Harbour seal pupping patterns, pup dispersal and stranding rates in Dundrum Bay, north-east Ireland

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Abstract

Harbour seal pupping has been recorded between 1994 and 2006 at a site in Dundrum Bay. Peak pupping was 4–9 July, with an average of 8 pups counted. Total abundance in Dundrum Bay was estimated at 220 seals. Five pups were radio-tracked for a 12 week period in 1995. All remained close to the nursery site for at least two weeks post-weaning, after which they established discrete foraging areas along a 50 km stretch of coast. There has been a total stranding rate recorded of about 43% between birth and 5 months of age, 19% of which were neonates.

Introduction

The aim of this study is to provide an insight into the dynamics of a harbour seal (*Phoca vitulina*) haul-out and pupping site on the northeast coast of Ireland (Fig. 1).. The site studied here is one of a number of harbour seal sites along the Co. Down coast (Nairn, 1979), some of which have experienced a decline in recent years (Wilson & Montgomery-Watson, 2002). A count of harbour seals in Ireland during the August moult in 2003 totalled 2,905 in the Republic of Ireland and an additional 1,248 in the three north-eastern counties of Ireland (Cronin et al., 2004; Lonergan et al., 2007). A count in Co. Down during the July pupping season in 2006 resulted in 179 pups and 637 adult seals, yielding an estimated population in Co. Down of about 1600 seals (Sea Mammal Research Unit, unpublished data). Both the harbour and the grey seal (*Halichoerus grypus*) are strictly protected under the Wildlife (Northern Ireland) Order 1985, and because of the perceived decline in numbers in Strangford Lough (Co. Down) in particular, the harbour seal was included in the 2004 Lists of Northern Ireland priority species and species of conservation concern (Northern Ireland Biodiversity Group).

A primary area of concern for a declining population include birth and pup survival rates. Data needs to be collected on pupping parameters in order to inform conservation management. However, published descriptions of pupping parameters are rather rare (Wilson, 2001; Jemison and Kelly, 2001), probably because harbour seal population censuses are usually made during the post-pupping moult (e.g, Cronin et al., 2004; Lonergan et al., 2007). Jemison and Pendleton (2006) highlight the importance of studying ‘index’ pupping sites in a population, since studies of diet and detailed accounts of pupping and pup survival at one particular site may help to interpret population trends obtained from wider population censuses.

This study focuses on pupping patterns, pup survival and post-weaning dispersal in one such ‘index’ pupping group in Dundrum Bay, north-east Ireland (Fig. 1) over a 13-year period.

Methods

The study area. Dundrum Bay is divided into two almost completely different areas in terms of both intertidal haul-out and benthic habitat (DARD, 2002; Fig. 1). In the western part the main haul-out site for both harbour and grey seals is the sandy beach at Ballykinler, and the benthic habitat in the western habitat is mainly rippled muddy sand. In the eastern part, by contrast, the intertidal area is mainly rock and boulder, with the flatter rocky ledges at Minerstown used for haul-out by harbour seals. The muddy sand in the eastern part is limited to the shallow water, while in waters deeper than 5m, the benthic habitat is mainly boulders with kelp forest.

Both sites are subject to a spring tidal range of about 4.5m. Haul-out space is available to seals throughout the tidal cycle at Ballykinler, although space is reduced during moderate high tides at Minerstown. During extreme high tides at Minerstown, some seals haul out close to the beach on rocks that are constantly above the high tide mark. As the tide recedes, the seals move to alternate space within the site. At Minerstown seals move at half-tide to rocks beyond the low water mark. The Minerstown ledges can probably accommodate a maximum of about 80 hauled-out seals. At Ballykinler the seals move closer to the water's edge and further out towards the mouth of the bay. The beach can probably accommodate over 200 seals at any state of the tide.

The seaward edge of both sites lies within the 2m depth contour, but the surrounding area of the Minerstown haul out site has a steeper depth gradient than Ballykinler. However, most of Dundrum bay lies within the 20m depth contour (Fig. 1).

Seal counting. At both sites seals were observed through binoculars or telescope and counted during the first 2.5h of the ebbing tide, during which period the maximum number of both adult seals and pups are most visible from the shore and therefore most easily and accurately counted. Counts were not made in rough weather with heavy sea state or during heavy rain. Seals were usually observed and recounted over a period of 30-60min or until a maximum count of both adults and pups was reached for that day. Presence of grey seals (*Halichoerus grypus*) was also noted. Observation records included presence and behaviour of mother-pup pairs, pups without their mothers in attendance and stranded pups.

Visits to the Minerstown site were made on as many days as possible between June 15 and September 1 each year from 1994 to 2006 (Table 1a). Regular counts at the Ballykinler site were made only in 2002, 2003 and 2005 (Table 1b).

Treatment of adult/subadult count data. Adult/subadult harbour seal counts (excluding pups) were separated into two periods in each year:

1. June 15 to July 31 (pupping)
2. August 1 to September1 (moulting).

Mean adult/subadult counts at Minerstown for each 5-day period starting from June 15 were calculated over all 13 years of the study 1994–2006. Where there was a minimum of five counts for each pupping and moulting period, the proportion of the local seal population visible at the haul-out site was calculated from the equation. $\boldsymbol{P_{av}} = \boldsymbol{C_x/[C_{max}} + (\boldsymbol{C_{max}} - \boldsymbol{C_{max-1})]}$, where $\boldsymbol{P_{av}}$ is the average proportion of seals that were hauled out and $\boldsymbol{C_x}$ $\boldsymbol{C_{max}}$ and $\boldsymbol{C_{max-1}}$ are the mean, the highest and the second highest of the replicate counts, respectively (Olesiuk et al., 1990). Estimated abundance for that period was then calculated from $\boldsymbol{C_x/P_{av}}$ (Thompson *et al*, 1997).

Treatment of pup count data. Mean pup counts at Minerstown for each 5-day period were calculated over all 13 years of the study 1994–2006 in order to obtain a 'pupping curve' as the season progressed. Average pupping curves were obtained for all 13 years of the study and also for the years 1994–1999 and 2000–2006. Pup counts before and after July 19 in these two year groupings were compared using the T-test. In order to compare the mean number of pups at Minerstown and Ballykinler in 2002, 2003 and 2005 as the season progressed, mean counts for 10-day periods starting from June 15 were calculated for each of these years.

Pup capture for radio tagging. Between July 19 and August 3 1995, six pups were caught by rushing the haul-out group on foot. Each catch attempt took place during the short period between the rocks becoming accessible from the shore and the seals transferring to other rocks. One or two pups were successfully captured on four of seven attempts. Captured pups were secured in hand-held nets and transferred to the top of the shore.

The pups were first weighed using a spring balance. Standard length and maximum girth were measured while the pup was strapped to a restraining board.

