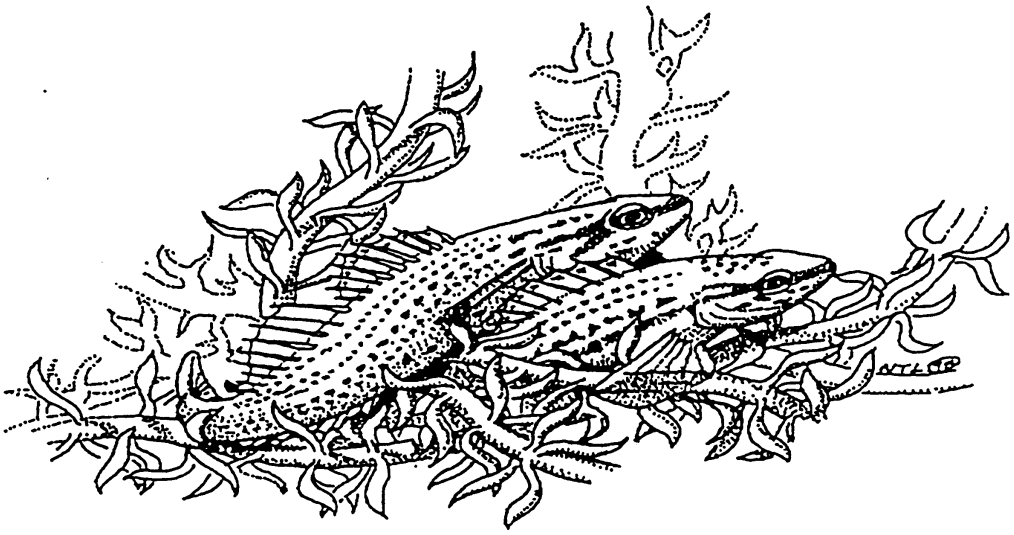
U.S. Fish & Wildlife Service

Recovery Plan for Okaloosa Darter

Etheostoma okaloosae



U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

OKALOOSA DARTER (*Etheostoma okaloosae*)

RECOVERY PLAN
(Revised)

Original Approved: April 18, 1981

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Southeast Region
Atlanta, Georgia

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Date: 10-26-98

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EXECUTIVE SUMMARY

Current Status: The endangered Okaloosa darter occurs in only six stream systems, which are located in Okaloosa and Walton Counties, Florida. Its restricted range has been further reduced by habitat modification and subsequent increases in the brown darter population.

Habitat Requirements and Limiting Factors: Okaloosa darters typically inhabit the margins of small streams fed by groundwater seeping from surrounding sandhills. Vegetation, woody debris, and root mats are used as spawning substrate. Okaloosa darters tend to avoid open sand stretches without cover and areas where stream flow is negligible. The potentially competitive brown darter occupies similar habitats in the lower reaches of streams in the Rocky Bayou system, although it tolerates areas with minimal current. Okaloosa darters have decreased in numbers and range where streams are impounded or subjected to extreme sediment loading. Natural processes (i.e., fire, flood, sediment transport, and vegetative succession) maintain headwater stream sections with characteristics that foster healthy Okaloosa darter populations.

Recovery Objective: Downlisting, and eventually delisting, the Okaloosa darter by enabling wild populations capable of coping with natural habitat fluctuations to persist indefinitely in the six stream systems they inhabit by restoring and protecting stream habitat, water quality, and water quantity.

Recovery Criteria: Downlisting to threatened may be considered when (1) the habitat and historical flows in all six systems are protected by cooperative agreements that appear likely to remain permanent, and (2) monitoring shows that Okaloosa darter populations in all six inhabited stream systems remain stable or increasing for 5 consecutive years. Delisting may be considered when (1) historic habitat of all six streams have been restored, (2) cooperative and enforceable agreements to protect habitat, water quality and stream flows are in effect, and (3) monitoring shows the populations in all six stream systems remain stable or increasing for a 20-year hydrologic cycle.

Actions Needed:

1. Restore and protect habitat in the six Okaloosa darter stream watersheds.
2. Protect water quality and quantity in the six Okaloosa darter streams.
3. Monitor and annually assess populations and habitat conditions of Okaloosa and brown darters, and water quality and quantity in the streams.
4. Establish a public information and education program and evaluate its effectiveness.

Costs ($000s):

Year	Need 1	Need 2	Need 3	Need 4	Total
1999	990	68	136	2	1,196
2000	770	53	121	2	946
2001	549	31	121	2	703
2002	319	1	121	2	443
2003	319	1	121	2	443
Total Cost of Recovery	2,947	154	620	10	3,731

Costs are estimated for the next five years of recovery efforts.

Date of Recovery: Downlisting should be initiated in 2001, if recovery criteria are met. Delisting should be initiated in 2016, if recovery criteria are met.

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PART I

INTRODUCTION

The Okaloosa darter, *Etheostoma okaloosae*, is known to occur in only six clear stream systems that drain into two Choctawhatchee Bay bayous in northwest Florida (Figure 1). The U.S. Fish and Wildlife Service (Service) included the species on the List of Endangered and Threatened Wildlife and Plants on June 4, 1973 (38 FR 14678). The extremely limited range of the darter and the amount of its habitat degraded by road and dam construction, as well as siltation from land clearing, were primary factors in the initial listing. In 1964, a potential competitor, the brown darter, *Etheostoma edwini*, was found in sections of four of the six Okaloosa darter streams. Mettee (1970) documented that the brown darter was increasing in both spatial range and numbers in some of the streams in the Rocky Bayou drainage. Siltation and impoundment continue to impact the species, but the two darter species seem to have reached a tenuous balance. Okaloosa darters dominate Boggy Bayou streams and headwater sections of Rocky Bayou streams, while brown darters occupy the lower reaches of Rocky Bayou streams. Additional threats include continued urbanization, ground and surface water withdrawal, and vulnerability to catastrophic, hazardous material spills.

A. Description and Taxonomy

The Okaloosa darter is a small percid fish (maximum size 49 millimeters Standard Length) that is characterized by a well-developed humeral spot, a series of five to eight rows of small spots along the sides of the body, and the first anal spine being longer than the second. General body coloration varies from red-brown to green-yellow dorsally, and lighter ventrally, although breeding males have a bright orange submarginal stripe on the first dorsal fin (Burkhead *et al.* 1992). The brown darter is similar in size, but the blotched patterns on the sides are not organized into rows and the breeding males have bright red spots on the body and fins.

The Okaloosa darter was first described as *Villora okaloosae* by Fowler (1941) from a single specimen collected by Francis Harper in 1939 at the headwaters of Little Rocky Creek (Figure 2, river kilometer (RKM) 10.9). The species was not collected again until 1959. Bailey *et al.* (1954) later synonymized the Okaloosa darter with the Gulf darter, *Etheostoma swaini*, in their Escambia River study. Collette and Yerger (1962) reestablished the Okaloosa darter as a legitimate species, which belonged in the subgenus *Villora* along with *E. edwini*, and did the first comprehensive review of collections. They concluded that the Okaloosa darter was a primitive relict species that had been reproductively isolated from the derived brown darter by Pleistocene interglacial sea levels (Neill 1957; Collette and Yerger 1962). Page (1981) reviewed the taxonomic relationships of 142 darter species based on 52 morphological characters. He placed *E. okaloosae*, along with *E. mariae* and *E. fricksium*, in the subgenus *Belophlox*. The latter

