MARINE MAMMAL SCIENCE, 5(2):173–192 (April 1989)

THE DISTRIBUTION, ABUNDANCE AND SELECTED PREY OF THE HARBOR SEAL, *PHOCA VITULINA CONCOLOR,* IN SOUTHERN NEW ENGLAND

P. MICHAEL PAYNE

LAWRENCE A. SELZER[1]

Marine Mammal and Seabird Studies, Manomet Bird Observatory, Manomet, Massachusetts 02345

ABSTRACT

The seasonal distribution and abundance of harbor seals occurring south of Maine were documented by counting the number of seals at traditional haulout locations. The average number of seals counted during each survey in Massachusetts and New Hampshire was 3,560 ± 255 (95% CI), 1983–1987. The maximum number of seals counted on any individual survey was 4,736 individuals. Fifty percent of all the surveys since January 1985 have resulted in counts greater than 4,000 seals reflecting a 27% increase in the abundance of seals in our study area since that date. Seventy-five percent of the seals in southern New England are located at haulout sites on Cape Cod and Nantucket Island. The largest aggregation of seals in the eastern United States occurs mid-winter at Monomoy Island and adjacent shoals. A single high count of 1,672 seals occurred at this site during the study period. An additional 271–374 seals were also counted in Rhode Island, Connecticut and eastern Long Island Sound during surveys conducted in March 1986 and 1987.

The American sandlance *Ammodytes americanus* was the single dominant prey item of harbor seals in waters adjacent to Cape Cod based on the modified frequency of occurrence of each prey species in scat samples collected from three haulout sites on Cape Cod between 1984–1987. During January and February sandlance was the near exclusive prey item at Monomoy (99%, $n = 80$). During March and April, the frequency of Atlantic herring *Clupea harengus* increased in the scat samples at this site. Regional differences in the diet of seals reflect distinct prey communities throughout the study area. Since 1986, the percent occurrence and importance of sandlance in the diet of seals has decreased, reflecting an overall decrease in abundance of this prey species in waters adjacent to Cape Cod. In spite of fluctuations in abundance, and regional differences in the diet of seals throughout the study area, sandlance still comprised a minimum 55% of the total prey species of harbor seals throughout the study area.

Key words: harbor seal, *Phoca vitulina,* distribution, abundance, prey.

[1] Present address: 1378 Minor Ridge Court, Charlottsville, Virginia 22901.

The harbor seal *Phoca vitulina concolor,* a year-round resident of eastern Canada (Boulva and McLaren 1979) and coastal Maine (Katona *et al.* 1983), occurs in southern New England (south of Maine) seasonally from late September through late May (Schneider and Payne 1983). It is the most abundant marine mammal in the nearshore waters of southern New England. Historic sighting records in Massachusetts and New Hampshire (Allen 1863, Brown 1913, Allen 1942), Connecticut (Goodwin 1935) and New York (DeKay 1842, Dutcher and Dutcher 1893, Fisher 1896, Miller 1899, Connor 1971) indicate that the overall range of harbor seals throughout coastal New England has not changed during the past century. However, the seasonal distribution and the geographical extent of pupping have changed considerably south of Maine, having been affected directly by wildlife and fisheries policies since the mid-1800s (Allen 1942).

Historically, the overriding management policy regarding seals throughout southern New England was to consider them predators of commercially important fish and to control their numbers through a town or state bounty (Allen 1880, Brown 1913, Allen 1942). In 1888 Massachusetts began offering a bounty on seals which lasted until 1962. Pressure from the bounty resulted in a reduction or complete elimination of seals in local or heavily hunted areas (Allen 1942), a limit to the southward dispersion of seals from Maine rookeries indirectly leading to their present seasonal occurrence (Payne and Schneider 1984), and the extirpation of breeding activity south of Maine (Katona *et al.* 1983). Complete protection of seals was not provided until implementation of the Marine Mammal Protection Act of 1972 (MMPA).

Since federal protection, the number of harbor seals throughout southern New England has more than doubled, increasing at one site in southeastern Massachusetts at an average rate of 11.9% per year (Payne and Schneider 1984). The recent increases in seal abundance have increased the potential for conflicts between commercial fisheries and seals. Harbor seals have been implicated continually as competitors with fishermen (Imler and Sarber 1947; Fisher 1952; Spalding 1964; Rae 1968, 1973; Boulva and McLaren 1979; Mate 1980; Everitt and Beach 1982; Brown and Mate 1983). In New England, the lobster (*Homarus americanus*) fishery, and gillnet and weir fisheries annually report commercial loss and gear damage due to harbor seals (Gilbert and Stein 1981, Gilbert and Wynne 1983). To estimate the extent of competition between seals and commercial fisheries, it is necessary to know the number of seals involved and the prey species being consumed. There is no published information on the present distribution and abundance of harbor seals throughout southern New England and published accounts of the food habits of harbor seals in southern New England (Griffin 1936, Selzer *et al.* 1986) do not accurately reflect the present, changing diet of seals in that area.

The objectives of this paper are to describe the present distribution and abundance of seals throughout southern New England and to summarize the diet of harbor seals in southern New England between 1983–1987. This study provides the first quantitative examination of the distribution and of the diet of harbor seals in southern New England.

Methods and Materials

Study area—The study area consists of the entire coastline and nearshore islands from the Isles of Shoals, a large granite outcropping on the Maine-New Hampshire border, south through the eastern half of Long Island Sound (Fig. 1). The middle portion of the study area is dominated by Cape Cod, Nantucket Island and Martha's Vineyard (Fig. 1). Throughout the study area seals haul out on a variety of substrates including subtidal rocky outcroppings or sand shoals exposed only at low tide, sand-peat hummocks in a tidal marsh, and larger, sandy beaches exposed throughout the tidal cycle.

Aerial surveys—distribution and abundance—During January and February of each year, 1983–1986, aerial surveys were conducted from the Isles of Shoals, New Hampshire south to the Massachusetts-Rhode Island border (see Fig. 1). During March 1986 and 1987 three surveys also were flown southward to include Rhode Island, Connecticut and the eastern half of Long Island Sound (see Fig. 1).

To maximize the number of seals counted on land, each survey was begun 1 h before an early to mid-day low tide. Harbor seals throughout New England haul out during low tide on rock ledges (Wilson 1978, Schneider and Payne 1983). Elsewhere (*i.e.,* sand beaches and tidal marshes), daily activity patterns have been shown to vary with location and substrate (Venables and Venables 1955, Loughlin 1979, Sullivan 1980, Pitcher and McAllister 1981, Calambokidis *et al.* 1987), but generally seals are most abundant on land during early to mid-afternoon low tides (Knudtson 1974, Allen *et al.* 1984, Stewart 1984, Stewart and Yochem 1984, Yochem *et al.* 1987).

Aerial surveys were flown parallel to the coastline at an altitude of 250–300 m and an airspeed of 167–204 km/h during optimum conditions (*i.e.,* wind speed <6 km/h and air temperature between 0–10°C). The observers continuously scanned the coastline counting individuals, and larger aggregations of seals at haulout sites which have been traditionally used (as documented in Knapp and Winn 1978, Kraus 1980). When we approached a concentration >25 individuals we reduced our speed and circled the group at a decreased altitude of 180–200 m in order to photograph the seals. The number of seals at each haulout site later was determined from the projected slides. This technique reduces the error involved in visually estimating large numbers of seals (Vaughan 1971). Seals seen between haulout sites were counted and added to the nearest large concentration of seals. The outer island area of Boston Harbor was not surveyed due to its proximity to the restricted area encircling Logan International Airport.

