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A SMALL POPULATION OF GREY SEALS AT NANTUCKET, MASSACHUSETTS

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ABSTRACT

A population of grey seals (*Halichoerus grypus*) near Nantucket, Massachusetts, was reduced by bounty hunting from 40-50 in the 1940's to about 20 individuals by 1960. Termination of the bounty in 1962 and enactment of protective legislation in 1965 were followed by further apparent decline to fewer than 10 in the late 1970's. 19 were counted in 1980, but only about 6 in 1981 for reasons which remain unclear. The quality of the traditional pupping site deteriorated after 1970, possibly contributing to a dearth of pups seen in the 1970's, but at least two were born in the study area since 1979. About 25% of the present Nantucket population may have originated at Sable Island, Nova Scotia based on sightings of branded and tagged seals. The future of the Nantucket population is uncertain, and continued monitoring is recommended.

INTRODUCTION

Canada's grey seal (*Halichoerus grypus*) stock has southern outposts in New England waters, where the species is poorly understood and considered rare. Nantucket, Massachusetts, is the grey seals' only known breeding site in the United States.

This report, based on records and sightings of grey seals at Nantucket and vicinity, attempts to clarify the status of the population. Data are pooled, analysed and interpreted in the context of environment, species biology, and population trends in the Canadian source area.

The grey is a large, sexually dimorphic seal of temperate to subarctic waters of North Atlantic coasts and the northern part of the Baltic Sea (Figure 1). Three stocks, separated geographically and by differences in reproductive behavior, are recognized:

A. Western North Atlantic, breeds in January and February, population in 1977 30,000 and increasing (Mansfield and Beck 1977). This stock, which includes the Nantucket group, is centered in the Gulf of St. Lawrence, with large colonies in the Gulf at Northumberland Strait and the Magdalen Islands, and, outside the Gulf, at the Basque Islands and Sable Island (Figure 2). Probably fewer than 300 occupy the Gulf of Maine, with breeding known only near Grand Manan Island in Canadian waters.

B. Eastern North Atlantic, breeds in autumn, population in 1977 72,000 and generally increasing (Gilbert et al. N.D.). This stock ranges from Iceland to the White Sea in the north, and south along the coasts of Norway and the British Isles to Brittany.

C. Baltic, breeds in February and March, population 2,000 and declining (Gilbert et al. N.D., Helle et al. 1976b).

In historic times grey seals were known at Nantucket since at least the late 19th century, and in the first part of the 20th century the population may have been 40 to 50. A period of bounty killing in the 1940's and 1950's evidently contributed to its reduction to 20 or fewer individuals by 1962, when the bounty was removed (Andrews and Mott 1967). In 1965 Massachusetts passed legislation giving complete protection to grey seals in the Commonwealth. The Marine Mammal Protection Act of 1972 mandates conservation and protection of all marine mammals in United States waters. Whereas the Act authorizes research on species ecology and population dynamics, the present report is intended as a data base and reference for the grey seal in southern New England.

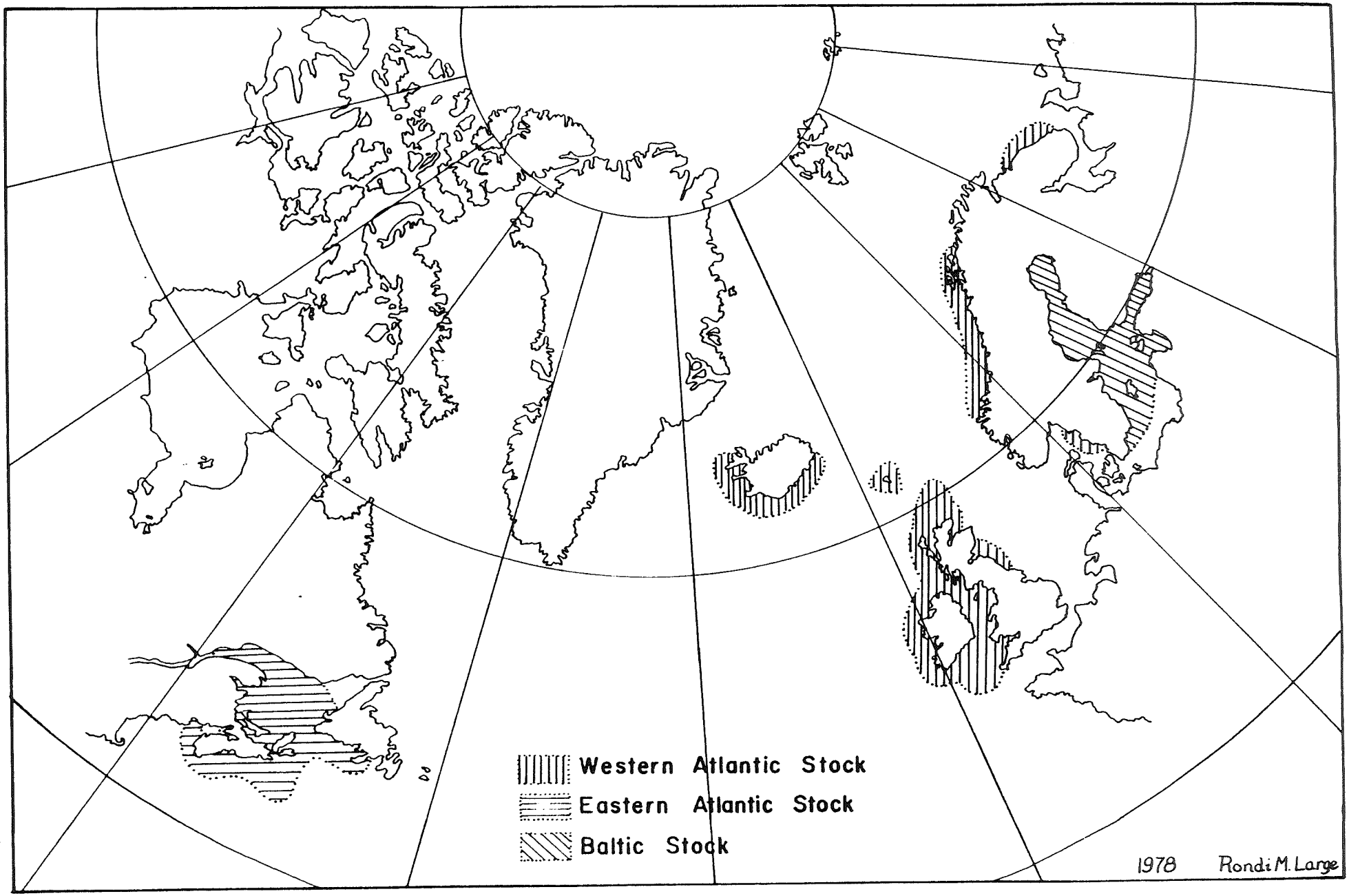


Figure 1. World distribution of grey seals.

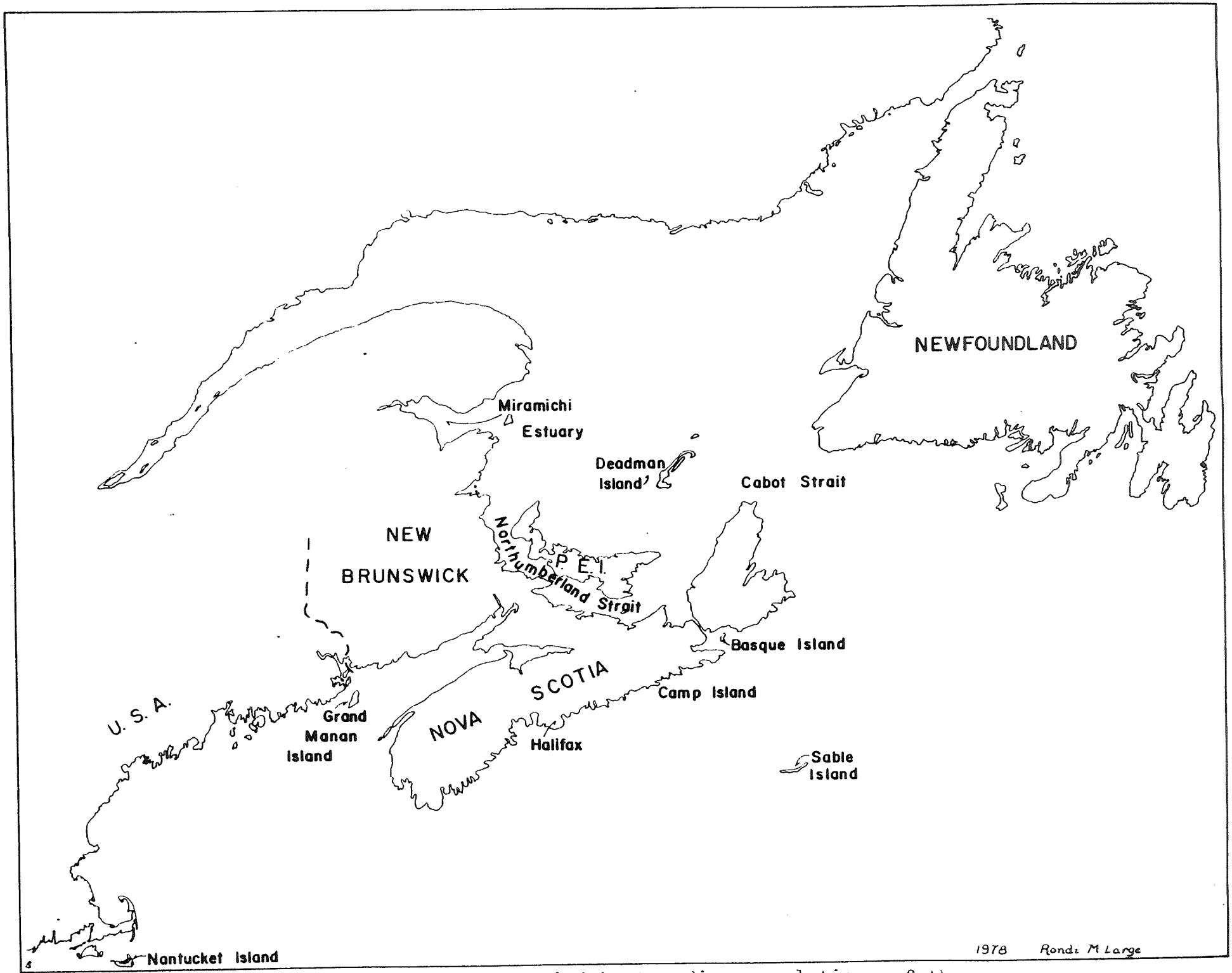


Figure 2. Areas occupied by breeding populations of the

STUDY AREA

The study area (Figure 3) encompasses Buzzards Bay and Nantucket Sound, including the Elizabeth Islands, Martha's Vineyard, No Man's Land, Nantucket, Muskeget, Tuckernuck and Esther Island. The majority of grey seal sightings occur at Nantucket and its associated islands. This apparently preferred habitat is described best by Andrews and Mott, 1967.

"Gray seals inhabit an area 7 miles long by about 3 miles wide, surrounding the islands of Muskeget and Tuckernuck, and extending a short distance east along both the north and south shores of Nantucket. The water is 3 to 5 ft. deep with a sandy bottom, partially covered with eelgrass, Zostera marina. The deeper parts are 8 to 12 ft. deep, and a few shifting sand shoals reach from the level of half tide to that of neap tide. Daily range of tide may be about 3½ ft. On the southwest side, sandbars with heavy breakers separate the area from the Atlantic Ocean. On the northeast, some shoals and flats partially break the waves of northeast storms. Southwest Point, Muskeget, where seals are found most consistently, is a low, sandy spit 300 to 400 yards long, extending southeast (now easterly) from the west end of the island. This, together with about 1½ miles of Smith's Point, is the only remnant of a barrier beach which once protected the area from the ocean. At the present time the shoals and points, with the exception of Smith's, are washed down and flattened to the greatest extent in memory, severely limiting the haul-out areas available.

"In seasons when much ice is formed, it grounds on the shoals while tidal currents keep the channels open. The area may be inaccessible to boats for as long as a month, making other shoals, if not some of the ice itself, available for safe breeding places." (Andrews and Mott 1967).

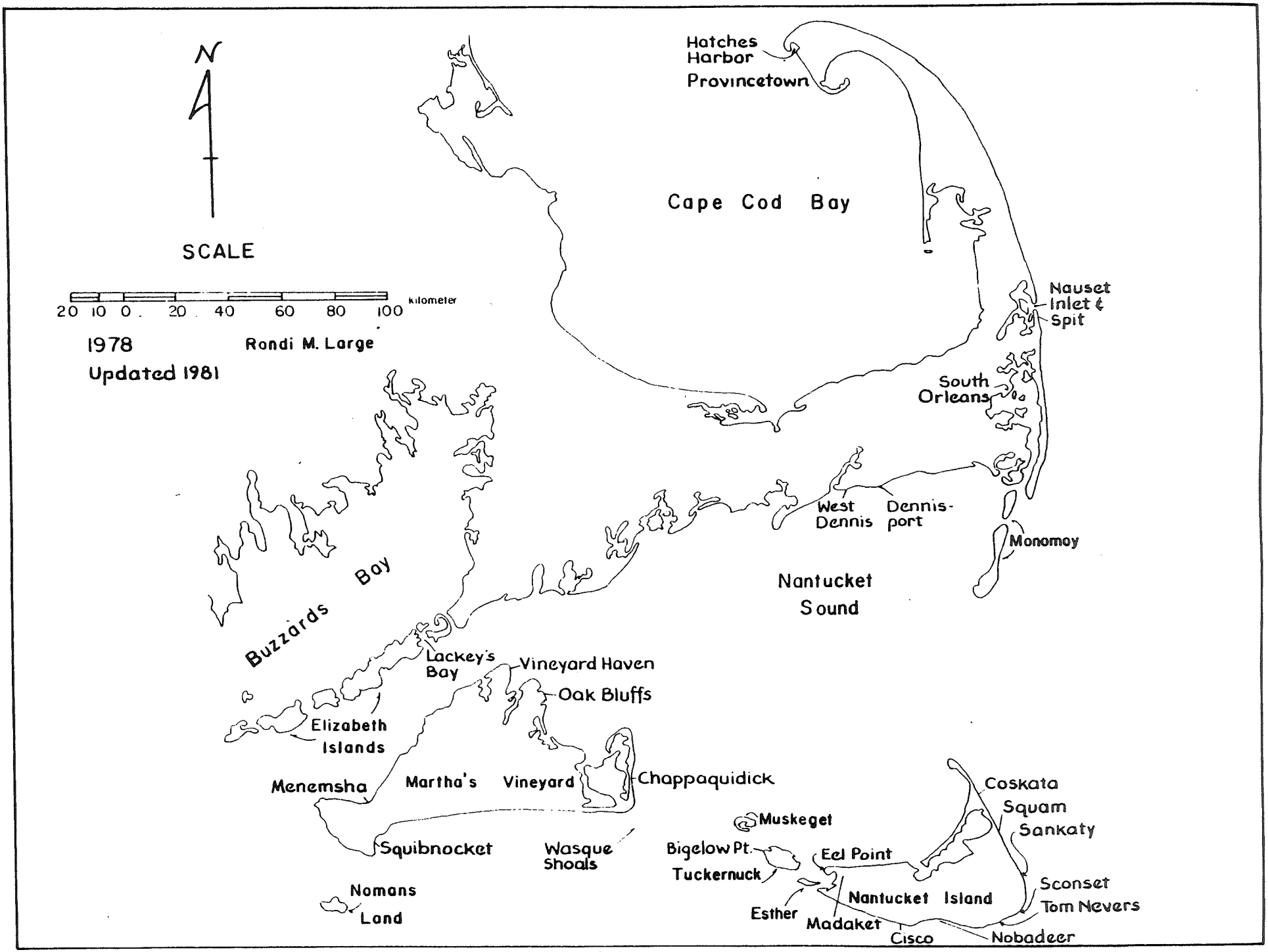


Figure 3. The coastal area of southern Massachusetts, showing place nam[illegible]

METHODS

The data on Nantucket's grey seals were acquired by aerial, ground and boat censuses, mostly in the last 25 years. Sightings were opportunistic; the seals' presence and exact location varied unpredictably from year to year as well as within survey seasons. Most sightings took place in fall, winter and early spring, for reasons discussed in a later section. Coverage in some of the years since directed research began was incomplete due to inadequate funds, or to inclement weather. Still, approximately 185 sightings were logged by various observers, and these sightings, along with published accounts, are the basis of the report.

OBJECTIVES

Topics to be considered from a historical and current perspective include:

a. Numbers of seals present.
b. Pupping and other recruitment.
c. Mortality factors.
d. Composition of the herd.
e. Mating behavior.
f. Identification and resighting of naturally or artificially marked individuals.
g. Movements; habitat use and seasonal patterns.
h. Food.
i. Habitat status and changes.
j. Climatic factors.
k. Presence and possible impact of harbor seals (Phoca vitulina concolor).
l. Human presence and impact.

FOSSIL AND ARCHEOLOGICAL EVIDENCE

Ray et al. (1968) report grey seal bones dating to about 40,000 years B.P. at Norfolk, Virginia.

The notes of Glover Allen (Museum of Comparative Zoology, Harvard University) refer to records of grey seal remains in New England shellheaps. The southern New England archeological finds include bones and teeth from Eastham (Dr. Johnson, 1936, Peabody Museum), Squam, Nantucket (Edward Brooks, 1947, J. Mass. Archaeol. Soc., 10: 7-13), Mott site, Block Is. (G.F. Eaton, 1898, Am. J. Sci., 6: 137-159), and the west end of Martha's Vineyard (Douglas Byers, 1940). The latter two sites also contained harbor seal material. No associated radiocarbon dates are available for these remains. (Cited in Andrews and Mott 1967).

Several grey seal teeth were found in excavations at the Hayward's Portanimicutt Site, South Orleans, Mass. (Eteson,1982, in press). No associated radiocarbon dates are available.

W.A. Ritchie (1969) found grey and harbor seal remains at several Martha's Vineyard middens. The sites were occupied by Indians primarily in fall, winter and spring. Dated strata range from about 4170 B.P. to about 600 B.P. The material was analysed to determine minimum numbers of individual seals (Table 1). Waters' (1967) evaluation of grey and harbor seal bones from Ritchie's sites concludes "precise age assignments impossible, and none assignable to other than adult age category."

Archeological evidence of grey seals in northern New England is reported in Gilbert et al. (N.D.).

TABLE 1

Approximate date B.P. of associated material	Individual grey seals	Individual harbor seals	Site
4170	5		Hornblower II
4170	4	1	Vincent
4050	1		Hornblower II
4050	1		Peterson
1580	2	1	Cunningham
830		1	"
680		1	"
600	2	1	Hornblower II
380		1	Howland I

Hornblower II and Peterson sites are at the north shore of Squibnocket Pond; Cunningham and Vincent sites are near Vineyard Haven; Howland is at the east shore of Menemsha Pond.

Evidence of seals from archeological sites at Martha's Vineyard (after Ritchie 1969).

RECENT EVIDENCE

J.A. Allen, in his 1880 monograph on North American pinnipeds, states that grey seals do not occur south of Sable Island. However in the section on hooded seals (Cystophora) he writes:

"A large Seal is occasionally seen on the coast of Massachusetts, which has been supposed to be the Crested Seal, but just what this large Seal is remains still to be determined.*" Footnote: "* In my 'Catalogue of the Mammals of Massachusetts,' I refer to this large Seal as follows, supposing it to be the Hooded Seal: 'From accounts I have received from residents along the coast of a seal of very large size observed by them, and occasionally captured, I am led to think this species is not of infrequent occurrence on the Massachusetts coast. Mr. C.W. Bennett informs me of one taken some years since in the Providence River, a few miles below Providence, which he saw shortly after. From his very particular account of it I cannot doubt that it was of this species. Mr. C.J. Maynard also informs me that a number of specimens have been taken at Ipswich within the past few years, that have weighed from seven hundred to nine hundred pounds. It seems to be most frequent in winter, when it apparently migrates from the north.' - Bull. Mus. Comp. Zool., vol. i, No. 8, 1869, pp. 193, 194. This identification was made almost solely on the ground of size, taken in connection with the fact that the species had been taken in Long Island Sound near New York City. The question, however, may fairly be raised whether the large Seals more or less frequently seen on the coast of New England are not really the Gray Seal (Halichoerus grypus)." (Allen 1880).

Clinton Andrews' notes mention a "fur seal" shot at Sconset Beach, Nantucket, on 4 June 1892, which he believes was probably a pup or yearling grey. The seal presumably was despatched by local men experienced in Antarctic sealing, and the leather may have been used to make caps and mittens.

"In the early decades of this century, 'horseheads' apparently bred on the outer bars southwest of Tuckernuck and Muskeget, and two old males were reported to have been killed near the old Coast Guard boathouse on Muskeget in the 1920's. Because of their large size, the killing of these animals has been remembered." (Andrews and Mott 1967).

From the notes of Glover Allen, "Aug. 1928. Dr. C.W. Townsend says an unusually large seal has been seen on & off this summer about the end of Plum Id., Mass. & is possibly a gray seal from his account."

"A gray seal was taken in the nets at Young's Million Dollar Pier, Atlantic City, N.J., following a severe northeast storm in March, 1931....The specimen, when taken, showed no signs of extreme exhaustion but lived for a year afterwards in captivity. ...The specimen is a young male from two to three years old and measures five feet seven and a quarter inches from nose to tip of tail." (Goodwin, 1933).

Andrews (pers. comm.) saw 40 probable grey seals on a shoal off Southwest Pt., Muskeget, from 1940 to 1948. In the fall of 1942 he saw greys come into the cove at Muskeget during gales.

Joseph Hagar, in his Muskeget field notes (1935-1952), records in 1948, early summer, "There was a herd of 40 to 50 Harbor (sic) Seals hauled out on a sandbar where the Gravelly Islands formerly stood, perhaps a mile south of Muskeget itself.

"I have never previously heard Harbor Seals make an audible sound, but these were noisy all day - a hoarse wailing and moaning which came to me intermittently and not unpleasantly on the fitful breeze." (In Wetherbee et al 1972). Only grey seals vocalize as described above by Hagar.

On 5 April 1949 Andrews saw 12 probable grey seals on a shoal towards Southwest Pt. (pers. comm.).

The bounty on seals was imposed sometime prior to the 1940's. Sometime in the early 1950's, in June, Andrews found the mummified carcasses of four grey seals pups, presumed killed for bounty, at Southwest Pt. (pers. comm.). Another year in the same time period he found there the skull and a few bones of a pup (Andrews and Mott 1967).

"Elwyn Francis, Allen Holgate, and Sam Mathison of Nantucket report that since 1940 they have killed at least 10 seals on Muskeget in each of two years. Since 1958, bounties have been paid on at least 25 seals. The general consensus is that approximately 40 gray seals were killed in about five years in the late 1940's and early 1950's. These were pups and their mothers, killed when hauled out on the sand." (Andrews and Mott 1967). Thus it appears at least 65 seals were killed for bounty at Nantucket.

In late September 1958 Andrews "collected the skull of a large seal found dead on the beach at Coskata, Nantucket." Barbara Lawrence at Harvard's Museum of Comparative Zoology identified the specimen as a grey seal (MCZ #51282), thus confirming the continued existence of a species thought to have been exterminated from Massachusetts in the 17th century. (Andrews and Mott 1967).

Massachusetts removed the bounty on all seals in 1962, and in 1965 passed an act giving grey seals complete protection.

Sightings from 1955 to 1981 are summarized below. Single letters denote seals whose markings permit individual recognition.

Legend for sources of sightings: op cit - Andrews and Mott 1967; JCA - J. Clinton Andrews; EA - Edith Andrews; WHD - William H. Drury, Jr.; PM - Peter Mott; WES - William E. Schevill; WW - William Watkins; KM - Karen Moore; SP - Stanley Poole; ARK - Allan R. Keith; VRS - Valerie Rough Schurman; RT - Robert Tamarin; OB - Oscar Bunting; RC/WNT - Robert Cole/Wesley N. Tiffney, Jr.; NG - Norman Gingrass; JS - John Sease; CK - Connie Knapp; GK - George King; CS - Carla Skinder; EM - Edward Metcalf; RV - Richard Viet; JB - Juliana Birkhoff; RP - Robert Prescott.

1955	12 November, 2 seen. (op cit).
1958	15 February, a small white seal (species?) at Coatue while harbor frozen. Late September, dead grey seal cow at Coskata. (EA, JCA).
1960	13 January, off Eel Pt., 2 seals chasing ducks. 17 February, Smith's Pt., seals taking 1/3 of ducks shot. (JCA).
Through 1961	Several winters, 20 or more grey seals on a shoal east of Tuckernuck. (op cit).
1962	Bounty removed. 7 November, 10 on a shoal off Eel Pt. (op cit).
1963	January, 3 pups at Muskeget; 1 taken to Madaket, where it died. (op cit). 25 March, 8 hauled out in two groups, one at Southwest Pt., the other on a bar southeast of the point. Each group included a bull and two cows. (WHD, PM). June, 4-5 vocalizing on shoal between Tuckernuck and Muskeget. (JCA). November, 10 on a shoal off Eel Pt. (op cit). Autumn, grey seal with open wound on its back found at west side of Muskeget. (JCA).

1964 — 6 February, an old female (MCZ #51488) shot (for defunct bounty) at Cedar Is., Lackey's Bay, Naushon, Elizabeth Islands. (op cit).
21 February, 1 at Squibnocket Pt., Martha's Vineyard. (ARK 1969).
No date - 3 adults, 2 "pups" on a Muskeget sandbar. (WES).

1965 — 14 February, a pup came ashore at Harthaven Harbor, Oak Bluffs, Martha's Vineyard, apparently abandoned; it died in a private home. (op cit).
April, at shoal between Tuckernuck and Muskeget, 12-17 grey seals, several large, including bull A. (JCA).
Grey Seals Protection Act passed in Massachusetts.