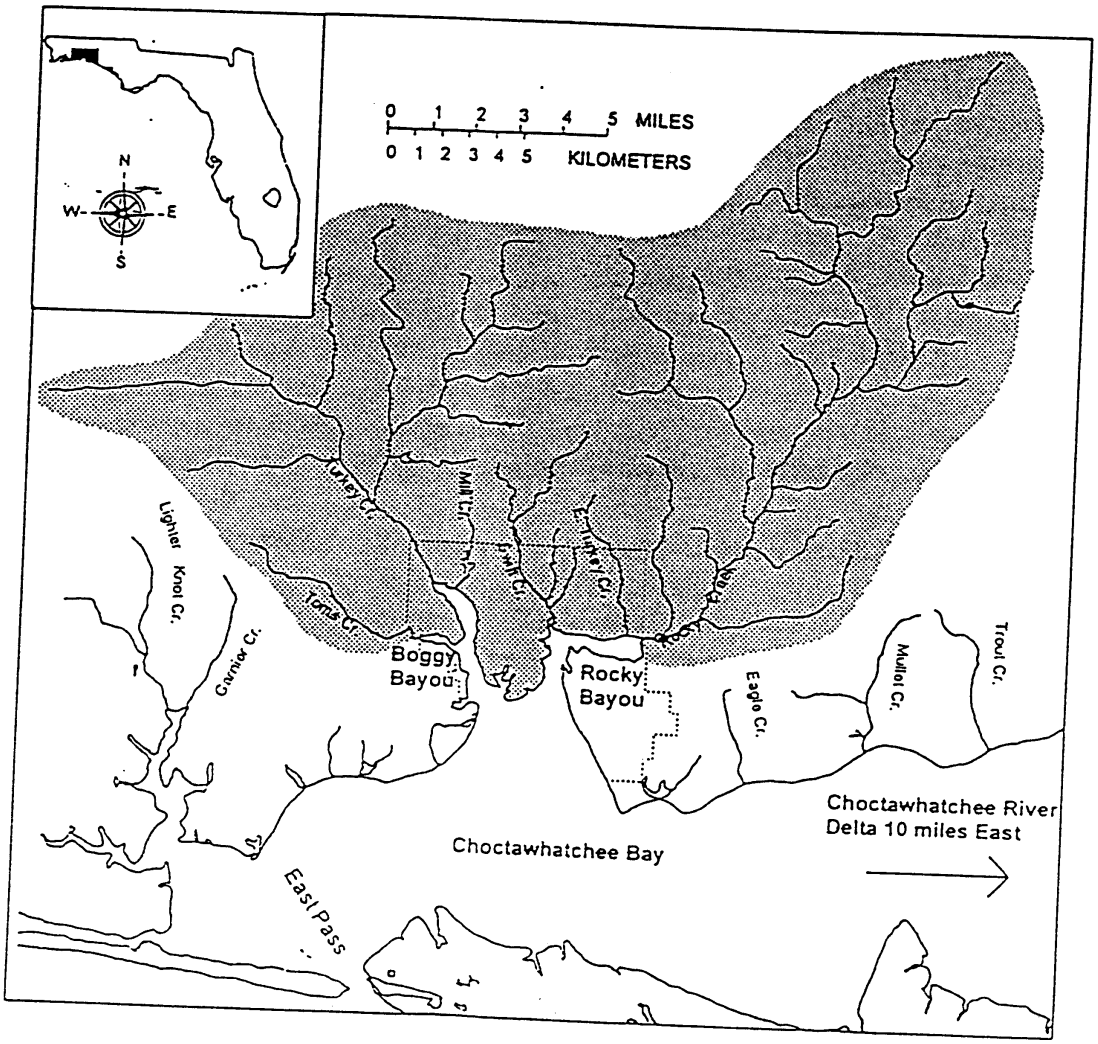
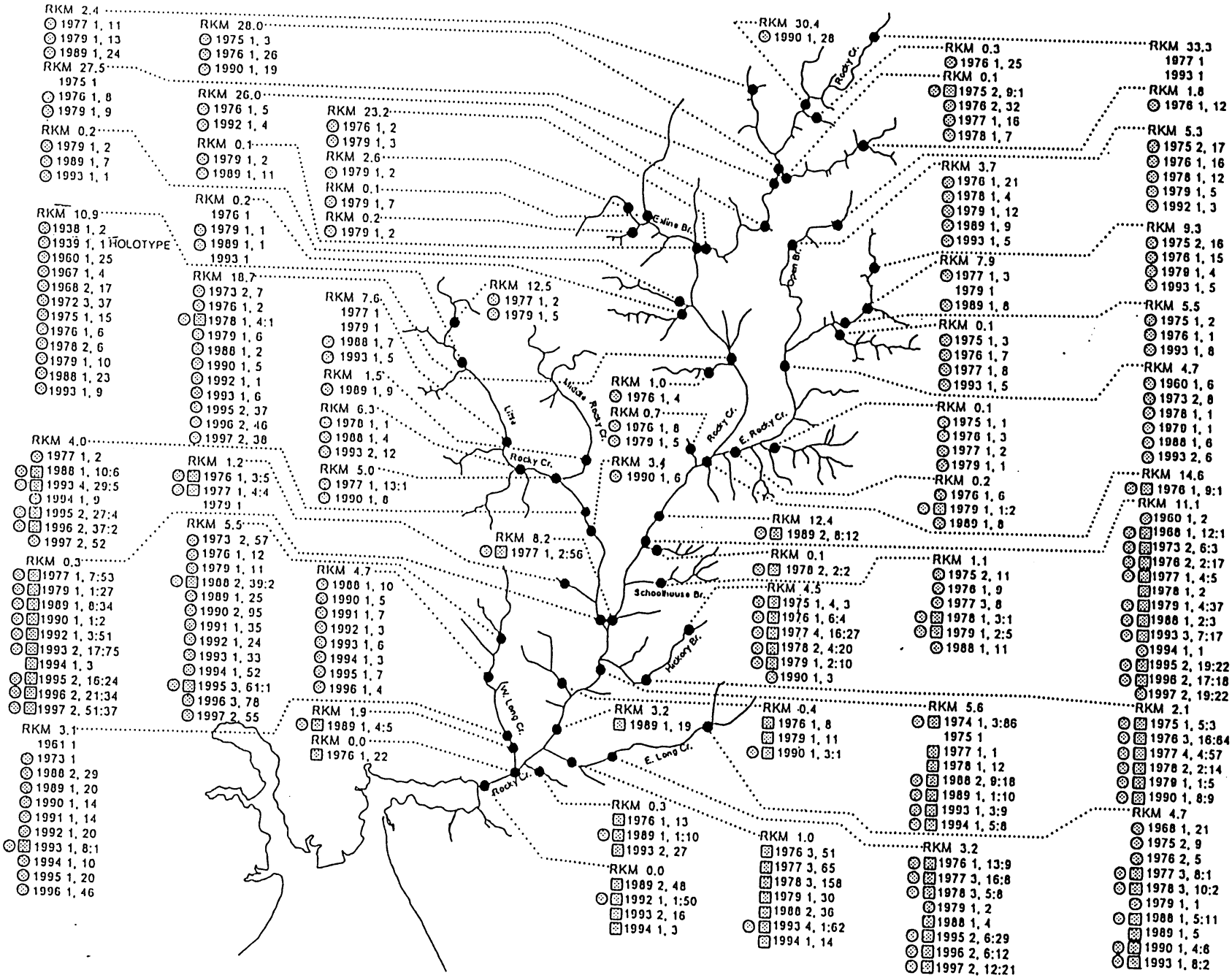


Figure 1. The six stream systems of Rocky and Boggy Bayous that comprise the range of the endangered Okaloosa darter (shaded area). Unshaded streams represent areas where brown darters have been collected and possible sources of dispersing brown darters. Brown darters are also found in the lower reaches of Swift, East Turkey, and Rocky Creeks. Dotted line indicates the boundary between Eglin Air Force Base and the cities of Niceville and Valparaiso.

Figure 2. The geochronology of the Okaloosa and brown darters from collections of the Rocky Creek system, Choctawhatchee Bay drainage, Florida. Solid circles reflect sampling site, while the digits following "RKM" refer to number of river kilometers to a confluence. The presence of Okaloosa darters (shaded circles) and brown darters (shaded squares) are followed by the year of collections, number of collections, and number of individuals collected, respectively (Okaloosa darters:brown darters).


RKM 2.4
1977 1, 11
1979 1, 13
1989 1, 24
RKM 27.5
1975 1
1976 1, 8
1979 1, 9
RKM 0.2
1979 1, 2
1989 1, 7
1993 1, 1
RKM 10.9
1938 1, 2
1939 1, 1 HOLOTYPE
1960 1, 25
1967 1, 4
1968 2, 17
1972 3, 37
1975 1, 15
1976 1, 6
1978 2, 6
1979 1, 10
1988 1, 23
1993 1, 9
RKM 4.0
1977 1, 2
1988 1, 10:6
1993 4, 29:5
1994 1, 9
1995 2, 27:4
1996 2, 37:2
1997 2, 52
RKM 0.3
1977 1, 7:53
1979 1, 1:27
1989 1, 8:34
1990 1, 1:2
1992 1, 3:51
1993 2, 17:75
1994 1, 3
1995 2, 16:24
1996 2, 21:34
1997 2, 51:37
RKM 3.1
1961 1
1973 1
1988 2, 29
1989 1, 20
1990 1, 14
1991 1, 14
1992 1, 20
1993 1, 8:1
1994 1, 10
1995 1, 20
1996 1, 46
RKM 28.0
1975 1, 3
1976 1, 26
1990 1, 19
RKM 26.0
1976 1, 5
1992 1, 4
RKM 0.1
1979 1, 2
1989 1, 11
RKM 0.2
1976 1
1979 1, 1
1989 1, 1
1993 1
RKM 18.7
1973 2, 7
1976 1, 2
1978 1, 4:1
1979 1, 6
1988 1, 2
1990 1, 5
1992 1, 1
1993 1, 6
1995 2, 37
1996 2, 46
1997 2, 38
RKM 1.2
1976 1, 3:5
1977 1, 4:4
1979 1
RKM 5.5
1973 2, 57
1976 1, 12
1979 1, 11
1988 2, 39:2
1989 1, 25
1990 2, 95
1991 1, 35
1992 1, 24
1993 1, 33
1994 1, 52
1995 3, 61:1
1996 3, 78
1997 2, 55
RKM 1.9
1989 1, 4:5
RKM 0.0
1976 1, 22
RKM 23.2
1976 1, 2
1979 1, 3
RKM 2.6
1979 1, 2
RKM 0.1
1979 1, 7
RKM 0.2
1979 1, 2
RKM 7.6
1977 1
1979 1
1988 1, 7
1993 1, 5
RKM 1.5
1989 1, 9
RKM 6.3
1978 1, 1
1988 1, 4
1993 2, 12
RKM 5.0
1977 1, 13:1
1990 1, 8
RKM 4.7
1988 1, 10
1990 1, 5
1991 1, 7
1992 1, 3
1993 1, 6
1994 1, 3
1995 1, 7
1996 1, 4
RKM 12.5
1977 1, 2
1979 1, 5
RKM 1.0
1976 1, 4
RKM 0.7
1976 1, 8
1979 1, 5
RKM 3.4
1990 1, 6
RKM 8.2
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RKM 3.2
1989 1, 19
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1976 1, 13
1989 1, 1:10
1993 2, 27
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1989 2, 48
1992 1, 1:50
1993 2, 16
1994 1, 3
RKM 30.4
1990 1, 28
RKM 0.3
1976 1, 25
RKM 0.1
1975 2, 9:1
1976 2, 32
1977 1, 16
1978 1, 7
RKM 3.7
1976 1, 21
1978 1, 4
1979 1, 12
1989 1, 9
1993 1, 5
RKM 7.9
1977 1, 3
1979 1
1989 1, 8
RKM 0.1
1975 1, 3
1976 1, 7
1977 1, 8
1993 1, 5
RKM 0.1
1975 1, 1
1976 1, 3
1977 1, 2
1979 1, 1
RKM 0.2
1976 1, 6
1979 1, 1:2
1989 1, 8
RKM 12.4
1989 2, 8:12
RKM 0.1
1978 2, 2:2
RKM 4.5
1975 1, 4, 3
1976 1, 6:4
1977 4, 16:27
1978 2, 4:20
1979 1, 2:10
1990 1, 3
RKM 0.4
1976 1, 8
1979 1, 11
1990 1, 3:1
RKM 1.0
1976 3, 51
1977 3, 65
1978 3, 158
1979 1, 30
1988 2, 36
1993 4, 1:62
1994 1, 14
RKM 1.1
1975 2, 11
1976 1, 9
1977 3, 8
1978 1, 3:1
1979 1, 2:5
1988 1, 11
RKM 5.6
1974 1, 3:86
1975 1
1977 1, 1
1978 1, 12
1988 2, 9:18
1989 1, 1:10
1993 1, 3:9
1994 1, 5:8
RKM 3.2
1976 1, 13:9
1977 3, 16:8
1978 3, 5:8
1979 1, 2
1988 1, 4
1995 2, 6:29
1996 2, 6:12
1997 2, 12:21
RKM 33.3
1977 1
1993 1
RKM 1.8
1976 1, 12
RKM 5.3
1975 2, 17
1976 1, 16
1978 1, 12
1979 1, 5
1992 1, 3
RKM 9.3
1975 2, 16
1976 1, 15
1979 1, 4
1993 1, 5
RKM 5.5
1975 1, 2
1976 1, 1
1993 1, 8
RKM 4.7
1960 1, 6
1973 2, 8
1978 1, 1
1979 1, 1
1988 1, 6
1993 2, 6
RKM 14.6
1976 1, 9:1
RKM 11.1
1960 1, 2
1968 1, 12:1
1973 2, 6:3
1976 2, 2:17
1977 1, 4:5
1978 1, 2
1979 1, 4:37
1988 1, 2:3
1993 3, 7:17
1994 1, 1
1995 2, 19:22
1996 2, 17:18
1997 2, 19:22
RKM 2.1
1975 1, 5:3
1976 3, 16:64
1977 4, 4:57
1978 2, 2:14
1979 1, 1:5
1990 1, 8:9
RKM 4.7
1968 1, 21
1975 2, 9
1976 2, 5
1977 3, 8:1
1978 3, 10:2
1979 1, 1
1988 1, 5:11
1989 1, 5
1990 1, 4:6
1993 1, 8:2
Rocky Cr.
E. Mine Br.
Open Br.
Little Rocky Cr.
E. Rocky Cr.
Schoolhouse Br.
Hickory Br.
W. Long Cr.
E. Long Cr.