Each pup over 15 kg weight (this excluded pup no. 3) was fitted with a head-mounted VHF tag glued to the fur on the top of the head (Fedak, Anderson & Curry, 1983). Each was also marked with a plastic numbered rototag in one hind-flipper and a fluorescent dye-mark applied with glue to the fur on the back (Thompson, 1989). The pups were then immediately released back to the haul-out site.

Location of radio-tagged pups and data treatment. The pups were located using a VHF receiver and Yagi aerial from vantage points along the coast. Two or three fixes were obtained from each of two vantage points using the null-average method (Springer, 1979) and the mean bearing was used to estimate the pup's position. Locations were made at random times, mainly during daylight hours. Logistical constraints prevented the location of all seals on every day, but an additional note was made of all days on which a signal was received from within the study area and also of sightings of the pups. The pup tracking data were split up into five 3-week periods: (1) 20/7 to 10/8; (2) 11/8 to 01/9; (3) 02/9 to 23/9; (4) 24/9 to 15/10; (5) 16/10 to 25/10. The approximate location of each pup was marked on a map of the study area.

Pup stranding records. Pups (i.e. seals in their first six months) reported as stranded newborns, or sick, injured or dead at any location in Dundrum Bay were collected by personnel either from Tara Seal Research Centre (TSRC), Exploris Aquarium or Environment and Heritage Service. Freshly dead carcasses were taken for post-mortem to the Veterinary Sciences Division at the Department of Agriculture and Rural Development (DARD). Live-stranded seals were taken either to TSRC or Exploris for treatment and rehabilitation.

Results

Counts of adults and subadults. Despite annual variation, the counts of adult and subadult seals at Minerstown during the pupping season (June 15 to July 31) have decreased gradually by about a third over the 13-year period (Fig. 2). With the season, the average number of seals at Minerstown increased from less than 20 in mid-June, to 20-30 in July and to just less than 40 in August, while the average number at Ballykinler rose from about 30-40 in mid June to about 100-120 in August (Fig. 3). Using the Olesiuk equation, the proportion of seals hauled out during August was estimated at 59.1% for Ballykinler ($\boldsymbol{C_x}$ = 111.1, $\boldsymbol{C_{max}}$ = 178, $\boldsymbol{C_{max-1}}$ = 168) , and 60.5% for Minerstown ($\boldsymbol{C_x}$ = 23.6, $\boldsymbol{C_{max}}$ = 36, $\boldsymbol{C_{max-1}}$ = 33), giving a total estimated abundance of about 188 seals at Ballykinler, 39 at Minerstown, and therefore 227 seals in total (excluding pups of the year) in Dundrum Bay.

Counts of pups. The maximum pup count at Minerstown up to July 15 (i.e. during the birthing period) between 1994 and 2006 varied between 4 and 17, with an average of 8 pups. There has been considerable annual variation, but between 2002 and 2006 the pup count exceeded the average for the 13 year period (Fig. 4). In 7 of the 13 years, the maximum pup count has increased at Minerstown after the middle of July (Fig. 4).

Additionally, an annual average of 3 pups dead or live-stranded at the site were recorded during the pupping period, bringing the Minerstown annual average births to about 11. Pups recorded at Ballykinler together with neonatal strandings in western Dundrum bay since 2000 bring an average annual total estimate for pup births in Dundrum Bay up to about 15.

Pupping curves for each year at Minerstown show large day-to-day fluctuations, with maximum counts often not repeated on successive daily visits (Table 2). A pupping curve for Minerstown (Fig. 5a) shows the average pup numbers for the 13-year period 1994-2006 (Fig. 5a). This indicated that the period of peak average pup counts (8.4 pups) was between July 05 and 09, with an average of 6.5 pups during the five-day period June 30-July 04 and an average of 7.5 and 7.3 pups during July 10-14 and 15-19 respectively. Thereafter the average pup count fell gradually to 4.25 pups during August 14-18 and then fell abruptly to less than two pups from August 19.

When this overall picture for the 13-year period was divided into the earlier years (1994-99) and more recent years (2000-06), a difference in the rate of waning of the pup counts in late July and August became apparent (Fig. 5b) - the pup counts from July 20 to Sep 1 were significantly lower in years 2000-06 than in years 1994-99 ($P<0.001$; 1-tailed T-test).

When the pup counts at Ballykinler in 2002. 03 and 05 were compared with those in the same years at Minerstown (Table 3), there appears to have been a gradual shift over this 4-year period of pups from Minerstown to Ballykinler during late lactation and post-weaning.

Use of the Minerstown haul-out site by mothers and pups. Mothers with newborn pups and females about to give birth tended to assemble in a discrete group separate from other seals. This pupping group tended to become less discrete by about the end of the first week in July, as mothers with pups a few days old mingled with other seals on the main haul-out rocks. Mothers used the shallow water in the vicinity of the haul-out rocks to swim with their pups – mother usually leading while pup followed – or keeping vigil beside the pup while it slept at the surface of the water. From around the beginning of the second week in July, mothers sometimes ‘parked’ their pups on a gently sloping ledge adjacent to the main haul-out rock, often favoured by mothers with pups, and were also seen to return there to reclaim them. Pups hauling out on their own also often hauled out on this ledge, thereby forming a ‘cluster’ of pups. Pups whose mothers were absent were always very alert to the movements of adjacent seals and would follow other seals – often other mothers – into the water when they moved at half-tide to other haul-out ledges further from the shore.

Pup tagging and re-sightings of tagged pups, 1995. Dates of capture and data for each pup tagged are given in Table 4. Pups 1, 2, and 4 were seen with their mothers and nursing on several occasions after tagging. Between July 24–26 Pup 3 was seen alone, but repeatedly trying to nurse from other mothers and being rejected. However, on July 27 and 29 she was seen nursing from a mother with fresh severe abdominal wounding just anterior to the nipple. After tagging, pups 1, 2, 4 and 5 were seen on more than 20% of visits to the Minerstown site during late summer and autumn, pup 3 on 15% and pup 6 on 8% (Table 4).

Diving locations of radio-tagged pups, 1995. The tracking results for each of the five radio-tagged pups is presented in Fig. 6. None of the pups ventured beyond the haul-out site and its immediate vicinity during period **1** (20/7-10/8). During period **2** (11/8-01/9) pups were still often located near the haul-out site, but also all of the pups made trips away from the immediate vicinity, two pups venturing about 30 km NE of Minerstown and one pup 2 km west of the site. From period **3** (02/9-23/9) onwards, pups were located near the haul-out site only occasionally and were located in areas mainly in a SW direction for 50 km to Carlingford Lough.

Two of the pups (1 and 6) established a fairly discrete diving area in period **2** and remained there through period **3**, pup 6 moving to a different area for periods **4** and **5**. Pup 5 established one discrete diving area in period **3** and a different area in period **5**. Pup 2 established a discrete diving area in period **4**. The area of boulders and kelp forest in the eastern part of Dundrum Bay appeared to be visited infrequently.

