of this species near Tchaun Bay, USSR. The neck-bands of 16 *C. c. cygnus* dropped off and 11 birds were found dead. For *C. c. bewickii* these figures were 1 and 8.

Resightings were made of 43 *C. c. cygnus* (47%), 7 Japanese-banded *C. c. bewickii* (37%) and 12 Soviet-banded *C. c. bewickii* (28%). Some individuals were resighted in several successive winters.

Editorial note

The paper presented at the Symposium included a number of tables and maps, full texts of which can be obtained from the author.

M YOSHII
Bird Migration Research Centre
Yamashina Institute for Ornithology
8–20 Nanpeidai-Machi
Shibuya-ku
Tokyo 150
Japan

TRADITIONAL RETURN OF *CYGNUS COLUMBIANUS COLUMBIANUS* TO WINTERING AREAS IN MARYLAND'S CHESAPEAKE BAY

R E MUNRO

Introduction

The continental population of *Cygnus columbianus columbianus* has averaged about 105 000 birds during the 1955 to 1977 period (unpubl data, US Fish and Wildlife Service (USFWS) Migratory Bird Management Office (MBMO), Laurel, Maryland), including about 56 000 swans in the Atlantic Flyway. Other than limited hunting seasons in some western states and subsistence hunting by natives in northern Canada and Alaska, swans have been completely protected from legal hunting for over 60 years.

Wintering waterfowl in the United States are surveyed each January by the USFWS in co-operation with the states. Survey procedure and documentation of results varied during the 1940s. Beginning in 1953, survey results have been summarized annually in the 'Special Scientific Report – Wildlife' series. The survey provides the only annual population estimate for *C. c. columbianus.*

From 1955 to 1977 more than 99% of Atlantic Flyway *C. c. columbianus* wintered in Maryland, Virginia, or North Carolina. Because of their stable or increasing numbers during this period, swan populations have received little attention. There is almost as much literature on populations of feral *Cygnus olor* in the eastern United States as there is on native *C. c. columbianus.* Similarly, studies on the previously endangered *Cygnus cygnus buccinator* are numerous.

Strong tradition in waterfowl movements, migrations and wintering area locations is usually assumed to be fact and has been generally demonstrated in a number of banding studies. Based on banding evidence, Hochbaum (1955: 111) suggested that '. . . not only do they (waterfowl) start and end the annual cycle of travel at a familiar home range, but the adults visit familiar stopping places along the routes of migration'. Specificity of food habits certainly has a marked effect on the distribution of eg *Branta bernicla nigricans* (Einarsen 1965). Reduced food availability, adverse weather or shortage of suitable water areas have been shown to alter winter distributions of, for example, *Anas platyrhynchos* and *Anas rubripes* (Bellrose and Crompton 1970), *Branta canadensis* (Rutherford 1970), *Anser rossii* (Dzubin 1965) and *Cygnus columbianus bewickii* (Ogilvie 1969).

Waterfowl return rates to specific wintering areas have also been examined over a wide array of species and locations. Examples include *A. platyrhynchos* (Anderson and Henny 1972), *A. rubripes* (Geis *et al* 1971), *Aythya valisineria* (Geis 1974), *Aythya americana* (Weller 1964), and *Anser anser* and *Anser brachyrhynchus* (Newton *et al* 1973). In general, most investigators found that at least 50% of the birds returned to the same wintering areas during subsequent seasons. However, few of these studies addressed the extent of return of individuals to wintering areas over a number of years.

Description of the Atlantic Flyway, the Chesapeake Bay and specific study areas

The Atlantic Flyway (Fig 1), easternmost of the four US flyways, is bounded by the Atlantic Ocean and encompasses states from Maine to Florida. One of the most important wintering areas in the Flyway is the Chesapeake Bay, the largest estuarine system along the eastern coast of North America. Shared by Maryland and Virginia, the Bay and coastal North Carolina are the winter range for almost all eastern *C. c. columbianus.*

With more than 13 000 km of shoreline (Lippson 1973), the Bay offers a great diversity of habitats for up to 30 species of wintering waterfowl (Stewart 1962). Salinities in the upper or Maryland portion of the Bay range from 0 to 15 parts per thousand. Waterfowl survey strata used by the Maryland Wildlife Administration were combined into five broad survey areas (Fig 2).

Five study areas (Fig 2) were selected. The Rhode/West River area, located south of

Fig 1. The Atlantic Flyway of the United States

Annapolis in Anne Arundel County on Maryland's western shore, annually wintered a small but relatively constant population of *C. c. columbianus.* The remaining study areas were located on Maryland's eastern shore. Claiborne, near the mouth of the Miles River in Talbot County, also wintered a small but stable population of swans. Blackwater National Wildlife Refuge (NWR) in Dorchester County was selected due to the relative ease of capturing swans there during late winter. Brackish impoundments on the Refuge had recently become attractive to swans. Eastern Neck NWR, an island between the lower Chester River and the Bay proper in Kent County, had long been known to be a major staging area for waterfowl. Although wintering swan populations were usually less than 1200 birds, many

