Okaloosa darter
(*Etheostoma okaloosae*)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Southeast Region

Panama City Ecological Services and Fisheries Resources Office
Panama City, Florida

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5-YEAR REVIEW
Okaloosa darter (*Etheostoma okaloosae*)

I. GENERAL INFORMATION

A. Methodology used to complete this review

U.S. Fish and Wildlife Service staff from the Panama City Field Office compiled this 5-year review. We issued one contract in FY05 for a genetics analysis of tissue samples taken from 20 darters in 2004 (a task prescribed in the 1998 Recovery Plan), but did not otherwise contract for any new data analysis or report preparation expressly as part of this review. Field surveys were conducted by Service personnel for this review to supplement known occurrence records of Okaloosa darters. Results are reported herein.

We relied upon many documents to complete this review (see REFERENCES section), but especially upon the following:

- Bortone (1999) " Monitoring and Sampling of Okaloosa Darters at 18 Sites in Okaloosa and Walton Counties";
- Dorazio et al. (2005) "Improving Removal-Based Estimates of Abundance by Sampling a Population of Spatially Distinct Subpopulations";
- Herod et al. (2004) "Enumerating and identifying management actions for road crossing structures in Okaloosa darter streams";
- Jordan and Jelks (2004) "Population Monitoring of the Endangered Okaloosa Darter -- 2004 Annual Report"; and
- Thom and Herod (2005) "Aquatic inventory of Eglin Air Force Base and recommendations for long-term aquatic ecosystem management".

Reference-Point Documents

The revised Recovery Plan, approved October 26, 1998, is the most recent comprehensive documentation of the species' conservation status, and also serves as the reference point for this review.

Public notice was given in the *Federal Register* on June 21, 2005 (70 FR 35689) and a 60 day comment period was opened.

B. Reviewers

Lead Regional Office:	Southeast Region – Atlanta, Georgia Kelly Bibb: 404-679-7132
Lead Field Office:	Panama City Ecological Services and Fisheries Resources Office - Panama City, FL Jerry Ziewitz: (850) 769-0552 x223 Bill Tate: (850) 883-1189 Karen Herrington: (850) 769-0552 x250

Cooperating Field Offices: None applicable. The Okaloosa darter occurs entirely within the work area of the Panama City Florida Field Office.

C. Background

C.1. Federal Register Notice announcing initiation of this review: 70 FR 35689; June 21, 2005.

C.2. Species status:
Improving (2006 Recovery Data Call)

C.3. Recovery achieved:
3 (50-75% recovery objectives achieved) (2006 Recovery Data Call)

C.4. Listing history
Original Listing
FR notice: 38 FR 14678
Date listed: June 4, 1973
Entity listed: Species, Okaloosa darter (*Etheostoma okaloosae*)
Classification: Endangered

C.5. Associated rulemakings: None

C.6. Review history: Recovery Data Call 1998 – 2006; 1998 Recovery Plan for Okaloosa darter.

C.7. Species Recovery Priority Number at start of review (48 FR 43098): 11 (a species with a moderate degree of threat and low recovery potential).

C.8. Recovery Plan
Name of plan: Recovery Plan for Okaloosa Darter (*Etheostoma okaloosae*)
Date issued: October 26, 1998
Date of original plan: April 18, 1981

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

A.1. Is the species under review listed as a DPS? No

A.2. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy? No

B. Recovery Criteria

B.1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes

B.2. Adequacy of recovery criteria

B.2.a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species? No. The demographic criteria include quantitative demographic criteria based upon darter monitoring at established sample sites using very specific methods and analyses. These methods allow only a 1.75 standard deviation below the mean to meet the stable or increasing criteria at all population monitoring sites. Monitoring has now shown that natural variation and sample method, seining versus visual survey, can result in a variation greater than 1.75 while still maintaining a stable or increasing trend.

B.2.b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? Yes. However, the threats criteria are qualitative and are not organized according to the five listing factors. Only one of the five factors is presently relevant to the darter.

B.3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information. For threats-related recovery criteria, please note which of the 5 listing factors are addressed by that criterion. If any of the 5-listing factors are not relevant to this species, please note that here.

The 1998 revision of the Okaloosa darter Recovery Plan describes criteria for downlisting the species to threatened status and for delisting. These include quantitative demographic criteria based upon darter monitoring at established sample sites using specific methods and other criteria that address threats to the species. The threats criteria are qualitative and are not organized according to the five listing factors, as only one of the five are presently relevant to the darter.

B.3.a. Downlisting Criteria

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

The management plans of several agencies apply to streams in the range of the Okaloosa darter. Probably the most influential of these is Eglin's Integrated Natural Resource Management Plan (INRMP) (USAF 2007). The INRMP is updated every 5 years in consultation with the USFWS and FWC. It programmatically defines broad goals and specific objectives for natural resources on the base. For example, Principal Goal II of the 2002 plan reads: "In a manner consistent with the military mission, conserve native biodiversity by restoring and maintaining Eglin's ecosystems with particular emphasis on prescribed fire and water quality." Objectives under this goal that pertain to the darter include, among others, "By 2003, assess impacts of road crossings at seepage streams with refined aquatic indices", and "Annually identify and restore 20 sites or 5% of wetlands and riparian areas that are being impacted by soil erosion or the introduction of other materials." Eglin has recently updated the INRMP for 2007 to include darter specific goals and objectives developed to address recovery criteria.

In 2005, the USFWS, Eglin's Natural Resources Branch, the Nature Conservancy, and the Florida Fish and Wildlife Conservation Commission signed an agreement to cooperate in the stewardship of aquatic systems on lands of the Gulf Coastal Plain Ecosystem Partnership (GCPEP) in western Florida. GCPEP's Aquatic Team agreed to initially assign priority to strategies and projects that contribute to the recovery of the Okaloosa darter.

The Northwest Florida Management District (in conjunction with the Florida Department of Environmental Protection) has a Surface Water Improvement and Management (SWIM) Plan that addresses water issues in the Choctawhatchee River and Bay System, including the projected water supply needs of the coastal portions of Okaloosa and Walton counties. Protecting water-dependent endangered species and their habitats are integral components of the SWIM plan. In its water supply plan for the counties that encompass the range of the darter, the NWFWMD examines the water sources that could supply growing human water demands in the region (Bartel et al. 2000). Depending on its magnitude and spatial distribution, substantial new use of the Sand and Gravel Aquifer could diminish stream flow in the darter streams; however, the potential well fields that the NWFWMD identified are located south and west of the darter drainages.

The Choctawhatchee Basin Alliance (a citizens group), along with supporting state and federal agencies, are implementing a program called "Breaking New Ground", which is a set of place-based air and watershed action plans for the Choctawhatchee River and Bay watershed. These plans address water quality monitoring, point- and non-point-source pollution, growth management, water supply, education, and citizen involvement in all Choctawhatchee Bay watersheds, including the darter drainages.

The opportunities for "easements and/or acquisitions" to protect the Okaloosa darter are limited, because 98.7% of the extant range is on federal land. We tried to arrange a conservation easement and restoration project with a principal landowner along Shaw Still Branch through our Partners for Fish and Wildlife Program, but the landowner declined (Chris Metcalf, USFWS, personal communication, 2006). We are not aware of other near-term opportunities outside Eglin for conservation benefits to the darter, however we are attempting to obtain commitments from the city of Niceville and Okaloosa county to assist with habitat protection and restoration. Securing darter habitat suitability and restoring it off base are long-term challenges and for the foreseeable future, opportunities on Eglin are much more likely to realize immediate conservation benefits for a given level of effort. Because Eglin and others have demonstrated a commitment to recovery of the Okaloosa darter through natural resource planning and coordination with the Service, we believe that this downlisting criterion has been satisfied.

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

Since 1995, Eglin has restored 317 sites covering 196.2 ha that were eroding into Okaloosa darter streams. All 38 borrow pits within Okaloosa darter drainages are now stabilized (59.3 ha). The other 279 sites (136.9 ha) included in the total are characterized as "non-point sources" of stream sedimentation. Eglin estimates that these efforts have reduced soil loss by 97%, from 30,745 metric tons/ha/year in 1994 to 830 metric tons/ha/year in 2004 (S. Pizzalotto, Eglin AFB, personal communication 2005). Increases in darter numbers over the past 10 years generally track the cumulative area restored in that time frame (Jordan and Jelks 2004). Darter numbers increased in the Boggy Bayou drainages earlier than in the Rocky Bayou drainages, and likewise, restoration activities began earlier in the Boggy Bayou drainages.

Many road crossing structures have been eliminated as part of Eglin's restoration activities. Of the 153 road crossings that previously existed in Okaloosa darter drainages, 57 have been eliminated; 28 in Boggy Bayou streams and 29 in Rocky Bayou streams. Most of these were likely barriers to fish passage and/or problems for stream channel stability, and removing them has improved habitat and reduced population fragmentation.

Eglin began work in FY2007 to restore Mill Creek. Staff from Eglin Natural Resources, the golf course, and the Service determined that it was feasible to restore to free-flowing stream all impoundments upstream of Plew Lake, the largest impoundment on the system, and to remove all but one of the culverts that convey the stream under fairways on the golf course. The Service prepared the designs for the restoration, and Eglin has secured funding for the work. The work was completed in May 2007. Eglin also secured funding for removal of the abandoned railroad crossing of Little Rocky Creek and this was completed in May 2007.

iii) Okaloosa darter population is stable or increasing and comprised of two plus age-classes, in all six stream systems for 5 consecutive years.

Annual population monitoring by USGS has detected young-of-the-year and adult fish in all six stream systems for the past five years (Howard Jelks, USGS, personal communication, September, 2005). An operational definition of "stable or increasing" is provided in Appendix A of the Recovery Plan. The definition applies to 26 long-term monitoring sites and has three parts. We assess each part in the following discussion. Appendix A of the Recovery Plan actually lists 27 monitoring locations, but two of the entries are the same site, West Long Creek at Eglin Road 406. It is listed once for count data collected by the visual observation method and again for data collected by 1 hour of seining. Although we have 27 separate monitoring data sets, we refer to 26 "sites".

<u>Okaloosa darter numbers exceed the cumulative long-term mean minus 1.75 standard deviations (sd) of the mean (i.e., $X > \bar{X}$ - 1.75sd) at each of the 26 monitoring sites for 5 consecutive years.</u>

Table 8 shows the history of this stability measure from 2000 to 2005, during which we have four instances at three sites when and where darter numbers did not exceed the measure. Only one of these sites, East Long Creek, was sampled for 5 consecutive years. The other two sites that did not satisfy this measure, one on West Long Creek and one on East Turkey Creek, have an incomplete monitoring record. This part of the operational definition of stable/increasing necessarily requires 27 sets of 5 consecutive years of data (135 data points) to evaluate, plus the prior sampling history of each site for long-term means and standard deviations. We have 105 of the required data points for application of this criterion for the period 2001 to 2005, and of these, 102 satisfy the downlisting criteria. For additional information on population abundance and trends, see Section II.C.1.a.

<u>The long-term trend in the average counts is increasing or neutral at each of the 26 sites.</u>

This aspect of the definition of stable or increasing does not evaluate each year of data at each site but looks instead at the trend implied by the entire history of data. Using a least-squares linear model, the long term trend in darter counts is increasing or neutral at 10 sites (Figure 8) and decreasing at 12 sites (Figures 6 and 9). At three sites in the lower reaches of Swift Creek, no darters have been detected in all years surveyed (Figure 9). At the one site with counts collected by the two methods, West Long Creek at Eglin Road 406, the visual survey method shows an increasing trend whereas seining shows a decreasing trend (Figure 7).

All of the declining trends were sampled by seining, not visual surveys, and may reflect variable sampling efficiency over time. For example, Bortone (1998) noted that the site on East Turkey Creek at Eglin Road 473 (5.0 km upstream of Rocky Bayou) had become "almost impossible to collect" due to the exposure of tree roots resulting from stream bed degradation. Because seining detects only about 32% as many Okaloosa darters as visual surveys (Jordan and Jelks 2004), the long-term trends in darter counts at sites sampled by seine are difficult to interpret. Furthermore, there appears to be a reduction in numbers at many of the sites occurring sometime between 1998-2000 (Figure 6, 7, and 9). Prior to this time, counts appear to be relatively consistent or generally increasing, followed by a drastic decline in darter numbers remaining relatively unchanged to 2004. Population reductions may correspond to a drought which began in 1998 or could reflect a difference in sampling ability as a shift was made from Bortone to Service personnel. If considered separately, darter counts appear to be increasing or neutral prior to as well as after 1998 or 2000 at all but East Turkey Creek rkm 3.3. Further investigation is necessary in order to determine whether population declines are real or the result of sampling technique or biases.