Disturbance has been shown to influence haulout behavior (Bartholomew 1949, Newby 1973, Paulbitski 1975, Allen *et al.* 1984) and thus the number of seals that can be counted on land. We considered accurate counts of harbor seals in the water impossible. If, during a survey, it appeared that the seals had been disturbed at a haulout site, the survey was discontinued and begun again on a later day.

In our study area, it is not possible to ground-truth our aerial survey estimates

of the larger haulout sites (as recommended by Eberhardt *et al.* 1979) due to the remoteness of haulout sites, or to the lack of adjacent land-based locations where ground counts might be possible. Therefore the results from these surveys are considered accurate indices of minimum abundance rather than absolute population estimates for the study area.

Treatment of aerial survey data—The number of seals counted in Massachusetts and New Hampshire is presented by haulout site for each survey. Yearly abundance estimates were calculated by determining the average number of seals counted at each haulout site within a year (based on the January–March surveys), then summing over all sites within the study area for that year. An average estimate for each haulout site in Massachusetts and New Hampshire, 1983–1987, was also determined in the same manner, independent of years.

The number of seals counted at each haulout site in Connecticut, Rhode Island and Long Island Sound during the March 1986–1987 aerial surveys is also presented by survey. We did not determine an average number of seals at each haulout site based only on the three surveys flown in this portion of the study area. Rather, an upper limit on the number of seals in Connecticut, Rhode Island and Long Island Sound for the years 1986–1987 was estimated by summing the maximum number of seals counted at each haulout site during the surveys to obtain a single estimate. This technique likely overestimates the actual number of seals in this portion of the study area. However, we believe the comparison between the number of seals counted during individual surveys to this calculated maximum provides a useful lower and upper index of abundance for the number of seals in Connecticut, Rhode Island and Long Island Sound.

Food habits—collection of scats—Because daily patterns of harbor seals throughout southern New England are constructed generally around periods of a mid-day lowtide haulout, scat samples were collected at, or just following low tide. The collection sites were chosen based on accessibility to haulout sites and the number of seals at accessible sites. We determined (based on the results of the 1983 survey) that 70% of the harbor seals in our study area were located on Cape Cod. Therefore, the contents of scats from the sites on Cape Cod would represent the diet from a similar percentage of seals in our study area. With the exception of the Isles of Shoals, sub- or intertidal rock ledge haulout sites are inaccessible during mid-winter.

Treatment of scat samples—Following collection, all scats were frozen individually for later examination. Prior to examination the scats were emulsified for 12–24 h in a mixture of 10 parts ethyl alcohol (95%), 3 parts water, and 1 part carboxymethylcellulose solution (following Pitcher 1980*a*, Treacy and Crawford 1981) and then sorted manually. Although otoliths were the primary prey indicators found in the scat samples, we also used scales, diagnostic bones and dermal projections (bony and cartilaginous fishes), or beaks and eye lenses (cephalopods) to identify prey species. Each prey component was identified to the lowest taxonomic level possible using available keys (Clarke 1962, Brodeur 1979), and by comparison with reference specimens at the National Marine Fisheries Service, Northeast Fisheries Center, Woods Hole, Massachusetts.

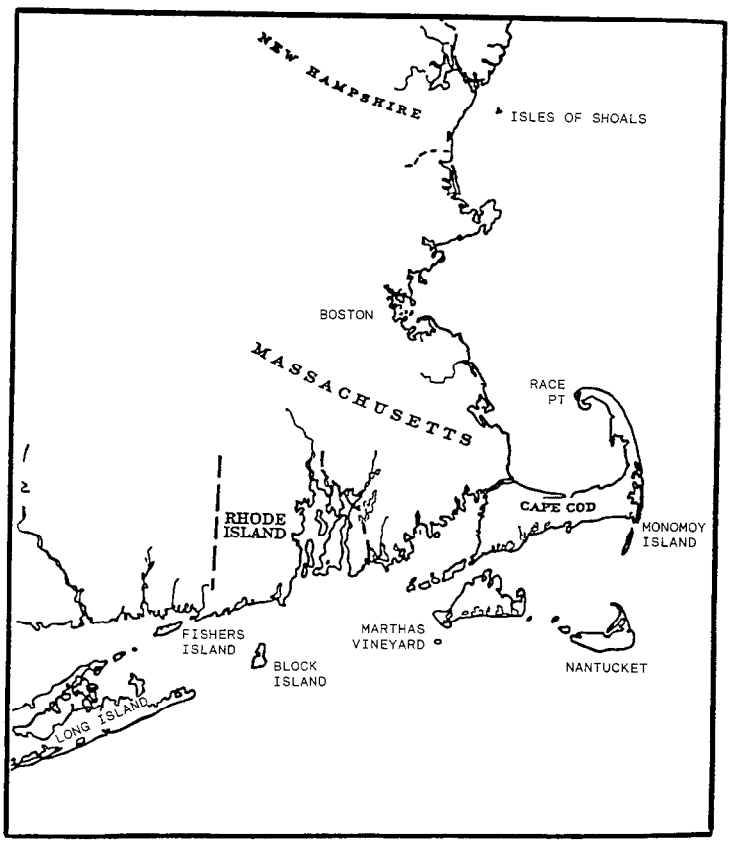

Figure 1. The study area extends along the coastline and nearshore islands of southern New England from the Isles of Shoals on the Maine–New Hampshire border south through the eastern half of Long Island Sound.

Ranking of prey items from scat samples—In this study, all recognizable otoliths and hard-bone parts from prey species are expressed as a percentage of the total sample based on an adjusted or modified frequency of occurrence of each prey species in the samples. The frequency of occurrence of a prey species is the percentage of stomachs or scat samples containing that species, independent of volume or number of prey (Hyslop 1980). However, because some samples contain more than one type of consumed prey, the summed frequency of occurrence always exceeds 100% (Spalding 1964). Therefore Spalding (1964) adjusted the proportion of each prey item to total 100%, a technique referred to by Bigg and Perez (1985) as the modified frequency of occurrence. When quantitatively estimating the number of fish species in the diet only by the contents of scats, this is the most accepted and widely used technique (Prime 1979, Treacy and Crawford 1981, Bailey and Ainley 1982, Brown and Mate 1983, North *et al.* 1983, Testa *et al.* 1985, Prime and Hammond 1987, Harwood and Croxall 1988).

Results

The present distribution and abundance of harbor seals in Massachusetts and New Hampshire—The number of seals counted at each haulout site in Massachusetts and New Hampshire during January–February 1983 and 1984 was very stable, increasing by less than 2.0% from 2,858 ± 172 in 1983 (the average estimate and the 95% CI, Table 1) to 2,894 ± 172 seals in 1984. In 1985 and 1986, the average number of seals counted during the surveys increased by approximately 27% over the two previous estimates to 3,945 ± 76 in 1986 and 3,870 ± 300 in 1987 (Table 1). The two greatest counts occurred during March 1986 and March 1987. The average number of seals counted during these two surveys (4,465 ± 295) reflect a maximum number of seals throughout the study area. Since January 1985, a minimum of 4,000 seals has been counted on 50% of the aerial surveys in Massachusetts and New Hampshire (Table 1).