1966 — April, at shoal between Tuckernuck and Muskeget, 12-17 grey seals, several large, including bull A. (JCA).
31 December, 1 bull off Cisco, 1 in Broad Creek opening. (JCA).

TABLE 2

SEAL BOUNTIES - FROM NANTUCKET TOWN REPORTS

$5.00 per seal paid. Clerk took another 50¢ for processing.

1940 - $ 0.00	($9.00 possible, under "all other" expenditure.)	
1958 - $55.00		10 seals
1959 - $33.00		6 seals
1960 - $22.00		4 seals
1961 - $11.00		2 seals
	Minimum total	22 seals

Although no species determination was made, it was common knowledge at the time that many of the seals were killed at Muskeget, including several pups.

Compiled by J.C. Andrews

Because data from 1967 to 1981 are incorporated in subsequent figures and tables, the following summaries are more general than those of previous years.

1967 — January, 1-3 seals at Tuckernuck and Muskeget. Pup, cow and attendant bull B at Muskeget 1-9 February. At Muskeget 15 in April, 6 in May, 3 in November. (JCA, VRS).

1968 — 23 January to 5 February, pup, cow C, and attendant bull B (February 1967) at Muskeget. Weaned pup still there 7 February. 14 at Muskeget late March. Bulls A and B (1966 and 1968), and cow C (1968) with herd 27 and 28 March. (JCA, EA, VRS, WHD).

1969 — 1 February, dead pup at Muskeget; cow nearby is not C. At Muskeget 8 in March, 10 in April, 4 in May. Repeat sightings, all at Muskeget: Bull A (March 1968) on 8 February, 13 and 19 March, and 13 April; cow C (1968) on 13 April. (JCA, EA, VRS).

1970 — 25 January, possible molted pup or yearling ashore at Nantucket town beach (Inquirer & Mirror, 5 February 1970). 7 February, pup, cow C (13 April 1968), and attendant bull (not B) at Muskeget. At Tuckernuck, 9 in late March, 6-11 in April; at Muskeget 7 on 2 May. Other repeat sightings, all at Tuckernuck: Bull A (March 1968) on 12 and 20 March, and 8 April; cow C (1970) on 20 March. Some seals molting 12 April. 3 at Muskeget sometime during summer. (JCA, VRS).

1971 — No local pups seen. 10 March, pup branded at Sable Is. ashore at Sconset. Few seals seen until 11 at Muskeget 27 April, including cow C (20 March 1970). 18 November, 7 at Tuckernuck, including cow C. (JCA, VRS).

1972 — 25 February, at Tuckernuck, 6, including yearling branded at Sable Is. 12 March, pup in whitecoat, probably 6 weeks old, at Sconset. Late March, 9 at Tuckernuck; November, 1-2 at Muskeget; 5 December, 5 at Tuckernuck. (JCA, RT).

1973 — January - early February, 1-5 at Tuckernuck, including yearling on 13 January. 15-24 February, 4-8 at Squibnocket Beach, Martha's Vineyard. First part of March, 8-11 at Tuckernuck. 20 March, 1 partially molted pup at Cisco. At Muskeget, 6-9 April - 2 May, 1 on 1 June, none 7 July. 13 December, 3 at Tuckernuck, plus 1 dead, branded at Sable Is. in 1972. (JCA, SP, RT).

1974 Few surveys. Late January, 1 at Esther Is. Late February 1 at Muskeget. (JCA, RT).

1975 At Muskeget, 2 in January, 4 in late February, several in April, 3 on 8 May. Emaciated 3 month old female stranded at Dennisport Beach 25 April. (JCA, RT, GK).

1976 Early January, 3 at Muskeget. February, 1-3 at Muskeget, 3-4 at Tuckernuck. 21 February, at Tuckernuck, a possible molted pup, and seal branded at Sable Is. in 1972. March, at least 4 at Muskeget. 11 April, molted pup at Low Beach, Sconset, and later at Tom Nevers. Summer, a few seen at Muskeget. Late November, 5 at Muskeget. (JCA, RT, OB, NG).

1977 12 aerial surveys. At Muskeget, 1 in January, 9 in late March, 3 in mid-April. Last half of April, 1-5 at Wasque shoals. 21 April, pup tagged at Sable Is. stranded at W. Dennis Beach. 3 December, 5 at Wasque shoals. (VRS, JS, CK, GK).

1978 2 February, 2 at Wasque shoals. 30 March, 5 at Wasque shoals, 3 at Muskeget. 8 April, at least 6 at Muskeget. (VRS, RT).

10 February, whitecoat pup stranded at Provincetown. (GK).

1979 Early February, 2 at Wasque shoals. March, 1-3 at Muskeget. Late April, 6 at Wasque shoals, including yearling female D. 1 May, 4 at Muskeget. (VRS, JCA, EA, WW, WES, KM).

4 May, pup tagged at Sable Is. stranded at Nauset Inlet (CS).

1980 6 February, probable pup at Muskeget. 11 February - 2 April, 1-4 at Esther Is. 11 March, 3 at Muskeget, including mature female G. 5-11 April, 17-19 at Muskeget. Bull branded at Sable Is. in 1971 sighted 6 and 11 April. Female branded at Sable Is. in 1978 sighted 11 April. 24 April, 4 at Muskeget. (VRS, EA, JCA). Other repeat sightings:
Young female D (20 April 1979) at Esther Is. 11-12 February, and at Muskeget 5-8 April.
Mature female E at Esther Is. 11-13 February.
Mature female F at Esther Is. 11-12 February and 10 March; and at Muskeget 5-8 April and 11 April.

4 March, whitecoat pup stranded at Nauset Beach. (RP).

1981 25 January, possible cow and pup on ice outside Nantucket Harbor. 15 February, whitecoat pup stranded at Chappaquiddick, Martha's Vineyard. 28 February, pup tagged at Sable Is. ashore at Sankaty. 13 March, another pup tagged at Sable Is. ashore at Cisco. 15 March same or different Sable Is. tagged pup ashore at Nobadeer. 4 at Esther Is. 1 March. Early March - early April, 1-3 at Esther Is. At Muskeget, 1 in March, 1 in April. (JCA, EA, VRS, RC/WNT, EM, RV, JB).
Repeat sightings:
Mature female F (1980) March 5, 9, 13, 16, 19, 20, 21, April 2-3, at Esther Is.
Female H at Muskeget March 10-11.
Bull I at Esther Is. March 5, 13, 16, 19, 20.
Bull J at Esther Is. March 5, 19, April 7.
Mature female G (11 March 1980) at Muskeget 17 April.

27 March, pup tagged at Sable Is. stranded at Nauset Beach (GK).

Each sighting 1967 - 1981 is a point on a yearly graph (Figure 14). Figures 5-19 give additional information, where available, on climatic factors, schedule of tides, numbers of harbor seals, and frequency and duration of sightings, for every year 1967 - 1981.

LEGEND AND GENERAL REMARKS

Figures 4-19

o - includes pup(s) () - approximate count + - seals present
▲ - aerial count △ - aerial count of pup(s) s - stranded

A vertical line between points indicates a range of numbers (i.e. maximum and minimum) for a particular day.

A horizontal line between points indicates a time span of more than one day.

⟷ - obervation falls sometime between arrow points.

Grey seal counts - zero counts included.
Harbor seal counts - zero counts not included.

Figures 5-19

Air temperature in degrees Farenheit at 1000 hrs measured by:

a) observer, or

b) Nantucket Airport; data obtained from National Climatic Center, Asheville, N.C.*

* 1000 air temperature at Nantucket Airport available from N.C.C. through 1969. After that only maximum daily temperatures at Nantucket Airport are available at reasonable cost from N.C.C. After 1969, 1000 air temperature is roughly approximated by subtracting 2 degrees from daily maximum.

Wind velocity in M.P.H. at 1000 hrs measured by:

a) observer, or

b) Nantucket Airport, 1967 - 1969; data obtained from N.C.C.

Water temperature in degrees Farenheit measured by observer, except, where noted, measured by U.S. Coast Guard personnel at Menemsha or Nantucket Shoals Lightship, and broadcast over NOAA Weather Radio.

Ice - fast ice in bays and harbors.

Time of low tide at Boston, per schedule (Eldridge Tide and Pilot Book, 1967 - 1981). Tide tables for various Nantucket locations are calculated based on the Boston table. Note these times are predicted, not necessarily actual, times of low tide. Winds often influence tides at Nantucket, causing marked deviations from tidal schedule.

Alewife run - Madaket Ditch. Dates from J. Clinton Andrews.

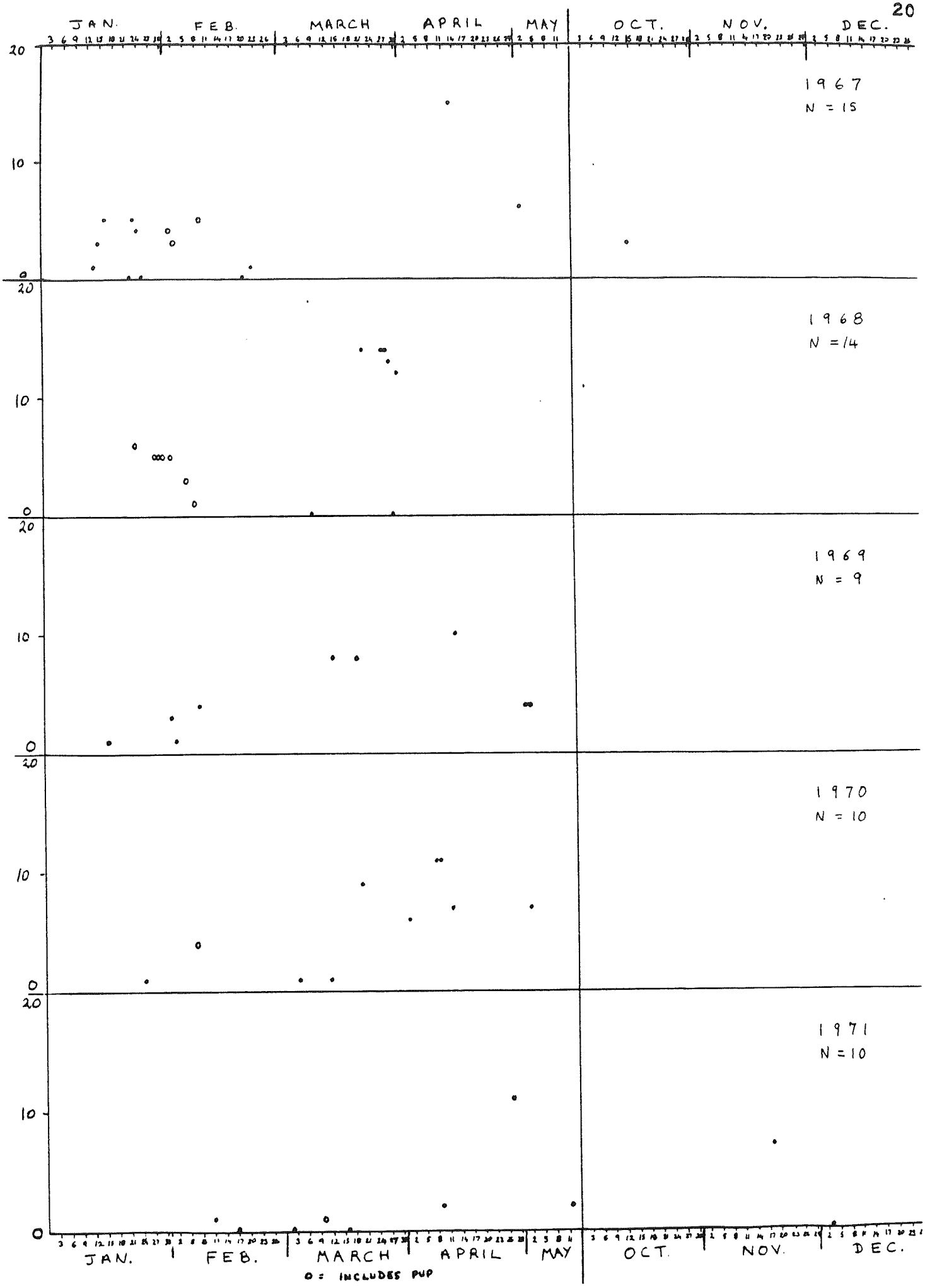

JAN.
FEB.
MARCH
APRIL
MAY
OCT.
NOV.
DEC.
1967
N = 15
1968
N = 14
1969
N = 9
1970
N = 10
1971
N = 10
Numbers of grey seals
0 = INCLUDES PUP

Figure 4a.

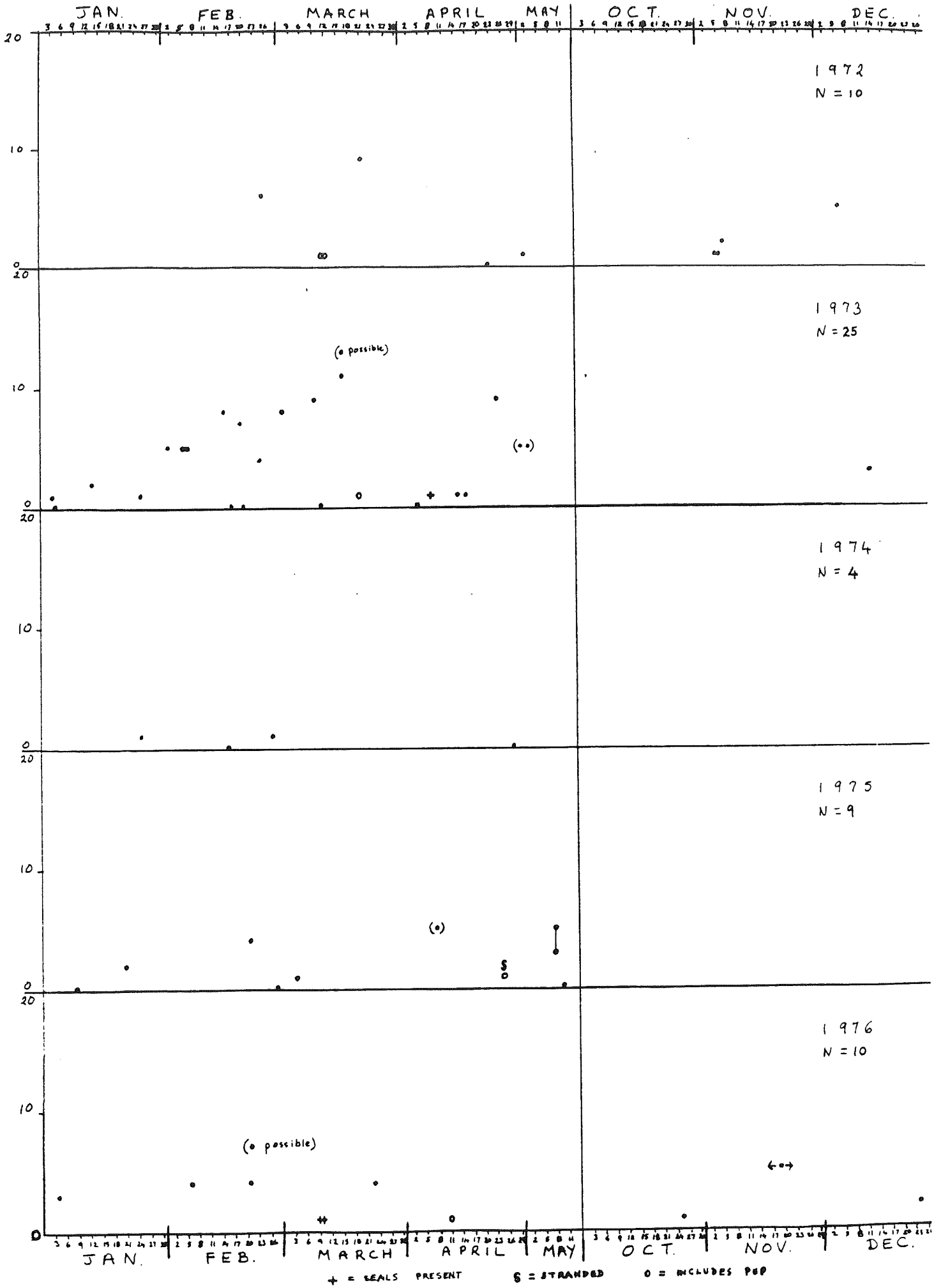

JAN.
FEB.
MARCH
APRIL
MAY
OCT.
NOV.
DEC.
1972
N = 10
1973
N = 25
(• possible)
(••)
1974
N = 4
1975
N = 9
(•)
1976
N = 10
(• possible)
Numbers of grey seals
+ = SEALS PRESENT
$ = STRANDED
0 = INCLUDES PUP

Figure 4b.

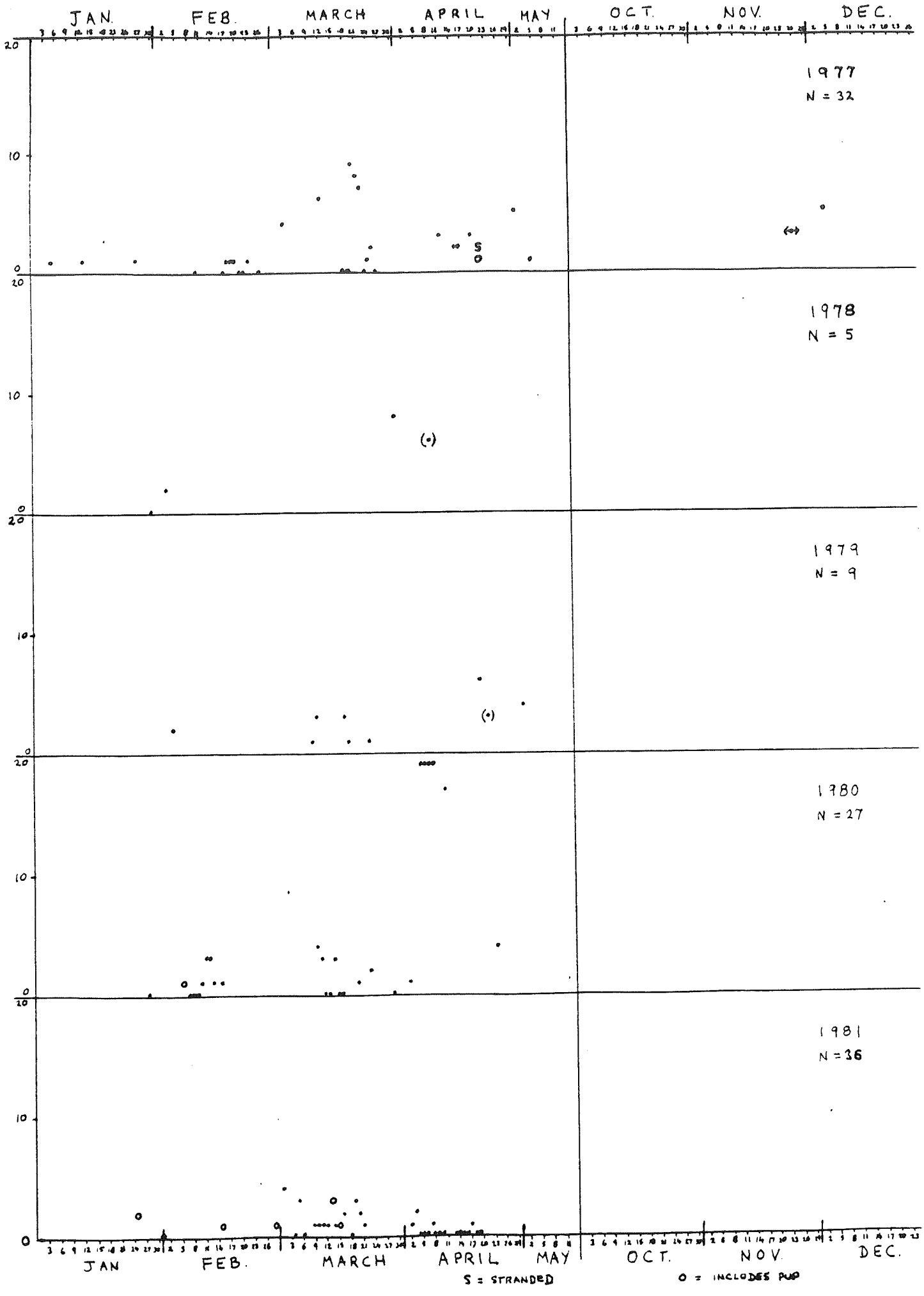

JAN.
FEB.
MARCH
APRIL
MAY
OCT.
NOV.
DEC.
1977
N = 32
1978
N = 5
1979
N = 9
1980
N = 27
1981
N = 36
Numbers of grey seals
S = STRANDED
O = INCLUDES PUP

Figure 4c.

