

TERNS IN MASSACHUSETTS: PRESENT NUMBERS AND HISTORICAL CHANGES^a

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Four species of terns—Common Tern (*Sterna hirundo*), Arctic Tern (*S. paradisaea*), Roseate Tern (*S. dougallii*), and Least Tern (*S. albifrons*)—breed in Massachusetts where they have been extensively studied. Their numbers have fluctuated considerably during the period of historical record, and are now again decreasing (Nisbet, 1972). Historical reviews of the changes in numbers at several colonies have been published—e.g., Crowell and Crowell (1946) for the Weepeeck Islands, by Anderson (1958) for Plymouth Beach, by Wetherbee et al. (1972) for Muskeget, and by the Austins (1929-1956) for the Cape Cod colonies. However, no state-wide review of these changes has been made, and the trends in total numbers have not been documented, even for the period when Austin and Austin (1956) were studying the demography of the Common Tern. In this paper I review the historical reports and present the results of surveys by the Massachusetts Audubon Society between 1968 and 1972, including an attempt at a complete census in 1972. To place the results of this review in a wider perspective, I summarize very briefly data from other areas along the North Atlantic coast.

For the sake of brevity secondary sources are quoted wherever I have found them complete and reliable, but I have found it necessary to consult all the original reports. Notes in seasonal reports in the journals *Audubon Field Notes*, *Bulletin of New England Bird Life*, *Records of New England Birds*, and *Bulletin of the Essex County Ornithological Club* are referred to only by abbreviations: *AFN*, *BNEBL*, *RNEB*, and *BECOC* respectively. Undated references to individuals signify unpublished data.

CENSUS METHODS AND THEIR RELIABILITY

Breeding terns are very difficult to count with precision. Apart from the well-known difficulty of estimating large numbers of birds, possibly dispersed over substantial areas or milling about in the air, the numbers of birds at a colony vary continuously throughout the season as new pairs settle and unsuccessful birds move away. Fresh eggs can be found in most colonies at any time from late May to late July. At least for Common and Arctic terns, several authors have reported that a well-marked peak of laying occurs early in the season, followed by one or more smaller peaks. These later peaks probably represent both young birds nesting for the first time and older birds reneesting after losing eggs or chicks. Birds not infrequently shift to a new colony after losing eggs in another, so that numbers often decrease during the season at unsuccessful colonies and increase at successful colonies. At the edge

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of most colonies are usually resting flocks whose numbers vary greatly with the time of day and the state of tide: these flocks include loafing breeders, unmated birds, and probably other non-breeders. In occasional bad years, colonies might be abruptly deserted, or large numbers of birds might not breed at all.

After several years of observation and counting, I have found that the period in the breeding cycle at which the numbers in each colony are the most stable (at least for Common and Arctic terns) is shortly after the main peak of laying, that is, when most of the birds in the most synchronized group are incubating eggs. At this time the average number of birds present in the nesting area (excluding those loafing on the edge of the colony) is usually close to 1.1 per nest, except in the very late evening when about 1.9 birds per nest are found. Accordingly, my recommended method for obtaining standardized, replicable counts of breeding pairs is to visit the colony once in this period, note the number of birds loafing on the beach, flush the remainder from the nesting area, and subtract 10% from the estimated number. This method has been used for most of our estimates cited in this paper. The principal class of birds omitted by this method of estimation is that of late nesters (some 10-15% of the number in the main group).

This method works best for Common and Arctic terns, which usually have a single peak of laying in late May and early June. Several visits might be required to span the main laying-peak of Roseate Terns, which is often more prolonged. The method does not work well for Least Terns, which in many colonies have a high rate of egg-loss and no clearly marked laying-peak. I know of no good way of estimating numbers in these colonies, and the figures given in this paper are estimates of the number of pairs behaving as though breeding in the second or third weeks of June.

Comparison with counts made in the past is more difficult. Counts of nests are very difficult to make complete, and usually represent substantial underestimates of the numbers of pairs. In some cases, such as the work of the Austins in which most of the adults were trapped, the numbers of breeding pairs are known with reasonable accuracy. Some of Hagar's estimates were obtained by mapping the colony and measuring the average nest density in sample quadrats. Most counts in the past, however, were given without explanation or stated method of estimation. Many of the published estimates were made in July, when there is often less than one bird per pair present. However, in some cases it appears that estimates of pairs were obtained by dividing estimates of birds by two. For this reason I suspect that there is a general bias towards underestimation in the historical reports, in addition to actual errors of counting. In this review, however, I have generally taken estimates of birds or pairs at face value; where necessary to relate the two, I have used a conversion factor of 1.5 birds per pair. I have discarded a small number (about 5%) of published figures that were markedly discrepant from other estimates in the same colonies within a few years. Clearly neither the past data nor my figures are precise estimates of population, but they should be

sufficiently accurate to detect substantial numerical changes and geographical shifts.

An additional difficulty is the problem of identification. Common, Arctic, and Roseate terns are not always clearly distinguished in past estimates, and it is especially difficult to estimate small numbers of one species among large numbers of another. In most colonies the Common Tern has always been numerically dominant, and the other species scarce enough to cause little error in estimates of its numbers. Estimates of Roseate and Arctic terns are liable to greater error, and the limitations of the published figures will be pointed out again in the discussion.

1972 CENSUS

The results of the 1972 census are summarized in Tables 1 and 3 and on Figures 1-2. The total numbers of terns breeding in Massachusetts in 1972 are estimated as follows: Common Tern, 7,500 pairs; Arctic Tern, 110 pairs; Roseate Tern, 2,300 pairs; Least Tern, 950 pairs. It is difficult to attach confidence limits to these composite estimates, but I believe that each is reliable within $\pm 25\%$ except that for the Least Tern, which is more uncertain because of continual changes in the numbers at many of the colonies.

COMMON TERN: HISTORICAL REVIEW

For convenience in quoting the literature, I follow here Austin's (1951) division of the Massachusetts colonies into three groups (Fig. 1): the "Cape Cod Group," including Cape Cod, Monomoy Island, the upper part of Buzzards Bay and Plymouth Beach; the islands to the south; and the coast and islands to the north.

Cape Cod Group

On Cape Cod, the early history of the terns is unknown (Hill, 1965), except that Thoreau (1894) recorded terns nesting on the mainland in the Wellfleet area in the 1850's, and a colony of thousands was thriving on Billingsgate Island about 1880 (Austin, 1932). However, Allen (1870) stated that the numbers on Cape Cod were small compared to those at Muskeget. The terns were severely reduced by human persecution in the late 19th century, the major surviving colony being at Chatham (Austin, 1940). They increased rapidly and had become common by 1915, when Bent (1921) reported a colony of many thousands at Nauset Beach (probably what is now called North Beach).

In the 1920's the major colonies were on Egg, Billingsgate, and Tern islands, Pamet and Jeremy's points, with smaller numbers on Monomoy Island and elsewhere (Forbush, 1921-1925; Floyd, 1925-29; Austin, 1929). Egg and Billingsgate islands were washed away during the 1930's (Austin, 1940) and Pamet Point became attached to the mainland. During the 1930's and 1940's Tern Island was the major colony, Ram and Bird islands increased in importance, and the smaller colonies declined (Austin, 1932-51). Plymouth Beach was probably settled about 1920; numbers there increased to 1,000 pairs by 1937, and by the early 1950's, it and Tern Island were the two major colonies (Austin, MS.; Anderson, 1958).

