

tuary, Maine, as determined by daily growth increments in otoliths. Fish. Bull., U.S. 79:123-130.

UCHIYAMA, J. H., AND P. STRUHSAKER.

1981. Age and growth of skipjack tuna, *Katsuwonus pelamis*, and yellowfin tuna, *Thunnus albacares*, as indicated by daily growth increments of sagittae. Fish. Bull., U.S. 79:151-162.

WILD, A., AND T. J. FOREMAN.

1980. The relationship between otolith increments and time for yellowfin and skipjack tuna marked with tetracycline. [In: Engl. and Span.] Inter-Am. Trop. Tuna Comm. Bull. 17:509-560.

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#### YEARLY CHANGES IN ABUNDANCE OF HARBOR SEALS, *PHOCA VITULINA*, AT A WINTER HAUL-OUT SITE IN MASSACHUSETTS

Information on the abundance of the harbor seal, *Phoca vitulina concolor*, population in New England consists of outdated estimates in the literature (King 1964; Maxwell 1967; Hewer 1974; Bonner 1976). A more recent series of unpublished reports (Richardson<sup>1</sup>; Knapp and Winn<sup>2</sup>; Kraus<sup>3</sup>; Gilbert and Stein<sup>4</sup>) suggests a harbor seal population which is increasing in numbers from its present breeding range north of Massachusetts southward into southern New England. A primary research need identified by Prescott et al.<sup>5</sup> was confirmation of this suspected increase in the harbor seal population throughout New England.

<sup>1</sup>Richardson, D. T. 1973. Distribution and abundance of harbor and gray seals in Acadia National Park. Final report to National Park Service and Maine Department of Sea and Shore Fisheries, State of Maine Contract No. MM4AC009, 59 p.

<sup>2</sup>Knapp, C. L., and H. E. Winn. 1978. Harbor seals, New Hampshire to Long Island. Unpubl. rep., University of Rhode Island, Graduate School of Oceanography, Kingston, RI 02881, 36 p.

<sup>3</sup>Kraus, S. 1980. The population of harbor seals (*Phoca vitulina*) in southern New England. Unpubl. rep. of harbor seal workshop, 5 March 1980, Boston, Mass. New England Aquarium, Boston, MA 02109, 9 p.

<sup>4</sup>Gilbert, J. R., and J. L. Stein. 1981. Harbor seal populations and marine mammal fisheries interactions. University of Maine, Department of Forestry and Wildlife Resources, Orono, Maine. Annual Report to NEFC/NMFS/NOAA, Contract No. NA-80-FA-C-00029, 55 p.

<sup>5</sup>Prescott, J. H., S. D. Kraus, and J. R. Gilbert. 1980. East Coast/Gulf Coast cetacean and pinniped workshop. Final Report for Marine Mammal Commission, contract 79/02. Available National Technical Information Service, Springfield, VA 22151 as PB80-160104, 142 p.

This study summarizes available data on annual fluctuations in seal numbers since 1972 at one site in southeastern Massachusetts.

The study was conducted at Stage Point, Manomet, Mass. (lat. 41°55'N, long. 70°32'W). Harbor seals occur seasonally at Stage Point from late October through May (Schneider and Payne 1983). A rapid decrease in numbers occurs at this site in May (Schneider and Payne 1983), prior to the pupping season which occurs mid-May to mid-June in Maine (Richardson footnote 1; Wilson<sup>6</sup>). A few seals are reported throughout the summer but most move northward out of the study area by June.

The study site consists of a shoreline with a sandy cliff to 25 m. Sand, rock, and cobble extend from the base of the cliff into the water. Seals haul out exclusively on the larger rocks in the immediate subtidal zone from about 1-2 h before to 1-2 h after low tide (Schneider and Payne 1983). A similar haul-out pattern has been described at other rock-ledge sites in New England (Richardson footnote 1; Wilson footnote 6). Because of the synchronized haul out observed at Stage Point, the number of seals seen on the rocks is considered representative of the number of seals in the immediate vicinity (Schneider and Payne 1983) and, therefore, a useful index for monitoring changes in the abundance of harbor seals at this location.

