rates observed at Redcar north beach and Redcar south beach is connected with the effect the tide has on the two beaches. At Redcar north beach the main effect of the tide is to change to amount of sand available for use. Most of the disturbances caused by people using the beach are at mid tide.

Redcar south beach is quite different. At low tide the rocks are exposed and the birds tends to feed more as different food items become available. The activities occurring on the beach are also affected by the presence of rocks. At low tide a lot of shell collection and exploration of the rocky outcrops occurs. At high tide disturbers like surfers and boat users use the beach because that is the only time the rocks are covered and access to the sea is a lot easier.

The levels of disturbance recorded at Seaton Carew were lower than at Redcar. There may be several reasons for this. One was its location. Compared to Redcar, Seaton Carew is a smaller resort with a lower number of visitors during the tourist season. It is close to Hartlepool and doubtless many of its visitors come from there; but there are also several other beaches, including Crimdon Dene, within a short distance from Hartlepool. Another factor which may reduce the number of visitors is the nature of the substrate found on the beach. As shown in Fig. 3. the beach is a mixture of sand and shingle and many parts are covered by patchy layers of coal dust. These factors combine to reduce the aesthetic quality of the beach compared to more sandy beaches like Redcar north beach and this may reduce its attractiveness to visitors. It does however increase the diversity of the bird species found at the site. The results indicate that the level of disturbance caused by vehicles visiting the beach in order to collect sea coal is very low, with only one such disturbance recorded during the cause of the project. Several vehicles were observed visiting the beach but they usually caused no interference to the birds because they usually collected coal from the high water mark while birds were feeding from the waterline. It is even possible that coal collection on the beach actually reduces the levels of disturbance, by discouraging other visitors, such as dog-walkers from visiting the beach.

The disturbance rate recorded at Crimdon Dene was very low. Although the site is a large, attractive sandy beach it may be that its relative isolation and position at the end of a short access road go some way to explaining the low number of people visiting it. As with Redcar north beach the site had only sanderling and oystercatcher present. A nearby caravan site would provide many of the visitors to the beach during the height of the holiday season but this occurred after observations had ceased.

(ii). The effects of disturbance on birds.

The effects of disturbance on birds may include stress and a movement away from their original feeding sites to alternative feeding sites but one of the most important is the energetic consequences of potential feeding time lost as a result of disturbance. The results show the potential feeding time lost by three of the species involved in the study. The two factors which determine this are the frequency with which disturbances occur and the average loss in feeding time which results from each type of disturbance. Although the total feeding time lost is a reasonable measure of the impact of disturbance on shorebirds, there are factors affecting loss of feeding time which were not recorded but which may well be important. One of these is the effects of acclimatization. Birds may become used to particular types of disturbance and the impact of these disturbances become less each time the bird experiences them. For example, some birds have been shown to become accustomed to particular types of low-flying aircraft (Koolhaas et. al. 1993). When new types of aircraft appeared the impact of disturbance increased, probably because the birds were unfamiliar with that type of plane. Another factor which affect the impact of disturbances is the time between them. Mean loss of feeding time might be higher for some disturbances if they occurred very close together. Certain disturbances which occurred further apart were found to have less of an effect on certain shorebirds.

With this in mind, the results I obtained showed that the causes of most loss of feeding time were walkers and dog-walkers. The effects of dog-walkers were greater than those caused by people alone. Amongst different types of dog-based disturbances there was a marked difference between species of bird. Sanderling lost most feeding time because of disturbances caused by active dogs. Turnstone lost feeding time to an equal extent in response to both calm and active dogs. Although calm dogs caused less disturbance during each individual disturbance they caused far more disturbance in terms of total feeding time lost. The frequency of disturbance is partly a factor of the birds tolerance to nearby dogs and partly a result of the sites where the birds are found and the chance of encountering dogs at such sites.