FIGURE 5

1967

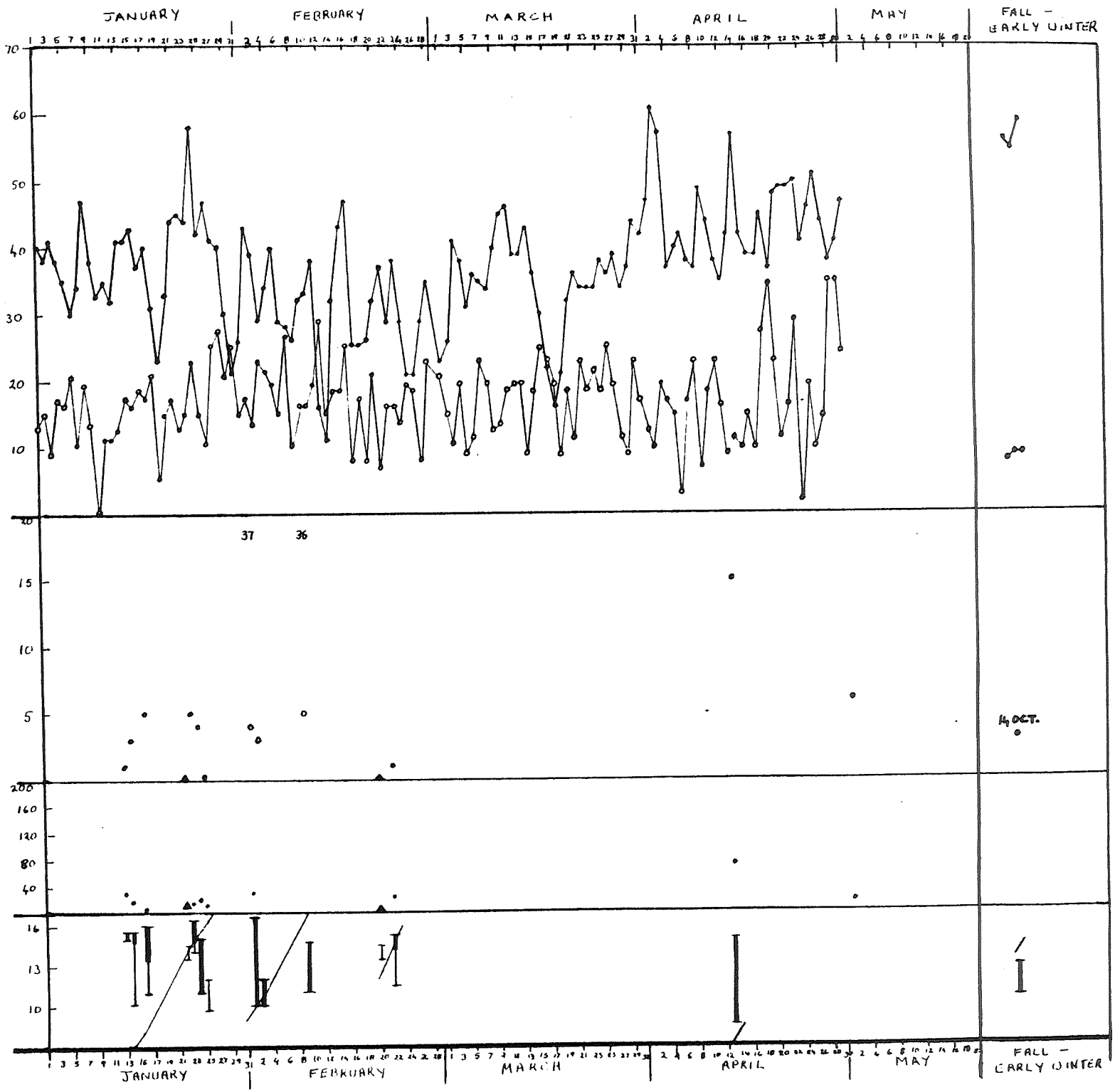


FIGURE 6

1968

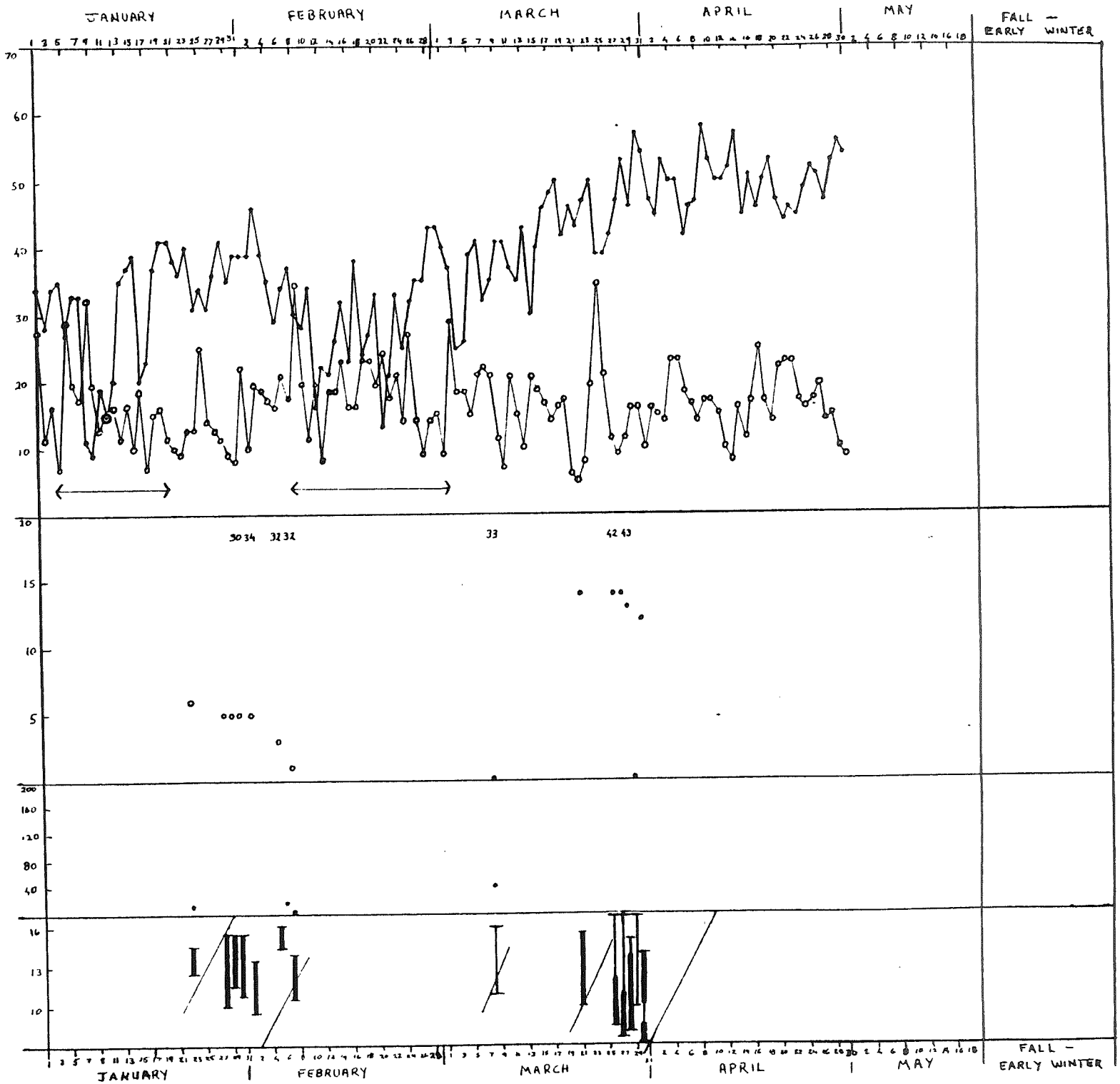


FIGURE 7

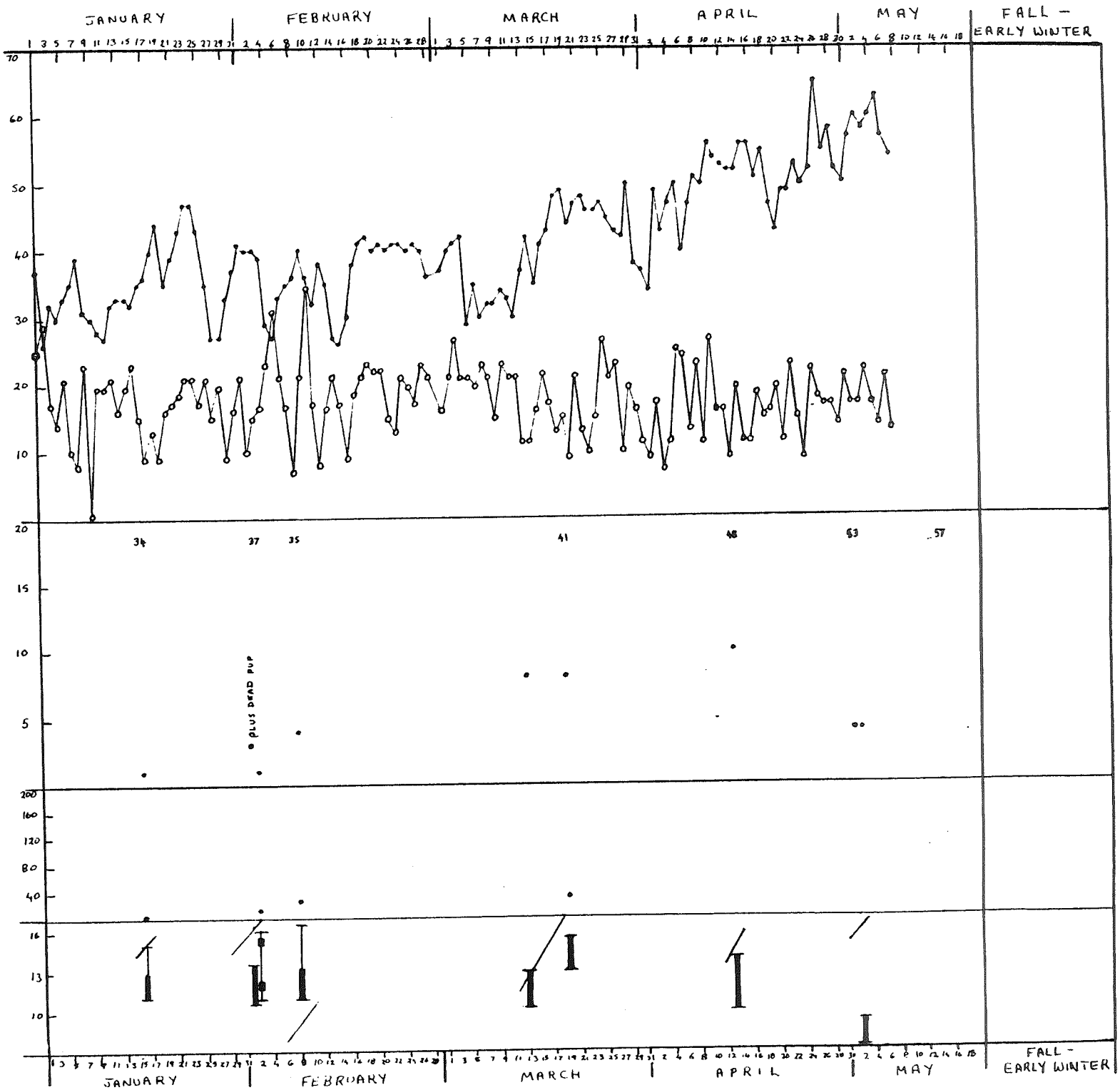

1969
JANUARY
FEBRUARY
MARCH
APRIL
MAY
FALL - EARLY WINTER
AIR TEMPERATURE IN DEGREES F AT 1000
WIND VELOCITY IN M.P.H. AT 1000
WATER TEMPERATURE °F
34
37
35
41
48
53
57
NO. OF GREY SEALS
* PLUS DEAD PUP
NO. OF HARBOR SEALS
00 HOURS
DURATION OF GREY SEAL SIGHTING
DURATION OF OBSERVATION
DIAGONAL LINE = LOW TIDE

FIGURE 8

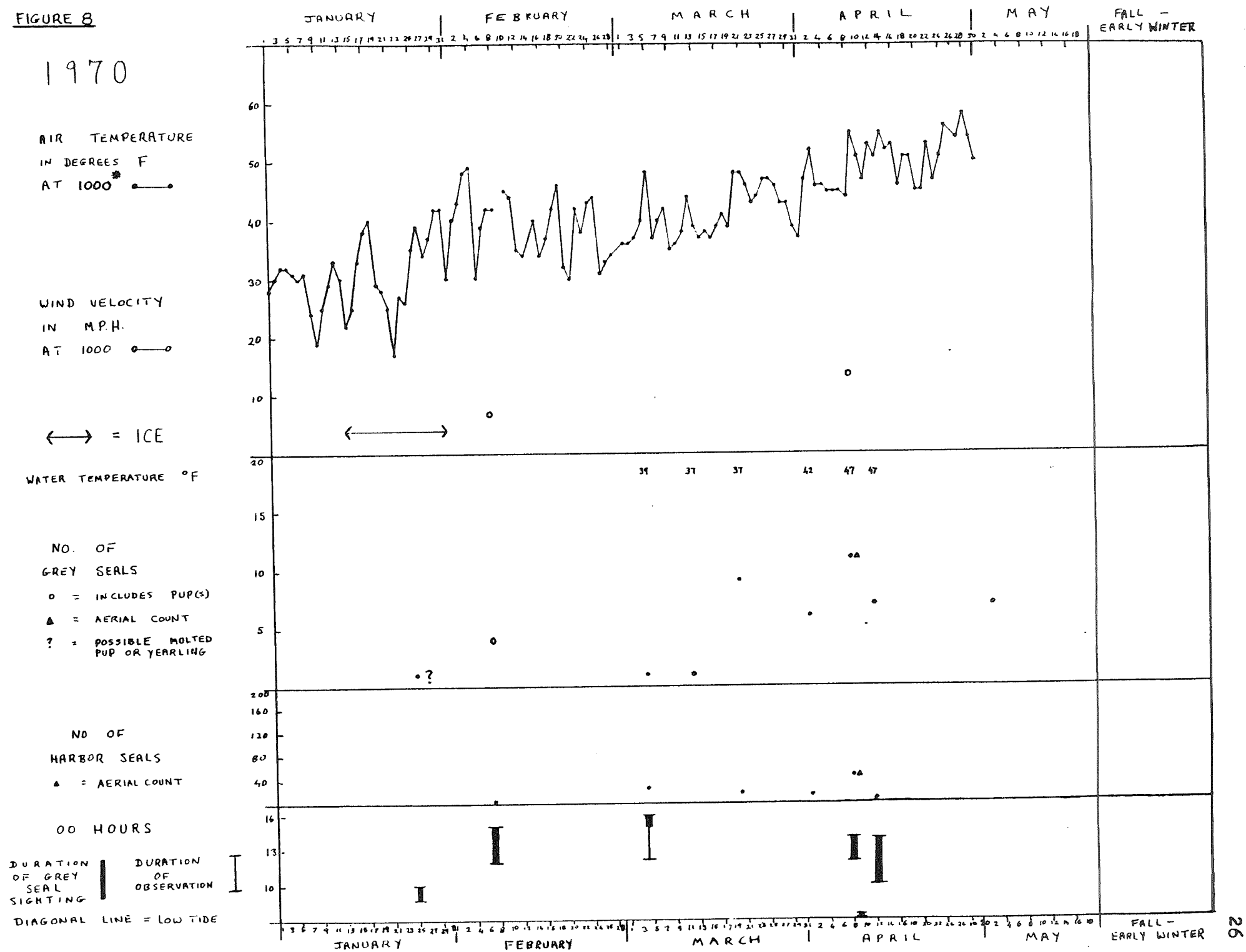

1970
JANUARY
FEBRUARY
MARCH
APRIL
MAY
FALL – EARLY WINTER
AIR TEMPERATURE IN DEGREES F AT 1000
WIND VELOCITY IN M.P.H. AT 1000
= ICE
WATER TEMPERATURE °F
39 37 37 42 47 47
NO. OF GREY SEALS
o = INCLUDES PUP(S)
▲ = AERIAL COUNT
? = POSSIBLE MOLTED PUP OR YEARLING
NO OF HARBOR SEALS
▲ = AERIAL COUNT
00 HOURS
DURATION OF GREY SEAL SIGHTING
DURATION OF OBSERVATION
DIAGONAL LINE = LOW TIDE

FIGURE 9

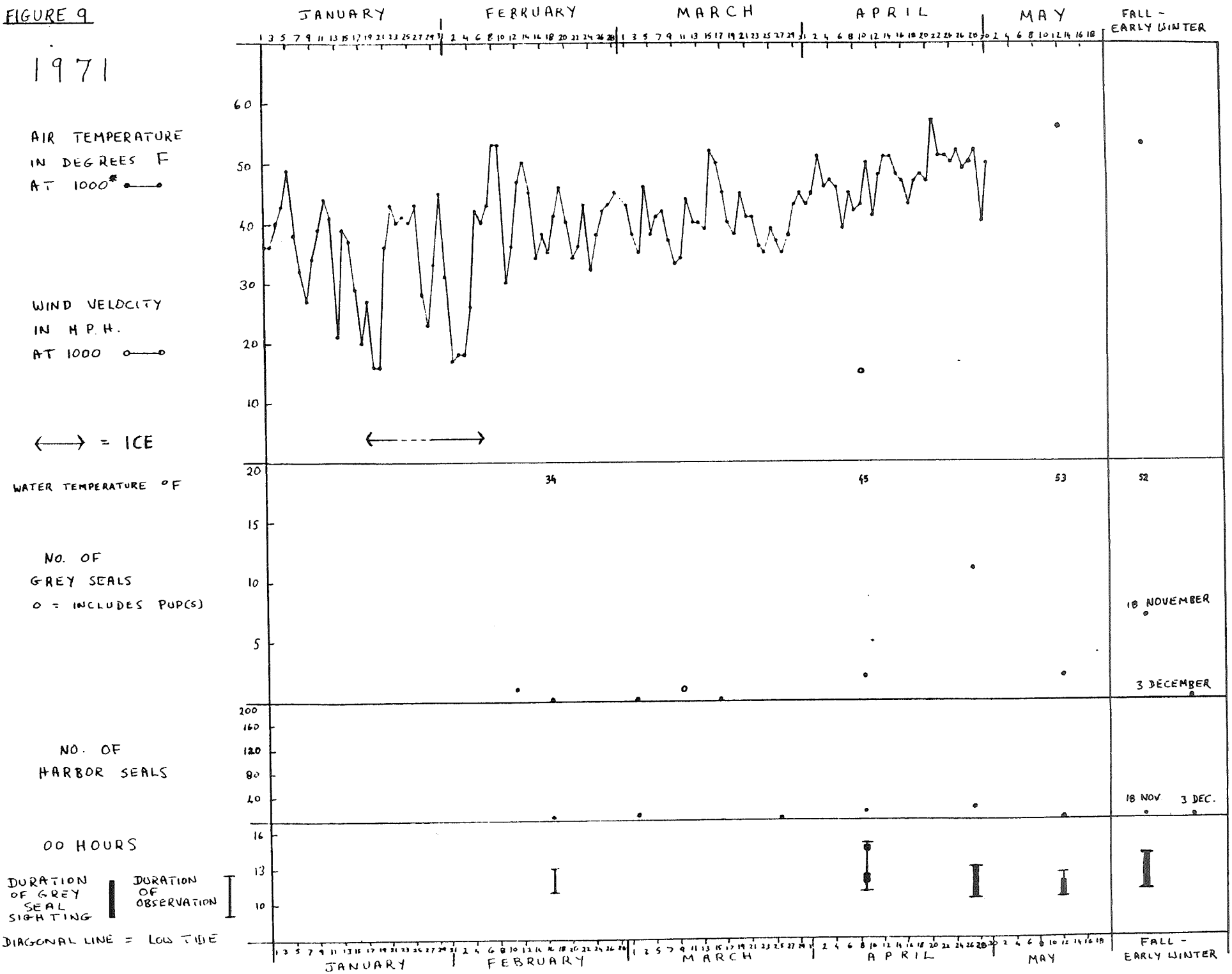

1971
JANUARY
FEBRUARY
MARCH
APRIL
MAY
FALL - EARLY WINTER
AIR TEMPERATURE IN DEGREES F AT 1000*
WIND VELOCITY IN M.P.H. AT 1000
= ICE
WATER TEMPERATURE °F
34
45
53
52
NO. OF GREY SEALS
0 = INCLUDES PUP(S)
18 NOVEMBER
3 DECEMBER
NO. OF HARBOR SEALS
18 NOV
3 DEC.
00 HOURS
DURATION OF GREY SEAL SIGHTING
DURATION OF OBSERVATION
DIAGONAL LINE = LOW TIDE

FIGURE 10

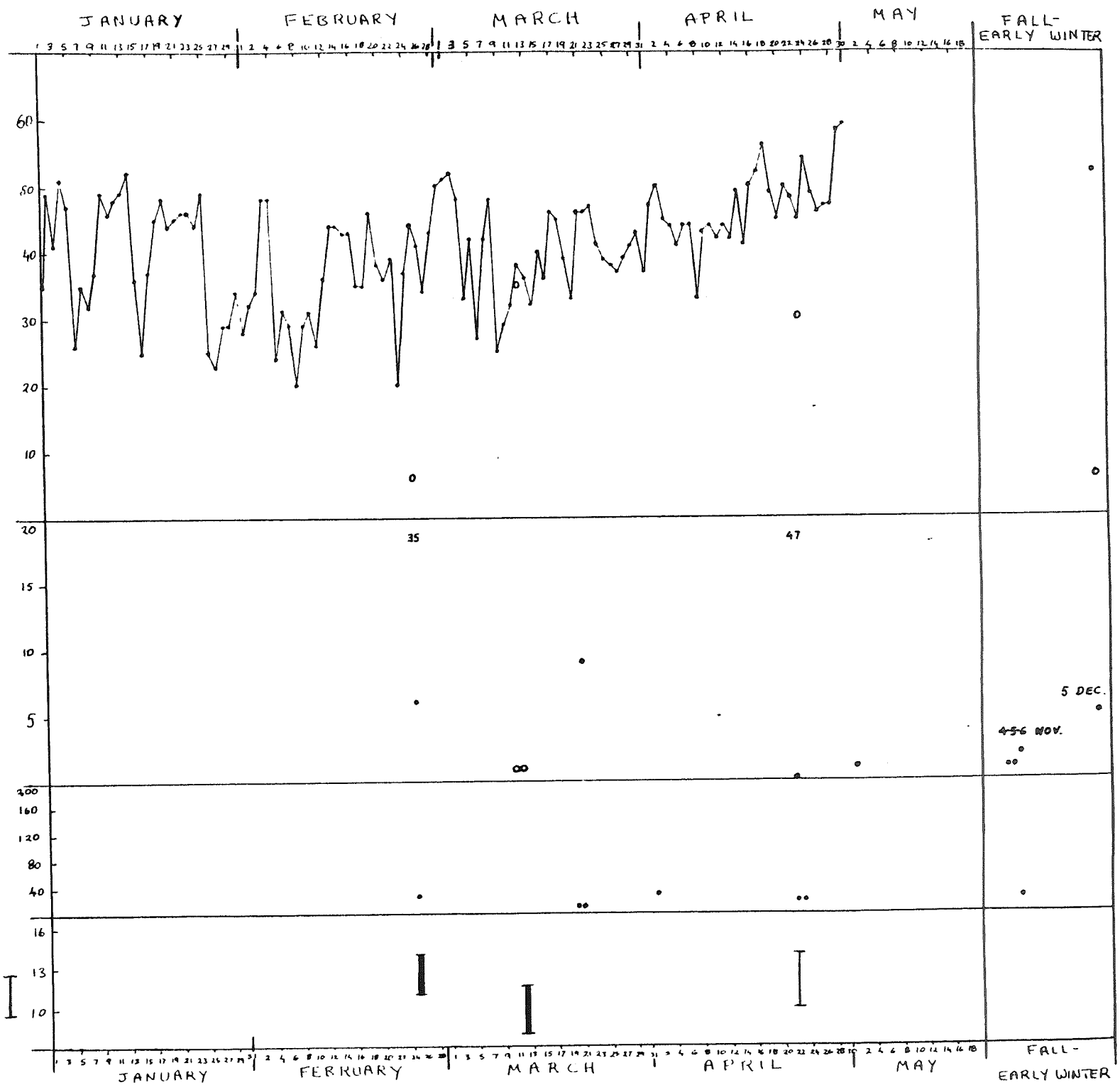

JANUARY
FEBRUARY
MARCH
APRIL
MAY
FALL-EARLY WINTER
1972
AIR TEMPERATURE IN DEGREES F AT 1000*
WIND VELOCITY IN M.P.H. AT 1000
WATER TEMPERATURE °F
NO. OF GREY SEALS
0 = INCLUDES PUP(S)
NO OF HARBOR SEALS
00 HOURS
DURATION OF GREY SEAL SIGHTING
DURATION OF OBSERVATION
DIAGONAL LINE = LOW TIDE
35
47
5 DEC.
4-5-6 NOV.