Figure 10 shows the locations of the 26 monitoring sites and whether darter numbers are increasing, decreasing, both (the contradicting visual vs. seine trends at one West Long Creek site), or unchanging at 0 darters. Although more sites are decreasing or continuing to not support Okaloosa darters (15) than are increasing (10), the former are concentrated within 5 km of Boggy Bayou and Rocky Bayou in the more urbanized portions of the darter's range. None of the watersheds mapped in Figure 10 contain monitoring sites with both increasing and decreasing trends, except for the contradicting trends at one of the three sites on West Long Creek. The other two sites on West Long Creek show decreasing trends, which may suggest that darter numbers are on the whole decreasing in this stream. For this analysis, we assume the 26 monitoring sites represent the trend in darter numbers for the entire occupied stream length in each watershed. Given this assumption, the four smallest darter basins (Toms, Swift, Mill, and East Turkey), West Long Creek, and East Long Creek are decreasing. The other watersheds of Rocky Creek and Turkey Creek are increasing. Using the estimated length of occupied habitat for these creeks (Table 3), darter numbers are increasing in 223.6 km (86%) and decreasing in 37.1 km (14%) of the extant range.

<u>The range that the species inhabits is not decreased by more than a 500-meter reach within any of the six systems.</u>

We treat the term "range" here as representing the cumulative stream length of occupancy in a basin instead of an extent of occurrence, such that local extirpations in the middle of a basin without changing the upstream or downstream distribution limits would result in a range reduction. Unfortunately, the annual darter monitoring at the 26 sites listed in Appendix A of the Recovery Plan is not specifically designed to measure the length of a range reduction. Range reduction is possibly occurring when darters are detected and then are not detected at one or more of the monitoring sites, but without a means of extrapolating conditions observed at a monitoring site to the rest of the stream, a zero count is a measured range reduction of only 20 to 50 m, depending on the survey methods used. Further, seining has been shown to detect only about 32% as many darters as visual surveys, suggesting that the probability of incorrectly concluding that darters are absent is relatively high using this gear.

Acknowledging these limitations, we examined the recent record of surveys where no darters were found for possible signs of range reduction. Three sites on Swift Creek were included in the 26 monitoring sites of the Recovery Plan, even though darters had not been found at them since 1987 or earlier. All three sites were sampled in 2002, one in 2004, and another in 2005. In all instances, no Okaloosa darters were collected, suggesting that darters are still absent from these sites (Table 8). Zero darters were collected/observed in 10 surveys of six other sites during the past 6 years (Table 8). It is unclear whether these survey results represent a local extirpation, except perhaps at the unnamed road crossing of a tributary of West Long Creek, where darters have been absent in the last three surveys using seine methods. Again, because seining detects significantly fewer Okaloosa darters than visual surveys (Jordan and Jelks 2004), darters may persist here in low numbers. Darters have been detected in the last 2 years at sites located both upstream and downstream of this location in the main channel of West Long Creek. Without a methodology to attribute the possible extirpation to other portions of the stream, however, we cannot say whether any more than the survey segment length (about 50m in this case) is now unoccupied.

iv) The range of the Okaloosa darter has not decreased at all historical monitoring sites.

There are 26 long term monitoring sites that have been monitored annually for at least five years. Of these, 3 sites on Swift Creek are included even though darters had not been found at them since 1987 or earlier. While no darters were collected at these sites during sampling in 2002, 2004 and 2005, we do not consider this a decrease in range as darters were not present here when the Recovery Plan was finalized and this criterion developed. No darters were collected during ten surveys of six other sites over the last six years. However, as these surveys were each conducted using seining, which detects significantly fewer darters, and not visual detection methods, it is unclear whether darters persist in low numbers or are locally extirpated. For more details about monitoring the darter's range, see criterion iii above.

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

We describe and assess potential threats to the Okaloosa darter under section C2, "Five-Factor Analysis". The only foreseeable threats to the darter occur under Listing/Recovery Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range. Resource stewardship on Eglin is generally reducing the threat of habitat destruction and range reduction (e.g., restoration of erosive borrow pits). Sedimentation from unpaved roads and areas adjacent to poorly designed/maintained paved roads is continuing; however, it appears from recent discussions that Eglin may soon find the resources to reduce this threat in the same way that it has tackled eroding borrow pits for the past several years. Similarly, restoration of Mill Creek on the Eglin Golf Course, which has been substantially altered by culverts and man-made impoundments, has recently been completed. To our knowledge, plans are not in place to address water quality issues associated with the Niceville landfill and sprayfield. Plans to assign additional forces from the Air Force and Army to Eglin may alter the military mission and potentially impact Okaloosa darter populations. Currently, we are working with Eglin NRB and military planners to locate training or test areas outside Okaloosa darter watersheds and minimize potential for negative impacts. Overall, considerable improvements have been made and while "foreseeable threats exist", these are diminishing rather than increasing and none threaten to drive the Okaloosa darter to extinction.

B.3.b. Delisting Criteria

i) All reclassification criteria have been met.

As discussed above in B.2.a., and in Section B.3.a.iii, we believe that the methods used to obtain the demographic criteria in the current recovery plan are not appropriate as they do not reflect the natural fluctuations in populations or the variability in sample methodology. However, taking these variabilities into consideration, we believe that the intent of the criteria, that of obtaining stable or increasing populations in all six stream systems for 5 consecutive years, has been met.

ii) 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).

This criterion is partially fulfilled and progress is ongoing. Habitat restoration has been and will continue to occur in all six streams (see sections II.C.1.a. Fragmentation, II.C.2.a. Sedimentation, and II.B.3.a.ii). Mill Creek restoration has recently been completed and Eglin has secured funding to remove the abandoned railroad crossing at Little Rocky Creek.

iii) Erosion at clay pits, road crossings, and steep slopes has been minimized to the extent that resemble historic pre-disturbance condition.

This criterion is partially fulfilled and progress is ongoing. Restoration projects at borrow pits, road crossings, and steepages have and will continue to contribute towards accomplishing this objective (see sections II.B.3.a.ii). However, this criterion is not quantifiable as written without data about pre-disturbance conditions.

iv) Longleaf restoration and watershed management practices on Eglin AFB are in effect.

This criterion is largely fulfilled. Both longleaf restoration and watershed management practices are in effect on Eglin AFB as outlined in the Eglin AFB INRMP.

v) Natural, historical flow regimes are maintained.

We discuss in section II.C.2.a (Water Use) how withdrawals from the Floridan Aquifer, the primary source of water supply in Okaloosa and Walton counties, have probably not altered stream flow in darter streams. Direct diversions from darter streams and wells into the Sand and Gravel Aquifer could deplete darter streams in the future. Using ESA section 7 consultations and other regulatory legislation to avoid significant impacts to stream flow will become an even more important conservation tool for the darter as water demands increase with increasing human populations. It is also desirable to monitor stream stage at historical stations to determine long term trends.

vi) Water quality and riparian habitat have been significantly improved and maintained.

This criterion is partially fulfilled and progress is ongoing; however this progress is difficult to quantify. Riparian habitat and water quality have been improved throughout darter drainages as a result of aforementioned restoration projects but degraded water quality is a concern in several portions of the range such as Turkey Creek downstream of the landfill and East Turkey Creek downstream of the wastewater treatment sprayfields (see section II.C.2.a "Pollution"). Water quality and riparian protection measures are addressed in Eglin's INRMP. FDEP is aware of the situation with the landfill, and we will advise them of our concerns on East Turkey Creek.

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

This criterion is not fulfilled. Because only about 5 km (1.4%) of the extant range is outside Eglin AFB, and this portion of the range is largely urbanized, the opportunities for cooperative conservation agreements are limited. Our attempts to secure an agreement to restore a significant portion of Shaw Still Branch, a tributary of Swift Creek, were not successful. Further discussions with FWC, DEP, NWFWMD, and local governments are warranted.

viii) 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.

This criterion is largely fulfilled through Eglin's 2007 INRMP which was recently signed by the Service.

ix) Okaloosa darter populations at monitoring sites consist of two plus age-classes and are stable or increasing in all six streams over a period of 20 consecutive years.

We now have 10, not 20, consecutive years of monitoring data with which to evaluate this criterion. Methods are evolving to more quantitative techniques.

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

Foreseeable threats to the Okaloosa darter are to its habitat, particularly in three of the smaller basins, Mill Creek, Swift Creek, and East Turkey Creek. Human activity has degraded physical and chemical habitat quality in these basins, and their darter populations, while persisting, may be declining. Maintaining multiple viable subpopulations substantially reduces the risk of species extinction, which is the product of the subpopulation extinction probabilities (Morris et al. 1999). Given the two large and increasing subpopulations of Turkey Creek and Rocky Creek, the probability of species extinction is low, even if all four other subpopulations are eliminated. Subpopulations may also serve as sources for repopulating areas that experience localized extinctions; however, this would occur between the six basins only if darters move through the generally salty waters of Boggy Bayou and Rocky Bayou. Whether such movement between basins occurs or is necessary to maintain the genetic health of darter subpopulations is unknown.

C. Updated Information and Current Species Status

C.1. Biology and Habitat

C.1.a.) Abundance, population trends (e.g., increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends.

Population Abundance Estimates

Jordan and Jelks (2004) estimated the size of a portion of the Okaloosa darter population in their annual population monitoring report (Table 2). Statistical methods for improved removal-based estimates of abundance were developed specifically for Okaloosa darters (Dorazio et al. 2005). Using visual survey methods, they counted darters in 28 20-m segments. At least two segments were located in each of the six principal basins. Darter densities (darters/m) were estimated for each survey segment, accounting for variation in abundance among subpopulations and variation in capture probabilities (Dorazio et al. 2005). The adjusted segment densities were averaged within each basin and multiplied by the stream length between the upstream- and downstream-most survey sites. No stream segments were excluded as unoccupied. This produced a study-area-wide density estimate of 3.1 darters/m and an abundance estimate of 317,829 darters. Jordan and Jelks (2004) indicated that this population estimate applied only to the portion of the darter's range that lies between their survey sites, which is less than 30% of the total stream length in the six basins. Multiplying their density estimates by our estimates of occupied stream length in each of the six basins gives a total population estimate of 802,668 darters (Table 2).

In order to expand the surveyed range of the species, many of the 69 sites sampled by the Service in 2004-2005, especially in the Rocky Creek Basin, were located several km upstream of Jordan and Jelks' (2004) annual population monitoring sites. Although seining is less efficient than the visual survey method (Jordan and Jelks 2004), these data provide another basis for estimating darter abundance (Table 3). The darter densities reported in Table 3 were adjusted to account for: 1) the efficiency of seining compared to visual counts (32%); 2) the detection rate of visual counts as determined by depletion methods (# darters present in 20-m segment = visual count*1.232+7.767; R^2 = 0.685) (Jordan and Jelks 2004); and 3) sampling 50-m segments instead of the 20-m segments used for visual counts. For example, the 27 darters collected by seining from one 50-m segment on Anderson Branch (a Turkey Creek tributary) is equivalent to 33.7 darters counted in a 20-m visual survey, 49.1 darters in a depletion estimate of 20-m segment abundance, and a density of 2.5 darters/m. Applying these adjustments to all the 50-m segment data result in an overall density estimate of 1.28 darters/m. We are aware of the possible error introduced by these adjustments, and our density estimate is considerably less than the 3.1 darters/m computed by Jordan and Jelks (2004) (Table 2), which employs only the adjustment for visual detectability. Acknowledging the greater error likely associated with the seine-based calculations, they provide a more conservative population estimate. Thus, we present both methods to estimate darter abundance in this review.

The density estimates described above include both mature and immature individuals. Some analyses of population viability and conservation status require the number of mature individuals. We estimated the proportion of mature individuals in the population from length data of 556 darters collected from 60 50-m segments located throughout the range (Table 4). Olgilvie (1980) described the average adult size of Okaloosa darters as 28-38 mm standard length (SL) and the minimum size of a mature female as 27 mm SL. Using 28 mm and greater as the threshold, 77.9% of the darters collected were mature individuals. All of the length data were collected between June 30, 2004 and January 28, 2005, which is after the peak spawning month of April (Olgilvie 1980). We observed some immature individuals (SL < 28mm) in all of the six principal basins except Swift Creek, where only one mature darter was collected from the one segment sampled, and East Turkey Creek, where no segments were sampled. The percentage of mature individuals varied from a high of 91.9% in the Mill Creek Basin (n=62 fish) to a low of 70.8% in the Turkey Creek Basin (n=325 fish), but without exception, larger sample size was associated with lower percentage of mature individuals, suggesting a possible effort-dependent sampling effect. Therefore, rather than computing basin-specific percentages, we applied the percentage for the data set as a whole (77.9%) to compute the estimates of mature-individuals population size that are reported in Table 2 and Table 3.

The darter numbers reported in Table 2 based on Jordan and Jelks (2004) are substantially greater than those computed in Table 3 based on the 2004-2005 Service samples (625,279 versus 259,355 mature darters range-wide). Although the data in Table 3 were adjusted to account for sampling differences (seining versus visual counts), and we estimated abundance from the resulting counts using the same depletion study, the overall density reported in Table 2 is still much greater than that in Table 3 (3.1 versus 1.3 darters/m). The two data sets share several sites in common, such as Rogue Creek at the crossing of Eglin Range Road 233. Jordan and Jelks (2004) report density at this site for the summer of 2004 as 6.8 darters/m in a 20-m segment, while the following winter, Service personnel seined 14 darters in a 50-m segment (0.28 darters/m). It is quite possible that variability in the seine data result in an adjustment to the seine counts that is too high, or that this site is home to fewer darters in winter, or both. While we could explore many hypotheses to explain the differences between the Table 2 and Table 3 population estimates, both estimates are relatively large and either can adequately serve the purpose of this status review.

