The Impact of Boat Disturbance on the Grey Seal, (*Halichoerus grypus*) around the Isle of Man

by

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Declaration and Statements

This work has not previously been accepted in substance for any degree and is not being concurrently submitted for any degree.

This dissertation is being submitted in partial fulfilment of the requirement of M.Sc. Marine Biology.

This dissertation is the result of my own independent work / investigation, except where otherwise stated.

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Abstract

Due to their coastal habitat and curious nature, grey seals (*Halichoerus grypus*) are often subject to anthropogenic disturbance from boat users and pedestrians. This can have many negative impacts upon the species, such as reducing the time they are able to spend resting and changing their haul-out patterns. Disturbance has been shown to be extremely detrimental during the breeding season, as it may interrupt lactation or cause separation of the mother and pup.

This study examined the behaviour of grey seals whilst in the water and hauled-out, in order to gain a full picture of how the seals are impacted by boat disturbance. Observations were made at two sites on the Isle of Man, one that was subject to large amounts of boat disturbance, whilst the other received minimal disturbance. In-water surveys involved focal follows of individual seals in order to construct behavioural budgets, and to record the responses of focal seals to boat disturbance. Haul-out surveys were conducted to record general count data, levels of vigilance and response to disturbance.

The proportion of time that seals in the water spent 'bottling,' (a form of rest at the surface of the water) was found to be significantly different between sites (U = 8.000, p = 0.04). On the other hand, the overall time spent resting was similar. A significant correlation was found between boat speed and the distance at which hauled seals showed alert behaviour ($X^2_{(14)}$ = 0.55, p = 0.04). There also appeared to be a similar association between boat speed and movement and flushing response (entering the water), but this was not tested due to small sample size. The duration of the boat interaction was found to be important, with flushing occurring in all interactions lasting four minutes or longer.

Due to unusually poor weather during the study, seals at the disturbance site were not subject to as high a level of boat traffic as is normal. However, boat disturbance would likely be much higher during good weather, and this location is close to a breeding site where seals are particularly vulnerable. Therefore stricter enforcement is needed to protect seals from the effects of disturbance.

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Chapter 1

Introduction

1.1 Project aim

The aim of this study is to assess the impact of boat traffic on the behaviour of the grey seal (*Halichoerus grypus*) whilst hauled-out and whilst in the water, in an attempt to determine whether boat traffic is causing significant disturbance to the grey seal population on the Isle of Man. This study also aims to determine how disturbance may be affecting this species and what measures could be introduced in order to mitigate any disturbance caused to the grey seal population.

1.2 The grey seal, *Halichoerus grypus*

1.2.1 Classification, Distribution and Abundance

The grey seal population consists of two sub-species; the Atlantic population, (*Halichoerus grypus grypus*), which occurs on both the eastern and western sides of the Atlantic, and the Baltic Sea population (*Halichoerus grypus macrorhynchus*) (Figure 1.1a). The two sub-species of grey seal have been recognised due to geographical separation and differences in the timings of their breeding seasons (Rice, 1998). Previously, the species had been split into three sub-species, with the Atlantic population split into an eastern Atlantic and a western Atlantic population and this distinction is still frequently used (Bonner, 1982). The population of interest in this study is the eastern Atlantic population, which is distributed primarily around the coasts of the United Kingdom and Ireland, as well as the Faroe Islands, Iceland, Norway and Northwestern Russia (Bonner, 1979). The United Kingdom is an extremely important location for grey seals, as approximately 45% of the world's grey seals breed around the United Kingdom, with 90% of these breeding colonies found in Scotland (Hammond et al., 2008, SCOS, 2010).

(a) (b)

Figure 1.1(a): The worldwide distribution of the grey seal. Image sourced from: http://www.eoearth.org. **(b):** The distribution of grey seals around Great Britain. Image sourced from: http://www.marlin.ac.uk

Although grey seals are distributed throughout the British Isles, the majority of the colonies are found on the western coast. The largest breeding colonies are located in Scotland, but smaller breeding colonies can also be found in Cornwall, along the Welsh coast and in the Isle of Man (Hammond et al., 2008; Baines and Evans, 2012) (Figure 1.1b). It is estimated that there are 182,000 individuals found around the UK. This number is calculated on the basis of pup production, which is monitored using a variety of aerial photography and ground counting survey techniques, as errors are likely to occur when reading the photographs from aerial surveys alone (Myers and Bowen, 1989). Pup production surveys have shown that the grey seal population in the UK has been increasing over the last few decades but is now beginning to show signs of levelling off (Duck, 2010). Consequently, the conservation status of the grey seal is currently listed by the IUCN Red List as being of Least Concern (Thompson and Härkönen, 2008). Another species of phocid seal, the harbour seal, or common seal (*Phoca* *vitulina*), is also a resident species to the UK. This species is far less numerous than the grey seal, counts in 1996 and 1997 recorded 32,825 individuals (Duck, 2010) and counts between 2002 and 2007 recorded 23,277 individuals (Frost and Hawkridge), indicating a decline in their population. Although the harbour seal is often hauled-out alongside grey seals, it is not difficult to identify one species from the other, with differences particularly in their head shapes. The harbour seal has a much smaller head and nose, with a rounded crown rather than the flattened crown seen in grey seals (Lerwill *et al*., 2003) (Plate 1.1).

Plate 1.1: Comparison between the harbour seal (left) and the grey seal (right), showing the difference in head shape and profile between the two species. Images sourced from Lerwill *et al*, 2003.

1.2.2 Grey Seals in the Isle of Man

The Isle of Man is an important location for the grey seal, with seals found at many sites all around the island (Travers, 2005) (Figure 1.2). The grey seal population on the Isle of Man has increased substantially over the last five decades, from a mean count of 20 individuals in the 1960s to a monthly mean of 220 individuals in 2007 (Manx Bird Atlas, 2007). The south of the island, around the area which encompasses the Calf of Man, Kitterland and Chicken Rock, has the largest concentration of grey seals and forms the main haul-out area for the species on the Isle of Man (Figure 1.2). This may be due to the fact that the coastline in this area provides shelter to the seals from all wind directions, so that the abundance of seals within sub-areas of this site can vary greatly with wind direction. This area has also been reported to be the most heavily used by pleasure boaters and coastal fishing vessels (Manx Bird Atlas, 2007). As a result of this, seals at the Calf of Man, Kitterland and nearby areas are likely to be subject to disturbance and suffer from the effects of high levels of boat traffic, as discussed further in section 1.3.7.

The Isle of Man is an ideal location for studying the impact of boat disturbance on grey seals. This is partly because the seals at the area around Kitterland are subject to large amounts of boat traffic and also because they are easily observable from the cliff tops that are around 100 – 200 m away, dependent on the exact location of the seals. At this distance the seals can be clearly seen, but the observer is far enough away to cause minimal disturbance to the colony. The Isle of Man is also a suitable location in that there are numerous other haul-out sites around the island that have minimal boat traffic compared with that of Kitterland. This allows comparisons to be made between the behaviour of grey seals at a heavily disturbed site against a minimally disturbed site.

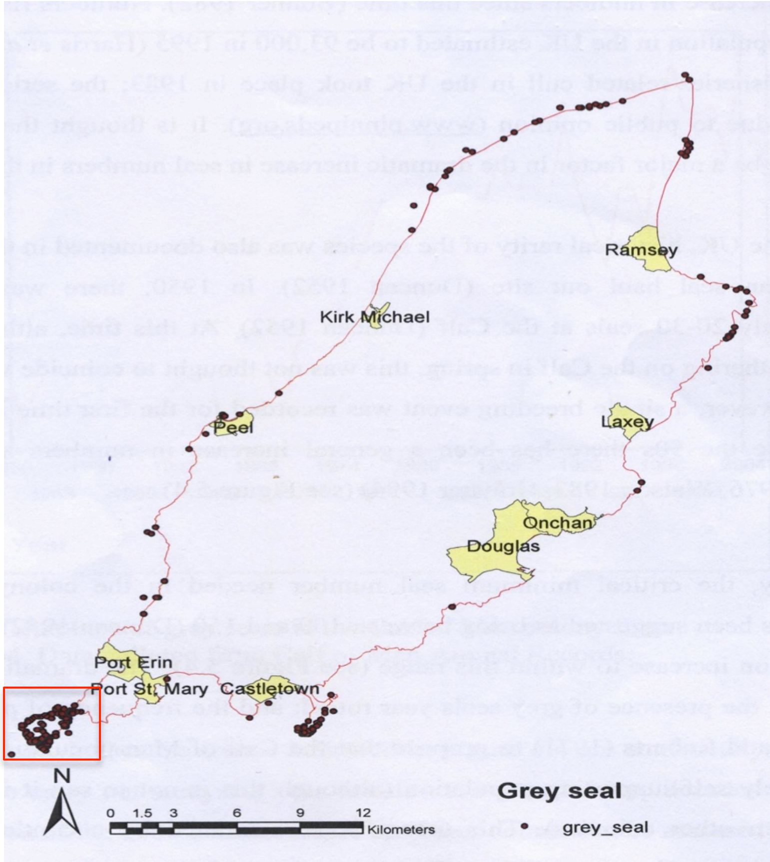


Figure 1.2: Distribution of the grey seal (*Halichoerus grypus*) around the Isle of Man, with the primary haul-out site found on the South of the Island outlined in red. Mapped using records from the Manx Bird Atlas 1998-2004. Image sourced from Travers, 2005.

1.2.3 Sexual Dimorphism

The grey seal is a sexually dimorphic species, and males and females can easily be identified from one another. Males are the larger sex, with an average body length of 2 m and weight of 233 kg, compared to 1.8 m and 155 kg for females (Thompson and Härkönen, 2008). Males also have a darker pelage colouration, usually having a dark coat with lighter patches, with females having a lighter coat with darker patches (Bonner, 1982; Hammond et al., 2008). The shape of the head also differs between the sexes; males have a large convex 'roman' muzzle and thickset shoulders due to buildup of scar tissue from fighting during the breeding season, whereas females have a much more slender head and shoulders in comparison (Bonner, 1982; Nowak, 2003; Hammond et al., 2008).

In terms of their life histories, females reach sexual maturity at a younger age, beginning to breed from the age of 5 years, with males not breeding until the age of 10. The life expectancy is also different, with average life expectancies of 30 and 20 years for males and females respectively (SCOS, 2010). Male and female grey seals may also differ in their behaviour. For instance, it has been found that males perform deeper dives than females, whereas females perform longer dives than males (Beck *et al*., 2003). The dives of grey seals have been noted as lasting an average of around three minutes, with the capability of remaining submerged for up to around nine minutes (Hammond *et al*., 2008)

1.2.4 Diet

Grey seals are generalist coastal feeders, foraging on the seabed at depths of up to 100 m (Duck, 2010). The majority of their food comprises a wide variety of locally abundant fish, predominantly sandeels and gadoids, and smaller quantities of cephalopods and crustaceans (Bonner, 1982; McConnell et al., 1999; Hammond and Grellier, 2006; Hammond and Harris, 2006). The stomach contents of two grey seals from the Isle of Man showed that their diet consisted primarily of fish, mainly *Gadus luscus*, otherwise known as bib or pout and *Gadus virens* (pollack), as well as bottom feeding crustaceans (Duncan, 1956). However, the diet of the grey seal may vary temporally as well as seasonally and geographically (Duck, 2010).

Grey seals occupy a high trophic level and do not have a large number of predators. Killer whales sometimes predate grey seals, but it is unlikely that this poses a significant threat to the East Atlantic population. It is also thought that the Greenland shark may predate grey seals in the UK. However, the largest threats to grey seal populations around the UK come from factors other than predation, as discussed in section 1.3.

1.2.5 The Annual Life-Cycle

The breeding season for grey seals around the UK occurs in the autumn, from late September until November (Bonner, 1982). There is variability in birth date around the UK, with seals in the South-west breeding first; then the birth dates follow a clockwise cline so that the colonies on the southern North Sea coast are the last to breed (Duck, 2010). It is possible that this clockwise cline in the timing of the breeding season is related to sea temperature (Coulson, 1981). The seals haul out during the breeding season, usually upon uninhabited islands and coasts, or in caves where exposure to harsh environmental conditions and anthropogenic disturbance will be minimal (Duck, 2010). Considerable site fidelity is shown in grey seals, with females returning to the same breeding sites year upon year, and around 70% of seals remain near to the area of their birth (Pomeroy et al., 1994; Corbet and Harris, 1991). The females give birth to a single, white-coated pup, which rapidly gains weight during the 16-18 day lactation period. Female grey seals fast throughout the lactation period, and therefore energy stores from the time of birth must be sufficient to support both maintenance metabolism and milk production (Mellish *et al*., 1999). It has been shown that female grey seals in the UK lose an average of 65 kg during the lactation period (Fedak and Anderson, 1982). Once the lactation period is over, the female seals may be mated with, perhaps several times, by the males that are present at the breeding site. The males may remain at the breeding sites for up to eight weeks, during which time they do not feed, in order to establish their territory. The total gestation period for grey seals is 11.5 months; this includes a three month delay in the implantation of the fertilized egg (Bonner, 1977).

1.2.5 The Importance of Haul Out

It can be seen from the previous section that the ability to haul out onto land is extremely important for grey seals during their annual life cycle. Firstly, grey seals aggregate on land during the breeding season from October to November in the UK in order to give birth, suckle and mate, and again in the months of January to March in order to moult (McConnell *et al*., 1999). Some pinnipeds haul out only during the breeding season and to moult. However, some species, such as the grey seal, haul-out throughout the year (Watts, 1996). This need to haul out has been attributed to a number of factors, the main one appearing to be the need to rest or sleep (Kreiber and Barrette, 1984; Brasseur *et al*., 1996; Da Silva and Terhune, 1988). Other factors that have been attributed to the need to haul out include thermoregulation (Watts, 1992), predator avoidance (Da Silva and Terhune, 1988; Watts, 1992), sociality (Kreiber and Barrette, 1984), vitamin-D synthesis (Watts, 1996), and routine skin growth and maintenance (Watts, 1996). Not all surfaces are suitable for pinnipeds to haul out upon, with haul-out sites usually requiring the following features: easy access to deep water (Terhune and Almon, 1983), a flat surface with a gentle slope leading to the water (Pauli and Terhune, 1987), and protection from waves and other elements (Sullivan, 1980).

1.3 Threats to the Grey Seal

There have been a large number of threats to grey seal populations throughout history, mostly due to interactions with humans. The threats may be direct, such as hunting, or indirect, such as pollution or habitat loss (Bonner, 1978). The following are not an exhaustive list of threats faced to grey seal populations worldwide throughout history, but are restricted to those particularly faced by the UK population of grey seals today.

1.3.1 The Fishing Industry

As grey seals forage in coastal waters, there is a large potential for interactions between the seals and the fishing industry, and as a result of this, grey seals are subject to a number of threats from fishing. Predation by grey seals has long been claimed to be a large factor in the decline of certain fish stocks, and cases of damage caused to fishing gear, such as nets and traps, by grey seals are well documented (Thorne-Miller, 1999). Although grey seals are protected in the UK (see section 1.4), it is legal under the 'Fisheries Defence Clause' of the Conservation of Seals Act, 1970 for fishermen to shoot seals that are causing damage to their gear or catch. Although the number of seals killed under this clause is uncertain, as a licence is not needed and there is no official reporting process, it has been estimated that in Scotland alone, several thousand grey and harbour seals are killed each year under this clause (Thompson *et al.*, 2007). Only seals that are killed under a licence granted by the government during their closed season (1st September – 31st December for grey seals) are reported. An example of the legal killing under licence is shown by salmon aquaculture companies in Scotland, which were reported by the Scottish government to have killed 229 seals in 2011, and a further 81 in the first four months of 2012 (URL 1). New Scottish legislation has recently been enforced which will allow a more realistic figure of the number of seals deliberately killed per year to be reported. However, the rest of the UK is yet to follow suit in enforcing a similar legislation (see section 1.4 for further details).

In addition to legal shooting of seals under the 'Fisheries Defence Clause' and under licence, many cases of illegal shooting of grey seals have been documented in the UK. A good example of this is the many instances of shootings in the Orkney Isles. Just a few of these cases include eight seals killed in 2001, 19 pregnant females and one juvenile in 2002, and a further four pregnant females and a juvenile in 2006. Illegal shootings have been occurring for a large number of years and, although rewards are often offered for evidence that can result in a conviction, the perpetrator is rarely caught.

Since grey seals feed on a number of commercial fish species, such as cod or salmon, they are often found congregated around fishing operations in an attempt to feed on the fish that are caught in the net, or the fish discards (Bjørge *et al.*, 2002). Consequently, seals may become trapped in the net and be caught as by-catch or become injured in fishing gear (Wickens, 1994). A tagging study on grey seals in Norway found that incidental mortality in fishing gear accounted for 79% of recovered grey seals, and that young seals up the age of eight months were the most vulnerable to incidental mortality in fishing gear (Bjørge *et al.*, 2002). Although this suggests that by-catch of seals by net fisheries might be a significant threat to seal populations, this is only examining the extent of grey seal by-catch in Norway, where fishing practices differ from those in the UK. The extent of seals caught as by-catch is actually poorly understood, as there is no official monitoring process (Bass, 2004). The Sea Mammal Research Unit (SMRU) cetacean observer scheme suggests that seal by-catch in the UK fisheries is at low levels, but more research is needed to confirm this (SCOS, 2003).

It is also possible that seals may be killed by 'ghost nets,' which are nets that have been lost whilst fishing. The fishing capacity of ghost net varies depending on net type. However, it has been shown that gill nets catch fish up to 70 days after deployment (Kaiser *et al*., 1996). As pinnipeds are susceptible to entanglement in marine debris, it is likely that ghost nets present an additional source of injury or mortality (Henderson, 1984). The significance of ghost nets as a source of mortality is difficult to assess, but seals are frequently recorded entangled in discarded netting or with distinctive scars as a result of entanglement (Balazs, 1979; Kenyon, 1980).