FIGURE II

1973

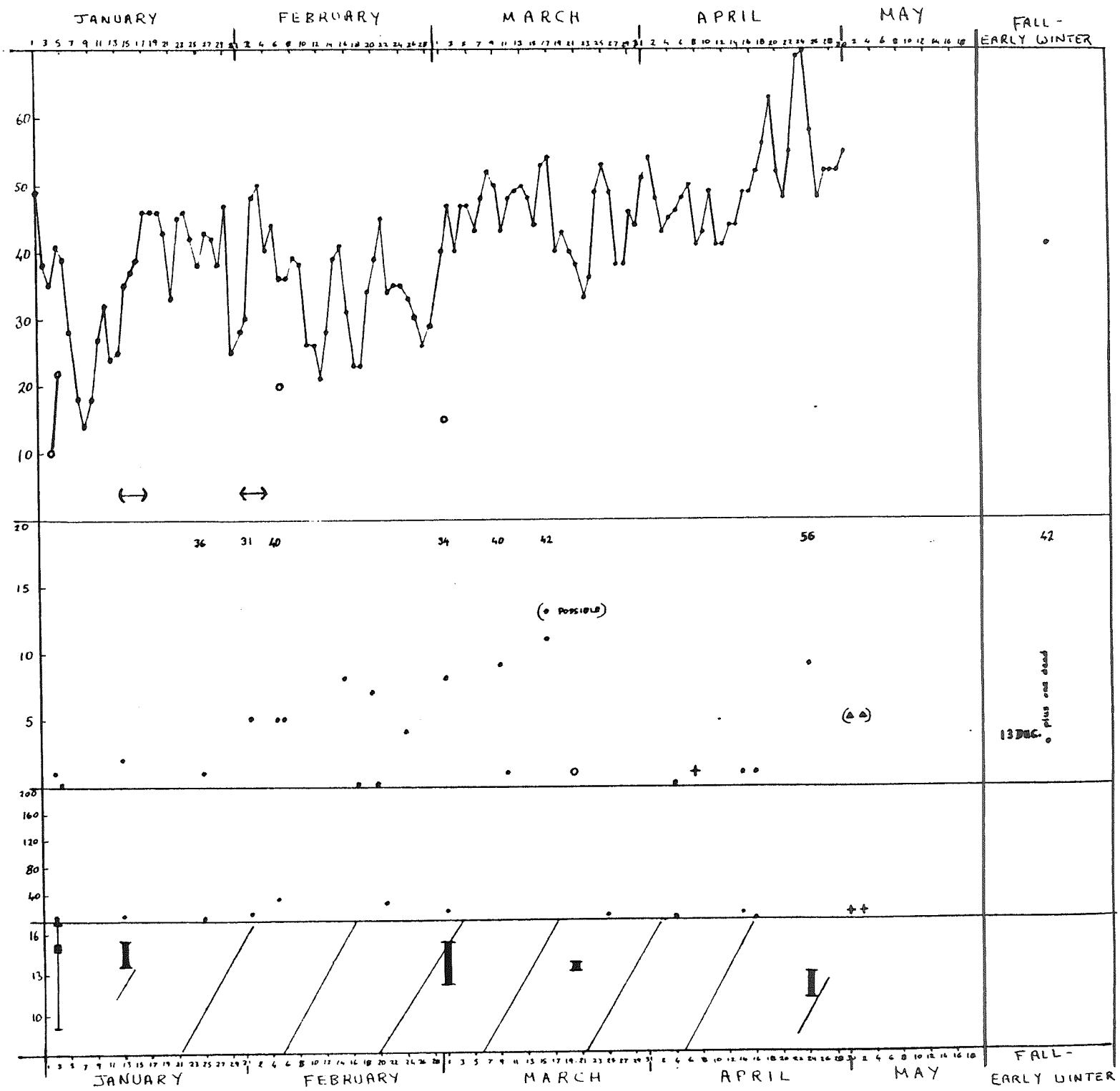


FIGURE 12

1974

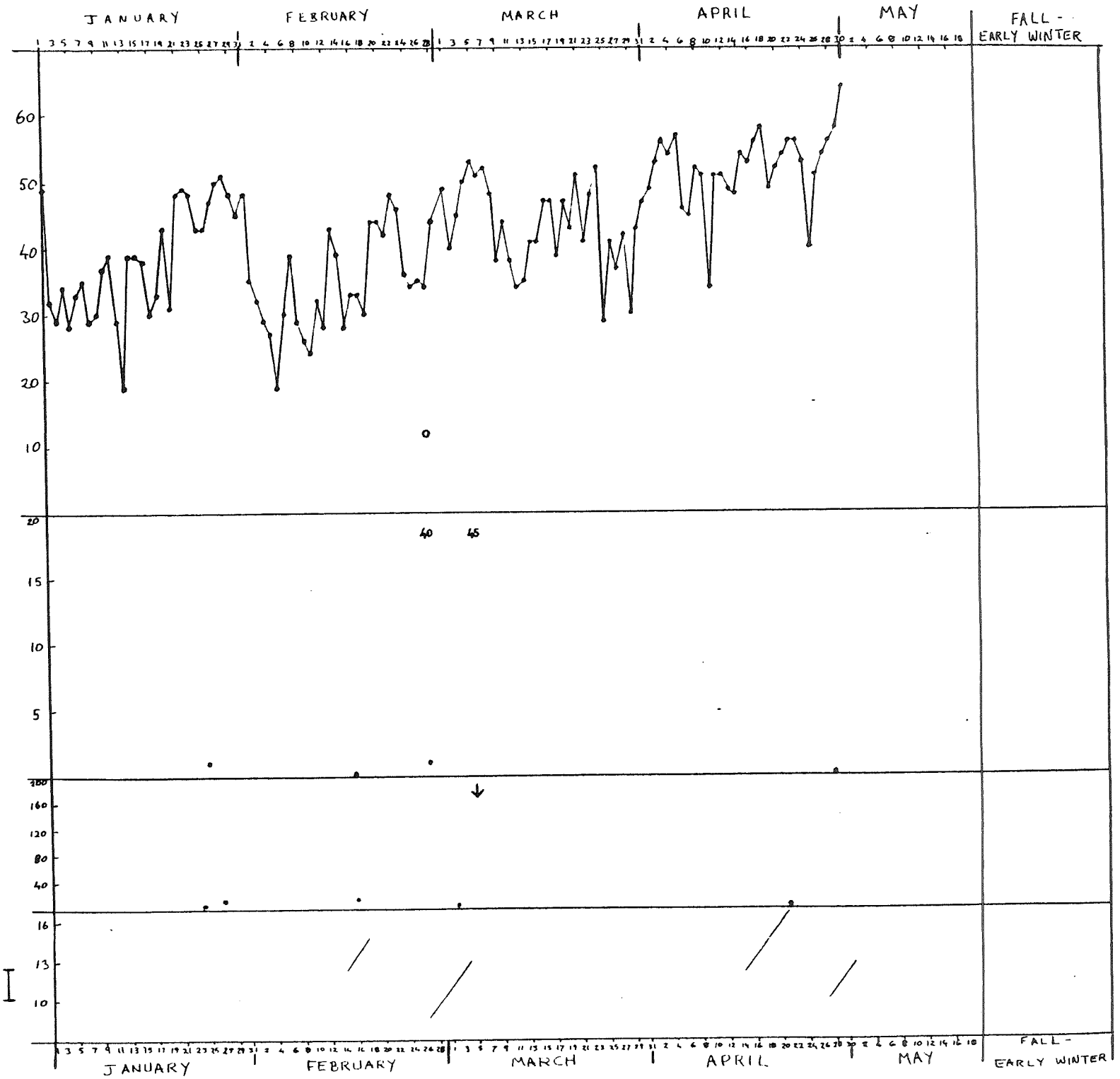


FIGURE 13

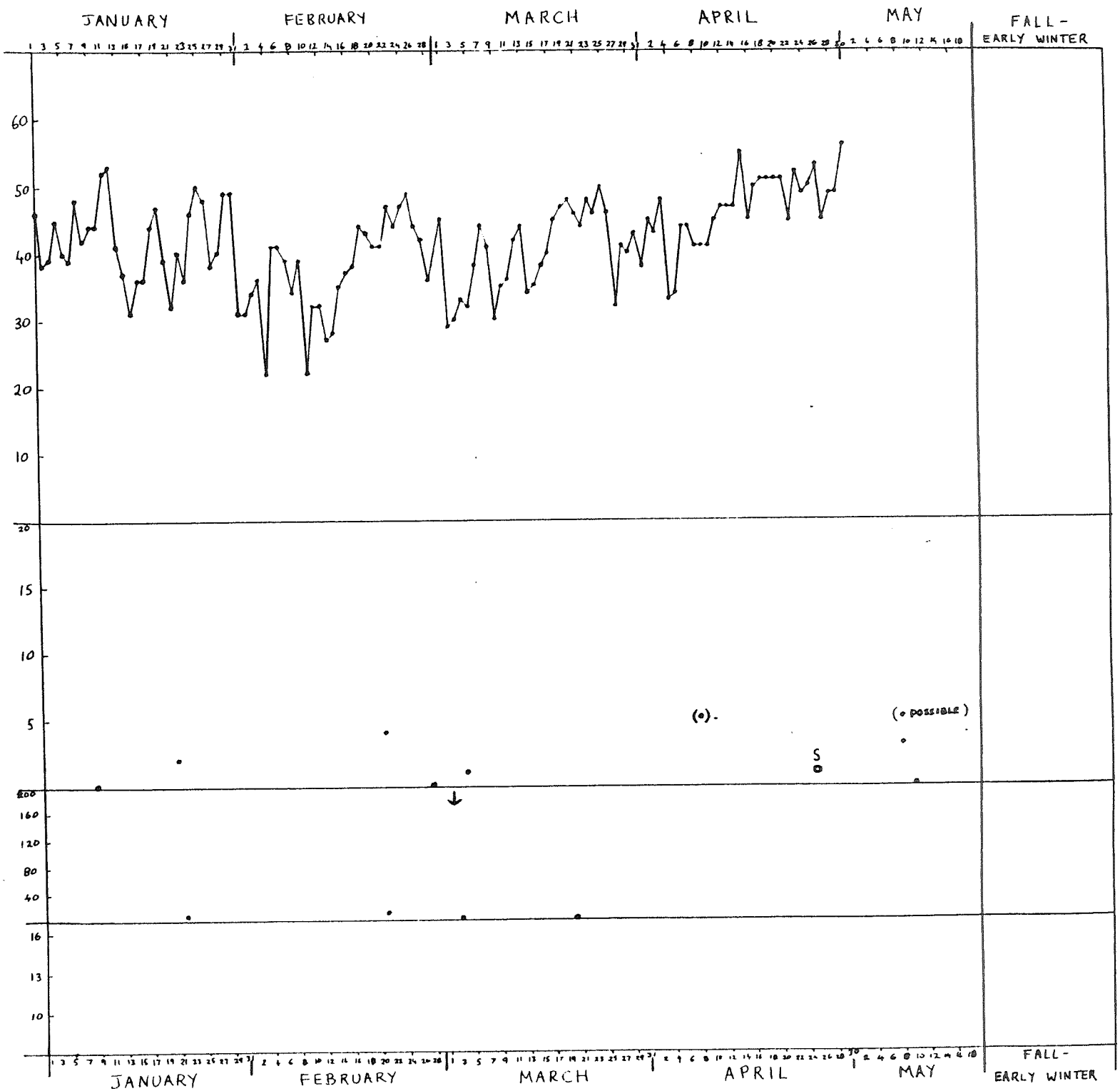

1975
JANUARY
FEBRUARY
MARCH
APRIL
MAY
FALL - EARLY WINTER
AIR TEMPERATURE IN DEGREES F AT 1000*
WIND VELOCITY IN M.P.H. AT 1000
NO. OF GREY SEALS
0 = INCLUDES PUP(S)
( ) = APPROXIMATE COUNT
S = STRANDED
(0).
(0 POSSIBLE)
S
0
START ALEWIFE RUN
NO. OF HARBOR SEALS
00 HOURS
DURATION OF GREY SEAL SIGHTING
DURATION OF OBSERVATION
DIAGONAL LINE = LOW TIDE

FIGURE 14

1976

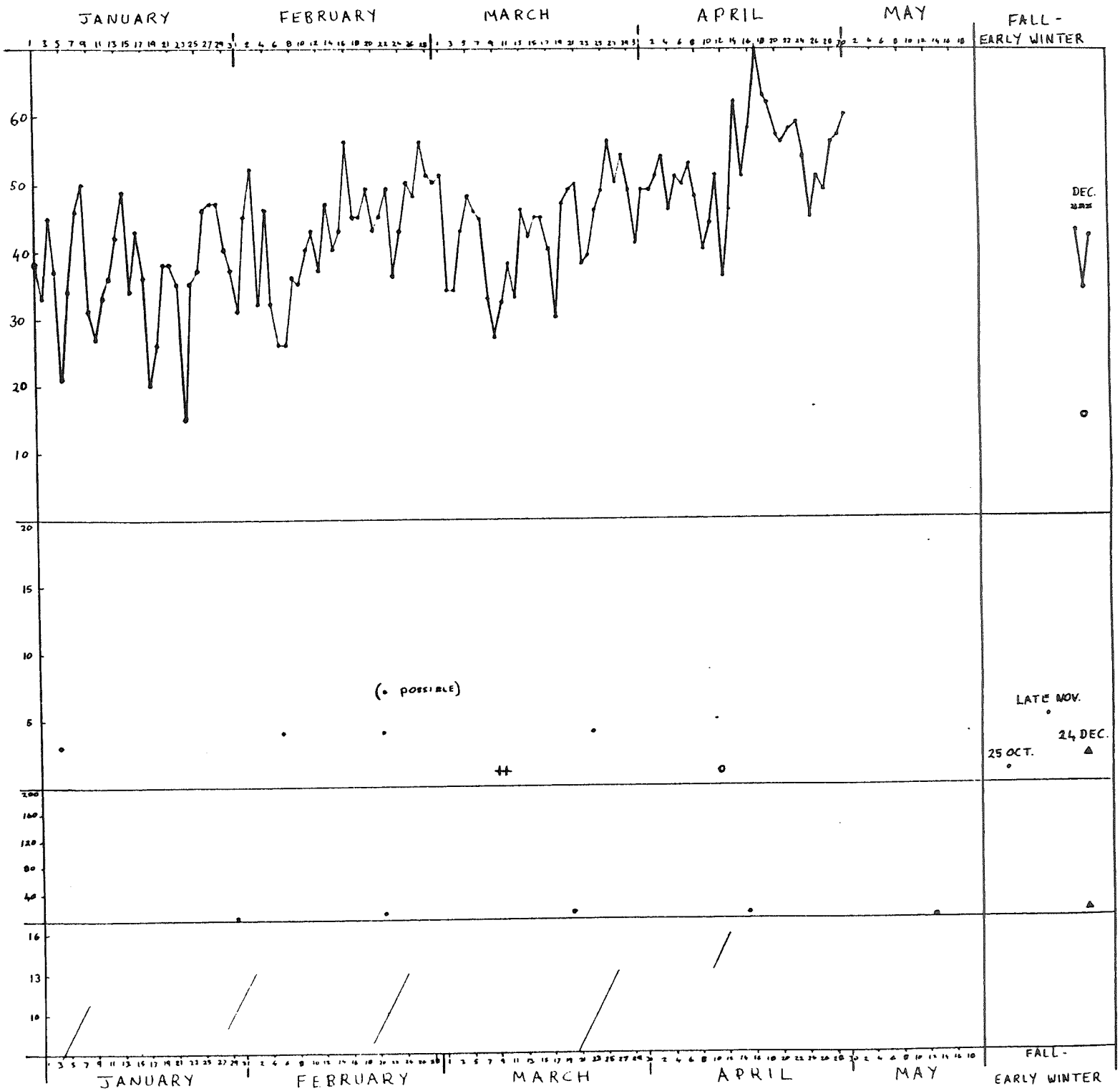


FIGURE 15

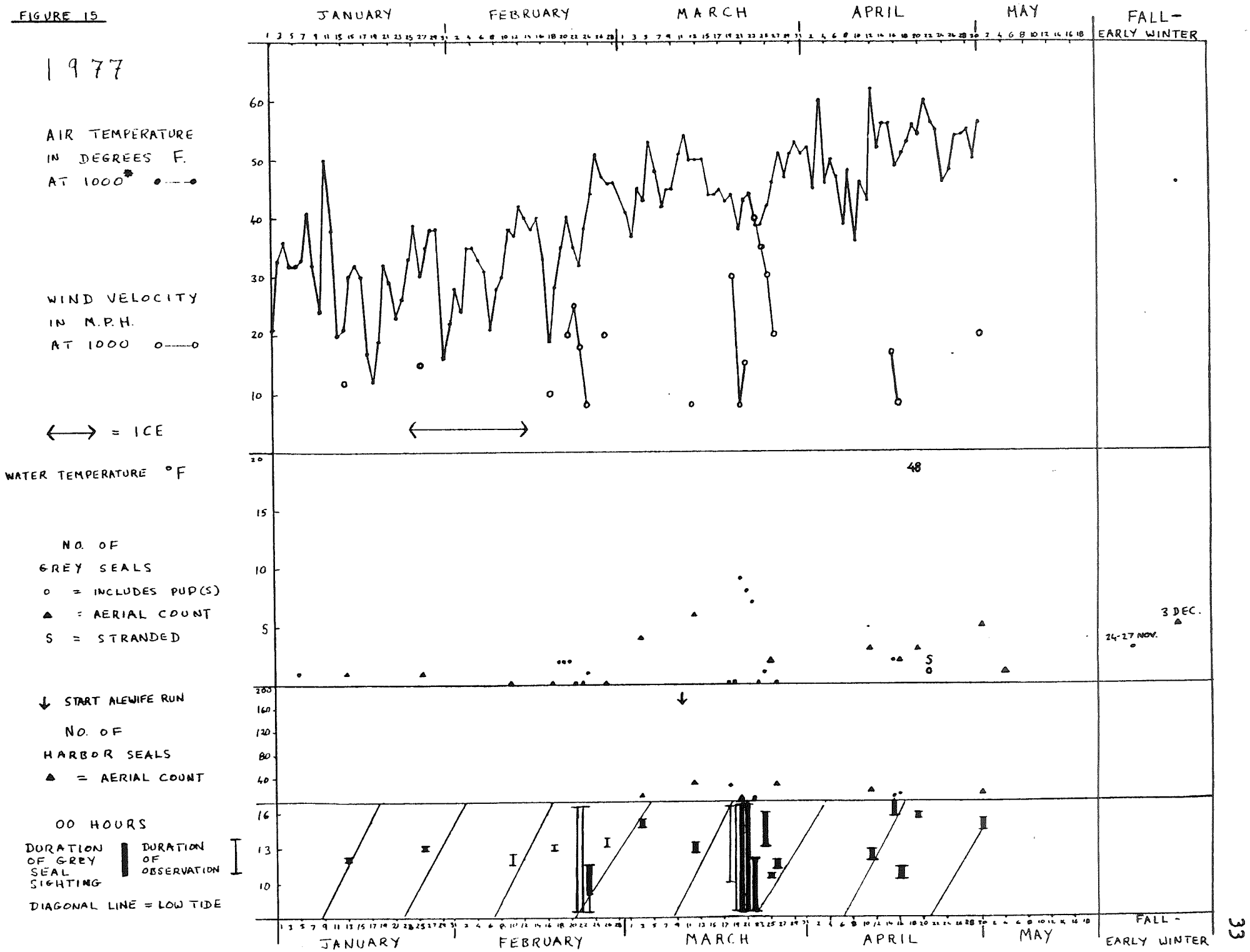

1977
AIR TEMPERATURE IN DEGREES F. AT 1000
WIND VELOCITY IN M.P.H. AT 1000
= ICE
WATER TEMPERATURE °F
NO. OF GREY SEALS
o = INCLUDES PUP(S)
▲ = AERIAL COUNT
S = STRANDED
START ALEWIFE RUN
NO. OF HARBOR SEALS
▲ = AERIAL COUNT
00 HOURS
DURATION OF GREY SEAL SIGHTING
DURATION OF OBSERVATION
DIAGONAL LINE = LOW TIDE
JANUARY
FEBRUARY
MARCH
APRIL
MAY
FALL - EARLY WINTER
48
3 DEC.
24-27 NOV.

FIGURE 16

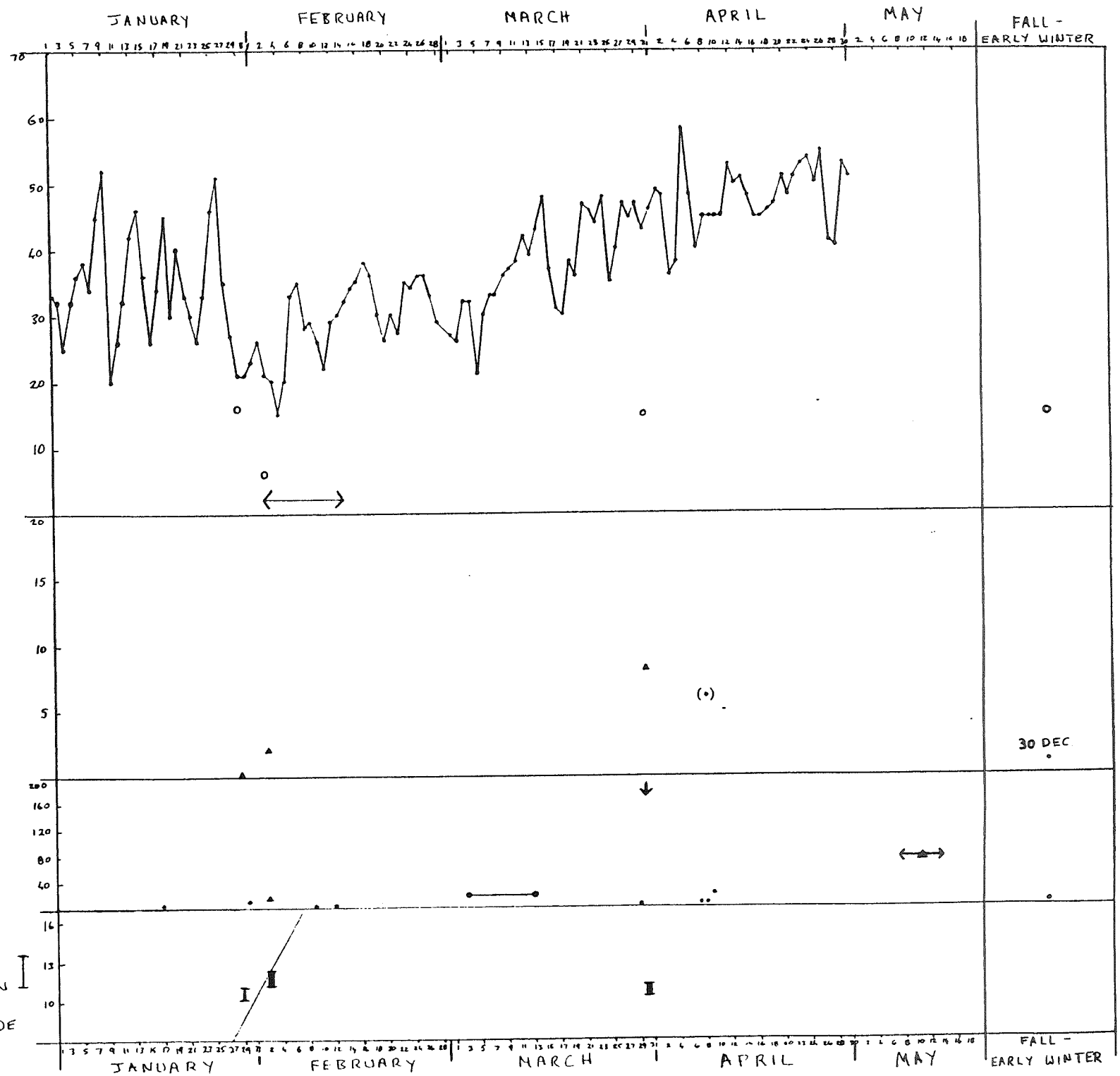

JANUARY
FEBRUARY
MARCH
APRIL
MAY
FALL - EARLY WINTER
1978
AIR TEMPERATURE IN DEGREES F AT 1000*
WIND VELOCITY IN M.P.H. AT 1000
= ICE
NO. OF GREY SEALS
o = INCLUDES PUP(S)
▲ = AERIAL COUNT
( ) = APPROXIMATE COUNT
30 DEC
START ALEWIFE RUN
NO. OF HARBOR SEALS
▲ = AERIAL COUNT
00 HOURS
DURATION OF GREY SEAL SIGHTING
DURATION OF OBSERVATION
DIAGONAL LINE = LOW TIDE
I
II
II
JANUARY
FEBRUARY
MARCH
APRIL
MAY
FALL - EARLY WINTER

FIGURE 17

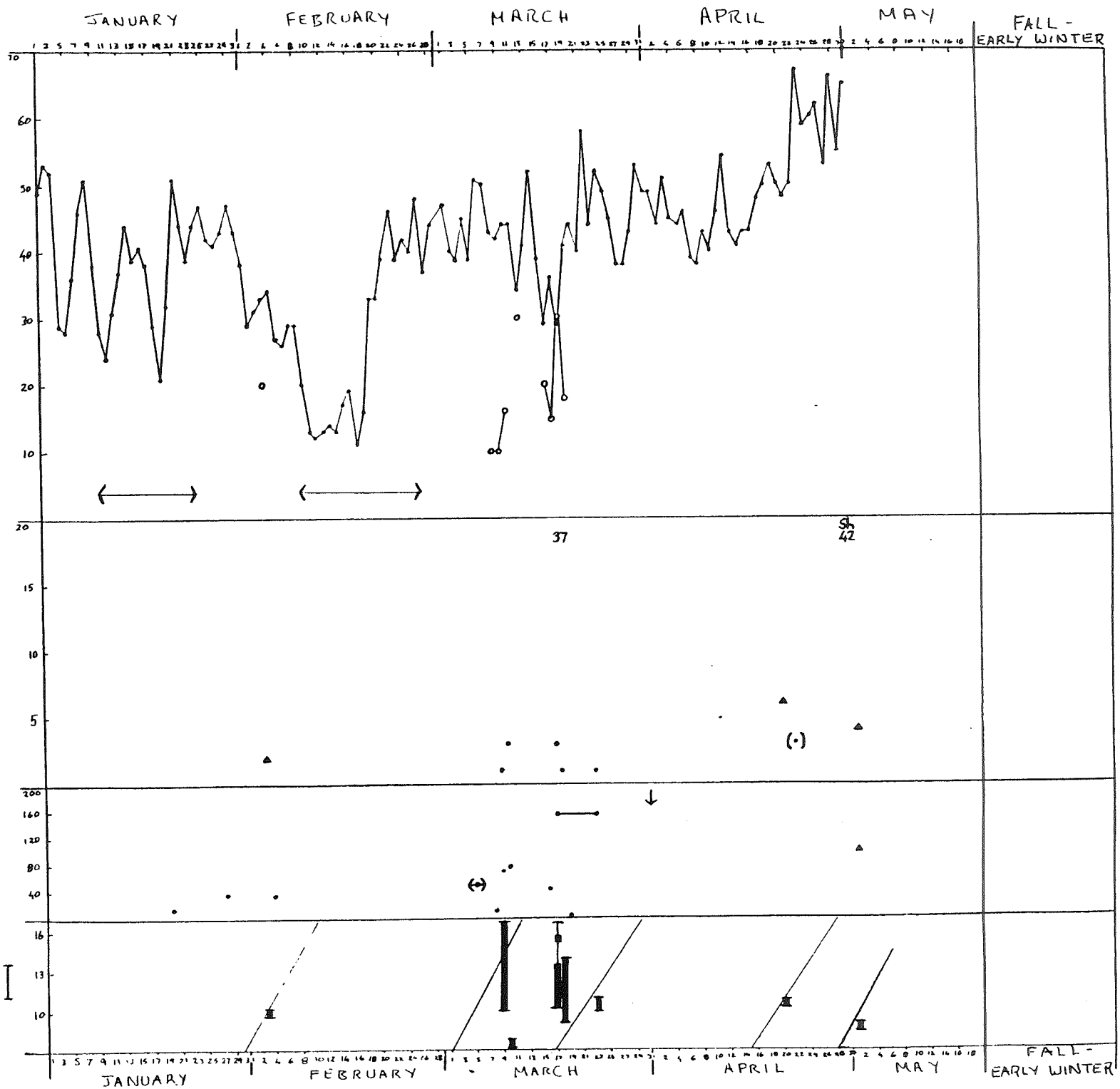

JANUARY
FEBRUARY
MARCH
APRIL
MAY
FALL - EARLY WINTER
1979
AIR TEMPERATURE IN DEGREES F AT 1000*
WIND VELOCITY IN M.P.H. AT 1000
= ICE
WATER TEMPERATURE °F
Sh = NANTUCKET SHOALS WATER TEMP.
37
Sh 42
NO. OF GREY SEALS
0 = INCLUDES PUP(S)
▲ = AERIAL COUNT
( ) = APPROXIMATE COUNT
START ALEWIFE RUN
NO. OF HARBOR SEALS
▲ = AERIAL COUNT
00 HOURS
DURATION OF GREY SEAL SIGHTING
DURATION OF OBSERVATION
DIAGONAL LINE = LOW TIDE