The total number of haulout sites and location of each site did not change during the 5-yr study period. Preferred haulout sites were apparent. Approximately 58% of the seals counted in Massachusetts and New Hampshire (based on the average number of seals for the combined data, 1983–1987, Table 1) overwintered at the Jeremy Point, the Monomoy Island National Wildlife Refuge (Monomoy), and the Nantucket Island haulout sites. These are the three largest concentrations of seals in southern New England. All three sites are sand beaches/shoals and are located on, or adjacent to, Cape Cod (Fig. 2). The average number of seals which occur at Monomoy represents approximately 34% of the minimum abundance estimate for the entire Massachusetts-New Hampshire study area. This is the largest single aggregation of seals throughout the study area.

Nine of the ten remaining haulout sites were rock ledges (Table 1). Thirty-one percent of the seals recorded in the survey area used these sites. The number of seals counted at the Isles of Shoals was extremely consistent between counts and years (369 ± 55 seals, average estimate and 95% CI, Table 1). This site is used by more seals than any other rock-ledge site in the study area.

The remaining 2% of the seals occurred at the Nauset Marsh haulout site which is comprised of peat beds and marsh grass.

Distributional shifts between sites did occur. For example, the number of seals at the Race Point haulout site significantly decreased between 1983–1987. The timing of this decrease corresponds to a shift in the sand beach configuration at the Race Point haulout site allowing easier access to the site at low tide. Since then, except for the January 1985 survey, the number of seals using this site during mid-winter has been significantly reduced (see Table 1). Also, the waters surrounding the Jeremy Point haulout site were completely iced-over during January 1986 preventing any seals from accessing this location resulting in a zero count during that survey. Subsequently, during the February and March 1986 aerial surveys, the water surrounding this haulout site became ice-free and the site was re-occupied (see Table 1).

The present distribution and abundance of harbor seals in Rhode Island, Connecticut and eastern Long Island Sound—The maximum number of seals counted

Table 1. The number of seals counted at each major haulout site in New Hampshire and Massachusetts by location and by year of survey. The average number of seals (±95% CI) counted during each year of the surveys and for the entire study period is also presented.

Haulout site		1983 Jan	1983 Feb	1984 Jan	1984 Feb	1985 Jan	1985 Feb	1986 Jan	1986 Feb	1986 Mar	1987 Mar	$\bar{x}$ ± 95% CI[a]
New Hampshire												
Isles of Shoals	rock	322	187	362	443	432	425	489	392	360	277	369 ± 55
New Hampshire coastline	rock	45	23	76	43	78	44	43	0	58	91	50 ± 17
Massachusetts												
New Hampshire to Boston Harbor	rock	131	25	233	40	328	246	406	202	396	393	240 ± 88
Strawberry Point	rock	184	133	187	220	195	236	165	194	271	524	237 ± 65
Plymouth Harbor	rock	36	38	33	53	34	54	43	52	43	59	45 ± 6
Stage Point	rock	98	104	44	51	74	77	51	88	134	210	93 ± 31
Ellisville	rock	49	47	61	75	55	15	15	43	47	171	58 ± 27
Race Point	sand	289	260	26	75	203	50	15	53	55	21	105 ± 65
Jeremy Point	sand	134	431	62	505	621	437	0	588	697	398	387 ± 150
Nauset Marsh	peat	—[b]	—	67	103	65	12	0	22	0	44	39 ± 23
Monomoy Island	sand	1,040	1,017	967	569	1,326	1,464	1,095	1,587	1,672	1,082	1,182 ± 206
Nantucket Island	sand	244	556	542	511	510	455	305	446	777	507	485 ± 90
Martha's Vineyard to Nomans Land	rock	—	27	23	104	0	37	136	40	75	164	68 ± 37
Elizabeth Islands to Rhode Island	rock	140	157	221	89	190	199	214	235	109	253	175 ± 41
Totals		2,712	3,005	2,904	2,881	4,111	3,779	2,977	3,942	4,736	4,194	
$\bar{x}$ ± 95% CI		2,858 ± 172		2,894 ± 172		3,945 ± 76		3,870 ± 300			4,194	3,560 ± 255

[a] Confidence intervals are the product of the standard error of the mean and the appropriate Student's-*t* level of confidence ($P < 0.05$).
[b] A dash indicates no data, not a zero count.

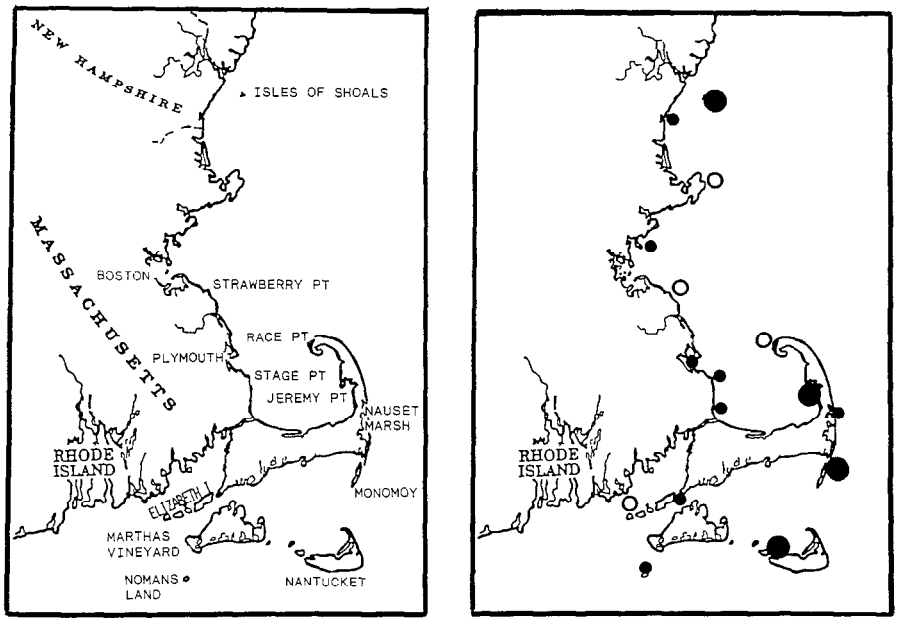

Figure 2. The location of the major haulout sites in New Hampshire and Massachusetts referred to in the text (left) and the relative number of harbor seals (based on the average number of seals from the aerial survey data, 1983–1987, Table 1) counted at each haulout site (right). Dot sizes represent the average number of seals counted at each site: small (solid) = <100, medium (open) = ≥100 and <300, large (solid) = ≥300.

on any of the 1986–1987 March surveys between the Massachusetts-Rhode Island border southwest to, and including, the eastern half of Long Island Sound was 271 individuals (counted during the March 1987 survey, Table 2). The only haulout site in this portion of the study area used consistently by more than 50 seals occurred at Fishers Island, New York. This site had a single, high count of 101 seals (the range was 78–101) during March 1986.

The estimated maximum number of seals in this portion of the study area during 1986–1987 (determined by summing the maximum number of seals counted at each of the major haulout sites during the surveys, Table 2) was 374 animals. Therefore, 271–374 seals is a realistic lower and upper limit on the present number of seals occurring in Rhode Island, Connecticut and eastern Long Island Sound. The location of each haulout site and the relative number of seals counted at each site during the 1986–1987 surveys (based on the maximum number at each site, Table 2) are shown in Figure 3. This upper and lower limit is between 7.0–10.0% of the estimated number of seals which occurred throughout New Hampshire and Massachusetts during 1987.

Food habits—selected prey based on scat analyses—Between 1984–1987, 248 scat samples were collected from the following four haulout sites in the study area: the Isles of Shoals, Race Point, Jeremy Point and Monomoy. Approximately

Table 2. The number of seals counted at each haulout site during the March 1986–1987 surveys to Rhode Island, Connecticut and eastern Long Island Sound.