The fishing industry can also pose a threat to the grey seal population by the direct removal of their prey species. As the target species become overfished, fishing efforts may begin to focus on species at lower trophic levels (fishing down the food chain). This will result in a simplification of food webs, and seals, along with other predators, will not have many options for prey switching. This could be important as the abundance of prey species fluctuates, either due to fishing effort or environmental fluctuations (Pauly *et al*., 2002). As well as a direct removal of their prey species, the fishing industry may reduce prey species further by destroying their habitat with fishing gear such as trawlers or dredgers, again resulting in less options for prey switching when needed (Thompson and Duck, 2010).

Management of fisheries-seals competition usually involves estimating how much of the shared resource is removed by each of these competitors. However, management actions will vary depending on ecological complexity and it is important that the main sources of this (spatial heterogeneity, individual variation, multi-species interactions and long-term dynamics) are considered in any scientific advice provided (Matthiopoulos *et al*., 2008).

1.3.2 Pollution

Grey seal populations may be at risk from marine pollution, especially from persistant organic pollutants (POP's). These include polychlorinated biphenyls (PCB's), polybrominated biphenyls (PBB's) and dichlorodiphenyltrichlorethane (DDT), which are persistent chemicals that concentrate through the food chain and accumulate in predators such as seals (Hutchinson and Simmonds, 1994). These pollutants have been shown to be harmful to grey seals in many ways: they can affect their immune system, interrupt hormone regulation, affect their fertility rate and cause skeletal abnormalities (Thompson and Duck, 2010). As these compounds are lypophilic, they are passed from mother to pup during lactation and will comprise a substantial proportion of the entire amount of contaminants that the pup will acquire during its life time (Ross et al., 2000; Hall et al., 2009). It has been shown that this accumulation of POP's can negatively affect the first year survivorship of grey seal pups (Hall *et al*., 2009). As females transfer a substantial amount of contaminants to their offspring, male seals usually have a larger concentration of contaminants as they will accumulate these contaminants throughout their life time (Hutchinson and Simmonds, 1994). Chemical pollution is an especially large problem in the Baltic Sea, as it is small and relatively enclosed, and it is thought that lesions and illnesses found in the Baltic Sea grey seal population can be attributed to this pollution (Olsson *et al*., 1994). Chemical pollution is not, however, thought currently to be a large problem for grey seals in the UK. Reijnders (1986), showed the difference in the concentation of contaminants between the Baltic and East Atlantic populations of seals. In this study, harbour seals that fed on fish from the Baltic, which contained a high level of PCBs, were found to have a significantly lower rate of reproductive success than seals that fed on fish from the North-east Atlantic. This gives evidence that accumulation of contaminants due to feeding on fish in polluted areas can result in reproductive failure (Reijnders, 1986).

Although there is concern about the health effects of grey seals coming into contact with oil spills, there is little evidence to suggest that oil spills negatively impact upon the survival of the seal. For example, seal and pup production surveys carried out after the *Sea Empress* oil spill at Millford Haven, South Wales in 1996 showed that the spill did not appear to have affected pup production or mortality, nor the condition of the seals or the size of the haul out figures (Strong, 1997; Strong, 1998). In addition to this, the behaviour of oil-covered seals did not seem to differ from the behaviour of non-oiled seals after a separate oil spill in Pembrokeshire, West Wales and no difference was found in the mortality of oiled and non-oiled seals (Davis and Anderson, 1976). However, although no change in behaviour was found, it is possible for oil spills to impact seals in other ways. An oil spill off Ramsey Island showed that the majority of grey seals appeared to be unaffected by their oil coating, but two seals were washed off beaches and subsequently died. Although the oil spill was thought to play some role in their mortality there was no conclusive evidence which showed this (Davies, 1949). It is also possible that an excessive oil spill would not allow seals to move through or away from the contaminated areas, especially those seals which are particularly vulnerable, such as pups or juveniles (Thompson and Duck, 2010).

1.3.3 Disease

In addition to the diseases caused to grey seals by an accumulation of pollutants, there have also been outbreaks of a viral disease known as phocine distemper virus (PDV). This virus caused mass mortality of harbour seals and grey seals in 1988 and again in 2002. Although this virus has been a more serious cause of mortality for harbour seals, resulting in the death of 17,000 individuals in 1988, it has also been a significant cause of mortality for grey seals, resulting in the death of 300 grey seals in the same year (Hall et al., 1992; Härkönen et al., 2006; Lerwill et al., 2003). The symptoms of PDV include respiratory problems such as coughing, nasal and optical discharge, fever, a reluctance to move, subcutaneous emphysema of the head and neck and problems with the central nervous system. The disease also results in an inability to dive and therefore feed, and the cause of mortality is usually a secondary infection such as pneumonia (Lerwill *et al.*, 2003).

1.3.4 Habitat Loss

As mentioned in section 1.3.1, habitat destruction of the seabed by various fishing practices, such as trawling and scallop dredging, will reduce the amount of habitat available to prey species and may therefore affect the distribution or abundance of grey seal populations as a result. However, habitat loss may also have a more direct impact upon grey seal populations. For example, intensive industrial development along the Tees River was attributed to be at least partially responsible for reducing a population of around 1000 harbour seals at the start of the 19th century to three animals in 1862, and then to none by 1930. This was due to the reduction in essential haul-out sites, as well as disturbance and increased pollution (Woods, 2012). Although this was observed in harbour seals, it is feasible that a similar situation could arise with grey seals. However, as seals are mobile animals, which are capable of finding other suitable haul-out sites should their original site be lost, habitat destruction is not thought to be a large threat to their population (Bonner, 1978).

1.3.5 Climate Change

The effect that climate change will have on grey seal populations is not yet clear. However, a few predictions can be made. The greatest impact is likely to be the change in the distribution of fish species, which in turn will alter the seal populations and their own distributions (Thompson and Duck, 2010). Although grey seals have a varied diet, the overexploitation of their prey species by the fishing industry will reduce the seals' opportunities to prey-switch, should this need arise due to their re-distribution, as discussed previously in section 1.3.1. Climate change may also result in the removal of breeding and haul-out sites, but it may also make new sites available in the process, so this may not be problematic (Thompson and Duck, 2010). Another hypothesis that has been put forward is that the rising sea temperature may increase the prevalence of toxic algal blooms, the occurrence of which have already been increasing in recent years. Harmful algal blooms can occur in coastal waters worldwide with four classes of algal toxins demonstrated to cause marine mammal mortality (Van Dolah, 2005). Seals and other marine mammals can be exposed to the harmful toxins directly through the respiratory system, or indirectly via food web transfer. Depending upon the toxin, symptoms may include loss of motor control, incoherence and death from respiratory paralysis, among others (Van Dolah, 2005). Although no mortality has been reported from toxic algal blooms on either of the seal species present in the UK, algal blooms are often reported, and it is thought that stranded harbour seals found in Scotland may have had high algal toxin levels (SCOS, 2008). Anthropogenic activities may also have contributed to the recent increase in toxic algal bloom events, via activities such as nutrient loading, overfishing, and the transportation of harmful species to novel environments (Van Dolah, 2005).

1.3.6 Marine Wind Turbines

It is likely that grey seal populations will face some negative impacts from the construction and operation of marine wind farms, due primarily to noise from an increase in ships and from the construction process, the physical presence of the turbines, and the loss of habitat near to the wind farm (Dietz *et al*., 2000). It has also been shown that seals suffered a reduction in the time they were able to spend resting due to disturbance by pile-driving activity during the construction phase (Tougaard *et al*., 2006). However, no overall change in abundance of seals was found during construction and no change in the behaviour of the seals could be attributed to the construction and presence of the turbines either to seals in the sea or on land (Tougaard *et al*., 2006).

1.3.7 Boats and Disturbance

The impact of boat disturbance on marine mammals, including seals, is a topic that has been of increasing importance in recent years. This is likely in part to be due to the increase in both commercial and recreational boat traffic. The worldwide commercial fleet, which includes vessels such as container ships and tankers, has grown from approximately 30,000 vessels in 1950 to approximately 85,000 vessels in 1998 (Southall, 2005). Recreational boat traffic has also increased due to the increased human interest in water-based activities such as sailing and kayaking, amongst many others (Evans, 2003). As grey seals are an easily observable coastal species, they are often the subjects of attention for recreational boat users, and for the same reason there is also a substantial amount of tour boats that engage in seal watching. In 1997, it was reported that there were 117 tour boats engaged in seal watching around the UK and Ireland, and it is likely that this number has increased further since then (Young, 1998). Although there are many benefits to the increase in tour boats for viewing marine mammals, such as an increased awareness of the general public to conservation issues and the provision of data and research opportunities to scientists, there is a wealth of information available in the literature which suggests that this increase in tour boats, along with the increase in all other types of boat traffic, may be negatively affecting seals and other marine mammals (Prideaux, 2012).

The most obvious negative impact from boat traffic is that of physical injury from collisions. Direct mortality from collisions with boats is thought to be a relatively common occurrence, although the true number of deaths is not known as the majority of cases are not reported (NOAA, 2005). An example of the physical injuries that seals may receive as a consequence of boat traffic can be seen with the recent occurrence of dead seals found with characteristic spiral injuries (Plate 1.2). There has been much speculation about what has caused these characteristic injuries, with possible explanations including predators such as killer whales or Greenland sharks, marine wind turbines and military activity. However, these explanations have all been deemed unlikely. The evidence suggests that the injuries sustained by these seals are caused by the seal being dragged through ducted propellers of the kind common to a wide range of ships, such as tugs, barges, rigs and various types of offshore support vessels and research boats (Thompson *et al*., 2010). In addition to injuries such as these, which are fatal, there are a great number of injuries obtained by seals from boat traffic that would not result in direct mortality, but may leave the animal with a reduced physiological condition that could lead to premature mortality.

Plate 1.2: Juvenile grey seal carcasses found in Norfolk (left) and the Firth of Forth (right) showing the characteristic spiral laceration consistent with being dragged through a ducted propeller. Image sourced from Thompson *et al*., 2010.

The recent increase in boat traffic has consequently led also to an increase in underwater ambient noise, which may act as a source of stress to marine mammals such as seals that use sound to communicate. It has been experimentally shown in a study by Lidgard *et al* (2008) that when grey seals are exposed to a stressor, which in this study was a capture and restraint period of 35 minutes, they experience an increase in cortisol concentrations. Cortisol is a glucocorticoid that is essential in the 'flight or fight' response (Lidgard *et al*., 2008). This increase in glucocorticoids could impact upon the seal's growth, reproductive behaviour and immune response (Lidgard *et al*., 2008). Although there does not appear to be any studies examining whether an increase in underwater noise results in an increase in glucocorticoids, and therefore stress, in pinnipeds, there is a study that shows a link between the two in North Atlantic right whales (*Eubalaena glacialis*). This study occurred after the terrorist attack of 11^{th} September 2001, the occurrence of which resulted in a large decrease of ship traffic, which subsequently resulted in a 6 dB decrease in underwater ambient noise levels. This decrease in noise was shown to be correlated with a decrease in the levels of glucocorticoids found in the whales, showing that the absence of ship-related noise lead to a decrease in hormones related to the stress response (Rolland *et al*., 2012).

Underwater noise from shipping and recreational craft can also present a problem to grey seals due to the effects of auditory masking. Auditory masking can be defined as background noise interfering and distorting the signal of interest (Richardson *et al*., 1995). Grey seals are extremely vocal animals and it is believed that they use sound for communication, orientation, navigation and for the location of predators and prey, and therefore it is important that the signal of interest is always clear and not masked by background noise from boats (Southall *et al*., 2000). It is the increase in shipping traffic, rather than the increase in recreational vessels, which poses the biggest problems to grey seals in terms of auditory masking. This is because low-frequency sounds produced by the seals overlap with the low-frequency sounds that are produced by shipping vessels (Richardson *et al*., 1995) (Figure 1.3). Although shipping vessels may be at a great distance to coastal grey seal populations, low-frequency noise from shipping is able to propagate extremely well underwater and intense low-frequency sounds can be heard as far as halfway around the globe from the source (Munk *et al*., 1994). In addition to masking signals, underwater noise can result in a temporary, or in extreme cases, permanent, threshold shift in pinnipeds (Kastak et al., 2005; Kastak et al., 2008).

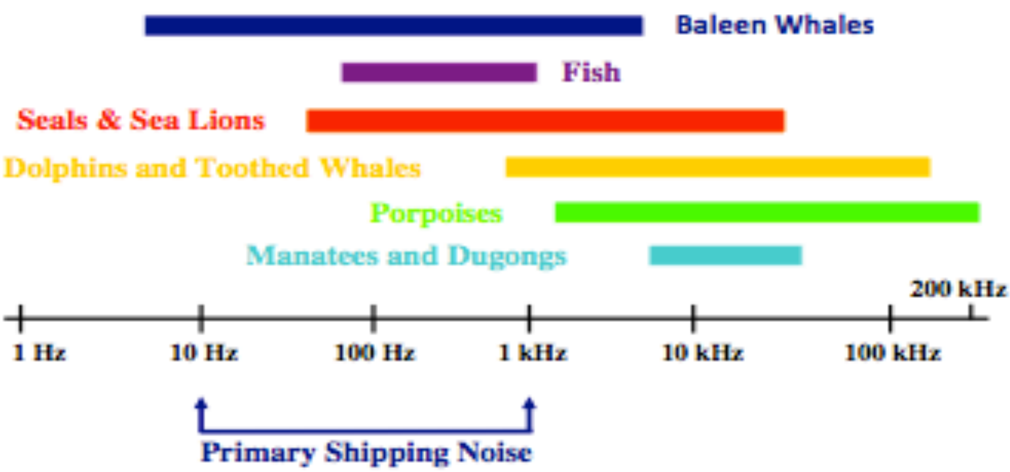


Figure 1.3: The frequencies of sounds produced by marine mammals in comparison to the frequency of sounds produced by shipping, showing a clear overlap between shipping noise and the sounds made by seals. Image sourced from Southall, 2005.

Boats may also contribute to the problem of pollution, as mentioned briefly in section 1.3.2. Although the effect of exhaust emissions on seals has not been studied, they have been found to be detrimental to the health of southern resident killer whales (*Orcinus orca*), with the current levels of boat traffic emitting enough carbon monoxide and nitrogen dioxide to exceed human threshold levels (Lachmuth *et al*., 2011). It is therefore a reasonable assumption that grey seals may be suffering adverse health effects due to exhaust emissions from boat traffic.

Of all the detrimental effects to seals relating to boats, the one that receives the most attention is probably that of general boat disturbance. As grey seals spend a substantial amount of time hauled out on land, they are extremely susceptible to disturbance by boats, especially by pleasure boats and tour-boats. The majority of research that has been carried out on boat disturbance to seals has examined its effects on seals hauled out on land. This is an important topic of research as seals need to haul out for a number of reasons, as discussed in section 1.2.4. Disturbance to hauled out seals has been shown to have many negative impacts, such as interrupting their resting period and subsequently lowering their fitness and health, changing their haul-out patterns, or in extreme cases leading the seals to abandon the haul-out site altogether, interrupting nursing by mothers, increasing levels of stress hormones, and causing separation of mothers and pups (Calambokidis *et al*., 1991). Nevertheless, although there is a wealth of information on the effects of boat disturbance to hauled-out seals, there does not appear to be much information available in the literature on the impacts of boat disturbance to seals whilst in the water, and whether their behaviour is altered as a result of the disturbance. This is surprising, as on an average day the grey seal spends around two thirds of its time in the water, compared to hauled-out on land (URL 2). One method of looking at whether or not seals experience disturbance due to boat traffic whilst in the water would be to use behavioural budgets.

Behavioural budgets have been used in a multitude of studies to examine the impact of boat disturbance, particularly of tour-boats, on cetaceans. These studies have revealed a number of different impacts of boats on the behaviour of cetaceans, presumably due to differences between species and differences between boat types and noise as well as other variables such as approach speed and distance. However, a universal result from the studies appears to be that cetaceans tend to increase the amount of time they spend travelling in times of boat presence, usually at the cost of other behaviours such as feeding, foraging, socializing and resting. (Evans, 1996, Würsig and Evans, 2001, Williams, 2002, Lusseau, 2003a, Lusseau, 2004, Bain et al., 2006, Lusseau, 2006, Williams, 2006, Dans et al., 2008, Arcangeli and Crosti, 2009, Tosi and Ferreira, 2009, Christiansen, 2010, Visser et al., 2011). It is possible that seals are also experiencing boat disturbance whilst they are in the water and are therefore altering their behaviour as a result.

1.4 Legislation Protecting Grey Seals

Although grey seals face a great number of threats, they are also a highly protected species in the UK and were in fact the first mammals to be protected by modern legislation under the Grey Seals Protection Act of 1914 (Lambert, 2002). Nowadays, grey seals are protected under the Conservation of Seals Act 1970, which prohibits the killing of seals by certain methods and during their closed season, which extends from the 1st September to the 31st December. The killing of seals during their closed season for the purposes of science, education, fisheries damage protection and management purposes is accepted, but requires a licence to be granted from the appropriate government. In addition to the Conservation of Seals Act 1970, there is also the Conservation of Seals (England) Order 1999, which extends the protection of grey seals to any time of the year for the counties of England that border the North Sea, from Northumberland down to East Sussex. As mentioned previously, it is legal to shoot seals which are causing damage to fishing gear or catch under the 'Fisheries Defence Clause,' however new legislation was brought in during 2011 in Scotland which now makes it illegal to shoot a seal at any time without a licence, except to alleviate suffering. Therefore, from 2011, the number of seals deliberately killed in Scotland will be recorded, but no official records will yet exist for the rest of the UK.

The grey seal is protected under Appendix III of the Berne Convention (1982), which aims to conserve wild flora and fauna and their natural habitats. The species is also listed on Annex II and Annex V of the EU Habitats Directive, which was implemented in order for the European Union to meet the obligations set out by the Berne Convention. Under the obligations of the EU Habitats Directive, the UK government has made the grey seal a species of 'UK Special Responsibility' and has created Special Areas of Conservation (SACs) in order to conserve the species. The sites with the largest breeding colonies, based on pup production, are chosen to become SACs, and several have been created around the UK to date. However, there are no SACs currently located on the Isle of Man (URL 3). Although the Isle of Man is not in the EU, the Manx government attempts to follow the same practices and is currently in the process of establishing the Isle of Man's first Marine Protected Area (MPA).

