PATTERNS OF SEAL STRANDINGS AND HUMAN INTERACTIONS IN CAPE COD, MASSACHUETTES

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ABSTRACT

From 1999 to 2004, 622 pinniped strandings were recorded by the Cape Cod Stranding Network (CCSN). Fifty-seven of these strandings were classified as human interaction cases. Strandings were defined as human interaction (HI) cases if there was evidence of anthropogenic injury or harassment present of noted upon necropsy. To minimize the frequency and severity of adverse interactions between seals and humans, it is important to first understand the spatial and temporal patterns of such interactions. Using stranding data obtained from the CCSN, I examined the seasonal and spatial distribution of interactions between humans and four pinniped species: harp seals (*Phoca groenlandica),* harbor seals (*Phoca vitulina),* gray seals (*Halichoerus grypus),* and hooded seals (*Cystophora cristata).* The majority of the HI cases were fishery entanglements (29 seals), followed by boat collisions (11 seals), harassment (9 seals) and blunt trauma (8 seals). I compared the frequency of all strandings with the length of shoreline in each of the Cape's fifteen towns. I then considered the frequency of strandings in relation to the number of beach vehicle permits sold in each town for the summer season. The highest number of HI strandings occurred in the summer months in the Chatham area. Knowledge of seasonal and spatial patterns of HI cases will allow managers to focus mitigation efforts in times and areas when such interactions occur frequently. This knowledge will also allow managers to better disseminate information on appropriate means of viewing wild seals.

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INTRODUCTION

Many seal populations in the United States have been recovering since the passage of the Marine Mammal Protection Act (MMPA) in 1972 (Read and Wade 2000). The MMPA calls for a moratorium on the "taking" of marine mammals, making it illegal to "harass, hunt capture or kill any marine mammal" (16 U.S.C 1362 Sec. 13). Under the Act's protection, seal populations are growing and expanding their ranges (Waring 1994). The average population of the North Atlantic stock of harbor seals (*Phoca vitulina*) increased by 6.6% during 1981-2001 (NMFS 2003). Gray seals (*Halichoerus grypus*) at two locations in Massachusetts have experienced a 20.5% increase in population from 1994-1999, although it is not know what proportion of this increase represents immigration (NMFS 2003). The highly migratory harp seal (*Phoca groenlandica*) and hooded seal (*Cystophora cristata*) appear to be increasing in United States waters although there is insufficient information to determine the exact population status of these two species (NMFS 2003). At the same time that seal populations are increasing, the human population along the coasts is rising.

Cape Cod, Massachusetts has experienced a 20% increase in its resident population since 1990 (Cape Cod Commission 2000). The Cape consists of fifteen towns with numerous villages in each town. Known for its beaches and coastal fishing villages, over 50,000 people visit the Cape each summer (Cape Cod Chamber of Commerce 2003). Cape Cod is also home to large resident populations of harbor and gray seals. Recently, the number of sightings and strandings of harp and hooded seals in New England has increased, particularly during January through May when they are at the southern most point of their migration (NMFS 2003). The growing number of people

flocking to the ocean each year combined with increasing populations of seals is likely to cause a problem as both groups cross each other's paths more frequently.

The Cape Cod Stranding Network (CCSN) is a non-profit organization that responds to stranded marine mammals on Cape Cod's shoreline. Acting on behalf of the Northeast Regional Stranding Network, the CCSN is responsible for providing for the well-being of live animals and maximizing the scientific information gained from dead animals (Geraci and Lounsbury 1993). A seal that hauls out and then is unable to reenter the water due to sickness or injury is considered stranded (Geraci and St. Aubin 1979). Many of the strandings that the CCSN responds to involve seals, some of which show evidence of being injured or harassed by humans. Strandings are defined as human interaction (HI) cases when evidence of an interaction is present or reliable eyewitness accounts are provided. Determination of whether an interaction contributed to a stranding or caused death of an animal requires further investigation, such as histopathology analyses, and the involvement of experts in the field (Touhey pers. comm.). Some examples of HI cases include illegal handling (harassment), vessel interactions (resulting in propeller wounds and/or blunt trauma), blunt trauma, and entanglement in fishing line and other marine debris.

Human interactions can result in injury or death to the seals or injury to the humans. Not all interactions result in an immediate mortality of the seal. If a seal is disturbed often enough it will move to a new haul-out site and abandon its old one (Schneider and Payne 1983, Stevens and Boness 2003). If the seal experiences a non-lethal injury, the injury may weaken the seal and make it more susceptible to infection or starvation (Northridge and Hofman 1999). When stranded, the behavior of a seal is often

unpredictable; such individuals are prone to attack if threatened (Geraci and Lounsbury 1993). Curious onlookers can potentially be injured by a stranded seal if they approach it too closely. Although rare there have been instances of seals transferring diseases, such as poxvirus and influenza to humans that have come in contact with an infected seal (Kennedy-Stoskopf 2001).