FIGURE 18

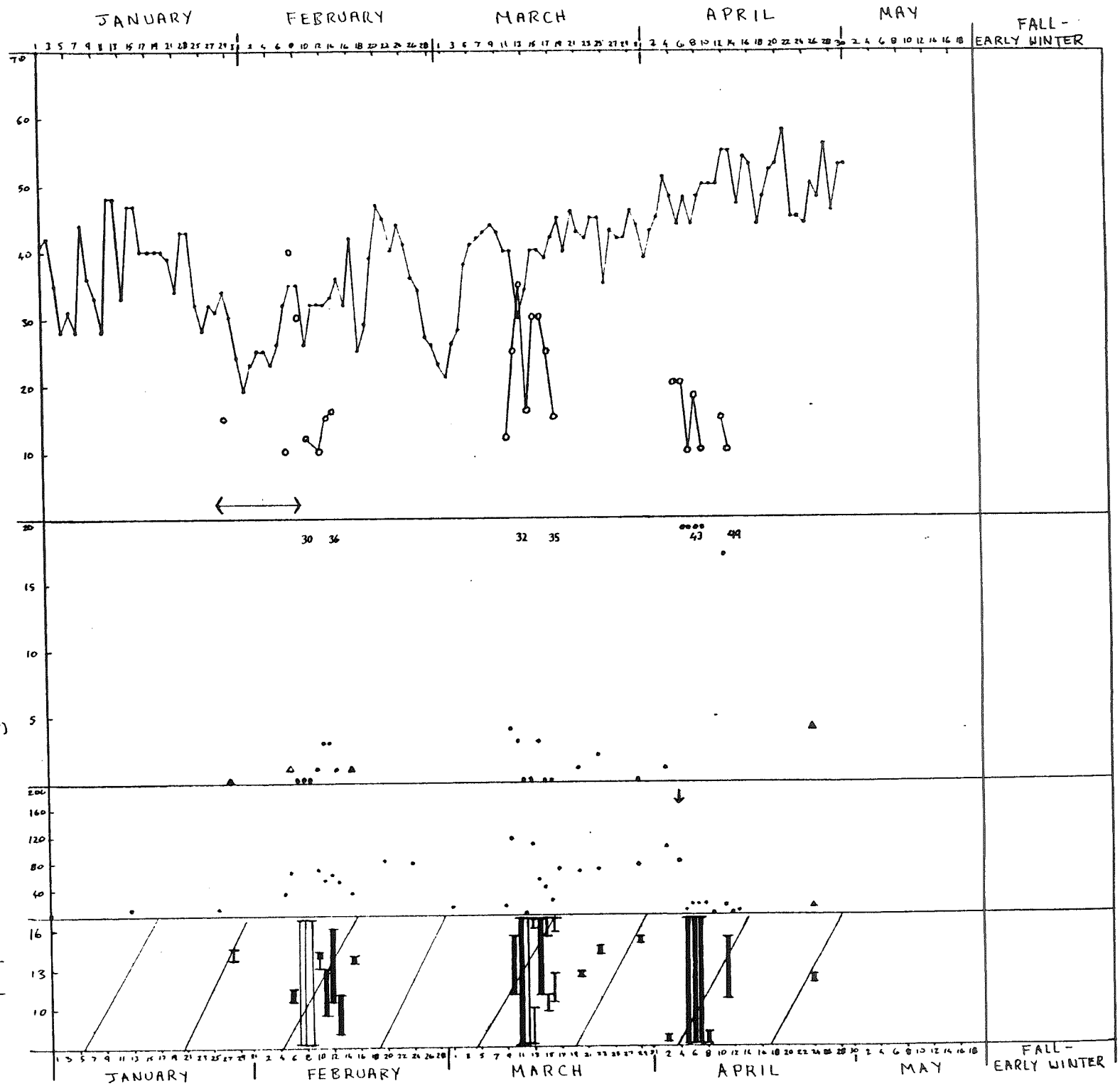
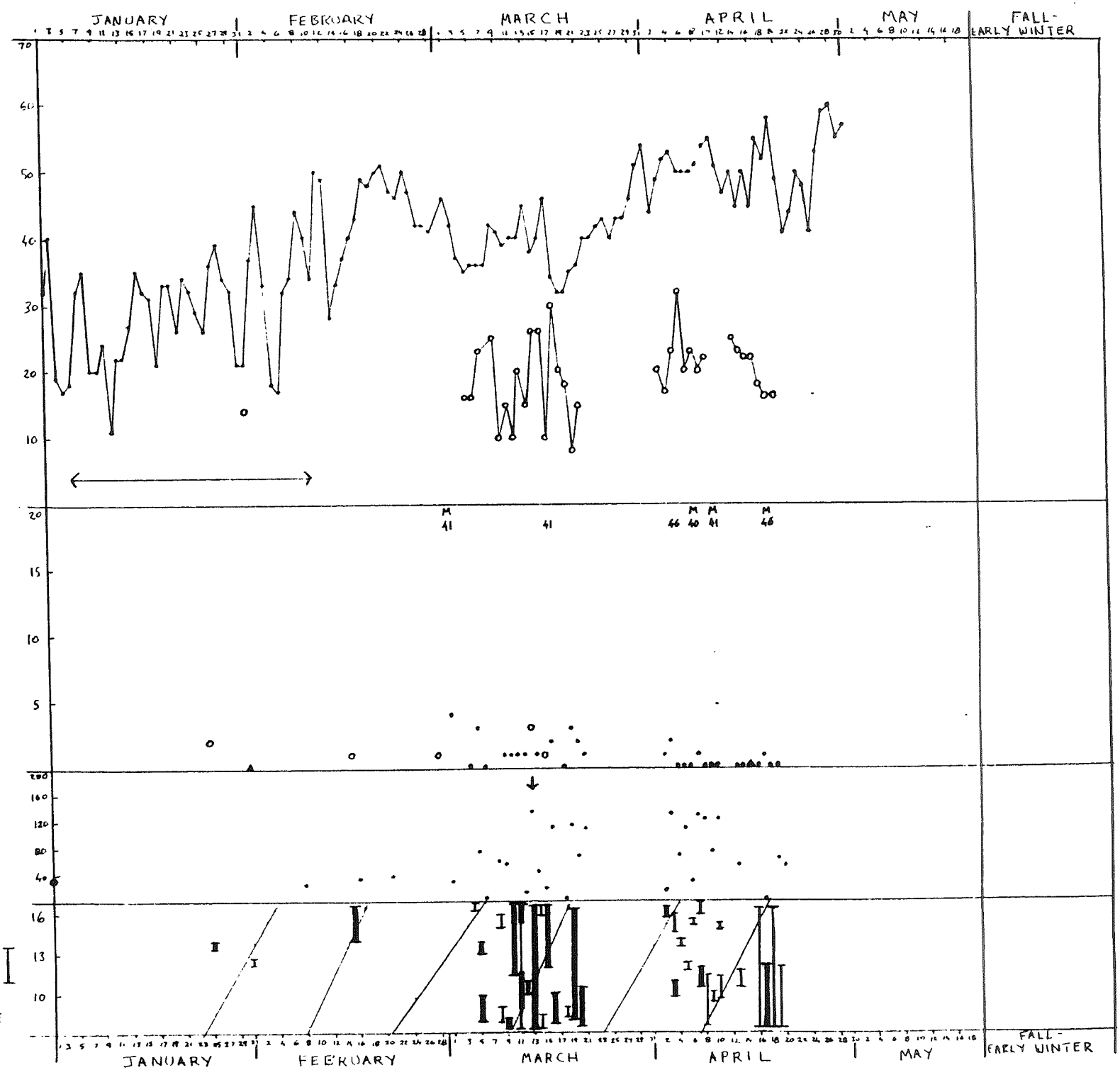

JANUARY
FEBRUARY
MARCH
APRIL
MAY
FALL - EARLY WINTER
1980
AIR TEMPERATURE IN DEGREES F AT 1000*
WIND VELOCITY IN M.P.H. AT 1000
= ICE
WATER TEMPERATURE °F
30 36
32 35
43 49
NO. OF GREY SEALS
0 = INCLUDES PUP(S)
▲ = AERIAL COUNT
△ = AERIAL COUNT OF PUP(S)
START ALEWIFE RUN
NO. OF HARBOR SEALS
▲ = AERIAL COUNT
00 HOURS
DURATION OF GREY SEAL SIGHTING
DURATION OF OBSERVATION
DIAGONAL LINE = LOW TIDE

FIGURE 19

1981



Population size

Mansfield and Beck (1977) estimate size of the Canadian grey seal colonies using a multiplication factor: 3.7 x number of pups equals number of seals one year or older.

The factor, derived from life tables developed by Mansfield and Beck (1977), is useful at the large Canadian colonies where significant numbers of pups are born every year. Pups are produced irregularly and in small numbers at Nantucket; a multiplication factor might not be applicable there.

A more or less consistent feature in the annual cycle of the Nantucket seals is a large haulout in early spring. Seals of all ages and both sexes are present at this assembly, which may be associated with the annual molt, and a high count is then possible. Table 3 and Figure 20 give high counts, where available, for each year 1961 to 1981. Note that the 1962 and 1963 counts were made in November and perhaps, in light of winter counts of previous years, are underestimates of herd size. Note also (Table 3) that haulout location may vary from year to year.

Figure 20 gives high counts of harbor seals as well as high counts of grey seals. The two species show similar trends, declining from respective high numbers in the early 1960's to apparent lows in the mid 1970's, followed by a resurgence of grey seals in 1980, and of harbor seals since 1979.

In 1981 the study area was poorly surveyed due to bad weather and funds shortage. The spring haulout was not located, so the count of 5 should be considered a minimum. The unpredictablity of the spring haulout is a drawback to its use. Furthermore, according to Mansfield and Beck (1977), counts outside the breeding season underestimate total numbers, at least in Canada. Mansfield and Beck do not mention a large spring haulout, nor do they discuss seasonal variations in haulout numbers, as does Cameron (1970), who

TABLE 3

Highest annual counts of grey seals in the Nantucket area, 1961-1981.

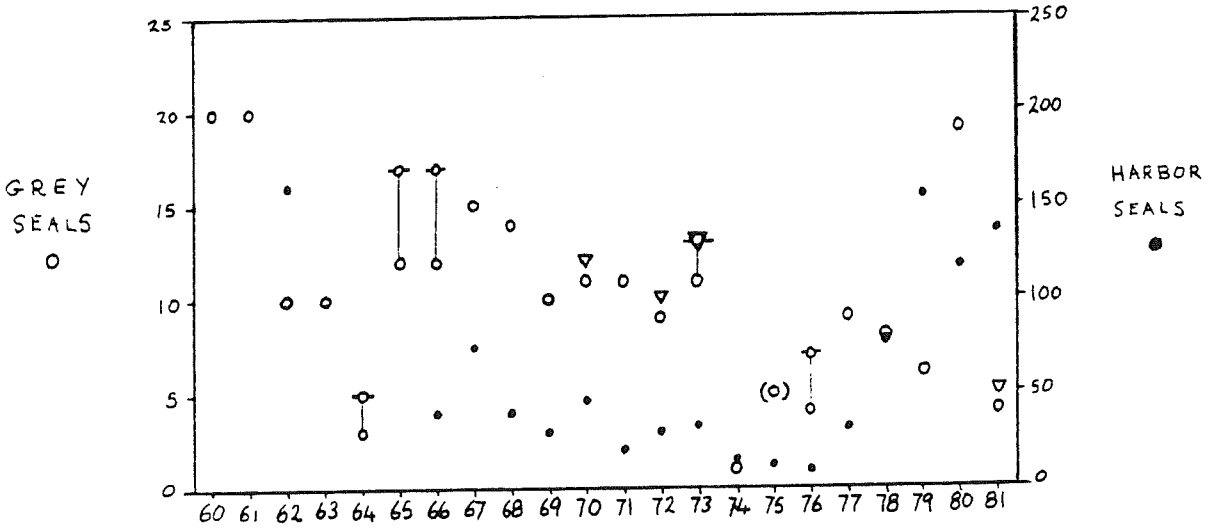
DATE	LOCATION	HIGHEST SINGLE COUNT	MAXIMUM COUNT*
Several winters through 1961	Shoal E of Tuckernuck	20	
1962 Nov 7	Shoal off Eel Pt.	10	
1963 Nov	Shoal off Eel Pt.	10	
1964	Shoal at Muskeget	3-5	
1965 Apr	Shoal between Tuckernuck & Muskeget	12-17	
1966 Apr	Shoal between Tuckernuck & Muskeget	12-17	
1967 Apr 13	Shoal NE of Muskeget	15	
1968 Mar 21-27	SW Pt., Muskeget	14	
1969 Apr 13	Shoal NE of Muskeget	10	
1970 Apr 8	Shoal S of Tuckernuck	11	12
1971 Apr 27	Shoal NW of Muskeget	11	
1972 Mar 21	Shoal S of Tuckernuck	9	10
1973 Mar 16	Shoal S of Tuckernuck	11-13	13
1974	--- INSUFFICIENT OBSERVATION ---		
1975 Apr 8	Shoal NE of Muskeget	Several	
1976 Feb 21	Bigelow's Pt., Tuckernuck	4-7	
1977 Mar 20	Shoal NW of Muskeget	9	
1978 Mar 30	Wasque shoals and shoal NE of Muskeget	8	
1979 Apr 20	Wasque shoal	6	
1980 Apr 5-8	Shoal NW of Muskeget	19	
1981 Mar 1	Esther Is.	4	5

*Maximum number of individuals, tallied from two or more sightings.

describes a springtime concentration of 300 grey seals at the Basque Islands. Seals continually arrive and leave at the haulout there, but the situation at Nantucket may be more stable; for example in 1980 the same 19 seals were seen on four consecutive days in early April. Spring counts undoubtedly will continue to provide the best estimate of herd size at Nantucket.

Figure 20

HIGHEST ANNUAL COUNTS



o Minimum number of grey seals - single sighting

-o- Maximum possible number of grey seals - single sighting

(o) Approximate number of grey seals - single sighting

▽ Maximum number of grey seals inferred by tallying individuals - two or more sightings

• Harbor seals - highest single count

Pups

Clinton Andrews' report of 4 mummified pup carcasses at Muskeget one year in the early 1950's is the only information on pup production during that period. A few years later, when about 20 seals were seen in several winters on a shoal east of Tuckernuck, Andrews once saw two cows lying broadside to breaking waves, as though protecting pups in the manner described by Lockley (1966). He was too far away, however, to see if this was the case.

Data on pups in the study area since 1963 are given in Table 4 and Figures 21 and 22. Two categories of pups emerge: a) locally born, usually in whitecoat when first seen; and b) immigrant, usually molted at time of first sighting.

Nantucket pups, like their Canadian counterparts, are born in January and February, at remote islands or on sea ice. At island colonies in Canada, particularly Sable Island, about 60% of the pups are born by 21 January (Mansfield and Beck 1977). Figure 21 gives pup sighting dates rather than birth dates; the latter are estimated according to the development scale of Hewer (1974) and shown in Figure 22. If an exact date were available the three whitecoat pups at Muskeget in 1963 would be included in the January column of Figures 21 and 22. Even with the 1963 pups added the Nantucket peak seems to occur later than Sable's, but the sample is too small and the surveys are too incomplete to prove anything. Later pupping may be advantageous in the warmer climate of southern New England (see next section); it is also adaptive as the Massachusetts waterfowl hunting season, which affects Muskeget, lasts until mid-January in some years.

A normally developing grey seal pup stays at its birthplace, nursing regularly and more than doubling its birthweight of 30-38 lbs. by the time it is weaned at two to three weeks of age. The cow mates before weaning and after weaning abandons her pup. In the next stage the natal fur is gradually shed and replaced by

TABLE 4 Grey seal pups seen in the Nantucket area 1963 - 1981

DATE	LOCATION	STATUS	SOURCE*	REMARKS
1963 Jan	SW Pt., Muskeget	3 whitecoat pups	L	1 taken to Madaket; died in private home.
1965 Feb 14	Oak Bluffs, Martha's Vineyard	Whitecoat	L	Died in private home.
1967 Feb 1	NE end, Muskeget	Whitecoat	L	
1968 Jan 23	SW Pt., Muskeget	Whitecoat, male	L	Cow "C".
1969 Feb 1	SW Pt., Muskeget	Whitecoat, male	L	Dead; very thin.
1970 Jan 25	Jetties Beach, Nantucket Harbor	Uncertain; molted	U	Pup or yearling?
1970 Feb 7	SW Pt., Muskeget	Whitecoat, female	L	Cow "C" (see 1968).
1971 Mar 10	Sconset Beach, Nantucket	Molted	SI	Branded "S1".
1971				See Table 5.
1972 Mar 12	Near Sconset	Whitecoat	U	Probably 6 wks old.
1973 Mar 20	Cisco Beach, Nantucket	Whitecoat	U	Probably 6 wks old.
1975 Apr 25	Dennisport Beach, Cape Cod	Female; molted	U	Emaciated; died.
1976 Apr 11	Sconset and Tom Nevers, Nantucket	Molted	U	
1977 Mar 20-22	NW Shoal, Muskeget	Molted	U	
1977 Apr 21	West Dennis Beach, Cape Cod	Molted, male	SI	Tagged. Now at Sea-land of Cape Cod.
1980 Feb 6	SW Pt., Muskeget	Whitecoat	L	Aerial sighting.
1980 Apr 5-8	NW Shoal, Muskeget	Molted	U	
1981 Jan 25	Ice outside Nantucket Harbor	Whitecoat	L	Distant sighting.
1981 Feb 15	Chappaquiddick, Martha's Vineyard	Whitecoat, male	L	Stranded and died.
1981 Feb 28	Sankaty, Nantucket	Molted	SI	Tagged; about 50 lbs.
1981 Mar 13	Cisco Beach, Nantucket	Molted	SI	Tagged; about 40 lbs.
1981 Mar 15	Nobadeer, Nantucket	Molted	SI	Tagged; about 40 lbs. Same as seen 13 Mar?

*Source: L - probably locally born SI - born at Sable Is. U - source unknown

N.B. All pups born at Sable Island since 1977 were tagged.

Figure 21

Dates of first sightings of pups 1965 - 1981

o whitecoat
● molted

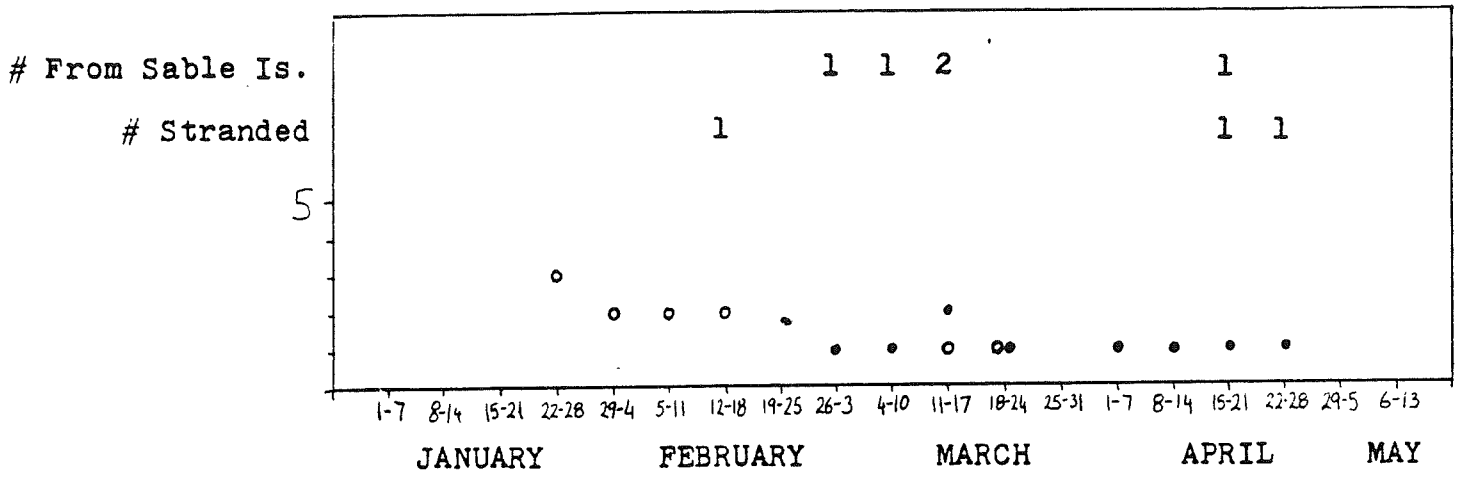
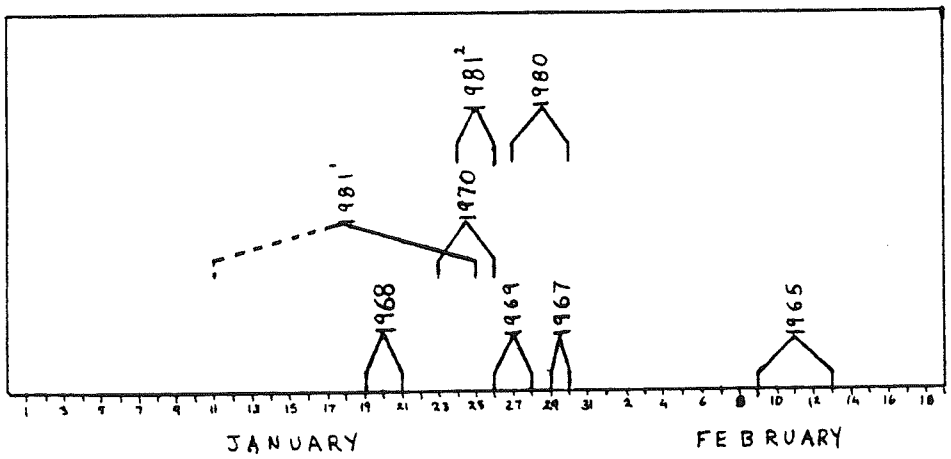


Figure 22

Approximate birth dates of pups seen in study area



Brackets indicate a range of possible dates

1981¹ - 25 January, outside Nantucket Harbor
1981² - 15 February, Chappaquiddick

the adult type coat. The pup then goes to sea if it has not done so already. At Sable Island weaned pups may lie ashore for several weeks while the first molt is completed (Mansfield 1966).

Molted pups, including immigrants, appear in the Nantucket area from late February until May. All the known immigrants were born at Sable Island, where a pup marking program has been carried out since 1969. Since 1977 every surviving Sable pup was tagged. It is likely some of the pre-1977 pups in the unknown source category of Table 4 came from Sable, as they behaved similarly to the immigrants. Typically a Sable Island pup comes ashore somewhere along Nantucket's south or southeast coast, apparently to rest, as though making landfall after a long journey. The seal often is oblivious to human presence while it rests, and if healthy leaves in a day or two. This pattern was followed by unknown source pups from 1971 to 1976, two of which were still in whitecoat, one ashore at Sconset 12 March 1972, and another at Cisco 20 March 1973. Andrews believes the two were about six weeks old; lanugo molt may be delayed in undernourished pups (Hewer 1974).

In contrast, the molted pups of March 1977 and April 1980 were untagged and first sighted with the herd at Muskeget, suggesting possible local birth. Figure 21 and Table 4 may include repeat sightings of a pup within a year, which is unavoidable in dealing with unmarked seals; the molted pup of April 1980 could have been the same one sighted 6 February 1980 in whitecoat.

Table 5 gives other recruitment evidence pertaining to seals one year or older. Note that plastic tags may not last longer than one year; permanent brands are far more useful for determining long term recruitment of Sable Island seals to Nantucket.

Table 6 lists pups found elsewhere in Massachusetts, most significant of which is a pup at Provincetown 10 February 1978, in whitecoat and retaining the umblical cord, evidently less than three days old. It probably was born somewhere in Massachusetts

TABLE 5

Other evidence of recruitment

YEAR OF BIRTH	DATE OF SIGHTING	LOCATION	SEALS SEEN
1971	25 Feb 1972	Shoal S of Tuckernuck	Yearling
1971	25 Feb 1972	Shoal S of Tuckernuck	Branded "S1"
1971	6-11 Apr 1980	NW Shoal, Muskeget	Branded "S1" (same as seen 25 Feb 1972?)
1972	13 Jan 1973	Shoal S of Tuckernuck	Yearling
1972	13 Dec 1973	North Pond, Tuckernuck	Branded "S2"; dead
1972	21 Feb 1976	Bigelow Pt., Tuckernuck	Branded "S2"
1978	11 Apr 1980	NW Shoal, Muskeget	Branded "S"

TABLE 6

Pups seen in other parts of Massachusetts

DATE	LOCATION	SOURCE*	STATUS AND CONDITION
1978 Feb 10	Hatches Harbor, Provincetown	L	Whitecoat, male. Died.
1979 Mar 17	Endicott Beach, Beverly	U	Molted female. Now at New England Aquarium.
1979 May 4	Nauset Inlet, Orleans	SI	Molted, tagged female. Died.
1980 Mar 4	Nauset Spit, Orleans	U	Whitecoat male. Died a week later.
1981 Mar 27	Nauset Spit, Orleans	SI	Molted, tagged. Very small; died after 2 days

*Source: L - probably locally born U - source unknown
SI - born at Sable Island

N.B. All pups born at Sable Island since 1977 were tagged.

TABLE 7

Tagged and branded grey seals seen or recovered at Nantucket - Cape Cod

DATE	LOCATION	BRAND OR TAG #	YEAR MARKED*	REMARKS
1971 Mar 10	Sconset, Nantucket	Brand S1	1971	
1972 Feb 25	Shoal S of Tuckernuck	Brand S1	1971	
1973 Dec 13	North Pond, Tuckernuck	Brand S2	1972	Dead
1976 Feb 21	Bigelow Pt., Tuckernuck	Brand S2	1972	
1977 Apr 21	West Dennis Beach	Turquoise tag # C414	1977	Male, stranded; now at Sealand
1979 May 4	Nauset Inlet, Orleans	Yellow tag # 1669	1979	Female; died
1980 Apr 6-11	NW Shoal, Muskeget	Brand S1	1971	Male
1980 Apr 11	NW Shoal, Muskeget	Brand S	1978	Female
1981 Feb 28	Sankaty, Nantucket	Black tag # 1410	1981	About 50 lbs.
1981 Mar 13	Cisco Beach, Nantucket	Black tag #	1981	About 40 lbs. # 1025, below?
1981 Mar 15	Nobadeer, Nantucket	Black tag # 1025	1981	About 40 lbs.
1981 Mar 27	Nauset Spit, Orleans	Black tag # 2006	1981	Very small; died

*All seals were marked at Sable Island, Nova Scotia

Bay, perhaps on ice broken up and carried to Provincetown during the northeast storm of 7 February. This is the only firm record of a pup born in New England outside the study area. The molted, tagless pup at Beverly in March 1979 is a possible candidate for New England birth. Nauset has had a stranded pup in three consecutive years, two immigrants and one in whitecoat without a tag, possibly New England born.

Table 7 lists all branded and tagged grey seals, including several pups, found in Massachusetts to date.

Pup mortality

First year mortality can be viewed in two stages, pre and post weaning. At British colonies the normal preweaning mortality is 10 to 15%, but at crowded breeding beaches such as those of the Farne Islands, density dependent mortality increases to give a total preweaning mortality of 15 to 20% (Hewer 1974). Studies of British colonies by Coulson and Hickling (1964) and Bonner (1975a) indicate all preweaning mortality above a value of about 8% is density dependent, while mortality below 8% is independent of crowding effects.

Preweaning or, more accurately here, premolting mortality at Sable Island ranged from 7 to 15.5% in four recent years, averaging 11.6%, based on data provided by B. Beck (pers. comm.). There is ample space for seals to spread out at Sable, so density dependent mortality likely is lower there than at some other island colonies in Canada, such as the Basques.

Postmolting mortality is not calculated directly. Total first year mortality in Britain is estimated by Hewer (1964) at 60%, and by Harwood and Prime (1978) at 33%. First year mortality in Canadian seals, inferred from the life tables of Mansfield and Beck (1977) is 49% in females and 55% in males.

The Nantucket data are too scanty to yield mortality rates; mortality factors are examined and discussed.