In the Isle of Man, grey seals are protected under Part 1 of the Manx Wildlife Act 1990, which aims to protect the species from harm and disturbance. It is therefore an offence in the Isle of Man to recklessly disturb grey seals, with offenders able to face a penalty of up to £5,000 (URL 4). The Manx Government has also created a voluntary seal watching code of conduct for boat operators in order to minimise the amount of disturbance caused to grey seals around the island. The code of conduct states that: operators should never land near a seal colony; the vessel should always be steered at an angle towards the seals and not directly; the seals should be approached at a speed lower than 5 knots; the vessel should never be positioned between seals in the water and pups on shore; and the seals should not be surrounded if other vessels are also present. The code of conduct also states that 50 m is the closest distance that motorboats, kayaks, rigid inflatable boats (RIBs) and sail boats should approach seals, and that personal watercraft (PWC – jet skis) should come no closer than 100 m to the seals. However, the code of conduct states that these are minimum distances and that boat operators should back away at the first sign of disturbance (Peters, 2007b). Unfortunately, since it's introduction in 2007, this code has not been widely published or enforced.

1.5 Rationale and Objectives of the Project

The Isle of Man is an important location for commercial fishing for scallop, queen scallop, crab, lobster and whelk, as well as additional pelagic and demersal fishing that is landed elsewhere, such as in Scotland and Ireland. Coastal waters around the Isle of Man are also subject to a high level of boat traffic from recreational boat users. The Island is home to a large breeding colony of grey seals, which are frequently disturbed by boat activity during haul-out periods. In previous work carried out at this seal colony, boat disturbance was shown to result in the seals abandoning their haul-out site in 57% of the periods under study (Peters, 2007a). As this is a breeding colony, this level of disturbance has serious implications for their breeding success in the autumn. This study aims to build on the research of Howard Peters (2007), and examine how grey seals at a disturbed site behave in response to boat traffic when compared to seals present at a minimally disturbed site. It also aims to build on previous research by looking into response distances, and identifying factors that may influence disturbance.

In order to meet the main aim of this project, which is to determine whether or not boat traffic is causing disturbance to the grey seal population on the Isle of Man, the following objectives of the project are:

1. Construct behavioural budgets for grey seals at a minimally disturbed site (control site) and a site with high boat disturbance (disturbance site).

2. Examine the impact of boat speed, boat distance, boat type, and interaction duration on hauled-out seals at the control site and treatment site.

3. Investigate the scanning behaviour of individuals at the control and disturbance site, and identify whether this is influenced by group size or position.

4. Investigate how environmental factors such as tidal phase, wind speed, wind direction and weather influence haul-out numbers and boat disturbance.

Chapter 2

Methods

2.1 Study Location

The Isle of Man was chosen to study the effects of boat disturbance as it has many large, easily observed, grey seal colonies at numerous locations around the island. Two study sites were needed in order to look at the impact of boat disturbance; one site with a high level of boat traffic that is likely to cause disturbance to a nearby seal colony, and one where the seal colony is subject to minimal boat disturbance. The requirements of these two sites were that seals should be able to be located whilst in the water as well whilst hauled-out, and that there was a good platform present from which the behaviour of the seals could be easily observed.

2.1.1 Disturbance Site

For the disturbance site, the small islet of Kitterland was chosen. Kitterland is located just off the southern tip of the Isle of Man, around 100 m from the mainland and 300 m from the Calf of Man (Figure 2.1). Both Kitterland and the Calf of Man are uninhabited nature reserves. As mentioned in the introduction, Kitterland is an ideal disturbance site as it is the most heavily used site on the island by boaters and there is always a clear view of the seal colony, whether they are hauled out on the northern or southern extremities of Kitterland. It is also ideal in that, when in the water, the seals often come very close to the mainland and so can be easily identified and observed. Two channels of water flow around either side of Kitterland. The larger channel of water between Kitterland and the Calf of Man is known as The Sound and this channel of water is around 250 m wide at the narrowest point and 350 m wide at the widest point. The smaller channel of water between Kitterland and the mainland is known as the Little Sound, which is around 50 m wide at the narrowest point and 180 m wide at the widest point. As boats regularly use these channels, especially The Sound, there is a large probability that boats come close enough to the seal colony hauled out on Kitterland to cause disturbance. The area of mainland directly opposite Kitterland is also known as The Sound and provides a good platform from which to observe both the hauled-out seals and the seals in the water. The Sound is a popular spot for visitors due to the beauty of the location and for the viewing of birds and the seal colony. The seal colony is therefore also subject to anthropogenic disturbance from people on the mainland. The Sound comprises a café and a car park, with low cliffs and a rocky intertidal area in between the café and the shore from which the seal colony on Kitterland can be easily observed. This site is easily accessible via a 45-minute drive each way.

Peel harbour, on the west coast of the Isle of Man, was originally considered for the disturbance site, as there is a resident population of seals in the harbour that are consistently disturbed by boat traffic coming in and out. This site was also used in a preliminary study the previous summer to test the methods for this research. However, this site was dismissed as there is no known haul-out site nearby and the behaviour of the seals was assessed to be unnatural due to their atypical environment.

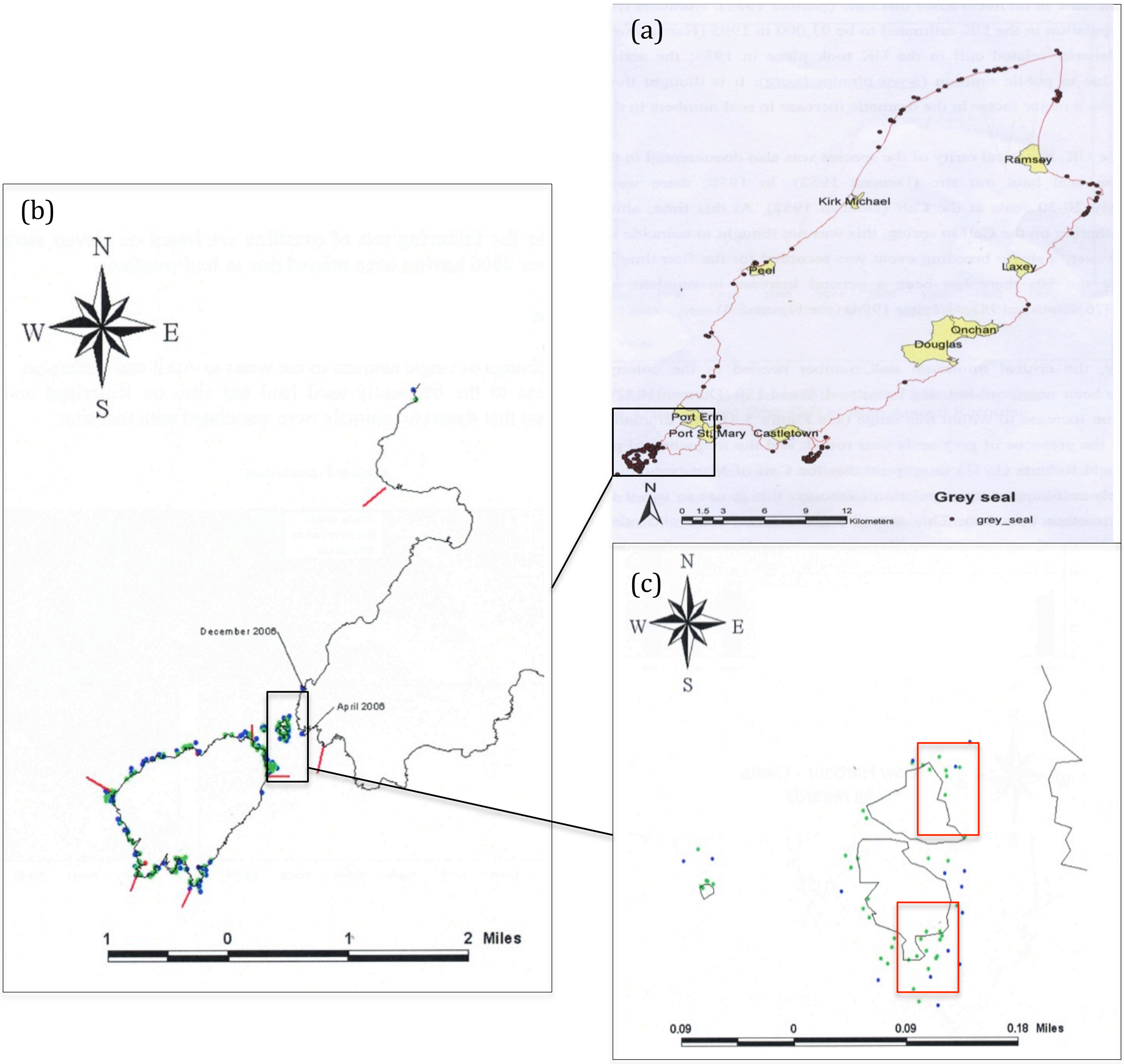


Figure 2.1(a): The location of disturbance site in relation to the rest of the Isle of Man. Image sourced from Travers, 2005. **(b):** A close up view of the area, showing the location of Kitterland in between the Calf of Man and The Sound (mainland). Image sourced from Manx Bird Atlas, 2007. **(c):** Kitterland, with the two usual haul-out locations of the seal colony outlined in red. The number of seals observed hauled-out during a recent grey seal survey are represented by green dots and the number of seals in the water are represented by blue dots. (Manx Bird Atlas, 2007).

2.1.2 Control Site

Langness, also located in the south of the island, was considered as the site of minimal boat disturbance (control) (Figure 2.2). This was based on the results of a survey of grey seals around the Isle of Man, carried out by Manx Bird Atlas (2007), which stated that seals were found hauled out at the southern tip of Langness Peninsula during ten of the twelve months. The two months that they were not found hauled out occurred during the autumn and winter, which would not affect this study. Seals were also reported to be regularly observed in the water in the same location, with only one occurrence of no seals being found in the water (Manx Bird Atlas, 2007). This location was also known to be a remote site, which boats occasionally passed, but did not often come into close contact with the seals due to their preference to haul out between rocky outcrops (Simon Mitchell, *pers.comm*.). An initial two-day trial period at this site resulted in no occurrences of boat traffic, or any form of anthropogenic disturbance, and confirmed that seals could be easily observed both in the water and hauled-out. As a result, this location was chosen as the control site. Once the normal haul-out sites were located, the seal colony at this site was easily accessed via a 30-minute drive and a 15-minute walk along the coastal footpath.

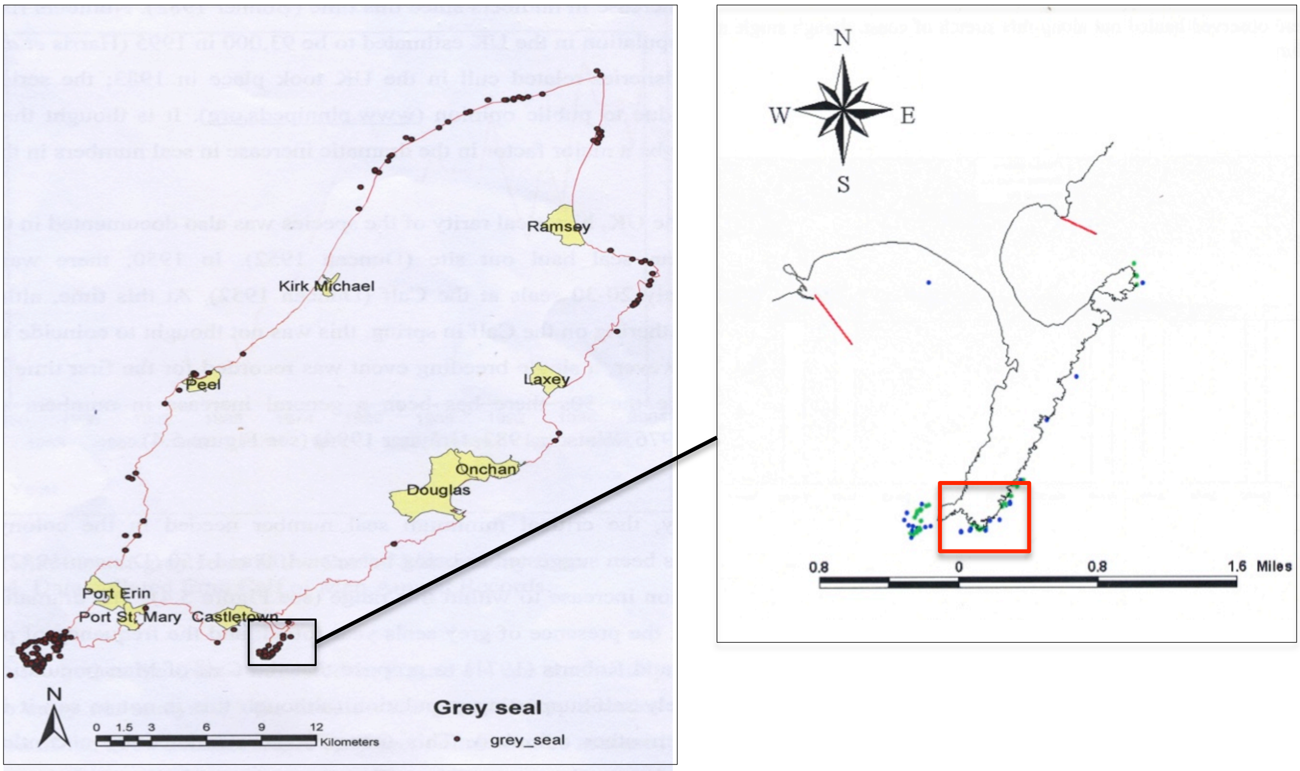


Figure 2.2(a): The location of Langness in relation to the rest of the Isle of Man (Image sourced from Travers, 2005) **(b):** A close-up view of Langness Peninsula. The green dots represent seals that were observed hauled-out during a recent grey seal survey and the blue dots represent seals that were observed in the water. The red box on the right indicates the actual survey location. Image sourced from Manx Bird Atlas, 2007.

2.2 Survey Dates and Times

A reconnaissance trip was carried out on the 16th June, in order to ensure that the two locations which were chosen for the study sites were suitable, with large enough colonies of seals present both hauled-out and in the water, and that they were close enough to land in order to be easily observable. Once this had been established, a two-day trial was carried out at each site to check the suitability of the methods of each survey and make adjustments.

Data collection was carried out between the dates of 28th June and 29th August. The data collection period was originally scheduled to end on the 1st August, but the survey period was extended due to unfavourable weather conditions restricting the survey dates. The survey was originally planned to last for five hours: three hours before and two hours after low tide. During the first hour, data were collected on the behaviour of a focal seal in the water (see section *2.3.2 In-water survey*) and the subsequent four hours were used to carry out the haul-out survey (see section *2.3.1 Haul-Out Survey*). However, the trial period revealed that there were low numbers of seals present in the water three hours before low tide, and that they would often haul out during this first hour, and therefore it was decided that the in-water surveys would be conducted one hour either side of high tide, when the greatest number of seals would be present in the water. It was also decided from the trial period that the haul-out survey should be conducted one hour before and one hour after low tide. This has been shown to be when the largest number of seals are hauled out, and this was confirmed during the trial period. Due to the location of the survey sites and the travel time involved (a 1.5 hour round trip for either site), the two surveys took place on separate days rather than the same day as a matter of convenience, with the site location changing on alternate days.

The planned number of surveys consisted of ten haul-out surveys at each of the sampling sites and ten in-water surveys at each site (with the focal seals consisting of five males and five females). Two in-water surveys could be carried out in a day and one haul-out survey in a day; therefore it was estimated that the surveys would take 30 days to complete. It was planned that if time became limited due to unfavourable weather conditions, two haul-out surveys could be carried out on days where two low tides occurred at hours suitable for data collection, and the haul-out survey and in-water survey could be carried out on the same day if it became necessary.

2.3 Data Collection Method

2.3.1 Haul-Out Survey

In order to examine the impact that boat traffic is having on grey seals when hauled out, two forms were designed to aid data collection (Appendix 1). Data for the first form (Effort Form: Haul-Out) were collected at 15-minute intervals for the two-hour survey period (one hour before and one hour after low water). The group was scan-sampled at the beginning of every 15-minute interval and the behaviour of the majority of the group was recorded. The group size was also counted every 15 minutes, and the sex composition of the group was determined. As discussed in section 1.2.3, grey seals are a sexually dimorphic species and the morphological features mentioned in this section can allow males and females to be identified from one another. Juveniles were defined as any individuals less than 150 cm in total length, following on from the methods used to identify juveniles in previous studies (Bass, 2004). Although the total length of seals could only be estimated, juveniles were noticeably smaller than adults and easy to distinguish. No attempt was made to sex juveniles as the typical male and female facial characteristics are not obvious in juveniles. A Nikon Fieldscope with a 25x zoom was used in this survey in order to obtain a more accurate count of group size and sex composition. The sex of a seal could not always be determined if the head was not visible or if the seal was partially obscured by other seals or rocks. In this case, the seal was included in the total group size and the sex was recorded as unknown.

Data were collected on the frequency of scanning behaviour at every alternate 15-minute interval. A focal animal was chosen and the number of times the seal raised its head and scanned the environment in a 5-minute period, was counted. The focal animal chosen was alternated between males and females (and juveniles when possible), and their position alternated between the edge of the hauled-out group (closest to the water) and the middle of the hauled-out group (furthest from the water). The seals could often be seen to be in distinct smaller groups, and so the immediate group size of the focal animal was also recorded.

Several environmental variables were also recorded every 15 minutes. The sea state was measured using the Beaufort wind force scale and the accompanying descriptions of conditions at sea (Table 2.1). Wind speed (km hour^{-1}) and wind direction were obtained using online data (URL 5) from a weather station located in Castletown, a location a short distance from both survey sites, also on the south coast of the Isle of Man. General weather conditions were recorded at the beginning of the survey period, using simple descriptive terms.

Table 2.1: The Beaufort wind force scale with descriptions for conditions at sea, for sea states in which surveys were conducted. Sourced from www.esac.org.uk.