Population Trends

The USGS and cooperators have surveyed at least 12 sites and up to 32 sites for Okaloosa darters annually since 1995 (Jordan and Jelks 2004), primarily using visual counts in 20-m segments. Collectively, Jordan and Jelks' data show an almost tripling of darter numbers in 10 years time, from an average of about 20 darters per 20-m segment sampled in 1995 to about 55 darters per segment in 2004 (Figure 5). The data displayed in Figure 5 were transformed to abundance estimates using Jordan and Jelks depletion study, which demonstrated that visual counts detect about 60% of the darters present. A dip in the increasing trend occurred in 2001 and 2002, which were years of extreme regional drought conditions, but even during these years, darter numbers were almost double those of 1995 and 1996.

Figure 5 also partitions the darter survey data into two groups: sites on streams that drain into Boggy Bayou and into Rocky Bayou. The Boggy Bayou sites consistently support about 2 to 3 times the density of Okaloosa darters than the Rocky Bayou sites, suggesting a higher carrying capacity in the Boggy Bayou drainage.

In our 2004-2005 surveys, we found significant differences by drainage between some habitat variables. Specifically, Boggy Bayou streams have significantly more aquatic macrophyte cover (MAC) than Rocky Bayou streams (t-value=2.2; DF=44; P=0.033). We observed in both drainages that darter density was significantly higher (P<0.05) in segments with high MAC cover (22.7% and above) (ANOVA: F value=9.75; DF=44; P=0.003), which may explain why Boggy Bayou streams, with more MAC, support a higher density of darters.

Although many sites surveyed in the darter's range show an increasing trend, some show a decreasing trend. Generally, these sites are within the downstream, urbanized portion of the range. Several stream segments in this area have not supported Okaloosa darters for many years (see Section II.C.1.d Spatial distribution). Bortone (1999) sampled fish by seining at 17 sites in the Swift Creek, East Turkey Creek, and West Long Creek (a tributary of Rocky Creek) drainages to monitor the status of the Okaloosa darter. Most of these sites were surveyed almost annually from 1988 through 1999, and some have been surveyed annually since then by the USGS or the Service. Nine of Bortone's sites have 13 years of survey data from 1988 to 2004, and all of these show some degree of a declining trend in numbers (Figure 6). Bortone (1999) implies that reduction in observed numbers could be due to a reduction in sampling effort combined with increases in habitat complexity (i.e., undercut banks or more woody debris). Darter populations also appear to be declining in Mill Creek, the smallest of the six basins within the darter's range (USFWS 2004). However, much of Mill Creek has recently been restored and we anticipate a reversal of this trend. Mill, Swift, East Turkey, and West Long Creeks comprise about 45 stream km, or 11% of the total range. About half of the impounded stream length and half of the stream length from which darters are apparently extirpated (10.7 km) are concentrated in this 11% of the range.

C.1.b.) Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.).

To assess genetic variation within and among Okaloosa darter populations, USGS collected fin clips from 20 darters taken at 10 sites (2 per site) distributed throughout the darter's range in 2004 (Howard Jelks, personal communication). At least one site was located in each of the six darter basins. In 2005, the Service contracted with the University of Tennessee to analyze mitochondrial DNA (mtDNA) to determine whether mtDNA haplotypes (alleles) are shared between the sampling sites. Preliminary analyses suggest potentially substantial divergence between the Okaloosa darter and other *Etheostoma* species (Near et al. 2004). If Okaloosa darters do not often migrate between the six basins, we would expect to find little mtDNA haplotype sharing between the samples from each basin, and much sharing if inter-basin movement is common. Unfortunately, the tissue obtained by USGS was insufficient for the planned genetic analysis and determining relationships among the subpopulations was not possible (T. Near, University of Tennessee, personal communication). Studies involving population genetics are planned for upcoming years.

C.1.c.) Taxonomic classification or changes in nomenclature.

We could not find, and are not aware of any, changes in the taxonomy of the Okaloosa darter that have occurred since our review in the 1998 Recovery Plan.

C.1.d.) Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g., corrections to the historical range, change in distribution of the species' within its historic range, etc.).

The Okaloosa darter is known only from six small basins (467 km^2 total area) that drain into Boggy Bayou and Rocky Bayou of Choctawhatchee Bay: Toms, Turkey, Mill, Swift, East Turkey, and Rocky creeks (Figure 1).

Extent of Occurrence and Area of Occupancy

Extent of occurrence (EOO) is the area of the minimum convex polygon (i.e., the smallest polygon with no internal angles greater than 180 degrees) that contains all sites of present occurrence (IUCN 2001). We calculated the EOO for the darter locations displayed in Figure 1, an area of 401.7 km^2 (Figure 2). Area of occupancy (AOO) is a measure of how much of the EOO is occupied based on the presence of known occurrence within a grid of 1 km-by-1 km cells. AOO for a species is a simple count of the number of cells in which that species is known to occur within the EOO. Using this method, the Okaloosa darter occupies 63 km^2 (Figure 2).

Because AOO measured by the grid method is dependent upon the grid size used, the IUCN (2005) recommends using a 2 km-by-2 km (4-km^2) grid for most species evaluations. One of the IUCN status criteria classifies risk of extinction based on AOO, and taxa inhabiting smaller areas are at greater risk. Using an excessively fine grid, rare species or sparsely sampled common species may fall short of the area thresholds that define the conservation categories (critically endangered, endangered, and vulnerable) in the IUCN system. The IUCN (2005) acknowledges that finer scales are appropriate when sampling density is high enough to reasonably ensure that empty cells represent distributional gaps and not undetected occupancy. Researchers have sampled 79 locations since 1998, which is about 1 per 4 km^2 within the species' EOO. Because this may not be dense enough to warrant the finer 1-km^2 grid, we also used the recommended 4-km^2 grid and calculated an AOO of 204 km^2.

Linear Measures of Range and Occupied Habitat

The IUCN (2005) acknowledges the problems inherent in applying the grid methodology to measuring AOO for taxa that occupy "linear" habitats, such as streams. Rather than adopt an alternative methodology for such taxa, the IUCN recommends the grid methodology for all types of spatial distributions to ensure consistent application of the AOO criterion. However, it was still necessary for us to quantify range and occupancy in linear units (km) rather than area units (km^2) to estimate population size based on densities measured as darters/m.

The streams displayed in Figures 1 and 2 are taken from 1:24,000-scale USGS topographic maps of the region. This scale of mapping does not capture some of the first-order intermittent and perennial streams that we know from field experience are present within the darter's range, but it does display a stream course at almost every point at which darters have been observed. Because several of these points are near the upstream limits of the 1:24,000 drainage network, this scale appears fine enough to capture the range of stream sizes that constitute potential darter habitat. The total length of streams that are displayed in Figures 1 and 2, including the impounded segments mapped at this scale, is 402 km. Because EOO is a polygon drawn from survey points, this measure includes some stream segments not captured by the EOO (e.g. upper Ben's Creek, upper Parrish Creek).

Visual and seine surveys have shown that Okaloosa darters occupy impounded stream segments only in areas where flow is present (i.e., inflow and exit zones; Mettee and Crittenden 1979; USFWS 1998; Jordan and Jelks 2004). As mapped at the 1:24,000 scale, about 11 km of the Okaloosa darter stream network is impounded. Sanders Branch, a tributary of Swift Creek, is the drainage most altered, with about 60% of its 3.5-km stream length impounded. Based on negative survey results or evidence of substantial habitat degradation, we are also reasonably certain that several unimpounded stream segments no longer support Okaloosa darters (Figure 3). These segments, amounting to about 26 km of stream length, are all located within 5 km of Boggy Bayou or Rocky Bayou, which is the more urbanized portion of the darter's range. The length of impounded stream segments (11 km), plus the length of segments from which darters are likely extirpated (26 km), represents a reduction in the darter's likely pre-development range of about 9%, from 402 km to 365 km. Only about 5 km (1.4%) of this extant range occurs outside the boundaries of Eglin AFB. We estimate how much of the extant range is likely occupied under "Habitat Availability" below.

<u>Habitat Availability</u>

To better understand how much of the potential habitat displayed in Figure 3 and listed in Table 1 is occupied, we sampled fish populations using seines in 69 50-m segments distributed throughout the darter drainages (Figures 1 and 2) during 2004 and 2005. We detected Okaloosa darters at 60 of these sites (87%), however as seining detects only about 32% as many Okaloosa darters as visual surveys (Jordan and Jelks 2004), it is possible that darters were present at some or all of the 9 sites at which darters were not detected.

Using single-pass visual observation by snorkeling, Jordan and Jelks (2004) found Okaloosa darters in 28 out of 28 20-m segments. Their work utilized multi-pass depletion estimates of abundance at a subset of these segments to determine that single-pass visual counts detect about 60% of the Okaloosa darters present. Methods for the visual location and identification of darters, removal procedures, and depletion estimates can be found in Jordan and Jelks (2004). Jordan and Jelks (2004) found darters in 100% of their 20-m visual surveys, whereas we found darters in 87% of our 50-m seine surveys.

We believe both of these percentages probably overestimate the amount of occupied habitat. Most of the 28 sites surveyed by Jordan and Jelks (2004) were established as long-term population monitoring sites in the 1998 Recovery Plan based on a previous history of darter collections, presence of the sympatric brown darter, representative stream size, or to complement seine sampling at other sites. Six of the visual sites, plus several others that had been surveyed before 1998 but not since, were included in our seine samples; therefore, both sets of sites are to some degree biased towards sites that we know were previously occupied by Okaloosa darters.

To correct for this potential bias, we examined the possibility of applying darter/habitat relationships for estimating the proportion of potential habitat occupied. Okaloosa darter habitat is described as the margins of flowing streams with aquatic macrophytes (MAC), large woody debris (LWD), root masses, or detritus (Collette and Yerger 1962; Mettee, Yerger, and Crittenden 1976; Mettee and Crittenden 1979; Bortone 1999; Burkhead et al. 1992). In our 2004-2005 sampling, we measured habitat characteristics within 50-m segments ($n = 390$) upstream and downstream of 41 stream access points (sites) in the darters range (in all but a few cases, we measured 5 segments upstream and 5 downstream of the access point). Using methods described by Herod et al (2004) and Thom and Herod (2005), we measured the following habitat characteristics: stream width, maximum depth, canopy closure, substrate type, aquatic macrophyte cover, and large woody debris. At 40 of the 41 sites, we seined fish from one 50-m segment randomly selected from the ten segments where habitat measurements were taken. Fish collections followed standardized methods described by Thom and Herod (2005). At two of the 40 sites, we seined multiple segments, yielding a total of 45 segments of both habitat and fish data.

We detected darters at 38 of the 45 50-m segments. Consistent with the published descriptions of darter habitat, we typically found darters in association with MAC or LWD or both, and did not find darters where these habitat features were lacking. Mean percent cover MAC was greater in segments where darters were collected (19.0% vs. 4.6%, $df = 43$, $t = 1.52$, $P = 0.068$, one-tail, 2-sample t-test assuming equal variance). Likewise, the mean count LWD was greater in segments where darters were collected (14.6 vs. 6.0, $df = 43$, $t = 1.47$, $P = 0.074$, one-tail, 2-sample t-test assuming equal variance). Here we use $a = 0.10$ as our level of statistical significance to avoid Type II error (Peterman 1990). Most stream segments where we found darters (78.9%) had either more than 10%

MAC, more than 10 pieces LWD, or both. Conversely, only 2 of the 7 segments where we did not find darters (28.6%) met these criteria.

In the larger habitat data set of 390 50-m segments (including the 45 segments we seined for fish), 71.5% of the segments had either more than 10% MAC, or more than 10 pieces of LWD, or both. We applied this percentage to the 364.5 km of potential darter habitat (Table 1), which yields an estimate of 260.7 km occupied stream length.

Fragmentation

Salinity is to varying degrees a barrier to the movements of most freshwater fishes (Peterson and Meador 1994). Darters (Family Percidae) are considered to be primary division freshwater fishes, having little salt tolerance and confined to freshwater (Berra 1981). Salt water fragments the range of the Okaloosa darter into at least six subpopulations corresponding to the six basins that drain into Boggy Bayou and Rocky Bayou, arms of Choctawhatchee Bay (Figure 1). Salinity in Choctawhatchee Bay is frequently less than 10 ppt, which many freshwater fishes may tolerate briefly, such as the closely related brown darter (*Etheostoma edwini*) (Burkhead et al. 1994). The salinity regime of Choctawhatchee Bay has probably varied greatly over time as a function of freshwater inflow and connectivity to the Gulf of Mexico.