When Pup 4 was located, he was always in Dundrum Bay, although in period **2** he was not located on four days, including two consecutive days. At the start of period **3** he disappeared for a week, after which he returned to Dundrum Bay for a further four days before disappearing again, after which he was never relocated.

With the exception of pup 4, the frequency and the duration of the radio signal became irregular before last date on which a signal was received, indicating either that the tag battery had begun to fail or that the tag was detaching from the head.

Stranded pups. Between 1994 and 2006 a total of 84 pups were found in Dundrum bay either dead or debilitated (Table 5). From a total number of Dundrum Bay births over this period, this represents a total mortality rate of pups aged 0–6 months of about 43%. In total there were twice as many pup strandings at Minerstown (55) than at Ballykinler (29).

The largest number of pup casualties occurred during the immediate post-natal period (to July 15; 38/84 strandings and 38/195 (19%) of total estimated births). The annual range was 1–6, with the worst years recorded being 2000 and 2001, each with 6 neonatal strandings. Overall, about two thirds of pups stranded in the post-natal period were of relatively low birth weight (6–9.5kg), while the remaining third were between 10-12.5 kg.

Strandings during late lactation and immediate post-weaning were less frequent, amounting to only 8 between July 16–31 in 13 years (about 4% of the estimated total births) and 11 in August (6% of estimated total births). Five of 8 pups in late July were found dead in a single weekend in 2006, when trauma from recreational craft jet-skis, speedboats) was suspected (though not confirmed) in at least some of the cases. One of the August pups was thought by the public to have been hit by a jet-ski and six were sick and underweight. .

Between September and January a total of 27 stranded pups were recorded (32% of the total pup strandings, and about 14% of the estimated total births). The annual range was 0–8, with the worst years being 2002 (8) and 2003 (7). Pups stranding or dying in the September-January period were all 10-17 kg, and most were suffering from lungworm infestation (S. Kennedy, pers. com.). Ten of the pups stranding in this period were recorded in 2002, which was the year of the 2nd PDV epizootic (Härkönen et al., 2006). One dead pup found near Ballykinler on 12.10.02 was diagnosed as positive for PDV (S. Kennedy, pers. com.). Four of the pups from this period were thought to have been killed deliberately, one in December 1996 and three in October 2003. One live-stranded pup had a broken and infected ulna (probably having collided with a boat or jet-ski).

Discussion

Size and distribution of the Dundrum Bay harbour seal population. The average annual pup production in Dundrum Bay is estimated here at about 15 pups in a group of around 220 animals, or less than 10%. Since Dundrum Bay is undoubtedly not a self-contained population, the possibility remains of a larger pupping nucleus elsewhere. A thermal imaging survey from a helicopter of the Co. Down coast produced a similar overall figure of about 176 pups from a total population estimate of about 1600, or about 11%, with the greatest concentration of pupping (61 pups) at the mouth of Carlingford Lough (Sea Mammal Research Unit, unpublished data). This percentage of reproducing females in the population is less than has been reported elsewhere, e.g. about 18% in a Shetland colony (Venables and Venables, 1955); 20-30% in the Wadden Sea (Reijnders, 1981) and 30–40% on Tugidak Island in Alaska (Jemison and Kelly, 2001), although these pup percentages are of actual seal counts rather than of abundance estimates.

It was clear from the variability of pup counts on successive daily visits that repeated daily counts are required to obtain reliable estimates for annual pup production. The average peak period of pupping over the 13 year period lasted only for a 5-day period between 5–9 July. A similar brief period of around 9 days was found on Tugidak Island in Alaska, where between 225 and 313 pups were recorded (Jemison and Kelly, 2001). Knowledge of the peak period is important for the timing of pupping surveys.

In the early years of this study pups tended to assemble at Minerstown in the post-weaning period, but the pup counts in 2003 and 2005 indicated that during late lactation and weaning pups tended to assemble at the Ballykinler site. Possibly this redistribution of seals to Ballykinler is related to differences in prey availability close inshore for both mothers in late lactation and newly weaned pups. Dundrum Bay seals during the moulting season have been found to eat relatively more flatfish and sandeels at Ballykinler than at Minerstown (Wilson et al., 2002; C. Richards, unpublished data). This prey difference between seals at the two sites is consistent with the differences in the nearby benthic habitat (DARD, 2002). Thompson et al. (1994) radio-tracking lactating females in the Moray Firth area similarly found that several females, when their pups were 15–17 days old, switched to sites at the entrance to firths and closer to feeding areas

Behaviour and movements of pups during late lactation and weaning. In late lactation –from the 2nd and 3rd week of July – pups were often seen to remain in the haul-out group while their mothers were absent. The group seemed to function as a primitive ‘crèche’ for the pups, who stayed close to other seals and followed them closely when they moved between rocks as the tide ebbed. Radio-tracking of three nursing pups in late July indicated that these pups indeed did not accompany their mothers on offshore foraging trips, but stayed behind at the haul-out site. In other studies harbour seal mothers have been found to resume diving and/or foraging trips offshore between 10 and 24 days after giving birth (Wilson, 1974; Thompson et al., 1994; Boness et al., 1994; Bowen et al., 1999). Bowen et al. (1999) suggested that a sizeable group of mothers, pups and other adults was a pre-requisite for mothers to leave their pups in an adequate ‘creche’ at the haul-out site while absent on a foraging trip. In Strangford Lough in 1969–1970, mothers in late lactation were found to dive close to the haul-out site, but to leave their pups sleeping at the surface, checking them between dives (Wilson, 1974). It is possible that this behaviour also occurs at Minerstown, but is not visible from the shore at sea level. Bekkby and Bjørge (2001), radio-tracked two mother-pup pairs in western Norway and found that one pup always accompanied its mother on foraging trips, while the other was often left at the haul-out site.

Even after weaning in late July, all of the five radio-tagged pups stayed for the next two weeks in the close vicinity of the haul-out site. In a study of harbour seal pups on Sable Island involving stomach lavage, Muelbert & Bowen (1993) found that the pups did not feed on prey at all while they were still nursing, but that virtually all pups had learned to feed by two weeks after weaning. If that is also the case at Minerstown, it would follow that the weaned pups must be learning to feed on small inshore prey in the shallow water in the vicinity of the haul-out site. Analysis of scats collected from two pups at Minerstown on August 13 1996 revealed that those pups had both been feeding on very small gadoid fish of average length 80mm and weight 3g (Wilson et al., 2002). There are also records from other areas of newly weaned pups feeding on diminutive fish or crustacean prey (Golitsev, 1972; Sergeant, 1951).

Dispersal of post-weaning pups. The results of the radio-tracking indicated that four of the five pups foraged locally along the coastal shelf, while only one appeared to disperse away from the area. This result is consistent with other studies indicating that most harbour seal pups remain in their natal area after weaning (Thompson et al., 1994; Bjørge et al., 2002; Small et al., 2005). Minerstown pups in October and November 1995–96 were found to eating mainly small gadoid fish and a smaller amount of flatfish. A scat collected from underneath pup 2, at Minerstown on Nov 13 2005, revealed 76 otoliths of *Trisopterus* of average fish weight of about 7g (Wilson et al., 2002). The pups located in Dundrum Bay seemed not to favour the kelp forest area, in contrast to the Norwegian pups studied by Bjørge et al. (2002).

Pup strandings. Over the past 13 years there has been an overall pup stranding record of about 43%, about 19% in the neonatal period, then a further 4% during late July (up to weaning), 6% in August and the remaining 14% between September and January. Since most of the live-stranded pups would have died if not rehabilitated, this may be considered an approximate mortality figure for Dundrum Bay (although this assumes that all pups stranded in Dundrum Bay were born there, which may not always be the case). Since 10 of the 84 stranded pups died due to deliberate killing or probable collision with boats or jet-skis, the total pup mortality due to ‘natural’ causes was probably closer to about 38%.

Our estimate of about 23% average mortality up to weaning is similar to the figure of 17% for Sable Island (Boulva, 1976) and 25% for the Swedish Baltic coast (Helander and Bignert, 1992), but much greater than the estimate of 7% or less on Tugidak Island in Alaska (Jemison and Kelly, 2001), The normal birth weight for harbour seals is about 10.5–11.5 kg, with about 11% of their body weight being a subcutaneous blubber layer (Bowen et al., 1993; Coltrell et al., 2002). Small pups have a high surface area to volume ratio and relatively less blubber at birth (Coltman et al., 1998), and as a consequence of high metabolic overhead, small pups may rapidly become hypothermic in the water, not strong enough to follow their mothers, and hence may be found stranded (e.g. Wilson, 2001). Birth weight is strongly correlated with maternal weight (Coltrell et al., 2002), and therefore it is possible that low birth weights in Dundrum Bay are associated with poor nutrition of pregnant females, or smaller, young mothers. Other possible causes of neonatal pup mortality that may be associated with normal birth weight include failure of post-natal bonding, injury or death of the mother (one dead pup was found beside its dead mother in 2001), human disturbance or stormy weather (e.g. Boness et al., 1992).

Our estimate of 26% pup mortality to the end of August is considerably lower than the 60% for the same period quoted for the Wadden Sea (Reijnders, 1978; 1981). However, the Wadden Sea figures were obtained by counting pups visible at the haul-out site and assuming that those not visible had died. Our results from radio-tracking pups during the weaning and post-weaning period to the end of August indicate clearly that the reason pups are not visible at the haul-out site during August is not because they are dead, but because they are at sea, foraging.

Most stranded pups from September onwards were thin, debilitated and found to be suffering from severe lungworm infestation. Post-weaning pups may be expected to lose as much as 20% of their weaning body weight until they learn to catch enough food to match their energy expenditure, which may normally take 4–6 weeks post-weaning ((Muelbert and Bowen, 1993; Muelbert et al., 2003). These late-stranding pups had presumably learned to feed (or they could not have contracted lungworm from infected fish), but were unable to catch sufficient food.

Harding et al. (2005) commented that because pups have to gain sufficient weight by about 4 months of age to survive the cold winter temperatures, they are very sensitive to food availability and poor food supply may affect survival of entire pup cohorts. Small pups show elevated metabolism in cold water, e.g. pups weighing 20 kg begin to be cold-stressed at water temperatures of 9.8° C (Harding et al., 2005). The surface water temperatures along the western Irish sea coast are about 11°C in November (Shand, 1985), but the stranded pups between September and January weighed only between 11.5 and 16.5 kg, and therefore the sea temperatures may nevertheless have been low enough to cause cold stress to these relatively small pups.

Poor nutrition of post-weaning pups may have been a growing problem in recent years, since almost all of the autumn-stranding pups were found between 2002 and 2005, with 2002 and 2003 being particularly bad years. Although more efficient records since the 2002 PDV epidemic may also be partly responsible for the higher rnumbers, the fact that there were several years with no recorded autumn strandings suggest that high pup mortality in the first year is by no means the norm, as is often suggested, but may reflect unusually poor years of prey availability. .

36 of the 53 pups stranded live in Dundrum bay over the past 13 years have been rehabilitated (by TSRC or Exploris aquarium) and returned to the Down population. However, if low birth weight and poor survivorship of 2–5 month-old pups is due in part to limited prey availability, it may be that this population size is close to the present carrying capacity of the Co. Down coast.

Minerstown as an index site. Counts of pups and older seals at Minerstown during the summer breeding and moulting season have been carried out much more frequently than is possible for the entire coastline. Thus, for this particular site we now have detailed information on the start and peak of pupping, the way in which the inshore habitat is used by mothers and pups, the number of older seals other than mothers using the site during the pupping season and the length of time that pups continue to haul out at the site. Moreover tracking studies of weaning pups at this site have provided supplementary information on the areas to which weaning pups disperse, i.e. where they are when they are no longer visible at the haul-out site in late summer.

The extent to which the Minerstown site may be typical of the Co. Down coast may determine its use as an index site for the area. The overall pupping and abundance records for Dundrum Bay (Minerstown plus Ballykinler) suggest that reproducing females are about 10% of the population in Dundrum Bay, similarly to Co. Down as a whole. However, during the years of this study there has been a bias towards Minerstown as a pupping site with reproducing females averaging about 20% of the seals centred on that site over the 13-year period.

Some changes have been observed over this period: the number of older seals at Minerstown has declined during the pupping season, while the number of pups has remained stable or increased slightly, i.e. in recent years few seals other than mothers with young pups have been using Minerstown during the pupping season. The reason for this could be that Minerstown is an ideal site for chaperoning young pups, but may be inconveniently far from currently-favoured foraging sites to be attractive to other seals.

This explanation fits with the pup count records showing fewer pups in recent years at the site during late lactation and post-weaning and more pups at Ballykinler. It also fits with information from the tracking study in 1995, which indicated that only one of the five pups continued to forage close to Minerstown after the immediate post-weaning period, and with information on the diet of seals at Minerstown (Wilson et al., 2002), which was extremely low in oily fish and high in gadid fish. Information on post-weaning pup foraging sites is evidently invaluable supplementary data for understanding local population dynamics, and a new study (using satellite telemetry) is now due.

How typical the patterns and changes in Minerstown may be of Co. Down pupping sites in general is not known: ideally a different site should also be studied in order to make a comparison. Broader surveys of the entire coastline can indicate broad trends in population dynamics and distribution, but cannot provide understanding or explanation of these trends (Lonergan et al., 2007) and more detailed work at index sites is needed to understand these trends. Since the harbour seal is now considered to be a priority species in Northern Ireland, it is suggested that this type of detailed study in Dundrum Bay should be continued and expanded in scope.