These interactions are dangerous from a human health and safety standpoint and also illegal under the MMPA. To minimize the frequency and severity of adverse interactions between seals and humans, it is important to first understand spatial and temporal patterns of such interactions. Knowledge of the distribution of these interactions will allow managers to concentrate enforcement and education efforts during peak interaction seasons in the appropriate locations.

In this study I examined five years of seal stranding data in the Cape Cod area and analyzed stranding patterns and the occurrence of human interaction cases in time and space. I hypothesized that the majority of the interactions will occur during the summer months at the height of the tourist season. I also hypothesized that most interactions will occur in the Chatham area because of the large group of grey seals that hauls out on Monomoy Island off Chatham.

METHODS

Data Collection

Personnel from the Cape Cod Stranding Network (CCSN) examined seals that stranded along the Cape's coastline from 1999-2004. They recorded Level A data from each specimen as outlined by the National Marine Fisheries Service protocol (Geraci and St. Aubin 1979). This same staff evaluated the condition of each seal using the Smithsonian Institute's scale (1= alive, 2= dead but fresh, 3= moderately decomposed, 4= severely decomposed, 5= skeletal remains) (Geraci and Lounsbury 1993).

Using the data collected by the CCSN, I analyzed 622 seal strandings. Each carcass was evaluated for signs of human interactions using a protocol adapted from Haley and Read (1993). If it was unclear whether or not the stranding event was caused by human activities, the case was conservatively categorized as "could not be determined" (CBD) and excluded from the analysis. Causes for finding of CBD included advanced states of decomposition, scavenger damage, and evaluation by an inexperienced examiner. The network documented 237 CBD cases from 1999-2004. I then excluded cases in which the seal's condition code was greater than three. Very decomposed carcasses could have originated from distant points and the location at which they were discovered may not be representative of their origin. There were 327 cases after I excluded the CBD and decomposed cases. Fifty-seven of these remaining cases were classified by the CCSN as human interaction (HI) cases. The HI cases were defined as: entanglement, boat collision, harassment, and other. I defined harassment as seals that were illegally handled or disturbed while hauled out. Physical evidence of HI cases included rope or net marks, gear on the animal, propeller wounds, broken bones, and

hemorrhaging. The remaining 270 seals were defined as non-human interaction (non-HI) cases when the staff was certain that there was no evidence of human interaction present.

Stranding Patterns

I plotted the number of non-HI and HI strandings over time to determine whether or not the number of strandings each year had changed from 1999-2004. I then generated linear regressions for both HI strandings and non-HI strandings.

To determine whether or not seal strandings on Cape Cod occurred randomly in time and space, I performed simple chi-square statistical analyses (Zar 1996). In these tests, I examined total strandings, non-HI strandings, and HI strandings. I stratified the data by month, town, and seal species. I divided the calendar year into four seasons: December through February (winter), March through May (spring), June through August (summer), and September through November (fall). I then analyzed the number and species of seal that stranded per season to verify the existence of a temporal stranding pattern.

For each town, I examined the number of strandings and the presence of human interactions. I calculated the local rate of stranding as the number of seals stranded per mile of beach. The towns of Cape Cod have very different lengths of shoreline, so even if seals stranded randomly, one might expect different numbers in each town. To address this factor, I corrected the expected number of strandings by the shore length of each town and conducted another Chi-square test with the corrected values. I used ArcMap and a data layer obtained from the Cape Cod Commission's GIS department to determine the length of each town's shoreline.

Cape Cod is a popular tourist destination in the summer, so I wanted to see whether or not the location of HI cases during the summer reflected the number of tourists, and not necessarily where the seals are located. To locate the most popular tourist areas on the Cape, I contacted the Beach and Recreation Department of each town, knowing that each one required beach passes. I used the number of beach passes sold for the 2004 season as an estimate of the number of people visiting each town's beach to try to determine whether the number of passes sold was a good indication of the popularity of the town's beach, and therefore, a good estimate of where HI cases would occur. For each town, I compared the local rate of HI cases during the summer season to the number of beach passes sold.

To obtain a visual representation of where the strandings occurred, I plotted the latitude and longitude coordinates of each stranding location using ArcMap. Due to the absence of some location coordinates from the stranding network's database, not all cases appear on the map. Because the Cape has a large fishing community and observed HI cases included some weir entanglements, I also included a map layer of fishing weir locations that I obtained from the Massachusetts Department of GIS.

RESULTS

Stranding Composition

Harp seals were the most common species to strand on Cape Cod during this period with 145 strandings, representing over half of the non-HI cases. The remaining non-HI strandings involved 78 harbor seals, 25 gray seals, and 22 hooded seals (Table 1).

