PITT, T. K.
1964. Fecundity of the American plaice, *Hippoglossoides platessoides* (Fabr.) from Grand Bank and Newfoundland areas. J. Fish. Res. Board Can. 21:597-612.
SIMPSON, A. C.
1951. The fecundity of the plaice. Fish. Invest. Ministr. Agric. Fish. Food (GB), Ser. II, 17(5):1-27.
STEPANENKO, M. A.
1980. Reproductive conditions and the assessment of the spawning part of the Pacific hake, California anchovy, horse-mackerel, and some other fish species in the California Current Zone in 1979. Pac. Inst. Fish. Oceangr. (TINRO), Manuscr. Rep., 29 p.
THOMSON, R. E.
1981. Oceanography of the British Columbia coast. Can. Spec. Publ. Fish. Aquat. Sci. 56, 219 p.
UTTER, F. M., AND H. O. HODGINS.
1971. Biochemical polymorphisms in the Pacific hake (*Merluccius productus*). Rapp. P.-v. Réun. Cons. int. Explor. Mer 161:87-89.
WIBORG, K. F.
1951. The whirling vessel: An apparatus for the fractioning of plankton samples. Rep. Norw. Fish. Mar. Invest. 9(13): 1-16.

J. C. MASON

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6, Canada

STRANDED ANIMALS AS INDICATORS OF PREY UTILIZATION BY HARBOR SEALS, *PHOCA VITULINA CONCOLOR*, IN SOUTHERN NEW ENGLAND

Since Federal protection began in 1972, the New England population of harbor seals, *Phoca vitulina concolor*, has more than doubled (Gilbert and Stein 1981[1]; Payne and Schneider 1984), increasing at a site in southeastern Massachusetts at an average rate of 11.9% per year (Payne and Schneider 1984). One of the primary management concerns regarding the New England seal population is the increasing potential for conflict between commercial fisheries and harbor seals (Prescott et al. 1980[2]).

Seals have been shown to be significant consumers of marine production (Brodie and Pasche 1982) and have been implicated as competitors for commercially valuable fish stocks, impacting fisheries through direct predation, gear damage, and entanglement (Boulva and McLaren 1979; Everitt and Beach 1982; Brown and Mate 1983). Despite the significant increase in harbor seal abundance, only anecdotal information exists on the diet of harbor seals along the eastern United States. To assess the impact of this common predator on fish and squid, information is required on the food species exploited.

In the past, seals were killed to facilitate quantitative analysis of their stomach contents (Imler and Sarber 1947; Spalding 1964; Boulva and McLaren 1979; Pitcher 1980a), although this procedure is impractical in New England. Two alternatives to this method are the analysis of the stomachs of stranded animals, and the examination of seal feces collected on accessible haul-out sites (Pitcher 1980b; Treacy and Crawford 1981; Brown and Mate 1983).

The first alternative for determining the food habits of the southern New England seal population was provided by the more than 500 harbor seals that have been found stranded south of Maine since 1977. The stranded seals were collected by the New England Aquarium (NEA), Boston, MA. The majority (59%) of the seals were collected between January and March (Table 1) along the perimeter of Cape Cod Bay, MA, primarily on the eastern side. This corresponds to the time when the peak number of seals occur south of Maine (Schneider and Payne 1983). Most of the stranded seals (65%) came from one year, 1980 (Table 1), when over 445 seals died of acute pneumonia associated with influenza virus (Geraci et al. 1982).

Upon necropsy at the NEA, most of the stomachs and intestinal tracts of the stranded seals were found to be empty. Only 63 stomachs contained food matter, and the contents from those were frozen for later

TABLE 1.—Monthly distribution of stranded *P. v. concolor* containing prey items examined 1977-83.

Month	1977	1978	1979	1980	1981	1982	1983	Total
Jan.	1			15			1	17
Feb.				7	2		1	10
Mar.				10				10
Apr.				1				1
May			1	1	1	2	1	6
June		1				2	1	4
July						1		1
Aug.				2		1	1	4
Sept.				3		2		5
Oct.				1				1
Nov.				1				1
Dec.			2			1		3
Totals	1	1	3	41	3	9	5	63

[1]Gilbert, J. R., and J. L. Stein. 1981. Harbor seal populations and marine mammal fisheries interactions. National Marine Fisheries Service, NOAA, Northeast Fisheries Center, Contract No. NA-80-FA-C-00029, Woods Hole, MA 02345, 55 p.