Sea State	Specifications for use at sea
0	Sea like a mirror.
1	Ripples with the appearance of scales are formed, but without foam crests.
2	Small wavelets. Crests have a glassy appearance and do not break.
3	Large wavelets. Crests begin to break. Foam of glassy appearance.
4	Small waves, becoming longer.
5	Moderate waves, taking a more pronounced form. Chance of some spray.
6	Large waves begin to form. White foam crests are extensive.

The total number of boats that were visible in the entire survey area, without using the fieldscope or binoculars, was also recorded. Tankers and ferries that could be seen on the horizon were excluded from this, as their large size makes them visible from great distances. When a boat came within 200 m of the hauled out seals, it was classified as a boat interaction and data about the boat and the behaviour of the hauled-out seals were collected on the second form (Boat Interaction: Haul-Out). A boat interaction was originally defined as the moment that a boat comes to within 50 m of the hauled-out seals, as this is the closest recommended distance for boat approaches as advised in the code of conduct (see section 1.4). However, after the trial period showed alert behaviour from the hauled-out seals in response to a boat over 100 m away, this distance was increased to 200 m. The duration of the boat interaction was recorded, as well as the boat type, speed and wake. The boat types were grouped into the following categories: motorboat, RIB, yacht, kayak, PWC, sailboat and speedboat. If the boat was used for a clear purpose such as potting for crabs and lobsters or as a tour boat, this was also recorded. The boat speed was estimated in knots and the boat wake was recorded in categories in order to give more accuracy to the estimation of boat speed (categories used: no wake, small wake, medium wake or large wake).

The reaction of the hauled seals to a boat interaction were categorised as:

1. Alert: where the head is raised and orientated towards to source of the disturbance
2. Movement: seal moved away from its resting place, either away from the disturbance or towards the water
3. Flushing: seal moved from its resting place and entered the water (Plate 2.1).

These categories were used to examine the reaction of grey seals to boat disturbance as they have been used successfully in a similar study on harbour seals (Suryan and Harvey, 1999). The distance of the boat at which each of these reactions was first shown by the hauled out seals was recorded, with a fine-scale navigational chart of the study locations used in order to obtain a more accurate estimate of the boat distance.

(a) (b)

Plate 2.1(a): Alert behaviour, showing the head raised and orientated towards the source of the disturbance. **(b):** Movement and flushing into the water in response to a boat disturbance (Foreground). Plate 3b sourced from Peters, 2007a.

2.3.2 In-water survey

An additional two forms were designed to examine the impact of boat disturbance on seals when they are present in the water (Appendix 1). Focal sampling of a seal was carried out over a one-hour period, with two seals being sampled over the two-hour survey period (one hour before and after high tide). Photo identification (Photo-ID) was used in this survey to allow recognition of the focal seal each time it surfaced during the sampling period. Photo-ID is commonly used as a form of mark-recapture for animals such as marine mammals, which are difficult to capture and where doing so may cause significant disturbance (Würsig and Jefferson, 1990, Hammond, 2002). Photo-ID takes advantage of the markings that may be present on these animals, such as scarring on the dorsal fin of cetaceans or the natural markings found on the pelage of seals. In order to employ photo-ID on seals, profile pictures are taken of the head and neck area. It is preferable to obtain both the left and right sides of the seal so re-identification can be made from either side, although this is not always possible (Plate 2.2). The focal seal in this study was not chosen at random, but was the first seal from which photo-ID of either side, or ideally both sides, was obtained. This was due to the difficulty of obtaining photos that clearly show pelage markings in rough weather conditions.

Plate 2.2: Photo-ID of a grey seal, showing the natural markings by which this seal can be identified on both the left and right sides.

The behaviour of the focal seal was continuously recorded in seconds, with the time and behaviour noted every time the behaviour changed, or when a boat came within the interaction distance of 200 m. Behaviours were separated into eight categories; these were: logging, bottling, travelling, aggression, feeding, vigilance, scanning and not seen/underwater (Table 2.2).

The environmental variables measured were consistent with the haul-out survey (sea state, wind speed, wind direction and general weather condition) and were measured in the same way. Environmental conditions were recorded with every behavioural change. As in the haul-out survey, the general weather conditions were only recorded once at the beginning of the survey.

If a boat came to within 200 m of the focal seal (or where the focal seal was last seen if not present at the water's surface), the response of the seal to the disturbance was recorded. The variables that were recorded were the direction of movement of the seal (towards, away, or no movement) with regards to the boat; the boat type, speed and wake size, all of which were measured consistently with the haul-out survey; the closest distance of the boat to the focal seal; the behaviour of the focal seal before, during and after the boat interaction; and the number of seals which were visibly present in the water during and after the boat interaction. The number of seals visibly present in the water before the boat interaction was not recorded as this information was unlikely to be known.

2.4 Statistical Analyses

The software package SPSS v.14 was used for all of the statistical analysis. All data were tested for normality using a Shapiro-Wilks test, due to the small sample sizes. Any data that were not normally distributed were tested for differences using a Wilcoxon signed ranks test (for paired data), a Mann-Whitney *U* test for two sets of independent data, or a Kruskal–Wallis test for three or more sets of independent data. A pairwise Mann-Whitney *U* test was used as a *post hoc* test to the Kruskal-Wallis test. Normally distributed data were tested for differences using a paired *t*-test or a one-way ANOVA, again for paired data and independent data respectively. Discriminant analysis was used to carry out one-way ANOVAs in cases where the independent variable consisted of continuous data and the dependent variable consisted of categorical data.

Associations between two variables are shown using a Pearson's product-moment correlation for normally distributed datasets. For non-normally distributed datasets, a Spearman's rank correlation was used to look at associations between two variables. In order to examine the association between two categorical variables, a Chi-square test was used. In cases where the sample sizes were small, a Fisher's exact test was used in place of the Chi-square test.

Table 2.2: Definitions of the behavioural categories used.

Behaviour	**Definition**
Logging	The seal assumes a horizontal, stationary position on the water's surface.
Bottling	A stationary, almost vertical position with the head above the water's surface. The nose may be pointing upwards, or horizontal at the surface. This behaviour is thought to be a form of rest or sleep.
Travelling	The seal appears to be moving in a specific direction
Aggression	Any aggressive interaction, usually characterised by grunting, snorting, head-thrusting or waving foreflippers.
Feeding	The seal is observed with food.
Vigilance	The seal appears to be looking at a specific object with the look maintained over a period of time.
Scanning	The seal appears to be looking at the environment around it, but not at any specific object or in any specific direction.
Not seen/ Underwater	The seal is not in view or is known to be underwater.

Chapter 3

Results

A total of 24 days of fieldwork was achieved, resulting in 58 hours of data collection (including travel time to the sites). A further 9 days and 39 hours of field effort were invested that did not result in successful data collection. Thus a total of 33 days and 97 hours were invested in field effort with a 60% success rate for effective data collection. Unsuccessful data collection was caused by a number of factors, such as surveys being abandoned due to unfavourable weather, seals not being present at the site upon arrival, and inability to identify focal seals due to weather conditions affecting photograph quality.

Over the entire survey period (encompassing the in-water survey and the haul-out survey), a total of 112 boats were observed at the survey locations (control site = 15 boats; disturbance site = 97 boats). Of these, a total of 29 came to within 200 m of the seals, and were therefore classified as an interaction (control site = 6 interactions; disturbance site = 23 interactions). The weather throughout the survey period was consistently poor, with high winds and heavy rain. Due to this, the number of boats encountered during the survey was lower than would normally be expected around the Isle of Man in the summer months. As a consequence, the sample sizes gained in this study for boat disturbance are small. Due to the small sample sizes, not all data could be statistically analysed, and results should therefore be treated with a degree of caution.

3.1 In-water survey Results

3.1.1 Male and Female Behavioural Budgets

Behavioural budgets were constructed for ten focal seals (5 male and 5 female) at the disturbance site, and five focal seals at the control site (5 females). Differences between the behavioural budgets of males and females could not be tested for at the control site, as males were never observed in the water, and therefore focal follows could not be carried out. However, gender did not seem to affect the proportion of time spent by seals at the disturbance site in any particular behavioural state (Figure 3.1). The proportion of time spent feeding was removed from any statistical analysis, as this behaviour was never observed. A Mann-Whitney U test showed that there was no significant difference between males and females in the proportion of time spent in each behavioural state (aggression: U = 12.000, p = 1.000; bottling: U = 7.000, p = 0.310; logging: U = 8.000, p = 0.421; not seen/underwater: U = 6.500, p = 0.222; scanning: U = 10.000, p = 0.690; travelling: U = 12.000, p = 1.000; vigilance: U = 9.500, p = 0.548). As a result of this, the data for males and females were combined for the purposes of carrying out other statistical tests.

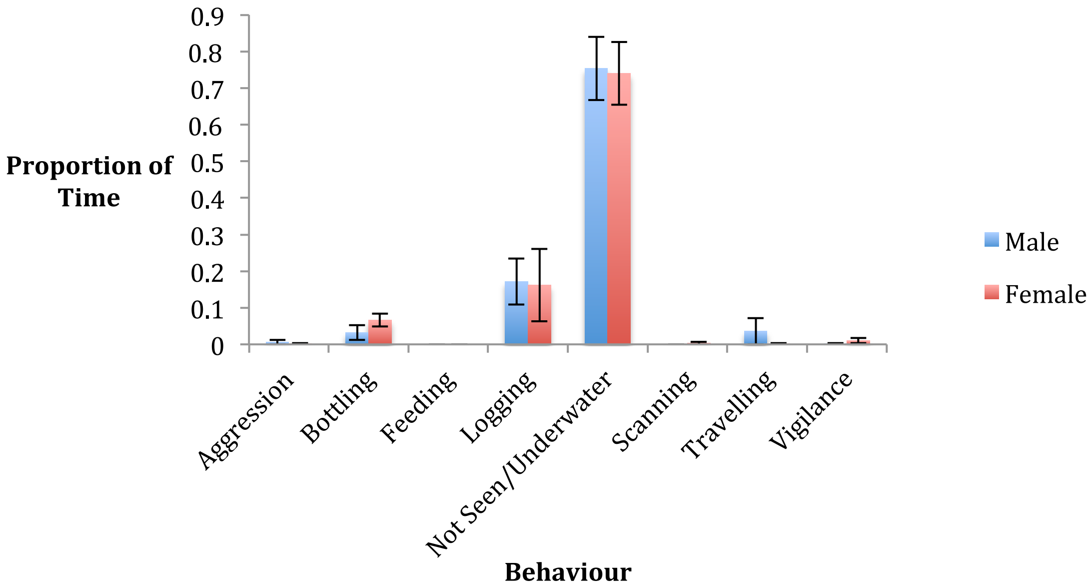
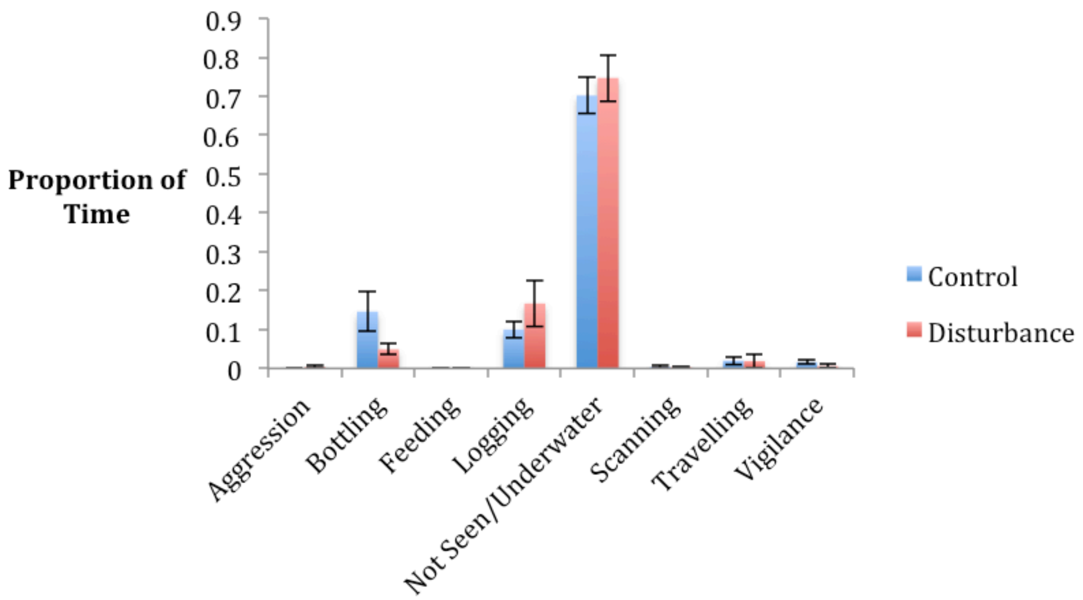


Figure 3.1: The mean (± 1 S.E.) proportion of time male and female focal grey seals spent in each behavioural state at the disturbance site (Kitterland). Males n = 5, females n = 5.

3.1.2 Differences in Behavioural Budgets by Site

The mean proportion of time seals at each site (control vs. disturbance) spent resting at the surface (bottling + logging) was very similar, with seals at the control site spending 24% of their time resting, compared with 22% for seals at the disturbance site. When the amount of time spent resting was examined in terms of time spent bottling and logging, the seals at the different sites show differences in the proportion of time spent in each of these resting behaviours (Figure 3.2a). This can be seen more clearly when the proportion of time the seal does not appear to be at the surface is removed from the behavioral budget (Figure 3.2b). A subsequent Mann-Whitney U test showed that there was a significant difference in the proportion of time that seals at the control and disturbance site spent bottling ($U = 8.000$, $p = 0.04$). No significant difference was found in the proportion of time the seals at the two sites spent logging, due to high levels of variability between focal animals ($U = 18.000$, $p = 0.440$). Nor was a significant difference found between the proportions of time that focal seals at each site spent in any other behavioural state (aggression: $U = 20.000$, $p = 0.594$; not seen/underwater: $U = 23.500$, $p = 0.859$; scanning: $U = 23.000$, $p = 0.859$; travelling: $U = 18.500$, $p = 0.440$; vigilance: $U = 24.000$, $p = 0.953$).

(a)



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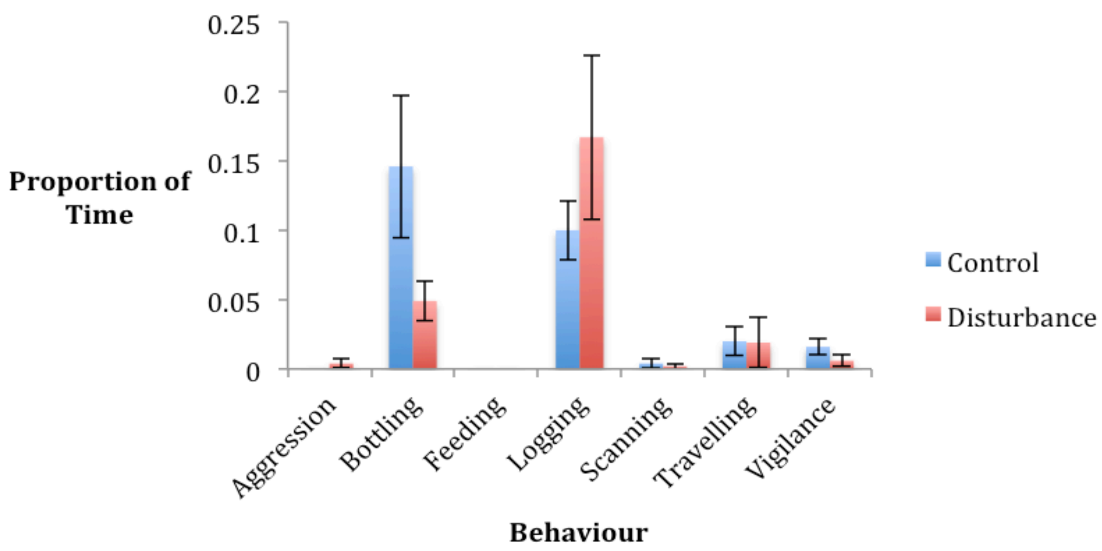
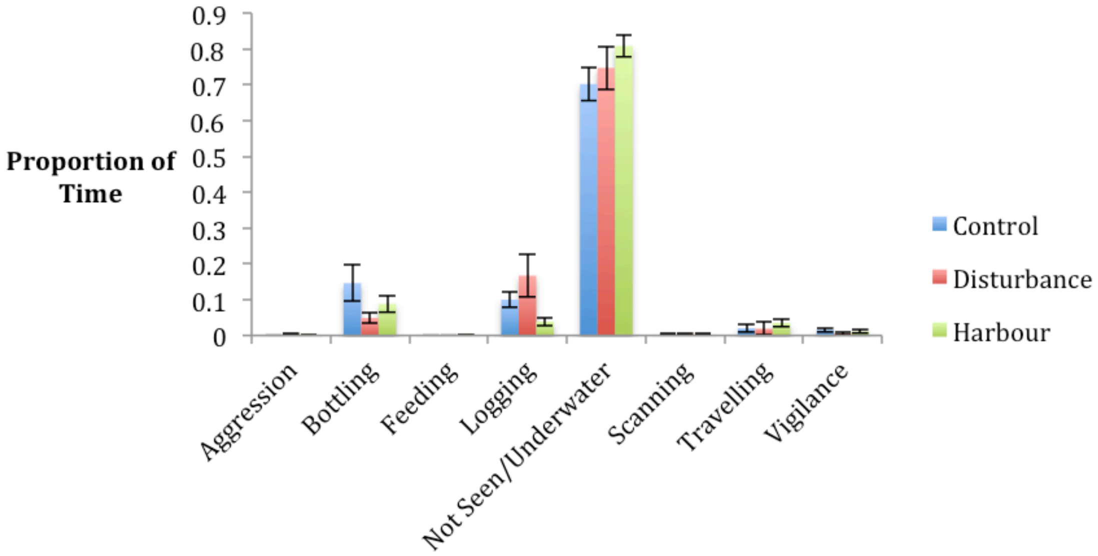


Figure 3.2(a): The mean proportion of time (±1 S.E.) spent in a single behavioural state shown by focal seals at the control site (Langness) and the disturbance site (Kitterland). Control n = 5, disturbance n = 10. **(b):** The mean proportion of time (±1 S.E.) focal seals at the control and disturbance sites spent in each behavioural state, with the proportion of time the seal was underwater or not seen removed.