Fifty-seven of the strandings were considered HI cases, with 28 of these strandings involving gray seals. With only two recorded cases, hooded seals were rarely involved in HI events. Harbor and harp seals comprised the rest of the HI events with seventeen and ten strandings, respectively (Table 1). The most frequent type of HI case was entanglement, occurring 29 times, with most of these cases (66%) involving gray seals. There were six definite cases of entanglement due to fishing weirs. The number of entanglements rose from one case in 1999 to ten cases in 2004.Boat collisions were the second highest interaction type, occurring eleven times and 72% of these interactions involved gray seals. Nine harassment cases were recorded with harbor seals involved in six of these strandings. There were eight cases of seals involved in a HI category other than the three mentioned above. These "other" types of HI categories include blunt trauma and gun shot wounds. The rise in the number of HI cases from 1999-2004 was marginally significant (P=0.05416). There was an increase in the number of non-HI cases from 1999-2004 (Figure 1), although this rise was not statistically significant (P = 0.1438).

Stranding Patterns

Both the total strandings and the HI cases exhibited a significant seasonal pattern ($X^2_{strandings}$= 60.74, df= 3, P<0.001), ($X^2_{interaction}$ = 224.94, df = 3, P<0.001). Total

strandings were highest in the spring, while most HI cases occurred during the summer season (Figure 2). Harp seals stranded only in the winter and spring seasons, while the other three species of seals were present in all seasons (Figure 3). Harbor and gray seals made up the majority of the strandings during the summer season.

Spatial Stranding Patterns

The number of total strandings and HI cases differed significantly among towns ($X^2_{strandings}$= 141.39, df= 14, P<0.001), ($X^2_{interaction}$ = 241.44,df = 14, P<0.001). The Chatham area had the highest concentration of both HI and non-HI strandings even when correcting for length of shoreline ($X^2_{interaction}$ = 144.6, df= 14, P<0.001) (Figure 4). Chatham also had a large number of fishing weirs in the area. Chatham accounted for 75% of the boat collisions and the 31% of entanglements. The towns of Yarmouth and Harwich also had a high number of fishing weirs and 17% of entanglements occurred in this area.

The number of beach passes sold per town was not an accurate prediction of the local HI stranding rate for the summer season and there appeared to be no direct relationship between the number of passes and strandings. The town of Dennis sold the most beach passes but had a lower local stranding rate than Chatham (Table 2).

Figure 1. Number of Strandings on Cape Cod from 1999-2004.