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Table 1. No. observations 15 June to 01 Sept in each year

(a) Minerstown 1994-2006

		94	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**Total**
June	**15-19**	0	0	0	0	0	0	0	0	2	3	3	2	0	10
	20-24	0	0	0	0	0	1	1	0	3	4	1	3	2	15
	25-29	0	1	0	3	0	2	1	0	2	3	1	5	2	20
Jun/Jul	**30-04**	0	2	3	1	2	2	3	3	2	3	1	4	2	28
July	**05-09**	0	2	4	1	2	1	0	2	4	3	2	3	5	29
	10-14	1	2	2	1	2	2	1	2	3	4	1	3	4	28
	15-19	1	2	2	1	1	1	3	2	1	5	3	3	4	29
	20-24	0	4	0	1	1	2	3	0	1	2	2	2	4	22
	25-29	1	5	3	1	1	1	2	2	3	2	2	2	3	28
Jul/Aug	**30-03**	2	5	1	1	1	1	0	1	4	2	1	1	4	24
August	**04-08**	3	5	1	0	0	1	1	1	1	2	0	0	2	17
	09-13	0	3	2	1	1	1	2	1	2	0	0	2	3	18
	14-18	1	5	0	0	0	0	1	0	3	2	0	2	2	16
	19-23	0	3	0	2	1	0	3	1	4	1	0	2	3	20
	24-28	2	3	0	0	0	1	0	0	1	3	2	2	0	12
Aug/Sep	**29-01**	0	2	0	0	0	1	0	0	0	1	1	1	0	6
	Total	11	44	18	13	12	17	21	15	36	40	20	37	40	265

(b) Ballykinler 2002, 2003, 20065

		02	**03**	**05**	**Total**
June	**15-19**	0	3	1	4
	20-24	1	2	3	6
	25-29	0	2	3	5
Jun/Jul	**30-04**	1	3	0	4
July	**05-09**	2	2	2	6
	10-14	0	1	1	2
	15-19	3	4	2	9
	20-24	0	3	2	5
	25-29	1	3	3	7
Jul/Aug	**30-03**	3	5	1	9
August	**04-08**	2	0	0	2
	09-13	2	1	2	5
	14-18	3	1	2	6
	19-23	4	0	2	6
	24-28	2	0	2	4
Aug/Sep	**29-01**	1	0	1	2
	Total	26	30	27	83

Table 2. Dates of maximum pup counts at Minerstown

	Date to 15/07	No. Times max. count Between July 1–15/no. counts	No. times max. count between July 5–9/no.counts
1994	July 11	0/0	0/0
1995	July 06	4/6	2/2
1996	July 09	1/10	1/4
1997	June 28	2/3	1/1
1998	July 06	1/6	1/2
1999	July 07	1/4	1/1
2000	July 13	1/3	0/0
2001	July 02	1/6	0/2
2002	July 08	1/9	1/4
2003	July 14	1/11	0/3
2004	July 08	1/4	1/2
2005	July 01	1/0	0/3
2006	July 04	5/12	2/5
Total		20/74 (27%)	10/29 (34%)

Table 3. Maximum pup counts at the Minerstown (Mt) and Ballykinler (Bk) sites in 2002, 2003 and 2005.

	2002			2003			2005	
	Mt	Bk		Mt	Bk		Mt	Bk
June 15–24	0	0		2	0		0	2
June 25–04	7	3		8	2		14	0
July 05–14	16	4		9	2		10	6
July 15–24	15	7		12	5		6	17
July 25–03	12	3		7	5		3	12
August 04–13	5	2		5	5		5	11
August 14–01	3	1		1	5		7	22

Table 4. Summary of pup radio-tagging and subsequent tracking, July–Nov 1995

pup	Sex	capture date	weight (kg)	length (cm)	nursing last seen	no. Days			last date signal received	% visits when sighted	last sighting
						diving location	haul-out signal	diving signal only			
1	♂	19/7	16.0	96	31/7	31	18	6	26/9	23%	18/09
2	♂	19/7	18.5	94	26/7	27	32	7	20/10	32%	13/11
3	♀	23/7	14.5	90	29/7	n/a	n/a	n/a	n/a	15%	28/09
4	♂	23/7	27.0	98	31/7	20	12	7	12/09	23%	30/08
5	♀	29/7	25.5	96	none	36	9	8	23/10	22%	23/08
6	♂	03/8	18.0	89	none	44	3	14	25/10	8%	06/11

Table 5. Pup stranding data summary for Dundrum Bay, 1994–2006

	Pupping period May 20 – July 15		Late lactation July 16–31		Post-weaning Aug 01–31		Dispersal Sep 01–Jan 31		Total Pups
	Mtown	Bkinler	Mtown	Bkinler	Mtown	Bkinler	Mtown	Bkinler	
Dead pup	5	0	5	2	2	2	7	8	31
Live pup	23	10	1	0	4	3	8	4	53
< 10 kg	21/32		1/1		3/5		0/13		
10–13 kg	11/32		0/1		2/5		9/13		
14 –17 kg	0/32		0/1		0/5		3/13		
(?Human cause)	zero	zero	(3)	(2)	zero	(1)	(2)	(2)	(10)
Total pups	38		8		11		27		84

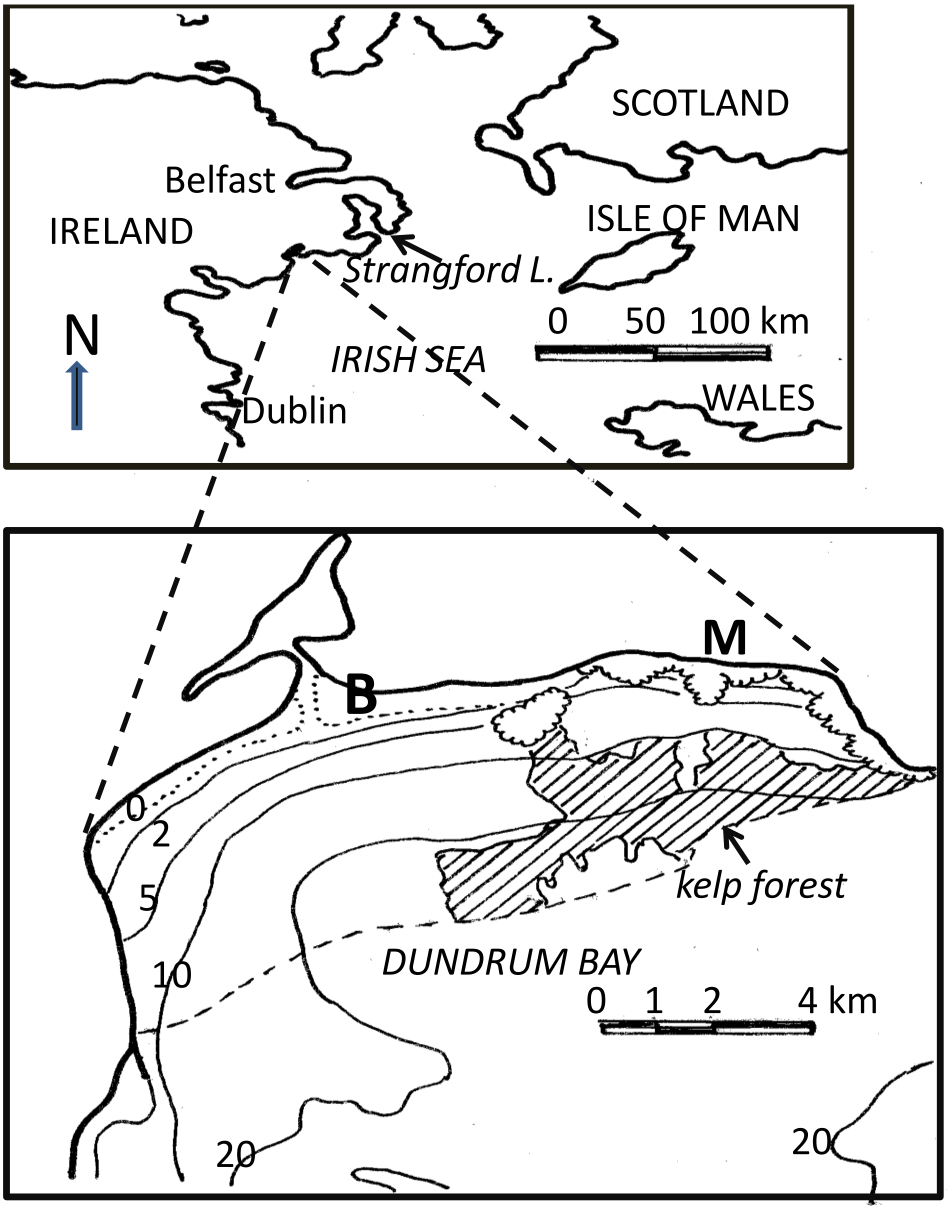


Fig. 1. Dundrum bay showing the haul-out sites at Minerstown (**M**) and Ballykinler (**B**), depth contour lines (m), the seaward boundary (- - - -) of the benthic survey (DARD, 2002) and the area of kelp forest.

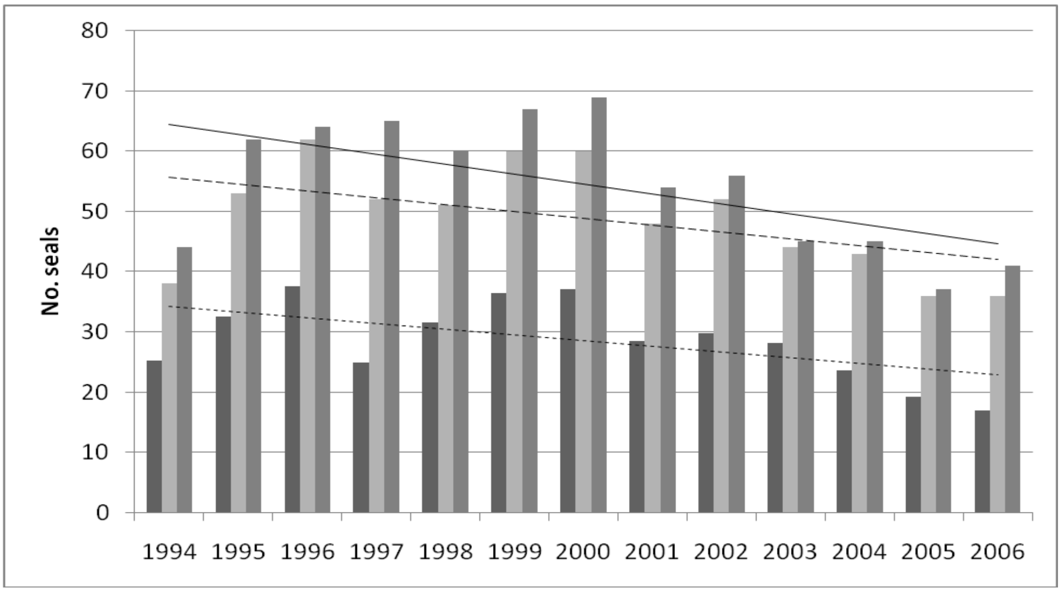


Fig. 2. Mean (dark), maximum (pale) and abundance estimates (medium) with linear trendlines for adult and subadult harbour seals at Minerstown during the pupping season (June 15 –July 31).

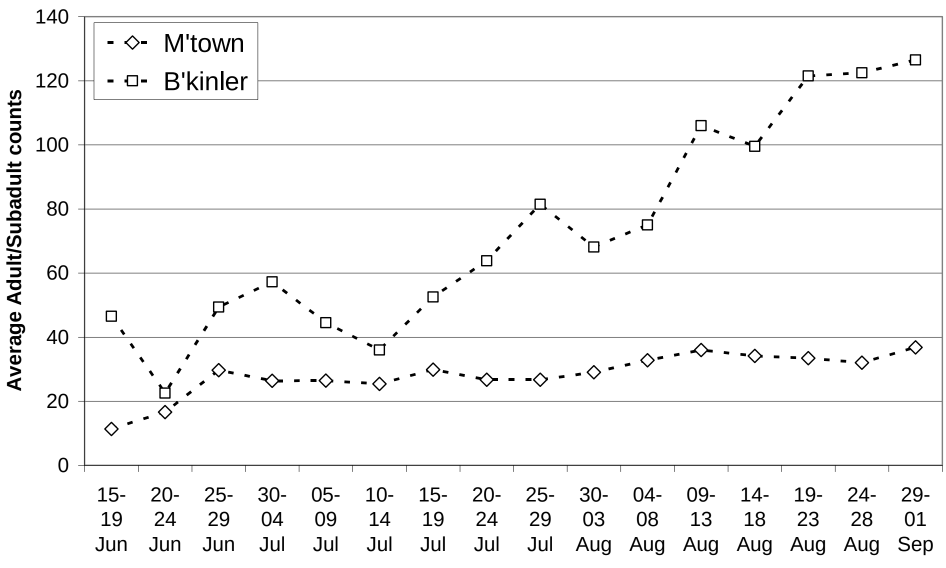


Fig. 3. Average counts of adult and subadult harbour seals in 5-day units from June 15 to September 01 for Minerstown (averages for 1994-2006) and Ballykinler (averages for 2002-03 and 2005)