The behavioural budgets for the control and disturbance site can be compared with data collected by the author in a preliminary study, which took place in the months of August and September 2011. This study used similar methods and carried out focal follows of seals in Peel harbour. This site is located on the west coast of the Isle of Man and was originally considered for the disturbance site (see section *2.1.1*). The seals at this location are thought to be resident to the site and experience high levels of boat traffic due to the vessels that regularly come and go from the harbour. It is likely that the seals in this location are habituated to the boat traffic and are often observed following and feeding from the boats in this area. As a result of the atypical environment of these seals, this site was not used in the present study. However, the data previously obtained do allow further insight into the behavioural changes that may occur with seals at heavily disturbed locations.

Seals at the harbour, the most disturbed site in terms of boat traffic, spent more time underwater/not seen, and seals at the control site spent the least time underwater/not seen (Figure 3.3), although this difference in the proportion of time spent underwater was not found to be significant ($F_{2,28} = 1.389$, $p = 0.266$). On the other hand, a significant difference was found between the proportion of time the focal seals at the control site and the harbour spent logging ($X^2_{(2)} = 7.625$, $p = 0.022$; control vs. harbour: $U = 27.000$, $p = 0.007$; control vs. disturbance: $U = 18.000$, $p = 0.220$; disturbance vs. harbour: $U = 30.000$, $p = 0.267$). Although the proportion of time spent bottling was not significant due to large variability in the samples, the *p* value did fall within the 10% acceptance level ($X^2_{(2)} = 5.139$, $p = 0.077$). Due to the small sample sizes obtained, this result should be treated with caution. No other significant differences were found between the proportions of time that focal seals at the sites spent in each behavioural state (aggression: $X^2_{(2)} = 3.500$, $p = 0.174$; scanning: $X^2_{(2)} = 0.971$, $p = 0.615$; travelling: $X^2_{(2)} = 3.982$, $p = 0.137$; vigilance: $X^2_{(2)} = 0.306$, $p = 0.858$).

(a)



(b)

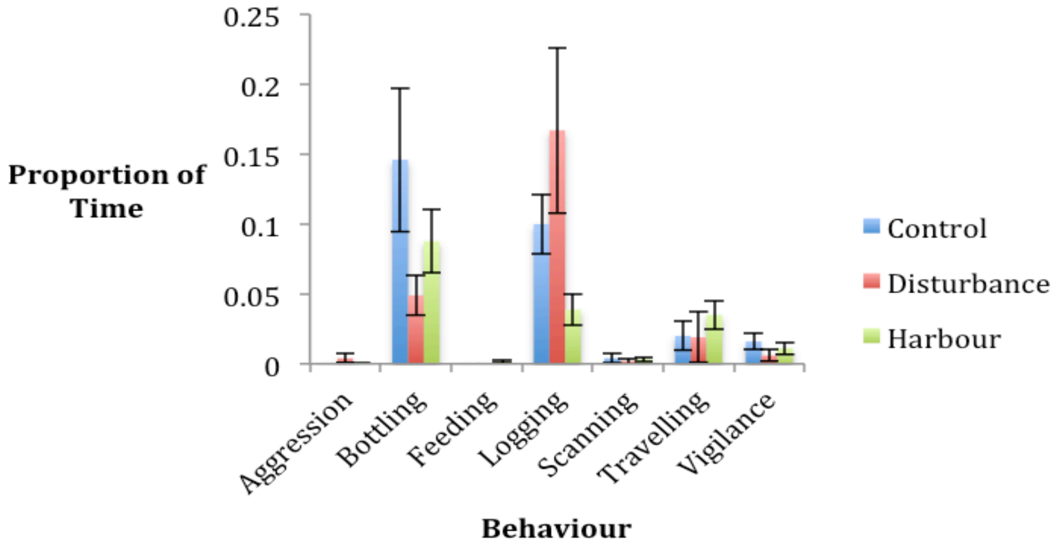


Figure 3.3(a): The mean proportion of time (±1 S.E.) spent in a single behavioural state by focal seals at the control site (n = 5), the disturbance site (n = 10) and at Peel harbour (n = 16).
(b): The mean proportion of time (±1 S.E.) spent in a single behavioural state by focal seals at the control site (n = 5), the disturbance site (n = 10) and Peel harbour (n = 16), whilst visible at the water's surface.

3.1.3 Behavioural Budgets with Boat Presence and Absence

Behavioural budgets can also be examined at each site, by conducting surveys where boats were present and comparing with surveys where they were absent. Only two surveys were carried out at the control site with no boats in the area, and only one survey was carried out at the disturbance site where no boats were in the area. Due to these sample sizes, these data cannot be statistically analysed, and no conclusions can be made. However, it would appear that with larger sample sizes, a similar difference might be seen as between sites, with the amount of time spent underwater increasing when boats are present. It should also be noted that the amount of time spent logging decreases at both sites in times of boat presence (Figure 3.4).

3.1.2 Boat Disturbance

During the five focal follows at the control site, a total of five boats were observed, resulting in an average of 1 boat hour^{-1}. These boats occurred in three of the surveys, with two surveys having no boats visible. Of the boats seen, two came close enough to the focal seals to be classified as an interaction. Both of these interactions occurred on the 7th August and were a result of the same boat - a motorboat being used for potting for crab and lobster. The presence of the boat resulted in vigilance being shown by the focal seal on each occasion. However, the seal did not dive or move away from the boat and resumed normal resting behaviour once the boat had moved further than 200 m away.

A total of 55 boats were observed over the 10 focal follows at the disturbance site, resulting in an average of 5.5 boats hour^{-1}. Of these 55 boats, seven came to within 200 m of the focal seal and were classified as interactions. This number was low as the majority of boats were travelling in a specific direction and did not come close to the shore where the seals were located. The closest distance of the boat to the focal seals varied greatly from 10 – 200 m. Three boat types were responsible for boat-seal interactions during the focal follows at the disturbance site: three interactions were a result of recreational motorboats, two were due to

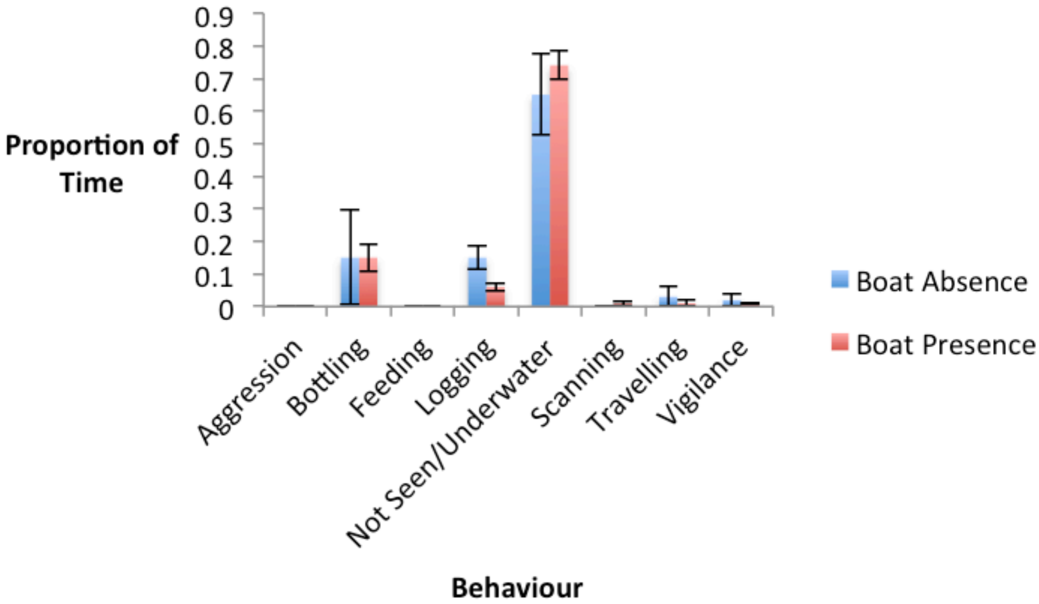
RIBs and two were due to yachts. Only one boat interaction by a RIB resulted in a change of behaviour from the seal, with the focal seal displaying vigilance towards the boat. On all other occasions, the focal seals continued the behaviour shown before the boat interaction.

3.1.3 Other Forms of Disturbance to Seals in the Water

Vigilance was shown by the focal seals at the control site on six occasions, or an average of 1.2 occasions per survey effort, with a total time of 5.43 minutes. The causes of this vigilance were spread equally, 50% towards boats and 50% towards the arrival of the observer at the beginning of the survey. Vigilance was shown on 11 occasions at the disturbance site, or an average of 1.1 occasions per survey effort, with a total time of 4.14 minutes. Boat disturbance was responsible for 18% of the vigilance shown at the disturbance site, whilst anthropogenic disturbance by people on the mainland watching the seals at a range of 15 -50 m, accounted for 82% of the vigilance shown by the focal seals.

Due to the location of the sites equidistance to the east and west of the airport (also located on the south coast of the Isle of Man), the seals at the two sites are often passed by low flying planes. Low flying planes were recorded to occur on five occasions during the surveys at the disturbance site, with no planes recorded during the in-water surveys at the control site. However, the behaviour of the focal seals was not altered on any occasion as the result of a low flying plane. It was therefore concluded that planes were not a significant form of disturbance to the seals present in the water at the disturbance site.

(a)



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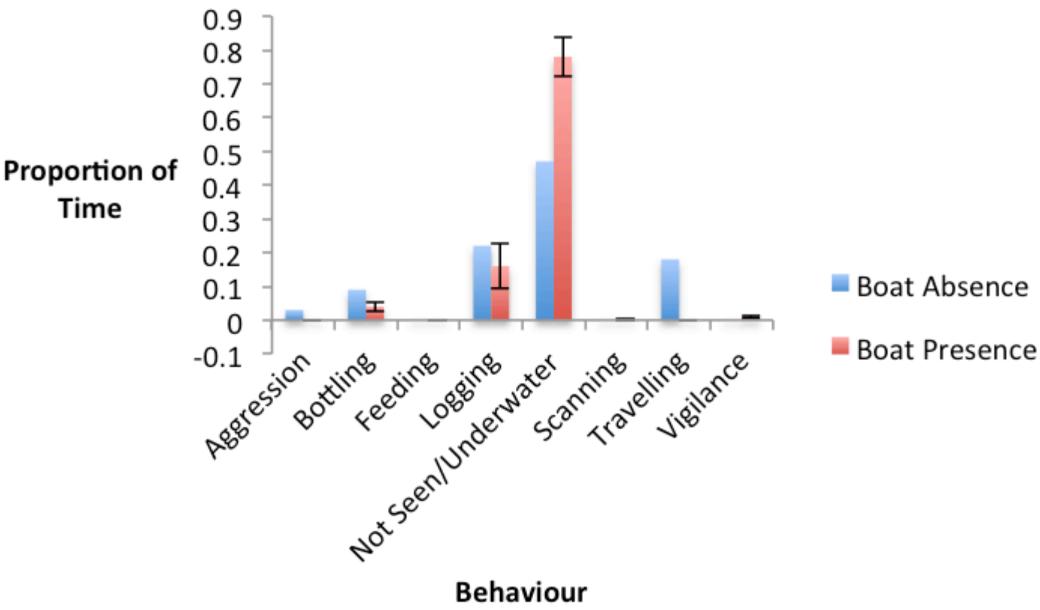

Figure 3.4(a): The mean proportion of time (±1 S.E.) spent in each behavioural state by seals with boat presence and absence at the control site. (Absence: n = 2; presence: n = 3).
(b): The mean proportion of time (±1 S.E.) spent in each behavioural state by seals with boat presence and absence at the disturbance site. (Absence: n = 1; presence: n = 9).

3.2 Haul-Out Survey Results

Seals were not found hauled out at the control site as reliably as at the disturbance site. Seals were observed hauled out at the disturbance site on every survey attempt, compared to four unsuccessful haul-out survey attempts at the control site. Unsuccessful survey attempts all occurred on days with a southerly or northerly wind, and a speed of between 25 – 35 km $hour^{-1}$. Therefore, the absence of hauled-out seals is probably due to the different topographies of the two sites, since in periods of high winds, the seals at the control site may be unable to find sheltered areas in which to haul out, whereas the disturbance site allows shelter from all wind directions. On occasions when no seals were observed at the normal haul-out location, a survey of the entire Langness Peninsula (control site) was undertaken in an attempt to locate further haul-out areas. No hauled-out seals were located on any of these surveys, but three seals were observed bottling in the water, possibly giving support to the suggestion that this site does not offer protection from all wind directions. As a result of the lack of hauled-out seals at the control site, more surveys were carried out at the disturbance site (12) than at the control site (7).

3.2.1 Haul-Out Counts

The number of seals hauled out at the two sites was consistently higher at the disturbance site than the control site (Figure 3.5). The mean group size for the total survey period was 22 (±0.22) seals $1hr^{-1}$ at the disturbance site, compared to a mean group size of 7 (±0.28) $1hr^{-1}$ at the control site. The groups comprised a mean male count of 12 (±0.53) and 1 (±0.03), a mean female count of 25 (±1.03) and 13 (±0.53), and a mean juvenile count of 3 (±0.12) and 0 (±0.00) at the disturbance and control sites respectively.

3.2.2 Behaviour of Hauled-out Seals

Hauled-out seals at the disturbance site spent 2.2% of the total survey time displaying alert behaviour, with the other 97.8% of the time spent resting. By comparison to this, the group at the control site spent 7.1% of the total survey time displaying alert behaviour, with a further 1.8% of the time spent showing aggression and the rest of the time (91.1%) resting. As the data resulted in only a small number of frequencies for alert and aggressive behaviour, a Fisher's Exact test was carried out, and the behaviour of the hauled seals at the control and disturbance site were not found to be significantly different from one another (p = 0.13).

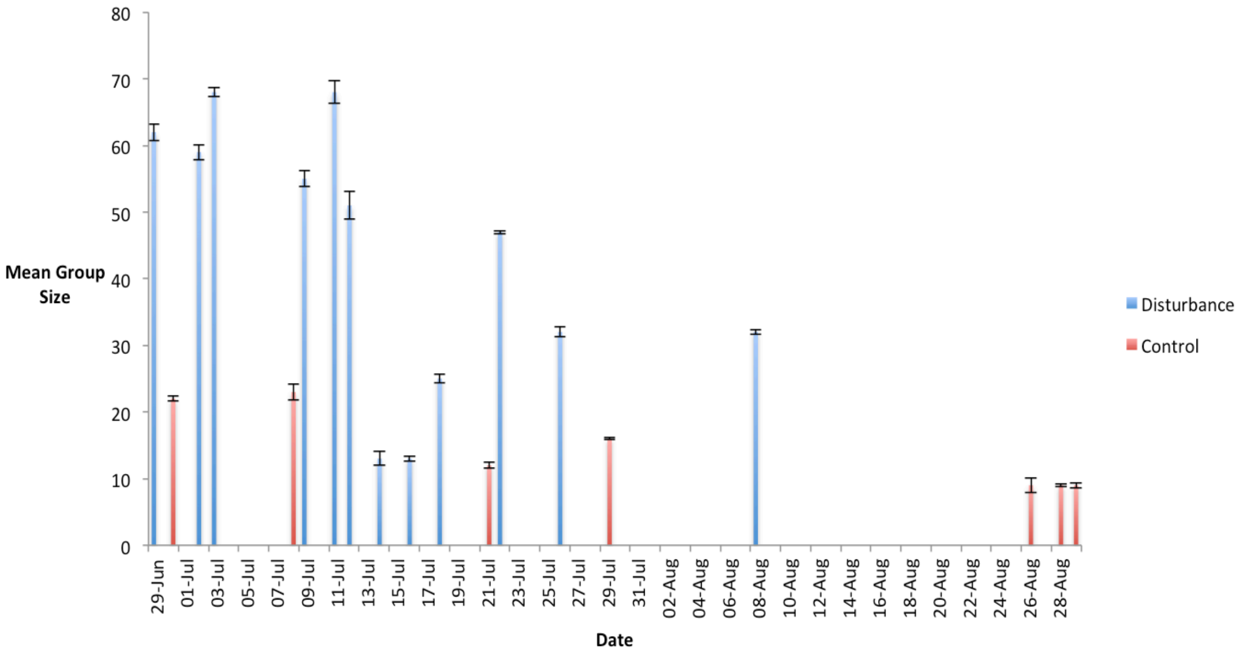

Figure 3.5: The mean group size (males, females and juveniles) for the disturbance and control site over a two hour survey period, 1 hour before and after low tide. Disturbance: n = 12, control: n = 7. Bars indicate ±1 S.E.

3.2.3 Scanning Counts

The number of scans per five minute interval was not found to differ significantly between males, females or juveniles at the disturbance site ($X^2_{(2)}$ = 0.34, p = 0.84), or between males and females at the control site (U = 77.50, p = 0.76). No juvenile seals were ever observed at the control site and therefore their scanning behaviour could only be examined at the disturbance site. As no significant difference was found in the scanning behaviour between the sexes, scanning data for the sexes were combined for the subsequent tests.

No significant difference was found in the number of scans performed in a five-minute period between the disturbance and control sites (U = 499.00, p = 0.12).

However the scanning frequency of a focal seal may be influenced by its' group size. This can be examined in terms of total group size (total number of seals hauled-out) or the immediate group size (the number of seals within approximately 1 meter to the focal seal, e.g. on the same rock). At the disturbance site, the number of scans performed by a focal seal over a five-minute period is strongly negatively correlated with the immediate group size ($r_{(30)}$ = -0.75, p = 0.00) (Figure 3.6). Therefore the number of scans performed by the focal seals decreases as the group size of the seals nearby increases. However, although the number of scans also slightly decreases with total group size, no significant correlation was found between the two variables ($r_{(41)}$ = -0.24, p = 0.14). At the control site, no significant association was found between the number of scans performed over a five minute period and the immediate or total group size (immediate group size: $r_{(28)}$ = -0.02, p = 0.94; total group size: $r_{(31)}$ = -0.19, p = 0.30).