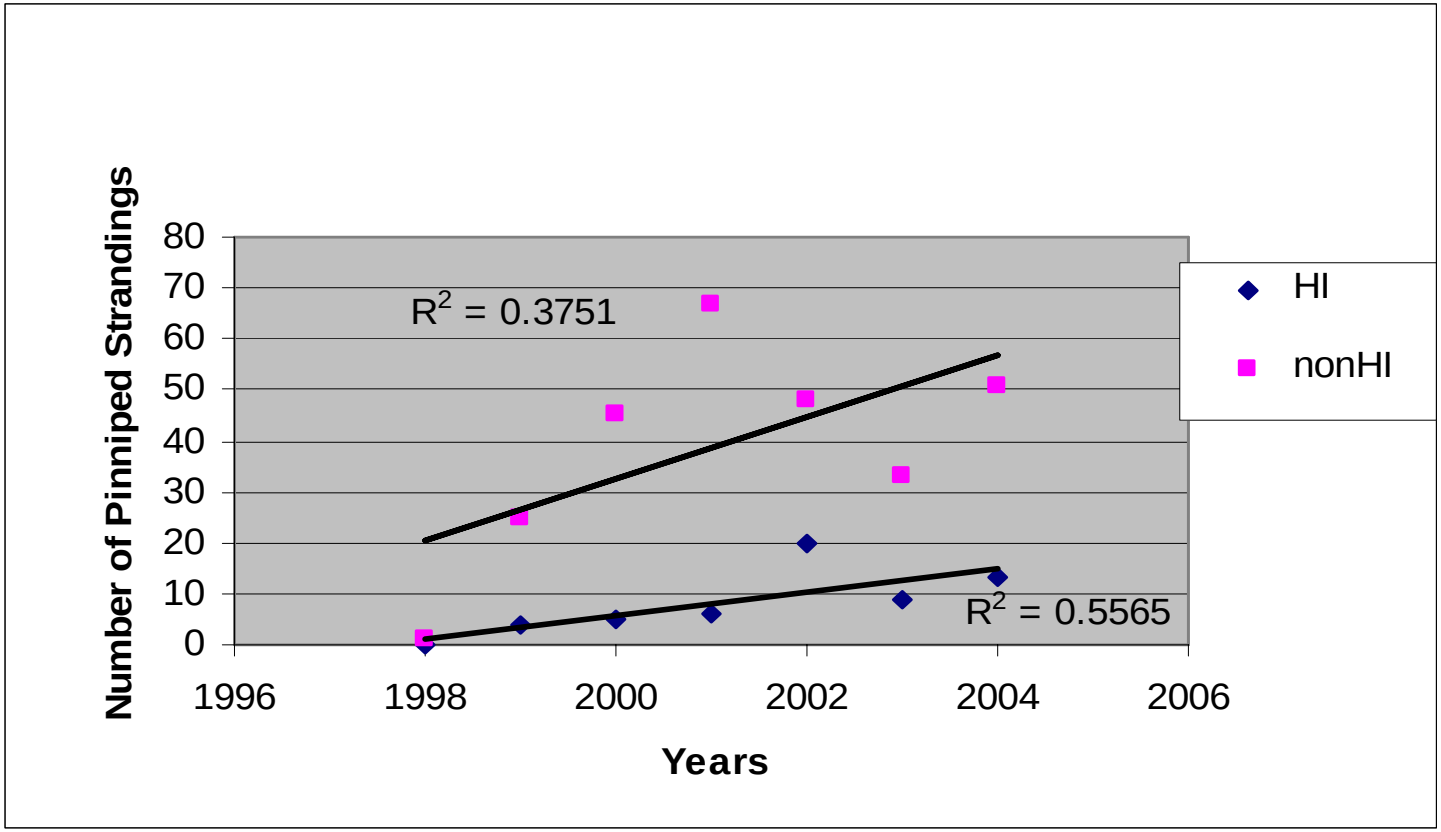

Figure 2. Seasonal Variation between HI and Non HI Strandings

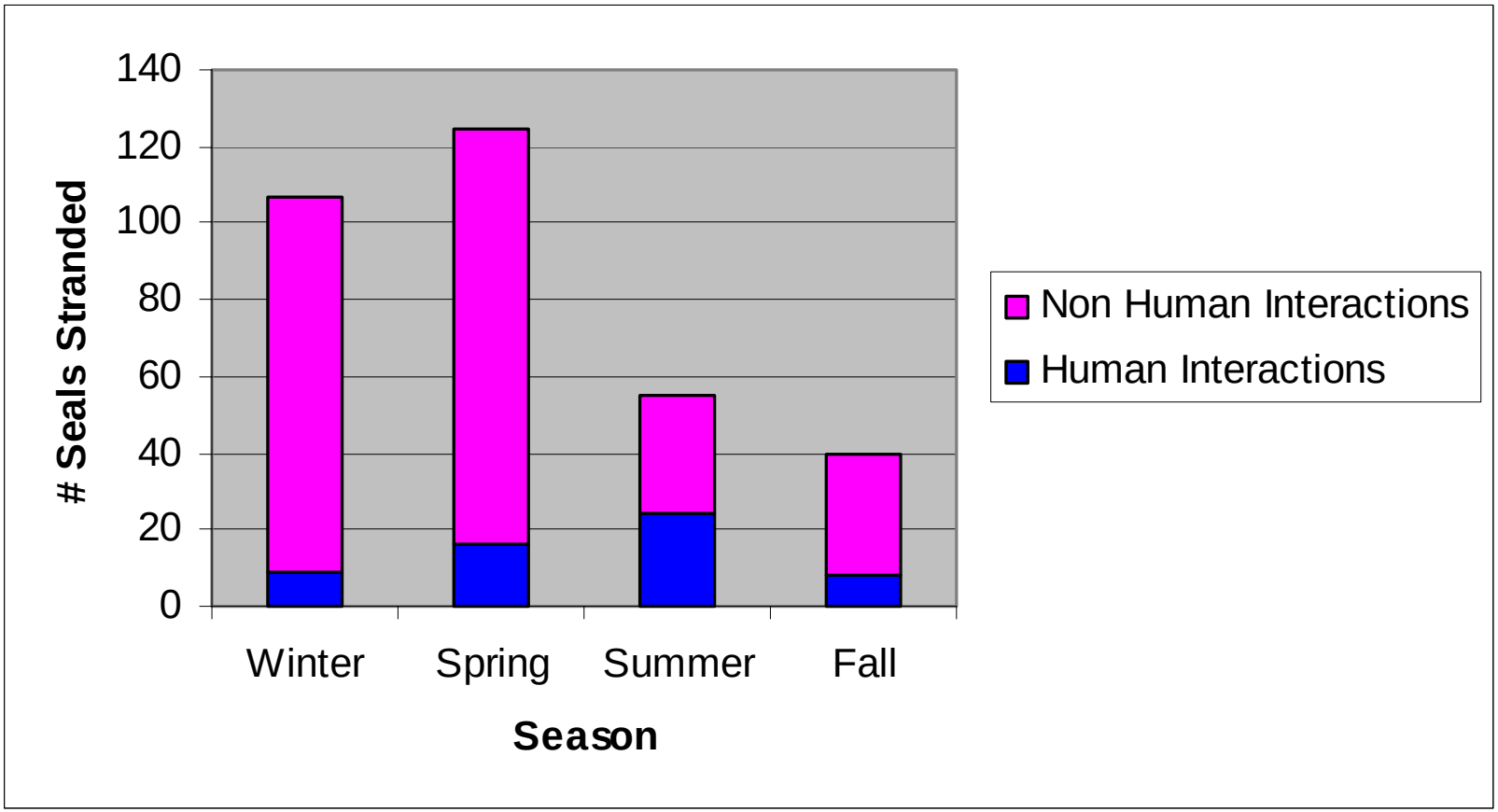