two geographically-disjunct species occur on the lower Atlantic slope from Georgia and southeastern North Carolina, thus implying that the ancestor to the Okaloosa darter was widespread. *E. edwini* was left as the sole species in the subgenus *Villora*, while *E. swaini* was put with 14 other species in the subgenus *Oligocephalus*. Bailey and Etnier (1988) did the most recent revision of darters and placed *E. okaloosae* in the subgenus *Oligocephalus* and following Page (1981), retained *E. edwini* in the monotypic subgenus *Villora*.

B. Distribution

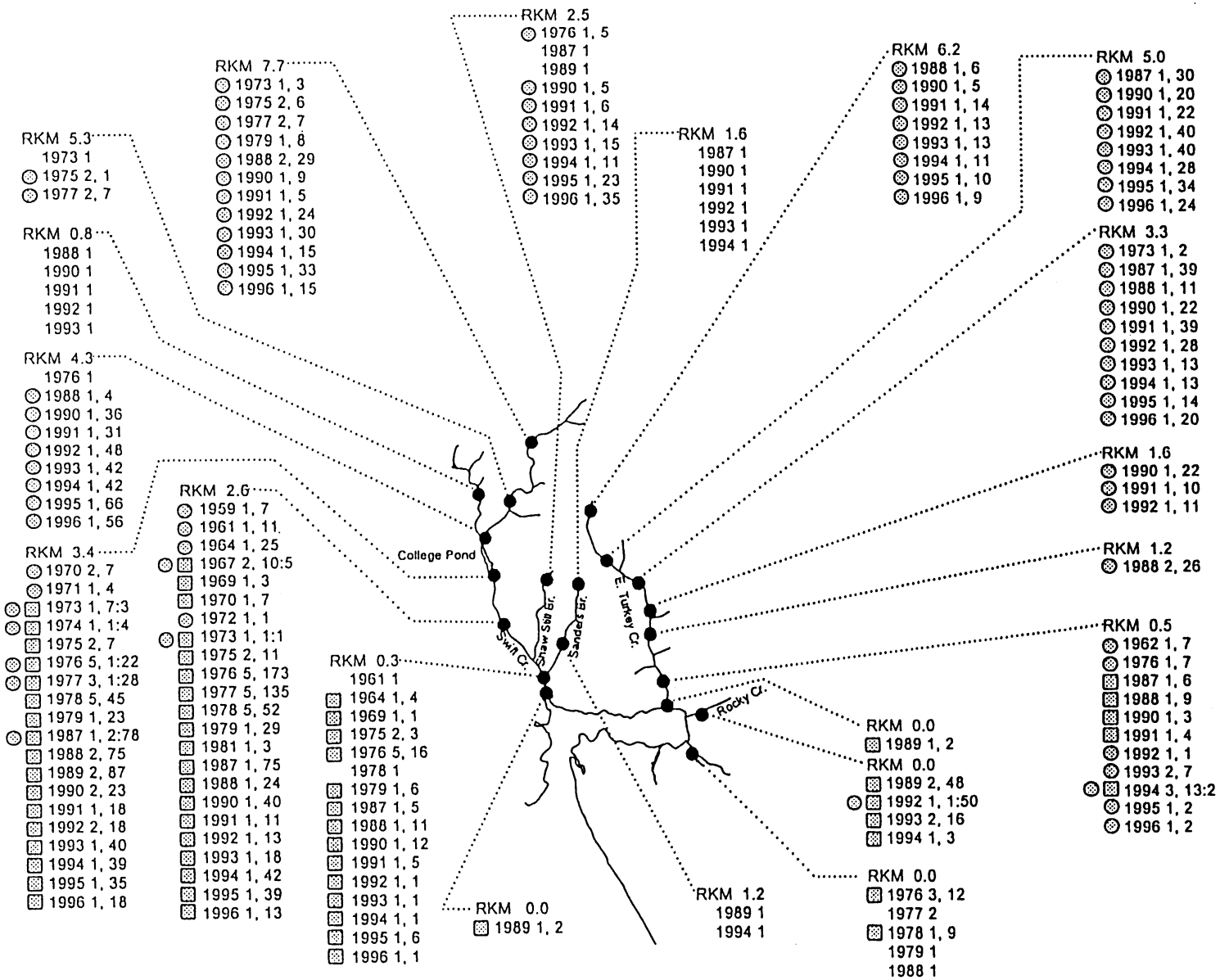
Okaloosa darters have only been found in the tributaries and main channels of Toms, Turkey, Mill, Swift, East Turkey, and Rocky Creeks. Approximately 90 percent of the 457-square kilometer (176 square miles) watershed drainage area is under the management of Eglin Air Force Base (Eglin AFB). They strive to maintain biological diversity and natural processes through an adaptive management program. The remainder of the watershed is in the urban complex of Niceville and Valparaiso (Fischer *et al.* 1994).

A geochronologic analysis of the genus *Etheostoma* in these streams was completed by Burkhead *et al.* (1994) to assess the distribution patterns of Okaloosa and brown darters (Figures 2, 3, and 4). The 705 collection records span 58 years of sampling and are maintained in a georeferenced database at the U.S. Geological Survey, Biological Resources Division in Gainesville, Florida (Mettee 1970; Crittenden 1974; Crews 1976a, b; Mettee and Crittenden 1977, 1978, 1979, 1980; Bortone 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996; Burkhead *et al.* 1994, Jordan and Jelks 1995, 1996, 1997). During the first collection review by Collette and Yerger (1962), the only darter known to co-occur with Okaloosa darters in the streams of Rocky and Boggy Bayous was the blackbanded darter, *Percina nigrofasciata*. Collette and Yerger (1962) were aware that, in some places, only a kilometer separated the headwater streams that contained both Okaloosa and brown darters, but these two species were not known to occur together at that time.

The brown darter ranges from the Perdido to the St. Johns Rivers in Florida, and north to below the fall line in Alabama and Georgia (Williams 1981). *Etheostoma edwini* is common in the Choctawhatchee and Yellow River systems, and in the smaller Garnier, Eagle, Trout, Basin, and Alaqua Creeks that drain into Choctawhatchee Bay. Thus, the brown darter is a widespread species in drainages that surround the streams containing the Okaloosa darter. Four other *Etheostoma* species, *E. colorosum*, *E. davisoni*, *E. fusiforme,* and *E. swaini*, are present in the Yellow and Choctawhatchee River systems, but are not found in the smaller Choctawhatchee Bay drainages.

In 1964, Mike Howell collected four brown darters from Swift Creek at the Florida Highway 20 bridge (Figure 3, RKM 0.3). It should be noted that these were the first *Etheostoma* ever collected at this site, and that Okaloosa darters have never been captured

Figure 3. The geochronology of the Okaloosa and brown darters from collections of the Swift Creek system, East Turkey (Bolton) Creek, the mouth of Rocky Creek, and an unnamed tributary to Rocky Bayou, Choctawhatchee Bay drainage, Florida. Solid circles reflect sampling site, while the digits following "RKM" refer to number of river kilometers to a confluence. The presence of Okaloosa darters (shaded circles) and brown darters (shaded squares) are followed by the year of collections, number of collections, and number of individuals collected, respectively (Okaloosa darters:brown darters).