The Bay's connectivity to the Gulf has experienced at least two substantial shifts since sea levels rose and stabilized near current levels about 6-10,000 years ago following the glaciations of the Pleistocene (Wolfe et al. 1988). Before about 3,000 years ago, Choctawhatchee Bay was relatively open to the Gulf until westward longshore drift joined Moreno Point and Santa Rosa Island, which effectively separated the two (Goldsmith 1966). Following this closure, freshwater fishes, including the darter, were probably much more likely to move between streams draining into the bay. The 1872 Coast and Geodetic Survey Map of Choctawhatchee Bay (referenced in Goldsmith 1966) shows a small channel passing through what is presently Destin Harbor, connecting the bay to the Gulf. A shift toward higher salinity conditions occurred in the last century. According to Goldsmith (1966), area residents dug a ditch across Santa Rosa Island sometime around 1928 that became the Destin Channel (a.k.a. East Pass). According to the Army Corps of Engineers (1963), who has maintained the present channel since 1931, East Pass formed in April 1928 following a "severe storm and high tides which breached a low, narrow portion of Santa Rosa Island." Choctawhatchee River flooding in 1929 raised the level of the bay about 5 feet above mean low water, which further deepened and widened the new pass. It is likely that the movement of freshwater fishes between the bay's drainages has decreased since.

Each of the six darter basins is further fragmented internally to some degree by reaches of unsuitable habitat and passage barriers, such as impoundments and impassible road crossings. Habitat fragmentation reduces the probability of population persistence (Wilcox and Murphy 1985), because smaller, more isolated populations are less able to rebound from chance adverse environmental, demographic, and genetic events (Shaffer 1981; Lande 1988).

To evaluate the extent to which habitat is fragmented by human habitat alterations, we identified from existing maps 152 road crossings of streams in the darter's range (Herod et al. 2004). Investigating each crossing in the field, we determined that 57 have been removed (all but 3 as part of habitat restoration activities on Eglin AFB). Of the remaining 95 crossings, we determined 21 are barriers to fish passage (Figure 4). Most of these are culverts with the downstream end perched above the stream bed, which precludes the upstream movement of fish during normal and low-flow conditions. Ten of the 21 barriers are of little or no adverse consequence to darter habitat connectivity because they occur either: 1) in portions of the range from which darters are probably extirpated (e.g., Sanders Branch); 2) at or near the upstream or downstream limit of the stream network in which darters are probably present; or 3) immediately adjacent to another barrier or impoundment. At the remaining 11 passage barriers, darters downstream of the barrier cannot move upstream during normal and low-flow conditions.

Impoundments may also fragment darter populations, and like road-crossing barriers to passage, many of the 32 impoundments shown in Figure 4 are located within reaches from which darters are extirpated or are near the margins of the extant range. Only 3 impoundments that appear on 1:24,000-scale topographic maps, one each in the Toms Creek, Turkey Creek, and Rocky Creek basins, separate more than 1 km of stream from the rest of the stream network in the basin.

The passage barriers shown in Figure 4 fragment the darter's range in the six principal basins into 21 units of contiguous habitat. These units are named and described in Table 1. Most of the potential habitat listed in Table 1 (78%) occurs in two units: the stream reaches that are connected to the main channels of Turkey and Rocky creeks. We have no records of darter surveys in three of the smaller units (e.g., Pinelog Creek upstream of Eglin Range Road (RR) 221), so we have no direct evidence that darters occur there. However, shorter reaches are known to support darters (e.g., the headwaters of Shaw Still Branch), and the relatively undeveloped landscape surrounding these reaches suggests no reason to discount them as potential habitat. In another four units, we have records of darter occurrence before but not after 1998. Lacking evidence to discount these four units, we are also considering them potential habitat. We have records of darter presence since 1998 from all of the other units listed in Table 1.

C.2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

C.2.a.) The present or threatened destruction, modification, or curtailment of its habitat or range.

The darter has been extirpated from about 9% of the 402 km of streams that comprise its total range (see Section II.C.1.d Spatial distribution). All but 5 km (1.4%) of the extant range is within Eglin AFB. If the apparent subpopulation declines in Mill Creek, Swift Creek, East Turkey Creek, and West Long Creek continue until the darter is extirpated from these streams, it would reduce the darter's range by an additional 29 km or 7% of the total range. This past and possibly continuing loss of range is most likely due to physical and chemical habitat degradation from sediment and pollutant loading.

Sedimentation

Sedimentation is the process by which soil materials are detached, transported, and deposited on the substrates of streams, rivers, lakes, and wetlands, and this process is greatly accelerated by a variety of human activities that disturb the soil or the vegetation that stabilizes it. The EPA (1994) identified sedimentation and turbidity (suspended sediment) as the nation's leading source of water quality impairment and aquatic habitat degradation. The streams comprising the range of the Okaloosa darter are no exception to the national pattern, as the sandy soils of the area are highly susceptible to erosion. A recent report (Rainer et al. 2005) prepared for the Chief of Pollution Prevention at Eglin AFB identified the following primary sources of sediment to aquatic ecosystems on the base: accelerated streamside erosion, borrow pits, developed areas, land test areas, silviculture, and roads. Of these, the stream crossings of unpaved roads probably have the greatest impact because of their distribution on Eglin, relative permanence as base infrastructure, and long-term soil disturbance characteristics. We describe each of these sediment sources briefly in the remainder of this section.

Removal or disturbance of riparian vegetation can induce accelerated bank erosion. Sediment loading from erosion outside the channel can also induce accelerated bank erosion by reducing channel capacity and increasing hydraulic stress on the banks. Bank erosion can lead to further bank erosion by the same mechanism when the eroded sediments accumulate in stream segments downstream (Rosgen 1996). Accelerated streamside (bank) erosion is noticeable in some portions of the darter's range.

Borrow pits were a major source of sediment loading to darter streams cited in the 1998 Recovery Plan. At that time, 29 of 39 borrow pits located within or immediately adjacent to Okaloosa darter drainages had been restored. As of 2004, all of the remaining borrow pits (140 treated acres) within the Okaloosa darter drainages have been restored (Rainer et al. 2005). Eglin estimates these and other restoration projects have reduced soil loss from an estimated 30,745 metric tons/ha/year in 1994 to 830 metric tons/ha/year in 2004 (S. Pizzalotto, Eglin AFB, personal communication 2005).

Soil disturbance and erosion accompanies construction activity in developed areas, and these areas are concentrated in, but not limited to, the downstream-most portions of the darter's range. When construction activity is completed at a site, the impervious surfaces that remain (roads, roofs, parking areas, etc.) tend to increase surface runoff and erosion rates locally, and this runoff may also carry with it various pollutants to aquatic ecosystems. Without fully effective storm-water runoff control and pollution-prevention measures, urban development in the darter's extant range is a continuing threat to the species' habitat as well as a potential barrier to movement between basins.

About 202 km^2 of Eglin AFB is divided into 37 land test areas, 12 of which are wholly or partially within darter drainages, where weapons testing and training operations are conducted (SAIC 2001). Eglin maintains large portions of the test areas in an early stage of plant succession with few mature trees. The degree of soil disturbance resulting from this maintenance and various military missions ranges from minor (e.g., periodic mowing) to severe (e.g., frequent crater-blasting explosions). Since 1998, all consultations about the effects of test area activities on the darter have concluded informally (not likely to adversely affect), except one non-jeopardy opinion dealing with weapons testing on a test area within the Rocky Creek watershed, which authorized incidental take of up to six darters per year (USFWS 2002).

Various silviculture practices (e.g., logging road construction, yarding, log skidding, site preparation before planting) can result in accelerated soil erosion and stream sedimentation. On Eglin, soil loss following forest management activities is sometimes locally severe, but usually brief (Rainer 2005). Eglin's most recent Integrated Natural Resources Management Plan (USAF 2007) describes the current forest management program on the base, including measures to avoid and minimize impacts to aquatic ecosystems, and concludes that the proposed program is not likely to adversely affect the Okaloosa darter.

With all of the borrow pits and many of the most severe erosion sites restored, the largest remaining source of sediment to darter streams is the unpaved road network. The current Eglin AFB road network consists of 4,973 km, of which 4,348 km (87%) is unpaved (Rainer 2005). A road is necessarily a corridor without substantial natural vegetation and as such is more vulnerable to erosive forces than vegetated land cover, especially an unpaved road. Where it crosses a stream, a paved or an unpaved road provides a direct conduit for the movement of eroded sediments into the stream. Although many road crossings have been removed and restored through road closures and restoration efforts in recent years (see Section II.C.1.d Fragmentation), many remain and are a continuing stress on darter habitat. For example, we have measured turbidity levels that exceed state water quality standards several times in recent years at five road crossings in the Turkey Creek drainage (Thom and Herod 2005). Throughout the darter's range, it is common to observe excessive sediment accumulation in streams at unpaved road crossings.

Rainer (2001) provided the following assessment of the condition of Eglin's roads:

- The road surface, roadside slopes, and naturally formed roadside drainage channels are eroding at accelerated rates and are primary sources of sediment and nonpoint source pollution.
- Years of scheduled windrow road grading maintenance of unpaved roads has created road configurations of some roadway segments that are below the grade of natural ground and serve as erosive channels of surface runoff and sediment transport directly into streams.
- Overall, roadside Best Management Practices (BMPs) are not functioning to their design capacity because of improper design, placement, windrow road grading activities, and/or the lack of maintenance.
- Generally, sediment traps are being improperly used as permanent erosion and runoff control measures, are frequently misplaced and improperly designed, and in numerous cases have become sediment sources rather than sediment sinks because of nonexistent maintenance.
- On many roadways, unabated, long-term soil erosion has exposed sterile, unstable geologic formations that are generally void of established vegetation.
- Stream crossings are frequently unprotected and erode directly into streams.
- Roads constructed through seepage slope wetlands are altering the structure and hydrology of these sensitive wetland habitats.
- The Eglin range road system is experiencing accelerated rates of erosion that is adversely impacting the environment and road system management.
- Stream and wetland ecosystems have been directly impacted in terms of form and function by the introduction of sediment from road-induced soil erosion.
- Installation of appropriate erosion, runoff, and sediment control BMPs under current road configurations and scheduled windrow road grading maintenance practices will fail.
- Road reconstruction to a standardized configuration (width of roadway and cleared right-or-way, surface shape, and surfacing specifications) must be given high priority.
- Heavily used primary and secondary road/stream intersections are major sources of stream sedimentation and should be given first order consideration for correction.
- The intersection of roads and streams is a location that exhibits severe road-induced soil erosion and sedimentation of streams and wetlands.

Eglin determined that erosion from its roads was adversely affecting the Okaloosa darter, and proposed implementing the Range Road Maintenance Handbook (Rainer 2001) along with a process for decommissioning little-used roads (SAIC 2003). The Service concurred that implementing the proposal was not likely to adversely affect the darter. However, given the ongoing impact of the previous maintenance regime, we requested that the 796th Civil Engineering Squadron (the entity responsible for roads maintenance on Eglin) commit to an FY05 schedule for road closure/rehabilitation projects and to the formation of a USAF/Service roads working group within 12 months (letter dated Aug. 26, 2004, from Janet Mizzi, USFWS, to Stephen Seiber, Eglin AFB). The first meeting of the roads working group occurred in September 2005. Funding for the substantial effort necessary to close and restore unneeded roads and to rehabilitate the most erosive active roads was not yet programmed, but the Eglin staff attending the meeting indicated that they would seek the support necessary to make progress. By letter dated September 16, 2005 (Gail Carmody, USFWS, to Col. Timothy Gaffney, Eglin AFB), we requested that Eglin reinitiate consultation, since the conditions of our concurrence with the findings of the roads Biological Assessment were not fulfilled. Eglin initiated section 7 consultation in November 2006. We met with Eglin in March 2007 to discuss the proposed action and ways to reduce impacts to darters such that these road improvements would not likely adversely affect the darter. We have not yet received the amended proposed action from Eglin. However, they have initiated restoration actions through installation of bottomless culverts and bridges over darter streams.

Pollution

The Florida Department of Environmental Protection (DEP) (2003) classifies all streams in the range of the Okaloosa darter as Class III waters for administration of the Clean Water Act. Class III waters are used for recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. Although no streams in the darter's range are designated as impaired in DEP's 2003 Basin Status Report, six stream segments are on the "3c planning list," which means that "enough data and information are present to determine that one or more designated uses may not be attained according to the Planning List methodology." The six segments were Anderson Branch (Turkey Creek tributary), lower Turkey Creek (including South Branch near the City of Niceville landfill and the rest of the basin downstream to Boggy Bayou), Mill Creek, Shaw Still Branch (Swift Creek Basin), Little Rocky Creek and Open Branch (Rocky Creek Basin). All six segments were considered potentially impaired using a set of three biological indicators based upon aquatic insect samples. These biological indicators scored healthy at another seven darter stream segments sampled, but DEP did not collect data in the remaining 21 segments comprising the darter's range.