#### Methods

Counts at Stage Point were made by direct observation within 2 h of low tide from the cliffs above the haul-out site. Schneider and Payne (1983) found that during 1979-80 the average number of seals observed at Stage Point peaked in January; therefore, the average number of seals ( $\pm$ SE) seen per daily count in January of each year was used in analyses among years. We transformed the January averages into logarithmic values, and the coefficient of correlation ( $r$ ) from the linear regression was used to describe the relationship between the average number of seals seen per daily count in January 1972 and 1983.

In addition, air temperature, wave intensity, and human disturbance influence the total number of seals seen per daily count at Stage Point

<sup>6</sup>Wilson, S. C. 1978. Social organization and behavior of harbor seals *Phoca vitulina concolor* in Maine. Final Report to Marine Mammal Commission, Contract No. GPO PB 280-3188. Available National Technical Information Service, Springfield, VA 22151 as PB 280 188, 103 p.

(Schneider and Payne 1983). Prior to the winter of 1979-80, a record of environmental conditions at the time of the count was not maintained. Since it is not known to what extent weather or human disturbance near the haul-out site had on zero or near-zero counts previous to 1979-80, all daily counts in January with less than five seals were considered unreliable and excluded from the analyses. There were no available data for January 1973 or January 1977.

### Results and Discussion

The average number of seals observed per daily count in January (Table 1) ranged from 9.3 seals (1974) to 88.25 seals (1980) with considerable variability among years. However, the observed number of seals was not randomly distributed among years; the January averages increased significantly ( $P < 0.05$ ,  $r = 0.63$ ,  $df = 9$ ) between 1972 and 1983 (Fig. 1).

The average annual rate of increase since 1972 at Stage Point (based on expected values from the semilogarithmic regression, Table 1) was 11.9%/yr. The expected average number of seals per daily count in January at Stage Point (Table 1) doubled between 1973 and 1980.

The observed increase in the average number of seals at Stage Point has followed the termination in 1962 of a Massachusetts bounty on harbor seals and passage in 1972 of the Marine Mammal Protection Act. Rapid expansion of seal populations after the passage of protective legislation has been observed in the past (Hewer 1974; Bonner 1975; Everitt and Beach 1982) and has likely facilitated the increase since 1972 of the number of seals seen at Stage Point.

TABLE 1.—January averages of seals observed per daily count, 1972-83, at Stage Point, Manomet, Mass. n.d. = no data.

Year	No. daily counts	$\bar{x}$ no. ( $\pm$ SE) seals/daily count	Expected $\bar{x}$ no. seals/daily count <sup>1</sup>
1972	2	12.5 (6.52)	12.86
1973	n.d.		14.39
1974	3	9.3 (1.85)	16.11
1975	15	18.8 (2.32)	18.02
1976	2	34.0 (4.00)	20.17
1977	n.d.		22.58
1978	9	20.0 (3.07)	25.28
1979	9	35.56(7.00)	28.29
1980	28	88.25(6.06)	31.66
1981	18	21.67(6.92)	35.43
1982	18	21.88(2.94)	39.66
1983	19	48.00(5.63)	44.39

<sup>1</sup>From the linear regression:  $y = 11.4898 e^{(0.11263)x}$ ,  $r = 0.628$ ,  $P < 0.05$  (Fig. 1).

An increase in seal populations (after protection) due to unrestricted dispersion of juvenile seals has also been noted elsewhere (Bonner and Witthames 1974; Reijnders 1983). Bonner and Witthames (1974) suggested that the population of common seals, *P. v. vitulina*, located at the Wash in England, acted as a reservoir from which other reduced populations were replenished. Existence of a seal population in the Dutch Wadden Sea depends on unrestricted dispersal of juvenile seals from adjacent rookeries (Reijnders 1983). Since no rookeries occur south of Maine, it is apparent that the population increase seen at Stage Point (and throughout southern New England) has occurred through the southward dispersion of seals from Maine rookeries, after protection was established in Massachusetts.