No stillborn pups were found in the study area.

Possible mortality risks to the newborn include congenital defects; starvation due to maternal inexperience or to separation from the mother caused by storms, crowding or human interference; storm related injuries; and crushing at densely crowded breeding sites. Chilling is another fatal risk. Before acquiring a subcutaneous layer of insulating blubber the pup depends on its lanugo to retain body heat, but the fur is effective only when dry; "avoidance of wetting at this time has considerable survival value" (Ling and Button 1975).

"Although newborn grey seals of the Baltic are able to swim on their first day of life, they do not normally enter the water until after they have completed their moult. They have difficulty climbing back onto ice floes and often succumb to the cold water which soaks them to the skin" (Ling and Button 1975).

Bud Loomis (pers. comm.) reports two instances in which newborn grey seal pups at Mystic Marinelife Aquarium suffered the consequences of premature wetting. One, after immersion at the age of one day, lost its hind flippers to frostbite, gangrene and amputation, but is still alive. The other, born with a liver infection, rapidly deteriorated after falling in a pool and soon died.

The very young pup at Provincetown 10 February 1978 was shivering when found, probably because of an earlier soaking. It died overnight.

Such observations suggest that avoidance of wet precipitation might be as critical as avoidance of immersion in the first days of life, and that ambient temperatures below 32° F might enhance survival. Information in Figures 5-19 and Figure 22 indicates Nantucket pups generally were born during subfreezing weather, often with sea ice present. Possibly time of pupping is adjustable to coincide with optimal conditions. Southern New England

may have considerable rain in winter, for example during the January thaw, a regular phenomenon occurring every year between late December and early February. Possibly freezing affects Nantucket Sound a few days later than the Canadian Maritimes, which could explain a slightly later peak pupping date at Nantucket.

Once it has a sufficient layer of blubber the pup can tolerate wetting of the pelage and skin. Blubber thickness is proportional to weight (Mansfield 1977). Bonner (1975a) reports that pups in crowded sections of the Farne Islands (Great Britain) gain about 2.6 lbs. per day, compared with 3.7 lbs. per day in uncrowded areas. He suggests a young seal which fails to attain 65 lbs. at weaning would be unlikely to survive the first winter. Sable Island pups, based on a sample of nine, grow larger and faster than their British counterparts, an average of 4.6 lbs. per day to final weight averaging 100 lbs. at day 14. One pup in the sample weighed 134 lbs. at day 12 (Mansfield 1977). Nursing at Sable Island lasts 14-16 days in contrast to 16-21 days in British pups (Bonner 1972). Only two Nantucket born pups were seen right after weaning, at Muskeget in 1968 and at Chappaquiddick in 1981. The 1968 pup was weaned at 15 to 18 days. Both pups were well filled out and weighed at least 75 lbs.

Table 8 gives information on dead pups from the study area, with both pre and post molting stages represented. Misadventure, infection due to injury, abscesses, and disease can be added to the previous list of mortality factors.

A bolus of fish scales in the throat of the 1975 Dennisport pup was perhaps secondary as a cause of death, however the 1977 West Dennis pup was unable to eat because of a flounder bone in its throat and might have died but for its removal. The seal is still alive at Sealand of Cape Cod, Brewster, Mass.

Human predation on grey seal pups is an ancient practice. Young seals were hunted originally for food and leather, but more recently they are taken for bounty or as part of culling operations conducted yearly at some British and Canadian colonies.

The Nauset pups in Table 8 illustrate other human impacts. The 1979 pup succumbed to infection at the tag site in the hind flipper; the 1980 pup was injured by either dogs or gulls, both companions to civilization; and the 1981 pup, perhaps already on the decline, had its suffering cut short by a beach vehicle.

Note that all the pups but one in Table 8 were of suboptimum weight, the exception being the 1981 pup at Chappaquiddick. It weighed 75 lbs. and was apparently healthy until suddenly overtaken, presumably by disease. Mycoplasmic pneumonia and viral influenza which killed several hundred harbor seals in Massachusetts in 1980 are suspected, but tests are incomplete. Brian Beck (pers. comm.) reports evidence that Canadian grey seals were exposed to the harbor seal disease but not severly affected by it.

It is worth noting here the condition of several immigrant pups which did not die, including: two possibly immigrant, apparently undernourished (in whitecoat at about 6 weeks) in March 1972 and March 1973 (previously cited); the pup at West Dennis, April 1977, weighing about 50 lbs.; and 2 or 3 at Nantucket in February and March 1981, ranging from 40 to 50 lbs. The connection between immigrant status and low weight or poor nourishment is not clear. The Sable Island marking program, in addition to conferring the risk of tag-induced infection, may have other detrimental impacts on pups there.

Pup mobility

Sable Island pups reaching Nantucket may travel almost 700 miles, assuming they enter the counter-clockwise Gulf of Maine gyre after leaving Cape Sable. The estimated distances are: 275 miles Sable Is. to Cape Sable; 350 miles to circuit the Gulf of Maine; 70 miles Provincetown to Nantucket. Maximum travel times are: 1971 (brand S1) - 33 days; 1977 (tag C414) - 90 days; 1981, 28 February (tag 7410) - 24 days; 1981, 15 March (tag 7025) - 39 days. The fastest time, 24 days, indicates an average of about 28 miles travelled per day.

TABLE 8

Mortality factors in pups

DATE	LOCATION	SEX	STATUS	FINDINGS	TENTATIVE DIAGNOSIS - CAUSE OF DEATH
*1969 Feb 1	Muskeget	M	Whitecoat	Std. lgth. 99cm, hind flipper 23cm; wt. 25 lbs (11.3kg). Very thin; intestine full of sand. Extensive hemmorhaging down right side; skin worn off back in patches. No parasites seen	Starvation. Low birth wt. a factor? Apparently battered by waves.
1975 Apr 25	Dennisport	F	Molted	Std. lgth. 99cm, hind flipper 24cm; wt. 45 lbs (20.4kg). BT .3cm. Emaciated; large bolus fish scales in oesophagus. Large chest abscess. No parasites mentioned.	None stated.
*1978 Feb 10	Provincetown	M	Whitecoat, still had umbilical cord	Shivering when found. Std. lgth. 108cm, hind flipper 22cm; wt. 44 lbs (20kg). BT 1cm. Emaciated. Congestion along rugal folds of stomach. No parasites mentioned.	None stated. Starvation? Chilling probably a factor.
1979 May 4	Nauset	F	Molted	Std. lgth. 108cm, hind flipper 24cm; wt. ca. 60 lbs (27kg). BT 1cm. Tagged (Sable Is.). Abscess along right dorsal flank; ascending infection from tag site. Tendinovaginitis. Parasites: heart, lung and stomach worms.	Aspiration of vomitus; parasites; purulent myositis, tendonitis and taenovaginitis, induced by tag.
†1980 Mar 4	Nauset	M	Whitecoat	Std. lgth. 101cm, hind flipper 28cm; wt. 52 lbs (23.5kg). BT .7cm. Puncture wounds on back (from dogs or gulls); lived 7 days while back became infected. No parasites mentioned.	None stated. Death probably due to the infection.
*1981 Feb 15	Chappaquiddick	M	Whitecoat	Std. lgth. 113cm, hind flipper 27cm; 75 lbs (34kg). No visible lesions generally, except for hemorrhaging in adrenal. No parasites mentioned.	Possible peracute pneumonia. Possible viral influenza.
1981 Mar 27	Nauset			Tagged (Sable Is.). Very small. Apparently struck by beach vehicle.	None available; vehicle impact.

* locally born † probably locally born BT blubber thickness (mid ventral)

1969 data from Andrews and Schurman; 1975, 1978 data from Sealand of Cape Cod and New England Aquarium; 1979, 1980 and 1981 (Chappaquiddick) data from New England Aquarium; 1980 data also from R. Prescott, 1981 data also from C. Ben David, 1981 (Nauset) data from Sealand

Population dynamics

Grey seal stocks in Britain and Canada expanded in the last 20 years, while Nantucket's population declined and rebounded, resulting in numbers unchanged from 20 years ago.

The Canadian growth is most apparent at Sable Island, where an 11% annual increase in pup production observed between 1962 and 1976 continues. A similar increase occurred at the Basque Islands between 1962 and 1967, before the advent of annual pup culls (Mansfield and Beck 1977, B. Beck pers. comm.). In Britain the overall yearly growth rate is 7%, and 9% at the Farne Islands (Harwood and Prime 1978).

The Canadian stock multiplier is 3.7, based on life tables assuming a stationary population (Mansfield and Beck 1977), and the multiplier for the British stock, similarly derived (Hewer 1964), and generally accepted (e.g. Bonner 1976), is 3.5. Harwood and Prime (1978), using Leslie matrix notation for survival and fecundity values, and assuming a growing population, propose a range of 3.5 to 4.5 for increasing populations in Britain, and suggest a "wide range of values may be appropriate for decreasing or stationary populations."

The limited Nantucket data warrant further study. Figure 20 and Tables 3 and 4 show, for overall numbers 1960 to 1980, a 1960's peak, a 1970's trough, and a 1980's peak, and parallel trends in local pupping, i.e. 1-3 native pups a year in the 1960's and 1980's, and none during several years in the 1970's. The parallel trend does not mean a valid multiplier exists, but the possibilities may be explored. If a multiplier could be hypothesized using the yearly data from Nantucket, it would range from 6 to 14, and average about 10. Andrews counted 40 seals in the late 1940's, and, one year in the early 1950's, 4 pups, suggesting a ratio of 10:1 might have some foundation in reality. What are the implications of a multiplier as large as 10?

A multiplier of 10 implies little or no growth, and this was observed. Possible explanations for an apparent value of 10 are:

a) some pups were missed in the surveys;

b) low pup production;

c) high adult survival rates.

It is difficult to know how many pups were missed due to incomplete survey coverage. Muskeget, the traditional site, was monitored in several breeding seasons, but any births on sea ice would have been hard to find without extensive aerial reconnaissance. The overall lack of population growth, and the observed small proportion of younger relative to older seals (see below), suggest pup production is not much greater than recorded in the available data.

Herd composition as known for most years 1968 to 1981 is shown in Table 9. Grey seal specimens usually are aged by counting rings in canine tooth cementum (after Hewer 1964), not a useful field method, however sex and broad age categories can be recognized in the field, and these, for present purposes, are designated as follows: Males - juvenile 1-3 years; adolescent 4-7 years; mature 8 years and older; females - juvenile 1-3 years; adolescent 4-6 years; mature 7 years and older.

Table 9 data are pooled into three 3-year groups, using years with status of most or all seals documented. Table 10 gives average percentages of males and females in the different age categories in three periods, "early" (1968, 1969 and 1970), "middle" (1971, 1972 and 1973) and "late" (1977, 1978 and 1980), compared with appropriate percentages from the life tables of Mansfield and Beck (1977) as the standard. The "early" period saw the tapering of 1960's high counts; the "middle" period immediately preceded the years of lowest numbers; and the "late" period includes two years of low counts and the high count of 1980, possibly marking the start of a new growth phase.

TABLE 9

Group composition 1967 - 1981*

1967

	M	F
M	2	1
A	1	1
J		
P		

1968

	M	F
M	3	4 (1 old)
A	1	3
J	2	1
P		1

1969

	M	F
M	1	2
A		1
J	2	3
P		

Both sexes, all ages present 13 April

1970

	M	F
M	1	3 (1 old)
A	3	1
J	1	2
P	1	

1971

	M	F
M	2	3 (1 old)
A	1	1
J	1	2
P	1	

1972

	M	F
M	2	3 (1 old)
A	1	1
J		2
P	1	

1973

	M	F
M	1	2
A	1	1
J	1	1
P	1	

1975

	M	F
M		3
A		
J	2	
P		

1977

	M	F
M	1	2
A	2	1
J	1	1
P	1	

1978

	M	F
M	1	1
A	1	
J	1	
P		

1979

	M	F
M	1	1
A		
J	2	2
P		

1980

	M	F
M	4	4
A	3	3
J	2	2
P	1	

1981

	M	F
M	1	2
A	1	1
J		
P		

Legend: M, F - Male, female
M, A, J, P - mature, adolescent, juvenile, pup

*1974 and 1976 omitted because of inadequate data

TABLE 10

Average percentages of juvenile, adolescent, and mature seals of both sexes in three periods between 1968 and 1980, compared to percentages in the life tables of Mansfield and Beck (1977)*.

1968, 1969 and 1970

	J	A	M
M	36	28	36
F	30	25	45

1971, 1972 and 1973

	J	A	M
M	33	25	42
F	21.5	21.5	57

1977, 1979 and 1980

	J	A	M
M	25	37.5	37.5
F	31	25	44

Mansfield and Beck (1977)

	J	A	M
M	34	34	32
F	35	29	36

*Assume categories represent ages thus:

	J	A	M	
M	1-3	4-7	8-	years
F	1-3	4-6	7-	years

The percentages in Table 10 are entirely without statistical significance, and are presented for illustration and comparison only. The Nantucket age structure apparently is weighted toward older animals, particularly among females, in all three periods compared to the age distribution of the standard. The skewed distribution is most pronounced in the "middle" period, as might be expected.

The information in Tables 9 and 10 supports no conclusions, but is generally consistent with a low pupping rate and possibly relatively high adult survival rates. The sexes are present in a ratio of about 1:1, and we may infer a pregnancy rate lower than known for the larger stocks.

Life table parameters and other vital statistics of British and Canadian grey seals are summarized below in Tables 11 and 12. The British data other than Hewer's are drawn largely from studies at the Farne Islands.

One of the hardest factors to determine, because of dispersal, is first year mortality. Estimates of this value, again, are Britain 60% (Hewer 1964) and 33% (Harwood and Prime 1978); Canada 49% in females and 55% in males (Mansfield and Beck 1977). The life table models of Mansfield and Beck (1977) and Harwood and Prime (1978) assume annual survival rates from 1 to 4 years are about equal to those of 5 or 10 year old seals (Table 11). However Hewer (1964) assumed 30% mortality at age 2, 12% at age 3, and 6.7% at age 4, in both sexes. Thus estimated survival rates to age 5 are Britain 21.3% (Hewer 1964) and 49% (Harwood and Prime), and Canada 28.8% in females, 27.5% in males.

The Canadian life table data, based on samples shot throughout the year, are more reliable than British data based on samples shot at rookeries during the breeding season. Rookery samples, obviously, represent breeding stock and not younger age classes. The resultant lack of information may explain the discrepancies among survival values assigned to 0-5 year old British seals. Survival values for older seals, being more accurately derived, are more similar between the various stocks.

TABLE 11

Longevity

	Canada[1]		Britain and Europe[2,3,4]		
	Normal	Maximum	Normal	Maximum	
Male	30		26	41	years
Female	45		38	46	years

Annual survival rate

Canada[1] (population assumed stationary)

Age	5	10	15	20	25	30	35	40	45	years
Male	88	87.2	85.1	80.6	66.6	0				%
Female	86.5	86.4	86.8	87.9	81.2	85.7	66.6	100		%

Britain[2] (population assumed stationary)

Male	93.3	60	60	60						%
Female	93.3	93.3	93.3	93.3	93.3	93.3				%

Britain[5] (population assumed increasing)

Male		80	80	80	80					%
Female		93.5	93.5	93.5	93.5	93.5	93.5			%

Annual adult pregnancy rate assumed for above survival rates

Canada[1] 85% Britain[2] 80% Britain[5] 90%

Britain[2] survival and pregnancy rates were assumed from those of Northern fur seals (Callorhinus ursinus).

Age of first pregnancy and age specific pregnancy rates

Canada[1]		Britain[5]	
Age	% pregnant	Age	% pregnant
3	16	3	
4	71	4	
5	89*	5	16
6	85	6	59
7	85	7	90
8	85	8	90

* Sample size 9 seals; 85% pregnancy rate at age 5 assumed in life table.

1. Mansfield and Beck (1977)
2. Hewer (1964)
3. Bonner (1971)
4. Platt et al (1975)
5. Harwood and Prime (1978)

TABLE 11 continued

Male reproductive data

Canada[1a]		Britain[2,5]	
Age of puberty	Age of tenure at breeding grounds	Age of puberty	Age of tenure at breeding grounds
3-4	10	5	10

Ratio of males to females at breeding grounds

Canada[6,7]		Britain[8]
Basque Is	Sable Is.	
1:4-1:6	1:1-1:2	1:2-1:15

Brian Beck (pers. comm.) has informed the author the British life table data were obtained from older than average stocks, and the age of grey seal puberty is 3-4 years in both sexes worldwide. A bias towards older animals in the British data might account for the reported high adult survival compared to that observed in the Canadian grey seals. Similarly the assertion of Harwood and Prime (1978), that density-dependent effects on age of first pregnancy are insignificant, would have to be revised in light of Beck's information.

On the other hand Mansfield and Beck's (1977) life table data, predicated on a stationary population, may require modification to reflect the expanding nature of the Canadian stock.

1a. Brian Beck, personal communication
2. Hewer (1964)
5. Harwood and Prime (1978)
6. Mansfield (1966)
7. Boness and James (1979)
8. Hewer (1974)

TABLE 12

Grey seal measurements

Mean body weight

Age	5	10	15	20	25	30	35	40	45	years
Canada[1]										
Male	150	230	295	325	350					kg
Female	120	168	175	178	178					
Britain[4]										
Male	88	188	232	250						kg
Female	125	138	155	163	165	165				kg

Mean standard length

Canada[9]										
Male	206	223	226	230	229	225				cm
Female	179	195	199	198	193	207	202			cm
Britain[2]										
Male	193	234	244	249						cm
Female	183	206	211	213	213					cm
Britain[4]										
Male	183	198	210	212						cm
Female	162	178	180	182	185	185				cm

Mean skull length

Britain[2]						
Male	25.6	28.5	29.5	29.6	29.6	cm
Female	23.0	24.2	24.5	25.0	25.2	

1. Mansfield and Beck (1977)
2. Hewer (1964)
4. Platt et al (1975)
9. Mansfield (1977)

Two specimens from the study area

MCZ #51282 was found dead at Coskata, Nantucket, in late September 1958, by Clinton Andrews. The carcass was several days old when discovered. Andrews, noting the flesh seemed leaner and firmer than on a healthy seal, speculates death possibly resulted from an old birdshot wound which healed over, then became infected from the inside.

MCZ #51488 was shot at Naushon 6 February 1964, by an uninformed bounty hunter. Measurements and collection were made by the late Stanley Poole of Menemsha.

The Museum of Comparative Zoology at Harvard University provided canine teeth from both seals for sectioning. Arthur Spiess, Maine Historic Preservation Commission, performed the sectioning and made counts of cementum annuli to determine age. Statistics on the two specimens are presented in Table 13.

Both skulls are slightly larger than equivalent age British skulls (Table 12). Standard length of #51488 is consistent with length of 25-28 year old Canadian females (Mansfield 1977), and falls between the lower value of Platt et al (1975) and the higher one of Hewer (1964). Hewer may have used curvilinear rather than standard length, which would explain his large measurements, but there is no information on this. Weights given by Platt et al are smaller than corresponding weights of Canadian seals, indicating same age grey seals are larger in Canada than in Britain (Table 12), as noted by Mansfield (1977). The measurements of Platt et al, however, are of seals at the Farne Islands, which are slightly smaller than those of other British stocks. Measurements of the two Massachusetts specimens apparently conform to those of Canadian grey seals of the same ages.

Table 13

MCZ #51282 and MCZ #51488: vital statistics

MCZ #51282 Female. Age 15 years. Narrowing of annual cementum layers between 4th and 5th year.*

Skull length 25.4 cm Max. skull width 14.6 cm

Mandible length 17.0 cm

MCZ #51488 Female. Age 25-28 years. Narrowing of annual cementum layers between 6th and 7th (?) year, with some doubt as to location of dentin-cementum interface.*

Skull length 26.7 cm Max. skull width 16.5 cm

Mandible length 17.8 cm

Standard length 201.0 cm Max. girth 137.0 cm

Weight 167 kg (368 lbs)**

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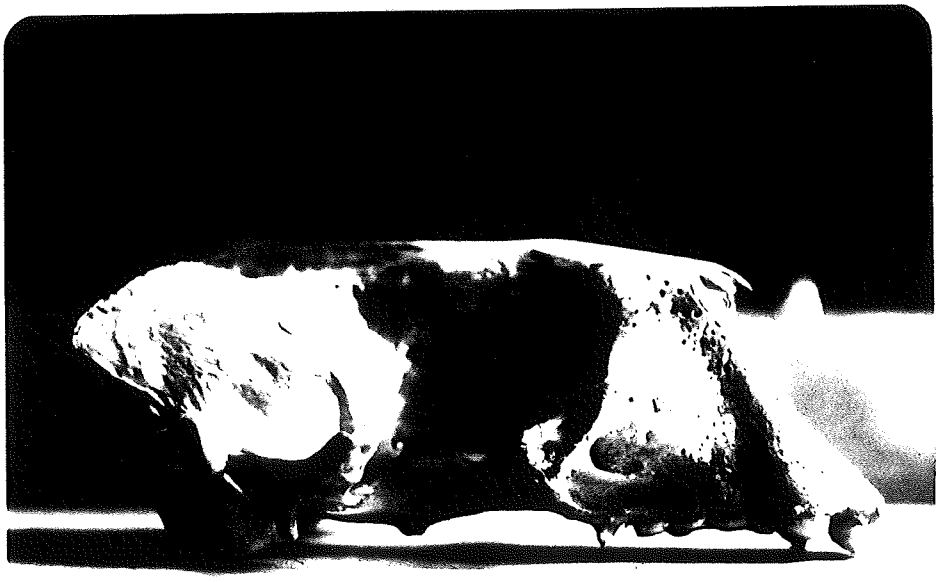
* Cementum bands narrow after 5 or 6 layers in cows and after 6 or 7 in bulls (Hewer 1974). The narrowing has been interpreted widely as marking the age of puberty, or, in females, the age of first pregnancy (Bonner 1971, Laws 1977, Harwood and Prime 1978). Brian Beck (pers. comm.) however states that annulus narrowing marks the end of the young seal's rapid growth period and may or may not coincide with sexual maturity.

** Calculated from the formula developed for harbor seals by Boulva and McLaren (1979): Weight = $\text{Length}^{1.675} \times \text{Girth}^{1.213}/13774$ This formula was found to overestimate the weight of 4 young grey seals by an average of 18% (range 16-22%), so 18% was subtracted from the formula result to get the weight shown above.

MCZ #51282
Skull.

MCZ #51488
Note convex profile, characteristic of mature bulls and old cows.



MCZ #51488
Skull. Note worn condition of teeth.

Two other dead grey seals, older than one year, are recorded. One found dead at North Pond, Tuckernuck, on 13 December 1973, was branded at Sable Island in 1972. No information is available except an observer's report of worms crawling out of the body, suggesting parasites may have contributed to death. A young male came ashore at Rock Harbor, Orleans in late October 1980. It died in captivity within a month. The vital statistics are: standard length 145 cm; weight 155 lbs. (70.3 kg); mid-ventral blubber thickness 2.3 cm. Autopsy findings include hemorrhaging and congestion in lungs, lymphatic inflammation, scarring and opacity of the corneae, Phocanema in the digestive system, and nematodes in the pulmonary artery. The tentative diagnosis, pending test results, is acute viral influenza, possibly the same disease which afflicted harbor seals the previous year.

Climate and seasonal pattern

Grey seals in the study area follow a seasonal pattern similar to that described by Cameron (1970) at the Basque Islands.

The seals' diurnal cycle, attuned to the tides, varies seasonally at the Basques, but diurnal trends are not easy to establish at Nantucket where tidal range is three feet and tidal behavior over shallow depths is variable and strongly affected by winds. The grey seals' choice of haulout sites is somewhat unpredictable as stated earlier, and the nature of a particular site may dictate daily regime. The Muskeget shoals can be used only when exposed, at low tide when they are flattened, and for longer periods when more built up. The large shoals south of Tuckernuck are rarely submerged except in severest storms. A tiny islet of salt marsh peat at Esther Island is used by seals primarily at higher stages of the tide. In late winter of 1980 and 1981 a few grey seals basked there with 50-150 harbor seals. Observations on a few occasions in 1981 showed at low tide the harbor seals used a sandbar north of Eel Pt., leaving the peat unoccupied; but as water rose over the Eel Pt. shoal they moved to the higher peat.

Nantucket tides often deviate from printed schedules; for example an extreme low tide may last all day after a westerly wind has blown for 1 or 2 days or just before a wind shift to the east, according to Andrews.

The clearer seasonal pattern is considered next, in a climatic context where appropriate

Breeding season. The possible importance of frigid temperatures for thermal balance in the newborn pup was discussed earlier, and coldness has other advantages. Sea ice augments the area available for pupping and acts as a barrier to human interference during the most vulnerable stage of the annual cycle. Mansfield and Beck postulate that completion of a causeway across Canso Strait in

1955 may have led to greater ice stability in Georges Bay, Nova Scotia, and a consequent enhancement of reproductive success there. Failure of Gulf St. Lawrence ice is associated with high pup mortality at Amet Island, as breeding beaches then become crowded, and pups are subject to injuries from heavy seas and aggressive females, as well as crushing when young ice piles ashore (Mansfield and Beck 1977).

Relatively little reconnaissance was conducted in the study area during periods of fast ice, except when support for the necessary aerial surveys was provided, as in 1977. No pups were found then, but more such surveys are needed.

Pupping occurs in January and February, as described before, followed within three weeks by mating of the cow and attendant bull. Breeding season behavior was observed best in 1967 and 1968 at Muskeget. In each year cow, pup, and attendant bull (the same bull both years) were seen on at least three occasions. The adults spent most of the time in the water while the pup lay on the beach. Nursing (ashore) was relatively infrequent, once or twice during a four to six hour observation period, with no apparent relation to tide state, and brief, lasting 5 to 10 minutes. The cow, while in the water, watched the pup attentively. In addition to the bull, younger seals, often in pairs, lingered offshore.