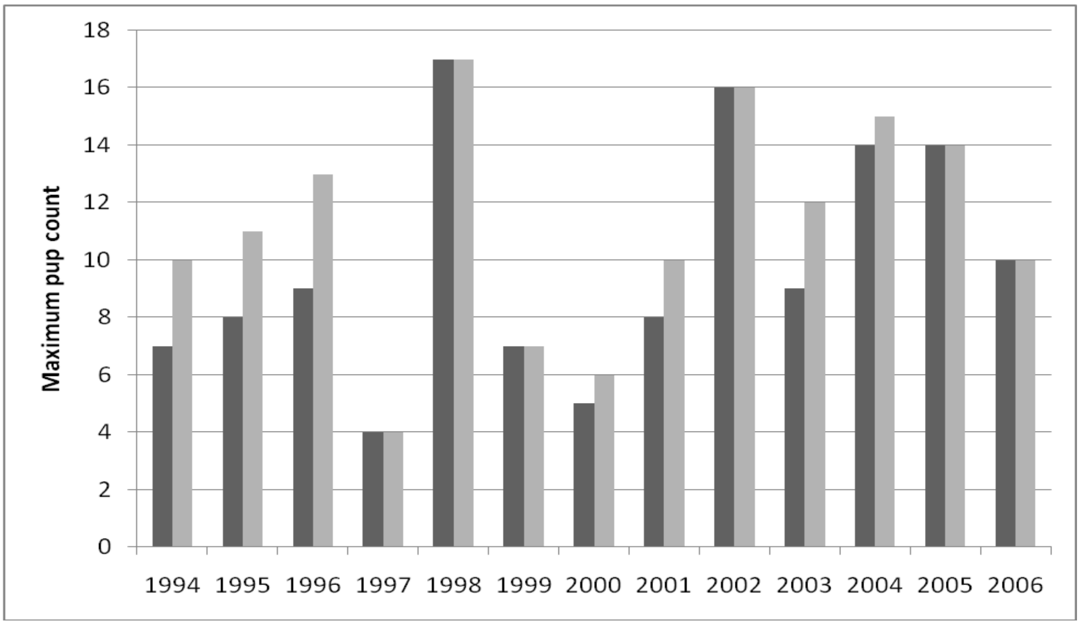
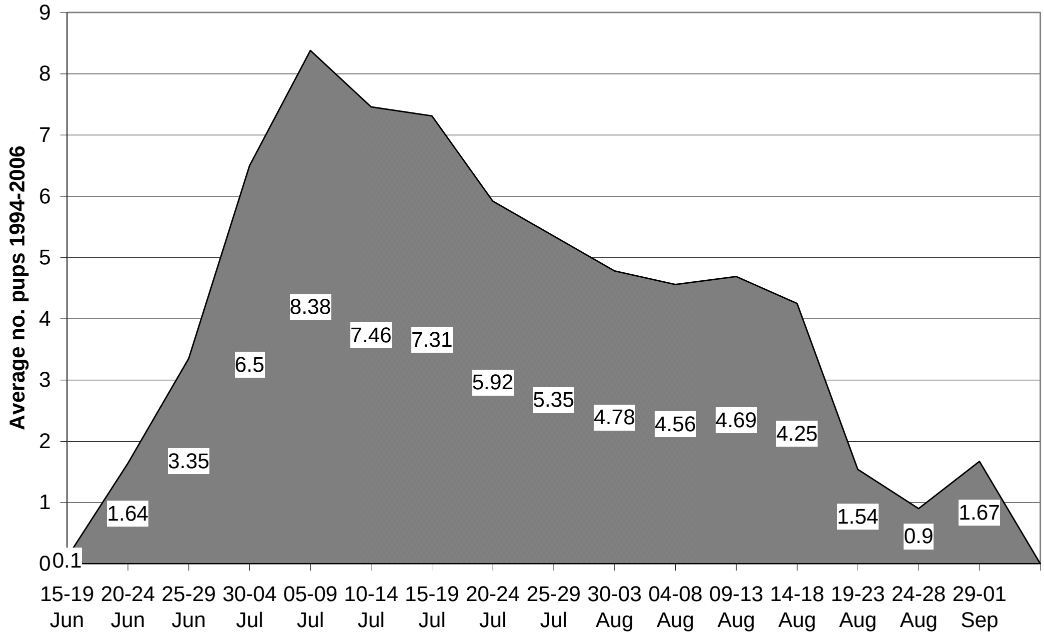


Fig. 4. The highest pup count at Minerstown in each year up to July 15 (dark) and to September 01 (pale).

(a)



(b)

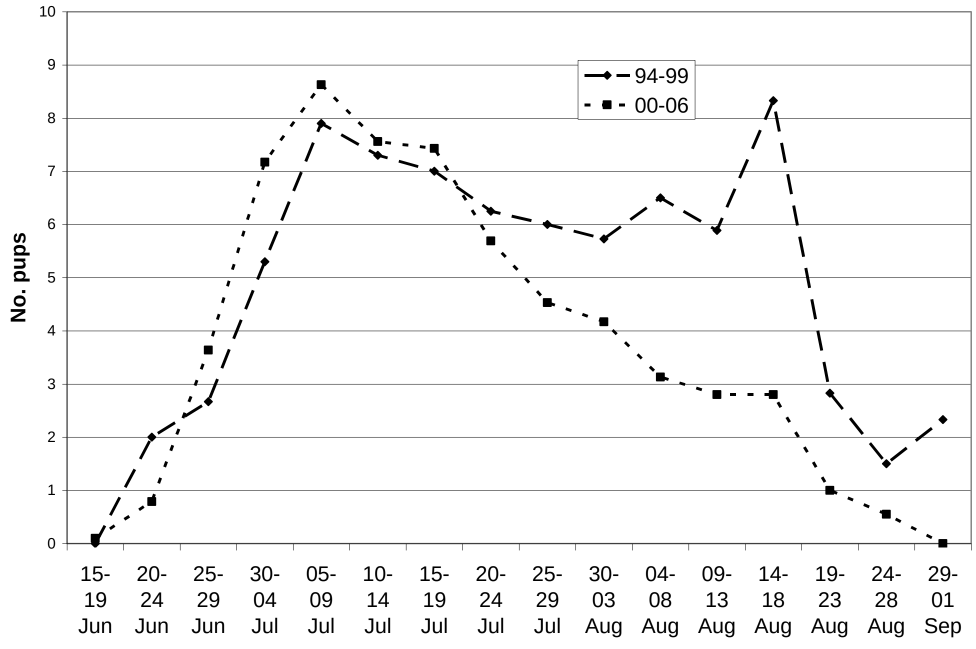
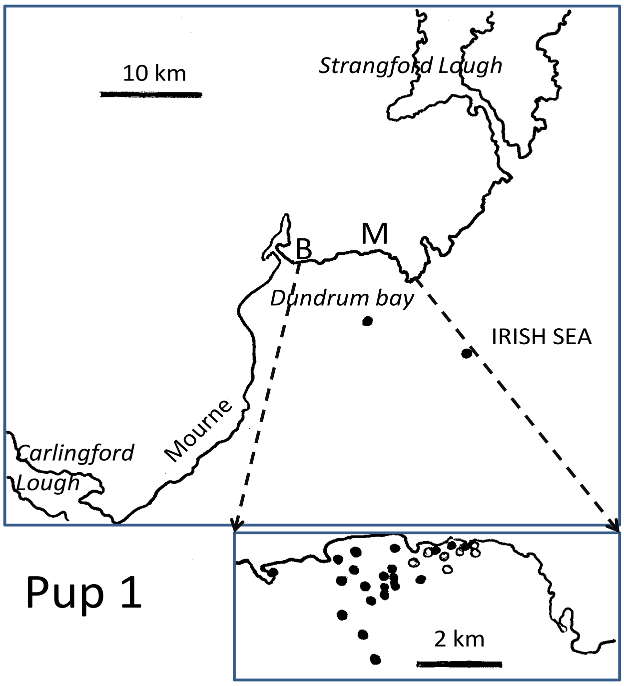
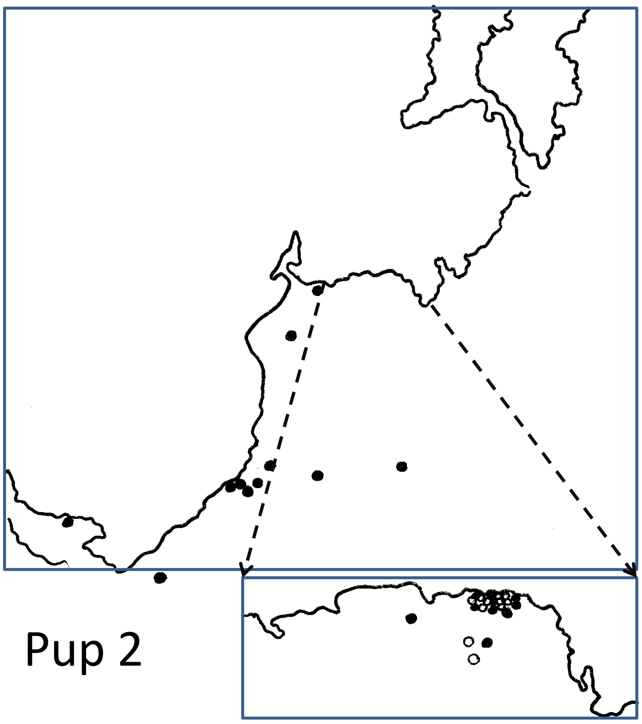