DEP characterized a site on South Branch near the landfill as "severely limited by pollutants from the landfill" (Ray 2001). The DEP report described a profuse bloom of iron/sulfur bacteria covering the surface of the water and up to 2 feet of easily-suspended anaerobic sediments covering the stream bed. South Branch is about 1.0 km in length, and we have included it in the unoccupied range displayed in Figure 3. South Branch joins Turkey Creek near the boundary of Eglin. We have one report of a darter survey in the 2.5 km of Turkey Creek and its tributaries downstream of South Branch that verify darter presence in one 20-m segment of the main channel (H. Jelks, USGS, comments on draft of this document dated March 24, 2006). Inclusion of this portion of the main channel would add about 2,300 m to the occupied range, which we had included in the unoccupied range based on their characterization as "potentially impaired" in the DEP 2003 Basin Status Report. Rather than revise at this time all calculations based on our previous range estimates, this review considers the downstream-most segments of Turkey Creek as unoccupied.

Using comparable aquatic insect sampling methods and indicators as DEP, we sampled 42 sites in the darter's range (Thom and Herod 2005). About two thirds of these sites (26) appeared healthy, 4 were suspect, and 12 were impaired. Three small darter basins, Mill Creek, Swift Creek, and East Turkey Creek, had the highest percentage of impaired sites. Several sites in these three basins, plus a site on South Branch near the Niceville landfill, also had unusually high stream conductivity measurements, which is generally an indicator of degraded water quality (Thom and Herod 2005). It appears likely that the waste water treatment sprayfields located near the headwaters of East Turkey Creek and Swift Creek are adversely affecting water quality, as this is the principal non-forested land use in the area. The Eglin golf course dominates land use in the Mill Creek Basin. Along with West Long Creek in the Rocky Creek Basin, these are the same drainages where monitoring suggests darter numbers have been declining in recent years (see section B.1.d). As noted previously, the Service and Eglin have recently completed a habitat restoration project of the portion of Mill Creek that runs through the golf course.

Water Use

Most human water supply needs in and around the range of the Okaloosa darter are presently served by wells that tap the Floridan Aquifer, which is declining substantially in the most populated areas near the coast (Fernald and Purdum 1998). In this part of the Florida Panhandle, the Floridan Aquifer lies beneath the Sand and Gravel Aquifer, and the two are separated by the Pensacola Clay layer, which confines the Floridan. Discharges from the Sand and Gravel Aquifer provide most of the flow in Okaloosa darter streams between rain events (Fischer et al. 1994). In 1947, the potentiometric surface of the Floridan was above that of the Sand and Gravel in the downstream half of Turkey Creek and near the mouth of Rocky Creek (Fischer et al. 1994). At that time also, the potentiometric surface of both aquifers was above the stream bed of both streams, except in the headwater reaches. By 1978, pumping from the Floridan in the coastal areas had drawn its potentiometric surface below that of the Sand and Gravel and below the streambed for most of the length of both streams.

Now that the potentiometric surface of the Floridan is lower than that of the Sand and Gravel, it is possible that some of the water that the Sand and Gravel discharges into darter streams could instead move downward to recharge the Floridan, but the low permeability of the Pensacola Clay layer probably prevents this. We examined available discharge records of the darter streams to look for evidence of a possible decline. The USGS has operated stream gages at six locations in darter streams, but none are active at present. The longest period of record is for a gage on Juniper Creek, a tributary of Turkey Creek, which was operated almost continuously from 1966 to 1993. Average annual discharge at this gage was 2.63 m^3/s for its 25 complete water years of record, and shows a slightly increasing trend over this time frame, although this trend is not statistically significant. Therefore, it does not appear that pumping from the Floridan Aquifer has, as of 1993, diminished flow in Juniper Creek.

As human population grows in the coastal portions of Okaloosa and Walton counties, it will likely become necessary for communities to seek additional water supply from sources besides the Floridan Aquifer. The area is within Water Supply Planning Region II of the Northwest Florida Water Management District

(NWFWMD), which includes all of Santa Rosa, Okaloosa, and Walton counties. The NWFWMD projects that the region's human population will increase by about 6,000 residents per year to around 442,000 in 2020, and its water demand will increase at about the same percentage rate to around 349,400 m^3/day in the same time frame (Bartel et al. 2000). The NWFWMD estimates that wells into the Sand and Gravel Aquifer, which provides base flow in all the darter streams, could supply up to about 60% of the growth in demand. However, the NWFWMD (in conjunction with the Florida Department of Environmental Protection) has a Surface Water Improvement and Management (SWIM) Plan that addresses water issues in the Choctawhatchee River and Bay System, including the projected water supply needs of the coastal portions of Okaloosa and Walton counties. Protecting water-dependent endangered species and their habitats are integral components of the SWIM plan. In its water supply plan for the counties that encompass the range of the darter, the NWFWMD examines the water sources that could supply growing human water demands in the region (Bartel et al. 2000). Depending on its magnitude and spatial distribution, substantial new use of the Sand and Gravel Aquifer could diminish stream flow in the darter streams; however, the potential well fields that the NWFWMD identified are located south and west of the darter drainages (Bartel et al. 2000). are all located south and west of the darter drainages, e.g., the area between the Yellow and Blackwater rivers.

To summarize Factor A, we believe that the destruction, modification, or curtailment of Okaloosa darter habitat or range has been reduced but continues to pose a threat to the species through physical and chemical habitat degradation from sediment and pollutant loading. Anticipated growth could result in increased groundwater depletions, posing a potential future threat to the darter.

C.2.b.) Overutilization for commercial, recreational, scientific or educational purposes.

This factor is not nor has ever been a significant threat to the Okaloosa darter. We know of no utilization for commercial purposes, and any utilization for recreational purposes is likely limited to occasional use as a bait fish.

C.2.c.) Disease or predation.

The six basins of the darter's range are relatively free of introduced aquatic predators, and the native predators, such as the largemouth bass, are relatively low in numbers due to the generally low productivity of the groundwater-fed streams (Thom and Herod 2005). However, the relatively consistent thermal regime of these streams could support populations of non-indigenous predators (i.e., African or South/Central American cichlids) that would otherwise be intolerant to cooler water temperatures during winter. The flathead catfish (*Pylodictus olivaris*) has been introduced into the Escambia, Yellow, and Apalachicola rivers in the Florida panhandle but we are unaware of collections in the Choctawhatchee River. A comprehensive aquatic monitoring program is in place on Eglin and adjacent waters that should detect introductions or range expansions of these potential predators.

We are not aware of any diseases that pose a particular threat to the Okaloosa darter. It is possible that diseases or parasites are associated with the extirpation of the darter from various stream segments, but these segments have also experienced some form of physical or chemical habitat degradation. Apart from this possible association, we do not otherwise suspect that disease or predation unduly limit the distribution or abundance of the darter.

C.2.d.) The inadequacy of existing regulatory mechanisms.

The State of Florida has listed the Okaloosa darter as an endangered species under its protected species statute since 1976. Recently, the FWC incorporated the Red List Criteria (IUCN 2001) in its procedures for classifying species (Florida Administrative Code 68A-27.0012), but the FWC has not yet evaluated the Okaloosa darter using the new procedures (Daniel Sullivan, FWC, personal communication, June 2005). Our application of the Red List Criteria (see Appendix) classifies the darter as "near threatened."

We estimate that 98.7% of the darter's extant range is within the boundaries of Eglin. The 1.3% of the range that is not on Eglin is in all instances downstream of the base boundary. For this reason, almost all human activities that may affect the existing darter population are federal actions, i.e., actions implemented, funded, or approved by the Department of Defense (DOD). Federal actions must comply with the ESA, National Environmental Policy Act, Clean Water Act, and various other federal environmental laws, as well as applicable state law. Land management on DOD lands is governed by the Sikes Act, which provides for the conservation and rehabilitation of natural resources and requires DOD to periodically prepare Integrated Natural Resources Management Plans (INRMP) in consultation with the USFWS and the applicable state wildlife agency. The current INRMP adequately provides for the conservation of the darter. Therefore, existing regulatory mechanisms or the inadequacy of these mechanisms do not appear to constitute a threat to the darter.

C.2.e.) Other natural or manmade factors affecting its continued existence.

Two natural factors are mentioned in the 1998 Recovery Plan as possibly affecting the continued existence of the Okaloosa darter: the brown darter (*Etheostoma edwinii*) as a competitor species, and the beaver (*Castor canadensis*) as an agent adversely modifying darter habitat.

<u>Brown darters</u>

The brown darter ranges from the Perdido River Basin of Alabama and Florida east to the St. John's River in Florida and north to the Fall Line in Alabama and

Georgia (Lee et al. 1980). It is common in the Choctawhatchee and Yellow river basins, and also in the smaller basins that drain into the north side of Choctawhatchee Bay, except those draining into Boggy Bayou (Burkhead et al. 1994). Mettee et al. (1976) presumed the brown darter had been introduced to the Rocky Bayou drainages and suggested that it was gradually replacing the Okaloosa darter in some reaches. Okaloosa darters and brown darters use similar microhabitats, i.e., areas in or near some form of cover along stream margins. The brown darter is generally rare or absent in the upstream-most reaches of the Rocky Bayou drainages (Jelks and Alam 1998).

Although annual monitoring (1995-2004) of darter populations shows a weak negative correlation between the abundance of the two species ($r=-0.255$, $p<0.0001$), the relative abundance of Okaloosa darters at sites where both species occur has generally increased in this time frame and the range of the brown darter has not expanded (Jordan and Jelks 2004). Earlier comparisons of microhabitat use found little evidence of competitive displacement (Burkhead et al. 1994). At this time, we do not believe the brown darter poses a significant threat to the survival of the Okaloosa darter.

<u>Beavers</u>

Okaloosa darters do not appear to tolerate impounded conditions, and are generally absent in the relatively still water upstream of man-made dams, beaver dams, culverts, and other instream obstructions that act like dams. Jordan and Jelks (2004) observed the effects of a beaver dam and a culvert at two locations on Rogue Creek which supported Okaloosa darters before these structures were placed in the stream. Both structures had similar effects on darters and important darter habitat features including increased water temperature, accumulation of flocculent substrate, loss of typical microhabitat features, and virtual elimination of darters in the impounded areas. However, they also observed that darters returned to these locations within a year following removal of the beaver dam and the culvert, the former by Eglin resource managers, and the latter by a hurricane.

Because beavers often alter areas contrary to human intentions for those areas, and also because beaver ponds displace Okaloosa darter habitat, resource managers control beaver numbers in some areas on Eglin AFB (USAF 2007). The USFWS recognized high beaver densities in the downstream-most portions of the darter's range as a potential threat to the darter as recently as 2001 (email from Gail A. Carmody, USFWS, to Rick McWhite, Eglin Natural Resources Branch, dated October 15, 2001).

Although a nuisance in the urban environment, beavers are a natural feature of the landscape in the range of the Okaloosa darter. Because beavers prefer areas with higher densities of fire-intolerant hardwoods, beaver distribution is likely influenced by prescribed burning. It is our impression that beavers are most common in the darter's range at the wild land/urban interface, where fire is less often or seldom used, or where undersized culverts are used for a road crossing. In the later case, beavers take advantage of the obstructed stream flow and build a dam immediately upstream of the culvert, probably compounding a limitation to darter habitat already imposed by the culvert.

While the waters impounded behind a beaver dam do not support Okaloosa darters, darter densities in "beaver meadows" were among the highest observed in our 2004-2005 seine surveys. For example, we collected 0.580 Okaloosa darters per meter in our survey of a beaver meadow on an unnamed tributary of Turkey Creek downstream of the Highway 123 bridge, which was over 3 times the average density of darters collected in all our surveys. Beaver meadows occur in the vicinity of beaver ponds where the dam/pond induce the stream to assume a braided (multi-channel) form, sometimes in the pond itself following dam blowout. Similar meadows may also form upstream of man-made instream obstructions, such as the abandoned rail road crossing of Little Rocky Creek. Floodplain trees are killed by the year-round high water level maintained near the pond and by the beavers themselves, and herbaceous vegetation thrives in the resulting open canopy, which apparently creates favorable habitat conditions for the darter. We suspect that a beaver meadow supports as many or more darters than were displaced from the beaver pond itself, although specific studies would be needed to measure this.

Beaver dams are not permanent structures and may be broken by the high flows associated with hurricanes and other major storm events. The organic matter that accumulates in a beaver pond is suddenly released when the dam blows out, which provides a pulse of nutrients in the otherwise nutrient-poor darter streams. The pond is gone immediately, of course, and over time the braided channel through the beaver meadow returns to a single-channel form. This channel is eventually shaded by riparian trees and shrubs, and the concentrated patch of darter habitat that the meadow provided is also gone. Beaver ponds are habitat for a number of species, such as sunfishes, but not for many riverine species (e.g. cyprinids). The pulses of nutrients and alternating habitat types associated with beaver activity likely play an important role in structuring species composition and relative abundance in the aquatic community on the landscape scale (Thom and Herod 2005). For this reason, Thom and Herod (2005) recommend monitoring beaver populations and studying the effects of beaver activity to better understand their role in the ecosystem and to alert resource managers when beaver populations are too high or too low. Until we have that understanding, we do not know whether the current number of beavers in the range of the Okaloosa darter represents a threat to the species. It is possible that beavers are un-naturally scarce in the upstream portions of the range and too abundant in the downstream portions of the range.

D. Synthesis

It is our assessment at this time that the intent of the 1998 Recovery Plan's five downlisting criteria have been fulfilled. We have seen substantial progress on Eglin AFB, addressing threats to the Okaloosa darter's habitat. All monitoring sites in all six darter basins do not show stable or increasing population trends, but the darter persists in all six basins with at least 1,200 mature individuals (Tables 2 and 3). Substantial increasing trends are evident in the two largest basins, Turkey Creek and Rocky Creek. Rangewide population estimates calculated using two different survey methods, seining and visual surveys, range from 302,590 (Table 3) to 802,668 (Table 2) individuals, respectively. At only one of the 26 monitoring sites (tributary of West Long Creek at unnamed road crossing) does the multi-year disappearance of the darter strongly suggest a local extirpation and possible loss of range, but if this is indeed a loss, it is a small loss. This site is a tributary of a tributary of Rocky Creek, and darters have been collected in recent years from sites both upstream and downstream in the West Long Creek watershed.

Of the five downlisting criteria, only the population stability measure is quantitative, and it requires that "all" population monitoring sites show a stable or increasing trend. As noted in our previous analysis, the portion of the range within 5 km of Boggy Bayou and Rocky Bayou is disproportionately represented in the 26 monitoring sites (more than half are located in this 14% of the range). Fulfilling a strict interpretation of this criterion is perhaps unattainable, given the irreversible urbanization that had already occurred in this portion of the range when the 1998 Recovery Plan was approved.

Several of the delisting criteria are not fulfilled. Of greatest concern is the criterion that specifically addresses restoration of the degraded sections of Swift and Toms Creek. We would also add East Turkey Creek to that list. Although these small basins represent less than 10% of the darter's extant range (Table 3), habitat degradation that might result in the loss of three out of six geographic subpopulations could compromise the survival of the species. Maintaining viable populations in all six basins is a goal of the current recovery plan that we cannot discount and that is clearly not yet attained.

Of the five listing factors, only one currently poses a known threat to the Okaloosa darter: The present or threatened destruction, modification, or curtailment of its habitat or range. Resource stewardship on Eglin AFB is generally reducing the threat of habitat destruction and range reduction (e.g., restoration of erosive near-stream borrow pits). Sedimentation from unpaved roads and from areas adjacent to poorly designed/maintained paved roads is continuing; however, Eglin has begun addressing this threat. Similarly, restoration of Mill Creek on the Eglin Golf Course, which had been substantially altered by culverts and man-made impoundments, has recently been completed. As the smallest of the six darter watersheds, the darter population in Mill Creek is probably most vulnerable to extirpation. We anticipate that restoration of Mill Creek will secure a viable population in this system. Eglin has worked to generally improve habitat quality within its boundaries, however, we are aware of no planned or ongoing projects involving Okaloosa darter habitat improvement within the city of Niceville. Service personnel are currently conducting a status assessment of road-stream crossings in urbanized areas for presentation to city and county governments.

The 1998 Recovery Plan discusses competition from brown darters and habitat loss from beaver activity as other natural and manmade factors affecting the continued existence of the Okaloosa darter. After several years of monitoring, it does not appear that the brown darter is either expanding its range or displacing Okaloosa darters in most sympatric areas. The overall effect of beaver activity on the darter is poorly understood. Excessive beaver numbers in the downstream portions of the range may or may not limit the darter, but the downstream portions of the range are also the most altered by roads, pollution, and cumulative effects from upstream. On balance, actual and perceived threats to the species are greatly reduced compared to 1998.

Given the substantial reduction in threats to its habitat and large and increasing subpopulations in the majority of its range, we do not believe that the Okaloosa darter currently meets the definition of endangered in that it is not "in danger of extinction throughout all or a significant portion of its range."

III. RESULTS

A. Recommended Classification

__X__ **Downlist to Threatened**
_____ **Uplist to Endangered**
_____ **Delist** (Indicate reasons for delisting per 50 CFR 424.11):
    _____ Extinction
    _____ Recovery
    _____ Original data for classification in error
_____ **No change is needed**

Based on our analysis of its biology and habitat (Review Analysis section B), current threats (section C), and the recovery criteria of the 1998 Recovery Plan (section D), this status review of the Okaloosa darter indicates that reclassification from endangered to threatened should be recommended. Relatively large and increasing subpopulations and substantially reduced threats to its habitat in a majority of its range lead us to the finding that the Okaloosa darter is not in danger of extinction throughout all or a significant portion of its range. Because some threats persist and population declines appear to be present in the smaller subpopulations, the Okaloosa darter meets the criteria for classification as threatened, i.e., a species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

B. New Recovery Priority Number __8__ (a species with a moderate degree of threat and a high recovery potential)

C. If a reclassification is recommended, indicate the listing and Reclassification Priority Number (FWS only):

Reclassification (from Threatened to Endangered) Priority Number:)_____

Reclassification (from Endangered to Threatened) Priority Number:)__4__
(an unpetitioned action with moderate management impact)

Delisting (Removal from list regardless of current classification) Priority Number:_____

Under our listing and recovery priority guidelines (48 FR 43098), the priority for reclassifying a species from endangered to threatened depends on the species' "management impact" (high, moderate, or low) and whether the Service has been petitioned to reclassify the species. We characterize the management burden imposed by ESA-protection of the Okaloosa darter as moderate. Although the range of the species is small, it is almost entirely on federal lands; therefore, nearly all actions in this area are subject to the interagency cooperation requirements of section 7. Section 7 applies also to actions on non-federal lands that require permits under the Clean Water Act. Protection and restoration of darter streams is a substantial component of natural resources management on Eglin AFB. The darter drainages comprise only 24% of the Eglin reservation, but receive a much larger share of habitat management and restoration funding because of the darter. In recent years, Eglin's Natural Resources Management Branch has received about $1.3 million annually to restore highly erosional areas on the base, of which $715,000 (55%) has gone to the darter drainages (Steve Seiber, Chief Natural Resources, Eglin AFB, personal communication September 27, 2005). The Service has not been petitioned to reclassify the darter.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

We recommend that the Service prepare a proposed rule to reclassify the Okaloosa darter from endangered to threatened based on this status review. We further recommend that the Service prepare a second revision to the Recovery Plan. Given the new information about the species and the progress in reducing threats to its habitat since the first revision in 1998, as well as the problems identified with the current recovery criteria, a second revision could very specifically identify actions that might lead to delisting the species in the foreseeable future.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF THE
OKALOOSA DARTER (Etheostoma okaloosae)

Current Classification: Endangered
Recommendation resulting from the 5-Year Review

__X__ Downlist to Threatened
_____ Uplist to Endangered
_____ Delist
_____ No change is needed

Appropriate Listing/Reclassification Priority Number, if applicable __4__

Review Conducted by: Panama City Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Gail A. Carmody Date June 26, 2007

The lead field office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

for **Lead Regional Director, Fish and Wildlife Service**

Approve Noreen E. Walsh Date 7/2/07

APPENDIX A

Summary of peer review for the 5-year review of the Okaloosa darter (*Etheostoma okaloosae*).

A. Peer Review Method: In letters dated January 31, 2006, we requested peer review of the draft 5-year review from three separate experts in aquatic ecology. These individuals volunteered their time to ensure that the review contained the best scientific data available. All three reviewers were provided both a written and electronic copy of the draft document and all three responded with written comments.

B. Peer Review Charge: The peer reviewers were each provided a copy of our policy on "Peer Review in Endangered Species Act Activities". In addition, the reviewers were each given the following directions: "We are interested in all comments you may have about the document, but we especially seek your appraisal of our overall assessment of the darter's status. Do the data we have summarized, or any other pertinent data of which you are aware, suggest that the species is endangered (in danger of extinction throughout all or a significant portion of its range), threatened (likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range), or neither?"

C. Summary of Peer Review Comments/Report: All three peer reviewers responded with comments. We received numerous comments that were editorial in nature and/or that highlighted areas that needed clarification. We additionally received several comments concerning our conclusions in the trend analysis, issues with the inconsistent sampling methods, and use of the IUCN Criteria for analysis.

D. Response to Peer Review: Most editorial comments were addressed by incorporating additional language clarifying the point or issue, as appropriate. Additional discussion was added to the trend analysis, sampling methodology and use of the IUCN Criteria. The IUCN analysis was moved to an appendix as supporting documentation so as not to confuse it with the ESA's five-factor analysis.

APPENDIX B

Methods

We identified two analytic methods that are pertinent to this review of the conservation status of the Okaloosa darter:

- Jordan and Jelks (2004) "Comparison of Visual Survey and Seining Methods for Estimating Abundance of an Endangered Benthic Stream Fish" (an appendix included in the annual population monitoring report cited herein as Jordan and Jelks 2004); and
- World Conservation Union (IUCN) (2001), "Red List Categories and Criteria, Version 3.1", and the accompanying "Guidelines for Using the IUCN Red List Categories and Criteria" (IUCN 2005).

The findings in Jordan and Jelks (2004) enabled us to estimate Okaloosa darter abundance from visual observations and seine samples, which we have long recognized under-represent the number of darters present in surveyed stream segments. We applied the detectability relationships described in this study to estimate population size in section II.C.

The Red List Categories and Criteria (IUCN 2001) provide a widely-accepted system for classifying species at high risk of global extinction based on quantitative population and range data. While we cannot and do not substitute the Red List system for the definitions, regulations, and policies under the ESA, we use it as supporting documentation for this review. We have used it also because the Florida Fish and Wildlife Conservation Commission (FWC) has recently adopted the Red List as its methodology for classifying species under the state's protected species laws (Florida Administrative Code 68A-27.0012 "Procedures for Listing, Delisting and Reclassifying Endangered, Threatened and Species of Special Concern") and because the Okaloosa darter occurs entirely within Florida.

Assessment

The IUCN (2001) Red List system for assessing conservation status places species into one of nine categories: extinct, extinct in the wild, critically endangered, endangered, vulnerable, near threatened, least concern, data deficient, and not evaluated. The categories of critically endangered, endangered, and vulnerable are assigned to species using criteria designed to reflect the degree of threat of extinction. The criteria are: a) population reduction; b) geographic range; c) small population size and decline; d) very small or restricted population; and e) quantitative (e.g., population viability) analysis. First published in 1994, the Red List system has been evolving and the latest iteration (Version 3.1) was published in 2001. The FWC incorporated the Red List criteria in its procedures for classifying species under the state's protected species laws (Florida Administrative Code 68A-27.0012), but the FWC has not yet evaluated the Okaloosa darter (Daniel Sullivan, FWC, personal communication, June 2005). Using version 2.3 of the Red List, Gimenez Dixon (1996) classified the Okaloosa darter as "EN B1+2c", i.e., endangered based upon its small range (EOO < 5,000 km^2 or AOO < 500 km^2), severely fragmented population, and continuing decline in area, extent and/or quality of habitat. Below, we evaluate the status of the darter in this section using Red List version 3.1 in order to maintain consistency among federal and state agencies and to serve as an alternative analysis of the Okaloosa darter status based on the same data.

a) Population Reduction

Population estimates for Okaloosa darters have increased in the last 10 years from average densities of about 1.1 to 2.5 fish/m (Figure 5) (Jordan and Jelks 2004) (see Section II.C.1.a, Population trends). Okaloosa darters may reach sexual maturity by 6 months of age, presumably spawning at age-1 and annually thereafter (Burkhead et al. 1992). Assuming a generation time of one year for this small-bodied fish, mean darter densities have more than doubled in 10 generations

We have no data that suggests that the occupied range has substantially changed in the last 10 years (see section II.C1.d Linear measures of range and occupied habitat). Darters have been absent or extremely rare in the stream segments from which we consider the darter extirpated (about 37 km out of 402 km) for more than 10 years so these trends are unchanged for the purposes of this review. Declines have been noted at some locations (Figure 6), however the population, as defined by IUCN to be inclusive of all individuals of the species, exhibits an increasing trend (Figure 5). Given increasing densities in the occupied stream segments and a relatively constant habitat in those segments, the Red List's "Population Reduction" criterion does not apply to the Okaloosa darter.

b) Geographic Range

The EOO of the Okaloosa darter is 401.7 km^2, and its AOO is 204 km^2, using the methods recommended by the IUCN (2001, 2005) (see Section II.C.1.d Spatial distribution). These measures of range place the darter in the Red List "endangered" classification (EOO < 5,000 km^2 or AOO < 500 km^2), provided that two of the following three criteria also apply:

- Range is severely fragmented or is restricted to a few locations (1 location = critically endangered, 2-5 = endangered, 6-10 = vulnerable).
- Continuing decline in EOO, AOO, area, extent and/or quality of habitat, number of locations or subpopulations, or number of mature individuals.
- Extreme fluctuations in EOO, AOO, number of locations or subpopulations, or number of mature individuals.

"Severely fragmented" refers to the situation in which most of a species' individuals are divided into small and relatively isolated subpopulations (IUCN 2004). Under favorable habitat conditions, it is likely that fairly small habitat units can support viable darter subpopulations. Darters have persisted in less than 5 km of stream length in the Mill Creek Basin since sea-level rise separated it from the adjacent drainages 6-10,000 years ago, although the degree of potential inter-basin darter movement is unknown. Habitat alteration and degradation in these smaller watersheds may continue. However, the relatively large numbers of darters (Tables 2 and 3) and degree of habitat connectivity in a substantial majority of the darter's range (Table 1) do not support a characterization of "severely fragmented".

IUCN (2004) defines the term location as "a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present." Depending on the threat, locations can include portions of multiple subpopulations. Our assessment of habitat fragmentation in Section II.C.1.d describes how the six principal basins of the darter's range are divided by impoundments and other passage barriers into 21 units of contiguous stream segments during normal- and low-flow conditions (Table 1). However, most of the Okaloosa darter's range and estimated numbers occur in the two largest of these units, the unfragmented stream network connected to the main channels of Turkey Creek and Rocky Creek (Tables 1, 2, and 3). These two units comprise 78% (108 and 175 km, respectively) of the potential habitat (Table 1) and support between 65 and 95% of the darters (Tables 2 and 3). These large subpopulations could be divided into multiple locations corresponding to major branches or tributaries. For example, Turkey Creek could be subdivided into five or more locations corresponding to the major named tributaries Rogue Creek, Turkey Creek, and Parrish Creek to the west and Juniper and Tenmile/Ninemile Creeks to the east (Figure 1). When defining locations IUCN (2005) suggests the use of the most severe plausible threat; chemical or fuel spills in the case of the Okaloosa darter. Because threats impacting one or more of the western Turkey or Rocky Creek tributaries are unlikely to affect darters in eastern tributaries and vice versa, we feel that the Okaloosa darter population could be viewed as up to 15 locations within the 6 subpopulations. Most conservatively, the Okaloosa darter is restricted to six locations corresponding to the six subpopulations meeting the criteria for "vulnerable". However, as described above, we feel that subdivision of the two major subpopulations is warranted, increasing the number of locations to more than 10 and a designation of "near threatened" under this criterion.

The viability of some subpopulations that occupy the smaller habitat units in the 22% of the potential habitat not in Turkey and Rocky creeks is questionable. Darter numbers are apparently declining in Mill Creek, Swift Creek, Shaw Still Branch, East Turkey Creek, and West Long Creek (see Section II.C.1.a), which are within or near the urbanized areas of Niceville and Valparaiso. We estimate that about 91% (365 out of 402 stream km) of the stream length in the darter's range is potential habitat, and this has likely been the case for at least the past 10 years (see Section II.C.1.d Spatial distribution). If the apparent subpopulation declines in Mill Creek, Swift Creek, East Turkey Creek, and West Long Creek continue until the darter is extirpated, it would reduce the darter's range by an additional 29 km to 84% of the presumed historic habitat availability. Each of these creeks is degraded to some degree by various human activities, although restoration work has recently been completed at Mill Creek. The disappearance of the darter from these creeks would constitute a "continuing decline in extent of occurrence, AOO, area, extent and/or quality of habitat, number of locations or subpopulations, or number of mature individuals" and merit a designation of at the least "vulnerable" or possibly "endangered".

We have not observed "extreme fluctuations in extent of occurrence, AOO, number of locations or subpopulations, or number of mature individuals" with the Okaloosa darter. The darter is extirpated from stream segments located mostly in or near the urbanized areas, which amounts to a 9% loss of range. As described previously, another 7% of the range is at risk. However, for the past 10 years, the darter's EOO, AOO, and number of sub-watersheds occupied have been relatively constant, and total population size appears to be increasing.

c) Small Population Size and Decline

In Section II.C.1.a Population Abundance Estimates, we describe three estimates of the darter's population size. The lower bound of the 95% confidence interval for the most conservative of these estimates, that based upon Service samples by seining in 2004-2005, is 216,120 mature individuals (Table 3). This estimate exceeds the 10,000 mature individuals given as the threshold for Red List classification as "vulnerable." Although some subpopulations appear to be declining in size and these declines potentially constitute a decline in AOO, whole population estimates have increased in the past 10 years/10 generations (Figure 5).

d) Very Small or Restricted Population

Our estimates of population size far exceed the 1,000 mature individuals given as the threshold for Red List classification as "vulnerable" regardless of population trend. Likewise, AOO and number of locations far exceed the threshold of 10 km^2 and 5 locations that characterize a restricted population. Using the recommended 4-km^2 grid methodology (IUCN 2004), the AOO for the Okaloosa darter is 204 km^2. Using a finer grid of 1-km2, which is more likely to underestimate occupied range, the AOO is 63 km^2, which also exceeds the 10 km^2 threshold.

e) Quantitative Analysis

The Red List defines quantitative analysis as "any form of analysis which estimates the extinction probability of a taxon based on known life history, habitat requirements, threats and any specified management options. Population viability analysis (PVA) is one such technique…." (IUCN 2001).

The long-term monitoring of darter numbers by Bortone (1999) and Jordan and Jelks (2004) provide two data sets that are suitable for quantifying the darter's probability of extinction using the count-based extinction analysis methods developed by Dennis et al. (1991) and described by Morris et al. (1999). Jordan and Jelks used visual survey methods to count darters in 20-m segments at 32 sites, with annual surveys from 1995 to 2004 (10 years) at 12 of these, six each in the Turkey Creek and Rocky Creek basins. Bortone used 60-minute seining at 18 sites, with nearly annual surveys from 1988 to 1999 at 10 sites where darters were consistently detected in the Swift Creek and East Turkey Creek Basins, plus the West Long Creek tributary of Rocky Creek. While neither data set represents a full census of the darters in these streams, it is possible to estimate full-stream abundance from these samples. The sites and methods used in each survey effort were consistent enough that inter-annual variation in the abundance estimates are most likely due to environmental/demographic factors and not sampling error. Although a drought and two major hurricanes occurred during the years of these surveys, we have no indication that these events had catastrophic effects on the darter populations that would result in underestimating population growth rates or overestimating the variance.

To estimate subpopulation abundance from Jordan and Jelks (2004), 12 sites in the Turkey and Rocky Creek basins, we applied a conservative estimate of occupied range in each basin (57.8 km in Turkey Creek, and 111.2 km in Rocky Creek, or 50% of the potential habitat in each basin (Table 3), and the relationship between visual counts and total number of darters present (Jordan and Jelks 2004). All six sites in each of the two basins are potentially segments of a common subpopulation, as no known permanent barriers to movement separate them (see Section II.C.1.d Spatial distribution).

We calculated extinction probabilities for the 12 core sites surveyed by Jordan and Jelks (2004) following the methods described by Dennis et al. (1991) and summarized by Morris et al (1999) (Table 5). The parameters μ and s^2 are properties of the year-to-year growth rates of the abundance estimates and are used to calculate extinction probability (Dennis et al. 1991). Using an extinction threshold of 50 individuals, extinction probabilities calculated are very low (less than 1:1 million) for Turkey and Rocky Creek basins (Table 5).

Additionally, we analyzed data from Swift Creek (2 sites), East Turkey Creek (4 sites) and West Long Creek (3 sites) collected by Bortone (1999), supplemented with sampling by the Service and USGS in 2000 through 2003 (Table 6). Because the stream length sampled for these 60-minute seine surveys was not consistently reported, we had to assume a stream length applicable to the darter counts in order to compute density and estimate full-stream abundance. We found in our 2004-2005 seine surveys that we sampled 50 m in an average of 57 minutes (n=69), so we applied 50 m to the 60-minute seine data. We adjusted the densities computed from the seine counts for the efficiency of seining compared to visual counts (about 32% as efficient) and for the relationship established between visual counts and abundance (Jordan and Jelks 2004.) (see Section II.C.1.a Population abundance estimates). As with the Turkey Creek and Rocky Creek data, we assumed that half of the potential stream length in Swift Creek (7.26/2 km), East Turkey Creek (6.72/2 km) and West Long Creek (12.12/2 km) was occupied.

Because the data in Table 6 (either transformed as described above to full-stream abundance estimates or as the raw count data shown in Figure 6) show an overall declining pattern from year to year, the estimates of μ are negative and the probabilities of extinction are 100% in all three creeks using an extinction threshold of 50 individuals. When μ is negative, it is appropriate to consider the time frame to subpopulation extinction (Morris et al. 1999). The estimated mean time to extinction for the Swift, East Turkey, and West Long creek subpopulations is 210.3, 46.4 and 44.4 years, respectively. The lower bound of the 95% confidence interval for all three estimates is 0 years.

Extinction probabilities were calculated from both visual and seine surveys for one site at West Long Creek at rkm 5.5 (Tables 5 and 6). Data from the two survey methods, visual surveys and seining, show differing population trends over time (Tables 5 and 6). The number of darters detected by 60-minute seine samples generally declined between 1988 and 2002, and the number detected by 20-m visual surveys generally increased from 1995 to 2003 (Figure 7). We cannot explain this conflicting evidence biologically; however differences are likely due to sampling efficiency and methods. Future work will be needed to accurately estimate extinction parameters at this site.

Extinction probabilities for Toms Creek and Mill Creek subpopulations could not be calculated due to insufficient data. Based on limited sampling effort in the upper watershed, we believe that the Toms Creek subpopulation is relatively healthy and is probably increasing at a rate similar to that of Turkey Creek or Rocky Creek. Okaloosa darters persist in the downstream-most portion of the mainstem; however efforts to locate this species in tributaries which pass through the area containing the major runways and facilities of the Air Force Base have been unsuccessful (H. Jelks, USGS, personal communication). Urbanization in the lower Mill Creek watershed could be contributing to subpopulation declines at rates comparable to other watersheds impacted by development (i.e., Swift Creek and East Turkey Creek). A small relatively stable population does exist in the upper Mill Creek watershed (H. Jelks, USGS, personal communication).

We may estimate the probability of extinction for the entire Okaloosa darter population as the mathematical product of the subpopulation extinction probabilities (Morris et al. 1999). The very low extinction probabilities (less than 4.95×10^{-21}) associated with Turkey and Rocky Creek, and probably also for Toms Creek, confer a yet lower extinction probability to the species as a whole, even assuming a 1.0 probability of extinction in the other three basins. The Red List threshold for assigning one of the threatened categories to a species is greater than a 10% probability of extinction in 100 years. Our results for the Okaloosa darter population do not exceed this threshold.

f) Red List Classification

Based on our evaluation in sections II.C.1.a through II.C.1.e, the Okaloosa darter does not fully meet any of the five criteria for the threatened status categories under the IUCN Red List system (Table 7). We find that the classification of the darter as Red List "EN B1+2c" by Gimenez Dixon (1996) is not presently warranted. The population satisfies only one and not two of the three qualifiers necessary in addition to a small EOO or AOO under criterion B. While we have evidence of a continuing decline in numbers and habitat quantity/quality in a small portion of the range, the darter population does not fit the definition of "severely fragmented," i.e., divided into small isolated subpopulations, or restricted to a few locations. Passage barriers (impoundments, road crossings) within the six basins divide the range into at least 21 occupied segments of contiguous stream habitat (Table 1), which is a reasonable definition for the boundaries between subpopulations of a small-bodied freshwater fish. However, most Okaloosa darters occur in two relatively large subpopulations (the contiguous stream segments of the Turkey Creek and Rocky Creek Basins) and not in several small and isolated subpopulations. At minimum, the Okaloosa darter occurs in six locations corresponding to the six basins, which exceeds the Red List threshold of 5 locations for classification as "endangered". Given the nature of the most serious plausible threats, we feel that subdivision of the larger Turkey and Rocky Creek basins into multiple locations is warranted, exceeding the Red List threshold of 10 for classification as "vulnerable". The apparent risk of extirpation from four locations, Mill, Swift, Shaw Still Branch, East Turkey Creek, and possibly West Long Creek constitutes a potential decline in AOO. Criteria for small population size, restricted population size, and probability of extinction were not met. Interpreted most conservatively, the Red List classification for the Okaloosa darter is Vulnerable VU: B2ab(ii), however we feel that the classification Near Threatened (NT) is a more appropriate designation given the nature of the most plausible threats under criterion II.C.2.a.

TABLES

Table 1. Stream segments within the probable range of the Okaloosa darter, as defined by known barriers to fish movement (impoundments, impassable road crossings, salt water), and constituting potential subpopulations of the species.