The only really clear conclusion which can be drawn from the results is that the more active dogs are not always responsible for the greatest loss of feeding time. Dogs chasing birds certainly cause the birds to cease feeding for a relatively long time, but such disturbances were comparatively rare. Dogs running down the beach into the sea did not always cause more disturbances than dogs running parallel to the shore. It may well be that dogs walking along the shore have quite a substantial effect, not because the birds are particularly disturbed by the dogs presence but because, when the birds fly away from the dog to a position maybe 100m or so along the shore, they will be disturbed by that dog again and again, either until the dog moves off in another direction or the birds fly to a point behind the dog.

The reason why dogs cause more disturbance than people may be less complex. Dogs on the beach are usually moving faster than their owners, often running away from their owners and then running back to them. The results of the test for disturbance distance have shown that the bird species studied do not react significantly differently to disturbances caused by short and tall disturbers so the dogs' low profile is unlikely to mean that birds perceive them as less of a threat than people. The fact that some dogs charge into flocks of bird may also mean that birds are slightly more wary of dogs in general.

An important question which needs to be considered in the project is possible bias in the number of observations recorded. As shown in Table 1. the number of hours recorded at each site varied considerably. The amount of time spent at each site was organised to gain the maximum number of recorded disturbances but this has resulted in areas with little disturbance becoming under-represented within the results. By spreading the observations out evenly over the different sites this problem could be avoided and disturbance rates at each site more accurately compared. A more accurate description of the disturbance rates at the under-represented sites would also be gained were the observations spread out more evenly.

When looking at other research into shorebird disturbance, the results of this project compare well with work by Kirby et. al. (1993). As in their project, the main disturbances I recorded in this work were dog-walkers and walkers. Both projects also recorded a wide variety of disturbances including windsurfers, boats and vehicles. Many of the sources recorded in their work, e.g. horse riders, cyclists, were also observed in this project, although in Cleveland they did not produce any disturbances. My project results also agree with those of Burger (1981) who recorded high levels of disturbance caused by joggers.

Compared to other projects (Scott 1989) the levels of disturbance I recorded from certain activities were either far less or entirely absent. These included disturbances caused by fishermen and bait diggers. South Gare was particularly popular with bait diggers, but disturbance levels were extremely low. This can be explained by the nature of the sites studied. Redcar and Seaton Carew are both seaside resorts and although the sites are used for activities like windsurfing, coal collection and launching fishing boats, other activities, such as wildfowling, low-flying aircraft, bait digging, many of which have been identified in other studies, had no effect on the shorebirds at my sites.

The overall impacts of disturbance on the shorebirds studied in this project are shown in Table 15. Although these impacts are not particularly high the values for potential feeding time are not entirely accurate. Oystercatchers in particular are restricted in the times at which they can feed to when their food is exposed at low water. At Redcar south beach, where most of the disturbances involving Oystercatchers were observed, the main disturbances occurring when the rocks were exposed were caused by dog-walkers, with relatively high levels of disturbance caused by people exploring the rocks.

In conclusion, this study has shown which disturbances are common and attempted to quantify the impact on bird feeding. Whether this impact has a significant effect on the birds and whether population levels suffer as a result is harder to quantify but I find it hard to believe that even a 0.56% loss of potential feeding time has a substantial effect of birds. This seems reasonable considering that the observations were concentrated around times when disturbances were commonest and actual % loss of feeding time may well be lower. Whether disturbances occurring during the height of the birds feeding activity, e.g. Oystercatchers at low tide, have a more significant effect is hard to tell but it seems clear that the results obtained cannot be used to justify imposing any restrictions on beach use, particularly when disturbances which might be thought to cause substantial impact, e.g. coal collection, have been seen only the occasionally.

APPENDIX A.

Data collection sheet.
M.Sc. Disturbance project.

DATE WEATHER SITE

Time	Dist	Species	Substr-ate	Alert	Scat-ter	Fly time	Fly dist

APPENDIX B.

Key describing causes of disturbance observed.

Source of disturbance.	Description.
A	Adults (Roughly 15+).
C	Children (Roughly below 14 years).
D1	Dogs on a lead.
D2	Loose well-behaved dogs.
D3	Loose excited dogs running parallel to the shore.
D4	Loose excited dogs running down shore towards sea.
D5	Loose excited dogs chasing birds.

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