The number of scans performed by a focal seal may also be affected by the position of the focal seal (i.e. at the edge of a seal colony near the water or in the middle of a seal colony far from the water). The number of scans was previously not found to differ between the sexes, and the similarity in the frequency of scanning behaviour by the two sexes can also be seen when examining this behaviour by position (Table 3.1). The number of scans performed by males positioned in the middle at the control site appears to be much higher than all other counts of scans from seals positioned in the middle. However, this is likely to be due to the small number of males present at the control site, (control site, male: n = 7).

When the effect of position on scanning frequency was examined, the scanning frequency of seals positioned in the middle as opposed to on the edge, was found to be significantly lower (U = 166.00, p = 0.00).

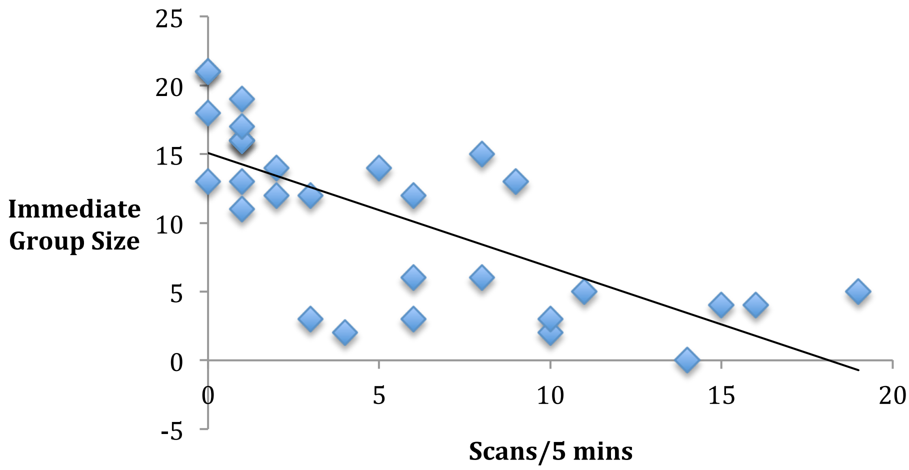

Figure 3.6: The number of scans per focal seal in a five-minute period with the immediate group size of hauled-out seals at the disturbance site.

Table 3.1: The mean number of scans (±1 S.E.) performed by focal seals at the disturbance and control sites, separated by sex and position (edge = hauled-out near the edge of the rock near to the water, middle = hauled-out towards the middle of the rock, far away from the water).

		Edge (±1S.E.)	**Middle (±1S.E.)**
Disturbance Site	**Female**	10 (±2.10)	2 (±1.37)
	Male	10 (±2.10)	3 (±1.43)
	Juvenile	7 (±1.50)	2 (±3.50)
Control Site	**Female**	11 (±1.70)	2 (±2.67)
	Male	8 (±4.5)	6 (±1.03)
	Juvenile	N/A	N/A

3.2.4 Boat Disturbance to Hauled-out Seals

During the haul-out surveys, a total of 42 and 10 boats were observed passing by the disturbance and control site respectively. This resulted in a mean of four boats per two-hour survey at the disturbance site and a mean of one boat per two-hour survey at the control site. Of these boats, 16 (38%) at the disturbance site and four (40%) at the control site came to within 200 m of the hauled seals, and were classified as a boat interaction. Therefore, although the disturbance site has a much higher level of boat traffic and therefore interactions, a higher proportion of the boats at the control site actually resulted in boat-seal interactions. Of the recorded interactions, 15 resulted in disturbance to the hauled seals (13 at the disturbance site, 2 at the control site).

The number of boat interactions that resulted in alert behaviour from the hauled seals was found to be higher at the disturbance site. This is likely due to boat distance, as the average closest distance of boats at the disturbance site was 49 m (±7.63), compared to 103 m (±54.87) at the control site. On the other hand, the number of interactions that resulted in movement from the seals was higher at the control site, and the number of interactions that resulted in the seals flushing into the water was the same at both sites (Table 3.2). The average distance of the boat at which movement occurred was 51 m (±18.53) and 110 m (±40.00), and for flushing the average distance was 50 m (±19.15) and 70 m (±0.00) for seals at the disturbance and control site respectively. All flushing events involved females, and males were never observed flushing from the haul-out site in response to a boat disturbance. Flushing and recovery rates were extremely variable (see section *3.2.4.4*).

Table 3.2: The percent of total boat interactions that resulted in a change of behaviour from the hauled-out seals at the control and disturbance sites (disturbance: n = 16, control: n = 4).

	Alert (%)	**Movement** (%)	**Flushing** (%)
Disturbance	81	25	25
Control	50	50	25

3.2.4.1 Boat Type

Motorboats caused all flushing events. Of these, recreational motorboats caused two flushing events, motorboats that being used as potting boats caused another two flushing events and one was a result of a boat being used as a charter/tour boat. The one PWC that was observed to come within 200 m of the seals caused movement, but there was no subsequent flushing into the water. All types of boats that were observed during the survey period resulted in alert behaviour from the hauled seals (PWC, recreational motorboat, potting boat, RIB, speed boat, charter/tour boat, yacht).

3.2.4.2 Boat Speed

Boat wake was used as an additional measure of boat speed in order to improve the accuracy of this measurement. The data show a strong positive correlation between boat speed and boat wake, and therefore this was considered an appropriate measurement (Figure 3.7).

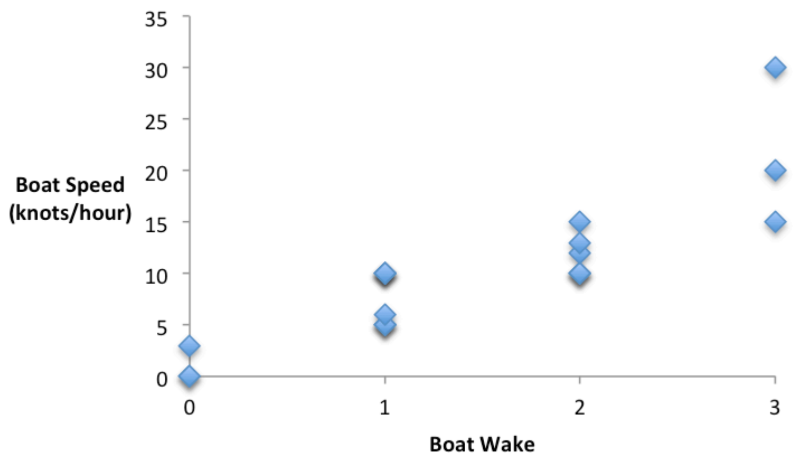

Figure 3.7: Scatter plot showing a positive correlation between boat speed (knots) and boat wake. (Boat wake: 0 = no wake; 2 = small wake; 3 = medium wake; 4 = large wake).

No solid conclusions can be reached about the effect of boat speed (or boat type and duration of interaction) on the distance at which the hauled-out seals are disturbed due to the small number of disturbance events which were observed. A positive correlation was found between boat speed and the distance at which seals show alert behaviour ($X^2_{(14)} = 0.55$, $p = 0.04$). Seals also occasionally seem to be alerted at large distances when the boat is making little or no noise. (Figure 3.8a and b). However, more data would be needed in order to analyse this effectively. There also appears to be a positive correlation between boat speed and the distance of movement and the distance of flushing, but again a larger sample size is needed to determine whether this association is significant (Figure 3.8c and d). It should also be noted that, although there appears to be a positive correlation between the boat speed and the distance of movement and flushing, these responses were also caused by a stationary boat and by two boats travelling $\leqq$ 5 knots.

3.2.4.3 Duration of Interaction

The duration of the interaction (how long the boat stayed within 200 m in any direction of the hauled seals) appeared to have an influence on the level of disturbance, with all flushing events occurring when the duration lasted for three minutes or longer. Discriminant analysis, used to carry out a one-way ANOVA, showed that this association was significant ($F_{1,18} = 144.95$, $p = 0.00$). No association was seen between interaction duration and alert response, with alert behaviour shown with all lengths of duration.

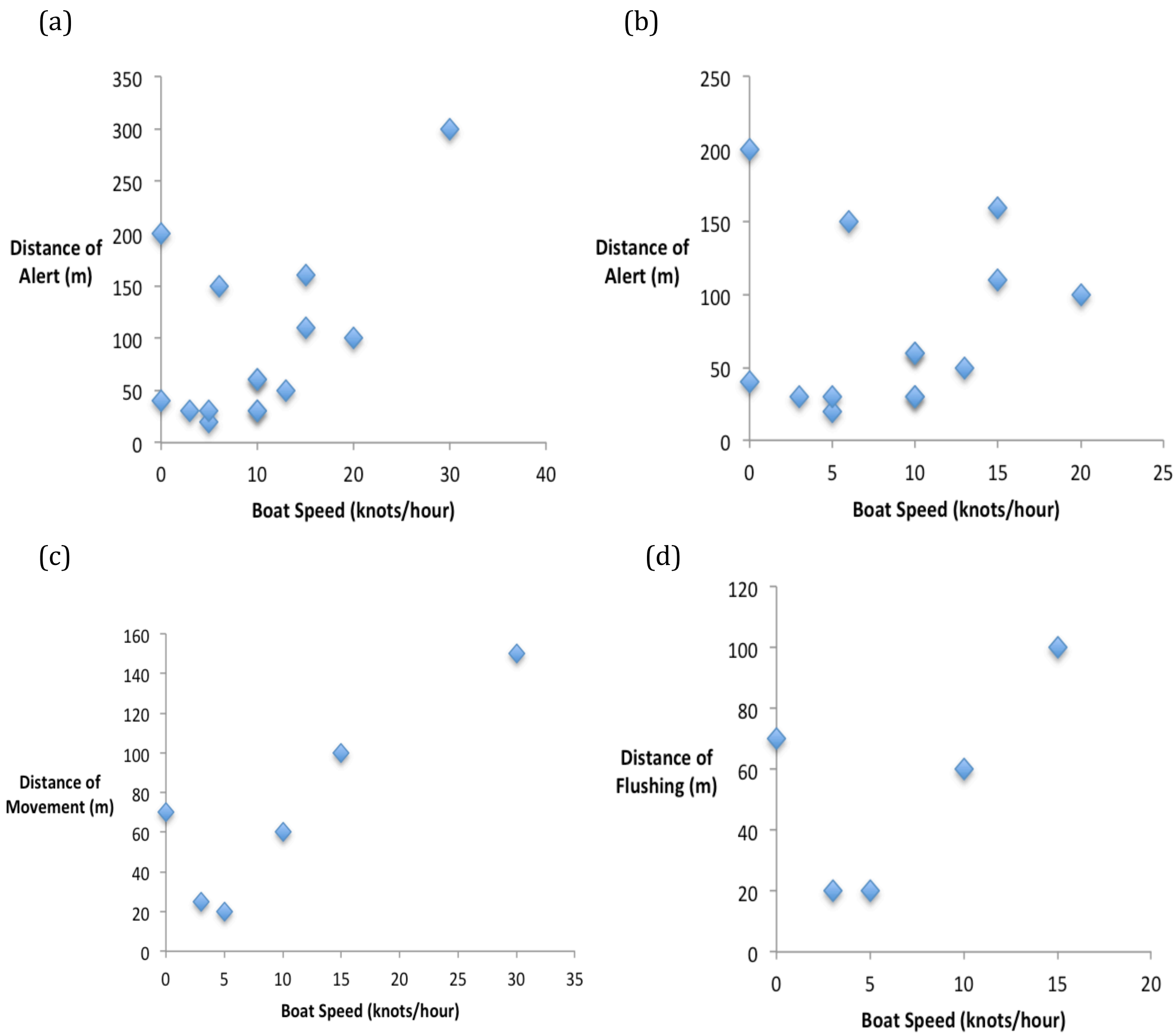

Figure 3.8(a): A scatter plot showing the association between the boat speed (knots) and the distance of the boat when the hauled-seals first show alert behaviour. The outlying point is caused by a fast speed PWC. N = 16. **(b):** The outlying point caused by the PWC removed to show the association between the normal boat speed range and the distance of first alert behaviour. N = 15. **(c):** The association between boat speed and the distance of the boat when hauled-out seals begin to move in response to the disturbance. N = 6. **d):** The association between boat speed and the distance at which seals begin to flush into the water in response to the disturbance. N = 5.

3.2.4.4 Flushing and Recovery Rates

It is not possible to determine whether there is a difference in flushing or recovery rates between the two sites, as only one flushing event occurred at the control site. This was the most severe flushing event, with 62% of the hauled-out seals moving into the water. By the end of the survey (53 minutes after the disturbance), 69% of the number of seals remained. Four cases of boat disturbance resulted in flushing at the disturbance site. Of these, the flushing rate was 14% for one case and only 1% for another, and both of these cases did not show any recovery after half an hour, when the survey ended. One case had a flushing rate of 9% and recovered by 94% after half an hour, but did not recover any further after this time. The fourth flushing event had a flushing rate of 33% and also recovered by 94% after half an hour, recovering fully to pre-disturbance numbers after 45 minutes.

3.2.5 Other Forms of Disturbance to Hauled Seals

As with the in-water surveys, low flying planes were a common feature during the haul-out surveys. Five planes were recorded passing over the hauled-seals at the disturbance site. However, no change in behaviour was recorded on any of these occasions. Low flying planes were recorded on three occasions at the control site. Of these, two resulted in alert behaviour from hauled-out seals and one did not result in a change in behaviour. Seals were also observed present in the water on these three occasions, but the planes did not result in any behavioural change to these seals.

Hauled-out seals at the two survey sites appeared to experience different levels of disturbance due to the presence of people on the shore. Although the in-water surveys showed that the presence of people appeared to result in high levels of vigilance by the focal seals at the disturbance site, hauled-out seals at this site did not appear to be actually disturbed as a result of this. The number of people present on the shore at the control site was minimal by comparison to the disturbance site. However, hauled-out seals at the control site were observed to be extremely susceptible to disturbance by people on the shore and regularly showed vigilance behaviour in response to their presence. Seals at this site usually showed vigilance upon arrival of the observer at the beginning of the survey, and although effort was made to keep a low profile to the ground and make minimal noise, on two occasions the arrival of the observer resulted in the flushing of one hauled seal into the water. This difference between sites is likely to be due to the position of the hauled-out seals, as seals at the disturbance site are protected from observers on the mainland by a channel of water (The Little Sound), whereas seals at the control site haul out on rocks attached to, or very close to, the mainland.

3.3 Environmental Variables

3.3.1 Time of Day

As the surveys were carried out around the times of low and high tide, time of day is not a constant variable and may therefore be a source of variation in the number of seals hauled-out and the response of seals to boat activity. In order to determine what effect, if any, the time of day is having, the surveys were grouped into the categories: morning (7.00am – 11:59am), afternoon (12.00pm – 4.59pm) and evening (5.00pm – 10.00pm). Different patterns were found in the relationship between average group size and time of day between the control and disturbance site. The number of seals hauled out was found to decrease in the afternoon at the disturbance site, whereas the numbers hauled out at the control site increased from morning until evening (Figure 3.9). However, this pattern may not be a true representation of average haul-out numbers due to the small sample size obtained for each time of day, and no significant difference was found in the number of seals hauled out in the morning, afternoon or evening at either site (disturbance: $F_{2,9} = 0.31$, $p = 0.74$; control: $F_{2,4} = 0.548$, $p = 0.62$).

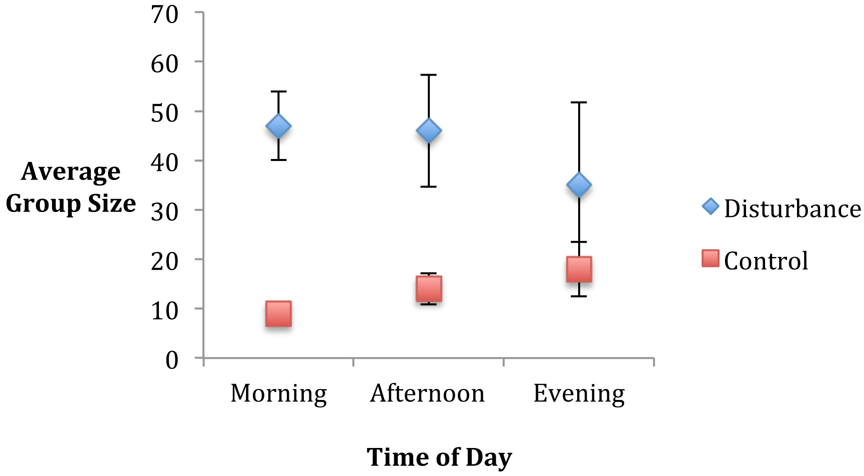

Figure 3.9: The mean group size of hauled-out seals at the control and disturbance sites per two-hour surveys, carried out in the morning (disturbance: n = 5; control: n = 1), afternoon (disturbance: n = 4; control: = 4) and evening (disturbance: n = 3; control: n = 2).

The difference in the average number of males and females hauled out at each site during surveys in the morning, afternoon and evening was also not significant, due to high levels of variability in numbers and small sample sizes (disturbance: male – $F_{2,9}$ = 0.84, p = 0.47; female – $F_{2,9}$ = 0.10, p = 0.90; control: male – $F_{2,4}$ = 0.55, p = 0.62; female – $F_{2,4}$ = 0.42, p = 0.68) (Figure 3.10).

The control and disturbance sites showed differences in the average number of boats present at each site at different times of day. The control site had the largest amount of boat traffic in the morning whereas the disturbance site experienced the largest amount of boat traffic in the afternoon. Both sites experienced the lowest amount of boat traffic in the evenings (Figure 3.11a). The difference in boat traffic with time of day was not found to be significant, again probably due to large variability and small sample sizes (disturbance: $X^2_{(2)}$ = 2.10, p = 0.35; control: $X^2_{(2)}$ = 1.97, p = 0.37). As would be expected, the number of boat interactions follows a similar pattern to that of the total number of boats, with the most interactions occurring in the afternoon at the disturbance site and in the morning at the control site (Figure 3.11b).