Figure 3. Seasonal Variation Among Species

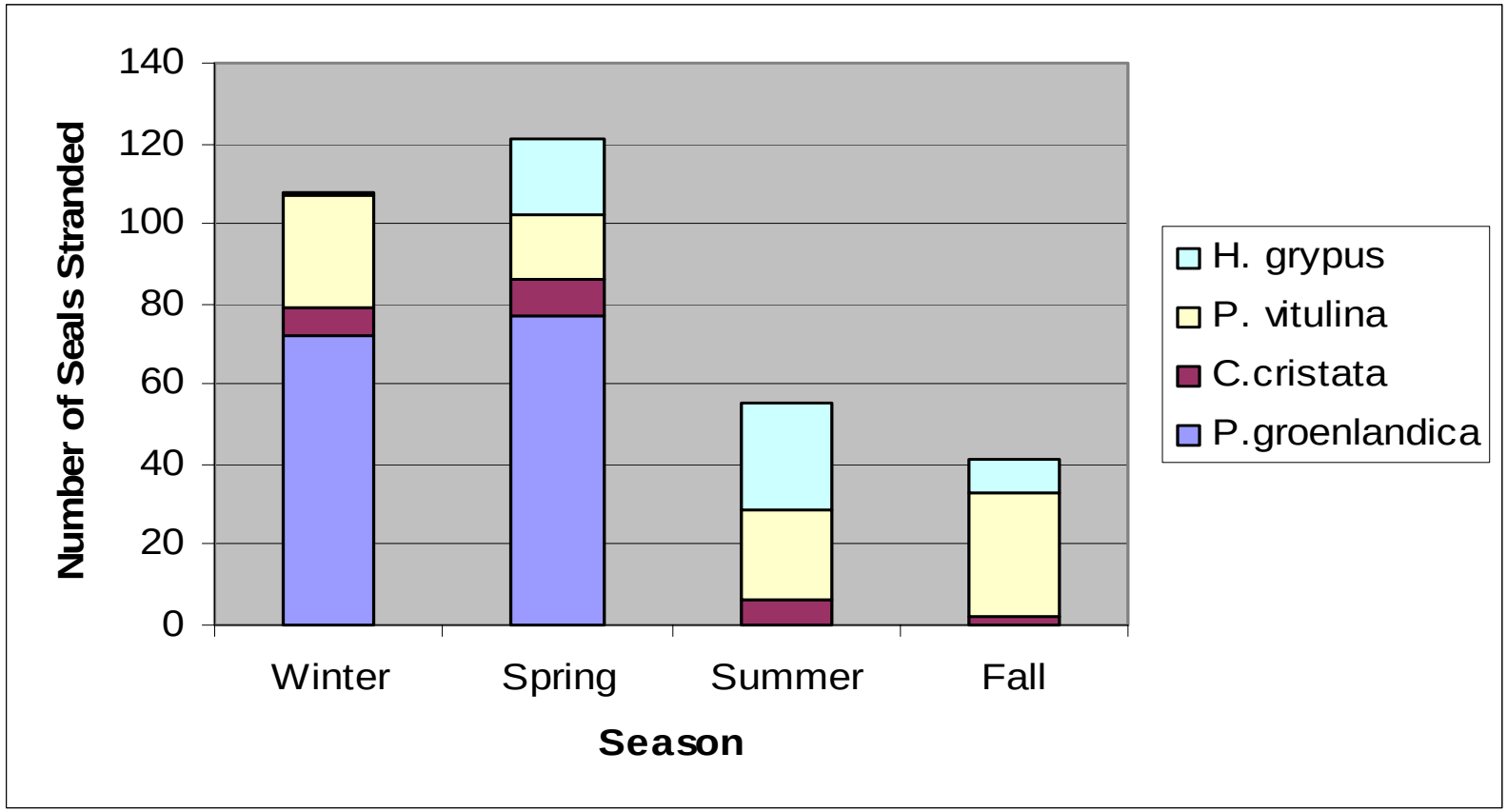

Figure 4. Map of Cape Cod displaying stranding locations and fishing weir locations

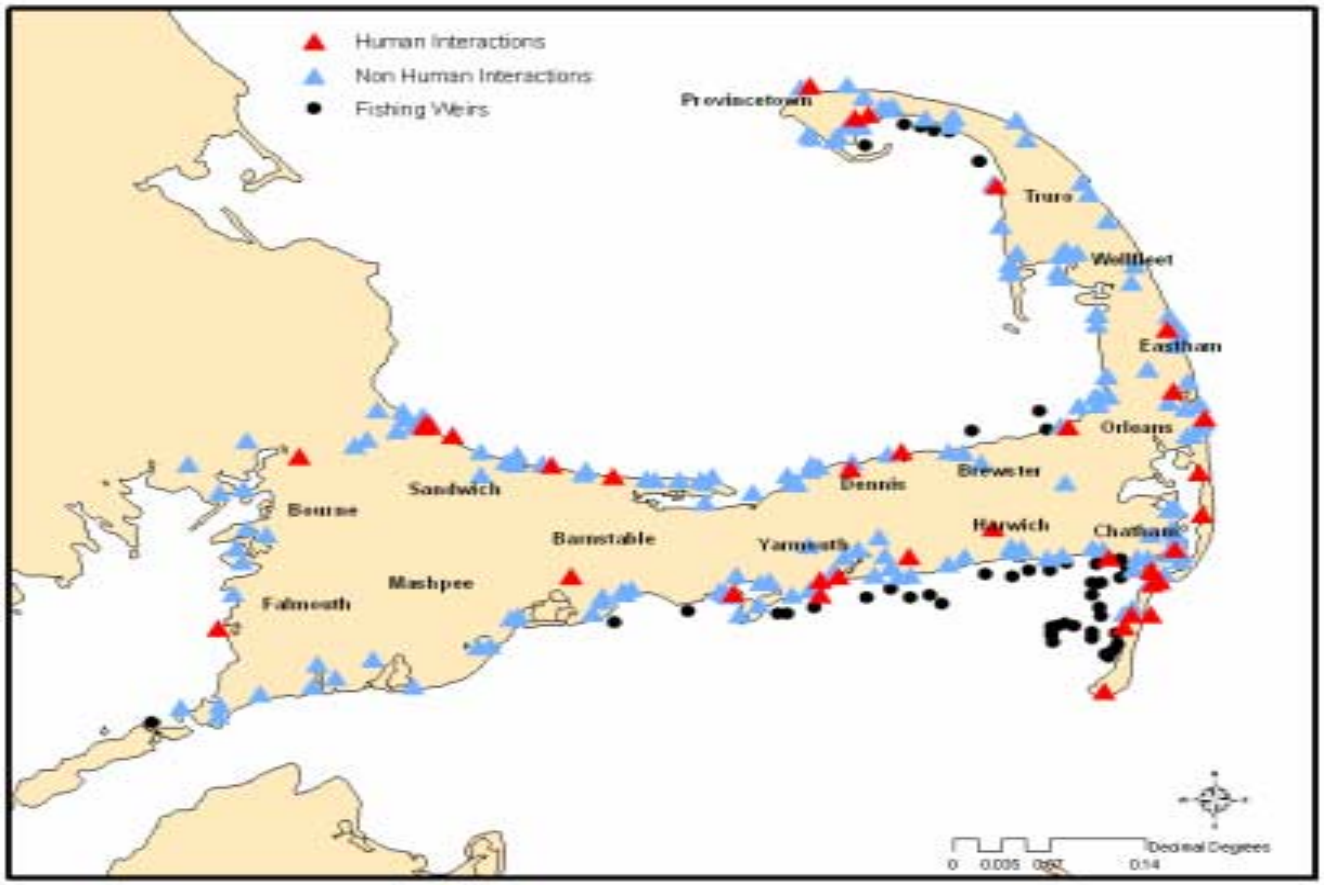

Table 1. Strandings by species and interaction categories

Species	Entanglement	Harassment	Boat Collision	Other	Non-HI
P.groenlandica	3	1	1	5	145
P.vitulina	7	6	2	2	78
H.grypus	19	1	8	0	25
C.cristata	0	1	0	1	22
Total	29	9	11	8	270

Table 2. Summary of number of beach passes, beach length, local rate of strandings, and HI strandings per town during the summer season

Town	HI Strandings	Beach Length (miles)	Local rate of stranding	Beach Passes Sold for the 2004 Season
Barnstable	0	10.29	--	23200
Falmouth	1	7.43	0.13	16685
Chatham	12	3.9	3.07	10637
Yarmouth	1	1.85	0.54	8750
Sandwich	3	2.69	1.12	6892
Mashpee	0	2.88	--	734
Bourne	0	3.07	--	4600
Dennis	2	4.53	0.44	70647
Harwich	3	2.18	1.37	10064
Brewster	0	3.44	--	Unavailable
Orleans	1	8.89	0.11	62920
Eastham	0	5.78	--	42283
Wellfleet	0	6.51	--	26675
Truro	0	14.5	--	4901
Provincetown	1	9.78	0.1	31985

DISCUSSION

Strandings of seals on Cape Cod peaked during the spring and consisted mostly of harp seals. Most of the Human Interaction cases involved gray seals and took place during the summer near Chatham. Entanglement was the most frequent type of interaction followed by boat collisions and then harassment.

Non-Human Interaction Cases

It is common for strandings of seals to occur frequently in the spring due to abandonment or separation of pups by their mother (Geraci and St.Aubin 1979). Pupping seasons for gray, harp, and hooded seals occur during late January through April (Geraci and Lounsbury 1993). It is perhaps not surprising that the total number of strandings on Cape Cod was highest in the spring. However, it is surprising that most of these spring strandings involve harp seals. The harp seal breeds in late winter mainly off the coast of eastern Canada. The reasons for the large number of harp seal strandings on Cape Cod are unknown, although changes in environmental condition and prey availability might be reasons for the seal's apparent shift in habitat distribution (NMFS 2003). In addition, this population may be growing and expansion of an animal's range may coincide with an increase in population abundance as well (Wilkinson and Worthy 1999). The high occurrence of strandings in Cape Cod supports the contention that the abundance of non-resident harp seals to New England and Mid-Atlantic waters is increasing. The harp seal appears to be expanding its southern range to include Massachusetts.

Human Interaction Cases

It is likely that the true number of Human Interaction cases on the Cape is actually greater than that noted here. Due to scavenging and decomposition, it is often impossible to accurately evaluate animals for signs of interactions. Consistent, systematic protocols for examining carcasses for evidence of human interaction are essential. In order to be conservative when an animal cannot be fully evaluated, it must be categorized as CBD. Thus, logically a portion of these CBD cases were potentially HI cases based on the rates of HI and Non-HI cases documented. It is important to have experienced stranding observers examine fresh carcasses as often as possible as HI evidence can be lost in transport, freezing or thawing of carcasses (Cox et al 1998).

HI cases occurred most often during the summer months of June, July, and August. July and August are the most popular months for tourists to visit the Cape (Cape Cod Chamber of Commerce 2003). Nevertheless, the location of interactions was not predicted by the number of beach passes sold during the summer, but instead corresponded to the major seal haul-out site on the Cape. To improve our understanding of human use of the shoreline throughout the year, future studies could examine the number of fishing/shellfish licenses and number of boat slips and moorings per town (Bogomolni pers. comm.).

Chatham is close to a major seal haul-out site in the Monomoy Channel, where gray seal numbers are increasing (NMFS 2003). The Monomoy Channel is not only home to a large number of gray seals, but is also a popular boating and recreational fishing location in the summer. Seal watch tour boats take visitors past the haul-out site on a regular basis and sometimes cause flushing events, scaring seals into the water. Due to

the narrow nature of the channel, these flushing events place the seals in greater danger of boat strike, resulting in propeller wounds and blunt trauma. The CCSN has consistently observed a number of seals at the haul-out site with plastic debris and fishing net and line entangled around their necks. Entangled seals swim less often and spend more time resting as the entanglement produces drag when swimming (Feldkamp et al 1988). It is thought that seals become entangled in small pieces of discarded line or nets by "playing" with the fragments much like they do with kelp
(Feldkamp et al 1988).

Commercial fishing weirs are set to the south of channel from March through June. These weirs catch squid and mackerel as they come through the Cape's inshore waters during April and May (Seufert 1999). The weir consists of a leader line and bowl (Figure 5). The leader line acts as a barrier for the fish and forces them to swim into the bowl where they swim in circles until the fishermen harvest them with a seine net.

Recently, the number of fishery entanglements has increased. Most of these entanglements involve adults, although other studies have shown that curious juveniles are more likely to become entangled in nets (Hanni and Pyle 2000, Page et al 2004, Stobo et al 1990, Whitman and Payne 1990). Some adult gray seals stranded with evidence of entanglement in large mesh nets, consistent with the local weir fishery and appear to have been feeding at or near their time of death (Swails pers. obs.). Juvenile seals may become entangled due to their curiosity (Feldkamp et al 1988) while adult seals may use the weirs to feed. Gray seals are known to eat herring, squid, (Benoit and Bowen 1990) and some of the stomachs of the entangled seals were full of partially digested squid and mackerel (Swails pers. obs.).