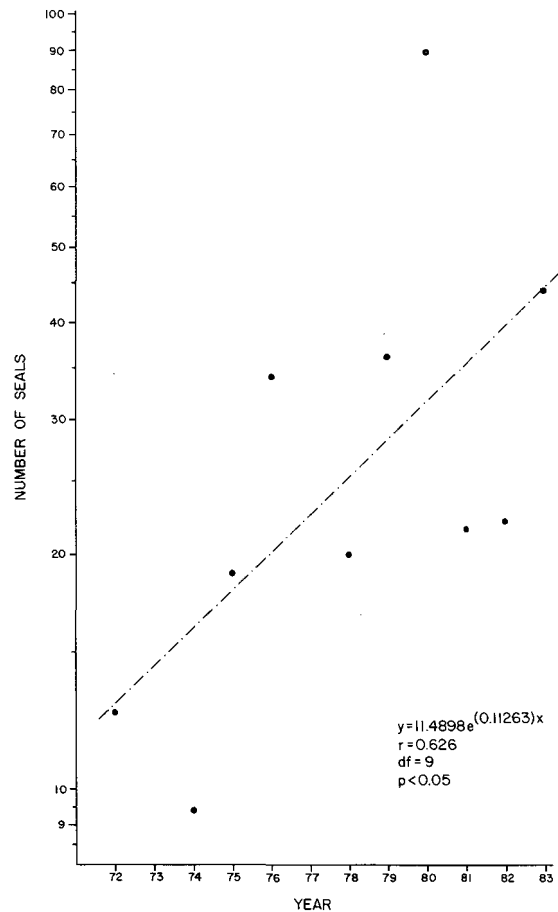


FIGURE 1.—Semilogarithmic plot of the average number of seals observed per daily count in January at Stage Point, Manomet, Mass., 1972-83.

Several investigators have reported an increase in seal numbers elsewhere in New England over the past decade. Gilbert and Stein (footnote 4) reported a total of 10,483 seals counted in June 1981 between Isles of Shoals on the Maine-New Hampshire border and the Canadian border. This nearly doubled the 1973 census of 5,786 seals reported for the same area by Richardson (footnote 1). Our data at Stage Point confirm this increase in southern New England.

The possibility does exist that the increase observed at Stage Point is merely the result of more thorough survey coverage in recent years; however, coastal bird observations were made regularly at Stage Point before 1973-74 by staff at the Manomet Bird Observatory. Any large number of seals would have been noticed during such counts.

The present harbor seal distribution, abundance, and breeding status in Massachusetts have changed considerably from the past. Allen (1869) reported "hundreds" of seals during the summer in Boston Harbor. As late as the 1930's and 1940's, harbor seals were permanent residents on Cape Cod (Prescott 1981) and pupping occurred throughout Massachusetts. Katona et al. (1983) suggested that the retention of the bounty until 1962 led to the extirpation of breeding activity in Massachusetts. The continued protection of an increasing harbor seal population throughout New England may result in expansion of the present breeding range southward into areas formerly used for pupping.

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#### Literature Cited

- ALLEN, J. A.  
1869. Catalog of the animals of Massachusetts with a critical revision of the species. Bull. Mus. Comp. Zool. No. 1, p. 143-252.
- BONNER, W. N.  
1975. Population increase of grey seals at the Farne Islands. Rapp. P.-V. Réun. Cons. Int. Explor. Mer 169:366-370.  
1976. The stocks of grey seals (*Halichoerus grypus*) and common seals (*Phoca vitulina*) in Great Britain. Nat. Environ. Res. Counc. Publ. Ser. C, No. 16, 16 p.
- BONNER, W. N., AND S. R. WITTHAMES.  
1974. Dispersal of common seals (*Phoca vitulina*), tagged in the Wash, East Anglia. J. Zool., Lond. 174:528-531.
- 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 American Wildlife and Natural Resource Conference, p. 265-277. Wildlife Management Institute, Wash., D.C.
- HEWER, H. R.  
1974. British Seals. William Collins, Press, Lond., 256 p.
- 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. 3d ed. Scribner's Sons, N.Y., 255 p.
- KING, J. E.  
1964. Seals of the world. Trustees of the British Museum, Lond., 153 p.
- MAXWELL, G.  
1967. Seals of the world. Constable and Co. Press, Lond., 151 p.
- PRESCOTT, R.  
1982. Harbor seals, mysterious lords of the winter beach. Cape Cod Life 3(4):24-29.
- REIJNDERS, P. J. H.  
1983. The effect of seal hunting in Germany on the further existence of a harbour seal population in the Dutch Wadden Sea. Z. Saeugetierkd. 48:50-54.
- SCHNEIDER, D. S., AND P. M. PAYNE.  
1983. Factors affecting haul-out of harbor seals at a site in southeastern Massachusetts. J. Mammal. 64:518-520.

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