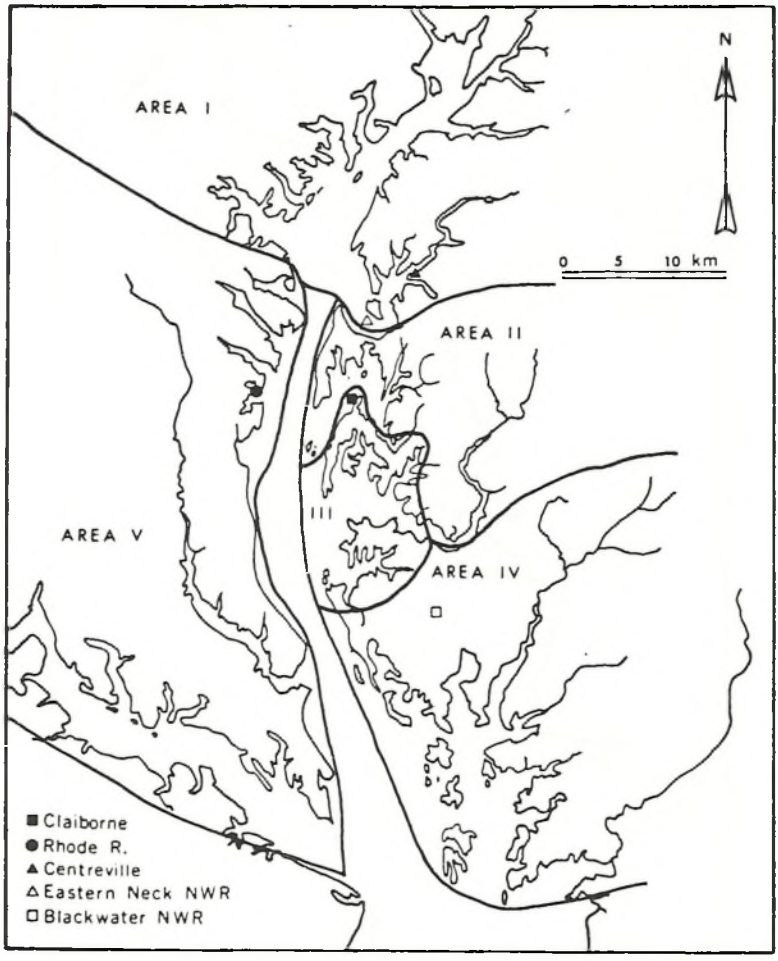

Fig 2. Locations of study areas in the upper Chesapeake Bay of Maryland, and waterfowl survey areas I–V

thousands of ducks, geese and swans frequented the shallow water areas surrounding the Refuge each fall and spring. An area near Centreville in Queen Anne's County was included because of the availability of a small number of swans captured in agricultural fields by the Maryland Wildlife Administration.

Methods and materials

Original tabulations of winter survey data from MBMO were used rather than transcribed data from over 20 publications. Since the January 1954 survey in the

Atlantic Flyway was severely hampered by inclement weather (Crissey 1954), January 1955 is the first year in the analysis. The years 1955 to 1971 were taken to represent the previous long-term distribution, and 1972 to 1977 to represent the current distribution of birds. The latter period corresponds to one during which submerged aquatic vegetation in Maryland's Chesapeake Bay became less abundant (Kerwin *et al* 1976). New long-term distributions based on all years (1955 to 1977) were also determined. Since most Flyway swans winter in Maryland, Virginia and North Carolina, survey results from 'other' areas were combined.

Laminated plastic neck-bands (Sladen 1973) 77 mm wide and 55 mm in diameter were used as the principal marker. Standard USFWS bands and plastic tarsus-bands were also used. All plastic bands were engraved with a letter prefix and three digit suffix for individual recognition.

Three hundred and forty swans were marked during the winter of 1969/70. Most swans were captured at Blackwater NWR in early March. Much of this report is based on about 3500 observations of these birds that accumulated during the next six years.

Birds were observed with 15-60x spotting scopes which enabled positive identification up to 150 m under ideal conditions. Although many observations of marked birds were collected at or near study areas, many were contributed by volunteers from all parts of the Bay. Observer effort was therefore opportunistic rather than random or systematic.

A computer algorithm was coded to approximate distances (km) between any two points or observations, based on latitude-longitude co-ordinates. A constant of 1.36 km per minute of longitude was used for the Chesapeake Bay area; the constant for latitude was 1.85 km per minute.

Analysis of variance (ANOVA) and linear regression used in this study followed the Statistical Analysis System user's guide (Barr *et al* 1976). ANOVA assumes, among other factors, sample independence. This assumption was not always met because observations of the same animals were represented a number of times across a six-year period. In spite of this difficulty, I concur with Myers (1974), who concluded, 'Although statistical rigor may be lost, the value of the additional insight into populations that can be gained from sequential samples seems more important.'

Analyses of percentages were based on arcsine-transformed data, as suggested by Snedecor and Cochran (1967), followed by a duplicate analysis on the untransformed data. Where no differences were indicated between results of the duplicate analyses, untransformed results were used. Indicator variables, discussed in detail by Neter and Wasserman (1974), were used to represent categories of a variable such as sex.

Distances (km) at which birds were observed from their banding sites were not

normally distributed because of a disproportionate number of zero values. A log transformation to stabilize variance (Snedecor and Cochran 1967) of distance measurements resulted in no improvement; untransformed distances were therefore used.