Location	Number of seals by survey		
	4 March 1986	21 March 1986	7 March 1987
Rhode Island			
Narragansett Bay			
Halfway Rock			1
Prudence Island			9
Patience Island	11	8	
Dumplings Islands			43
Rome Point			36
Sakonnet Point	11	16	6
Block Island	1		
Connecticut			
Mouth of Connecticut River		21	
Long Island Sound			
Fishers Island	101	78	90
Falkner Island	18		
Great Gull Island	8	25	48
Gardiners Island			26
Sag Harbor	22		
Shinnecock Inlet		1	
Montauk Point		30	12
Total	172	179	271

95% (n = 234) were collected from the three haulout sites on Cape Cod. To simplify the presentation of data in the figures, similar prey types were combined into species or related prey groupings. These include gadiform or cod-like fishes, the flounders and members of the rockfish family. The gadiform group includes the following species: Atlantic cod, *Gadus morhua,* haddock, *Melanogrammus aeglefinus,* red hake, *Urophycis chuss,* long-finned hake, *Phycis bilinearis,* and ocean pout, *Macrozoarces americanus.* All of the unidentified, young-of-the-year gadids were also included in this group. The flounder group included the following species: American plaice, *Hippoglossoides platessoides,* witch flounder, *Glyptocephalus cynoglossus,* windowpane, *Lophopsetta maculata,* yellowtail, *Limanda ferruginea,* and winter flounder, *Pseudopleuronectes americanus.* The rockfish group included two species, the redfish, *Sebastes marinus,* and the black-bellied rosefish, *Helicolenus dactylopterus.*

Sandlance represented 86.8% (n = 46) and 84.6% (n = 125) of the total prey taken at Race Point and Monomoy, respectively (Fig. 4). During the January–February collections, sandlance was the dominant, near-exclusive prey item at Race Point (90%, n = 80) and Monomoy (99%, n = 80). Sandlance otoliths represented over 99% of the total otoliths collected from Cape Cod, occurring in all but nine of the scat samples. Although sandlance was the

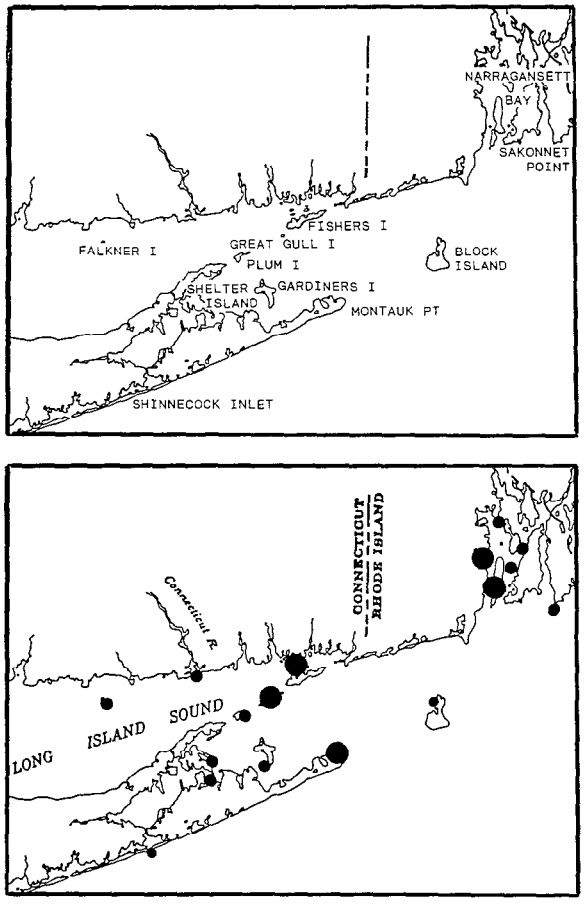

Figure 3. The location of the major haulout sites in Rhode Island, Connecticut, and eastern Long Island Sound referred to in the text (upper) and the relative number of harbor seals (based on the maximum number of seals, 1986–1987, Table 2) counted at each haulout site (lower). Dot sizes represent the number of seals counted at each site: small = <10, medium = ≥10 and <30, large = ≥30.

dominant prey taken by seals at Jeremy Point (50%, $n = 63$), other prey items including squid (22%, $n = 63$) were also consumed throughout the winter (Fig. 4).

A seasonal change in the diet of harbor seals was evident only at Monomoy. The occurrence of sandlance in the scat samples decreased from 99% ($n = 80$) in the January–February collections to 66% ($n = 45$) in the March–April collections. During March–April 1986, sandlance represented only 32% ($n = 11$) of the diet of seals at Monomoy. Concurrent with this apparent decrease in the frequency of sandlance in the diet at this location during 1986–1987, several other species (flounders and Atlantic herring, *Clupea harengus*) became more apparent. The frequency of Atlantic herring increased in the diet of seals from 5% ($n = 80$) in January–February to 16% ($n = 45$) in the March–April collections. Due to the known low recovery rate of herring otoliths in scats (da

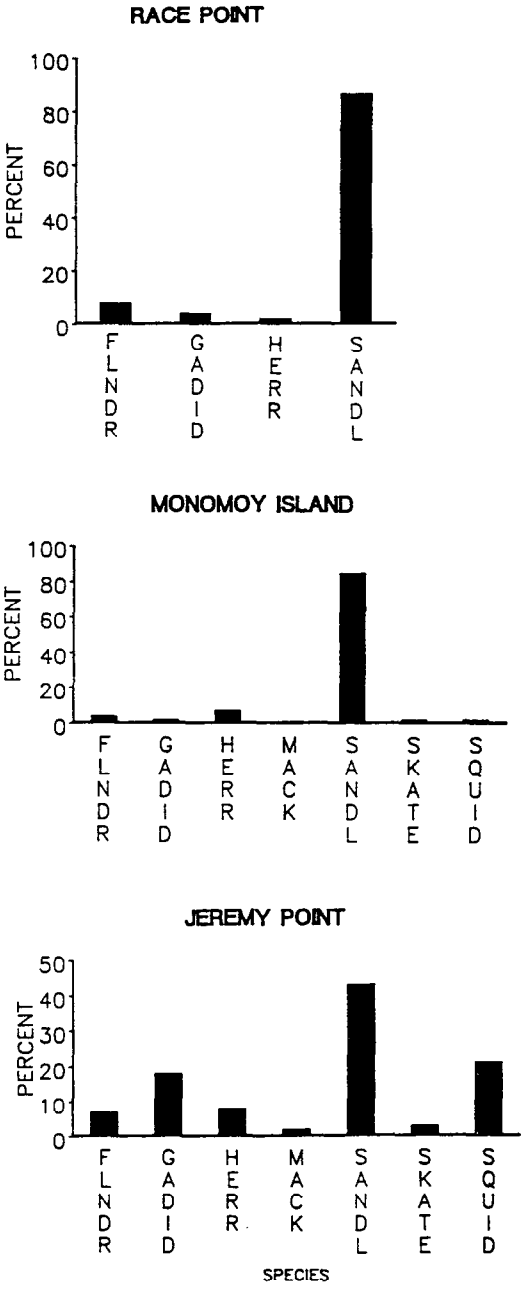

Figure 4. The percent composition of each prey species or species-group in the diet of harbor seals at Race Point, Monomoy and Jeremy Point, based on modified frequency of occurrence of the prey in the scat samples collected at each site. Species codes include the following: FLNDR = flounder spp.; GADID = Gadidae, or cod-like fishes; HERR = Atlantic herring, *Clupea harengus*; SANDL = American sandlance, *Ammodytes americanus*; MACK = Atlantic mackerel, *Scomber scombrus*; SKATE = *Raja* spp.; SQUID = short-finned, *Illex illecebrosus* or long-finned squid, *Loligo pealei*.