In 1967 Andrews and Schurman saw the bull challenged, unsuccessfully, by a younger male. They saw the attendant bull mount the cow, and other preliminary approaches, but never witnessed copulation.

After weaning and mating the adult seals apparently leave the immediate area, as does the weaned pup once it has molted. In some years grey seals are seldom seen in mid and late February, but they were seen in 1972, 1973, 1975 and 1976. Cameron (1970) reports a late February dispersal from the Basque Islands, followed by a spring concentration from mid-April to mid-June, apparently associated with the molt. This too has a Nantucket counterpart.

Spring haulout and summer dispersal.

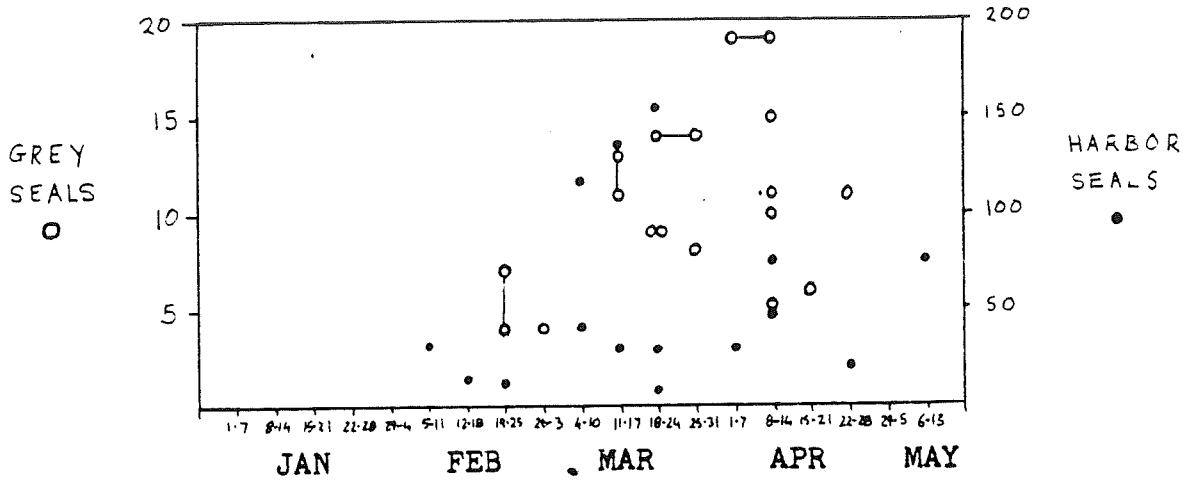
The Nantucket seals gather sometime between mid-March and early May, at one of several haulout sites (Table 3, Figures 23 and 24), and may stay for two to four weeks, or possibly longer. After about 1 May haulouts are disturbed by nearby boats fishing for striped bass. The number of shallow draft boats at Nantucket grew steadily in the last 20 years, and now the increased boating activity keeps the seals farther from shore and causes them to leave their haulouts earlier in the spring. Hagar saw a large concentration in June 1948, but this would be unlikely today.

Molting was observed on 12 April 1970, at Tuckernuck, and on 11 April 1980, at Muskeget. The literature contains scant information on the Canadian grey seal molt. In Britain females molt from January to March, and males from March to May (Hewer 1974). There is no such division, apparently, in the western North Atlantic populations. In Maine the author saw females at the end of molting on 22 May 1980, and both sexes molting heavily on 26 May 1981. Data from Jack Schneider on six captive grey seals at Mystic Marinelife Aquarium, Connecticut, confirm a single molting period for both sexes. Schneider reports: 1979, 1 male molted by 12 March, and 3 females and 2 males molting heavily on 11 April; 1980, males and females in various stages of molt on 16 March, and all molting heavily on 30 March; 1981, a male starting to molt, and a female molting heavily, on 10 March. Schneider's data also show that the relative timing of molt in individual seals varies from year to year.

Ambient temperature may influence the spring haulouts. Numbers of grey seals are plotted against air temperature, for most years 1967-1981, in Figure 25. There is a general positive correlation between the high counts, especially of 10 or more, and temperatures over 40° F. Figure 26, plotting numbers against available water temperatures, shows a similar correlation. Water temperature at time of molt at Nantucket, 12 April 1970 and 11 April 1980, was about 47° F. in both instances. Water temperature at times of molt in Maine were 44° F on 22 May 1980, and 49° F. on 26 May 1981.

Figure 23

Highest annual counts and their dates 1967 - 1981

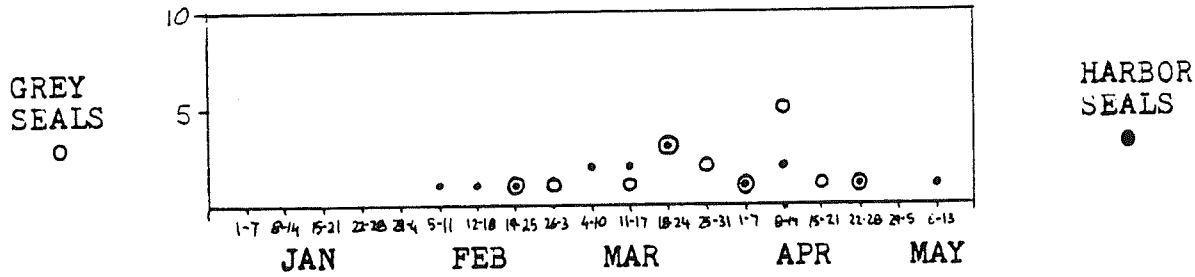


Vertical line between points = range of numbers

Horizontal line between points = extended time span

Figure 24

Dates of highest annual counts - frequency distribution 1967 - 1981



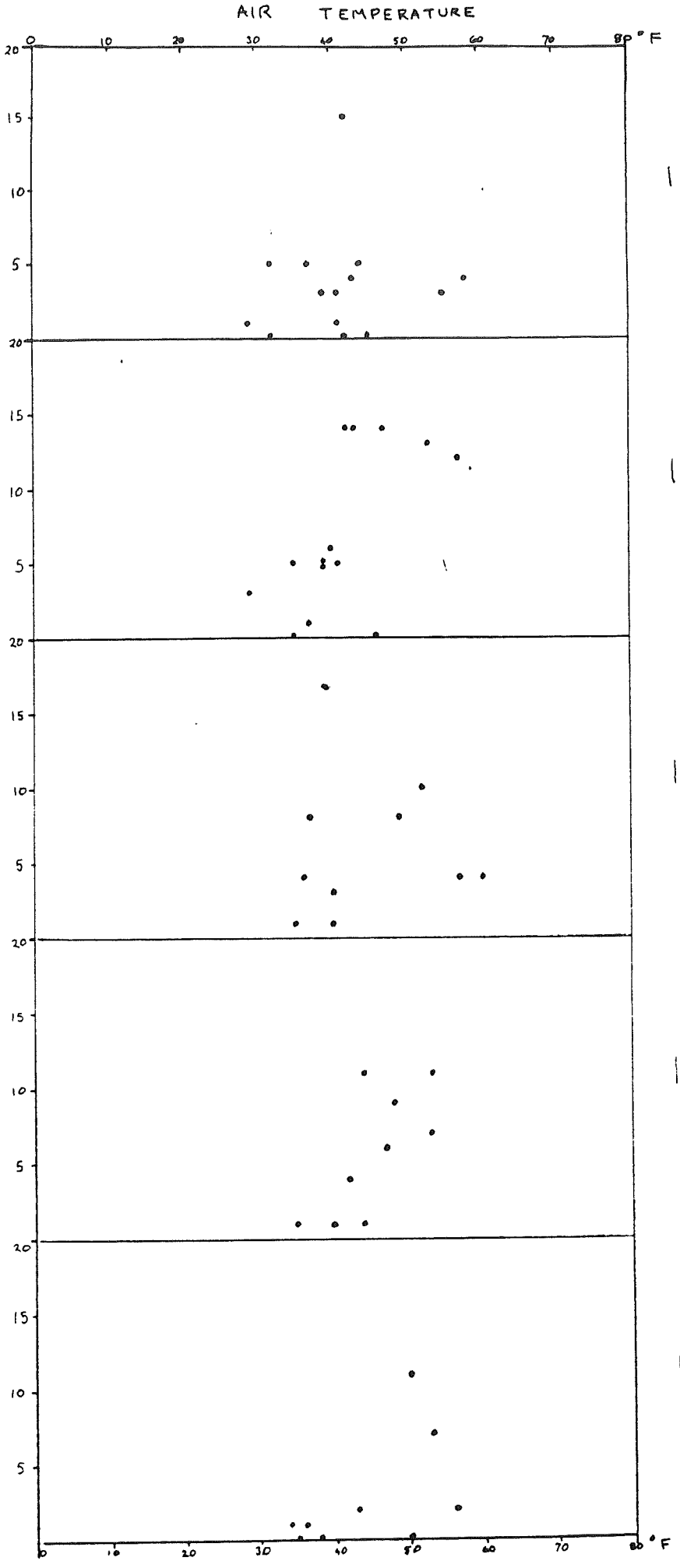


Figure 25a.

Numbers of grey seals and air temperature, from Figs. 5-19.

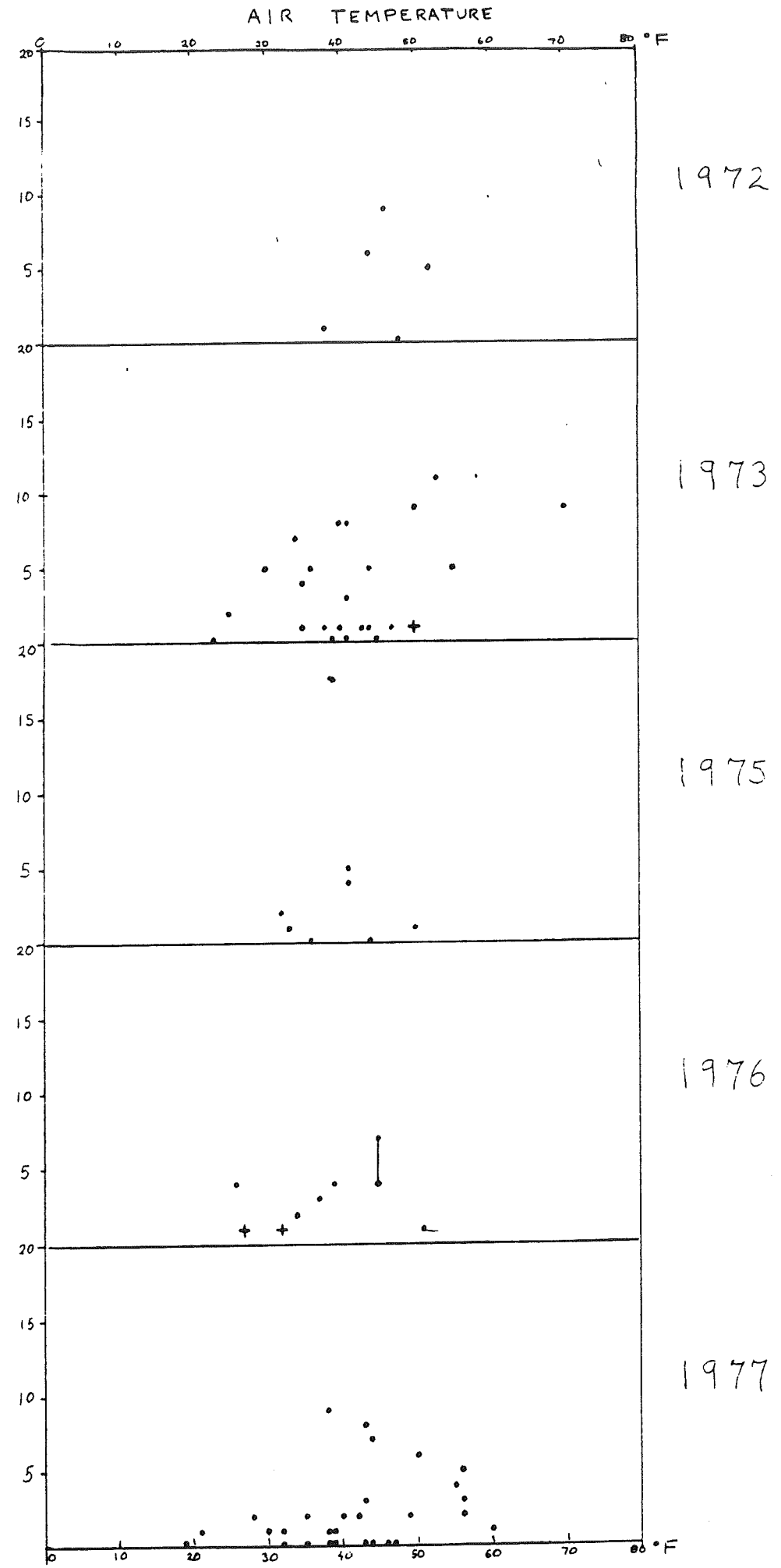


Figure 25b.

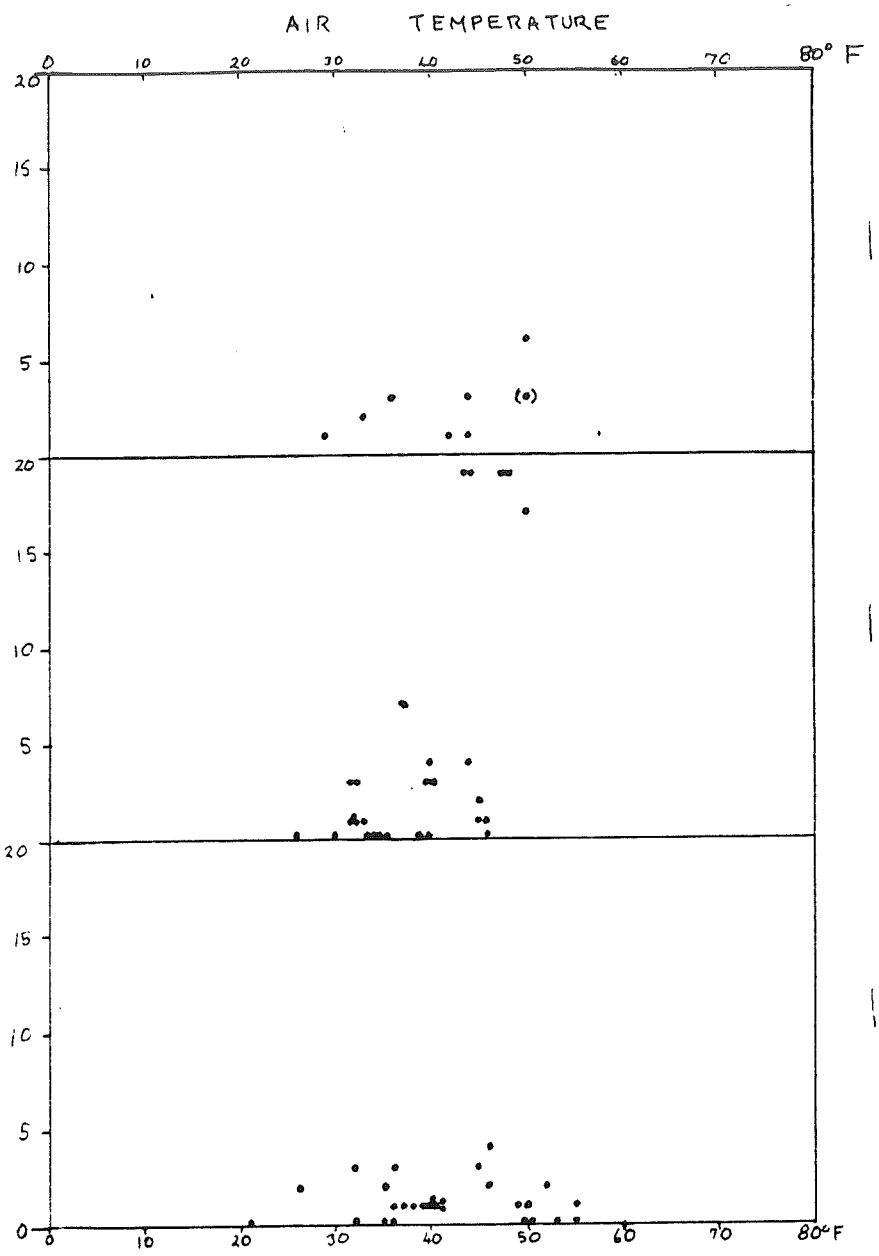

AIR TEMPERATURE
0 10 20 30 40 50 60 70 80° F
NO. OF GREY SEALS
1979
1980
1981
0 5 10 15 20

Figure 25c.

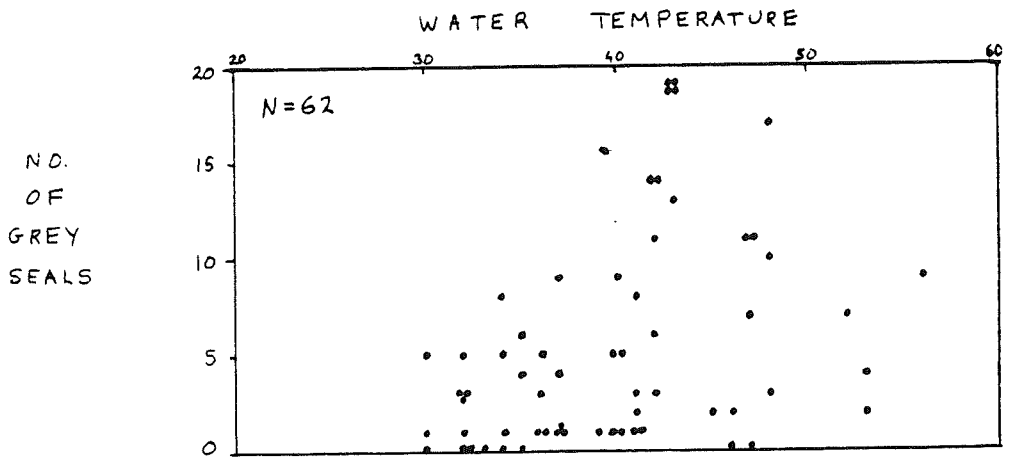


Figure 26. Numbers of grey seals and sea surface temperature 1967-1981, from Figs. 5-19. All readings taken at Nantucket.

Ling et al cite "general discomfort experienced by pinnipeds in warm air except perhaps when peripheral warming may be important in cutaneous cell division and growth during molting....Feltz and Fay (1967) and Fay and Ray (1968) have suggested that certain behavioral traits observed in walrus, Odobenus rosmarus (L.), at the time of the molt when they form close-knit aggregations are related to the need to maintain epidermal temperatures sufficiently high to permit the necessary mitotic activity to proceed."

"Both sexes fast during the breeding season, and minimal feeding may occur until the moult has ended. In eastern Canada this occurs in May when schools of cod, mackerel and herring move inshore..." (Mansfield and Beck 1977). Cameron (1970) states that the Basque Islands herd disperses in mid-June, apparently coincidental with the arrival of mackerel. Thereafter only small groups are seen and the majority elude discovery. Eastern Atlantic grey seals disperse in summer and are believed to be at sea feeding (Hewer 1974).

Grey seals virtually disappear from view at Nantucket in summer. Andrews reports frequent summer sightings in the south breakers of Tuckernuck Bank in the years before a large pleasure boat fleet existed, but sightings there now are rare. Three were spotted on the northeast shoal at Muskeget in summer 1970, and pilot Norman Gingrass observed up to 5 or 6 in the water there from May to July 1976. Andrews speculates the seals may spend the summer in shallow, treacherous water between Muskeget and Chappaquiddick, including Wasque Shoals.

The possibility that some go further afield cannot be ruled out. The drift atlas of Bumpus and Lauzier (1965) and recent experiments by George Kurlychek (1981) show that drifters left 15 to 20 miles east of Cape Cod, or somewhat farther from Nantucket, may be carried north and east to Canada or the Gulf of Maine. If any grey seals moved offshore to the east in late spring

or early summer they would have the opportunity to go with the surface currents to Nova Scotia and the Gulf of Maine. There seems to be considerable potential for interchange between populations of the western North Atlantic stock.

Sport fishing at Nantucket concludes in October, and grey seal haulouts may start in November (see records for 1955, 1962, and 1963), although they were not noticed in recent years. Muskeget probably is not used for haulout until the end of the waterfowl hunting season which may run most of the fall and into January. For example the Massachusetts waterfowl season in 1979-1980 was:

Ducks	Oct. 10 - Oct. 20
Geese	Oct. 10 - Oct. 27
Ducks	Nov. 2 - Nov. 24
Geese	Nov. 2 - Nov. 30
Ducks	Dec. 28 - Jan. 12
Geese	Dec. 28 - Jan. 19

Grey seals resume haulout at reefs near the Basques in December, and move to the island as pupping commences (Cameron 1970). Prebreeding haulouts were seen at the shoal south of Tuckernuck in January 1967, December 1971, December 1972 and January 1973, and December 1973.

Food

Information on food habits at Nantucket is scarce except for two sightings of a probable grey seal with a flounder. Stomach contents were not examined. The diet in Canada, based on stomach content analysis, is chiefly herring, cod, skate, flounder, squid and mackerel (Mansfield and Beck 1977). Skates are very abundant at Nantucket and probably form the mainstay of the grey seals' diet in winter when other species are absent. In the warmer

months the other fish listed above become available to the seals. Availability and ease of capture are likely critical factors in the seals' choice of food items, so it is not surprising that sea ducks are taken occasionally. In January and February 1960 Andrews lost up to one third of the ducks he shot to seals watching from behind his decoys, just out of shotgun range. Wendy Greene, a former College of the Atlantic student, reported a grey seal eating eider ducks and guillemots at Little Duck Island, Maine in early summer 1979.

Daily feeding rate of the Canadian seals is assumed to be 4.0% of body weight in females, and 4.5% in males, with "no feeding in January and February, half the normal feeding rate in March and April, and full feeding for the remainder of the year" (Mansfield and Beck 1977).

Habitat use and habitat change

Strong rips and shifting shoals create hazardous water between Nantucket and Martha's Vineyard, an area long known as a ships' graveyard. Grey seals on both sides of the Atlantic seem to prefer such conditions, whether the substrate is rock or sand. Remoteness, exposure and difficult boat access are near-prerequisites for haulout and breeding sites, as is adjacent deep water for the seals' arrival and departure. The ideal breeding beach, in addition to meeting the above criteria, lies above spring tides, and offers some shelter or distance from storm breakers and swell. Southwest Point, Muskeget, is the favored pupping site in the study area. Composed of reworked glacial drift, sand and gravel, all of Muskeget is changed continually by wind and sea; the island moves eastward at the rate of about one half mile per century (Wetherbee et al 1972).

The same processes reshape many other seal haunts in the study area. Major sites are illustrated in Figures 26-28.

Skiffs Island. A 1784 map (Figure 27) shows Skiffs Island Shoal at the present site of the Wasque shoals; a map dated 1891 and 1904 (Figure 28) shows Skiff Island itself. Records indicate it supported salt marsh hay harvests and nesting gulls in the early 20th century (Forbush 1925). Seals undoubtedly frequented Wasque-Skiffs at least occasionally throughout its existence, but there is a dearth of sightings at this location because an aircraft is needed to view it. The half tide shoals remaining today were used at times by the seals after 1975, according to aerial surveys.

Norman Gingrass reports spotting seals at Wasque Point, the southeast corner of Chappaquiddick, in the days before oversand vehicles were common, but seals do not haul out there now.

Muskeget. Changes at Muskeget are documented in Figures 27-29, and in Wetherbee et al (1972). A shoal indicated two miles west northwest of Muskeget in Figure 28 may be Swile (old English for seal) Island, mentioned in an 1890 Inquirer and Mirror. Note, in Figure 28, the Adams and Gravelly Islands, and the great length of Smith Point.

Figure 29 shows Smith Point in 1935 broken through south of Muskeget and the western piece of it amalgamated with Adams and Gravelly Islands. The 1938 post-hurricane map shows the storm's destruction of Smith Point west of Tuckernuck, and a long spit almost joined to Muskeget. The 1938 hurricane, by removing the barrier to the ocean, gave the seals access to Muskeget; in the earlier decades of the century they "apparently bred on the outer bars southwest of Tuckernuck and Muskeget" (Andrews and Mott 1967).

In 1943 the only remnant of Smith Point west of Tuckernuck was the spit at Muskeget, Southwest Point. Deep water around the tip continued through the 1960's, and this dropoff along with the tip's elevation made Southwest Point suitable for pupping, which occurred there from the 1940's onward. By 1970, however, the point had moved north, closer to Muskeget, with increased shoaling around the tip.

A hurricane force storm in March 1976 broke through Southwest Point, forming a small, low island, with little deep water around it (1977 map, Figure 28). In 1979 the island reattached, and the point now forms a mostly shallow lagoon. Shoaling and loss of elevation contributed to the Point's deterioration as a pupping site. A probable pup was there 6 February 1980, but no adults were seen.

Tuckernuck. The grey seals hauled out at Bigelow Point, on the west end of Tuckernuck, in 1976. Andrews saw seals at the shoals south of Tuckernuck after the early 1960's, and grey seals were observed there from 1967 through 1973. By 1974 a large shoal on the south side joined to the main island, making the area unattractive to seals. Harbor seals then preferred Dry Shoal (between Tuckernuck and Eel Point), the North Head of Tuckernuck, and Meadow Point (Esther Island).

Esther Island. In the late 1950's Smith Point was breached again, at Broad Creek near Madaket, forming Esther Island. The island's eastern end, Meadow Point, was used by harbor seals after 1974. In 1978 (?) a storm broke through the tip of Meadow Point, cutting off a small peat island which the harbor seals continued to use. In March 1980, and March and early April 1981, up to four grey seals hauled out there too, including a distinctively marked mature female who was present both years. The tiny island is surrounded by strong currents which the grey seals favor, and at this site they seemed to tolerate nearby boating activity, a necessary accomodation if the species is to endure near development-prone Nantucket.

The above account shows a net loss of island habitat for grey seals. Sandbars and halftide shoals continually migrated closer to land, and, in recent years were washed down and flattened, so that haulout space as well as pupping habitat was diminished.

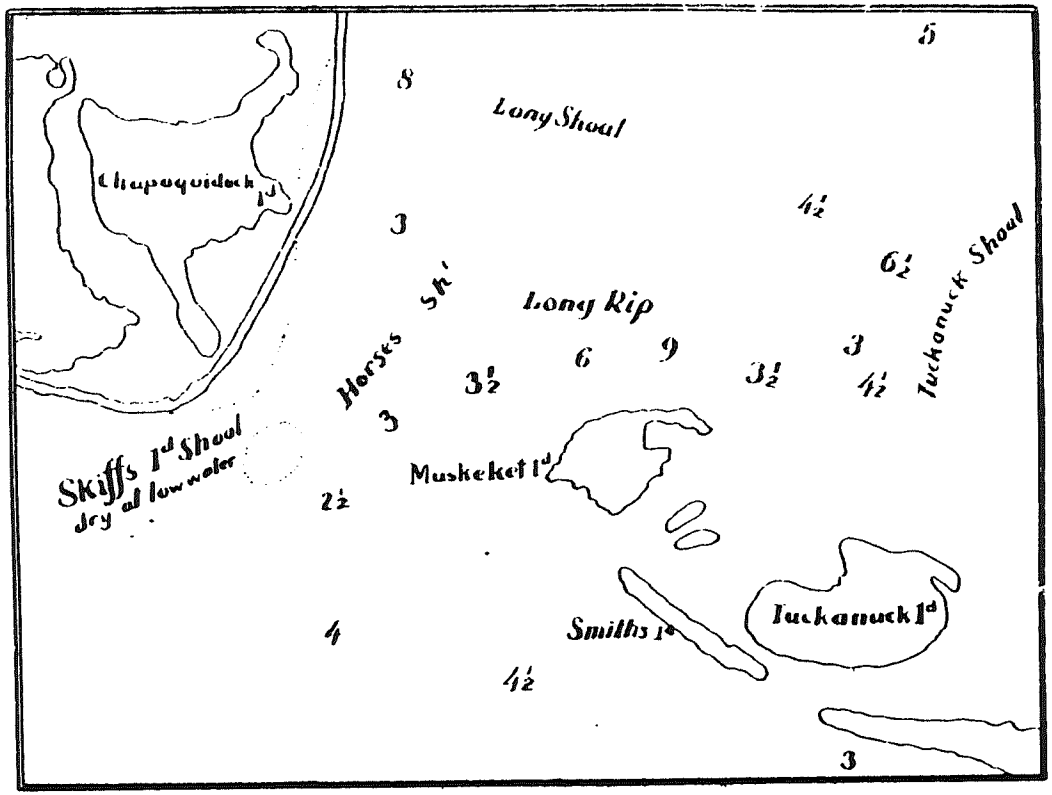


Figure 27. Chart of Muskeget Island, 1784 (copied from Pinkham, Chart of Nantucket Shoals). From Wetherbee et al 1972.

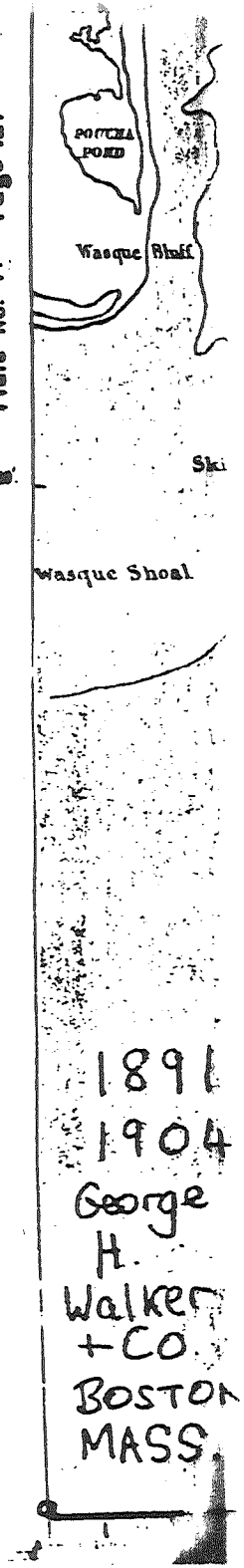
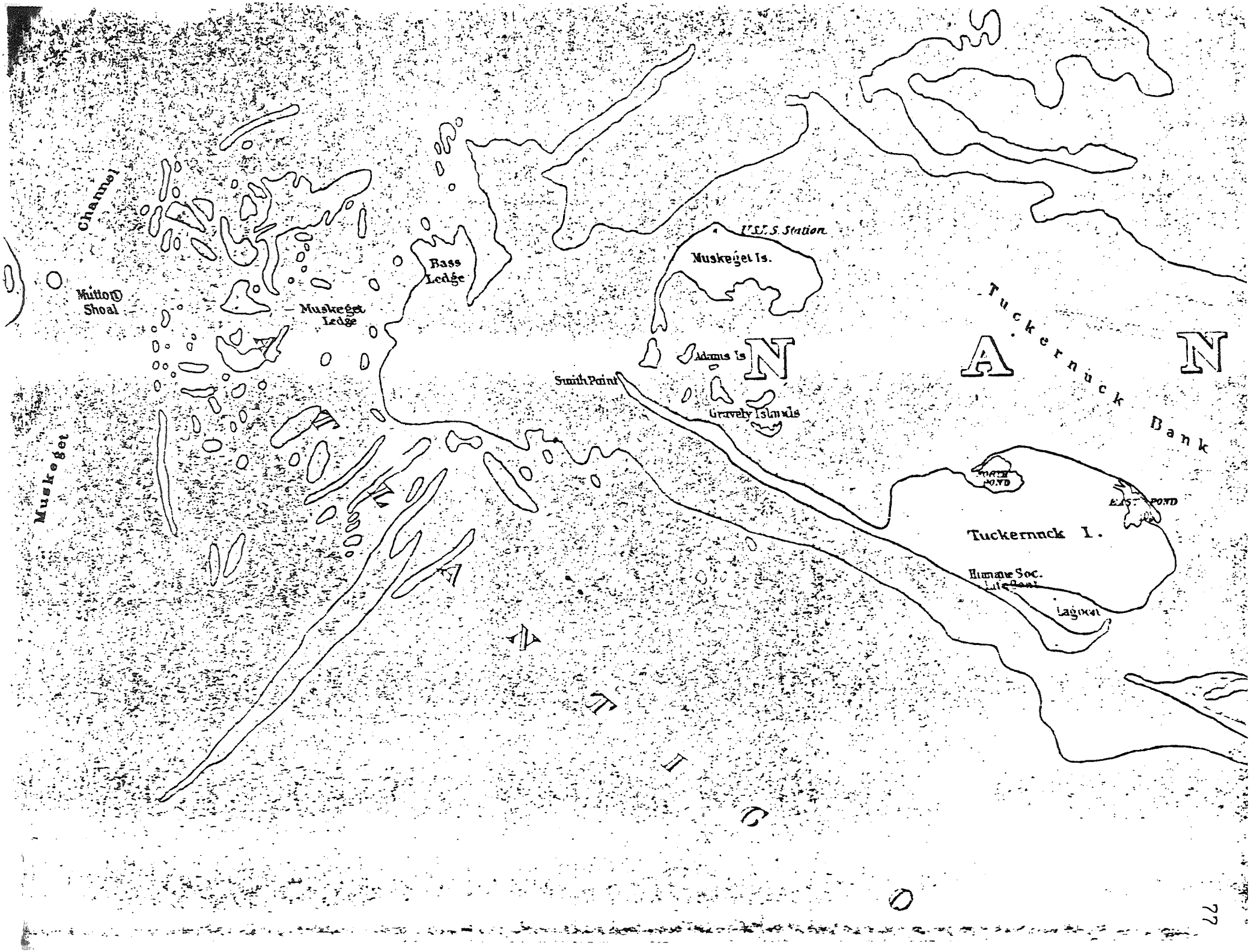


Figure 28. 1891, 1904. George H. Walker & Co., Boston, Mass.


Channel
Mutton Shoal
Muskeget Ledge
Bass Ledge
U.S.L.S. Station
Muskeget Is.
Adams Is
Smith Point
Gravely Islands
Muskeget
Tuckernuck Bank
NORTH POND
EAST POND
Tuckernuck I.
Humane Soc.
Lifeboat
Lagoon
77

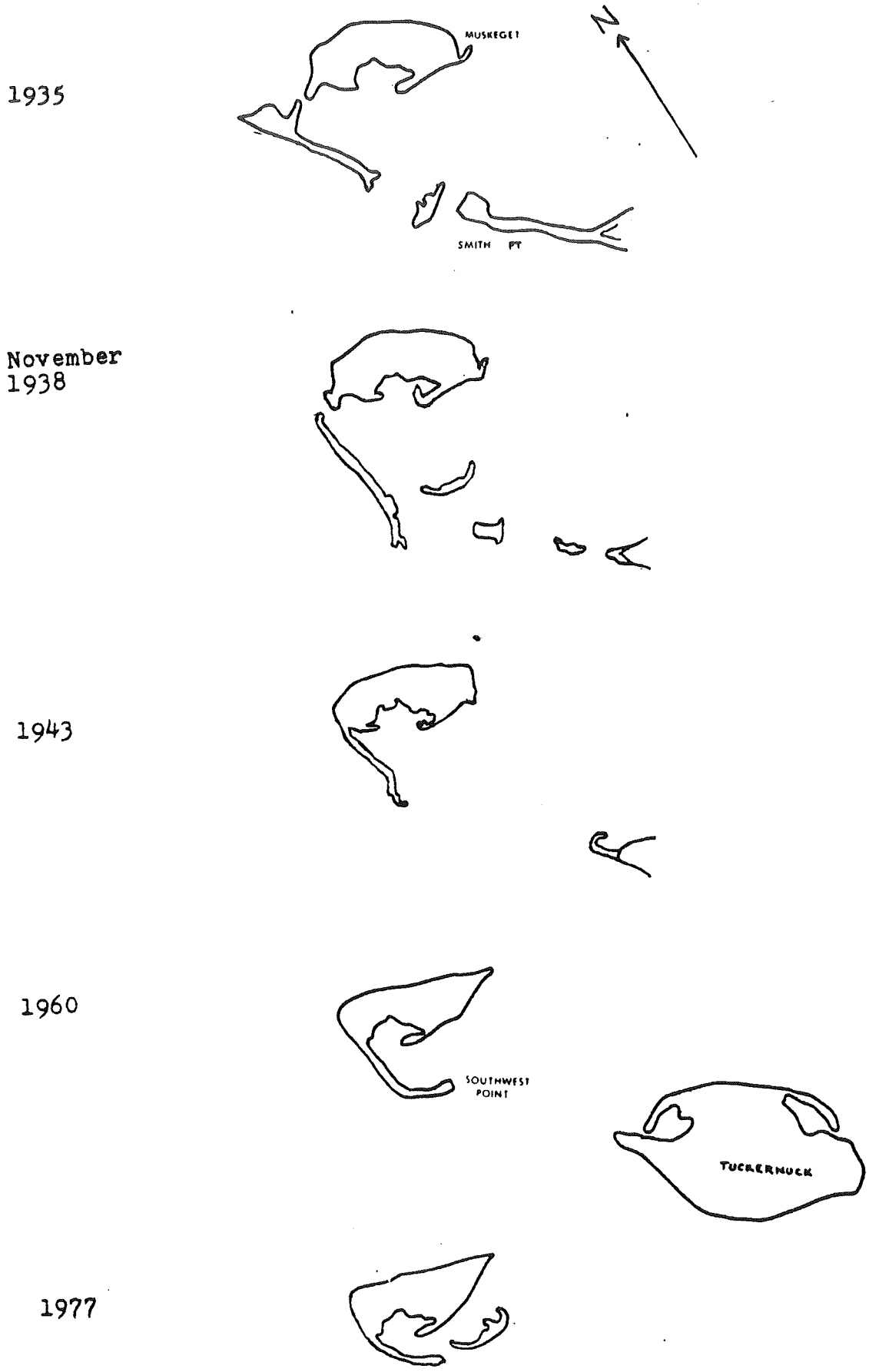


Figure 29. Sketch maps showing the changes in the Muskeget area.

Presence and impact of harbor seals

Andrews did not see harbor seals at Nantucket until the early 1960's; high counts since then are shown in Figure 20. The evident decline and increase in harbor seal numbers is paralleled by similar trends in grey seal numbers over the time represented in Figure 20, based on springtime counts. The harbor seals seen at Nantucket are part of a large wintering stock around Cape Cod and the Islands, ranging southward to Rhode Island, Long Island Sound, and even farther in some years. These seals presumably breed and summer in northern New England and eastern Canada.

The eastern Canada stock of harbor seals, about 12,000, decreased from earlier levels due to bounty hunting (Boulva and McLaren 1979). The bounty was removed in 1976, the same year it was imposed on grey seals in Canada.

Preliminary surveys conducted in 1981 by the University of Maine found a substantial increase of harbor seals in Maine from the 6,000 estimated by Richardson in 1973 (J. Stein pers. comm., Richardson 1976). It is likely this growth has led to the increased wintering population at Nantucket.

Mansfield and Beck (1977) report considerable overlap in diet between harbor and grey seals in Canada, and postulate that some competition for food occurs. Harbor seals in Canada consume the same food species cited above in the grey seal diet, with the exception of skate, and with the addition of alewife which evidently is not eaten by grey seals in Canada. Alewife runs at Nantucket are noted in Figures 12, 13 and 15-19; they occur when harbor seal numbers are high, and alewives are probably an important food item for that species.

Figures 5-19 show harbor seal counts for each year 1967-1981. Peak numbers occurred in the spring, slightly earlier than those of grey seals (Figures 23 and 24). Most harbor seals left the study area by June 1.

The greatest potential for impact of harbor seals on grey seals is from December to early March, before the arrival of alewives; in most years harbor seal numbers are low then, but in 1980 up to 80 were seen in February. At such times, with other prey species scarce, harbor seals might take the less preferred skates, probably the staple of the grey seal diet.

Although there may be overlap in the seals' diet, the availability of food to satisfy the two species' divergent preferences would minimize the effect of any competition. There would be no competition during summer and fall when harbor seals are absent. Where both species occur year round, as in Canada, competition may be an important factor. Mansfield and Beck (1977) speculate that reduction of harbor seal numbers may have favored the population growth of grey seals in that country.

Other possible mutual impacts of the two seal species include sharing and spreading of parasites, an important topic beyond the scope of this report, and the spreading of infectious disease. Grey seals in Canada were exposed to the harbor seal epizootic of 1979-1980, but apparently developed resistance to it (B. Beck pers. comm.). However two grey seals in southern New England succumbed to unknown illness in 1980-1981, as noted above. Mycoplasmic pneumonia and viral influenza are suspected pending test results. If grey seals in southern New England are susceptible to the disease the small local population or populations could be devastated.

Human impacts

Human predation on grey seals in the study area is documented above. Killing is now illegal (Marine Mammal Protection Act of 1972), and the present threat to the seals is from disturbance due to increased traffic of boats, beach vehicles, and low flying aircraft. Annual waterfowl hunting is a potential disturbance in fall and early winter. Most of these impacts are unavoidable in modern civilization; however some changes are feasible, and recommended in the next section.

Indirect human impacts on seals include environmental contaminants, such as heavy metals, pesticides, PCB's, and petroleum hydrocarbons. A comprehensive review of the occurrence and effects on marine mammals of these substances is beyond the scope of this report, but the information is much needed. Contaminant levels in marine mammal tissues serve as an index of pollution in the human environment, and should be routinely monitored.

Pertinent findings to date are cited in Gilbert et al (N.D.): "The effects of environmental contaminants on grey seals are incompletely known. Mercury levels (Sergeant and Armstrong 1973; Hepplestion and French 1973) and total DDT and PCB levels (Holden and Marsden 1967; Heppleston 1973; Olsson et al 1974; Helle et al 1976a; Addison and Brodie 1977) have been measured in grey seals at a variety of locations. Olsson et al (1974), Helle et al (1976a,b), and Olsson (1977) have attributed uterine lesions to high PCB levels in Baltic grey seals. This finding has been partially corroborated by experiments which demonstrated similar lesions could be produced in mink (another animal with delayed implantation) by introducing PCB into the diet (Kihlstrom et al 1973). The PCB levels found in harbor seals in Maine (Gaskin et al 1973) approached those levels measured in Baltic grey seals."

Reproducing females may be at less risk than males from certain contaminants, specifically those which may be transferred from the body load to the offspring via placenta or lactation. Frank et al (1973) found DDT and PCB residues in harp seal (Pagophilus groenlandicus) tissues increased with age, but levelled off in females at age of breeding; residues apparently were lower in females than in males.

"Little is known of the effects of petroleum hydrocarbons on grey seals. Gill et al (1967) reported only three grey seals died of oil related causes following the wreck of the TORREY CANYON in March, 1967, off the coast of Great Britain. An oil spill on the coast of Wales in 1974 coated grey seal pups. Although they had lower weights at weaning than their non-oiled counterparts, no differences in survival to weaning were observed (Davis and Anderson 1976). Geraci and Smith (1976) concluded that the effect of oil coating on ringed seals (Phoca hispida) varied with physiological condition and amount of stress." (Gilbert et al N.D.). Geraci and Smith noted that newborn phocid seal pups would be vulnerable to thermal effects of oil coating until the blubber layer developed.

DISCUSSION

Nantucket and Sable Island have been available to grey seals longer than other North American sites, probably since the time of the Wisconsin glaciation.

In addition to being of historic and biogeographic interest, the Nantucket area is important because of current United States policy concerning marine mammals, as stated in the Marine Mammal Protection Act of 1972, with particular reference to sections on depleted stocks.

In the 1940's the Nantucket grey seal population was about 40, and possibly about 4 pups were born each winter. In earlier time the seals apparently occupied bars southwest of Tuckernuck and Muskeget, and were not readily visible to fishermen and other observers. A natural event, the 1938 hurricane, broke up the outer bars, thus bringing the seals to Muskeget and its neighboring shoals. Here they were vulnerable to human predation, and bounty killing took place whenever weather and sea conditions permitted crossing to Muskeget during the breeding season. 40 were killed in 5 years in the late 1940's and early 1950's, with at least 10 killed in each of two years, and 25 were killed in 4 years between 1958 and 1961 (Andrews and Mott 1967). The population, reduced to about 20 by the early 1960's, dropped to fewer than a dozen by the mid-1970's. In 1980 there were 19 present, but the 1981 count was much lower due probably, but not certainly, to inadequate surveys.

The grey seals killed at Muskeget included cows and pups, in unknown proportions. It is unlikely, if 10 seals were killed in each of two years, that all were pups. A population of 40 producing about 4 pups a year has a potential annual increase rate of 3.25% (assuming mortality to breeding age of about 66%), and would not be reduced to half its numbers by pup deaths alone.

Attempts to control grey seal numbers in Britain indicated stocks are reduced most effectively by adult rather than pup culls (Summers 1978). In Canada, while pup killing "reduced the relatively small breeding population at the Basque Islands, it has had no discernable effect on the Gulf population. In fact the limited evidence available suggests that this breeding colony is still expanding" (Mansfield and Beck 1977). "Rate of increase is most likely to be determined by variations in adult" and to a lesser degree juvenile survival. "Variations in fecundity have little effect on the rate of increase" (Harwood and Prime 1978). These accounts suggest that the population reduction at Nantucket hinged on the death of a number of mature females.

A population of 40 in 1945, experiencing an annual increase rate of 3.25%, would have grown to about 60 by 1958 if undisturbed. Of course there is no way to know whether 4 pups were born every year, and the undisturbed population might have grown more slowly than this, or not at all, but likely would not have diminished 50% by 1958.

The hypothetical multiplier of 10 is consistent with reduced fecundity; the Nantucket pregnancy rate apparently has been lower than the 85% rate in mature females of the Canadian stock. If a reduced pregnancy rate is associated with increased survival in adult females (see Bonner 1971), as is likely, the Nantucket grey seals may have an adaptive response to unpredictable climate and habitat conditions at the extreme limit of the species' range. An alternative explanation for the observed low pupping rate is that mature females are breeding elsewhere, at least in some years. There is no data available concerning outmigration, although dispersal of Sable Island seals to Nantucket is well documented.

Habitat deterioration, together with any possible residual effects of the bounty killing which ended in 1961, may have contributed to depressed numbers and growth in the mid-1970's. By the 1980's some recovery of the population might be expected. The 1980 count of 19 and the production of pups in 1980 and 1981 are favorable signs. Poor quality of pupping habitat, however, may continue to hinder growth.

The 1980 herd included two individuals branded as pups at Sable Island, one in 1971 and one in 1978. Extrapolating from data of Mansfield and Beck (1977) it is likely a minimum of 25% of the 19 seals seen in 1980 came from Sable. As the Canadian stock, particularly the Sable Island population, continues to expand the proportion of immigrants at Nantucket may increase; conversely the proportion would have been smaller going back in time to the mid-1960's and earlier, when the Canadian populations were smaller than at present.

A minimum immigrant proportion of 25%, and a low pupping rate might prompt dismissal of the Nantucket group as transient. Possibly part of it is, but there are arguments for its local character, including resightings of distinctively marked individuals (see sighting synopses). 6 females and 4 males were identified and resighted over periods ranging from 2 days to 5 years. 2 mature females were sighted over a period of a few days, and 1 immature and 3 mature females were seen over periods ranging from 1 to 3 years. 4 mature males were seen over periods of 2 weeks, 5 weeks, 1 year and 5 years.

The possibility of discerning pigmentation, scars, and brands depends on viewing conditions, which vary greatly according to the seals' location. More repeat sightings were logged since the seals began to use Esther Island, which is easily observed, but obviously this does not necessarily mean an increase in long term occupation.

No branded animals were seen breeding at Nantucket, however there were no satisfactory observations of breeding behavior after 1970, and systematic marking at Sable Island did not start until 1969. No brands were spotted on mature females at Nantucket in 1980 and 1981. Two individual females were seen both years. The presence of these females and of pups in 1980 and 1981 tends to confirm the continued existence of a local breeding population.

Mating behavior was not observed at Nantucket, although preliminary activities seen suggest a 1:1 ratio of males to females on the breeding grounds there as at Sable Island. B. Beck (pers. comm.) reports the oestrus cows at Sable Island are ovulating not at time of mating with dominant tenured bulls, but rather upon mating with younger untenured bulls, some of them juveniles, at the peripheries of the breeding areas. Whether the phenomenon is recent or of long standing and whether it operates at Nantucket are not known.

Sable Island has supplied recruits to New England recently. Many years ago about 200 pups were born annually at an island near Grand Manan Island in the Bay of Fundy. All these were killed for bounty. Today about 15 pups are born each year at the Northeast Shoal, but there is probably a high degree of disturbance from lobster fishing in the breeding season. When 200 pups a year were produced it is likely populations in Maine and possibly farther south were bolstered from that source.

Opportunities for population expansion may be limited at Nantucket because of reduced habitat, but there appears to be considerable growth potential in Maine. Groups of up to 25, containing at least 50% mature females, were seen by the author in lower Penobscot Bay, Maine, in 1980 and 1981. The islands there are not fished for lobster in winter and would be undisturbed in the breeding season. No pup surveys were ever conducted in Maine, although such surveys are desirable. There is too narrow a perspective in looking only at Nantucket for evidence of grey seals breeding in New England. Sightings of Sable Island marked animals in the Gulf of Maine as well as at Nantucket demonstrate the potential continuity of New England stocks.

With favorable conditions, including continued protection, the Nantucket population should grow slowly to a level compatible with environmental conditions. Future population surveys are necessary to monitor the trends. The low count in 1981, following the count of 19 in 1980, was probably due to inadequate survey coverage,

but possible alternative explanations include:

a) the majority of seals seen in 1980 were transient;

b) some seals may have succumbed to disease, specifically the harbor seal epizootic of 1979-1980. Two possible cases, both fatal, were noted above, a juvenile male originally taken from Cape Cod Bay, and an otherwise healthy male pup stranded at Chappaquiddick. Both cases occurred within a year after the peak of the harbor seal outbreak. Positive identification of the causative organisms awaits test results. The unknown extent of southern New England grey seals' exposure and susceptibility to the mycoplasmic pneumonia-viral influenza syndrome lends urgency to field surveys proposed for 1982.

Most of the human impacts described earlier are unavoidable. There are at present good relations with the Nantucket public concerning seals, but the goodwill might be strained if new restrictions were imposed. The following steps are recommended:

1) Altitude restrictions governing aircraft should be enforced at Martha's Vineyard and Nantucket.

2) The Massachusetts waterfowl season should be rearranged (not shortened) so as to end not later than 10 January.

3) A directed survey program should be carried out at Nantucket in 1982 and 1983.

4) An aerial search for pups at certain Maine islands should be conducted within three years.

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A small population of grey seals at Nantucket, Massachusetts. MS

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ERRATA

Page 13, 3rd paragraph.

The bounty on seals was imposed sometime prior to the 1940's. In June 1948 Andrews found the mummified carcasses of four grey seal pups and an adult, evidently killed for bounty, at Southwest Pt. He found seal bones there several other years in that time period (pers. comm.).

Page 41, 1st paragraph, 1st sentence.

Clinton Andrews' report of 4 mummified pup carcasses at Muskeget in 1948 is the only information on pup production during that period.

Page 52, 4th paragraph, next to last sentence.

Andrews counted 40 grey seals from 1940 to 1948 and, in 1948, four (dead) pups, suggesting a ratio of 10:1 might have some foundation in reality.

Page 72, 1st paragraph, 1st sentence.

Ling et al (1974) cite "general discomfort.....