RKM 5.3
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1975 2, 1
1977 2, 7
RKM 0.8
1988 1
1990 1
1991 1
1992 1
1993 1
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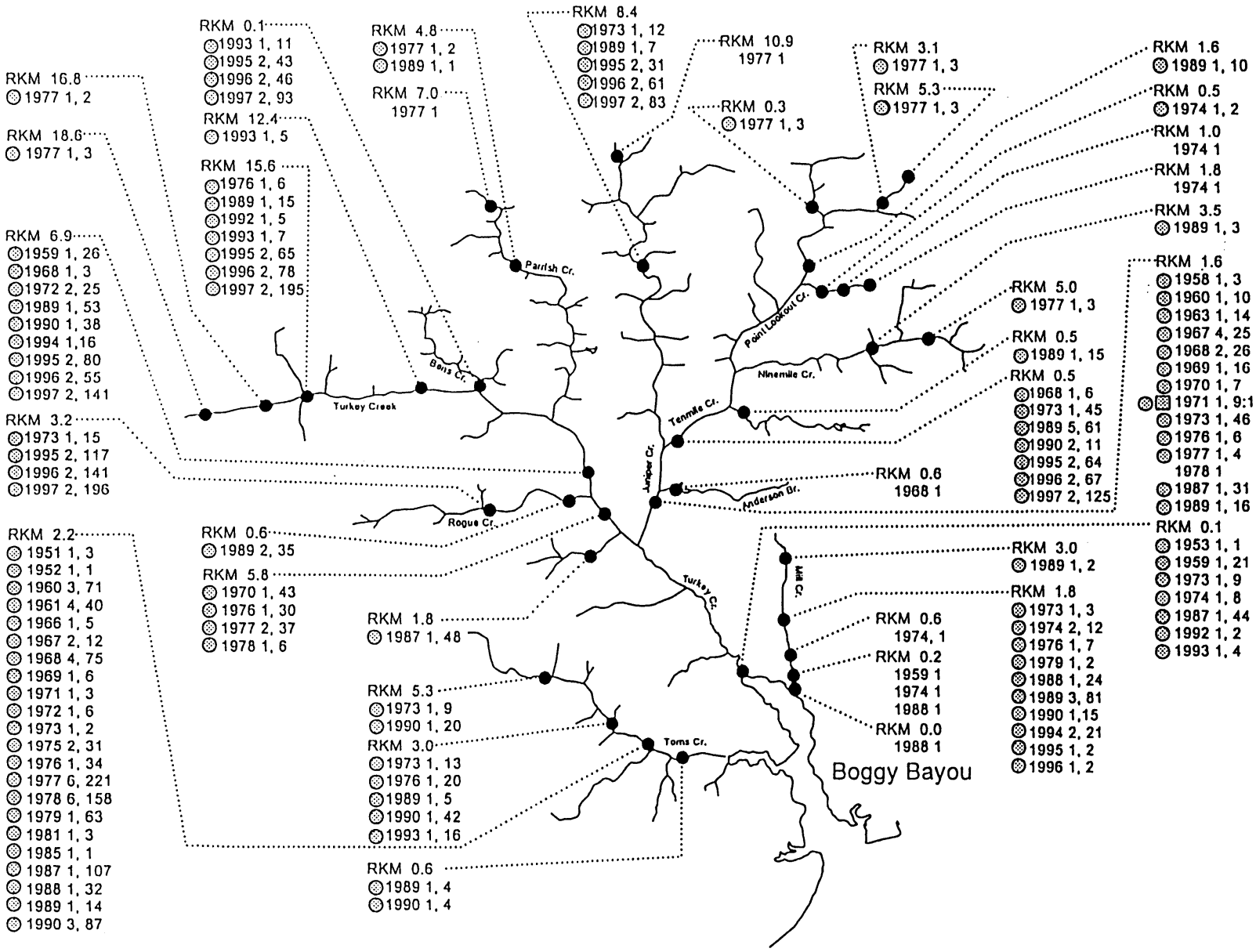
1988 1, 4
1990 1, 36
1991 1, 31
1992 1, 48
1993 1, 42
1994 1, 42
1995 1, 66
1996 1, 56
RKM 3.4
1970 2, 7
1971 1, 4
1973 1, 7:3
1974 1, 1:4
1975 2, 7
1976 5, 1:22
1977 3, 1:28
1978 5, 45
1979 1, 23
1987 1, 2:78
1988 2, 75
1989 2, 87
1990 2, 23
1991 1, 18
1992 2, 18
1993 1, 40
1994 1, 39
1995 1, 35
1996 1, 18
RKM 7.7
1973 1, 3
1975 2, 6
1977 2, 7
1979 1, 8
1988 2, 29
1990 1, 9
1991 1, 5
1992 1, 24
1993 1, 30
1994 1, 15
1995 1, 33
1996 1, 15
RKM 2.6
1959 1, 7
1961 1, 11
1964 1, 25
1967 2, 10:5
1969 1, 3
1970 1, 7
1972 1, 1
1973 1, 1:1
1975 2, 11
1976 5, 173
1977 5, 135
1978 5, 52
1979 1, 29
1981 1, 3
1987 1, 75
1988 1, 24
1990 1, 40
1991 1, 11
1992 1, 13
1993 1, 18
1994 1, 42
1995 1, 39
1996 1, 13
RKM 2.5
1976 1, 5
1987 1
1989 1
1990 1, 5
1991 1, 6
1992 1, 14
1993 1, 15
1994 1, 11
1995 1, 23
1996 1, 35
RKM 1.6
1987 1
1990 1
1991 1
1992 1
1993 1
1994 1
RKM 6.2
1988 1, 6
1990 1, 5
1991 1, 14
1992 1, 13
1993 1, 13
1994 1, 11
1995 1, 10
1996 1, 9
RKM 5.0
1987 1, 30
1990 1, 20
1991 1, 22
1992 1, 40
1993 1, 40
1994 1, 28
1995 1, 34
1996 1, 24
RKM 3.3
1973 1, 2
1987 1, 39
1988 1, 11
1990 1, 22
1991 1, 39
1992 1, 28
1993 1, 13
1994 1, 13
1995 1, 14
1996 1, 20
RKM 1.6
1990 1, 22
1991 1, 10
1992 1, 11
RKM 1.2
1988 2, 26
RKM 0.5
1962 1, 7
1976 1, 7
1987 1, 6
1988 1, 9
1990 1, 3
1991 1, 4
1992 1, 1
1993 2, 7
1994 3, 13:2
1995 1, 2
1996 1, 2
RKM 0.3
1961 1
1964 1, 4
1969 1, 1
1975 2, 3
1976 5, 16
1978 1
1979 1, 6
1987 1, 5
1988 1, 11
1990 1, 12
1991 1, 5
1992 1, 1
1993 1, 1
1994 1, 1
1995 1, 6
1996 1, 1
RKM 0.0
1989 1, 2
RKM 1.2
1989 1
1994 1
RKM 0.0
1989 1, 2
RKM 0.0
1989 2, 48
1992 1, 1:50
1993 2, 16
1994 1, 3
RKM 0.0
1976 3, 12
1977 2
1978 1, 9
1979 1
1988 1
College Pond
Swift Cr.
Shaw Sub Br.
Sandel's Br.
E. Turkey Cr.
Rocky Cr.

Figure 4. The geochronology of the Okaloosa and brown darters from collections of the streams of the Boggy Bayou system, Choctawhatchee Bay drainage, Florida. Solid circles reflect sampling site, while the digits following "RKM" refer to number of river kilometers to a confluence. The presence of Okaloosa darters (shaded circles) and brown darters (shaded squares) are followed by the year of collections, number of collections, and number of individuals collected, respectively (Okaloosa darters:brown darters).


RKM 16.8
1977 1, 2
RKM 18.6
1977 1, 3
RKM 6.9
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1968 1, 3
1972 2, 25
1989 1, 53
1990 1, 38
1994 1,16
1995 2, 80
1996 2, 55
1997 2, 141
RKM 3.2
1973 1, 15
1995 2, 117
1996 2, 141
1997 2, 196
RKM 2.2
1951 1, 3
1952 1, 1
1960 3, 71
1961 4, 40
1966 1, 5
1967 2, 12
1968 4, 75
1969 1, 6
1971 1, 3
1972 1, 6
1973 1, 2
1975 2, 31
1976 1, 34
1977 6, 221
1978 6, 158
1979 1, 63
1981 1, 3
1985 1, 1
1987 1, 107
1988 1, 32
1989 1, 14
1990 3, 87
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1993 1, 11
1995 2, 43
1996 2, 46
1997 2, 93
RKM 12.4
1993 1, 5
RKM 15.6
1976 1, 6
1989 1, 15
1992 1, 5
1993 1, 7
1995 2, 65
1996 2, 78
1997 2, 195
RKM 4.8
1977 1, 2
1989 1, 1
RKM 7.0
1977 1
RKM 8.4
1973 1, 12
1989 1, 7
1995 2, 31
1996 2, 61
1997 2, 83
RKM 10.9
1977 1
RKM 0.3
1977 1, 3
RKM 3.1
1977 1, 3
RKM 5.3
1977 1, 3
RKM 1.6
1989 1, 10
RKM 0.5
1974 1, 2
RKM 1.0
1974 1
RKM 1.8
1974 1
RKM 3.5
1989 1, 3
RKM 1.6
1958 1, 3
1960 1, 10
1963 1, 14
1967 4, 25
1968 2, 26
1969 1, 16
1970 1, 7
1971 1, 9:1
1973 1, 46
1976 1, 6
1977 1, 4
1978 1
1987 1, 31
1989 1, 16
RKM 5.0
1977 1, 3
RKM 0.5
1989 1, 15
RKM 0.5
1968 1, 6
1973 1, 45
1989 5, 61
1990 2, 11
1995 2, 64
1996 2, 67
1997 2, 125
RKM 0.6
1968 1
RKM 0.1
1953 1, 1
1959 1, 21
1973 1, 9
1974 1, 8
1987 1, 44
1992 1, 2
1993 1, 4
RKM 3.0
1989 1, 2
RKM 1.8
1973 1, 3
1974 2, 12
1976 1, 7
1979 1, 2
1988 1, 24
1989 3, 81
1990 1,15
1994 2, 21
1995 1, 2
1996 1, 2
RKM 0.6
1974, 1
RKM 0.2
1959 1
1974 1
1988 1
RKM 0.0
1988 1
Boggy Bayou
Parrish Cr.
Bens Cr.
Turkey Creek
Point Lookout Cr.
Ninemile Cr.
Tenmile Cr.
Juniper Cr.
Anderson Br.
Rogue Cr.
Turkey Cr.
Mill Cr.
Toms Cr.
RKM 0.6
1989 2, 35
RKM 5.8
1970 1, 43
1976 1, 30
1977 2, 37
1978 1, 6
RKM 1.8
1987 1, 48
RKM 5.3
1973 1, 9
1990 1, 20
RKM 3.0
1973 1, 13
1976 1, 20
1989 1, 5
1990 1, 42
1993 1, 16
RKM 0.6
1989 1, 4
1990 1, 4

there (Mettee 1970). It is unknown how and when brown darters arrived in Swift Creek. Some hypothesize that brown darters were released from bait-buckets by fishermen. Another possibility is intra-estuarine dispersal from Eagle Creek along the shoreline of Choctawhatchee Bay during periods of low salinity. A third hypothesis is that the brown darter has been present in the lower reaches of Rocky Bayou streams for a long period of time, but those areas were not sampled in earlier efforts, or the species was simply overlooked in those collections.

Although the origin source and arrival time are uncertain, the brown darter's ultimate success in Swift Creek below College Pond is well documented. College Pond Dam was constructed in 1968 when College Boulevard was paved (Mettee *et al.* 1976). Only two Okaloosa darters have been collected downstream of the pond since 1977, and these were captured with 78 brown darters in 1987 (Figure 3, RKM 3.4). Essentially, the brown darter has numerically replaced the Okaloosa darter below the pond. This pattern contributed to the concern that the brown darter might eventually out-compete the Okaloosa darter to the point of extinction (Mettee *et al.* 1976; Britt *et al.* 1981). Above College Pond, however, brown darters have never been collected while Okaloosa darters remain common (Figure 3, RKM 4.3, 5.3, 7.7). It should also be noted that Okaloosa darters are the only *Etheostoma* collected in Shaw Still Branch, a tributary that joins Swift Creek over 2 km below College Pond (Figure 3, RKM 2.5).

There is a 3-meter vertical drop from College Pond to the Swift Creek outlet. It has been suggested that this physical barrier prevents brown darters from moving upstream (Mettee *et al.* 1976). One could also surmise that the pond and spillway prevent Okaloosa darters from moving downstream. The pond and dam have affected water quality in the lower reach of Swift Creek. The highest and lowest temperatures (35.5°C and 7°C, respectively) of any sampling sites in the database were measured at Swift Creek below the dam. Higher water conductivity (120 micromhos/centimeter) was measured at this site than in any other stream section sampled. These conditions may favor the brown darter over the Okaloosa darter.

Following the discovery of brown darters in Swift Creek, *E. edwini* were collected in Rocky Creek (Figure 2, RKM 11.1) in 1968, an unnamed creek in the southeast section of Rocky Bayou (Figure 3, RKM 0.0) in 1976, and East Turkey (Bolton) Creek (Figure 3, RKM 0.5) in 1987. This apparent expansion of the brown darter into what was considered allopatric (only one species) Okaloosa darter streams caused some researchers to predict that the brown darter posed a biological threat to the Okaloosa darter through competitive interactions (Mettee *et al.* 1976). Besides the two stations in Swift Creek below the dam (Figure 3, RKM 2.6, 3.4), there are only nine sites in the Rocky Bayou system where Okaloosa darters were collected prior to brown darters: East Turkey (Bolton) Creek (Figure 3, RKM 0.5), West Long Creek (Figure 2, RKM 3.1, 5.5), Little Rocky Creek (Figure 2, RKM 4.0), Rocky Creek (Figure 2, RKM 11.1, 18.7), Schoolhouse Branch (Figure 2, RKM 1.1), East Rocky Creek (Figure 2, RKM 0.2), and

East Long Creek (Figure 2, RKM 4.7). In the most recent collections, seven of these sites were allopatric with *E. okaloosae*, while the other two were sympatric (both species present). Forty-one sites in the Rocky Bayou system have only *E. okaloosae* records, while 22 sites had some brown darters in the initial collection (Figures. 2 and 3). Of the 22 sites with brown darters, six were consistently allopatric brown; seven remain sympatric; two went from sympatric to allopatric Okaloosa; and the remaining seven sites fluctuated between sympatric and allopatric brown.

In general, Okaloosa darters are distributed allopatrically in headwater streams of Rocky Bayou, while the brown darter becomes more prevalent toward the mouth. The only exception to this pattern is the anomalous single brown darter caught in the extreme northeast part of the system (Figure 2, RKM 0.1). This unnamed tributary to Rocky Creek has a pond where a bait-bucket release is probable. With the exception of Swift Creek below College Pond, there is no consistent trend of brown darters replacing Okaloosa darters. As the above examples illustrate, there tend to be fluctuations in the ratio of the two species in the lower reaches of the Rocky Bayou drainage. To date, there have been no reports of hybridization between the two species.

With one exception, the Okaloosa darter is completely allopatric in the Boggy Bayou stream systems. Only one brown darter was ever collected in 113 collections within this drainage. This individual was captured with nine *E. okaloosae* in Juniper Creek at the Florida Highway 85 bridge (Figure 4, RKM 1.6). This site is near Anderson Pond, a popular fishing location at Eglin AFB. This collection record might be additional evidence supporting the bait-bucket release hypothesis.

Figure 5 summarizes figures 2 to 4 showing that Okaloosa darters occupy headwater streams exclusively and all of the Boggy Bayou streams, while brown darters tend to occupy the lower reaches of Rocky Bayou streams. Areas of sympatry (both species present at any collection) fluctuate in the ratios of the two species.

After considering all of the geochronology data on Okaloosa and brown darters, there is evidence supporting all three theories proposed for the presence of the brown darter. The two anomalous and isolated records of brown darters in the Boggy Bayou system and in the headwaters of Rocky Creek support the notion that bait-bucket releases of darters may be occurring. The lack of collections at many of the sites where brown darters eventually were found is an example of the tendency for ichthyologists to repeatedly collect at type localities and known stations. If collections had been made in the 1950s of the lower reaches of Swift Creek, we might know if the Okaloosa darter was there prior to the brown darter. The theory of intra-estuarine dispersal may have the most supporting evidence.

Brown darters were able to tolerate salinities typical of Choctawhatchee Bay in laboratory experiments (Burkhead *et al.* 1994). Adult brown darters tolerated up to 14 parts per

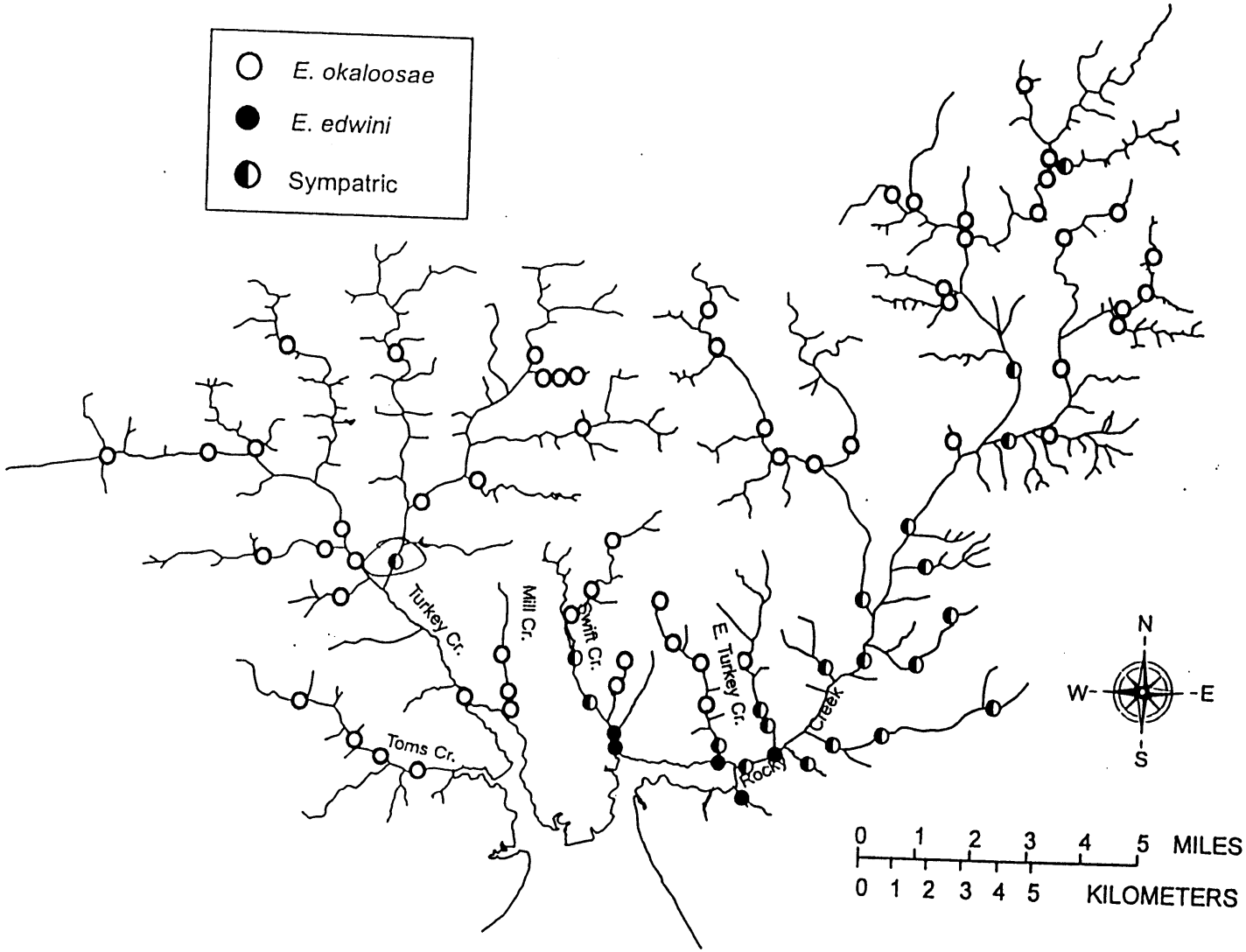

Figure 5. The distribution of Okaloosa and brown darters in the six stream systems of Boggy and Rocky Bayous. Open circles indicate sites where only Okaloosa darters (*E. okaloosae*) have been found, while shaded circles indicate brown darter sites (*E. edwini*). Circles that are half shaded indicate sites where at least one brown darter was collected together with Okaloosa darters (Sympatric).

thousand (‰) salinities in acute tests and experienced 96 percent survivorship after 25 days at 10‰. Salinities along the periphery of Choctawhatchee Bay range from zero to 24‰, with an average of 10‰ (unpublished data for 1985-86, Northwest Florida Water Management District). The extreme flood of the Choctawhatchee River in March 1929 may have introduced the brown darter to the Rocky Bayou system from adjacent streams (United States Department of Agriculture 1975).

Although the exact method and timing of brown darter colonization will probably never be known, brown darters seem to occur where the Okaloosa darter formerly did when stream conditions change, as they did in lower Swift Creek. As streams flow through the landscape, their physical, chemical, and biological characteristics change. In the Rocky Bayou system, these subtle, gradual, changes are associated with increases in the prevalence of brown darters. It is possible that higher ratios of runoff to sand-filtered groundwater is what encourages brown darters at the expense of Okaloosa darters. A geomorphology study of Eglin AFB found that sub-surface clay layers in the middle and lower reaches of the Rocky Creek system decrease water infiltration rates, thus increasing drainage density (length of streams per area) and amount of surface runoff (Barr *et al.* 1985; Fischer *et al.* 1994).

C. Habitat/Ecosystem/Life History

Longleaf pine-wiregrass-red oak sandhill communities dominate the vegetation landscape in Okaloosa darter watershed basins. These areas are characterized by high sand ridges where soil nutrients are low and woodland fire is a regular visitor. Where water seeps from these hills, acid-bog communities of sphagnum moss, pitcher plants and other plants adapted to low nutrient soils develop. In other areas, the water emerges from seepage springs directly into clear-flowing streams where variation of both temperature and flow is moderated by the deep layers of sand. The streams support a mixture of bog moss (*Mayaca fluviatilis*), bulrush (*Scirpus etuberculatus*), golden club (*Orontium aquaticum*), burr-weed (*Sparganium americanum*), pondweed (*Potamogeton diversifolius*), spikerush (*Eleocharis* sp.) and other aquatic and emergent plants.

The areas inhabited by the Okaloosa darter are typically the margins of flowing streams where detritus, root mats, and vegetation are present. Densities average about one darter in every 2.7 meters of stream length (Burkhead *et al.* 1994). Okaloosa darters have not been collected in areas where there is no current nor have they been collected in the open, sandy areas in the middle of stream channels. Brown darters also occupy similar stream margins; however, they are capable of living in areas of little to no flow (Burkhead *et al.* 1994). Okaloosa darters feed primarily on fly (Diptera), mayfly (Ephemeroptera), and caddis fly (Trichoptera) larvae (Ogilvie 1980). The breeding season extends from late March through October, although it usually peaks in April. Spawning pairs have been videographed attaching one or two eggs to vegetation, and they also have been observed attaching eggs to woody debris and root mats (Burkhead *et al.* 1994; Collette and Yerger

1962). Ogilvie (1980) found a mean of 76 ova and 29 mature ova in 201 female Okaloosa darters. These numbers may under-represent annual fecundity as the prolonged spawning season is an indication of fractional spawning (i.e., eggs develop and mature throughout the spawning season). Estimates of longevity range from two to three years (Burkhead *et al.* 1992; Mettee and Crittenden 1979; Ogilvie 1980).

D. Reasons for Listing and Present Threats

The Okaloosa darter was initially listed because of its extremely limited range and potential problems resulting from erosion, water impoundment, and competition with brown darters. Since the listing in 1973, several stream sections have either decreased population levels or Okaloosa darters are no longer found at all. In Swift Creek, downstream of College Pond, no Okaloosa darters have been caught since 1987. Mill Creek has lost much of its Okaloosa darter habitat to erosion, culverting, and beaver ponds associated with culverts. Populations, however, appear stable in the upper reaches of the Boggy and Rocky Bayou stream systems since monitoring began in 1995.

Eglin AFB has maintained its system of roads by mining clay and sand from 144 pits of various sizes (Eglin 1993). Thirty-nine of these pits are located within or immediately adjacent to Okaloosa darter drainages. Ten of these pits are still active. These pits have been sites of extreme erosion where stream vegetation was entombed beneath sediments. The roads have also been sources of excessive sedimentation.

Sand-filtered groundwater, the primary source for Okaloosa darter streams, is susceptible to reduced contributions as the amount withdrawn from the sand-gravel aquifer increases (Barr *et al.* 1985). Increases in impermeable surfaces in the urban areas cause increased surface runoff with associated fluxes in water temperature and chemistry. Finally, the potential for catastrophic spills of toxic substances increases as traffic across Okaloosa darter streams expands in volume and extent.

E. Conservation Measures

It is imperative that the management of the lands and waters of the drainage area maintain conditions that support Okaloosa darters. Managing the landscape with techniques that preserve natural processes in the ecosystem (i.e., fire, flood, sediment transport, vegetation succession) will help ensure the continued existence of the Okaloosa darter and avoid range expansion of the brown darter.

The potential for maintaining favorable conditions for the Okaloosa darter is high because over 90 percent of the drainage area of the Okaloosa darter streams is managed by Jackson Guard Natural Resource Branch of Eglin AFB. The darter population has persisted through drought conditions in 1984, hurricanes in 1995, and severe erosion problems in the watersheds. Eglin AFB strives to improve their resource stewardship

through an adaptive ecosystem management process (Eglin 1993). Currently, projects to restore clay borrow pits, correct road erosion, and close nonessential roads have improved Okaloosa darter stream habitat by reducing sediment scouring and entombment of submerged vegetation. Eglin AFB has committed over 3.6 million dollars since 1994 to restoring 20 pits and 57 non-point erosional sources. These actions resulted in an estimated 15,500 ton annual reduction in sediments flowing into darter streams.

Eglin AFB has designated an Okaloosa Darter Management Emphasis Area that includes the drainages of all six Okaloosa darter streams. The goals of this effort are to (1) stabilize and increase the Okaloosa darter population, (2) prevent or significantly reduce erosion from degrading Okaloosa darter habitat, and (3) identify and modify road culverts which have resulted in stream gradients detrimental to Okaloosa darters.

Eglin AFB has consistently funded research on the ecology of the Okaloosa darter and long-term monitoring of darter populations. Educational brochures and signs have been prepared with the assistance of the University of Florida, and public surveys have tested their effectiveness.

The following outline details specific tasks identified in the 1981 Okaloosa Darter Recovery Plan and the progress made on each.

I. Determine biological characteristics and habitat requirements.

I-1. Determine optimum habitat of the Okaloosa darter.

I-1-A. Determine distribution. **The U.S. Geological Survey Biological Resources Division, Florida Caribbean Science Center (USGS) maintains a geochronology database of over 700 collection records.**

I-1-B. Determine reproduction, growth, feeding, and other life history aspects. **Florida Game and Fresh Water Fish Commission, USGS, and the Service have reports that were used in developing the habitat/ecosystem/life history section of this plan.**

I-1-C. Determine physical parameters of Okaloosa darter streams. **USGS and the Service are currently investigating stream temperature and other water quality parameters. Okaloosa-Walton Counties have ongoing water quality studies in association with treated sewage sprayfields. The Northwest Florida Water Management District (NWFWMD) and USGS Water Resources Division water gauging station on Juniper Creek that started collecting surface flow data in**

1966 was removed in 1992. Eglin AFB funded Resource Consultants and Engineers to study the geomorphology of Okaloosa darter streams.

I-2. Determine potential hazards to the Okaloosa darter.

I-2-A. Define any competitors and predators. **The role of the brown darter as a competitor has been investigated in the field by USGS. Fish predators have not changed from those encountered in the past.**

I-2-B. Monitor sympatric populations of Okaloosa and brown darters. **Eglin AFB, USGS, the Service, and the University of West Florida are all involved in darter monitoring.**

I-2-C. Monitor habitat modification. **Eglin AFB has developed a geographic information system to track habitat restoration while USGS monitors stream sites for changes in stream habitat.**

I-3. Determine population size and fluctuations of the Okaloosa darter.

I-3-A. Conduct population studies. **Same as I-2-B.**

I-3-B. Determine fluctuations of populations by periodic sampling. **Same as I-2-B.**

II. Protect extant populations and habitats.

I-1. Define permissible and prohibited activities in Okaloosa darter habitats. **The Service has done several consultations under Section 7 of the Endangered Species Act with Eglin AFB, U.S. Army Corps of Engineers, and Florida Department of Transportation to protect Okaloosa darter habitat.**

II-2. Reduce possible competitors and predators. **This task has not been deemed necessary at this time.**

II-3. Investigate need for land acquisition. **Since 90% of the watershed area is under federal ownership, additional land acquisition has not occurred.**

III. Increase Okaloosa darter populations and reestablish range.

III-1. Create more optimum habitat by manipulating physical parameters. **Ongoing erosion abatement by Eglin AFB is associated with increased numbers of darters.**

III-2. Reestablish extirpated populations with transplants. **As we have not lost any stream populations to date, there has not been a need for captive propagation and release. If the situation occurs, the revised plan includes a catastrophe prevention and response plan.**

The Okaloosa darter population appears to be stable or increasing at most of the sites from 1995 to 1998 and comprised of two plus age-classes. Sites that have low or decreasing numbers of darters have identified threats that can be alleviated (i.e., impoundment, sedimentation and golf course runoff). If these situations improve and no new problems arise then the Okaloosa darter will be a candidate for downlisting after completing five years of population monitoring in 2001.

PART II

RECOVERY OUTLINE

A. **Objective and Criteria** - The objective of this Recovery Plan is to restore and protect Okaloosa darter habitat and stream ecosystems so that the Okaloosa darter may be initially downlisted and eventually delisted. The Okaloosa darter only occupies the unique habitats of six stream systems, and recovery tasks are focused on habitats within their historic range. All recovery criteria are preliminary and may be revised on the basis of new information (including research specified as recovery tasks).

The Okaloosa darter will be considered for reclassification from endangered to threatened in 2001, if:

1. Instream flows and historical habitat of stream systems have been protected through management plans, conservation agreements, easements, and/or acquisitions;

2. Eglin Air Force Base has and is implementing an effective habitat restoration program to control erosion from roads, clay pits, and open ranges;

3. Okaloosa darter population is stable or increasing and comprised of two plus age-classes, in all six stream systems for 5 consecutive years (see Appendix A for definition and methods);

4. The range of the Okaloosa darter has not decreased at all historical monitoring sites; and

5. No foreseeable threats exist that would impact the survival of the species.

The Okaloosa darter will be considered for delisting when: [Note: Goal may not be achievable with significant changes in military mission.]

1. A. All reclassification criteria have been met;

   B. Historic habitat of all six streams has been restored to support viable populations of Okaloosa darters (including degraded sections of Mill, Swift, and Toms Creeks);

   C. Erosion at clay pits, road crossings, and steep slopes has been minimized to the extent that resemble historic predisturbance condition;

D. Longleaf restoration and watershed management practices on Eglin AFB are in effect;

E. Natural, historical flow regimes are maintained; and

F. Water quality and riparian habitat have been significantly improved and maintained.

2. A. Cooperative and enforceable agreements are in place to protect habitat, water quality and quantity for the historic range outside of Eglin AFB; and

B. Management plans that protect and restore habitat, water quality and quantity have been effective and are still in place for the 90 percent of the historic range currently managed by Eglin AFB.

3. Okaloosa darter populations at monitoring sites consist of two plus age-classes remained stable or increasing in all six streams over a period of 20 consecutive years (see Appendix A for definition and methods); and

4. No foreseeable threats exist that would impact the survival of this species (assumes military mission is compatible).

B. Narrative Outline

1. Restore and protect habitat in the six Okaloosa darter stream watersheds. The Okaloosa darter is restricted in distribution to six streams of which about 90 percent of the basins are on Eglin AFB and the remaining 10 percent in the Niceville and Valparaiso municipal area. Because of the specific habitat requirements and limited distribution of the darter, habitat which is essential for spawning, rearing, feeding, and cover needs to be restored and protected to prevent the species from declining irreversibly and to recover the species.

   1.1 Continue to restore habitat on Eglin AFB by implementing erosion and sediment control measures. Continue best watershed management practices and longleaf pine ecosystem restoration. Managing the landscape with techniques that preserve natural processes (i.e., fire, flood, sediment transport, and vegetation succession in riparian and upland zones) will help ensure the continued existence of the Okaloosa darter.

      1.1.1 Apply erosion and sedimentation control measures at clay pits, road crossings, open ranges, and steep slopes within the Okaloosa darter watershed. This is a continuation of an active erosion control program involving site restoration, revegetation, and road access control.

         1.1.1.1 Continue the restoration of clay pits and road crossings throughout Okaloosa darter watersheds.

         1.1.1.2 Continue road access control program that reduces erosion and the number of sites where contaminants or nonindigenous species might be introduced to stream systems.

         1.1.1.3 Widen riparian buffers in open ranges of Eglin AFB to the normal hill crest so that mission visibility will not be impaired, and darter habitat will be improved.

         1.1.1.4 Apply best management practices to road construction and maintenance.

   1.2 Improve Mill Creek habitat to increase the very low darter population remaining there. Because of the small size of this creek and the golf course and urban impacts it receives, the population of darters in Mill Creek is the most imperiled. Okaloosa darters in Mill Creek may

represent robust strain that is important to the long-term survival of the species. In case of a catastrophic event, having multiple streams populated with Okaloosa darters decreases the probability of extinction.

1.2.1 Stabilize headwater banks on the golf course.

1.2.2 Remove impediments to flow such as sediment beds, beaver dams, and clogged culverts.

1.2.3 Minimize the use of pesticides, herbicides, and other contaminants on the golf course that impact Mill Creek darters by developing and implementing a chemical use plan.

1.2.4 Restore open channel stream habitat between State Routes 190 and 20 by converting underground piped and beaver ponded segments into free flowing streams.

1.3 Evaluate the effects of ponds on Okaloosa darters and make ecological restoration recommendations. Improve stream habitat by modification or removal of water control structures where appropriate. Effects to consider include, but are not limited to, potential blockage to emigration and genetic mixing of Okaloosa darters, introduction of contaminants and nonindigenous species at ponded sites, downstream water quality problems, and loss of suitable habitat.

1.3.1 Evaluate Eglin AFB ponds for ecological restoration.

1.3.2 Evaluate and modify the spillway of College Pond on Swift Creek to improve water quality below the dam.

1.4 Incorporate Okaloosa darter habitat conservation and restoration measures in Eglin AFB Natural Resources Management Plan. The Sikes Act (Public Law 86-797, as amended) provided for cooperation by the Departments of the Interior and Defense with State agencies in planning, development, and maintenance of fish and wildlife resources on military reservations. Natural resource management plans developed by Eglin AFB will be reviewed by the Service for the sound management of the Okaloosa darter as part of the ecosystem. Actions taken to benefit the darter will be evaluated for effectiveness.

1.5 Prepare an Okaloosa darter habitat catastrophe response plan. The plan should be implemented if necessary to ensure the continued survival of this species if a short-term catastrophe occurs. If a segment of Okaloosa

darter stream habitat is destroyed in a catastrophic event and appropriate sampling indicates that Okaloosa darters have been extirpated, then Okaloosa darters may be re-introduced once sufficient habitat has been restored. Habitat should be restored using native vegetation while re-introduced darters should be from the closest viable population that can donate fish to preserve the local genetic strain. Captive breeding will be utilized as a part of this recovery effort only if a major perturbation makes such an action necessary to ensure the continued survival of the species.

1.6 Ensure that the design and construction of roads outside of Eglin AFB use best management practices to reduce erosion of embankments, stormwater runoff, and floodplain structures in Okaloosa darter watersheds. County and municipal governments should work with the Florida Department of Transportation to accomplish this task.

1.7 Include conservation actions for Okaloosa darters in the comprehensive plans of surrounding communities. Assist city (Niceville, Valparaiso) and county (Okaloosa, Walton) government agencies to incorporate best management practices in their planning so that conflicting use of aquatic resources can be avoided. Currently, these communities have developed Comprehensive Plans to provide buffers along creeks. Additional sections should address erosion, buffer maintenance, stormwater retention, and planned water usage and withdrawals. The Panama City field office of the Service will review comprehensive and development site plans for relevance to Okaloosa darter recovery objectives.

1.8 Develop cooperative ventures with private landowners to restore habitat. The Service as well as other State and Federal agencies in cooperation with willing landowners, have begun to implement programs to restore, enhance, and manage aquatic habitats on private lands.

2. Protect water quality and quantity in Okaloosa darter streams. Other than Swift and Mill Creeks, most of the Okaloosa darter streams have relatively stable, viable populations of darters. About 90 percent of the 51,397 hectares (127,000 acres) that represent the drainage basins of darter streams are managed by the Jackson Guard Natural Resource Division of Eglin AFB. The remaining 485.6 hectares (12,000 acres) are situated in the Niceville-Valparaiso urban complex. Okaloosa darters are found at reduced levels or absent from much of this latter area. Current stream impacts include erosion, non-point discharge of nutrients and pollutants, impoundment, alteration of flow, and culverting. The tenuous balance between Okaloosa and brown darter may hinge on water quality. It is imperative that management of the lands and waters of the area maintain conditions in the headwaters so Okaloosa darter is not replaced by brown darter.

2.1 Incorporate water quality and quantity conservation into natural resource management plans for Eglin AFB to benefit Okaloosa darters and stream ecosystems.

2.2 Ensure that water quality criteria established by the Florida Department of Environmental Protection (FDEP) are protective of Okaloosa darters and their habitat so that the recovery is not impaired by any permitted activity. Identified concerns include, but are not limited to, treated wastewater discharge, stormwater runoff, landfill leaching, and adverse impacts on the sand-gravel aquifer.

2.3 Ensure that flow volumes and regimes continue to resemble historic conditions. The Okaloosa darter is restricted to six streams that are hydrologically linked to the sand-gravel aquifer and the amount of darter habitat is dependent on the volume of water flowing down these streams. During drought condition the darter population will experience stress that should not be increased by human use of the resource. Unfortunately, human needs for water use are highest during droughts. Establish agreements between NWFWMD and the Service to specify a threshold level of consumption at which applications for consumptive water use permits within the drainage basins of Okaloosa darter streams will be reviewed for potential adverse impacts.

3. Monitor and annually assess darter populations, habitat conditions, water quality, and water quantity of the recovery program and recommend new actions.

3.1 Monitor populations and habitat conditions of Okaloosa and brown darters. During and after recovery actions are implemented, the status of the species and its habitat must be monitored to assess any progress towards recovery. Monitoring data are necessary to determine whether or not recovery criteria for reclassification and delisting have been met. Continued monitoring of the two darter species will provide understanding of the periodicity, magnitude, and causal factors of population fluctuations in zones of sympatry.

3.1.1 Darter population monitoring methods should be standardized and comparable with the efforts of the USGS, Biological Resources Division and University of West Florida so that long-term trends can be quantitatively analyzed (see Appendix A for methods).

3.1.2 Establish new darter monitoring stations at sites where habitat has been restored.

3.1.3 Link darter habitat conditions to the population monitoring by using a geographical information system (GIS) to document changes in land use, water quality and quantity, fire periodicity, vegetation cover, restoration of erosional sites, and natural fluvial processes. Data being compiled for Eglin AFB need to be expanded to include the entire watershed.

3.2 Monitor water quality. Water quality parameters (temperature, conductivity, dissolved oxygen, turbidity, pH, total dissolved solids, total suspended solids, nutrients and other contaminants) will be measured at wastewater treatment facilities, golf courses, sanitary landfills, and other point discharge locations. Data will be reviewed by the Service for adverse trends.

3.2.1 Investigate the load of nutrients and contaminants from golf course by studying chemical use needs and using indicator aquatic insect surveys.

3.2.2 Inventory pollutants on Eglin AFB that affect darter streams to determine toxicity potential and consider alternatives.

3.2.3 The Service will review the 305(b) report developed by the Florida Department of Environmental Protection for status and trends of water quality.

3.3 Monitor water quantity.

3.3.1 Monitor groundwater wells in the Okaloosa darter drainage basins. The NWFWMD currently monitors a groundwater well network on Eglin AFB. Continuation of this monitoring will help predict cone-depression profiles in the sand-gravel aquifer as new wells are installed or old wells increase pumpage rates.

3.3.2 Re-establish surface water flow monitoring. Seven surface water stations were maintained in Okaloosa darter streams by the NWFWMD and the USGS Water Resources Division. Re-establishing two of these is necessary for monitoring flows of streams. The station at the State Route 85 bridge over Juniper Creek has the longest record of surface flows (1966-1992) in the immediate area and should be given the highest priority. An additional station in the Rocky Creek system would also be important.

3.4 Annually assess the overall success of the recovery program and recommend action (changes in recovery criteria, status classification, protection measures, new research studies, etc.). The recovery plan must be evaluated periodically to determine if it is on track and to recommend future actions. As more is learned about the species, the recovery objectives may need to be modified.

4. Establish a public information and education program and monitor its effectiveness. Public awareness of the species is essential to the long-term success of recovery efforts. Informative posters, brochures, slide shows, videos, and other outreach materials and efforts will help focus attention on the uniqueness of the Okaloosa darter and describe its habitat requirements. These materials will be available at canoe landings, golf courses, municipal buildings, school systems, public libraries, Jackson Guard Natural Resource Division headquarters, etc.

4.1 Develop a fact sheet on the survival and recovery needs of the Okaloosa darter for distribution to the local community.

4.2 Summarize best management practices for golf course operation that are important to the survival and recovery of the Okaloosa darter in Mill Creek. Encourage that all new golf course personnel be trained on these practices and the activities that could potentially result in a violation of Section 9 under the Endangered Species Act.

4.3 Provide periodic reminders to Federal, State, and local agencies to continue to incorporate Okaloosa darter recovery actions into local planning activities.

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PART III

IMPLEMENTATION SCHEDULE

Task priorities in column one of the following Implementation Schedule are assigned as follows:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objectives.