Silva and Neilson 1985), the role of Atlantic herring in the diet of harbor seals may be higher than we indicate. However, given the large sample of scats collected from Cape Cod haulout sites, we feel this bias to be minimal.

During 1984–1985 95% (n = 99) of the diet at Monomoy consisted of sandlance. This amount decreased to 57% (n = 26) during 1986–1987. The percent occurrence of Atlantic herring in the samples increased from 0% (n = 99) during 1984–1985 to an average of 15.0% (n = 26) during 1986–1987 at Monomoy.

Regional variation between the diet of seals was most obvious when comparing the contents of scats collected at the Isles of Shoals to those collected from haulout sites on Cape Cod (Fig. 5). The rockfish family (redfish and black-bellied rosefish) and gadiforms (Atlantic cod, haddock, and four-bearded rockling, *Enchelyopus cimbrius*) made up 44% (n = 14) of the major prey species at the Isles of Shoals. Atlantic herring, yellowtail flounder, and American plaice were other major prey species represented in the scat collections from the Isles of Shoals. The sandlance was represented in the diet of seals at the Isles of Shoals by a single otolith, whereas they dominated numerically the combined samples collected on Cape Cod (73.8%, n = 234, Fig. 5).

In spite of regional, seasonal, and annual fluctuations in the composition of prey, sandlance was obviously the most common single prey item consumed by seals in southern New England (based on the frequency of occurrence in scat samples). Sandlance contributed a minimum of 55% to the harbor seal prey species throughout New Hampshire and Massachusetts during the period 1984–1987. This estimate is based solely on the percentage of seals occupying Cape Cod relative to the entire total number of seals in New Hampshire and Massachusetts (2,686 seals or 75% based on average abundance data, Table 1) multiplied by the percent occurrence of sandlance in the diet of seals in waters adjacent to Cape Cod (73.8% based on dietary data presented in Fig. 5). The total contribution of sandlance to the dietary requirements cannot be calculated accurately due to the inability to collect scat samples from haulout sites away from Cape Cod and due to the lack of knowledge of the relative digestible energy of different prey species.

Discussion

Distribution and abundance—The distribution of harbor seals in southern New England reflects the distribution of available haulout locations. Harbor seals have been shown to select haulout sites on the basis of topography and degree of exposure (Sullivan 1980, Schneider and Payne 1983), tide (Fisher 1952, Venables and Venables 1955) and degree of isolation from human disturbance (Newby 1973, Sullivan 1980). The four largest concentrations of seals in our survey area (Isles of Shoals, Jeremy Point, Monomoy, and Nantucket) occur at sites where these conditions extend over a relatively large geographic area. The seals which occur at Monomoy are the largest, single aggregation of seals in the eastern United States. The only larger aggregation at a single site occurs at Sable Island, Nova Scotia (Boulva and McLaren 1979), another large,

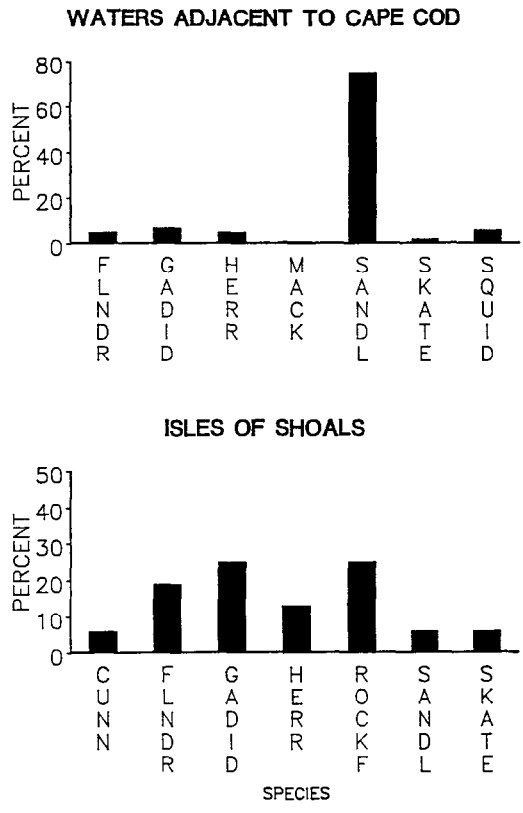

Figure 5. The percent composition of each prey species or species-group in the diet of harbor seals on Cape Cod, Massachusetts, based on the modified frequency of occurrence of the prey in the combined scat samples from Cape Cod (n = 234) as compared to the percent composition of each prey species or species-group represented in the scat samples collected from the Isles of Shoals (n = 14). Species codes include the following: FLNDR = flounder spp.; GADID = Gadidae, or cod-like fishes; HERR = Atlantic herring, *Clupea harengus*; SANDL = American sandlance, *Ammodytes americanus*; MACK = Atlantic mackerel, *Scomber scombrus*; SKATE = *Raja* spp.; SQUID = short-finned, *Illex illecebrosus* or long-finned squid, *Loligo pealei*; CUNN = cunner, *Tautogolabrus adspersus*; ROCKF = rockfish, either redfish, *Sebastes marinus* or black-bellied rosefish, *Helicolenus dactylopterus*.

isolated island dominated by sand beaches. The apparent preference by harbor seals in southern New England for sand beach/shoal haulout sites may be a function of the greater area available to seals for hauling out. Competition for space, which probably occurs at rock ledge sites, would be reduced.

The differences observed in the number of seals counted during aerial surveys between the period 1983–1984 and 1985–1987 in the present study can be explained as an indirect result of an age-specific mass mortality of harbor seals which occurred throughout southern New England (primarily in Massachusetts) in 1980 (reported by Geraci *et al.* 1981). Over 90% of the seals which died

during this mortality were less than 3 yr of age. Therefore, during the years immediately following the epidemic, a very reduced number of seals would become adult-age and be recruited into the breeding component of the New England population. Boulva and McLaren (1979) found that female harbor seals did not pup until age 4 but that all were mature by age 6. Due to the mortality and the age at which female seals reproduce, we would not expect any significant increases in the number of breeding adults or increased pup production in New England until 1984–1986 (four to six years following the epidemic). The average number of seals counted on the aerial surveys during 1983–1984 was very similar (range 2,712–3,005, Table 1). These counts indicate a very stable breeding population and rate of pup production. We believe that the rapid increase observed during the winter 1985 is directly related to an increase in the number of breeding animals in New England during 1984 (four years after the epidemic), followed by an increase in the total number of pups born that season. This, subsequently, resulted in the observed increase in the number of seals dispersing southward into southern New England since that date.

Food habits of harbor seals—Two distinct prey communities are represented in the data. The prey selected from the Cape Cod areas was dominated by sandlance. Sandlance prefer sandy shoals and banks (Reay 1970), characteristic of the Cape Cod area. The community of fishes selected by harbor seals at the Isles of Shoals was more diverse, reflecting the bottom fishes characteristic of the deeper, colder waters of the Gulf of Maine. The differences in the oceanographic features between the two regions likely influence the distribution and availability of prey species to harbor seals. Harkonen (1987) also found that seals found on rocky shores have not only a different diet, but also a more diverse diet than those seals found on sandy shores.