The marked increase in probable weir entanglements may be due to a change in the gear used in the fishery. During this period the Cape experienced a rise in the occurrence of *Pylaiella* red-brown algae. This algae is denser near the mouth of channels and the increase in algae seems to follow the increase in population up the coast (Leggett 1999). The algae forms dense mats, pulling over fishing weirs, and smothering shellfish beds. Some fishermen have increased the size of their weir mesh to allow the algae to flow through the net more efficiently (Seufert 1999). This slight change to the weir structure could be enough to entangle even adult seals experienced in swimming in and out of the weirs. Dolphins have been observed playing and feeding around weirs, becoming entangled in the leader line of the net. A larger mesh size is likely to cause greater entanglements because it allows animals to pass their head through the net before hitting resistance (Touhey, pers. comm.). Smaller mesh does not allow for the penetration of head or flippers. Studies in the Chesapeake Bay suggest that dolphin entanglement rates may depend on the mesh size of the lead net (50 CFR 229). Future monitoring and observations are needed to determine whether or not this is the case with seals.

The third most frequent type of Human Interaction case is the harassment of seals. These cases often stem from people trying to help what they assume to be a distressed seal. The harbor seal is the species most often harassed on the Cape. The harbor seal's pupping season takes place from May to June in Maine and then seals migrate down the coast to Cape Cod at about the same time that tourists arrive (NMFS 2003).The harbor seal's big brown eyes and dog- like features attract many people who want to care for an abandoned pup. Harbor seal pups are not fearful and will often remain still and not retreat

to the water when approached (Tezak 2004). This type of behavior leaves them vulnerable to harassment or illegal handling.

Implications for Management

It is important to understand the patterns of stranding and human disturbance from a management perspective. If seals and humans are to coexist, managers need to find ways to minimize harm to both species. The management of natural resources typically involves managing the human behavior within the environment where these resources exist (Wallace 2003).

By knowing where and when interactions between seals and humans are occurring managers can increase enforcement and monitoring efforts at peak times and locations. In addition, management agencies can make recommendations to the public to minimize interactions. For example, the use of propeller guards on boats traveling through the Monomoy Channel during the summer months might reduce the incidence and/or severity of boat strikes.

Managers on Cape Cod should use the information presented in this study to better understand where and when information on properly viewing wildlife would be best distributed. In an effort to educate the public on properly viewing marine wildlife, the non-profit organization Watchable Wildlife has created a set of guidelines. Watchable Wildlife works with wildlife protection groups as well as federal and state wildlife agencies when creating their guidelines. These marine viewing guidelines were recently updated in January 2004 with the support of the National Marine Fisheries Service. The guidelines are as follows: learn about the wildlife before you go; keep your distance; do

not touch, feed or attract marine wildlife; never chase or harass wildlife; stay away from wildlife that appears abandoned or sick; and finally, pets and wildlife don't mix. These guidelines are available online as a three page document.

The Watchable Wildlife viewing guidelines should be widely distributed in areas where interactions are likely to occur. The guidelines should be available for tourists when they check into their cottage or hotel rooms or when purchasing their beach or boat mooring permits. The three- page form, while visual pleasing, is not user friendly or easy to carry and reference, so the guidelines should be condensed to a pocket-sized reference card. In an attempt to decrease the number of entanglements, it would be beneficial if the viewing guidelines were accompanied by a reminder of how to properly dispose and discard of fishing line and gear after use. At present the CCSN publishes seal watch guidelines that should be disseminated on a larger scale possibly by accompanying the wildlife viewing guidelines.

A similar wildlife viewing education effort, Sanctuary Education Awareness and Long-Term Stewardship (SEALS), is taking place in the Gulf of Farallones National Marine Sanctuary in California. In an attempt to decrease the amount of disturbance to the harbor seals along the coasts, a monitoring program and education outreach to boaters was created (Tezak et al 2004). During pupping season volunteers are present at low tide to reduce the number of seal disturbances due to clamming. The number of flushing events due to motorboats has decreased by half in the past two years, most likely due to the presence of a National Park Service boat patrolling the coast (Tezak et al 2004). Wildlife viewing guidelines are posted at boat launches and a laminated viewing card-- PADDLER's Etiquette-- is disseminated to those wishing to kayak or canoe in the

sanctuary. Since the distribution of this card, the number of kayak and canoe related disturbances has decreased (Tezak et al 2004). Clark (2001) states that the public has a desire to become involved in conservation policy and management. It is up to wildlife managers to show them how. These same programs and outreach materials could be adapted for implementation on Cape Cod.

The growing population of humans moving to the coast makes it necessary to inform and educate people about the coastal environment. Increased education, enforcement and monitoring efforts are vital to decreasing the number of negative interactions occurring between seals and humans on Cape Cod.

Figure 5. Diagram of a Fishing Weir. National Museum of Man. National Museum of Canada

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