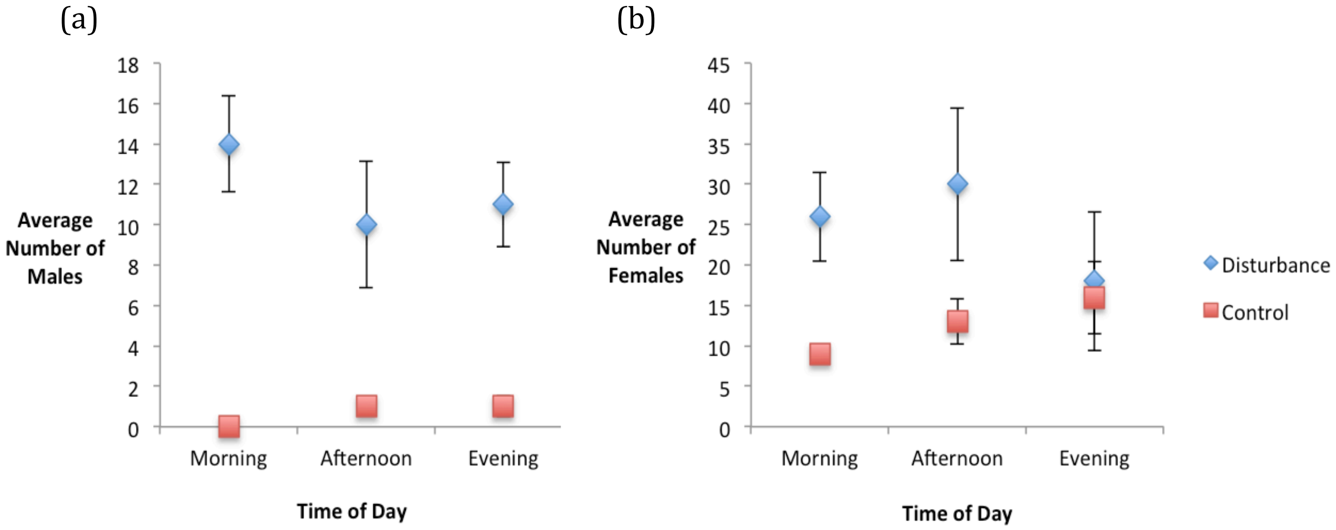

Figure 3.10(a): The mean (±1 S.E.) number of males hauled-out per two-hour survey, during the morning (disturbance: n = 5; control: n = 1), afternoon (disturbance: n = 4; control: n = 4) and evening (disturbance: n = 3; control: n = 2) hours at the control and disturbance sites.
(b): The mean (±1 S.E.) number of females hauled-out per two-hour survey, during the morning (disturbance: n = 5; control: n = 1), afternoon (disturbance: n = 4; control: n = 4) and evening (disturbance: n = 3; control: n = 2) hours at the control and disturbance sites.

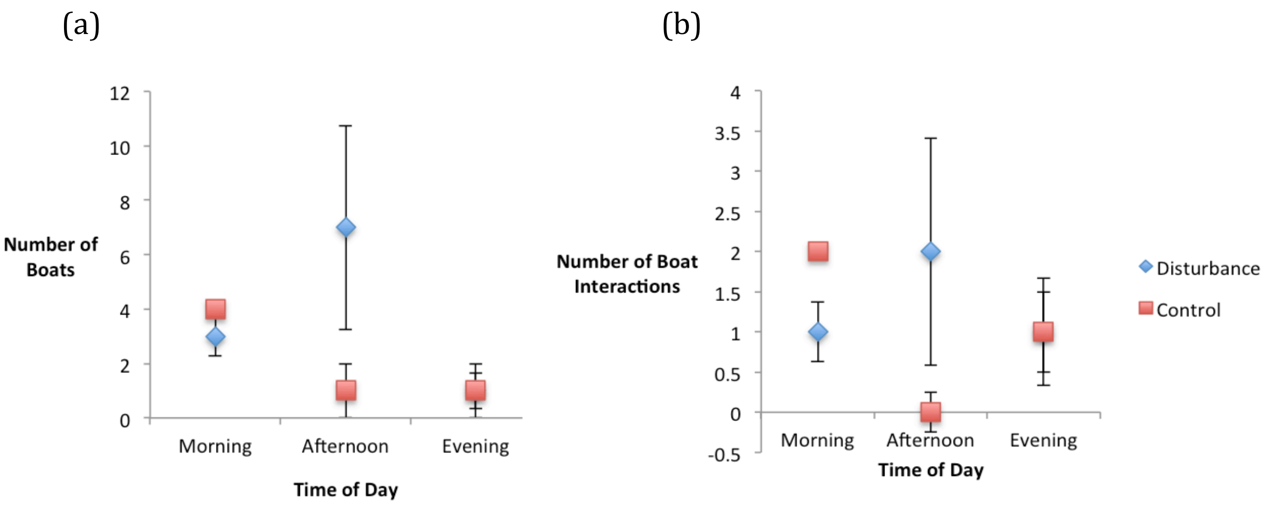

Figure 3.11(a): The mean (± 1 S.E.) number of boats and at the disturbance and control sites per two-hour survey during the morning (disturbance: n = 5; control: n = 1), afternoon (disturbance: n = 4; control: n = 4) and evening (disturbance: n = 3; control n = 4) hours. **(b):** The mean (± 1 S.E.) number of boat interactions and at the disturbance and control sites per two-hour survey during the morning (disturbance: n = 5; control: n = 1), afternoon (disturbance: n = 4; control: n = 4) and evening (disturbance: n = 3; control n = 4) hours.

3.3.2 Sea State

Haul-out surveys were carried out in sea conditions that ranged from a sea state 1 to a sea state 6. Sea state did not appear to have any effect on the mean group size hauled-out either at the disturbance or the control site (Figure 3.12). When differences between the sites were tested for, sea state was not found to have any influence on the mean number of seals hauled out (disturbance: $F_{3,8} = 0.44$, $p = 0.73$; control: $F_{3,3} = 1.09$, $p = 0.47$). As would be expected, the total number of boats and boat interactions were higher in lower sea states, with no boats observed above a sea state 3 for either site (Figure 3.13). Although the total number of boats at the control site is highest in a sea state 2, this is probably due to the fact that only one survey was carried out in a sea state 2, with the majority of surveys carried out at the control site in a sea state 1.

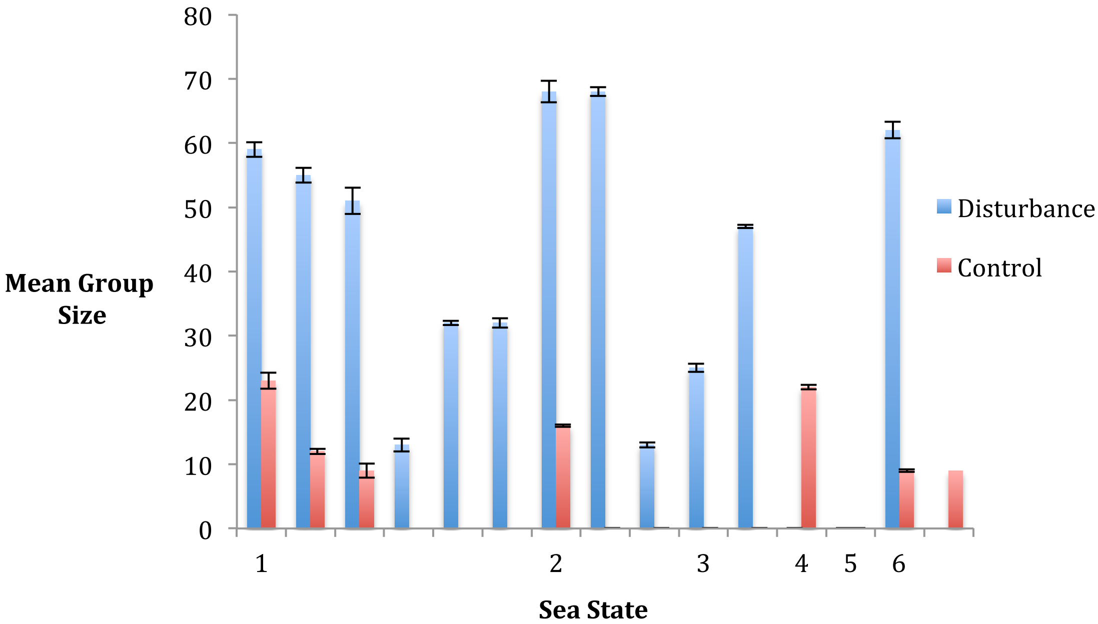

Figure 3.12: The mean (±1 S.E.) number of hauled-out seals per two-hour survey, in sea states 1 to 6, at the control and disturbance sites.

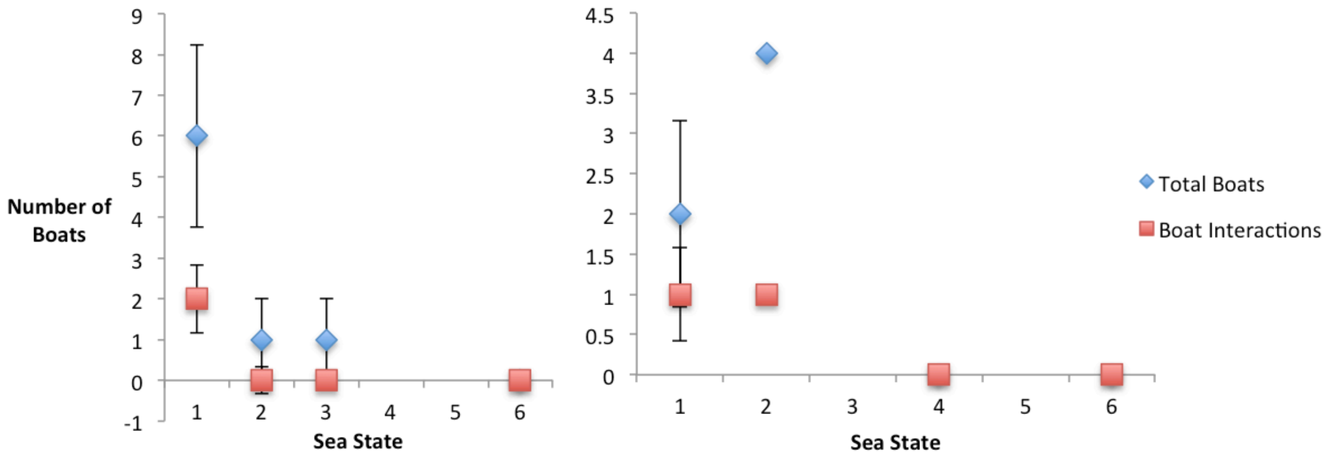

Figure 3.13(a): The total number of boats and boat interactions at the disturbance site in each sea state. No surveys were carried out in sea states 4 and 5 at the disturbance site. **(b):** The total number of boats and boat interactions at the control site in each sea state. No surveys were carried out in sea states 3 and 5 at the control site.

Focal follows of seals in the water were carried out in sea states 0 – 4. Attempts to follow a focal seal were made in sea states higher than 4, but the rough sea conditions either made it difficult to identify the seal or seals were not observed to be present at the site.

3.3.3 Wind Speed and Wind Direction

Wind direction appeared to influence the location of the hauled-out seals at the disturbance site. The seals were observed to haul out on the southern and northern extremities of Kitterland equally (50% of all surveys at each location). When this was examined according to wind direction, the wind was blowing in a southwesterly or northwesterly direction (SW, SSW, WSW, WNW) on 80% of all occasions when the seals were hauled out at the southern extremity. Seals were observed to haul out at the northern extremity on all occasions of an easterly wind (E and SE), thus sheltering themselves from high winds. Similarly at the control site, seals were not observed hauled out at the southern tip of the Langness Peninsula during high southerly winds (S, SSW, WSW) and were instead observed approximately 300 m further round the eastern coast, where they would be provided with shelter.

The average number of seals hauled out per survey was variable with wind speed, and no significant association was found between the two variables at either survey site (disturbance: $r_{(11)}$ – 0.00, p = 0.99; control: $r_{(6)}$ = - 0.24, p = 0.60) (Figure 3.14).

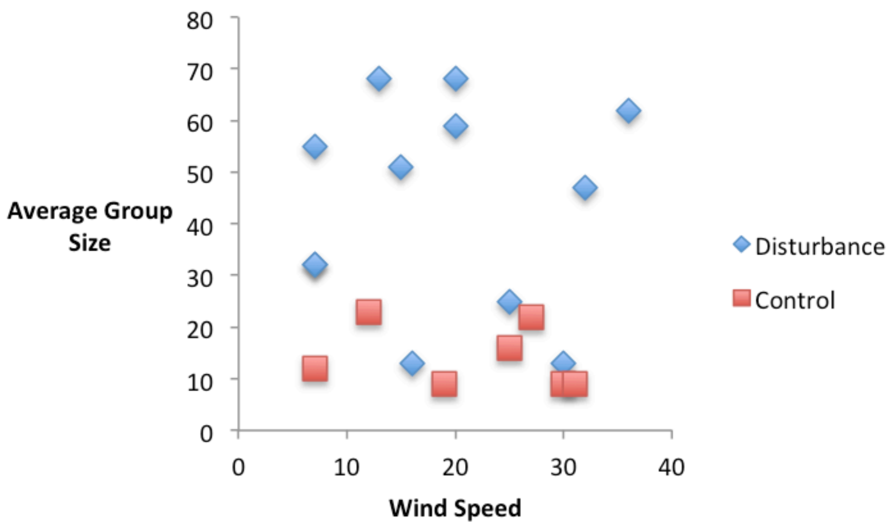

Figure 3.14: The association between wind speed (km/hour) and average group size of hauled-out seals per two-hour survey at the disturbance (n = 12) and control sites (n = 7).

3.4 Code of Conduct

The voluntary code of conduct put in place by the Isle of Man Government states that boats should maintain a distance of at least 50 m from seal colonies. This code of conduct was abided by in all cases of the in-water survey, with the closest vessel approaching a seal being 50 m. This may be due to the fact that the focal seals during the in-water survey were all very close to the shore and not obviously noticeable to boat operators, as large groups of hauled-out seals may be. It could also be due to small sample sizes resulting in a bias in the results. Data from the haul-out surveys show that boat operators regularly approach the seal colony closer than the recommended distance, with 38% of all boat interactions occurring at a distance closer than 50 m. The closest distance of a vessel to the seal colony was 10 m, although this did not result in any movement or flushing of the seals present at the disturbance site. The code of conduct also recommends that the seals are not approached at a speed of more than 5 knots. Of the boats which approached the seals closer than 50 m, 63% did so at a speed greater than 5 knots.

Chapter 4

Discussion

4.1 Behavioural Budgets

The seals at Kitterland were shown to be subject to a large amount of boat traffic. However, the seal colony at this site do not seem to be showing changes in their behavioural budgets which would be synonymous with boat disturbance. It is possible that this may be due to the small sample sizes that were obtained for this study as, although not significant, a difference was seen between the amounts of time spent underwater at the control and disturbance sites. This difference was even more pronounced when compared to Peel harbour, where the focal seals were found to spend the largest amount of time underwater and where the largest amount of boat traffic was present. It is possible that seals at the harbour and the disturbance site are spending a large amount of time underwater as a means of vertical avoidance of the boats. It is not clear whether vertical avoidance of the boats is a common strategy in pinnipeds as there does not appear to be a wealth of information available about their baseline behavioural budgets. However, it has been shown that cetaceans regularly increase their dive time and spend a large proportion of their entire behavioural budget underwater in response to boat presence (Janik and Thompson, 1996; Jahoda, 2003; Lusseau, 2003b; Ng and Leung, 2003).

A common response of cetaceans to levels of high boat traffic is to increase the proportion of time spent travelling, as a means of horizontally avoiding the boat disturbance. This increase usually comes at the cost of time normally spent feeding, resting or socializing (Lusseau, 2003a). No difference was found in the overall time spent travelling or resting between seals at the disturbance and control sites, indicating that the seals, whilst in the water, are unlikely to be suffering any detrimental impacts as a result of a change in their behaviour. As grey seals show a high level of fidelity to their haul-out sites, vertical rather than horizontal avoidance of the boats would be a more appropriate strategy for the seals to adopt. Horizontal avoidance would be a more appropriate strategy for cetaceans due to their faster speed.

Although the overall proportion of time that seals spent resting did not significantly differ between the control and disturbance sites, seals at the control site spent a significantly larger proportion of time in the aquatic resting behaviour of 'bottling,' than seals at the disturbance site. It is possible that seals at the control site would prefer to adopt this strategy of resting behaviour over 'logging,' as it would allow them a clearer view of their environment to scan for any signs of danger. The amount of time spent logging at each site also shows a decrease when boats are present compared with when they are absent. It is not clear whether this is a strategy adopted for boat avoidance or whether, this preference is simply a result due to differences in their respective environments.

4.2 Habituation

It is also possible that the seals at the disturbance site have become habituated to the presence of boats. Seals, both in the water and hauled out, actually spent a higher proportion of time showing vigilance behaviour at the control site than at the disturbance site. When the causes of vigilance were examined, seals at the control site showed equal vigilance to boats and to pedestrians on the shore, whereas seals at the disturbance site directed the majority of their vigilance to pedestrians, even though a much higher number of boats were present. This is in contrast to previous findings, which show a stronger response to boats than to pedestrians (Andersen *et al.*, 2012). However, it is thought that this strong response to boats was indicative of a lack of habituation, due to the wide variety of different boat types present in the area. Here, a wide variety of boats were not found at the disturbance site, the majority being recreational motorboats. Therefore, the lack of vigilance directed towards boats may be due to habituation at this site.

4.3 Male and Female Response

Male and female seals may respond to anthropogenic disturbance in different ways. Boren *et al* (2002) demonstrated that male fur seals were significantly more likely to remain hauled out in response to boat disturbance, whereas females were significantly more likely to flush into the water. An explanation for this difference in behaviour may be that as this study took place at a breeding site, males had invested far more energy into defending their territory and were therefore much more reluctant to leave the site (Boren *et al*., 2002). Although this was found in New Zealand fur seals rather than the grey seal, a similar result was obtained in this study with every flushing event involving only females.