The large number of sandlance otoliths found in the scat samples on Cape Cod in 1984 and 1985, then the decline in the frequency of occurrence of sandlance otoliths in the samples collected in 1986 and 1987 appear directly related to the recent population fluctuations of that species. The relative abundance of sandlance increased in waters adjacent to Cape Cod in the mid 1970s (Smith *et al.* 1978, Meyer *et al.* 1979, Sherman *et al.* 1981, Morse 1982). During this time, sandlance became an important prey for cetaceans (Overholtz and Nicolas 1979, Hain *et al.* 1982, Payne *et al.* 1986), fishes (Bowman *et al.* 1984) and seabirds (Powers and Backus 1987) in waters around Cape Cod. Since the mid 1980s sandlance biomass has declined (Bowman *et al.* 1984) and in 1986, completely disappeared from several locations around Cape Cod (based on the results of standardized trawl surveys conducted by the National Marine Fisheries Service, Northeast Fisheries Center, Woods Hole, Massachusetts, unpublished data).

Our study supports the findings of previous studies (Rae 1973, Boulva and McLaren 1979, Pitcher 1980*b*, Beach *et al.* 1982, Brown and Mate 1983, Harkonen 1987) which indicate that harbor seals feed opportunistically on species which are regionally and seasonally dominant, with a preference for small, schooling fishes (Boulva and McLaren 1979, Pitcher 1980*b*, Bigg and Perez

1985), and have the capability to shift prey selection rapidly in response to shifts in availability.

There are biases inherent in the interpretation of the diet of seals from examination of scat contents (Pitcher 1980*a*, Frost and Lowry 1981, Brown and Mate 1983, Bigg and Fawcett 1985, Bigg and Perez 1985, Murie and Lavigne 1986, David 1987) and otoliths may not be used to completely reconstruct the proportion of fish species (by biomass) in the diet of pinnipeds (daSilva and Neilson 1985, Dellinger and Trillmich 1988). However, it is generally considered that the hard-bone parts found in feces provide the most useful information on the range of prey species consumed (Pitcher 1980*b*), and are a biased but consistent sample of those prey ingested by the seal (Harwood and Croxall 1988). Further, reliable estimation of the diet composition in terms of number (not biomass) can be quite accurately assessed with an adequate sample size (Dellinger and Trillmich 1988).

Management considerations—Since protection under the MMPA, the increase in the harbor seal population in New England has precipitated a similar increase in the number of seals overwintering in southern New England (Payne and Schneider 1984). The continued growth of the New England seal population will require either a progressive increase in the number of seals at present pupping sites, an increase in the number of new pupping sites, or both. Along the coast of Maine, suitable natal or pupping sites are rock ledges with a low profile, exposed at all tides, and protected (Gilbert and Wynne 1984). Wilson (1978) showed a tendency for harbor seals to return to their natal sites in successive years. Therefore, without human disturbance, it is possible that pups born in southern New England would, in turn, become year-round residents south of Maine and resume pupping on the more remote haulout sites.

However, there are few rock ledges in southern New England suitable for pupping, and all beaches are major recreational areas, particularly during the breeding season (late spring to late summer). Given the lack of suitable pupping ledges, and the likelihood of human disturbance which has been shown to deter seals from pupping (Allen *et al.* 1984), it seems unlikely that seals will again establish pupping sites in southern New England. Therefore, while seals will continue to winter in southern New England due to continued recruitment from the breeding stock north of Massachusetts, the lack of pupping will preclude any large numbers of seals from remaining south of Maine on a year round basis.

There is widespread perception among fishermen that if seals were eliminated or at least if their numbers were reduced, more commercial fishes would become available to humans. David (1987) suggested that this was due partly to the conspicuous "high-profile" behavioral patterns of seals. Furthermore, he suggested that the role of seals as top predators and competitors with commercial fisheries has been over-emphasized as compared to other, less obvious predators (*i.e.*, fish). The information examined in this study indicates that since the early 1980s (and likely since the mid 1970s) a significant percentage of the diet of seals throughout southern New England has consisted of American sandlance, a small, non-commercial species. Given the present population level of seals in

southern New England, their seasonal pattern of occurrence, and the frequency of non-commercial fish species in their diet, we contend that since protection (including the period of recent population growth) harbor seals have not been, nor have they yet become, a threat to commercial fisheries in southern New England.

Acknowledgments

The authors wish to thank many individuals who have contributed ideas and suggestions, or provided technical support and field assistance on our work over the years. The following individuals provided assistance in either obtaining the scat samples, or analyses of their contents: Jennifer M. Brown, Steve Morello, Blair Nikula, Gordon T. Waring, Peter W. Whan and Andrew A. Whitman. Technical or logistical support necessary to collect the scat samples was also provided by the following employees of the Cape Cod National Seashore: Herbert Olson, Irving Tubbs, Vern Hurt, and Barbara Samora. Verification of our identification of otolith samples was provided by Jay Burnett and Louise Dery-Wells, National Marine Fisheries Service, Northeast Fisheries Center. We wish to thank Sam Sadove, Colleen Coogan, Howard Winn, Carol Fairfield and Olli Brazier for making seal-sighting data openly available to us. The following have generally provided support and ideas throughout the study and on previous drafts of this manuscript: David Schneider, James Gilbert, Kate Wynne, John Prescott, Greg Early, Scott Kraus, Patricia Fiorelli, Josette Carter, and Thomas French. In our office Jennifer Robbins, Nancy Poikonen and Martha Rustigian supplied editorial and clerical assistance. The study was funded by private funding, and by the National Marine Fisheries Service, Northeast Fisheries Center.

Literature Cited

Allen, G. M. 1942. Why a bounty on seals? Bulletin of the Massachusetts Audubon Society 26:11–13.

Allen, J. A. 1863. Catalogue of the mammals of Massachusetts, with a critical revision of the species. Bulletin of the Museum Comparative Zoology, Harvard University, Cambridge, Massachusetts 1(8):143–252.

Allen, J. A. 1880. History of North American pinnipeds—A monograph of the walruses, sea-lions, sea-bears and seals of North America. Department of the Interior, U.S. Geological and Geographical Survey of the Territories, Washington, DC, Miscellaneous Publication No. 19, 785 pp.

Allen, S. G., D. G. Ainley, G. W. Page and C. A. Ribic. 1984. The effect of disturbance on harbor seal haul out patterns at Bolinas Lagoon, California. Fishery Bulletin 82:493–500.

Bailey, K. M., and D. G. Ainley. 1982. The dynamics of California sea lion predation on Pacific hake. Fisheries Research 1:163–176.

Bartholomew, G. A. 1949. A census of harbor seals in San Francisco Bay. Journal of Mammalogy 30:34–35.

Beach, R. J., A.C. Geiger, S. J. Jeffries and S. D. Treacy. 1982. Marine mammal-fisheries interactions on the Columbia River and adjacent waters, 1981. Northwest and Alaska Fisheries Center Processed Report No. 82-04, National Oceanic and Atmospheric Administration, Seattle, WA, 186 pp.

Bigg, M. A., and I. Fawcett. 1985. Two biases in diet determination of northern fur seals (*Callorhinus ursinus*). Pages 284–291 *in* J. R. Beddington, R. J. H. Beverton and D. M. Lavigne, eds. Marine mammal-fishery interactions. George Allen and Unwin, London.

Bigg, M. A., and M. A. Perez. 1985. Modified volume: a frequency volume method to assess marine mammal food habits. Pages 278–283 *in* J. R Beddington, R. J. H. Beverton and D. M. Lavigne, eds. Marine mammal-fishery interactions. George Allen and Unwin, London.

BOULVA, J., AND I. A. MCLAREN. 1979. Biology of the harbor seal, *Phoca vitulina,* in eastern Canada. Bulletin of the Fisheries Research Board of Canada 200, 24 pp.

BOWMAN, R., J. WARZOCHA AND T. MORRIS. 1984. Trophic relationships between Atlantic mackerel and American sandlance. International Council for Exploration of the Seas (ICES), Document C.M. 1984/H:27, 10 pp.

BRODEUR, R. D. 1979. Guide to otoliths of some northwest Atlantic fishes. National Marine Fisheries Service, Northeast Fisheries Center, Woods Hole, Massachusetts, Laboratory Reference Document No. 79-36, 70 pp.

BROWN, C. E. 1913. Mammals of eastern Massachusetts with special reference to Essex County. Publication of the Peabody Academy of Science, Salem, Massachusetts, 53 pp.

BROWN, R. F., AND B. R. MATE. 1983. Abundance, movements and feeding habits of harbor seals, *Phoca vitulina,* at Netarts and Tillamook Bays, Oregon. Fishery Bulletin 81:291–301.

CALAMBOKIDIS, J., B. L. TAYLOR, S. D. CARTER, G. H. STEIGER, P. K. DAWSON AND L. D. ANTRIM. 1987. Distribution and haul-out behavior of harbor seals in Glacier Bay, Alaska. Canadian Journal of Zoology 65:1391–1396.

CLARKE, M. R. 1962. The identification of cephalopod "beaks" and the relationship between beak size and total body weight. Bulletin of the British Museum (Natural History) of Zoology, London 8:422–480.

CONNOR, P. R. 1971. The mammals of Long Island, New York. New York State Museum Scientific Services, University of New York, Albany, New York, Bulletin Number 416, 78 pp.

DASILVA, J., AND J. D. NEILSON. 1985. Limitations of using otoliths recovered in scats to estimate prey consumption in seals. Canadian Journal of Fisheries and Aquatic Sciences 42:1439–1442.

DAVID, J. H. M. 1987. Diet of the South African fur seal (1974–1985) and an assessment of competition with fisheries in South Africa. South African Journal of Marine Science 5:693–713.

DEKAY, J. E. 1842. Zoology of New York, or the New York fauna. Pages 1–146 *in* Natural history of New York, part I, Mammalia. Appleton and Company, New York.

DELLINGER, T., AND F. TRILLMICH. 1988. Estimating diet composition from scat analysis in otariid seals (Otariidae): is it reliable? Canadian Journal of Zoology 66:1865–1870.

DUTCHER, W., AND B. H. DUTCHER. 1893. Notes on mammals of Montauk Point, Suffolk County, Long Island, New York. Smithsonian Institution, United States Natural History Museum, Washington, DC, 7 pp.

EBERHARDT, L. L., D. G. CHAPMAN AND J. R. GILBERT. 1979. A review of marine mammal census methods. Wildlife Monograph 63, 46 pp.

EVERITT, R. D., AND R. J. BEACH. 1982. Marine mammal-fisheries interactions in Oregon and Washington: an overview. Pages 265–277 *in* K. Sabol, ed. Transactions of the American Wildlife and Natural Resource Conference. The Wildlife Management Institute, Washington, DC.

FISHER, A. K. 1896. The mammals of Sing Sing, New York. The Observer, Portland, Connecticut 7:193–200.

FISHER, H. D. 1952. The status of the harbour seal in British Columbia, with particular reference to the Skeena River. Bulletin of the Fisheries Research Board of Canada 93, 58 pp.

FROST, K. J., AND L. F. LOWRY. 1981. Trophic importance of some marine gadids in northern Alaska and their body otolith size relationships. Fishery Bulletin 79:187–192.

GERACI, J. R., D. J. ST. AUBIN, I. K. BARKER, R. G. WEBSTER, V. S. HINSHAW, W. J. BEAN, H. L. RUHNKE, J. H. PRESCOTT, G. EARLY, A. S. BAKER, S. MADOFF AND R. T. SCHOOLEY. 1981. Mass mortality of harbor seals: pneumonia associated with influenza A virus. Science 215:1129–1131.

GILBERT, J. R., AND J. L. STEIN. 1981. Harbor seal populations and marine mammal-

fisheries interactions, 1981. Annual report to the National Marine Fisheries Service, Northeast Fisheries Center, Woods Hole, Massachusetts, Contract Number NA-80-FA-C-00029, 49 pp.

GILBERT, J. R., AND K. M. WYNNE. 1983. Harbor seal populations and marine mammal-fisheries interactions, 1982. Second annual report to the National Marine Fisheries Service, Northeast Fisheries Center, Woods Hole, Massachusetts, Contract Number NA-80-FA-C-00029, 43 pp.

GILBERT, J. R., AND K. M. WYNNE. 1984. Harbor seal populations and marine mammal-fisheries interactions, 1983. Third annual report to the National Marine Fisheries Service, Northeast Fisheries Center, Woods Hole, Massachusetts, Contract Number NA-80-FA-C-00029, 52 pp.

GOODWIN, G. G. 1935. The mammals of Connecticut. Bulletin of the State Geological and Natural History Survey, Hartford, Connecticut 53:1–221.

GRIFFIN, D. R. 1936. Stomach contents of Atlantic harbor seals. Journal of Mammalogy 17:65–66.

HAIN, J. H. W., G. R. CARTER, S. D. KRAUS, C. A. MAYO AND H. E. WINN. 1982. Feeding behavior of the humpback whale, *Megaptera novaeangliae,* in the western North Atlantic. Fishery Bulletin 80:259–268.

HARKONEN, T. 1987. Seasonal and regional variations in the feeding habits of the harbour seal, *Phoca vitulina,* in the Skagerrak and the Kattegat. Journal of Zoology, London 213:535–543.

HARWOOD, J., AND J. P. CROXALL. 1988. The assessment of competition between seals and commercial fisheries in the North Sea and the Antarctic. Marine Mammal Science 4:13–33.

HYSLOP, E. J. 1980. Stomach contents analysis—a review of methods and their application. Journal of Fisheries Biology 17:411–429.

IMLER, R. H., AND H. R. SARBER. 1947. Harbor seals and sea lions in Alaska. United States Department of the Interior, Fish and Wildlife Service, Special Publication Report 28, 23 pp.

KATONA, S. K., V. ROUGH AND D. T. RICHARDSON. 1983. A field guide to whales, porpoises, and seals of the Gulf of Maine and eastern Canada, Cape Cod to Newfoundland. Scribner's Sons, New York.

KNAPP, C. L., AND H. E. WINN. 1978. Harbor seals, New Hampshire to Long Island. Report to the Graduate School of Oceanography, University of Rhode Island, Narragansett, Rhode Island, 36 pp.

KNUDTSON, P. M. 1974. Birth of a harbor seal. Natural History 83:30–37.

KRAUS, S. 1980. The population of harbor seals (*Phoca vitulina*) in southern New England. Report of the Harbor Seal Workshop, 5 March 1980, New England Aquarium, Boston, Massachusetts, 4 pp.

LOUGHLIN, T. R. 1979. Harbor seals in and adjacent to Humboldt Bay, California. California Fish and Game 64:127–132.

MATE, B. R. 1980. Workshop report for marine mammal-fisheries interactions in the eastern Pacific. Marine Mammal Commission Report Number MM8AC-003, Washington, DC, available National Technical Information Service Publication Number PB80-175144, Springfield, Virginia.

MEYER, T. L., R. A. COOPER AND R. W. LANGTON. 1979. Relative abundance, behavior, and food habits of the American sand lance, *Ammodytes americanus,* from the Gulf of Maine. Fishery Bulletin 77:243–253.

MILLER, G. S. 1899. Preliminary list of the mammals of New York. Bulletin of the New York State Museum, Albany, New York 69:273–390.

MORSE, W. 1982. Spawning stock biomass estimates of sand lance, *Ammodytes* sp., off northeastern United States, determined from MARMAP plankton surveys, 1974–1980. International Council for Exploration of the Seas (ICES), Document C.M. 1982/G:59, 14 pp.

MURIE, D. J., AND D. M. LAVIGNE. 1986. Interpretation of otoliths in stomach content

analyses of phocid seals: quantifying fish consumption. Canadian Journal of Zoology 64:1152–1157.

NEWBY, T. C. 1973. Changes in the Washington State harbor seal population, 1942–1972. The Murrelet 54:4–6.

NORTH, A. W., J. P. CROXALL AND D. W. DOIDGE. 1983. Fish prey of the Antarctic fur seal at South Georgia. British Antarctic Survey Bulletin 61:27–34.

OVERHOLTZ, W. J., AND J. R. NICOLAS. 1979. Apparent feeding by the fin whale, *Balaenoptera physalus,* and humpback whale, *Megaptera novaeangliae,* on the American sand lance. *Ammodytes americanus,* in the northwest Atlantic. Fishery Bulletin 77:285–287.

PAULBITSKI, P. 1975. The seals of Strawberry Spit. Pacific Discovery, California Academy of Sciences, San Francisco, California 28:12–15.

PAYNE, P. M., AND D. C. SCHNEIDER. 1984. Yearly changes in abundance of harbor seals, *Phoca vitulina,* at a winter haul-out site in Massachusetts. Fishery Bulletin 82:440–442.

PAYNE, P. M., J. R. NICOLAS, L. O'BRIEN AND K. D. POWERS. 1986. The distribution of the humpback whale, *Megatera novaeangliae,* on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, *Ammodytes americanus.* Fishery Bulletin 84:271–277.

PITCHER, K. W. 1980*a*. Stomach contents and feces as indicators of harbor seal, *Phoca vitulina,* foods in the Gulf of Alaska. Fishery Bulletin 78:797–798.

PITCHER, K. W. 1980*b*. Food of the harbor seal, *Phoca vitulina richardsi,* in the Gulf of Alaska. Fishery Bulletin 78:544–549.

PITCHER, K. W., AND D. C. MCALLISTER. 1981. Movements and haulout behavior of radio-tagged harbor seals *Phoca vitulina.* Canadian Field-Naturalist 95:292–297.

POWERS, K. D., AND E. H. BACKUS. 1987. Energy transfer to seabirds. Pages 372–374 *in* E. H. Backus and D. W. Bourne, eds. Georges Bank. MIT Press, Cambridge, Massachusetts.

PRIME, J. H. 1979. Observations on the digestion of some gadoid fish otoliths by a young common seal. International Council for Exploration of the Seas (ICES), Document C.M. 1979/N:14, 6 pp.

PRIME, J. H., AND P. S. HAMMOND. 1987. Quantitative assessment of grey seal diet from faecal analysis. Pages 165–188 *in* A. C. Huntley, D. P. Costa, G. A. J. Worthy and M. A. Costellini, eds. Approaches to marine mammal energetics. The Society for Marine Mammalogy Special Publication 1. Allen Press, Lawrence, Kansas.

RAE, B. B. 1968. The food of seals in Scottish waters. Department of Agriculture and Fisheries for Scotland, Marine Resources, Document No. 2:1–23.

RAE, B. B. 1973. Further observations on the food of seals. Journal of Zoology 169: 287–297.

REAY, P. J. 1970. Synopsis of the biological data on north Atlantic sand eels of the genus *Ammodytes*: *A. tobianus, A. dubius, A. americanus,* and *A. marinus.* Fisheries and Agriculture Organization (FAO) Fisheries Synopsis 82, 28 pp.

SCHNEIDER, D. C., AND P. M. PAYNE. 1983. Factors affecting haul-out of harbor seals at a site in southeastern Massachusetts. Journal of Mammalogy 64:518–520.

SELZER, L. A., G. EARLY, P. M. FIORELLI, P. M. PAYNE AND R. PRESCOTT. 1986. Stranded animals as indicators of prey utilization by harbor seals in Southern New England. Fishery Bulletin 84:217–220.

SHERMAN, K., C. JONES, L. SULLIVAN, W. SMITH, P. BERRIEN AND L. EPYMONT. 1981. Congruent shifts in sand eel abundance in western and eastern North Atlantic ecosystems. Nature 291:486–489.

SMITH, W. B., L. SULLIVAN AND P. BERRIEN. 1978. Fluctuations in production of sand lance larvae in coastal waters off the northeastern United States, 1974 to 1977. International Council for Exploration of the Seas (ICES), Document C.M. 1978/L:30, 22 pp.

SPALDING, D. J. 1964. Comparative feeding habits of the fur seal, sea lion, and harbour

seal on the British Columbia coast. Bulletin of the Fisheries Research Board of Canada 146, 55 pp.

STEWART, B. S. 1984. Diurnal hauling patterns of harbor seals at San Miguel Island, California. Journal of Wildlife Management 48:1459–1461.

STEWART, B. S., AND P. K. YOCHEM. 1984. Seasonal abundance of pinnipeds at San Nicolas Island, California, 1980–1982. Bulletin of the Southern California Academy of Sciences 83:121–132.

SULLIVAN, R. M. 1980. Seasonal occurrence and haul-out use in pinnipeds along Humboldt County, California. Journal of Mammalogy 61:754–760.

TESTA, J. W., D. B. SINNIFF, M. J. ROSS AND J. D. WINTER. 1985. Weddell Seal-Antarctic cod interactions in McMurdo Sound, Antarctic. Pages 561–565 *in* W. R. Siegfried, P. R. Condy and R. M. Laws, eds. Antarctic nutrient cycles and food webs. Springer-Verlag, Berlin.

TREACY, S. D., AND T. W. CRAWFORD. 1981. Retrieval of otoliths and statoliths from gastrointestinal contents and scats of marine mammals. Journal of Wildlife Management 45:990–993.

VAUGHAN, R. W. 1971. Aerial photography in seals research. Pages 88–98 *in* R. Goodier, ed. The application of aerial photography to the work of the Nature Conservancy. Proceedings of the Nature Conservancy Staff Seminar, Edinburgh, Scotland, 14–15 October 1970.

VENABLES, V. M., AND L. S. V. VENABLES. 1955. Observations on a breeding colony of the seal *Phoca vitulina* in Shetland. Proceedings of the Zoological Society of London 128:387–396.

WILSON, S. C. 1978. Social organization and behavior of harbor seals, *Phoca vitulina concolor,* in Maine. Marine Mammal Commission Report Number MMC-76/10, available National Technical Information Service, Springfield, Virginia, Report Number GPO-PB-280-188, 103 pp.

YOCHEM, P. K., B. S. STEWART, R. L. DELONG AND D. P. DEMASTER. 1987. Diel haul-out patterns and site fidelity of harbor seals (*Phoca vitulina richardsi*) on San Miguel Island, California, in autumn. Marine Mammal Science 3:323–332.

Received: June 17, 1988
Accepted: February 8, 1989