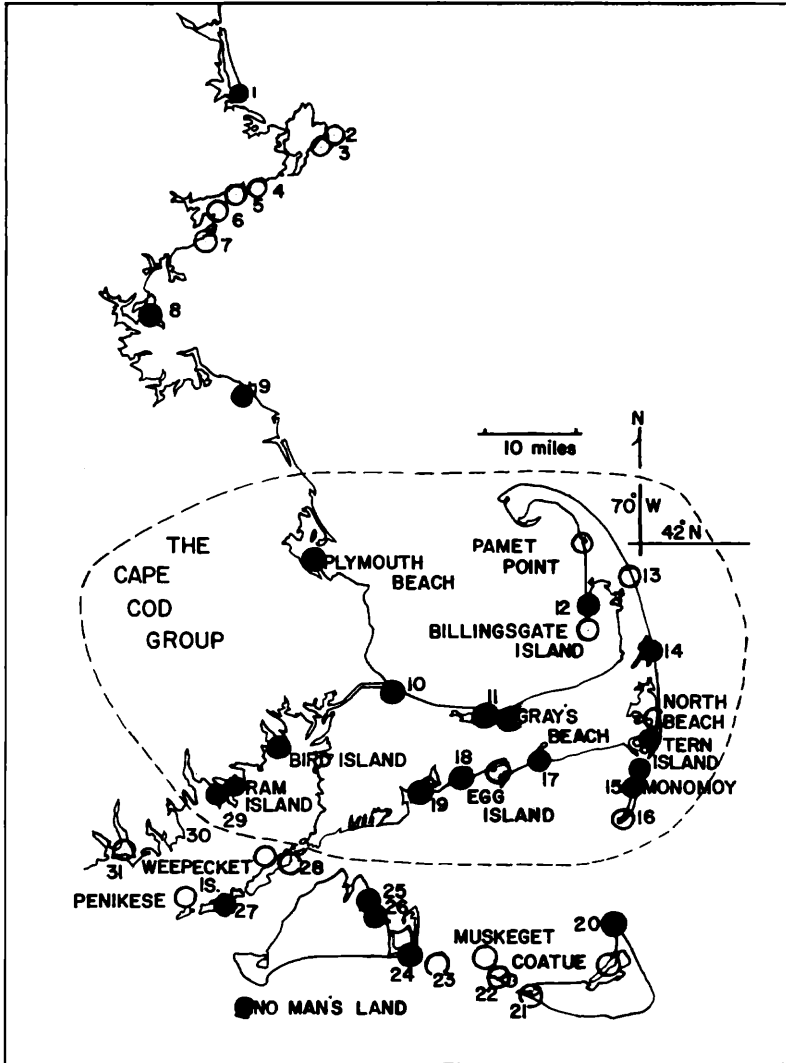


FIGURE 1. Common Tern colonies in Massachusetts mentioned in the text. Filled circle: colonies occupied in 1972 (for numbers, see Table 1. Open circle: colonies not occupied in 1972. The dotted lines delimit the "Cape Cod Group" as described by Austin (1951). The major colonies of the past and present are identified by name, the remainder by number, as follows:

1. Plum Is., 2. Thacher Is., 3. Milk Is., 4. Dundy Rock, 5. Chubb Is., 6. Coney Is., 7. Ram Is., 8. Snake Is., 9. Cohasset, 10. N. Sandwich, 11. Sandy Neck, 12. Jeremy's Point, 13. Wellfleet, 14. Nauset, Eastham, 15. Monomoy Center, 16. Monomoy South, 17. West Dennis, 18. Craigville, 19. Sampson's Is., 20. Great Point, 21. Madaket, 22. Tuckernuck, 23. Skiff's Is., 24. Norton's Point (Katama), 25. Sylvia Beach, 26. Sarson Is., 27. Nashawena, 28. Naushon, 29. Fish Is., 30. S. Dartmouth and Acoaxet Rocks, 31. Westport River.

During the 1930's Austin (1938) reported the total adult population in the three major colonies as fluctuating between 20,000 and 40,000 adults, with several thousand more in 6-7 smaller colonies. Later the total population was stated by Austin (1942, 1945) to be 30,000 adults, by Austin (1949, 1951) to be 25,000 adults, and by Austin and Austin (1956) to be 15-20,000 adults. (These figures have been erroneously quoted as referring to pairs by several authors.) Austin and Austin reported each of these estimates as referring to a stable population, but the progressive downward revision of the estimates at least suggests a decrease. The peak may in fact have been reached still earlier, for Forbush (1921-25) reported several bad breeding years and expressed doubts about the population's future.

During the 1960's several major changes occurred. The colony at Plymouth Beach declined and was replaced in importance by a new colony at Gray's Beach, founded before 1953 (Austin, MS.). Tern Island was overrun by gulls between 1961 and 1965 and the terns shifted to Monomoy, which had again become an island in 1959 (Drury, 1965); up to 3,000 pairs nested on Monomoy between 1962 and 1967 (W. Bailey; *RNEB*). The colonies at Ram and Bird islands were also overrun by gulls between 1964 and 1966. Subsequently, gull control operations on all three of these islands permitted partial resettlement by terns between 1967 and 1970 (Table 1). A colony at Sampson's Island was estimated at over 1,000 pairs in 1958 (*RNEB*), but subsequently dwindled.

Southern Islands

Nantucket. Brewster (MS., quoted by Griscom and Folger, 1948) noted in 1870 that the entire length of Coatue Beach (about 8 km) was one great colony, and he estimated the numbers as several hundred thousand pairs. It is impossible to assess such an estimate today. Brewster was one of the leading naturalists of the period, but his estimates for Muskeget appear high (see below). On the other hand plume-hunters killed 40,000-100,000 birds in a season in several different colonies at this period (Brewster, 1879, MS.; Bent, 1921; Forbush, 1925; Scott, 1888; Anon., 1887a,b): these figures were presumably related to market sales and give some support to the high estimates of nesting birds.

By 1874 plume-hunting had taken its toll, and practically no terns were left on Coatue (Brewster, MS.). It is not known whether any birds survived through this period, and subsequent records are fragmentary. Mackay (1898, 1899) referred to two small transitory colonies. Forbush (1925) referred to breeding on Nantucket. In the 1940's colonies of up to 50 pairs were located at four sites, but none was known in 1945 (Griscom and Folger, 1948). A colony at Great Point was occupied fairly continuously from 1940 to 1967, with a peak in the early 1950's when up to 300 pairs might have bred (J. C. Andrews; *AFN* 1954-55). A colony also existed at Little Neck, Madaket, where 75 pairs were found in 1952 (J. C. Andrews). None was known in 1966 (Burroughs, 1966), and only 3 or 4 pairs in 1972 (E. Andrews).

TABLE 1. Estimated numbers of pairs of terns in Massachusetts colonies, 1970-1972.

	Common Tern		Arctic Tern		Roseate Tern	
	1970	1971	1972	1970	1971	1972
<i>Buzzards Bay</i>						
Fish Island	—	—	35	—	—	0
Ram Island	300	250	220	0	120	170
Bird Island	250	350	310	0	1,300	1,100
Nashawena	100	60	35	0	0	0
<i>Martha's Vineyard</i>						
No Mans Land	1,200	1,000	1,000	25	35 ^a	35
Sylvia Beach	—	—	80	—	—	0
Sarson Island	—	—	70	—	—	0
Norton's Point	—	—	10	—	—	0 ^b
<i>Nantucket</i>						
Great Point	—	—	3	—	—	0
Quaise	—	—	0	—	—	0
<i>Cape Cod</i>						
Sampson's Island	—	—	40	—	—	0
Craigville	—	—	90	—	—	0
W. Dennis	50	200	75	0	0	0
Monomoy South	1,350	450	0 ^b	—	25	0 ^b
Monomoy Center	0	0	140	0	0	0
Monomoy North	2,600	2,500	1,600	0	0	0
Tern Island	750	600	425	30	15	35
Nauset, Eastham ^c	—	—	130	—	—	4
Jeremy's Point	—	—	20 ^d	—	—	0

Table 1.—Continued. Estimated numbers of pairs of terns in Massachusetts colonies, 1970-1972

	Common Tern			Arctic Tern			Roseate Tern		
	1970	1971	1972	1970	1971	1972	1970	1971	1972
Gray's Beach	900	1,500	1,450 ^d	0	0	0	300	250	350
Sandy Neck	—	—	30	—	—	0	—	—	0
N. Sandwich	—	—	30 ^d	—	—	0	—	—	0
<i>South Shore</i>									
Plymouth Beach	1,500	1,400	1,450	25	15	25	40	15	30
Cohasset	—	25	20	—	0	0	0	0	0
<i>Boston Harbor</i>									
Snake Island	—	—	275	—	—	0	—	—	0
<i>Essex County</i>									
Crane's Beach	2	—	0 ^b	0	0	0	0	0	0
Plum Island	—	—	100	—	—	0	—	—	0
TOTAL	—	—	7,460	—	—	105	—	—	2,280
TOTAL for colonies counted in all 3 years	9,000	8,310	6,700	80	75	95	2,200	2,045	2,280

Notes. —, no reports available. 0, colony visited, none nesting.

^aA higher published count is withdrawn after a more careful survey in 1972.

^bBirds present but probably not nesting.

^cIncluding a new island formed in 1972.

^dHigher numbers in July, but these probably included birds displaced from other colonies by Hurricane "Agnes" on 22 June. Small numbers of Common Terns (less than 20 pairs) were also seen and probably attempted to nest at Westport, Martha's Vineyard South Beach, Muskeget Island, and Hingham Harbor.

Tuckernuck (including *Nan's Island* and sandbars to the west). J. A. Hagar found 900 pairs nesting on the sandbars in 1936. The only other definite records are of small numbers nesting in the 1940's (Griscom and Folger, 1948). Burroughs (1966) marked *Nan's Island* as a breeding site at some time between 1948 and 1966.

Muskeget (including *South Point*, *Adams*, and *Gravelly islands*, intermittently joined to the main island.) A history of this island, for long the largest tern colony in Massachusetts, is given by Wetherbee et al. (1972). Terns were abundant in the mid-19th century (Baird et al., 1884; Forbush, 1925). In 1870, when intensive eggging was already in progress (Allen, 1870), Brewster (1879) estimated hundreds of thousands of birds. Hagar (in Wetherbee et al., 1972) has calculated that physical and biological limitations make any estimate greater than 100,000 pairs suspect, but on the basis of a mean territory size of 2m² (Nisbet and Drury, 1972) this island of about 120 ha might have held several hundred thousand pairs even if not fully occupied.

By 1874, Brewster (MS., 1879) estimated that the numbers had been reduced to no more than 5% of those in 1870, but nevertheless mentioned flocks of hundreds circling over wounded birds. Numbers continued to decrease between 1885 and 1889 (Bent, 1921), but increased progressively between 1890 and 1902 (Mackay, 1895-99; Bent, 1921). Conflicting estimates make it difficult to assess the numbers at the low point. A reference to thousands of birds in 1886 is known (Anon., 1887a). In 1890 Brewster (MS.) estimated 10,000 pairs, "about half as many as in 1869 and considerably more than twice as many as in 1878" (the dates appear to be incorrectly cited). In 1894 Mackay (1895) found only about 750 nests in an "exhaustive survey," but referred to thousands of birds, many more than in 1893. In 1896, following three successive years of marked increases, Mackay (1897b) stated that more were present than on *Penikese Island* where he had estimated 6-7,000 birds. These reports suggest that the low point was reached in the 1880's and was probably less than 5,000 pairs, of which only 60-70% would have been Common Terns. However, it is possible that the numbers genuinely fluctuated and that birds were kept off the island by the presence of a life-saving station between 1885 and 1889 (Wetherbee et al., 1972).

Reports since 1900 are summarized in Table 2. It appears that the peak might have been reached before 1920, that the numbers declined abruptly after 1935, and that since 1948 only sporadic nesting attempts by small numbers have occurred. The decrease has been attributed to vegetational change and to displacement by gulls, and has been much discussed (Gross, 1948, 1955; Wetherbee et al., 1972).

Skiffs Island. Hundreds of Common Terns were nesting here in 1908 and 1919 (Forbush, 1908, 1925), but the island was washed away in the 1920's.

Martha's Vineyard. Griscom and Emerson (1959) listed the Common Tern as always a common summer resident, but actual

TABLE 2. Estimates of Common Terns and Roseate Terns nesting at Muskeget Island, 1900-1972.

Year	Common Terns	Roseate Terns	Authority
1904	— increasing —		Dutcher, 1904
1908	— 10,000 birds —		Forbush, 1908
1913	20,000 birds	1,000 birds	Bent, 1921
1921-22	— decrease —		Forbush, 1921-22
1925	— beyond estimation —		Mackay, 1925
1927	— thousands —		Keniston, 1927
1935	— 15,000 birds —		J. A. Hagar
1936	2,000 pairs	1,800 pairs	J. A. Hagar
1938	1,000 pairs	3,300 pairs	J. A. Hagar
1940	— 3,000 pairs —		Noble and Wurm, 1943
1940	200 pairs	2,100 pairs	J. A. Hagar
1944	50 birds	2 birds	<i>BNEBL</i>
1945	— 200 birds —		J. A. Hagar
1946	— 2,500 birds —		Griscom and Folger, 1948
1947	— 1,000 birds —		Gross, 1948, 1951
1948	few hundred pairs	0	J. A. Hagar
1949	0	0	Gross, MS.
1951	3 pairs	1 pair	Gross, 1951
1952	0	0	J. A. Hagar
1952	several hundred birds	0	Church and Shaub, 1953
1953	0	0	Gross, 1955
1953	800 birds	0	Church et al., 1954
1957	0	0	<i>AFN</i>
1966	— 420 birds —		Wetherbee et al., 1972
1967	80 pairs	0	J. C. Andrews
1968	8 pairs	200 pairs	W. H. Drury
1968-9	— 50 pairs —		Wetherbee et al., 1972
1972	0	0	E. Andrews

records are fragmentary. Brewster (MS.) found about 500 birds in three colonies in 1890. Reports of small numbers at Katama were made in 1904-1908 (Anon., 1905a; Jones, 1906; Forbush, 1908), 1921 (Forbush, 1921), and 1964 (*AFN*). In 1967, 190 pairs were found (R. Forster) and 160 pairs in three colonies in 1972 (Table 1, from data of S. Beach).

No Mans Land. Jones (1906) mentioned a colony in 1904. The colony was probably refounded in the 1960's, and 1,000-1,200 pairs were found in 1970-72 (Lazell and Nisbet, 1972).

Penikese Island (including *Gull Island*). Mackay (1897a) stated that this island had been a major tern colony since the earliest recollection, despite regular eggging. Brewer had estimated 1,000 birds present in August 1873, and Mackay (1897a,c) found 1,458 nests and estimated 6-7,000 birds (including a substantial minority of Roseate Terns) in 1896. The birds responded promptly to protection in 1897 and increased rapidly (Mackay, 1899; Dutcher, 1904; Anon., 1905a). Subsequent estimates include 7,000 birds in 1908 (Forbush, 1908), 15,000 birds in 1929 (Tyler, 1929), 5,000-7,500 pairs in the years prior to 1932 (Floyd, 1932), 6,500 pairs in 1934 (Townsend, 1934), 7-10,000 pairs in 1939-41 (Griffin, 1943), 5,000 birds in 1945 (Crowell and Crowell, 1946), 20,000 birds in 1946, 10,000 birds in 1947 (Gross, MS.), 2,500 birds in 1947 (Zinn and Rankin, 1952), 5,000 birds for many years prior to 1951 (Austin, 1951), 7-10,000 pairs in 1952 (J. A. Hagar). All these estimates, except those of Griffin and Austin, include Roseate Terns; Common Terns appeared to comprise 80-90% of the total where figures were available (Floyd, 1933; Mackay, 1897c; Zinn and Rankin, 1952; J. A. Hagar), except in 1947 when Gross estimated 25-30% Roseates. The island appears to have been overrun by gulls at some time in the late 1950's; no terns were found there in several visits between 1962 and 1972 (P. R. Mott, W. H. Drury).

Weepecket Islands. The history of this colony has been summarized by Crowell and Crowell (1946). Probably no more than 50 Common Terns nested in 1896 (Howe, 1897b), rising rapidly to 750 pairs in 1903 (Jones, 1903), to over 1,000 pairs in 1907 (Bowditch, 1909), and to over 2,000 pairs in 1915 (Cahn, 1916). After a bad year in 1921 (Forbush, 1921), the numbers dropped to 200 birds in 1925, but rose again to 3,500 in 1931-34; they fell to 1,000-2,000 between 1935 and 1940, and then to zero from 1941 onwards as gulls took over the islands (Crowell and Crowell, 1946). All these figures except that for 1896 include a minority (about 25%) of Roseate Terns.

Other Elizabeth Islands. Only sporadic records of small colonies are known. A few were said to breed on Nashawena in 1896 (Mackay, 1897c), and up to 75 pairs have bred there in recent years (Table 1). On Naushon Island 25 pairs bred in 1967 and 1968 (W. Bailey; W. H. Drury).

Westport area. The first report of nesting was in 1949 and 150 pairs were reported on the South Dartmouth and Acoaxet Rocks in 1951 (*RNEB*). A few attempted to breed on an island in the Westport River in 1972 (Table 1, fide J. Fernandez).

Northern Islands

Boston area. I have traced no records suggesting breeding until 1968, when 20 pairs were reported from Logan Airport (*RNEB*). Nesting was reported on nearby Snake Island in 1970-71, and 275 pairs were counted there in 1972 (Table 1). About 20 pairs attempted to breed in Cohasset Harbor in 1971 and 1972 (G. Osborne).

Essex County. Townsend (1905, 1920, 1921) stated that "the Common Tern once bred on all the rocky islands and back of all the sandy beaches on the Essex County coast," but the only records cited are of small colonies, 30-100 pairs, all prior to 1889. In 1905 and 1921, the only surviving colony was at Milk Island (9 pairs in 1919), but this had gone by 1939 (Phillips, 1939). Between 1939 and 1947 colonies were present on Dundy Rock and Coney Island, where 100 and 50 birds were found respectively in 1945 (*BECOC*, *BNEBL*, *RNEB*). On Ram Island 250 birds occurred in 1947 (Gross, MS.), 35 birds on Chubb Island, Manchester, in 1952, and 200 pairs on Thacher Island in 1954 (D. E. Snyder; *RNEB*). None was found on any of these islands 1965-1972 (W. H. Drury) although terns were seen in summer in the area until 1967 (P. R. Mott). The only surviving colony is on Plum Island, where the first record was in 1949, rising to 4 pairs in 1966 (*RNEB*) and to 50-100 pairs by 1972 (R. C. Tibbetts).

Synthesis

Data from the 19th century are fragmentary, but Common Terns were apparently widely distributed in Massachusetts prior to 1870. Brewster's estimates, which seem not unreasonable, suggest that hundreds of thousands might have bred on Nantucket and Muskeget in 1870. The numbers dropped abruptly in the 1870's and 1880's under intense human predation and only three or four sizable colonies survived (at Chatham, Muskeget, Penikese, and probably at Billingsgate Island). The total numbers at the low point in the 1880's might have been below 5,000 pairs, and probably no more than 10,000 pairs were nesting in 1896 after several years of marked increase.

Numbers increased steadily and rapidly between 1890 and 1915, but at least on Muskeget, the peak numbers appear to have been reached before 1920. In the early 1920's unsuccessful breeding and/or decreases in numbers were reported at several colonies. Except perhaps at Penikese, no substantial increases were reported between 1920 and 1934. Hence the peak population might have been reached before 1920.

The first year in which a reasonably complete assessment seems possible is 1935, when estimates were given as follows: about 35,000 birds in the "Cape Cod Group," 12,000 at Muskeget, 13,000 at Penikese, 1,200 at the Weepeckets, and perhaps a few hundred elsewhere. Based on these estimates, the total population would have been about 30,000 pairs. Estimates in 1952 were 15-25,000 birds in the "Cape Cod Group," 15,000 or more at Penikese, and about 1,500 birds in the smaller colonies. Conflicting estimates at Penikese at this period cause some uncertainty, but it is unlikely that the total was substantially greater than 15,000 pairs. By 1972 the number had fallen by about one-half again, to about 7,500 pairs (Table 1). Where comparative estimates are available, the numbers appear to have decreased steadily in most colonies between 1970 and 1972 (Table 1). Estimates in a number of colonies in 1969 had been some 5-10% higher than those in 1970 (W. H.

Drury). Low counts in 1968 might have reflected extensive non-breeding, as large numbers seen at Monomoy early in that year did not settle to breed there (W. H. Drury).

During the period of decrease (1920-1972), substantial geographical shifts also occurred (Fig. 1). The major colonies on the southern islands were occupied by gulls between 1936 and 1960 and the terns displaced. On Cape Cod, four of the five major islands occupied in the 1920's became unsuitable in the 1930's, and the two major colonies of the 1950's have now declined markedly. The small numbers in the northern colonies did not build up until after 1939.

Austin (1951) claimed that the terns in the "Cape Cod Group" formed a discrete population unit, with negligible interchange with the colonies on the southern islands. However, the evidence given (Austin 1938, 1940, 1946, 1951) does not give strong support to this conclusion, and the most critical evidence offered (Austin, 1951:5-6) seems in fact to show that terns from Penikese and the Weepeckets interchanged rather freely with those from the nearest colonies in the "Cape Cod Group." The low frequency of recorded interchanges can be adequately explained by the very low frequency (4%) of return of birds banded as chicks (Austin, 1940; Austin and Austin, 1956), the small number of adults banded in the southern colonies (Austin, 1951), and the fact that adults tended to lose their bands after about 10 years (Austin, 1942, 1945, 1947; Austin and Austin, 1956). I therefore agree with Crowell and Crowell (1946) that the available evidence indicates that most of the birds displaced from the southern colonies shifted to the Cape Cod colonies. The latter thus appear to have been maintained by massive immigration, and their apparent stability in numbers between 1929 and 1956 was misleading.

ARCTIC TERN: HISTORICAL REVIEW

Nineteenth century records

The status of the Arctic Tern in the 19th century is uncertain because of the difficulty of identifying it among much larger numbers of Common Terns. It was recorded breeding at two or three sites in Essex County (Townsend, 1905), on Cape Cod (Hill, 1965), and on Muskeget (Baird et al. 1884; Allen, 1870). Brewster saw a few at two sites on Martha's Vineyard in 1890, but did not find evidence of nesting (Griseom and Emerson, 1959). Except perhaps at Muskeget, where Baird et al. (1884) listed it in the same way as the Roseate Tern, numbers appear to have been small. Forbush's (1925) statement that it was abundant at Muskeget was apparently based on data pertaining properly to Common Terns. However, Samuels (1875) listed it as almost as abundant in Massachusetts as the Common Tern.

The species was extirpated from Essex County before 1900 (Townsend, 1905), reduced but not eliminated by 1890 on Cape Cod (Hill, 1965), and almost eliminated from Muskeget, where Brewster (MS.) recorded only one bird in 1874 and none in 1890.

Mackay (1895-99) recorded only small numbers there, but shot 8 and saw others in 1896. Hersey (in Bent, MS.) identified "quite a number" on Muskeget in 1903, but Bent (1921) saw only a couple in 1913. Subsequent records are summarized below by regions.

Cape Cod Group

Hill (1965) stated that Arctic Terns increased slowly after 1890, with a marked increase after 1942. Forbush (1925) mentioned a few at Chatham, Monomoy, and Orleans in 1920-21. In 1929 a few were at Tern Island (Floyd, 1929), 60 pairs at Pamet Point, and 10 pairs at Hopkins Island (Austin, 1929). Little further information is available until 1937-38, when 60-70 birds were reported at Plymouth, 20 pairs on Monomoy, 12 pairs at Nauset, 25 pairs at South Chatham, and 150 pairs at Tern Island (*BNEBL*). At this time, however, Austin (1938) estimated the total number as not more than 400 birds. In 1946-47, 180 birds were reported at Plymouth and 100 pairs at North Beach, but no reports from Monomoy and Nauset (*BNEBL*; Hill, 1965). Austin and Austin (1956) estimated the total population at a few hundred birds, including 50-100 pairs at Plymouth in 1954 (*RNEB*). However, only 65 pairs were found in 1972 (Table 1).

Southern Islands

Nantucket. Apart from a record of 10 pairs at Tom Never's Head in 1937 (J. A. Hagar) no records are known prior to 1945, when about 185 birds were seen and 40 nests found in 5 colonies (Griscom and Folger, 1948). Subsequent records (J. C. Andrews; *RNEB*) indicate a slow decrease: at least 80 birds in 3 colonies in 1954, dozens in 1956, 20 pairs at one site in 1958, 15 pairs at another site in 1967. Only one colony (4 nests, 8 birds) was found in 1972 (E. Andrews).

Tuckernuck. In the colony on the sandbars "a scattering" was found in 1936 (J. A. Hagar).

Muskeget. The only numerical estimates are by Hagar: 150 pairs in 1935 (a very rough estimate to be treated cautiously), more than 50 pairs in 1940, none in 1948, one pair in 1952.

Martha's Vineyard. Griscom and Emerson (1959) cite a record of Arctic Terns apparently nesting in 1913. Up to 12 pairs were reported at two sites between 1939 and 1944 (Griscom and Emerson, 1959; *BNEBL*).

No Man's Land. A colony was discovered in 1970 (W. H. Drury). A published figure of 50-100 pairs in 1971 (Lazell and Nisbet, 1972) is thought to be an overestimate, following a more careful survey in 1972 when only 35 pairs were found.

Dartmouth area. Seven pairs were reportedly seen on S. Dartmouth and Acoaxet Rocks in June 1951 (*RNEB*).

Northern Islands

Very small numbers nested on Milk Island from 1932-1938, with 15 pairs in the last year (*BNEBL*, *BECOC*), on Dundy Rock in 1945, on Coney Island in 1947, on Thacher Island in 1955 (*RNEB*) and probably on Tinker's Island in 1967 (P. R. Mott). None has been reported since 1967.

Synthesis

Arctic Terns apparently were reduced to a mere handful in Massachusetts by 1890, and probably recovered more slowly than the Common Terns, with no records of significant numbers before 1920. Records are known of about 250 pairs around 1937-38, of nearly 400 pairs around 1945-47, and of at least 250 pairs in 1954, falling to only about 110 pairs by 1968-1972. The larger counts should be treated cautiously, because of problems with both identification and counting, but the available evidence suggests that the total population reached a peak in the 1940's and has decreased substantially since.

ROSEATE TERN: HISTORICAL REVIEW

Cape Cod Group

The early history of Roseate Terns is unknown. Bent (1921) mentions a major colony at Nauset Beach in 1915, "many thousand pairs of Common and Roseate Terns." The banding totals of Floyd (1925-29) suggest 1,000-2,000 pairs on Tern Island in the late 1920's, at a time when few occurred elsewhere on the outer Cape (Austin, 1929). At least 1,500 pairs were reported there in 1934 (Austin, 1934). Austin (1946) reported that usually 1,000-2,500 birds nested on Bird Island, apparently in addition to those at Ram Island, but by that time the numbers at Tern Island appear to have decreased. Austin and Austin (1956) estimated the entire adult population of the Cape Cod Group in the early 1950's as about 4,000 birds. However, this was probably an underestimate, since 2,859-3,759 chicks were banded each year from 1951-54 (Austin, MS.), and my studies in 1970-72 indicate that the average clutch size is only about 1.7 and only about 1.2 chicks per pair survive to banding age (Nisbet and Drury, 1972). The best year in the Cape Cod Group was 1947, when 5,771 chicks were banded (Austin, MS.), suggesting a total population of at least 4,000 pairs.

During the 1960's the three major colonies were overrun by gulls, and for a few years large numbers were noted on Monomoy (900 pairs in 1966; *AFN*). However, by 1968 Bird Island was re-established as the major colony (800-850 pairs), and this, Ram Island, and Yarmouth have had the largest numbers since that time (Table 1).

Southern Islands

Nantucket. Brewster (MS.) recorded it as abundant with the nesting Common Terns on Coatue Beach in 1870. Subsequently I

have traced no nesting records except for a few on Great Point in 1949 (J. C. Andrews).

Muskeget. In 1870, Brewster (MS.) recorded Roseate Terns only as a small minority among the Common Terns. However, in 1874, after the Common Terns had been decimated, he thought that the Roseate Terns had increased and represented nearly one-half of the total. He found 200 pairs there in 1890, without visiting Gravelly Island which was their stronghold a few years later. The figures of Mackay (1895-97) suggest that Roseates comprised 30-40% of the nesting terns in the 1890's, decreasing to 25% in 1898 (Mackay, 1899), and to 17-20% in 1903 (Bent, MS.) as the Common Terns increased. On the basis of the discussion under Common Terns, it seems likely that the numbers of Roseate Terns did not fall below 1,000-1,500 pairs. Subsequent records are listed in Table 2.

Tuckernuck. Hagar found about 225 pairs on the sandbars west of Tuckernuck in 1936. Burroughs (1966) listed Nan's Island as a nesting site.

Skiffs Island. Nesting in unspecified numbers in 1908 and 1919 (Forbush, 1908, 1925).

Martha's Vineyard. "A local and uncommon summer resident," recorded nesting at four sites (Griscom and Emerson, 1959). Brewster's (MS.) count of 60 pairs in 1890 is the largest figure.

No Mans Land. A colony of 200-400 pairs first recorded in 1970 (Table 1) was probably founded in the 1960's.

Penikese. Mackay (1897b) stated that Roseate Terns comprised a substantial minority of the 6-7,000 terns estimated on the main island in 1896, in addition to some 150 birds on nearby Gull Island. In 1904, Roseates increased and were thought to be as numerous as Common Terns (Anon., 1905a). Subsequently, several estimates indicate that Roseates comprised 10-20% of the 5,000-7,500 pairs of terns nesting there between 1920 and 1952 (see discussion under Common Tern).

Weepeckets. About 150 Roseate Terns were seen in 1896 (Howe, 1897b). Subsequently, they increased less than the Common Terns (Jones, 1903) and comprised only about one-fourth of the totals cited above for the 1920's and 1930's (Crowell and Crowell, 1946).

Northern Islands

The only definite record of breeding is in 1846 (Townsend, 1921). Small numbers were seen in summer and suspected of breeding in 1933, 1934, and 1954 (*BECOC*, *RNEB*).

Synthesis

Brewster's vague notes in 1870 are the only evidence that the Roseate Tern was ever abundant in Massachusetts. His notes on Muskeget in 1874 suggest that it had suffered much less from human

persecution than the Common Tern; his statement that it had increased there between 1870 and 1874 might indicate that birds had moved there from other colonies. It is unlikely that the numbers on Muskeget and Penikese together fell below 2,000 pairs at their lowest point, in addition to some at Chatham.

In the 20th century Roseate Terns have been recorded in numbers (over 50 pairs) at only 12 colonies. Data from the late 1920's suggest that about 2,500 pairs occurred on Tern Island and Penikese alone, in addition to substantial numbers on Muskeget and probably some on Egg, Bird, and Ram Islands. In the late 1930's at least 2,000 pairs occurred on Muskeget (discounting the discrepant estimate in 1938), about 1,000 pairs on Penikese and probably 2,000 pairs in the Cape Group, where 2,564 chicks were banded in 1936, 2,668 in 1938, and 2,014 in 1940. In 1947, when the numbers at Penikese were variously estimated as 500 and 1,500 birds, probably at least 4,000 pairs were breeding in the Cape Group. In the early 1950's probably some 3,000 pairs were known in the Cape Group and 500-1,000 pairs on Penikese. Thus, the peak population was apparently nearly 5,000 pairs around 1940, falling below 4,000 pairs by 1952 and to about 2,300 pairs in 1972.

LEAST TERN: HISTORICAL REVIEW

Least Terns have always nested primarily on the mainland and on the large islands, hence largely separated from the other species. Their numbers are especially difficult to count because the colonies are scattered and the birds continually shift between them. Although large numbers of counts in individual colonies have been published, sufficient data are available for only a few years to make even a guess of the total population. Accordingly, the following review is arranged chronologically rather than by localities.

Nineteenth century

Least Terns were formerly common to abundant in Buzzards Bay, on Nantucket, Cape Cod, and north to Ipswich (Bent, 1921; Forbush, 1925; Brewster, 1879; Hill, 1965; Townsend, 1921). They were eliminated from Essex County and greatly reduced elsewhere during the 1870's and 1880's. On Monomoy, Cahoon (1890) reported that several hundred pairs had nested around 1884, reduced to less than 25 pairs by 1890. On Muskeget, 100 were seen in May 1894 and 10 nests were found in 1896 (Mackay, 1895, 1897c). Mackay (1895) also referred to a few breeding on Tucker-nuck. On Martha's Vineyard, Brewster found 80 pairs in three colonies in 1890 (Griscom and Emerson, 1959), Howe (1897a) found 60 birds in two colonies in 1896, and Smith (1902) reported an increase, with an estimate of 500 adults and young in one flock on 1 October 1901. Hill (1965) also states that colonies survived on most of Cape Cod, but his reference to Forbush (1925) is incorrect and I have found no direct evidence for this.

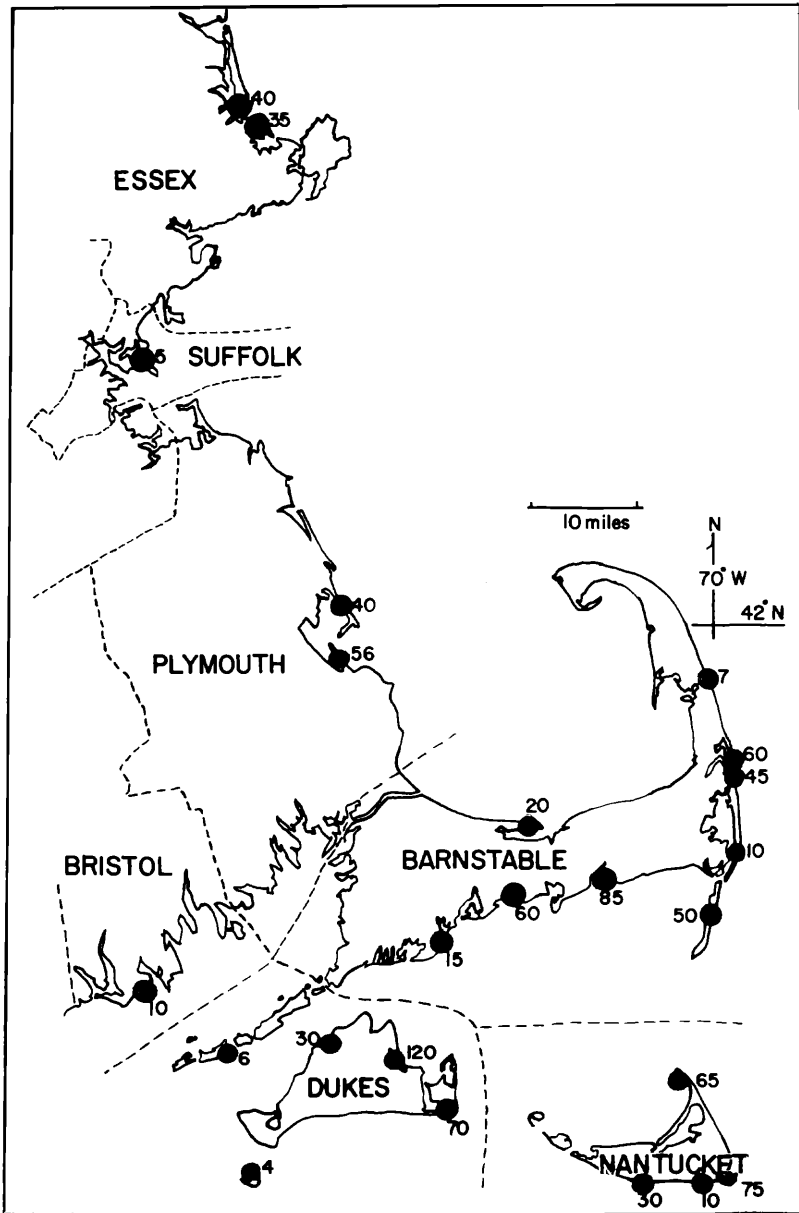


FIGURE 2. Least Tern colonies in Massachusetts in 1972, with estimates of the number of pairs nesting in June. County boundaries are marked for comparison with the census of Hagar (1937)—see Table 3.

1902-1923

Bent (1921) stated that Least Terns increased slowly from 1905 onwards. The only precise records are from Martha's Vineyard, where Forbush (1917) reported a decrease from at least 200 pairs "a few years ago" to less than 50 pairs in 1917. Forbush (1925) mentioned five breeding-sites on Cape Cod, and also colonies in Bristol County, and north to Duxbury. Forbush (1921, 1925) estimated that the total number in Massachusetts was less than 200 birds in 1921 and less than 300 birds in 1923.

1923-1937

During the 1920's Least Terns established colonies north to Plymouth Beach (Hagar, 1937) and Scituate (Griscom and Snyder, 1955). In 1934 and 1935 Hagar (1937) attempted a census of most of the suitable coastline in the state and found 830 pairs. The area omitted, embracing the east and north parts of Nantucket, the north shore of Cape Cod and the Elizabeth Islands, included about 10% of the total population in the 1972 census (Fig. 2). Hence the best estimate of the 1934-35 population is probably between 900 and 1,000 pairs.

1938-1966

On Cape Cod, Hill (1965) reported an increase to a peak around 1945, falling to about 500 pairs in 1964. During this period large colonies were reported in the Chatham area (up to 300 birds around 1953), at Hyannis (150-200 birds nesting in 1958), Monomoy (5 pairs in 1943 increasing to a reported 200 pairs in 1966), and Nauset (40 pairs in 1943 increasing to 150 pairs in 1966). At the same time the numbers dwindled at Plymouth (from 200 pairs in 1939 to 50-100 birds 1954-66) and at Scituate (from 250 birds in 1954 to 30 pairs in 1966). In the same period, however, Least Terns spread northward to Ipswich (colonized about 1945, increasing to 20 nests in 1964) and Plum Island (colonized before 1949, peaking at 40 nests in 1950-51 and falling to 20 birds in 1960). On Nantucket, where Hagar had found 125 pairs in 1934-35, numbers built up during the 1940's to a recorded peak of over 600 birds in 3 colonies in 1954, but appear to have declined thereafter (data from *AFN*, *BNEBL*, and *RNEB*). Little information from Martha's Vineyard is available for this period, and only small colonies were reported elsewhere.

Although without a complete census at this period, the data suggest that a peak was reached between 1945 and 1954, some 50% higher than Hagar's figure for 1934-35. Our estimate of about 950 pairs in 1972 (Table 3) represents a decrease to near the 1934-35 total. It is possible, however, that both these estimated totals are somewhat too high, because the birds move frequently and some might have been counted twice.

TABLE 3. Estimated total number of pairs of Least Terns, by counties, at various periods.

	ca. 1910 (Forbush, 1917)	1934-35 (Hagar, 1937)	1945-52 (various sources)	1972 (this paper)
Essex	—	—	40	75
Suffolk	—	—	—	5
Plymouth	—	245	200	95
Barnstable (Cape Cod)	a few	300	700	360
Nantucket	a few	200	300	180
Dukes (Martha's Vineyard)	200	155	250	230
Bristol	—	50	30	10
Total	250	950	1,500	950

NUMBERS AND TRENDS IN OTHER AREAS

Only a few detailed surveys of changes in tern populations in other parts of their breeding range have been published, and I have not attempted to trace all the original data in local publications. However, in this section the major sources are summarized in order to place the fluctuations in Massachusetts in a wider perspective.

Common Tern

In *Maine*, Common Terns were reduced to perhaps 1,500-2,000 pairs around 1900, increased to roughly 6,000-8,000 pairs between 1930 and 1940, but now number only about 2,400 pairs (various sources, summarized by W. H. Drury). In *New Hampshire*, the species was extirpated before 1900 (Allen, 1903); a colony of about 1,000 pairs on Londoner's Island in 1928 (Jackson and Allan, 1931) disappeared at some time after 1944 (Gross, MS.; W. H. Drury); two small colonies were found at Hampton Harbor in the 1950's (RNEB). In *Rhode Island* numbers have never exceeded about 300 pairs dispersed among many small colonies (Clement and Woodruff, 1962); about 200 pairs were known in 1972 (D. Duffy, R. Ferren, W. H. Drury). In *Connecticut* 75 pairs in 4 colonies were known in 1900 (Dutcher, 1901); subsequently few records are available until 1947-48, when 700 pairs were found in a census along the western half of the coast (AFN); these decreased as the main colony was occupied by gulls in the 1950's and many terns moved to Falkners Island (Mackenzie, 1961). In an aerial survey in 1972 roughly 500-750 pairs were found in 9 small colonies (W. H. Drury), plus 500 pairs on Falkner's Island (D. Duffy). On *Long*

Island the species apparently decreased in the 1880's and 1890's to a few thousand pairs, shifting between 3 colonies at the eastern end of the island (Dutcher, 1889; Reed, 1898; Dutcher, 1901, 1902; Latham, 1915; Bull, 1964; Heilbrun, 1970); in 1923 only 4 known colonies remained (Griscom, 1923). In the early 1930's at least 7,000 pairs were known in eastern Long Island (Wilcox, 1938; Allen, 1933; Bull, 1964); the data and map in Wilcox (1938) suggest that this was a fairly complete survey and that only a few hundred pairs occurred in western Long Island. Little further information is available until the 1960's: reasonably comprehensive surveys between 1968 and 1972 indicate a total of about 5,000 pairs in western Long Island and 6,000-7,000 pairs in eastern Long Island (*Kingbird*, 1968-71; Hays, 1970; J. Bull, D. Duffy, W. H. Drury, M. Gochfeld, D. Puleston).

To summarize, the recent decrease in Massachusetts and Maine has been partially offset by an increase in western Long Island. However, the total number in the area between New York City and eastern Maine, now about 22,000 pairs, is less than one-half the corresponding estimate for the 1930's. Although the numbers in Massachusetts apparently levelled off before 1930, most of the decrease in the whole region took place after 1940.

I have not found comparably complete information for other parts of the East Coast breeding range. An aerial survey in Nova Scotia in 1971, combined with ground counts and a literature search, suggested a total of about 2,000-3,000 pairs (Lock, 1971). In the Gulf of St. Lawrence, at least 5,000 pairs are known in northeastern New Brunswick (S. Homer, P. A. Pearce), more than 1,000 pairs in the Magdalen Islands (J. A. Hagar) and probably over 500 pairs in the North Shore Sanctuaries (Moisan and Fyfe, 1967; Nettleship, 1972). Smaller numbers have been reported from Newfoundland (Peters and Burleigh, 1951) and Labrador (Todd, 1963). I have found no indications of marked trends except on Sable Island, Nova Scotia, where numbers were apparently much larger in the past (A. R. Lock).

To the south, Common Terns nest as far south as South Carolina, with a few small colonies in the Caribbean region (Voous, 1963). I have found reports of only three large colonies in recent years. At Fisherman's Island, Virginia, P. A. Buckley estimated 5,000 pairs in 1967, but only 950 pairs in 1971 (M. Byrd). At Indian River Inlet, Delaware, over 1,200 nests were counted in 1967 (*AFN*). At Tuckerton, New Jersey, over 2,000 pairs were reported in 1953 (*AFN*). Numbers are believed to have declined in recent years in Maryland (C. S. Robbins) and probably in New Jersey, where I have traced no records of colonies larger than 250 pairs in recent years.

These data fall far short of a complete census, but they suggest that the 20,000 pairs of Common Terns now estimated between New York City and southern Maine comprise slightly less than one-half of the entire East Coast population. In the 1930's, Massachusetts probably contained a major fraction of the East Coast population, but it has now probably been replaced in importance

by the populations of the southern Gulf of St. Lawrence, Long Island, and Virginia.

A substantial population of Common Terns also nests in the interior of the continent (see Ludwig, 1962). I have not found reports on population trends, but some colonies are now reproducing badly (Switzer et al., 1971; M. Gilbertson).

Arctic Tern

Massachusetts is at the extreme southern fringe of the extensive breeding range of this tern (one inconclusive report suggested nesting in Connecticut (*RNEB*, 1954).) The numbers nesting in the Gulf of Maine and Bay of Fundy, estimated at 7,000 pairs in 1972, have not changed significantly since 1931 and probably not markedly since the 1890's (W. H. Drury). However, in the same period a vast colony on Sable Island, Nova Scotia, has decreased from reportedly hundreds of thousands of birds in 1913 to less than 2,000 birds in 1971 (A. R. Lock). Little or no information exists for changes elsewhere in eastern Canada.

Roseate Tern

South of Long Island negligible numbers of Roseate Terns have been reported in this century (Bent, 1921; Stone, 1937; *AFN*), except in the Caribbean region where a number of small colonies exist (Sprunt, 1949; Bond, 1956; Voous, 1963). On eastern *Long Island* the species was rare in the 1880's, but some 500 pairs were known in the 1930's (Wilcox, 1938; Bull, 1964). During the 1960's Roseate Terns settled on Great Gull Island and built up to 1,100-1,500 pairs by 1970-71 (Heilbrun, 1970; Pessino, 1970; Hays, 1970; J. Bull); several hundred pairs have been reported in at least eight other colonies, including a few as far west as Short Beach on the south shore and Stony Brook on the north shore (*Kingbird*, 1960-1971; Bull, 1964). In *Connecticut* a colony of 500 pairs at Goose Island was broken up before 1900 (Dutcher, 1901); several records of up to 125 pairs were reported between 1947 and 1951 (*RNEB*; Mackenzie, 1961); 65 nests were found in two colonies in 1972 (D. Duffy). In *Rhode Island* only scattered nesting pairs have been recorded (Clement and Woodruff, 1962), and none was reported in 1972. In *New Hampshire* 10 pairs were reported in 1929 (Jackson and Allan, 1931). In *Maine* 550 birds were found in 1931 and 250 pairs in 1972 (W. H. Drury). In *Nova Scotia* roughly 200 pairs were found in an incomplete survey in 1971 (Lock, 1971).

In summary, much of the decrease in numbers in southern Massachusetts since 1940 can be accounted for by a shift to eastern Long Island. The population in these two areas, now 4,000-4,500 pairs, is not significantly lower than the peak estimate of nearly 5,000 pairs around 1940; it now comprises almost 90% of all the Roseate Terns nesting in eastern North America north of the Caribbean region.

Least Tern

Historical records (e.g., state avifaunas, and Bent, 1921) suggest that the Least Tern might have fluctuated in numbers more than any of the other three species. After the population crash in the 1880's, the species was thought to be extinct or virtually extinct in every state for which I have found records, except southeastern Massachusetts and Virginia, where perhaps a few hundred pairs survived. However, it became abundant again in the 1920's and 1930's in North Carolina, South Carolina, and Georgia, with 25,000 birds estimated for North Carolina alone in 1939 (Pearson et al., 1942).

In 1972 R. L. Downing, E. J. Fisk, and others revisited most of the North Carolina nesting areas listed by Pearson et al. (1942) and found most sites deserted. Only 18 colonies were found, totalling less than 1,000 pairs, and Downing estimated less than 2,500 pairs in the state. Downing, Fisk, and others also visited many traditional colonies in Florida, Georgia, Virginia, and New Jersey and found most of them deserted or markedly reduced. These surveys will be continued and reported elsewhere. Least Terns recolonized *Long Island* about 1924, and by 1942 more than 300 pairs were known in 6 colonies (Bull, 1964). The species is believed to have reached a peak in the 1950's and now to be declining (J. Bull). However, counts reported in the *Kingbird* (1966-1971) and unpublished data of D. Duffy and M. Gochfeld from 1972 account for at least 1,500 pairs in 20 colonies. I have no up-to-date counts for *Connecticut* and *Rhode Island*, but published reports (Clement and Woodruff, 1962; Mackenzie, 1961; *RNEB*; *AFN*) are of small numbers only. Least Terns colonized *New Hampshire* in 1953 and *Maine* in 1961, and at least 80 birds in two colonies were found in *Maine* in 1971 (*RNEB*, *AFN*).

Surveys of this species have been less complete than for the other three species, but the Least Tern has apparently decreased in most areas since the late 1940's or early 1950's, and the center of its population might have shifted northwards as far as New Jersey or Long Island.

CAUSES OF THE CHANGES IN NUMBERS

The Common, Arctic, and Least terns decreased catastrophically in Massachusetts in 1870's and 1880's, increased rapidly to a peak between 1920 and 1950, and have steadily declined since to a new low in the 1970's. Table 4 summarizes my estimates of the numbers of each species at the low and high points. As shown in the previous section, qualitatively similar changes have been recorded in some other parts of the terns' breeding ranges in eastern North America.

Doubtless the decline in the late 19th century was due to human persecution. The terns apparently withstood repeated eggging for a number of years (Allen, 1870; Mackay, 1897c), but each colony was decimated within a few years after the start of plume-hunting (Anon., 1887a,b; Bent, 1921; Brewster, 1897, MS.). Protection

TABLE 4. Estimated numbers of pairs of terns breeding in Massachusetts at four periods. Only the last two columns are based on comprehensive surveys; for details see the text.

	Before 1871	Low Point	High Point	(1972) Present numbers
Common Tern	"hundreds of thousands"	ca 5,000	30-40,000 (1920-1930)	7,500
Arctic Tern	probably scarce	ca 20	300-400 (1935-1945)	105
Roseate Tern	probably thousands	ca 2,000	4,500-5,000 (1930-1940)	2,300
Least Tern	"abundant": probably thousands	ca 100	1,500 (1945-1954)	950

for the birds, followed immediately by their rapid increase, makes a dramatic story best read in the original reports (especially Dutcher, 1901-1904).

At least in Massachusetts, previous writers apparently overestimated the extent to which the terns were reduced at their lowest point. According to the estimates in this paper (Table 5), their recovery represents no more than a doubling every 8-10 years, which is not particularly remarkable in comparison, for example, with that of the Laughing Gull (*Larus atricilla*; Nisbet, 1971).

The reasons for the subsequent decrease are still under investigation (Nisbet, 1972), and only preliminary and tentative conclusions can be given now. For the Least Tern, human disturbance (especially beach driving) is an obvious adverse factor, in addition to the problems of predators and high tides: the most remarkable feature is the slowness of the decline. Human disturbance is probably an important factor for the Arctic Tern also, as it usually nests in open areas on the edge of Common Tern colonies.

For the other two species, the decrease in numbers has coincided with the loss of all the major colonies favored during the period of increase. The large colonies on the outer islands have been successively occupied by gulls, whereas the inshore islands close to Cape Cod have been washed away, attached to the mainland, or occupied by gulls. One obvious explanation, therefore, is that the terns have been forced to nest in unsuitable places on or near the mainland where they are subject to predation, human disturbance, and pollution. This explanation was proposed by Norton (1921) for an early decline in Maine. This is unlikely to be a complete explanation for Massachusetts, however, for two reasons. First, the increase in the Common Terns apparently stopped around 1920, before Herring Gulls had started to nest in Massachusetts and before Laughing Gulls had seriously limited their nesting area even on Muskeget. Second, terns have recently occupied two offshore

islands that have newly become suitable (Monomoy and No Mans Land), but have not bred very successfully there (Nisbet, 1972; Lazell and Nisbet, 1972).

Table 5 summarizes the available records of breeding success in Common Terns of Massachusetts. Although the basis for the early estimates is not very clearly specified, Table 5 suggests that the mean breeding success in Common Terns has declined substantially since the 1900's and might now be lower even than in the 1950's. At Tern Island and Plymouth, where Common Terns bred very successfully as recently as 1953-54, breeding success has been consistently low in recent years (Nisbet and Drury, 1972; Nisbet,

TABLE 5. Estimates of breeding success of Common Terns in Massachusetts

Year	Locality	Chicks raised per pair	Notes
1905	Weepecket Is.	1.1 ^a	Anon., 1905b. Stated to be 1,500 young raised from 1,320 nests, of which 100 nests were washed out.
1908	Weepecket Is.	1.5-2.5 ^a	Bowdish, 1909. 2,800 young raised (94% of those hatched) from a population of the order of 1,500 pairs. About 5% higher success than in 1907.
1925-1945	Weepecket Is.	0-1.5	Crowell and Crowell, 1946. About 1.4 birds banded per pair in the best season. Only 4 good seasons out of 11 described.
1929	Cape Cod (5 colonies)	1.1	Austin, 1929. 42% of eggs produced fledged chicks: these data appear to refer primarily to Commons, although Roseate eggs were included in the counts. Clutch size 2.6 (Austin, O. L., Jr., 1932).
1929-1955	Cape Cod Group	0.3-2.0 (mean 1.07)	Austin and Austin, 1956. Based on number of chicks banded annually, plus 10% for chicks missed (see p. 58), divided by estimated adult population. Note, however, that Austin (1938-51) had given estimates of adult population 40-60% higher. The best years were 1934 (Austin, 1934), 1949 (RNEB), 1953 and 1954 (AFN).
1970-1971	6 colonies	0.0-2.1 (mean 0.92)	Nisbet and Drury, 1972. Weighted mean of measurements in 6 colonies.
1972	8 colonies	0.0-1.8 (mean 0.40)	Nisbet, 1972. Weighted mean of measurements in 8 colonies.

^aIncluded a minority (not more than 25%) of Roseate Terns.

1972). This suggests that low breeding success is one factor in the population decline. The Austins (1929-51) placed primary emphasis on predation, human disturbance, and vandalism in limiting breeding success, and Austin (1946) specifically rejected food shortage as a possible cause. However, in my studies low breeding success has been consistently associated with slow chick growth, and most of the chicks that were taken by predators in 1972 were already in poor condition (Nisbet, 1972). These problems are under further study.

SUMMARY

The four species of terns (*Sterna* spp.) that nest in Massachusetts were greatly reduced in numbers by human persecution in the late 19th century, increased under protection to reach peak numbers between 1920 and 1950, but are now decreasing again.

Hundreds of thousands of terns were reported at two colonies in 1870: these estimates are unverifiable but are not implausible. The total numbers were probably reduced to between 5,000 and 10,000 pairs in the 1880's. However, Common Terns and Roseate Terns were not as close to extirpation as is often stated.

Common Terns reached a peak population in Massachusetts of 30-40,000 pairs about 1920, and have now decreased to about 7,500 pairs. Arctic Terns reached a peak of 300-400 pairs about 1940 and have decreased to about 100 pairs. Roseate Terns reached a peak of nearly 5,000 pairs about 1935 and have decreased to about 2,300 pairs. Least Terns reached a peak of roughly 1,500 pairs about 1950 and have now decreased to about 950 pairs.

Common, Arctic, and Least terns have also decreased in some other areas along the east coast of North America. A substantial fraction of the east coast populations of Common and Least terns now breeds in Long Island and Massachusetts. The recent decrease of Roseate Terns in Massachusetts has been offset by an increase in eastern Long Island: the total population of 4,000-5,000 pairs in this region probably comprises some 90% of the total number nesting north of the Caribbean region and has not changed markedly since 1920.

One factor that has probably contributed to the decline is that the offshore islands formerly preferred by the terns have been occupied by gulls, and other islands have become unsuitable for other reasons, so that the terns are now nesting on inshore islands or on the mainland where they are vulnerable to human disturbance, pollution, and predation. For the Common Tern some evidence suggests that breeding success is now generally lower than in the past: this is believed to reflect local food shortage.

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