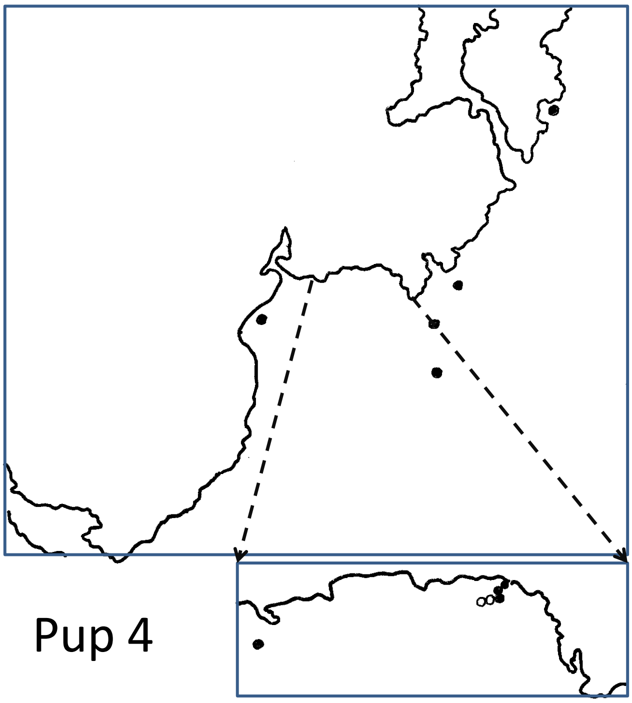
Fig. 5. Pupping curve for Minerstown, showing the maximum count for each 5-day period averaged over 13 years 1994–96 (a) and averaged separately for 1994–99 & 2000–06 (b).


10 km
Strangford Lough
B
M
Dundrum bay
IRISH SEA
Mourne
Carlingford
Lough
2 km

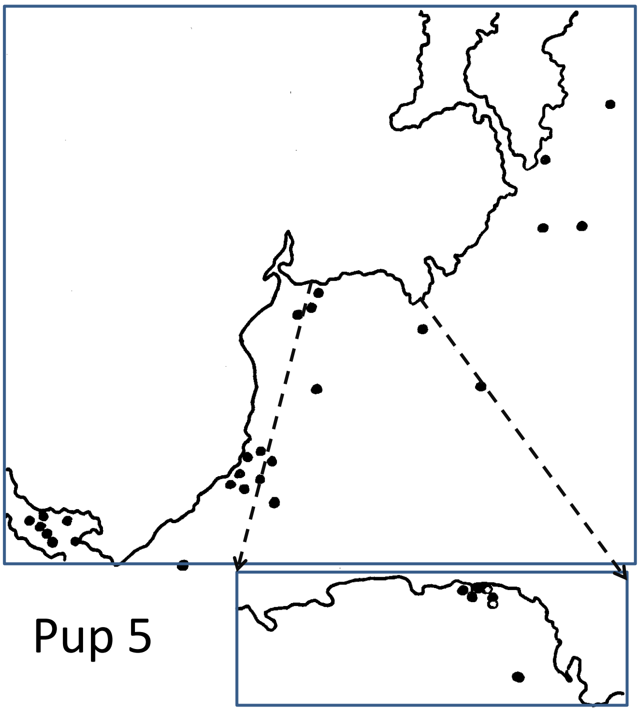
Pup 1



Pup 2



Pup 4



Pup 5

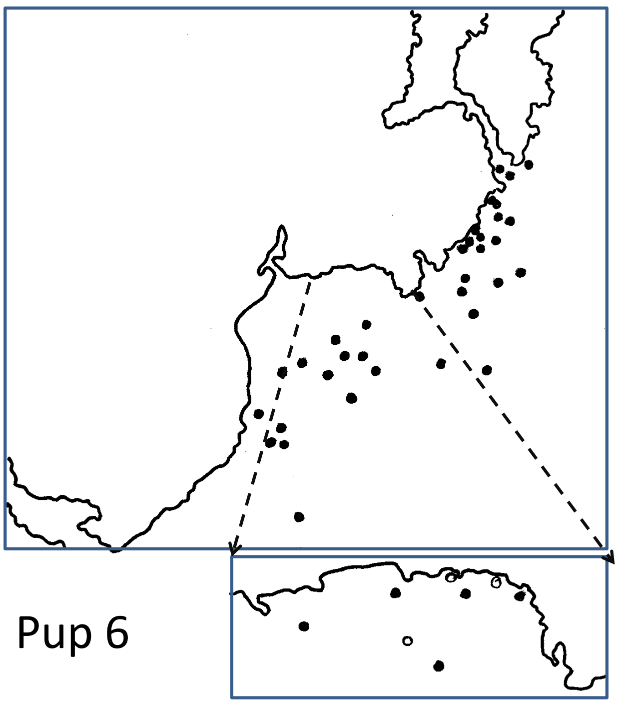


Fig. 6. Diving locations for five pups tracked using VHF transmitters, July – October 1995.