Table 1. Numbers and linear regression analyses of percent distributions of Atlantic Flyway *Cygnus columbianus columbianus* over three time periods

		Number and % of Atlantic Flyway				
Species, period and parameter	US total	Atlantic Flyway	Maryland	Virginia	North Carolina	Other
1955 to 1971						
Mean number	97 976	52 712	35 018	3 741	13 868	85
Percent mean		53.8	65.4	7.6	26.9	0.2
S.E.		2.5	2.7	1.6	2.1	0.0
C.V.		19.3	16.8	86.9	32.7	74.0
F value		0.0	0.1	1.7	1.6	1.0
p>F		0.898	0.779	0.208	0.229	0.342
slope estimate (%)		—	—	—	—	—
1972 to 1977						
Mean number	124 284	67 583	33 167	4 083	28 833	1 500
Percent mean		55.1	50.2	5.9	41.6	2.3
S.E.		3.3	4.8	0.9	4.7	0.6
C.V.		14.7	23.2	35.4	27.4	63.8
F value		2.5	25.5	0.3	108.3	2.7
p>F		0.189	0.007	0.609	0.001	0.175
slope estimate (%)		—	–5.8	—	+6.0	—
1955 to 1977						
Mean number	104 839	56 591	34 535	3 830	17 772	454
Percent mean		54.1	61.4	7.2	30.7	0.7
S.E.		2.0	2.7	1.2	2.4	0.2
C.V.		17.9	20.9	80.5	37.0	167.2
F value		0.2	6.2	1.0	13.5	18.1
p>F		0.656	0.021	0.334	0.001	0.000
slope estimate (%)		—	–0.9	—	+1.1	+0.1

Since cygnets (hatch-year swans) could be distinguished from adult-plumaged birds throughout their first winter, they will be referred to as 'young', even though after January they would be in their second calendar year of life. These birds of known

age, if observed during their second winter, would be considered 'subadults'. However, they would be indistinguishable from adults of unknown age on the basis of plumage alone.

The term 'winter', unless otherwise specified, will refer to the period 1 November to 30 March. The term 'upper Bay' means 'Maryland's Chesapeake Bay'.

Results

Distribution of Atlantic Flyway C. c. columbianus

For each time period a hypothesis of no consistent, linear change (zero slope) in percent distribution was tested.

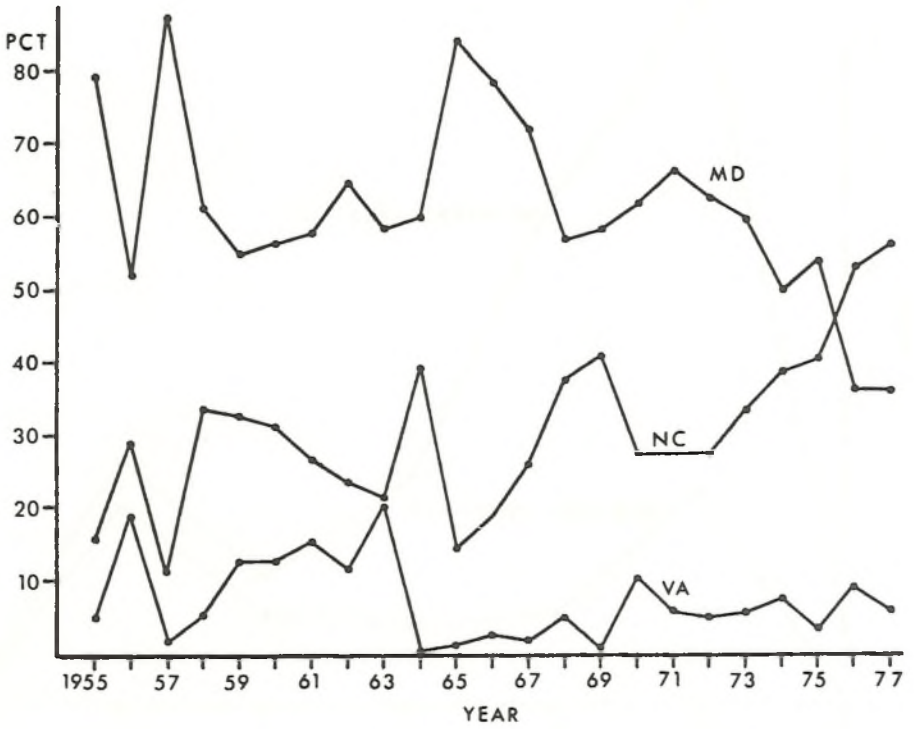

Fig 3. January inventory of *Cygnus columbianus columbianus* in Maryland, North Carolina and Virginia for the years 1955 to 1977. (Unpublished data, Migratory Bird Management Office, Laurel, Maryland).

The Flyway population averaged 53 000 birds or 54% of the US total during the previous long-term period, and about 67 000 birds or 55% of the total during the current period (Table 1). Although numbers of birds were greater during the current period, there was no trend in the proportion of the continental population that wintered in the Flyway during either period. Maryland, Virginia and North Carolina wintered 99.8% of the Flyway total through 1971, and only slightly less through 1977. Percent distribution is therefore illustrated only for these three states (Fig 3).

Within the Flyway there was no change in percent distribution for any area during the 1955 to 1971 period (Table 1). However, highly significant trends were detected for Maryland (–5.8%/year, $p = 0.007$) and North Carolina (+6.0%/year, $p = 0.001$) during the current period. In January 1976, North Carolina wintered

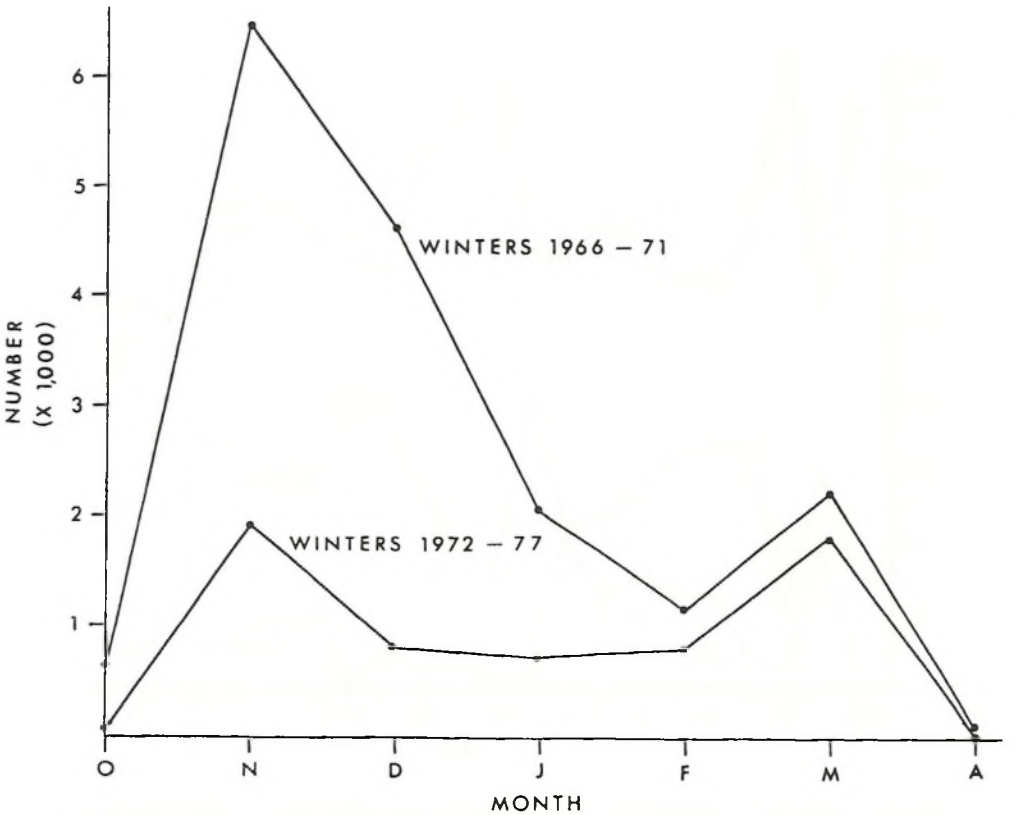

Fig 4. Peak numbers by month of *Cygnus columbianus columbianus* at Eastern Neck NWR averaged over the winters 1966 to 1971 and 1972 to 1977.

more swans than Maryland for the first time in more than 20 years. Trends for the new long-term period (1955 to 1977) were: (1) a gradual decrease in Maryland (−0.9%/year); (2) an increase in North Carolina (+1.1%/year); (3) an increase in 'other' areas (+0.1%/year).

Temporal and geographic distribution of swans in the upper Bay

Numbers of swans observed by Refuge personnel at Eastern Neck NWR during the winters 1966 to 1971 and 1972 to 1977 were examined to determine maximum monthly numbers averaged for each of the two periods (Fig 4). The Refuge, a major staging area for waterfowl, annually received large numbers of swans during November. During both periods, the initial November increase was followed by a sharp decline through December and January to a February low (wintering population), and then an increase during March as swans staged for spring migration. Although curve shapes were similar for the two periods, numbers of swans observed were considerably less during the later period when other surveys (Kerwin *et al* 1976) indicated reduced availability of submerged aquatic vegetation in the Bay.

Surveys of swans from November to January (Table 2) indicate the northern portion of the upper Bay (Area I, Fig 2) decreases in importance from November (35.6%) to December (21.0%). Also, at least 50% of swans during these months are found in the middle eastern shore area (Areas II and III). These areas include Eastern Bay, the Miles and Wye Rivers, as well as the Choptank and Little Choptank Rivers. Together with the Chester River (southeast portion of Area I), these rivers and Eastern Bay represent the main wintering area for about 75% of the upper Chesapeake Bay swan population. Although substantial brackish estuarine bay communities are found in Area V, such as along the lower reaches of the Patuxent and Potomac Rivers on the western shore, and to a more limited extent in Area IV on the lower eastern shore, these areas winter only about 25% of the January population of upper Bay swans.

Table 2. Distribution of *Cygnus columbianus columbianus* by survey area; average numbers during winters 1967 to 1975.

Survey area	November		December		January	
	Number	%	Number	%	Number	%
I	11 000	35.6	8 550	21.0	8 300	20.8
II	9 620	31.1	12 000	29.5	11 250	28.2
III	6 120	19.8	11 400	28.0	9 780	24.5
IV	1 650	5.3	2 280	5.6	3 630	9.1
V	2 530	8.2	6 470	15.9	6 940	17.4
	30 920		40 700		39 900	

Unpublished data, Maryland Wildlife Administration, Annapolis, Maryland. December surveys were not conducted after the 1970 winter. The November 1974 survey was not conducted.

Stewart (1962) also estimated that about 75% of upper Bay swans wintered in the middle eastern shore area during the mid to late 1950s. However, a direct comparison with Stewart's results cannot be made, as he included the Magothy, Severn, South, Rhode and West Rivers of the western shore in his tabulations. Nevertheless, the brackish estuarine bay community is still the preferred habitat of swans wintering in the upper Bay.

Observer effort

All upper Bay observations of 340 neck-banded swans in the original cohort were summarized by 15 day period and year (Table 3). Of 2038 total Bay observations,

Table 3. Numbers of observations of neck-banded *Cygnus columbianus columbianus* during 1970 to 1975 by 15 day period

Delaware is included with Maryland

Period and dates	State totals			
	Maryland		North Carolina	
1 Nov – 15 Nov	80	3.9	0	0.0
16 Nov – 30 Nov	242	11.9	1	2.3
1 Dec – 15 Dec	230	11.3	2	4.6
16 Dec – 30 Dec	97	4.8	3	6.8
31 Dec – 14 Jan	240	11.8	7	15.9
15 Jan – 29 Jan	285	14.0	6	13.6
30 Jan – 13 Feb	196	9.6	7	15.9
14 Feb – 28 Feb	257	12.6	18	40.9
1 Mar – 15 Mar	271	13.3	0	0.0
16 Mar – 30 Mar	140	6.9	0	0.0
	2 038	100.1	44	100.0

about 70% were collected during the first (699) and second (741) winters (1970 and 1971). Subsequent winters provided 365, 124, 59 and 50 observations. Observer effort at first resulted in 5.9 and 5.4 sightings per marked bird, but apparently declined after the 1972 winter to between 2 and 3 observations per marked bird, although effort and availability of marked swans cannot be separated. Both mortality of swans and loss of neck-bands reduced availability of marked birds. Given these limitations, seasonal distribution of observations, other than during the first and last periods when fewer marked birds were available, was fairly uniform and fluctuated around 10% per period except for the last half of December. Only 44 observations of these birds in North Carolina were recorded during six years. The value of these few observations and of even smaller numbers in Pennsylvania and Virginia was realized only when examined on an individual basis.

Seasonal movement and winter residence

With the winter divided into 10 periods of 15 days, there were 60 periods for observation of swans during the 1970 to 1975 winters. In actuality, sightings were much less frequent and scattered, as indicated by a sample set out according to banding site in Table 4. There was much variability within and among individuals.

Table 4. Resighting data for a sample (22) of the 224 *Cygnus columbianus columbianus* seen in winters following that of banding (1969/70)

M = Maryland/Delaware, C = North Carolina, P = Pennsylvania, V = Virginia

Banding site/swan	Winter of resighting						Resighted in	
	70/71	71/72	72/73	73/74	74/75	75/76	Years	15 day periods
Rhode River								
C007	M	C	–	M	M	M	5	10
C037	–	M	C	–	–	–	2	4
C040	M	M	C	M	–	–	4	12
C048	M	M	M	M	–	–	4	28
Eastern Neck								
C116	M	C	M	M	–	–	4	16
C119	M	M	M	M	–	–	4	16
C120	M	M	–	–	C	–	3	18
Claiborne								
C129	–	–	M	–	–	C	2	2
C605	–	M	M	C	C	M	5	9
C609	M	–	–	C	P	P	4	6
C622	M	M	M	M	M	–	5	17
C637	M	M	–	–	–	–	2	6
Blackwater								
C176	M	M	M	M	M	M	6	20
C193	M	C	–	C	M	M	5	9
C671	M	–	–	–	–	–	1	1
C689	M	–	–	C	–	–	2	2
C692	M	–	M	V	M	M	5	6
C858	M	M	M	P	–	–	4	3
C886	M	–	C	–	C	–	3	4
C900	–	–	–	M	–	M	2	2
C917	–	C	C	–	–	–	2	2
C940	–	M	–	–	–	–	1	6

For example, C048 was frequently observed in Maryland throughout the 1970 to 1973 winters. C007 was observed early in February 1972, in North Carolina. Not located during the 1972 winter, C007 was then observed in Maryland during the early winter of 1973 and not again until the following winter. A similar pattern was suggested by observations of C037 and C040.

These examples indicate a pattern of seasonal movement and winter residence with which nearly all observations of individually marked swans were consistent. Swans migrated into the upper Bay area during November. Of swans observed in the Bay at any time from early December to mid-February, none was observed outside the Bay area until spring migration. From mid-February on, however, swans moved into the Bay area from wintering areas farther south. Therefore, the period of winter residence in the upper Bay extends from at least the first days of December to mid-February.

Examples of birds banded on other study areas further substantiate this pattern. C116 and C119 were observed together for 20 days during the 1970 winter and always within one-half km of their Eastern Neck banding site of the previous winter. Banded as male and female, their behaviour indicated they were a pair. On 11 and 12 November 1971 both were observed back at Eastern Neck near their band site. C119 was next observed alone for the first time on 16 and 17 November in the usual cove, and then on 19 and 22 November while feeding in corn fields about 8 km from the Refuge. C116, presumed dead at the time, was observed alone later that same winter on 12 February 1972 about 350 km to the south in North Carolina. Fifteen days later C116 and C119 were observed together field feeding on Maryland's eastern shore. Over the next two winters, both were observed only in Maryland and only during mid-winter.

C120 was another winter resident at Eastern Neck, with 40 observations there throughout the 1970 and 1971 winters. This bird was not observed again for over two years and then was found in North Carolina. From Claiborne C605 was observed early or late in Maryland, and during mid-winter in North Carolina. The same pattern was indicated by observations of C193 and by a general lack of observations of Blackwater-banded birds during mid-winter. Since many of these birds were banded during late February and early March, some of them (C689, C886 and C917) were marked while on migration from wintering areas in North Carolina.

Table 5. Number of winters in which *Cygnus columbianus columbianus* neck-banded at various areas of Chesapeake Bay were resighted

Banded in 1969/70 in area	Years subsequently seen							Total resighted
	0	1	2	3	4	5	6	
Rhode River	11	13	10	5	5	2	2	37
Eastern Neck	10	10	9	8	3	1	1	32
Claiborne	12	23	14	6	5	3	–	51
Blackwater	64	54	21	22	3	2	2	104
Consecutive	–	69	26	21	10	2	5	133
With breaks	–	31	28	20	6	6	–	91

The number of winters, consecutive or with breaks, that swans were subsequently seen are summarized in Table 5.

Availability and survival

All available data on the original neck-banded sample of 340 birds were used to tabulate known survivors for eacn winter to 1975/76 (Table 6). These data include not only direct observations of swans in the various winters, but also those that could be inferred to be alive because they were observed during later years.

Table 6. Minimum numbers (N) of neck-banded *Cygnus columbianus columbianus* known to be available in Chesapeake Bay, expressed as the percentage of the number available the previous year

A = adult, I = immature, U = unidentified, M = male, F = female

Age	Banded	1970/71		1971/72		1972/73		1973/74		1974/75		1975/76	
Sex	1969/70	N	%	N	%	N	%	N	%	N	%	N	%
AM	128	94	73	65	69	39	60	26	67	11	42	7	64
AF	146	117	80	98	84	71	72	51	72	35	69	16	46
IM	26	20	77	16	80	7	44	5	71	2	40	1	50
IF	25	13	52	10	77	8	80	7	87	5	71	3	60
UU	15	13	87	10	77	9	90	3	33	2	67	1	50
All	340	257	75.6	199	77.4	134	67.3	92	68.7	55	59.8	28	50.9

The analysis of variance was designed to detect changes in annual proportions of marked birds (all study areas combined) of each age-sex class that were known to survive from one year to the next. No overall differences in intercept or slope were indicated among age-sex classes. A significant ($p = 0.0047$) downward trend through the years in the combined data was found. One arbitrarily chosen class, adult females (AF), was tested for zero intercept and zero slope, the former being somewhat meaningless. A marginally significant difference (−6.2%, $p = 0.0069$) in slope was detected, ie the percentage of the marked adult female population that remained was estimated to decrease about 6 percentage points per year from 92% (intercept) during the year of banding.

These data provide minimum estimates of annual survival rates that were near 75% for each of the first two years after banding. The 25% lost from the marked population each year include those that 1) died, 2) lost neck-bands, 3) emigrated to other wintering areas and 4) were still marked and alive but not observed. All factors considered, annual survival rates of adult swans probably approach 85% to 90%.

A similar analysis by study area of banding was made with all age-sex classes combined. No differences in intercept or slope were indicated among study areas.

Rates of return to the Bay

Observations of marked swans in Delaware, bordering Maryland on the eastern shore of Chesapeake Bay, were treated as returns to the Bay area, whereas observations in Virginia (south of the Potomac River) and Pennsylvania (north of Maryland's Susquehanna Flats) were excluded. Numbers of neck-banded swans observed each winter were summarized by age-sex class (Table 7) and expressed as a percentage of those known to be available that year (Table 6). For example, 68 neck-banded adult male swans were observed during the 1970/71 winter, of 94 known to be available. Therefore 72.3% of the available marked adult male population were observed in the Bay during the 1970 winter.

Table 7. Numbers (N) of neck-banded *Cygnus columbianus columbianus* which returned to the Chesapeake Bay, expressed as the percentage of the number known to be available that year (see Table 6)

Age	1970/71		1971/72		1972/73		1973/74		1974/75		1975/76	
Sex	N	%	N	%	N	%	N	%	N	%	N	%
AM	68	72	38	58	18	46	13	50	2	18	5	71
AF	83	71	67	68	38	53	23	45	16	46	12	75
IM	11	55	8	50	3	43	0	0	1	50	0	0
IF	9	69	5	50	5	62	3	43	3	60	3	100
UU	10	77	7	70	4	44	1	33	2	100	1	100
All	181	70.4	125	62.8	68	50.7	40	43.5	24	43.6	21	75

Analysis of variance of percent return yielded no differences in intercept, slope or year effect in the combined data or among age-sex classes. Of 340 swans marked during the 1969 winter, only 28 were known to be available for observation after six winters. The fact that 21 (75%) of those individuals were observed six winters after banding had a substantial effect on the analysis and may have obscured an apparent downward trend over the intervening five winters.

A similar analysis by study area of banding also produced no detectable differences or trends in return rates. Since no significant effects were detected in either analysis, the estimated return rate of neck-banded swans to the upper Bay area was between 65% (intercept for adult females) and 75% (Rhode River birds) of the number available each winter.

Return to specific Bay wintering areas

The above analyses examined return rates of marked swans to the Chesapeake Bay wintering area and not their return to specific sites in the Bay. Using the same observations, a more detailed analysis was constructed. Co-ordinates of observation of a marked individual were compared with those of the band site and a return

distance (km) determined for each record. Within a winter season, all return distances for an individual were examined to identify the smallest value (nearest to the band site). This resulted in 459 observations of return distance for Bay-marked swans, some of which were represented four or five times (only once per season).

To provide a larger sample as well as a source of comparison, records of swans neck-banded during the summer of 1970 in the Northwest Territories (NWT) were examined to identify individuals that were observed in the Chesapeake Bay area during at least two different winters. The first Bay location of a NWT bird was taken as a 'home base' with which the bird's subsequent return during another winter could be compared. This resulted in 104 observations of return distance for 56 NWT-banded swans.

The analysis of variance examined the effects of age at banding, sex and years since banding on return distance. The most important effect on return distance was an increase with years (6.3 km/year, $p = 0.0001$). Return distances of males and females were similar; those of subadults (marked as young of the previous year) were not significantly different ($p = 0.0656$) from those of adults. Of the between-study area comparisons, only return distances for Blackwater birds were different from those for all other areas. A simplified model, based on significant effects from the full model, yielded very similar parameter estimates; the year effect was 6.2 km/year and the area effect was −0.7 km/year multiplied by an appropriate coefficient.

Swans banded in the Northwest Territories had return distances, similarly measured, which were essentially the same as those for birds banded in the Bay. In effect, these birds represented many more populations, widely dispersed over the Bay area, that showed the same tendency to return to specific areas.

Despite the indicated increase with time in return distance, most swans were observed near their banding areas. Of swans that returned to the Bay within six winters of banding, about 30% were observed within 0.5 km of the band site and about 56% within 10 km. The maximum distances for the same individuals did not exceed 20 km in 50% of cases.

Blackwater birds also differed from others in timing of return. All observations of birds that returned to their band site (same one-half minute block of banding for Maryland-banded swans, or area of observation for NWT-banded swans) were grouped by 15-day periods and categorized as Blackwater birds or 'others'.

Dates of return were not necessarily the first observations during a winter season, but the first dates of return to band sites. By mid-December, more than half of swans from areas other than Blackwater NWR had returned to their band sites (Fig 5). In contrast, Blackwater swans returned mostly during February and March, which provides further evidence that some of these birds wintered farther south of the Bay in Virginia or the Carolinas.

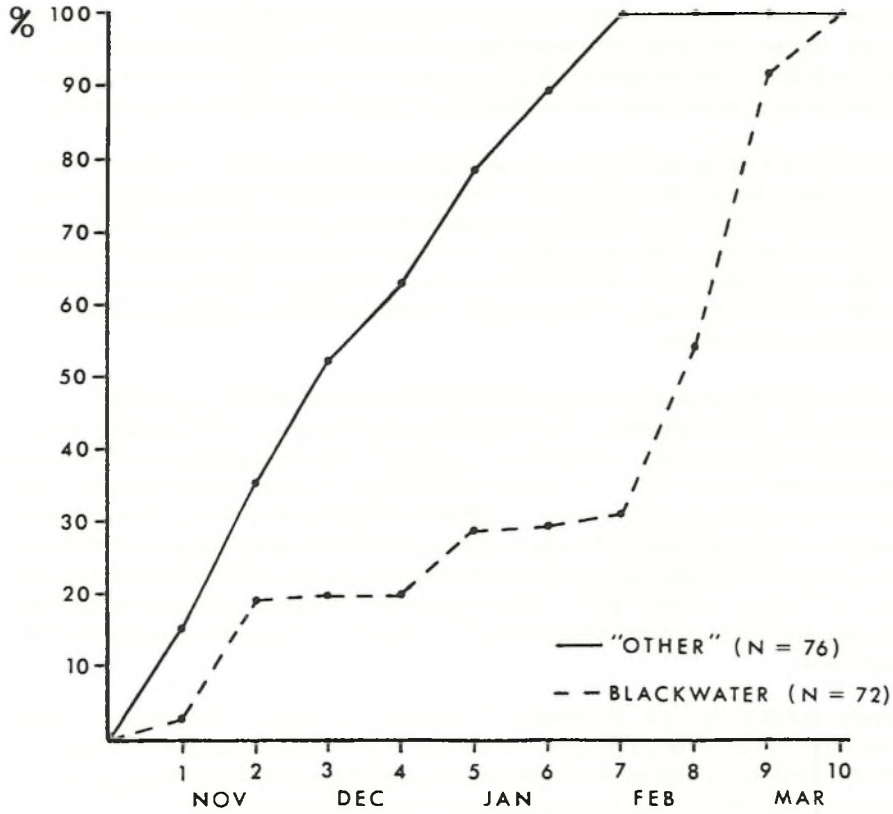

Fig 5. Cumulative percent distribution by time period during which Blackwater and 'other' neck-banded swans were initially observed back at their one-half minute blocks of banding

Conclusions

Traditional use of the Chesapeake Bay by *C. c. columbianus* has been known since the earliest accounts of the Bay were written. Recent winter surveys demonstrated that the middle eastern shore area of Maryland, with its abundance of brackish estuarine bay habitat, continues to be the primary Bay wintering area for swans. Some swans use the Bay during November and after mid-February while on migration to and from wintering areas farther south such as North Carolina. Those that remain until early December comprise the winter residents; most of these birds remain until spring migration.

Based on observations of neck-banded swans, annual survival rates of adults exceed 75% and probably 85% to 90%. Mortality, loss of neck-bands and emigration to

other wintering areas account for the remainder.

Annual return rates to Chesapeake Bay wintering or staging areas were estimated at 65% to 75% during the 1970 to 1975 winters. Specifically, about 70% of the number of marked swans known to be available for observation were seen in the upper Bay area at least once each winter. No trend over years or differences between age-sex classes in return rates could be detected. Since January surveys indicated a substantial shift of swans from Maryland to North Carolina during the 1972 to 1977 period, there probably was some reduction in rate of return or use of the Bay by wintering and/or migrating swans.

Swans tended to return to the same locality each winter. Detailed analysis showed a measurable drift of about 5 km per year for all but Blackwater-banded birds. Of more importance, about 56% of all neck-banded swans that returned to the Bay (regardless of year) were observed within 10 km of their banding site.

The most important factor affecting distribution of swans in Maryland and the Atlantic Flyway during the 1970s has been the reduction in aquatic food resources of the Chesapeake Bay. Significant numbers of swans then began feeding in agricultural fields, which they had done perhaps 20 years earlier while on spring migration from the Flyway. The interplay between traditional return to specific Bay wintering areas and adaptation to field feeding will continue for a number of years. New traditions have already formed, as many swans now return to the Bay and feed in the same group of fields each year. It is anticipated that Maryland's Chesapeake Bay will winter an increasing number and proportion of Atlantic Flyway swans, as adaptation becomes tradition for more individuals.

Acknowledgements

For their many observations of neck-banded swans or their help in capturing birds, I thank the following: Ray Schweinsburg, John Moore, Jeanette and Floyd Evans, William Julian, the late Edward Folsom, Willie Parker and William Kensinger. William Sladen advised this study and provided much guidance and assistance. I also thank USFWS biometrician Paul Geissler and research biologists Charles Kimball, Ronald Kirby and James Nichols for their review of this report. Sharon Rhoades (MBMO) is acknowledged for her assistance in obtaining original data. This study was supported by the Johns Hopkins University School of Hygiene and Public Health. Analysis of data and report preparation were supported by the USFWS Migratory Bird and Habitat Research Laboratory.

Summary

The paper reviews return of neck-banded *Cygnus columbianus columbianus* to wintering areas in Chesapeake Bay over a number of years. Annual survival rates of adults probably approach 85%; annual return rates were about 70%, and 56% of birds were observed within 10 km of their banding site. Reduction in aquatic food resources has led to agricultural field feeding, and it is suggested that this adaptation will become a tradition for more individuals.

References

Anderson, D R and C J Henny (1972). Population ecology of the mallard: I. A review of previous studies and the distribution and migration from breeding areas. *US Fish Wildl Serv Resour Publ* 105. 166 p.

Barr, A J, J H Goodnight, J P Sell and J T Helwig (1976). *A user's guide to SAS 76.* SAS Inst Inc, Raleigh, N C. 329 p.

Bellrose, F C and R D Crompton (1970). Migration behavior of mallards and black ducks as determined from banding. *Ill Nat Hist Surv Bull* 30: 167–234.

Crissey, W F, ed (1954). Status report of waterfowl, 1954. *US Fish Wildl Serv Spec Sci Rep – Wildl* 26. 97 p.

Dzubin, A (1965). A study of migrating Ross geese in western Saskatchewan. *Condor* 67 (6): 511–534.

Einarsen, A S (1965). *Black brant, sea goose of the Pacific coast.* Univ Washington Press, Seattle, Wash. 142 p.

Geis, A D (1974). Breeding and wintering areas of canvasbacks harvested in various states and provinces. *US Fish Wildl Serv Spec Sci Rep – Wildl* 185. 78 p.

Geis, A D, R I Smith and J P Rogers (1971). Black duck distribution, harvest characteristics, and survival. *US Fish Wildl Serv Spec Sci Rep – Wildl* 139. 241 p.

Hochbaum, H A (1955). *Travels and traditions of waterfowl.* Charles T Branford Co, Newton, Mass. 301 p.

Kerwin, J A, R E Munro and W W A Peterson (1976). Distribution and abundance of aquatic vegetation in the upper Chesapeake Bay, 1971–1974, p 393–400 *in* J Davis, coord. The effects of tropical storm Agnes on the Chesapeake Bay estuarine system. Chesapeake Res Consortium Publ No 54, The Johns Hopkins Univ Press, Baltimore, Md. 639 p.

Lippson, A J, ed (1973). *The Chesapeake Bay in Maryland – an atlas of natural resources.* The Johns Hopkins Univ Press, Baltimore, Md. 55 p.

Myers, J H (1974). Genetic and social structure of feral house mouse populations on Grizzly Island, California. *Ecology* 55 (4): 747–759.

Neter, J and W Wasserman (1974). *Applied linear statistical models.* Richard D Irwin Inc, Homewood Ill. 842 p.

Newton, I, V M Thom and W Brotherston (1973). Behaviour and distribution of wild geese in south-east Scotland. *Wildfowl* 24: 111–121.

Ogilvie, M A (1969). Bewick's swans in Britain and Ireland during 1956–69. *Brit Birds* 61 (12): 505–522.

Rutherford, W H (1970). The Canada geese of southeastern Colorado. *Colo Dept Nat Resour Tech Publ* 26. 65 p.

Sladen, W J L (1973). A continental study of whistling swans using neck collars. *Wildfowl* 24: 8–14.

Snedecor, G W and W G Cochran (1967). *Statistical methods.* The Iowa State Univ Press, Ames, Iowa. 593 p.

Stewart, R E (1962). Waterfowl populations in the upper Chesapeake Bay region. *US Fish Wildl Serv Spec Sci Rep – Wildl* 65. 208 p.

Weller, M W (1964). Distribution and migration of the redhead. *J Wildl Manage* 28 (1): 64–103.

R E MUNRO
USFWS Migratory Bird and Habitat Research Laboratory
Laurel
Maryland 20811
USA