As hauled out seals respond to disturbance in different ways depending on their gender, it follows that they may also differ in their response when in the water. However, no significant difference was found in the behavioural budgets of male and female seals at the disturbance site. This could be because they are habituated to boat disturbance at this site, but since no males were ever observed in the water at the control site, a difference in response between the sexes could not be properly examined. Differences have been observed between the response of male and female bottlenose dolphins (*Tursiops* spp.) to boat disturbance, with males adopting a vertical avoidance strategy upon arrival of a boat, and females only adopting a vertical avoidance strategy once the interactions became intrusive. It is believed that this difference in response by gender is due to the fact that vertical avoidance of boats would be more energetically expensive for females as their energy stores are not as great as that of males (Lusseau, 2003b). Although the ecological constraints of seals are different to that of dolphins, it is possible that no difference was found between the response of male and female grey seals as they are both energetically constrained. A male seal fasts throughout the eight weeks of the breeding season and body energy in males is positively correlated with the amount of time spent at the breeding site (Lidgard *et al*., 2005). Therefore, in order to achieve high reproductive fitness, males need to conserve their body energy before the breeding season. Females also have a need to conserve their energy stores, as they require energy to give birth, and large amounts of energy are transferred to their pups during the lactation period, resulting in a loss of around 40% of their total body weight (Anderson and Fedak, 1987). As a result of this need to conserve energy, it is likely that grey seals do not respond to boat traffic until the disturbance becomes intrusive.

It is thought that pinnipeds may have individual personality types, for example vocalisations made by male elephant seals (*Mirounga* spp.) have been shown to be individually repeatable (Sanvito and Galimberti, 2003). More specifically, it seems that grey seals may have their own individual personalities or behavioural types, with evidence of individually repeatable reproductive performance (Lang *et al*., 2009), and, more recently, female grey seals showing evidence of individually consistent levels of pup checking in response to a controlled disturbance (Twiss *et al*., 2012). It is recognised that information about individual behavioural types can be gathered from observational studies when repeated observations of known individuals can be made (Twiss and Franklin, 2010). However, analysis of the photo-ID of focal seals (Appendix 2) indicates that the no seal was followed on more than one occasion, and therefore a large amount more data would need to be collected before data on individual behavioural types could be analysed.

4.4 Scanning Frequency

It was, however, noticed in this study that individual differences in scanning behaviour might exist. Scanning can be defined as the lifting of the head with the eyes open (Chilvers *et al*., 1999). From making repeated observations of the scanning frequency of the same focal seals, the number of scans per five-minute period was shown to be consistent in each seal with a maximum difference of two scans per five-minute period in a focal seal. Only one exception was made to this, when eight scans per five-minute period were seen in a focal seal upon moving from a position in the middle of a haul-out site to the edge of the haul-out site. It was found that the frequency of scans is much higher by seals on the edge of the haul-out site than seals in the middle. This result has also been found in other studies on pinnipeds (Terhune and Brillant, 1996) and has also been observed in other groups of mammals, such as the prairie dog (*Cynomys* spp.) (Hoogland, 1979) and the coati (*Nasua narica*) (Burger and Gochfield, 1992). This high level of vigilance by animals on the periphery is attributed to the greater risk of predation that animals on the edge of a group face, compared to those in the middle (Krebs and Davies, 1997).

In the present study, the scanning frequency of grey seals was also found to differ with immediate group size at the disturbance site but not at the control site, nor with total group size at either site. This may be because the number of seals hauled out at the control site is far less numerous than at the disturbance site, and therefore the group size may not be large enough at this site to result in a decrease in scanning frequency. A decrease in vigilance (or scanning frequency) with an increase in group size is a common response amongst pinnipeds, and has been reported in a number of other studies (Kreiber and Barrette, 1984; DaSilva and Terhune, 1988; Terhune, 1985). Although individual vigilance decreased with increasing group size, overall group vigilance increased. It is thought that grouping functions as an anti-predator strategy and it has been shown, for example, that larger groups detect predators at greater distances (DaSilva and Terhune, 1988).

It is interesting that no significant difference was found in the scanning frequency of grey seals between the two sites. It has been previously shown that harbour seals at sites that are more susceptible to disturbance spend a greater percentage of their time being vigilant (Suryan and Harvey, 1999). As the seals at Kitterland are subject to much higher levels of disturbance, it would be expected that they would also spend a higher proportion of time scanning their environment. The lack of difference in scanning frequency between the sites may be another indicator that the seals at this site have habituated to the presence of boats. This habituation is probably dependent on the type of boat encountered, as the boats observed in this study represent little threat the to seals and are likely to be boats which are regularly encountered.

4.5 Factors Affecting Disturbance

A positive correlation was found between boat speed and the distance eliciting alert behaviour. This is in contrast to findings on harbour seals, where powerboat speed did not influence the distance of disturbance. However, the authors in that study concluded that greater sample sizes would be likely to result in significant differences among distance of disturbance for various approach speeds (Suryan and Harvey, 1999).

Due to the small sample sizes in the present study, it is difficult to determine whether the type of boat is influencing the probability or the distance of disturbance. Seals showed alert behaviour regardless of boat type. However, flushing was only ever observed in response to motorboats. Although this would seem to show that the seals are more seriously disturbed by motorboats, this is more likely to be due to their prominence in the area, with 70% of all boat-seal interactions involving this boat type. It is likely to be the type of motorboat and its behaviour that is important in determining the response of seals. However, seals flushed in response to all motorboat types (recreational, potting boat and tour/charter boat). It is possible that sample sizes were too small in this study to determine any patterns of response. Kayaks and canoes in fact have been shown to cause disturbance more frequently, and at much greater distances, than motorboats (Calambokidis et al., 1991; Lewis and Mathews, 2000). It is thought that boats such as kayaks and canoes cause disturbance at greater distances as their approach is not heard and the seals receive no acoustic warning of their presence. Therefore, as the arrival of a kayak is not anticipated, seals are more likely to flush upon observation of the boat (Fox, 2008). Other explanations may be that their low profile makes them more difficult to detect. However, as it was shown that disturbance is caused at greater distances by kayaks, this seems not to be the case. It has also been hypothesized that their low profile and slow, quiet approach gives them the resemblance of a predator (Henry and Hammill, 2001). The duration of the encounter may also influence the severity of the disturbance, as kayaks/canoes will stay close to the seal colony for a longer period of time than motorboats, due to their slower nature (Henry and Hammill, 2001). The duration of the interaction was shown to be an important factor affecting disturbance in this study, with all interactions that lasted for a total duration of four minutes or longer resulting in a flushing event.

The distance at which seals show disturbance responses appears to be extremely variable between studies. The majority of studies examining the impact of boat disturbance on seal colonies only consider the distance at which flushing occurs, but usually disregard the distance at which alert behaviour is displayed. Calambokidis *et al*. (1991) reported that seals were flushed into the water at an average distance of 56 m, but flushing events were observed at distances up to 246 m. In contrast to this, flushing has been reported by a number of studies to only occur when the boat was within 10 m of the seal colony (Kovacs and Innes, 1990; Cassini, 2001). The average distance of the boat for seals to respond by flushing in this study was 54 m, i.e. very similar to the study by Calambokidis *et al*. (1991), with the maximum distance being 100 m and the minimum distance being 20 m. The variability in disturbance distance reported by studies indicates that the distance from the boat at which seals will move into the water is dependent on many other factors, such as the type, speed, and noise of the boat. In addition to this, the response may also be influenced by many environmental factors.

4.6 Habituation

It has been shown that New Zealand fur seals (*Arctocephalus forsteri*) respond to boat disturbance to a lesser extent, in a less dramatic way, and at closer distances at sites where there are high levels of tourism, compared to control sites (Boren *et al*., 2002). Although sample sizes in the present study were too small to detect significant differences between response distances at sites, the average distances of alert response, movement and flushing were all much higher at the control site. This, combined with the lack of vigilance towards passing boats, suggests that at least some of the seals at the disturbance site have become habituated to boat traffic. Habituation may be beneficial to the seals at the disturbance site, as the boats passing by are not generally a threat to the seals and by not responding to the disturbance, the animals can conserve energy.

However, habituation to boat traffic may have long-term impacts on the population and could result in the seals not responding appropriately to real threats if they were to occur (Boren *et al*., 2002). Habituation in other species have shown it to result in new behaviours arising, and this can be seen in bottlenose dolphins (*Tursiops truncatus*) that began to display biting and begging behaviours after habituation to ecotourism activities (Connor and Smolker, 1985). A similar situation is seen with the seals resident to Peel harbour on the west coast of the Isle of Man, which are regularly seen to beg for and accept food (Peters, 2007a).

4.7 The Influence of Environmental Factors

Various environmental factors have been shown to influence the response of seals to boats and other forms of disturbance. On overcast days, hauled out seals appear to be more tolerant of boat approaches and react at a closer distance than on sunny days (Calambokidis *et al*., 1991). Disturbance of seals by low flying aircraft is often a cause of contention, with some studies, including this one, reporting no change in behaviour in response to aircraft, and others reporting movement of seals into the water. Some of this variability may be explained by differences in weather conditions as seals have been shown to respond to low flying aircraft more on calm days. This is thought to be because weather conditions such as strong winds, heavy rain and rough seas will create a lot of noise that will help mask the noise of the aircraft (Johnson, 1977). Other explanations may include the time the aircraft is passing, whether the seals have habituated to the passing of the aircraft and what the site is being used for, e.g. breeding site. Differences in environmental conditions are also important in determining the type of disturbance that may occur. It has been shown, as would be expected, that windy days affect human activities resulting in more disturbances by sailboats whereas calm days result in a higher proportion of disturbance by kayaks (Henry and Hammill, 2001).

Variability in environmental factors also appears to be important in determining haul out numbers. For example, lower numbers of seals tend to haul out in inclement weather conditions. This is most pronounced during moult, when an important function of hauling out is to raise the skin temperature in order to accelerate the moulting process (Feltz and Fay, 1966, Boily, 1995). The number of hauled out seals has also been shown to be positively correlated with air temperature, percentage sun and wind velocity, and negatively correlated with percentage cloud cover (Henry and Hammill, 2001).

Disturbance events and environmental conditions may also interact to influence the number of seals hauled-out. Henry and Hammill (2001) showed that a larger number of seals would haul out on cloudy days, on days when they were disturbed. The reason for this is not clear, as it may be that there is a reduction in the number of disturbances on cloudy days, or it could be a result of the seals compensating for haul-out time that had been lost due to previous disturbances (Brasseur *et al*., 1996).

4.8 Limitations of the Study

A number of difficulties arose and were overcome during the course of this study. The greatest limitation of the study was the unfavourable weather conditions, which persisted throughout the entire study period. Bad weather restricted the use of equipment, affected the presence of the seals at the survey sites, and affected whether the quality of the photographs would be sufficient to identify focal seals. In order to obtain the data necessary for this study, the survey period was extended until the end of August rather than ending at the beginning of August, as originally proposed.

The poor weather conditions also resulted in minimal boat disturbance as, even when conditions were good enough to survey, the sea state and wind speed would often be much higher than would be ideal for any form of recreational boating. This resulted in small sample sizes and did not allow statistical analysis of data relating to the distance at which seals showed disturbance responses or factors that may influence the level of frequency of response. Other options were considered to try and gather more data on disturbance, such as carrying out controlled disturbances or conducting a questionnaire to regular boat operators such as charter boat companies or kayaking companies, concerning their experience of seal disturbance. However, these ideas were eventually dismissed, due to the inability to obtain permission to carry out controlled disturbances and the limited time available to gain ethical approval and to conduct questionnaires.

Another limitation found in this study was the difficulty in identification of focal seals. In the majority of cases, the focal seal could usually be followed with ease throughout the hour-long survey period, as it would be close to shore with distinguishing markings and would usually surface in the same general area on every occasion. However, due to a lack of distinguishing markings or the presence of a large number of seals in the water, the focal follow could sometimes become confusing. To overcome this, additional photo-ID was undertaken at every opportunity, when it was not certain that the seal being followed was the correct focal animal so that mistakes could be rectified.

The low abundance of males at the control site also presented a limitation to the study. A lone male was observed hauled out in the majority of surveys, but no males were ever observed in the water to enable a focal follow to be conducted in order to construct behavioural budgets. Location of males at a different site where there was minimal disturbance, was considered. However, this idea was rejected as a different location would introduce a multitude of changes in environmental factors, which could potentially influence the behaviour of the seals.

4.9 Conclusions and Recommendations

This study has shown that the grey seals at Kitterland (disturbance site) are regularly subject to disturbance due to boat traffic. However, due to the unseasonal weather conditions, the level of boat disturbance was not as high as would be expected. Peters (2007a) also reported low levels of disturbance to the seals at Kitterland as a result of poor weather conditions. Therefore, as the Isle of Man is frequently exposed to bad weather, it is possible that the seals are not experiencing as much disturbance from boat traffic as might occur elsewhere.

It is possible that the seals at Kitterland are habituated to boat traffic to some degree. Although it is difficult to draw firm conclusions with a small data set, it would appear that the seals at this site respond to disturbance at much closer distances, and are less likely to move in response to disturbance, than the seals at Langness. Hauled out seals at Kitterland also spent a smaller proportion of time displaying alert behaviour, although this was not significant.

No significant differences were found in the behavioural budgets of seals at the two sites that would appear to be associated with boat disturbance. A significant difference was observed in the form of rest adopted by the seals, and more work is required to determine whether this is an artifact of the different environmental conditions at the sites, or due to boat disturbance. As this difference was also observed within the same site between surveys with and without boat presence, the decrease in the proportion of time spent logging may be a form of boat avoidance. A difference was also seen in the amount of time spent underwater. However, this was not significant and more research is needed to determine whether lack of significance is due to small sample sizes. There was also no significant difference found in their scanning behaviour, with seals at both sites appearing to be equally vigilant. From this study, it is recommended that it would be advantageous for the scanning behaviour of focal seals to be measured in percentage of time, rather than frequency of occurrence, as it was observed that seals show differences in the length of the scan.

Although the levels of boat disturbance do not appear to be having a large detrimental impact on the seal colony at Kitterland, it is important to take into account that levels would be much higher in improved weather conditions. In addition to this, The Calf of Man, which is located only 300 m away from Kitterland, is used as a breeding site. Therefore, boat disturbance around this site may have a far greater impact during the breeding season when it could result in an interruption of lactation or separation of mother and pup.

It should also be noted that although the voluntary code of conduct was initiated in an attempt to protect the seal colonies from disturbance, 38% of boats approached the colony at a distance closer than 50 m, and 63% of boats came to within 100 m of the seals at a speed greater than 5 knots. The code of conduct has not been widely distributed or enforced since its introduction in 2007, which may explain why these violations regularly occur. As boat speed was shown to be positively correlated with disturbance distance, more effort should be made to make boat users aware of the code of conduct, and the impact that disturbance may have to the seal colony. The duration of the boat interaction was also found to be an important factor in managing boat disturbance, with all interactions over four minutes in duration resulting in the flushing of seals into the water. It is recommended that the code of conduct be updated to allow boat users to make sensible decisions about the amount of time they spend near to hauled out seals.

Several recommendations for future research and improvements have arisen from this study. Continuation of data collection pertaining to this study would be useful to allow a fuller investigation into the effect of boat type, speed and duration. It would be particularly interesting to determine whether disturbance is caused to seals by silent vessels such as kayaks or motorboats which have turned their engine off, as this is an action often taken by people in an attempt to approach seals without disturbance. Collection of further data would also allow more analysis to be carried out on the influence of environmental factors on disturbance response. It would also be interesting to monitor boat disturbance during the breeding season, so that the impact of disturbance during this particularly vulnerable time can be assessed. If a similar study were to be carried out it is recommended that tankers and ferries on the horizon, which were omitted in this study due to their visibility from great distances, be included as noise from these boats can be heard and potentially mask communication at large ranges. Although it wasn't possible in this study as sample sizes were generally too low, it is also recommended that environmental data collected in similar studies be analysed using a multivariate approach, such as a generalised additive model. This would be allow all variables to be considered and would account for interactions between variables.

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Personal Communications

1. Simon Mitchell: Seal researcher at the Manx Whale and Dolphin Watch.

Appendices

Appendix 1: Forms Used to Aid Data Collection

Effort Form: Haul-out

Date: Observers (Effort, Interaction):

Start Time	End Time	Sea State	Wind Direction	Wind Speed	Group Size	Number Male	Number Female	Number Unknown	Number Juveniles	Behaviour	Scanning /5 mins	Notes	Boat Interaction ID

Total Number of Boats:

Boat Interaction: Haul-out

Date: Observers (Effort, Interaction):

Boat Interaction ID	Start Time	End Time	Boat Type	Boat Speed	Boat Wake	Distance of Alert	Distance of Movement	Distance of Flushing	Number of Males Flushed	Number of Females Flushed	Number of Juv. Flushed	Closest Distance

Behaviours:

Logging = LG

Bottling = BT

Travelling = TR

Aggression = AG

Feeding/Foraging = FD

Vigilance/Scanning = VG

Not seen/underwater = NS

Seal Effort Form

Date: Observers (Effort, Interaction):

Start Time	Sea State	Wind Direction	Wind Speed	Photo ID?	Behaviour	Boat Interaction? (Y/N)	Total No of Boats in Interaction Distance	Total No of Boats outside Interaction Distance	Notes	Interaction ID

Total Number of Boats:

Seal Interaction Form

Date: Observers (Effort, Interaction):

Interaction ID	Response Movement (positive, neutral, negative)	Boat Type	Boat Name/ Description	Boat Speed	Boat Wake	Boat Distance	Closest Distance	Behaviour Before	Behaviour During	Behaviour After	No. of Seals During	No. of Seals After	Notes

Appendix 2: Photo-Id of Focal Seals

Langness (control site):

30th June 2012, right side only:

7th July 2012, left and right sides:

8th July 2012, left and right sides:

21st July 2012, left and right sides:


29th July 2012, left and right sides:


Kitterland (disturbance site):

3rd July 2012, right side only:

9th July 2012, left side only:

27th July 2012, left and right sides:

7th August 2012, left and right sides:

20th August 2012, right side only:

20th August 2012, left and right sides:

24th August 2012, left and right sides:

24th August 2012, right side only: