Sixth in the Fuertes print series

The original painting was published as the color frontispiece of *Bird-Lore,* Vol. XVII, Number One, January-February 1915. The text that accompanied it was entitled "The Migration of North American Sparrows, 32nd paper" and was compiled by W.W. Cooke, chiefly from data from the Biological Survey. Unlike earlier texts that accompanied the Fuertes paintings for *Bird-Lore,* there were no plumage descriptions. The following is an abridged version of the Cooke text, with modern nomenclature added in brackets. The print facing was reproduced directly from the original painting, which until recently was in the possession of the National Audubon Society.

The main range of the Rocky Mountains, from southern to northern Mexico, is occupied in summer by four forms of junco The ***Pink-sided*** [now considered a race of the Dark-eyed Junco, *Junco hyemalis mearnsi*] is the most northern, breeding from southern Saskatchewan through central Montana to northern Wyoming and southern Idaho.

Just to the south of its range comes the ***Gray-headed Junco*** [still considered a full species, *Junco caniceps*], which is the commonest summer bird of the central Rocky Mountain region and is particularly abundant in the mountains of Colorado, where at 8-9000 feet, it nests in dooryards and about porches . . . It breeds from southern Wyoming to northern New Mexico and west in Utah and Nevada. [It is possible that the *J. caniceps* group may be merged as two additional subspecies of the Dark-eyed Junco, for where ranges meet, *J. caniceps* unquestionably interbreeds with *J. hyemalis thurberi* and *J. hyemalis mearnsi;* but a problem exists as to assortative mating].

The principal breeding junco of New Mexico and Arizona is the ***Red-backed Junco***, [not shown] which occupies the higher slopes of the mountains of northern Arizona and most of the mountains of New Mexico, except the extreme northern part and a small section of the southwestern part of the state. [This junco is for the present considered a race of the Gray-headed Junco, with the name *J. caniceps dorsalis*].

The ***Arizona Junco*** is found principally in northern Mexico, but a few nest in the mountains of southern Arizona and southwestern New Mexico. [This form is currently regarded as a race of the Yellow-eyed Junco, *Junco phaeonotus palliatus*]

Baird's Junco is a non-migratory species, inhabiting the mountains of the southern end of Lower (Baja) California [It is now considered a race of Yellow-eyed Junco, *J. p. bairdi*].

Guadalupe Junco. This species is known only from Guadalupe Island, off the coast of Lower (Baja) California [It is now considered a race of Dark-eyed Junco, *J h insularis*].

The assistance of Eugene Eisenmann in updating the taxomony of this group is acknowledged.

Key to painting
1 Gray-headed Junco
2 (Arizona) Yellow-eyed Junco
3 (Pink-sided) Dark-eyed Junco
4 (Guadalupe) Dark-eyed Junco
5 (Baird's or Cape) Yellow-eyed Junco


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Louis Agassiz Fuertes.

Decline and disappearance of the Dusky Seaside Sparrow from Merritt Island, Florida

One last chance to save a small, unobtrusive, critically endangered Florida endemic

Paul W. Sykes, Jr.

THE DUSKY SEASIDE SPARROW, *Ammospiza maritima nigrescens,* (Figs. 1 and 10) was first discovered by Charles J. Maynard near Salt Lake on the St. Johns River west of Titusville, Brevard County, Florida, on March 17, 1872 (Maynard 1875, 1881). Later that spring, Maynard found the sparrow to be quite common in the salt marsh on the Canaveral Peninsula in what is now the Merritt Island National Wildlife Refuge (hereafter, N.W.R.) on the John F. Kennedy Space Center. The first Dusky nests were found 42 years later when Oscar E. Baynard and Henry Simpson located three on the peninsula along the edge of Indian River on May 21, 1914 (Baynard 1914). The sparrow was abundant in the marsh on the east of the Indian River until the 1950s (Maynard 1881, chapman 1899, Baynard 1914, Vars 1926, Howell 1932, Sprunt 1954). By the early 1960s, the sparrow had disappeared from much of its former range and a decline occurred in an area under study on Merritt Island (Trost 1964, 1968).

The Dusky Seaside Sparrow, relegated to subspecific rank in 1973 (A.O.U. Check-list Committee 1973), has, as far as we know, always been restricted to northern Brevard Country. It was once present on the east side of the St. Johns River in the vicinity of Salt Lake south to Persimmon Hammock, and on the Canaveral Peninsula (North Merritt Island) from Haulover Canal south to Banana Creek and east to the north end of the Banana River (Chapman 1899, Howell 1932, Trost 1968).

Before 1961, little work had been done on the sparrow other than some minor habitat studies by Nicholson (1928), and extensive collecting of specimens and clutches of eggs. Trost (1964, 1968, pers. comm.) was the first to actually conduct a study of this sparrow, concentrating his work mainly on the Canaveral Peninsula from 1961 to 1963. The limited range, alternation and destruction of its habitat for mosquito control and other purposes, and its declining population led the U.S. Fish & Wildlife Service to declare the Dusky Seaside Sparrow endangered in 1966 (Committee on Rare and Endangered Wildlife Species 1966). Following this, Sharp (1968, 1970) made an extensive study of the sparrow's status and distribution on the Merritt Island N.W.R. and on the St. Johns River from March to July 1968. From 1972 through 1978, Baker (1973, 1978) made surveys on the St. Johns and experimented with fire as a management tool. All these studies were primarily surveys, some incorporating vegetative analysis. Little is known of this subspecies' biology.

I monitored the population status of the Dusky Seaside Sparrow on the Merritt Island N.W.R. on the North Merritt Island from the spring of 1969 through the spring of 1976. The present paper presents the general history and habitat of the sparrow on the Canaveral Peninsula, the results of this study, and management recommendations.

AREA AND METHODS

THE ENLARGED PORTION of the Canaveral Peninsula on the east shore of Indian River and opposite Titusville, here referred to as North Merritt Island (Fig. 2), consists mostly of upland habitats with bordering marshes along Mosquito Lagoon, Indian River, Banana Creek, and Banana River. Except where otherwise noted, reference to Merritt Island refers to North Merritt Island, which is separated from Merritt Island to the south by Banana Creek and contains the remaining habitat for the Dusky Seaside Sparrow.

Between 1958 and 1962 the National Aeronautics and Space Administration (NASA) acquired all of North Merritt Island as well as most of Merritt Island north of Cocoa and established the John F. Kennedy Space Center. An agreement between the U.S. Fish and Wildlife Service and NASA on August 28, 1963, established the Merritt Island National Wildlife Refure on NASA-owned land The refuge is administered by the Fish and Wildlife Service and includes all Kennedy Space Center lands not directly used for space program purposes. These lands encompass all of the sparrow's habitat on Merritt Island.

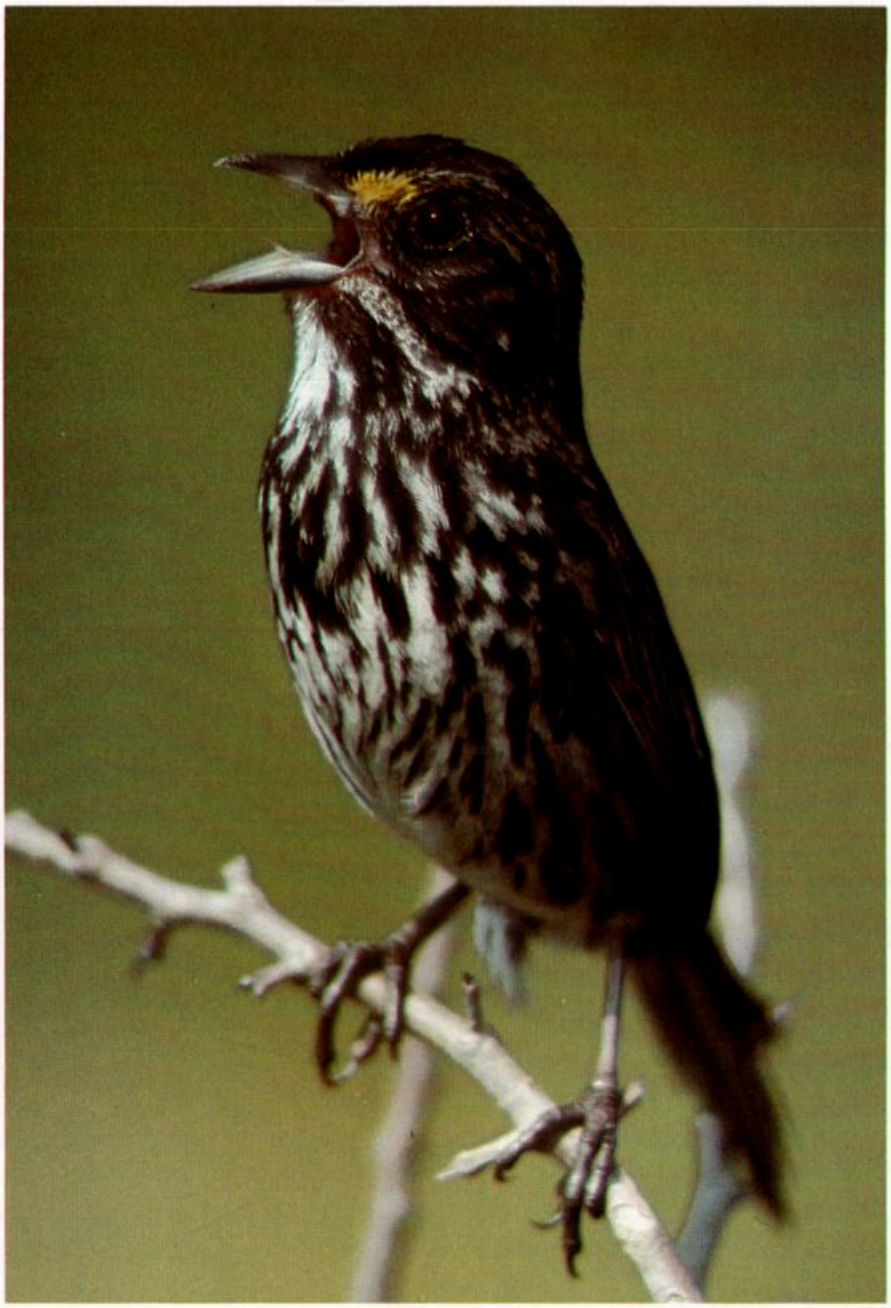
In 1969 the Fish and Wildlife Service entered into a cooperative agreement with the Brevard Mosquito Control District that allows the district to manage water levels in the three impoundments under my study. The District constructed the dike system and still controls the water levels in the impoundments on the refuge for mosquito control purposes. A subdike was constructed along a NW-SE axis across the center of impoundment T-10-K (see Fig. 2D) so that the east half could continue to be flooded for mosquito control. The outer dike on the west half was breached at the head of Black Point Creek to allow the drainage of rainfall into the creek and permit the inflow and outflow of tidal waters. Thus, T-10-K was to be flooded

only by natural means and T-10-J remained flooded for mosquito control. Impoundment T-24-C was drained from February through August and flooded from September through January. The subdike in T-10-K was completely removed in December 1972, eliminating continuous flooding in the east and west half of the outer dike along Black Point Creek and Indian River was removed in 1978 to allow more natural movement of water in the marsh.

The original high-type (relatively dry) salt marsh on Merritt Island extended from the shore of Indian River eastward to the upland habitats. The width of this marsh ranged from 0.8 to 4 km and extended unbroken except for numerous short tidal creeks and small ponds from Dummit Creek south to the west end of Banana Creek (Fig. 2A). This contiguous marsh community contained about 3076 ha. Much smaller and discontinuous marshes were scattered along Banana Creek and at the north end of Banana River. The main marsh consisted of dense stands of glasswort (*Salicornia bigelovii, S. virginica*), pickleweed (*Batis maritima),* and salt marsh grass (*Distichlis spicata*) along the shore. It extended inland and mixed with extensive stands of salt marsh bunch grass (*Spartina bakerii*) and scattered stands of black needle rush (*Juncus roemerianus*) on the slightly higher elevations. Small stands of sea-ox-eye (*Borrichia frutescens*) and groundsel (*Baccharis halimifolia*) were scattered on elevation knolls in the marsh. Small black mangroves (*Avicennia germinans*) were also found widely spaced in places in the marsh (Baynard 1914, Nicholosn 1928, Trost 1964, 1968, Baker 1978). There is no detailed description of this large salt marsh community before extensive alteration by man. However, published photographs (Baynard 1914, Nicholson 1928) give a general idea of the appearance of the original marsh.

Under natural conditions the marsh was intermittently flooded by rains and fresh water sheet-flow from the uplands and periodic innundation by salt water from the Indian River, producing a pattern of alternate flushing of the marsh with fresh and salt waters. Heavy flooding with salt water occurred only during storms, as a result of wind tides, and during the high spring and fall tides. Only the outer edge of the marsh was flooded frequently. There was no flooding of the marsh on a daily basis as occurs in the low-type (*Spartina alterniflora)* marsh. The tidal fluctuation was rather small; over a month, it normally ranged about 0.3m (Trost 1964) but higher with wind and storm tides.

FROM 1969 TO 1976 I monitored the Dusky Seaside Sparrow population in the three areas in which it remained on Merritt Island N.W.R., with some follow-up research through the spring of 1979. The census method chosen was the singing-male count, but non-singing birds were also censused. This method and its limitations are discussed by Sharp (1970). The study areas were the southern third (77 ha) of T-10-J, west half (116 ha) of T-10-K, and the east half (41 ha) of T-24-C (see Fig. 3B for locations of impoundments). I established transects to give complete coverage of all sparrow habitat remaining in these areas. I plotted the location of each singing male during each census and usually censused between 6:50 a.m. and 9:45 a.m. to take advantage of the most active period of singing. Twenty-nine censuses totaling 80 hours ($\bar{x}$ = 10/yr) were



Adult male Dusky Seaside Sparrow on territory, Impoundment T-24-C, Merritt Island N.W.R., Brevard County, Florida, May 29, 1971.

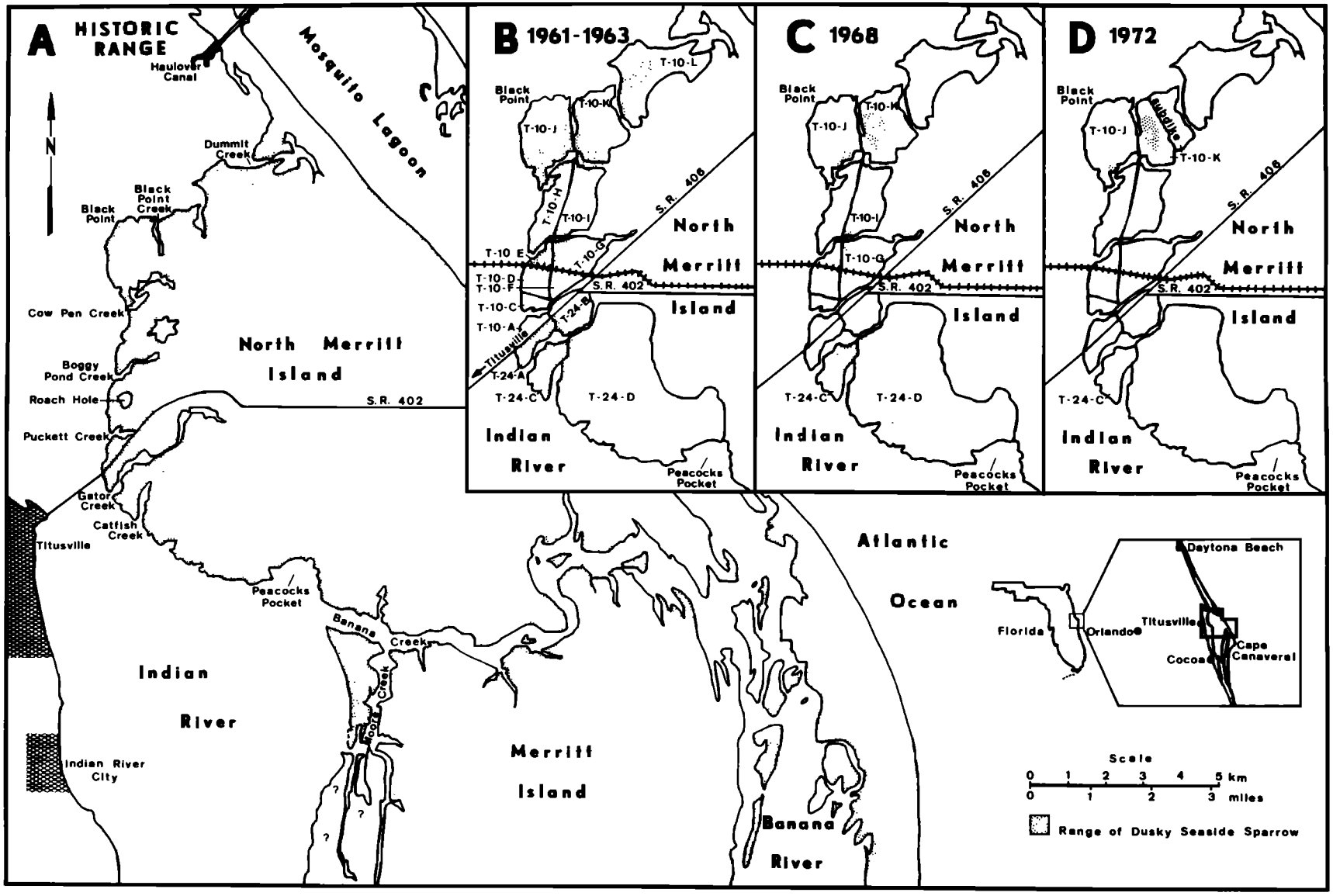


Fig. 2. Changes in the range of the Dusky Seaside Sparrow on North Merritt Island 1945-1972. Maps A through D are all to the same scale. A. The approximate original range (1945 and earlier). B. The range in 1961-1963 (Charles H. Trost, pers. comm.). The newly completed impoundments in the marsh are shown with their designations as established by the Brevard Mosquito Control District. C. The range in 1968 (Sharp 1968). D. The range in 1972 as determined by this study.

conducted on the transects from mid-April to mid-July 1969 through 1976 ($\bar{x}$ = 3.6/yr). I discontinued censusing in T-24-C after 1972 because the sparrows had disappeared from that area. I captured sparrows in mist nets and banded them with unique color combinations in September 1970 and 1972 to determine movements, age, and longevity. Sex was determined on the basis of behavior on territory and age by checking the extent of the skull ossification; birds with fully ossified skulls were considered adult, and those with unossified skulls, immature.

RESULTS AND DISCUSSION

Distribution on Merritt Island

THE HISTORIC RANGE of the Dusky Seaside Sparrow on Merritt Island before alteration of the salt marsh, except for the road from Titusville to the beach, is shown in Fig. 2A (Maynard 1881, Chapman 1899, Nicholson 1928, Howell 1932, Trost 1968). Banana Creek and Banana River populations were less precisely known than that along Indian River. The marsh on the creek and the north end of Banana River was fragmented, resulting in a discontinuous distribution of the sparrow. Other than its general location, little is known of the isolated population on the south shore of Mosquito Lagoon.

Sharp (1970) and Trost (pers. comm.) indicated that in 1961-1963 the birds (Fig. 2B) were concentrated in four widely spaced aggregations centered around major tidal creeks. Trost (1968 and *pers. comm.*) found the birds using the narrow tidal zone along the creeks for feeding. The birds were often observed flying 180 m or more to reach these feeding areas. The recently-completed dike system was in place and the impoundments were flooded at the time of Trost's (1964, 1968) study. Trost banded sparrows in the T-10-E part of his study area. The condition of that impoundment as it appears in 1979 (Fig. 3), has drastically changed since the 1961-1963 period. Following completion of the impoundments, the narrow relict natural marsh along the creeks probably offered the best, if not the only areas, where the birds were able to forage in their usual manner for long periods especially when the main marsh was deeply flooded. Baynard (1914), Nicholson (1928), and Trost (1968) stress the importance of the pristine marsh in the immediate vicinity of the Indian River and tidal creeks for nesting and feeding.

By 1968 (Fig. 2C) the sparrow's range on Merritt Island had been reduced for the most part to T-10-K (14 singing males), T-10-J (7 males), T-24-C (8 males), and 4-5 birds divided among T-10-G, T-10-I, and T-24-C (Sharp 1968, 1970). The distribution in 1972 (Fig. 3D) was confined to a small part of southern T-10-J (4 singing males) and the west-central sector of T-10-K (7 males). The range decreased only slightly in T-10-J and T-10-K after 1972 and up to the time the sparrow was last recorded on Merritt Island in 1977.

Longevity and Movements

THIRTEEN SPARROWS were color banded in T-10-K, six in 1979, and seven in 1972. Of these, eight were adults and five were immatures. Sex was determined for seven individuals, four males and three females.

Insufficient data exist to generate a life table for *A.m. nigrescens.* However, a color-marked adult male banded in May 1972 on the St. Johns (Baker 1978) was observed in the spring of 1979 (Willard Leenhouts and Beau Sauselein, *pers. comm.)* making it 8+ years old and an adult female banded on September 2, 1970 on Merritt Island was seen there on June 14, 1974, making it at least 4.8 years old. These two birds constituted the oldest known individuals of this subspecies. The Northern Seaside Sparrow *(A.m. maritima)* has been found to live for at least 9 years (William Post and Jon Greenlaw, pers. comm.).

The Dusky Seaside Sparrow is not sedentary and will move relatively long distances, although Trost (1968) stated that of the birds he banded, none were found away from the vicinity in which it was marked. Six of the individuals (46%) I banded were seen in T-10-J in 1971, 1972, and 1974, a distance of 1.2 km from the banding site in T-10-K. Two of these birds were later found in T-10-K. Between May 16 and July 14, 1972, a banded male was seen in both T-10-J and T-10-K, at points about 1.6 km apart, straight line distance. Based on observations of marked individuals, movement between the two impoundments appeared to take place on a somewhat regular basis, although the exact frequency was not determined. Baker (1978) reported that some of his marked birds moved up to 1.6 km from the banding locality on the St. Johns River. Thus, there appears to be some regular but poorly understood long-range movement within and between aggregations (see Post [1974] for discussion of grouping as related to Seaside Sparrows). Such movement may be related to water levels, rainfall, preferred feeding sites, or perhaps a search for more suitable habitat.

What would be considered dispersal has been recorded only twice, both during the non-breeding season. Individuals were found on Merritt Island 8 and 32 km from the nearest known breeding areas in 1962 (Trost 1968).

The Population Decline

Fig. 3. The north end of impoundment T-10-E as it appeared June 1979. In 1961-1963, Charles H. Trost (pers. comm.) banded Dusky Seaside Sparrows in this area, at which time it was still salt marsh, although deteriorating rapidly.

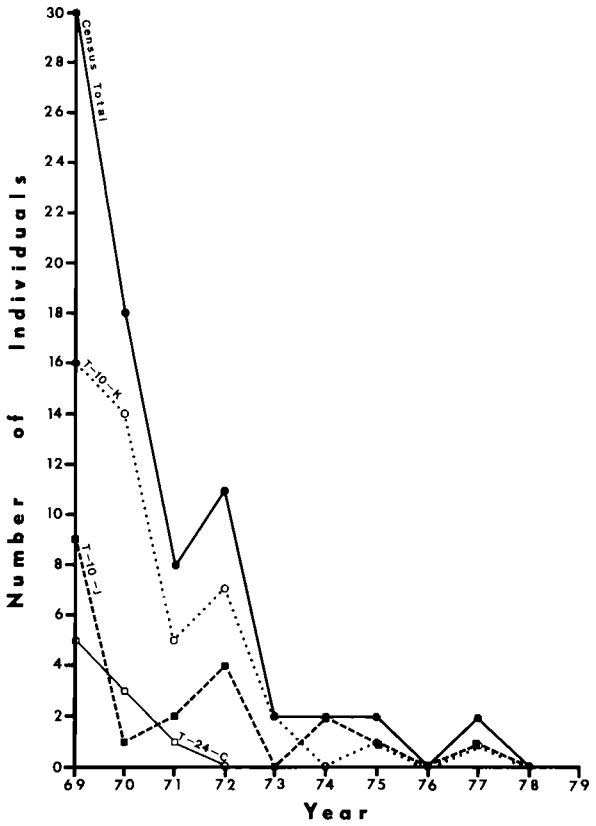


Fig 4. Counts of singing males on transects on Merritt Island, 1969-1979.

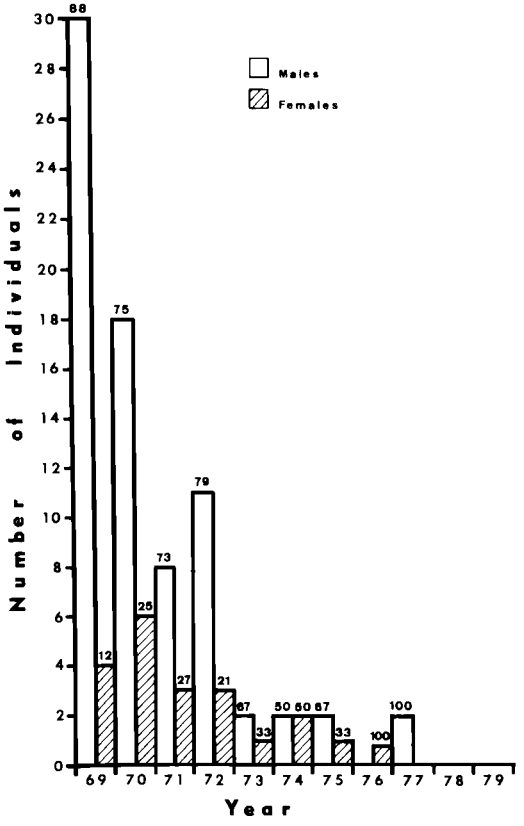


Fig. 5. Comparison of both sexes recorded during singing male censuses on Merritt Island, 1969-1979. Number above each bar is the percent total for both sexes observed per year.

THE RELATIVE ABUNDANCE of the Dusky Seaside Sparrow on Merritt Island could be assessed at least into the 1950s (Maynard 1881, Chapman 1899, Baynard 1914, Vars 1926, Nicholson 1928, Howell, 1932, Pettingill 1951, Sprunt 1954). For example, on a collecting trip in May 1914, Baynard (1914) mentioned seeing a minimum of 20 birds perched at one time within a small area. Nicholson (1928) found birds singing around him in all directions in June 1926 and located 14 active nests in one day. Sharp (1970), quoting Charles E. Carter, a friend of Nicholson, stated that the latter would often find up to 30 of the sparrows' nests in the course of a day. Unfortunately, no population estimates were made when the birds were plentiful Sharp (1970) estimated that the original population on Merritt Island may have approached 2000 pairs if all suitable habitat were occupied; if the sex ratio was about equal, and if the densities were similar to several aggregations he found on the St. Johns River in 1968.

By 1957, the sparrow population had decreased on Merritt Island by 70% (Trost 1968). If one uses Sharp's estimate of the original population, this would leave about 600 pairs or 600 singing males. Trost found about 70 pairs during 1961-1963 (Sharp 1970). An indication of the rapid deterioration of the sparrow's habitat taking place under flooding was provided by Trost (1964) in his study areas (T-10-D and T-10-E). At that time flooding of the marsh was relatively recent. Trost estimated that 35 pairs were in T-10-D and T-10-E (which were one impoundment until the railroad causeway built in 1963 divided them into two cells) at the start of his study; by the end there were only two pairs remaining. Sharp (1970) could account for only 33-34 males in 1968, a decrease of roughly 50% in 5 years, and four or five of the males did not appear to have mates. Obviously the sparrow population was undergoing a continuous decline.

In 1969, the water level was lowered in impoundments T-24-C and T-10-K in an effort to rejuvenate the remaining stressed salt-marsh vegetation and to re-establish it by natural means where it had disappeared as a result of flooding. The vegetation slowly responded over the next several years (Sykes unpubl.), but the sparrows continued to decline (Figs 4 and 5). In 1969, I located only 30 singing males and by the following year the number had decreased to 18, a loss of 40%. The downward trend continued No sparrows were found in T-24-C after 1971; by 1973, only two males and an undetermined number of females remained. The two males apparently lived out their life span and were last seen in 1977, one in T-10-J and the other in T-10-K (James Baker and Beau Sauselein, *pers. comm.*). A census in 1978 by Baker and Sauselein (pers comm.) and another in 1979 by Sauselein and Sykes revealed no sparrows present.

When singing males were being censused, females were also recorded but no concerted effort was made to locate all the females that might be present. The number of birds identified as females is given in Fig. 5. The last female (sexed by behavior) was seen on Merritt Island in 1976, and the last evidence of successful nesting (young of the year seen away from the nest) in T-24-C was in 1969, in T-10-J in 1974, and in T-10-K in 1975

Human Impact on the Marsh

THE FIRST PERMANENT alteration to the marsh on Merritt Island was the construction in the late 1920s of what is now State Road (S.R.) 402 from Titusville to the ocean beach. The road, unpaved until 1942, crossed the marsh between Puckett and Gator Creeks and had little effect on the sparrow habitat except for that lost to the highway corridor and the slight interruption of drainage in its vicinity.

Since the first settling in Brevard County, man has been bothered by biting insects during the warmer months, particularly salt-marsh mosquitos (primarily *Aedes taeniorhynchus* and *A. sollicitans*). Attempts to control these insects were not successful until the 1940s. Treatment for control of adult and larval mosquitos in the marsh on Merritt Island was initiated in 1946 by the Brevard Mosquito Control District. Infrequent aerial spraying of 0.2 kg/ha of DDT in a Number 2 diesel fuel carrier was carried out from June through October to alleviate the mosquito problem in Titusville and adjoining communities. The frequency of application was increased in 1947 and its use was continued through 1951, after which its use was greatly reduced because the mosquitos had become resistant to it (Deonier *et al.* 1950). In 1951, the district started using benzenehexachloride (BHC) mixed with diesel fuel and experimented with a number of other chemicals, including dieldrin, through 1957. The use of malathion to control adult mosquitos was begun in 1956 and discontinued in 1962. No larviciding was done during this period. Chemical treatment for adult mosquitos on Merritt Island was terminated in 1962 when the marsh impoundments were completed. There was essentially no chemical treatment for mosquito larvae in the impoundments until 1969, when water levels were lowered in 3 impoundments (T-10-J, T-10-K, T-24-C) in connection with the Dusky Seaside Sparrow habitat management program and study. Periodic treatment for mosquito larvae from 1969 to 1972 in these impoundments consisted of various aerial applications of (1) flit (a petroleum derivative) at 56 l/ha; (2) paris green (5%) at 0.7 kg/ha with a granular vermiculite carrier; and (3) 187 liters of diesel fuel/ha. Periodic aerial treatment with chemicals in two impoundments (T-10-J and T-10-K) was continued during the mosquito breeding season from 1973 to 1979. T-24-C was reflooded starting in 1972 after the sparrows had disappeared.

The harmful effects of insecticides on birds is well known (Hickey 1961, Hickey and Anderson 1968, Stickel, L. 1973, Dustman and Stickel 1969, Heath *et al.* 1970, Ohlendorf *et al.* 1974, Stickel, W. 1975). Hickey (1961) revealed the serious problems posed by the use of insecticides in the habitats of birds with limited distribution. Donald J. Nicholson estimated that by 1957 the sparrow population had been reduced on Merritt Island by at least 70% and attributed this reduction to the aerial spraying of insecticides. (Trost 1968). The Dusky Seaside Sparrow has probably been affected by applications of various insecticides on Merritt Island over the last 30 years, although the precise nature of the effect (*i.e.*, direct or indirect poisioning, various physiological problems, reproductive failure, reduction of food supply, or other factors) is not known.

The impounding and flooding of salt marshes has been demonstrated to be a highly effective mosquito control technique (Provost 1959). Low dikes, that were open at the creeks, were constructed along the shore of Indian River during 1955-1958. The building of higher, permanent dikes that completely enclosed the salt marshes on Merritt Island began in 1959 and was completed in December 1962. Flooding with rainwater began as each cell was closed. Present water levels in the impoundments are the results of rains, storm tides, or pumping. With the completion of the dike system, almost 100% of the sparrow's habitat on Merritt Island, including that along Banana Creek and the upper part of Banana River, was impounded. Only small narrow strips of the original marsh were left in places between the dike and the open water of the river to protect the dike system from wave action, but were too small to support the sparrows.

A railroad causeway was constructed across the marsh north of Roach Hole in 1963 (Trost 1964) further subdividing the wetland and forming impoundments T-10-D, T-10-E, T-10-F, and T-10-G.

The dependence of the Dusky Seaside Sparrow upon a high salt marsh (Figs. 6 and 7) with its aforementioned plant associations and their associated fauna is well recognized (Baynard 1914, Nicholson 1918, Trost 1964, 1968, Sharp 1970, Baker 1973, 1978, Baker and Kale 1978). Those plant species can tolerate flooding for only a relatively short period. Historically, *S. bakerii* appears to be more common on the St. Johns River, where it is the dominant species, than on Merritt Island with its heterogeneous vegetation. The impounding and flooding of the marsh on Merritt Island primarily with fresh water, has now eliminated approximately 91% of the sparrow's former habitat in that area. Only impoundment T-10-K and a very small area in the

Fig. 6. High salt marsh in impoundment T-10-K, Merritt Island N.W.R., as it appeared in 1979 after marsh restoration. The taller vegetation is *Spartina bakerii* intermixed with stands of *Distichlis spicata*. Small mangroves (*Avicennia germinans* and *Laguncularia racemosa*) border the canal in the foreground.

Fig. 7. Typical habitat of the Dusky Seaside Sparrow on Merritt Island N.W.R. in 1979 in impoundment T-10-K after removal of flood waters and part of the dike system. The tall *Spartina bakerii* interdigitates with the shorter *Distichlis spicata.*

southern part of T-10-J vaguely resemble the original salt marsh.

Drastic vegetation changes caused by long periods of flooding have taken place in the marsh over the last 17 years. Among the first halophytes to disappear from the flooded marsh, usually within the first 1 to 3 years, were *Batis* and *Salicornia* (Provost 1959, Trost 1964). It is evident from Baynard (1914) and Nicholson (1928) that these species were important to the sparrow, particularly for nesting. Also soon after flooding, dense stands of *Distichlis* became thin and scattered, and stands of *Spartina* decreased in both density and in distribution (Trost 1964). Such conditions existed in T-24-C, (Fig. 8) and the southern part of T-10-J in 1979. As the transition from saline to fresh conditions took place, many of the impoundments were invaded by cattails *(Typha* spp.) (Provost 1959, Trost 1964). T-24-D, the largest impoundment, is now dominated by cattails; which have invaded gradualy since 1969.

Some impoundments have been flooded almost continuously to a water depth of 2-40 cm, and in many areas the emergent vegetation has disappeared, turning the impoundments into open ponds (Table 1 and Fig. 9).

In four impoundments some widely scattered clumps of *S. bakerii* and *J. roemerianus* continue to grow on the tops of pedestals elevated above the marsh substrate (Fig. 9). These pedestals consist of both organic and mineral materials and appear to be the result of work by ant colonies. These clumps may remain alive for years but are in a stressed condition; reproduction is vegetative and confined to the area on top of the pedestal. The last Dusky Seaside Sparrows recorded in T-10-J and T-24-C were found in *S. bakeri* growing under such conditions.

Additional Problems

SHORTLY AFTER ITS completion, the dike system on Merritt Island was invaded by shrubs, primarily *Baccharis halimifolia* and *B. angustifolia*. This encroachment by the two species of *Baccharis* has been a continuing problem in the higher central part of T-10-K. A prescribed burn in the area in mid-February 1973 and again in early December 1975 killed back the above-ground portion of some shrubs, but they returned within a year or so. Apparently, the combination of absence of alternate periods of flushing by fresh water from the uplands and salt water from the Indian River has favored establishment of *Baccharis* With a readily available seed source along the dikes these plants continue to be a problem, and have altered the marsh physiognomy by creating walls of vegetation crisscrossing the marsh. Such conditions are very different from the sparrow's preferred habitat (Maynard 1895, Baynard 1914, Nicholson 1928, Howell 1932, Trost 1968, Sharp 1969a, 1969b, 1970, and Baker 1973, 1978). The sparrows tend to vacate the marsh when it is dominated by shrubs and are not generally found closer than 50 m to dense stands of trees and shrubs, or uplands (Baker 1978).

The dike system has created conditions that enable upland vegetation to invade the most distant fringes of the marsh. This may facilitate visitation by upland predators (i.e., snakes, rodents, racoons) that would otherwise be absent, or whose numbers would be small, and whose visits into the marsh would be less frequent under the original natural conditions. As the number of sparrows grew smaller, each interacting negative factor, such as predation, became more significant.

The enroachment of shrubs on the dikes and in T-10-K have made those areas more attractive to nesting Red-winged Blackbirds (*Agelaius phoeniceus).* On many occasions I have recorded Red-wingeds chasing male sparrows from their song perches. The densi-

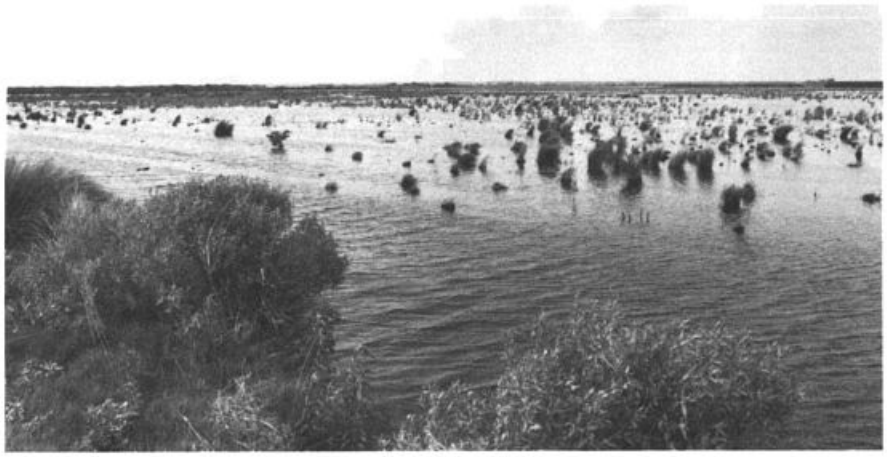


Fig. 8. Deteriorated high salt marsh as the result of long periods of flooding as seen in the east end of T-24-C in 1979. Most of the marsh vegetation has died out and only a few stressed clumps of *Spartina bakerii* remain. These are confined to the tops of widely space pedestals that are above water. The sparrows in Figures 1 and 10 were photographed in the central part of this picture in 1970 and 1971.

ty of blackbirds in the sparrow areas was high during the period 1969-1976. In 1971 and 1972 four counts of territorial male blackbirds in the sparrow habitat averaged 5.3, 3.3, and 1.2 birds/ha for T-10-J, T-10-K, and T-24-C, respectively. Increased density of blackbirds may have been detrimental to the maintenance of normal territorial behavior by the dwindling number of sparrows.

CONCLUSIONS

IN RETROSPECT, efforts to aid the Dusky Seaside Sparrow on Merritt Island appeared to have begun too late, and too little has been done (*i.e.*, not enough habitat provided, no predator control, too much flooding for mosquito control and insufficient control of invading shrubs). It is possible that the population decline may have progressed too far by 1969 to permit recovery with the condition of the habitat, and the response of the marsh to management was evidently too slow to check that decline. The nearly complete destruction of habitat by the mosquito control project was more than the sparrows could endure. The minimum number of sparrows above the extinction threshold needed to permit continued breeding success is not known for Merritt Island; when habitat deterioration was stopped on a limited scale in the early 1970s less than a dozen pairs remained. Had sufficient suitable habitat as is present today in T-10-K (Figs. 6 and 7) been available in the late 1960s, a small population of sparrows might have survived on Merritt Island.

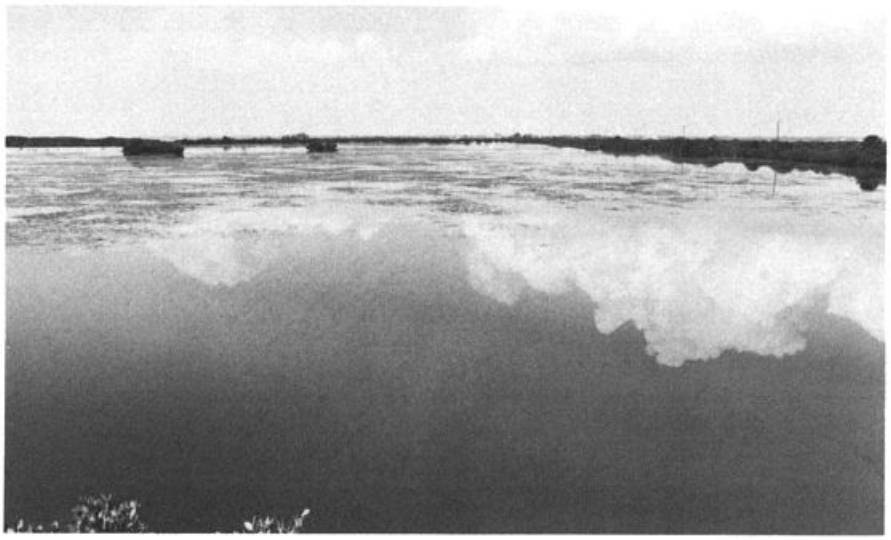


Fig. 9. View looking westward toward Titusville across an open pond fringed by mangroves that is impoundment T-214-A along the south side of S.R. 402 (along utility line in the right background) on Merritt Island, June 7, 1979. This was high salt marsh habitat before being impounded and is the site where Pettingill (1951), in the first edition of his *A Guide to Bird Finding East of the Mississippi,* suggested one look to find the Dusky Seaside Sparrow.

RECOMMENDATIONS

ALTHOUGH THE Dusky Seaside Sparrow has disappeared from Merritt Island, the possibility exists for reintroducing it into the area. Even if the effort were to fail, it would still be highly desirable to preserve some examples of the original high salt marsh on the island. In addition to providing sparrow habitat, this salt marsh provides nesting habitat for the Mottled Duck (*Anas fulvigula*), Clapper Rail (*Rallus longirostris*), Black Rail (*Laterallus jamaicensis*), Willet (*Catoptrophorus semipalmatus*), and several other species. This marsh type is the winter home of the Clapper Rail, Sora (*Porzana carolina*), Black Rail, Short-eared Owl (*Asio flammeus*), Long-billed Marsh Wren (*Cistothorus palustris*), Short-billed Marsh Wren (*Cistothorus platensis*), Common Yellowthroat (*Geothylpis trichas*), Sharp-tailed Sparrow (*Ammospiza caudacuta*), Swamp Sparrow (*Melospiza georgiana*), and many other birds. A number of other vertebrates found in this high salt marsh include Marsh Rabbit (*Sylvilagus palustris*), Rice Rat, (*Oryzomys palustris*), Alligator Snapping Turtle (*Macyochelys temmincki*), Diamondback Terrapin (*Malaclemys terrapin*), Atlantic Salt Marsh Snake (*Nerodia fasciata taeniata*), and a host of fish species. The array of invertebrates is impressive. The major plant species of this type of marsh were discussed earlier and the important function of salt marshes in the estuarine ecosystem and littoral zone of the ocean is well known.

I recommend the following:

1. Remove all of the remaining dike system around T-10-K, and all of the diking around T-10-J. This includes both the river and creek edge and the upland dikes. The ditches created when the dikes were built should be filled. These

Table 1. General condition of impoundments in 1979 along the Indian River on the Merritt Island N.W.R.

Impoundment	*Condition*
T-10-A	Open pond
-B	Open pond
-C	Open pond
-D (Roach Hole)	Open pond
-E	Open pond
-F	Open pond
-G	Open pond with some widely scattered heavily stressed emergent vegetation
-H (Salt Cell)	Mostly bare mud flats with some open pond and a stressed stand of *Salicornia* that has attempted to re-establish in the central portion
-I	Open pond being invaded by mangroves
-J (Black Point)	Heavily stressed salt marsh vegetation with mangroves invading the central portion
-K (restored marsh)	Best salt marsh vegetation remaining on Merritt Island but invasion by *Baccharis* and *Schinus* is serious problem
-L	Much salt marsh vegetation remains but heavily stressed and in poor condition
T-24-A	Open pond
-B	Open pond
-C	Heavily stressed vegetation with open pond condition in many places
-D	Extensive stand of *Typha* and open ponds

two impoundments are the most distant from the residential, recreational, and Space Center work areas, so that the problems resulting from a population increase of mosquitos should be small. With both impounded areas (a total of 462 ha or 1,143 acres) restored to natural marsh, sufficient habitat to support a small viable sparrow population should result.

2 Remove most of the black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), Brazilian pepper (*Schinus terebinthifolius*), both species of *Baccharis*, and leather fern (*Acrostichum aureum*) that have invaded the two impoundments since the dike system was constructed. Following initial removal of these invaders, any regrowth should be routinely controlled until such time as a simulation of the original salt marsh has been restored. Except for the persistence of shrubs, the response of the natural marsh vegetation in T-10-K following elimination of the long periods of flooding has been most encouraging (Sykes ms in prep.)

3 Use fire as a management tool (Baker 1973, 1978) to achieve the optimum density of *S. bakerii* (Sharp 1968). Stands of grass preferred by the sparrows are those that shade about 80-90% of the ground. As a general "rule of thumb," such stands are relatively easy for a person to walk through. If the *S. bakerii* is difficult to walk through, it has become too dense to be good habitat for the sparrows. Burning of up to 25 ha of marsh during August or early September of each year, on a rotation basis, or as conditions warrant, is suggested for T-10-K. Summer or early fall patch burning should increase the amount of edge that is heavily used by the sparrows and will aid in control of shrubs. Pure stands of *Spartina* are not suitable habitat for the sparrows; some open areas are needed It is essential that the *Spartina* stands be intermixed with stands of *Distichlis, Batis*, and also have scattered salt pans, exposed areas of mud, and include small tidal creeks or creek edge.

4 Reintroduce the Dusky Seaside Sparrow in T-10-K on Merritt Island as soon as the shrubs have been removed from within the impoundment. This can be done using birds produced through captive propagation. The sparrows should also be re-established in T-10-J once the habitat is determined to be suitable. I estimate that 20 or more pairs will be required to re-establish a viable population on Merritt Island.

Unfortunately in the last four years the population on the St. Johns River has rapidly declined (Baker 1978); 13 singing males were found in 1979 (Willard Leenhouts and Beau Sauselein, pers. comm.), and by July 1980 only four singing males remained and no females had been found after a thorough search of the remaining habitat (Michael Delany, Herbert W. Kale II, Leenhouts, and Sauselein, pers. comm.). These four birds and the two males at the captive propagation facility of the Florida Game and Fresh Water Fish Commission at Gainesville, Florida, now constitute the extant population of the Dusky Seaside Sparrow (Michael Delany, William Post, and Lois Wood, pers. comm.). *The only hope of perpetuating the gene pool of the Dusky is to capture the remaining wild birds, create a semen bank from the existing six males to preserve as much genetic diversity of the population as possible, backcross these males with females of one of the other races of the Seaside Sparrow (i.e.,* A.m. macgillivraii *might be the best choice), and artificially inseminate females of another race.* After six backcrosses the F_6 generation would have a Dusky genotype of over 98 percent and would in fact be a Dusky phenotypically. Birds propogated in this manner would then be used to re-establish a population on Merritt Island and eventually on the St. Johns. Whether or not this approach will be taken has not been decided. Time is of the essence if we are to preserve this unique sparrow that is now almost extinct in the wild.

5. Reduce the Red-winged Blackbird population in the release areas just before release of the sparrows to reduce competition for food and harassment. Control of the blackbirds should be continued until the sparrows have become established, and thereafter if warranted.

6. Monitor the transplanted sparrows to determine success. If the transplant is successful, census thereafter should be accomplished on a permanent grid.

7. Convert other impoundments (*i.e.,* T-10-L and T-10-H) to salt marsh for inclusion in a management program to increase the amount of habitat for the Dusky Seaside Sparrow on Merritt Island, if the sparrows are successfully re-established in T-10-K and T-10-J.

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Fig. 10. Dusky Seaside Sparrow photographed at Merritt Island N.W.R., May 29, 1971. All photos by the author.

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