[2]Prescott, J. H., S. D. Kraus, and J. R. Gilbert. 1980. East Coast/Gulf Coast Cetacean and Pinniped Workshop. Marine Mammal Commission (MMC), Final Report, Contract 79/02. (Available National Technical Information Service, Springfield, VA 22151 as PB80-160104, 142 p.)

examination. In the fall of 1983, we pilot-tested the analysis of stomach contents from stranded seals using those 63 stomach samples as an indicator of prey utilization. The objectives of this study were 1) to identify prey items selected by seals in southern New England and 2) to determine whether stomach contents from stranded animals can provide accurate information on the utilization of most kinds of prey.

Methods

The stomachs were thawed and the contents washed with water through a series of nested sieves (1.80, 1.00, and 0.50 mm^2). Identifiable materials were rough-sorted into fish and fish components, invertebrates and invertebrate components. Intact specimens and cephalopod beaks were preserved in a 70% ethanol-30% glycerin solution. Persistent prey hard parts (primarily otoliths) were removed and stored dry in glass vials.

Otoliths from the stomach samples were identified against a reference collection at the National Marine Fisheries Service, Northeast Fisheries Center (NMFS/NEFC), Woods Hole, MA. Cephalopod beaks were identified against a reference key (Clarke 1962).

To estimate the size of fish taken by harbor seals, otoliths removed from the stomach samples were measured under a dissecting microscope using vernier calipers. Regression equations relating otolith length to fish length (Frost and Lowry 1980; Brown and Mate 1983) were calculated using measurements obtained from the reference collection of fishes collected in the Gulf of Maine, located at the NMFS/NEFC. Fork lengths were estimated for four prey species.

Results

Fifty-three stomachs (84%) held identifiable food items (Table 2). Cephalopod beaks were recovered from 35 stomachs, representing at least 168 individuals and 2 species. Thirty-three stomachs contained beaks from the short-finned squid, *Illex illecebrossus*, with a range of 1-22 beaks per stomach. Beaks of the long-finned squid, *Loligo pealei*, were found in two stomachs, ranging from 4 to 5 beaks per stomach, and accounted for only 5% of the squid recovered. The two species were not found together in any of the stomachs. Twenty-nine stomachs contained squid remains and no other type of prey. Six stomachs contained both squid and fish remains.

Seventeen stomachs contained some fish remains, including intact specimens, copious semidigested flesh, and 121 free otoliths. In total, seven species and five families were represented. Fourteen stomachs held otoliths from only one species of fish, while seven stomachs contained otoliths from more than one fish species.

Four species of Gadidae comprised the majority of all fish species found in the stomachs of the stranded seals. A total of 86 otoliths in six stomachs were recovered. Haddock, *Melanogrammus aeglefinus*, was the most frequently found gadid (45 otoliths in four stomachs) with a maximum of 24 otoliths recovered from a single stomach. Silver hake, *Merluccius bilinearis*, remains were found only slightly less frequently (34 otoliths from three stomachs). Pollock, *Pollachius virens*, otoliths were found in one stomach (five otoliths), and two red hake, *Urophycis chuss*, otoliths of equal length were recovered from one stomach, presumably from a single fish.

Fifteen free otoliths and three intact specimens of American sand lance, *Ammodytes americanus*, were recovered from two stomachs, and three stomachs contained otoliths from members of the flatfish family Pleuronectidae.

Two stomachs contained shells: the Atlantic mussel, *Mytilus edulis*, and the common slipper shell, *Crepidula fornicata*.

The estimated mean fork length for the four gadid prey species ranged from 170 to 340 mm (Table 3). Regressions were not available to estimate the lengths of the sand lance found in the stomachs; however, studies on sand lance in Cape Cod Bay found a mean size of 93 mm SL (Richards 1982).

TABLE 2.—Analysis of stomach contents from stranded harbor seals, *P. v. concolor*, in Southern New England, 1977-83.

Species	Stomach (*N* = 63) Frequency *N*	%	Min. no. animals
Cephalopoda:			
Illex illecebrossus	33	58.4	159
Loligo pealei	2	3.7	9
Mytilidae:			
Mytilus edulis	2	3.7	12
Calyptraeidae:			
Crepidula fornicata	2	3.7	10
Clupeidae:			
Clupea harengus	1	1.8	1
Gadidae:			
Melanogrammus aeglefinus	4	5.6	23
Pollachius virens	1	1.8	3
Urophycis chuss	1	1.8	1
Merlucciidae:			
Merluccius bilinearis	3	5.6	17
Ammodytidae:			
Ammodytes americanus	2	3.7	11
Pleuronectidae:			
Pseudopleuronectes americanus	3	5.6	10
Unidentified pisces	11	20.8	

TABLE 3.—Estimated sizes of four fish prey species of harbor seals in Southern New England, based on regression equations relating otolith length (OL) to fish fork length (FL).

Species	Regression equation	r^2	n	Estimated prey size (FL, mm) Range	Mean
Melanogrammus aeglefinus	FL = 3.4(OL) − 9.32	0.97	45	110-310	230
Merluccius bilinearis	FL = 22.4(OL) − 1.44	0.98	34	30-460	170
Pollachius virens	FL = 4.9(OL) − 22.58	0.95	5	160-310	280
Urophycis chuss	FL = 25.0(OL) + 0.63	0.96	2		340

Discussion

Analyzing stomach contents from stranded animals to determine prey preference or selection does yield a partial list of prey species exploited; however, several apparent biases prohibit the realization of accurate quantitative results. Therefore, the utility of this method is questionable.

The limited number of stomachs containing food was likely due to the weakened condition of seals prior to stranding and their inability to obtain food. The stomachs that did contain food all came from stranded animals, and therefore may not reflect on what a healthy seal was feeding. The stranded seals were generally animals with debilitating conditions like lungworm and heartworm, and may not have been able to feed in usual feeding areas, or secure usual prey, and thus were probably less selective about prey items.

For example, the shells found in the two stomachs may represent prey items desirable only to a disease-weakened seal. The size and number of these shells suggest that they were not ingested incidentally. Comparing the stomach contents to a "condition index", such as length vs. girth or blubber thickness, might indicate whether the stranded animals are less selective about prey species than healthy ones.

The abundance of squid beaks found in the stomachs suggests that squid are an important part of the diet of harbor seals along coastal New England; however, our own finding of squid beaks in 56% of 63 stomachs may be inflated. Boulva and McLaren (1979) found squid remains in 20.6% of 279 stomachs examined from eastern Canada, and Pitcher (1980b) similarly found cephalopod beaks in 21.1% of 351 harbar seals collected in the Gulf of Alaska. Seals have been shown to retain, then regurgitate, cephalopod beaks rather than pass them through their digestive tract (Miller 1978[3]; Pitcher 1980b). Retention of squid beaks will tend to overrepresent the utilization of squid as a prey species (Pitcher 1980a). The retention of beaks during a period of fasting prior to death may also account for the large percentage (41%) of stomachs containing squid beaks and no other type of prey remains.

Large fish may be underrepresented if the heads (i.e., otoliths) are not eaten (Boulva and McLaren 1979; Brown and Mate 1983). Pitcher (1980b) suggested that seals often fragment large fish while eating them, usually discarding the head.

Finally, the relationship between the time when prey was eaten and when the stomach was collected may determine what types of prey remains will be recovered (Frost and Lowry 1980; Pitcher 1980a; Brown and Mate 1983). For example, the low number of sand lance otoliths found in the stomachs may not accurately represent the importance of sand lance as a prey species of harbor seals in southern New England because otoliths of the size of the ones recovered are very small and delicate and may not remain for long in the seal stomachs once freed from the skull (Smith and Gaskin 1974).

Thus, using only frequency of occurrence as a measure of prey preference or selection may be misleading by overemphasizing the importance of some species. For example, based on number, cephalopods were the major prey item; however *fewer* otoliths representing fish of *greater* weight may show that fish indeed are more improtant. The full importance of fish or squid in the diet of seals can be accurately described only if quantitative assessments such as weight or volume of food items in the stomachs can be determined (Rae 1973; Frost and Lowry 1980).

In summary, given a large sample of animals the analysis of stomach contents from stranded seals does provide information on the types of prey selected. However, the analysis of stomach contents from stranded seals greatly overemphasizes cephalopod remains while likely underrepresenting most

[3]Miller, L. K. 1978. Energetics of the northern fur seal in relation to climate and food resources of the Bering Sea. Marine Mammal Commission, Final Report, Contract MM5AC025. (Available National Technical Information Service, Springfield, VA 22151 as PB-275 296, 32 p.)

species of fish prey due to an extended period of fasting prior to stranding. We consider comparative frequencies of selected prey to be too biased to be useful in any ranking of prey items. Therefore, this technique of analyzing prey utilization should be considered only if the examination of feces or the stomach contents from seals that were healthy when collected are not possible options.

Acknowledgments

We wish to thank all those from the New England Aquarium, Marine Mammal Rescue and Release Program, who helped collect the stranded animals. Paul J. Boyle and Kevin D. Powers commented on previous drafts of this manuscript. Research was conducted with the New England Aquarium's Edgerton Research Laboratory. This study was funded by National Marine Fisheries Service/Northeast Fisheries Center, Contract No. NA-82-FA-00007.

Literature Cited

BOULVA, J., AND I. A. MCLAREN.
1979. Biology of the harbor seal, *Phoca vitulina*, in Eastern Canada. Fish. Res. Board Can., Bull. 200:1-24.

BRODIE, P. F., AND A. J. PASCHE.
1982. Density-dependent condition and energetics of marine mammal populations in multispecies fisheries management. *In* M. C. Mercer (editor), Multispecies approaches to fisheries management advice, p. 35-38. Can. Spec. Publ. Fish. Aquat. Sci. 59.

BROWN, R. F., AND B. R. MATE.
1983. Abundance, movements, and feeding habits of harbor seals, *Phoca vitulina*, at Netarts and Tillamook Bays, Oregon. Fish. Bull., U.S. 81:291-301.

CLARKE, M. R.
1962. The identification of cephalopod "beaks" and the relationship between beak size and total body weight. Bull. Br. Mus. (Nat. Hist.), Zool. 8:421-480.

EVERITT, R. D., AND R. J. BEACH.
1982. Marine mammal-fisheries interactions in Oregon and Washington: An overview. *In* K. Sabol (editor), Transactions of the North American Wildlife and Natural Research Conference, p. 265-277. Wildl. Manage. Inst., Wash., DC.

FROST, K. J., AND L. F. LOWRY.
1980. Feeding of ribbon seals (*Phoca fasciata*) in the Bering Sea in Spring. Can. J. Zool. 58:1601-1607.

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.
1982. Mass mortality of harbor seals: pneumonia associated with influenza A virus. Science 215:1129-1131.

IMLER, R. H., AND H. R. SARBER.
1947. Harbor seals and sea lions in Alaska. U.S. Fish. Wildl. Serv., Spec. Sci. Rep. 28, 23 p.

PAYNE, P. M., AND D. C. SCHNEIDER.
1984. Yearly changes in abundance of harbor seals at a winter haul-out site in Massachusetts. Fish. Bull., U.S. 82:440-442.

PITCHER, K. W.
1980a. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fish. Bull., U.S. 78:544-549.
1980b. Stomach contents and feces as indicators of harbor seal, *Phoca vitulina*, foods in the Gulf of Alaska. Fish. Bull., U.S. 78:797-798.

RAE, B. B.
1973. Further observations on the food of seals. J. Zool. (Lond.) 169:287-297.

RICHARDS, S. W.
1982. Aspects of the biology of *Ammodytes americanus* from the St. Lawrence River to Chesapeake Bay, 1972-75, including a comparison of the Long Island Sound postlarvae with *Ammodytes dubius*. J. Northwest Atl. Fish. Sci. 3:93-104.

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

SMITH, G. J. D., AND D. E. GASKIN.
1974. The diet of harbor porpoises (*Phocoena phocoena* (L.)) in coastal waters of eastern Canada, with special reference to the Bay of Fundy. Can. J. Zool. 52:777-782.

SPALDING, D. J.
1964. Comparative feeding habits of the fur seal, sea lion, and harbour seal on the British Columbia coast. Fish. Res. Board Can., Bull. 146, 52 p.

TREACY, S. D., AND T. W. CRAWFORD.
1981. Retrieval of otoliths and statoliths from gastrointestinal contents and scats of marine mammals. J. Wildl. Manage. 45:990-993.

LAWRENCE A. SELZER

Manomet Bird Observatory, Manomet, MA 02345

GREG EARLY
PATRICIA M. FIORELLI

New England Aquarium, Boston, MA 02110

P. MICHAEL PAYNE

Manomet Bird Observatory, Manomet, MA 02345
Present address:
Boston University Marine Program, Woods Hole, MA 02345.

ROBERT PRESCOTT

Massachusetts Audubon Society,
South Wellfleet, MA 02663

SCAVENGER FEEDING BY SUBADULT STRIPED BASS, *MORONE SAXATILIS*, BELOW A LOW-HEAD HYDROELECTRIC DAM[1]

A spawning run of striped bass, *Morone saxatilis*, has not been found in the Connecticut River, but subadults from other rivers were reported in the lower 100 km of the river in the 1930's (Merriman

[1]Contribution No. 84 of the Massachusetts Cooperative Fishery Research Unit, which is supported by the U.S. Fish and Wildlife Service, Massachusetts Division of Fisheries and Wildlife, Massachusetts Division of Marine Fisheries, and the University of Massachusetts.