Key to Acronyms Used in this Implementation Schedule

BRD - Biological Resources Division, U.S. Geological Survey
COE - United States Army Corps of Engineers
EGLIN - Jackson Guard Natural Resource Branch of Eglin Air Force Base
ES - Ecological Services Division of the U.S. Fish and Wildlife Service
FDEP - Florida Department of Environmental Protection
FDOT - Florida Department of Transportation
FGFWFC - Florida Game and Fresh Water Fish Commission
FWS - United States Fish and Wildlife Service
NICE - City of Niceville
NWFWMD - Northwest Florida Water Management District
OKA - Okaloosa County
USDA - United States Department of Agriculture
SUS - State University System
VALP - City of Valparaiso
USGS - United States Geological Survey
WAL - Walton County
* = Lead Agency

OKALOOSA DARTER IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	other	Cost Estimates ($000's) FY1	FY2	FY3	FY4	FY5	Comments
1	1.2.3	Minimize use of contaminants on Golf Course.	ongoing		EGLIN*	2	2	2	2	2	
1	2.3	Establish consumptive use permit agreements.	2 years	ES	NWFWMD*	1	1	0	0	0	
2	1.1.1.1	Abate erosion program on Eglin AFB.	ongoing		EGLIN*	900	700	500	300	300	
2	1.1.1.2	Control road access on Eglin AFB.	ongoing		EGLIN*	15	10	5	5	5	
2	1.1.1.3	Widen riparian buffers in open ranges of Eglin AFB.	ongoing		EGLIN*	25	15	10	5	5	
2	1.1.1.4	Use road BMPs on Eglin.	ongoing		EGLIN*	5	5	5	5	5	
2	1.2.1	Stabilize headwater banks on Golf Course.	2 years		EGLIN*	20	20	0	0	0	
2	1.2.2	Remove impediments to flow in Mill Creek.	2 years		EGLIN*, COE, OKA WAL	15	10	0	0	0	
2	1.2.4	Create open channel in Mill Creek.	3 years		EGLIN*	50	40	30	0	0	

Implementation schedule continued on next page

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	other	Cost Estimates ($000's) FY1	FY2	FY3	FY4	FY5	Comments
2	1.3.1	Evaluate and restore Eglin AFB ponds.	3 years		EGLIN* BRD	5	5	5	0	0	
2	1.3.2	Evaluate and modify College Pond spillway.	2 years	ES	FDOT*, OKA, WAL, NICE, BRD	0	1	20	0	0	
2	1.4	Include habitat conservation and restoration measures in Natural Resource Management Plan.	ongoing	ES	EGLIN*	1	1	1	1	1	
2	1.6	Review BMPs for roadways outside of Eglin.	1 year	ES	FDOT*, OKA, WAL, NICE, VALP	3	0	0	0	0	
2	1.7	Include conservation actions in comprehensive plans.	ongoing	ES	OKA*, WAL*, NICE*, VALP*	1	1	1	1	1	
2	2.1	Address water quality and quantity to Natural Resources Plans at Eglin.	ongoing	ES	EGLIN*, BRD	1	1	1	1	1	
2	2.2	Establish protective water quality criteria .	2 years	ES	FDEP*	1	1	0	0	0	
2	3.1.1	Monitor darter populations.	ongoing	ES	BRD*, SUS, EGLIN, FGFWFC	30	30	30	30	30	

Implementation schedule continued on next page

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	other	Cost Estimates ($000's) FY1	FY2	FY3	FY4	FY5	Comments
2	3.1.2	Monitor darters at habitat restoration sites.	ongoing	ES	EGLIN*, BRD	10	10	10	10	10	
2	3.1.3	Analyze habitat by GIS.	ongoing	ES	EGLIN*, BRD	50	50	50	50	50	
2	3.2.1	Investigate nutrient and contaminant loads from golf course.	ongoing	ES	EGLIN*	2	2	2	2	2	
2	3.2.2	Inventory of pollutants on Eglin .	ongoing	ES	EGLIN*	2	2	2	2	2	
2	3.2.3	Maintain status and trends of water quality .	ongoing	ES*	EGLIN, FDEP, OKA, WAL	2	2	2	2	2	
2	3.3.1	Continue groundwater monitoring.	ongoing		NWFWMD*, EGLIN, USGS	8	8	8	8	8	
2	3.3.2	Re-establish surface water flow monitoring.	ongoing	ES	NWFWMD*, USGS, EGLIN	30	15	15	15	15	
2	3.4	Assess darter recovery annually.	ongoing	ES*	BRD, EGLIN	2	2	2	2	2	
3	1.5	Prepare catastrophe response plan.	1 year	ES	EGLIN*, BRD	3	0	0	0	0	
3	1.8	Initiate cooperative agreements with private landowners.	2 years	ES*	USDA	10	10	0	0	0	

Implementation schedule continued on next page

Priority	Task Number	Task Description	Task Duration	Responsible FWS	Agency other	Cost Estimates ($000's) FY1	FY2	FY3	FY4	FY5	Comments
3	4.1	Prepare public education fact sheet on darter.	5 years	ES	BRD*, NICE, VALP, OKA, WAL, SUS FGFWFC, EGLIN	1	1	1	1	1	
3	4.2	Summarize BMPs for golf course operations.	ongoing	ES	EGLIN*	1	1	1	1	1	
3	4.3	Remind involved agencies to incorporate recovery actions into local planning activities.	ongoing	ES*	BRD	0		0	0	0	

APPENDIX A

POPULATION STABILITY STANDARDIZED SAMPLING METHODOLOGY FOR OKALOOSA DARTER (*Etheostoma okaloosae*) --- MAY 1998

Recovery is the process by which the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured. The goal of this process is the maintenance of secure, self-sustaining wild populations of the species with the minimum necessary investment of resources. A self-sustaining population is one that is of sufficient size and genetic diversity to cope with natural habitat fluctuations without the involvement of intensive management. Without an intensive genetics study, it is necessary to operationally define population stability at some subjective level. It is recognized that the population of darters fluctuates naturally and failing to detect a trend in population abundance that is real is often more serious, especially in threatened or endangered species, such as Okaloosa darter. A common problem in detecting trends in population abundance is that variability in the population indices obscure the trends that are occurring in the true population. Therefore, we would use standard deviation metrics to quantify a change over time. The metric described below is intended to determine any declining trends in the status of the population.

The 1.75 standard deviations below the mean was chosen as the threshold level as according to Tchebycheff's inequality equation, at least 67.3 percent of the values will be between 1.75 standard deviations above and below the mean (Brown and Hollander 1977). If the distribution of the number of darters counted at each site is symmetrically distributed, then only 16.3 percent of the observations will be below 1.75 standard deviations of the mean. This level has not occurred in the streams that are being quantitatively surveyed.

A population will be considered stable if (1) Okaloosa darter numbers remain above 1.75 standard deviations below the cumulative long-term average at each of the monitoring sites, (2) the long-term trend in the average counts at each monitoring site is increasing or neutral, and (3) the range that the species inhabits is not decreased by more than a 500-meter stream reach within any of the six stream systems. This operational definition of stability relies on continuing monitoring efforts that are currently being done by U.S. Geological Survey, Biological Resources Division and University of West Florida researchers. A list of monitoring sites, survey techniques, cumulative average number of Okaloosa darters and brown darters, and 1.75 standard deviations below the average, are presented in Table 1.

Biological Resources Division Methods: Twenty-four 20-meter permanent sites in 12 streams are visually surveyed for Okaloosa and

brown darters by snorkeling in the spring and fall. Two transects at each site give a cross section stream profile with stream velocities measured every tenth of the width of the stream. Substrate, submerged vegetation, canopy cover, dissolved oxygen, pH, temperature, turbidity, and conductivity are recorded at each site.

University of West Florida Methods: Fish are collected with a 3.05-m x 1.22-m minnow seine with 3.2-mm mesh at each site for one hour during early spring each year. Okaloosa darters were immediately placed in a clear plastic dish, standard-length measured, and returned to the water within one minute of capture. Water temperature, vegetation, bottom substrate, shore conditions, current speed, and stream depth and width were recorded.

Table 1. Average number of Okaloosa and brown darters observed at sites monitored by the U.S. Geological Survey Biblical Resources Division and University of West Florida.

Stream	Road Crossing	Sampler/ Method*	N	*Etheostoma okaloosae* Mean	STD	Mean-1.75(STD)	*Etheostoma edwini* Mean	STD
Bens Creek	E 619	U / visual	6	15.2	7.0	2.9	0.0	0.0
East Long Cr.	E 192	U / visual	6	2.3	0.8	0.8	5.6	3.2
Juniper Cr.	E 221	U / visual	6	15.6	4.3	8.1	0.0	0.0
Little Rocky Cr.	E 477	U / visual	6	7.8	3.7	1.3	8.3	1.7
Rocky Creek	E 200	U / visual	6	4.9	1.8	1.8	5.7	2.4
West Turkey Cr.	E 232	U / visual	6	23.0	10.7	4.2	0.0	0.0
Rogue Creek	E 233	U / visual	6	37.8	13.5	14.2	0.0	0.0
Tenmile Creek	E 231	U / visual	6	23.5	8.7	8.4	0.0	0.0
Little Rocky Cr.	E 200	U / visual	6	11.1	4.8	2.8	0.6	0.6
Rocky Creek	E 201	U / visual	6	11.7	4.0	4.7	0.0	0.0
West Turkey Cr.	E 637	U / visual	6	29.7	14.1	4.9	0.0	0.0
West Long Cr.	E 406	U / visual	6	12.3	3.8	5.7	0.2	0.4
Toms Cr.	SR 85	M / seine				site to be added in 1998		
Mill Cr.	SR 190	M / seine	12	12.1	13.9	-12.3	0.0	0.0
East Turkey Cr.	Rocky Bayou	M / seine	14	2.1	2.1	-1.6	2.0	2.9
East Turkey Cr.	SR 285	WF / seine	8	10.1	3.1	4.7	0.0	0.0
East Turkey Cr.	E 473	WF / seine	8	27.4	6.6	15.9	0.0	0.0
East Turkey Cr.	Baseline	WF / seine	8	23.5	10.2	5.7	0.0	0.0
Shaw Still Br.	SR 190	WF / seine	8	13.6	10.4	-4.6	0.0	0.0
Swift Cr.	SR 190	WF / seine	8	0.3	0.7	-0.9	32.5	19.8
Swift Cr.	SR 20	WF / seine	8	0.0	0.0	0.0	4.0	3.6
Swift Cr.	SR 285	WF / seine	8	0.0	0.0	0.0	31.4	20.7
Swift Cr.	No #	WF / seine	7	45.9	11.1	26.5	0.0	0.0
Swift Cr.	E railroad	WF / seine	8	19.0	9.2	2.9	0.0	0.0
West Long Cr.	E 406	WF / seine	8	33.5	8.5	18.7	0.0	0.0
West Long Cr.	E 469	WF / seine	8	18.9	11.1	-0.5	0.1	0.3
West Long Cr.	No #	WF / seine	8	5.6	2.2	1.7	0.0	0.0

* Note: All sampler methods are detailed above
U = U.S. Geological Survey, Biological Resources Division and Jacksonville University
WF = University of West Florida
M = Rick Crews, Scott Mettee, University of West Florida, U.S. Geological Survey

APPENDIX B

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The following agencies, organizations, and individuals were mailed copies of this recovery plan. This does not imply that they provided comments or endorsed the contents of this plan. All comments received have been addressed in this final plan. (Reviewers' comments and letters are maintained in the administrative record).

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