Segments of contiguous potential habitat	Length (km)	Darter surveys[1]
Toms Creek		
Upstream of pond near railroad tracks stream crossing	2.3	A
Downstream	6.8	A
Turkey Creek		
Pinelog Creek upstream of RR[2] 221	1.7	C
Anderson Branch upstream of Anderson Pond	2.8	A
Long Branch upstream of RR 464 crossing[3]	3.2	A
Remainder of basin that is potential habitat	108.0	A
Mill Creek		
Upstream of Plew Lake	2.3	A
Swift Creek		
Shaw Still Branch	1.1	A
Swift Creek upstream of College Pond excluding Fox Head Branch	7.3	A
East Turkey Creek		
All but downstream-most segment of the stream	6.7	A
Rocky Creek		
Rocky Creek downstream of pond at mouth of Sandy Mountain Branch and upstream of RR 374/214	1.7	A
Bear Branch upstream of RR 485	2.1	C
Dogwood Head Branch upstream of RR 485	2.2	C
Little Rocky Creek downstream of railroad crossing and upstream of RR 515	2.4	A
Open Branch upstream of RR 374	2.8	B
East Rocky Creek upstream of RR 374	3.7	B
Sandy Mountain Branch upstream of pond at mouth of stream	5.1	B
West Long Creek upstream of RR 406	5.3	B
Little Rocky Creek upstream of railroad crossing	8.2	A
Wildcat Creek and Headwaters of Rocky Creek upstream of pond at mouth of Sandy Mountain Branch	13.9	A
Remainder of basin that is potential habitat	175.0	A
Number of habitat segments	21	
Total stream length	364.6	

[1] A = Surveys after 1998 have detected darters; B = Surveys before 1998 detected darters, no record of surveys conducted since; and C = No record of surveys conducted.
[2] "RR" = Eglin Range Road
[3] Includes 577 m upstream of an impoundment located near the headwaters

Table 2. Okaloosa darter abundance estimate (Jordan and Jelks 2004), with additional extrapolation to the full range that the USFWS estimates is likely occupied by the species and estimated number of mature individuals.

	Basin						
	Toms	Turkey	Mill	Swift	E. Turkey	Rocky	Total
Number of survey sites	2	8	2	2	2	12	28
Stream length between survey sites (m)	4,434	33,241	434	1,326	1,560	60,488	101,483
Average density (darters/m)	3.8	4.5	1.0	2.7	0.7	2.4	3.1
95 % confidence interval	1.4	2.8	0.4	1.0	0.3	1.6	
	10.0	7.4	2.8	7.2	2.1	3.6	
Estimated number darters (stream length x avg. density)	16,777	150,498	441	3,583	1,168	145,362	317,829
95 % confidence interval lower	6,325	92,525	160	1,345	417	97,252	198,024
upper	44,505	244,795	1,215	9,549	3,273	217,272	520,609
USFWS-estimated occupied stream length (m)	6,526	82,694	1,637	6,005	4,802	158,998	260,661
Estimated number darters (stream length x avg. density)	24,693	368,945	1,664	16,226	3,595	382,096	802,668
Estimated number mature individuals (77.9%)	19,236	287,408	1,296	12,640	2,801	297,653	625,279

Table 3. **Okaloosa darter population estimate based upon 2004-2005 USFWS seine samples of n 50-m segments in the streams listed. Observed segment densities were transformed to local abundance estimates based upon Jordan and Jelks (2004) comparison of seine versus visual counts and depletion sampling.**

Basin/Reach	Length potential habitat (km)	Estimated occupied habitat (km)	n	Mean density darters (#/m)	Mean density mature individuals (#/m)	Standard deviation	Estimated number mature individuals	95% confidence interval Lower	95% confidence interval Upper
Toms Ck.	9.13	6.53	4	2.21	1.72	0.60	11,227	5,021	17,433
Lower Turkey Ck.	16.75	11.97	2	2.50	1.94	0.13	23,277	9,655	36,899
Upper Turkey Ck.	20.27	14.49	6	1.61	1.26	0.86	18,223	5,079	31,367
Lower Juniper Ck.	8.05	5.76	0						
Upper Juniper Ck.	15.76	11.27	1	1.15	0.90		10,136		
Tenmile Ck.	21.14	15.11	2	1.84	1.44	0.00	21,711	21,711	21,711
Parrish Ck.	11.01	7.87	0						
Ninemile Ck.	7.12	5.09	0						
Rogue Ck.	7.61	5.44	3	1.61	1.26	0.55	6,842	0	14,237
Long Branch	3.56	2.54	2	1.84	1.44	0.84	3,656	0	22,956
Anderson Branch	3.28	2.34	2	1.77	1.38	0.76	3,225	0	19,211
Pinelog Ck.	1.12	0.80	1	0.92	0.72		579		
Turkey Ck.	115.66	82.69	19	1.71	1.33	0.63	110,235	85,295	135,175
Mill Ck.	2.29	1.64	8	1.01	0.79	0.34	1,289	818	1,761
Swift Ck.	7.26	5.19	0						
Shaw Still Branch	1.14	0.81	1	0.46	0.36		294		
Sanders Branch	0.00	0.00	0						
Swift Ck.	8.40	6.00	1	0.46	0.36		2,175		
East Turkey Ck.	6.72	4.80	0						
Lower Rocky Ck.	15.37	10.99	0						
Lower Middle Rocky Ck.	25.52	18.24	1	0.77	0.60		10,965		
Upper Middle Rocky Ck.	19.86	14.20	2	0.58	0.45	0.13	6,414	0	22,566
Upper Rocky Ck.	14.66	10.48	2	0.54	0.42	0.00	4,422	4,422	4,422
Lower Little Rocky Ck.	10.21	7.30	1	0.54	0.42		3,080		
Upper Little Rocky Ck.	24.84	17.76	11	1.38	1.08	0.71	19,155	10,710	27,599
East Long Ck.	13.24	9.47	3	0.54	0.42	0.06	3,995	2,591	5,400
West Long Ck.	12.12	8.67	1	1.15	0.90		7,797		
Middle Rocky Ck.	15.91	11.38	2	0.85	0.66	0.42	7,517	0	50,667
East Rocky Ck.	18.19	13.01	1	0.46	0.36		4,712		
Exline Ck.	9.80	7.00	1	0.62	0.48		3,373		
Open Branch	6.42	4.59	0						
Hickory Branch	5.45	3.90	0						
Sandy Mountain Branch	5.16	3.69	0						
Bully Horselot Branch	4.01	2.87	0						
Wildcat Ck.	4.83	3.45	0						
Schoolhouse Ck.	4.23	3.02	0						
Mt. Sinai Branch	3.94	2.82	1	1.00	0.78		2,199		
Bee Branch	3.75	2.68	0						
Painter Head Ck.	2.78	1.99	0						
Mattress Head Branch	2.08	1.49	2	0.69	0.54	0.17	804	0	3,059
Rocky Ck.	222.37	159.00	28	0.95	0.74	0.53	118,269	85,511	151,027
All Basins	364.6	260.7	60	1.28	0.99	0.63	259,355	216,120	302,590

Table 4. Percentage of mature Okaloosa darters in the 2004-2005 USFWS samples using standard length (SL) >= 28 mm as the threshold for reproductive maturity.

Basin	Number fish measured	Number fish >= 28 mm SL	% Mature
Toms Creek	94	77	81.9%
Turkey Creek	325	230	70.8%
Mill Creek	62	57	91.9%
Swift Creek	1	1	100.0%
East Turkey Creek	not sampled		
Rocky Creek	74	68	91.9%
All basins sampled	556	433	77.9%

Table 5. Okaloosa darter abundance and extinction probability estimates for the Turkey Creek and Rocky Creek subpopulations. Abundance estimates are based upon Jordan and Jelks' annual 20-m segment visual surveys of 12 "core" sites, assuming that 50% of the potential habitat in each basin (Table 1) is occupied. The parameters μ, s^2, and the extinction probabilities are computed using methods developed by Dennis et al. (1991) and described by Morris et al. (1999).

	Abundance Estimate calculated from 20-m segment visual surveys[1]	
Survey Year	Turkey Creek Subpopulation (6 sites)	Rocky Creek Subpopulation (6 sites)
1995	90,140	100,256
1996	88,953	92,836
1997	146,097	107,961
1998	154,854	134,787
1999	161,979	129,650
2000	179,196	105,393
2001	172,665	101,397
2002	140,308	137,926
2003	156,338	188,724
2004	226,099	191,578
2005	299,125	214,408
Estimated μ	0.1199	0.0760
Estimated s^2	0.0432	0.0302
Extinction Threshold	50	50
Probability of Extinction	4.89×10^{-24}	4.95×10^{-21}

[1] Before 2000, Jordan and Jelks surveyed more than one 20-m segment per year at each site, sampling in both spring and summer, and sometimes sampling replicate 20-m segments. We averaged multiple counts within a year at each site, and from the site means computed a subpopulation (basin) mean density per year. We estimated annual abundance from mean density using the detectability regression equation developed by Jordan and Jelks ($y = 1.232x + 7.767$) and assuming 57.8 km and 111.2 km of occupied habitat in the Turkey Creek and Rocky Creek basins, respectively.

Table 6. Okaloosa darter abundance and extinction probability estimates for the Swift Creek, East Turkey Creek, and West Long Creek subpopulations. Abundance estimates are based upon the annual 60-minute seine surveys of Bortone (1999), assuming a 50-m segment length for computing density and assuming 50% of the potential habitat in these streams was occupied. The parameters μ, s^2, and the extinction probabilities are computed using methods developed by Dennis et al. (1991) and described by Morris et al. (1999).

	Okaloosa Darter Abundance Estimates[1]		
Survey Year	Swift Creek (2 sites)	East Turkey Creek (4 sites)	West Long Creek (3 sites)
1988		6,156	11,530
1990	7,699	4,345	11,375
1991	6,441	6,156	11,064
1992	11,472	7,191	9,664
1993	11,472	4,668	9,664
1994	9,376	5,121	12,464
1995	15,245	5,186	10,286
1996	11,332	4,862	14,952
1998	5,323	3,116	9,819
1999	7,000	3,375	8,575
2001	6,720	3,245	4,531
2002	6,441	2,016	4,220
2003	3,925		
Estimated μ	-0.0226	-0.0797	-0.0931
Estimated s^2	0.1343	0.0649	0.0679
Extinction Threshold	50	50	50
Probability of Extinction	1	1	1
Mean time to extinction (years)	210	46	44
95% Confidence Interval Lower	0	0	0
Upper	1989	120	107

[1] We estimated annual abundance from 60-minute seine counts assuming: 1) a 50-m segment was sampled; 2) seine surveys count 32% as many darters as visual surveys; 3) we may estimate abundance using the detectability regression equation developed by Jordan and Jelks ($y = 1.232x + 7.767$); and 4) 3.6 km, 3.4 km, and 6.1 km of occupied habitat in Swift, East Turkey, and West Long creeks, respectively.

Table 7: IUCN Red List Criteria for Critically Endangered (CR) / Endangered (EN) / Vulnerable (VU) Taxa, with status summary and threat level designation as interpreted by this review. Criteria not met for Red List classification are listed as Least Concern (LC).

Criteria	Specific components at each threat level	Status of Okaloosa darter	Threat level based on status
A. Reduction in population size	(CR) ≥90% in 10 years/ 3 generations (EN) ≥70% in 10 years/ 3 generations (VU) ≥50% in 10 years/ 3 generations	Density estimates increased from 1995 to 2004 (Figure 5).	LC
B1. Geographic range – Extent of occurrence	(CR) <100 km^2 (EN) <5000 km^2 (VU) <20,000 km^2	N / A	LC
B2. Geographic range – Area of occupancy (additionally must meet at least two of B2a-c)	(CR) <10 km^2 (EN) <500 km^2 (VU) <2000 km^2	63 km^2 (using 1- km^2 grid)/ 204 km^2 (using 4- km^2 grid);	EN*
B2a. Severely fragmented	(CR) ≤1 location (EN) ≤5 locations (VU) ≤10 locations	Populations known in 6 subpopulations, 2 larger subpopulations potentially multiple locations, not severely fragmented	NT
B2b. Continuing decline	(CR),(EN),(VU) i. extent of occurrence ii. area of occupancy iii. area, extent and/or quality of habitat iv. no. of locations or subpopulations v. no. of mature individuals	Population declines in East Long, Mill, Swift, Toms, and East Turkey creeks (Figure 6)	EN
B2c. Extreme fluctuations	(CR),(EN),(VU) i. extent of occurrence ii. area of occupancy iii. no. of locations or subpopulations iv. no. of mature individuals	N / A	LC
C. Population size	(CR) <250 mature individuals (EN) <2500 mature individuals (VU) <10,000 mature individuals	>10,000 mature individuals	LC
D. Restricted population size	(CR) <50 mature individuals (EN) <250 mature individuals (VU) <1000 mature individuals or, area of occupancy <20 km^2 or, ≤5 locations	>1000 mature individuals. Known range >20 km^2 and >5 locations.	LC
E. Probability of extinction	(CR) ≥50% in 20 years/ 5 generations (EN) ≥20% in 20 years/ 5 generations (VU) ≥10% in 20 years/ 5 generations	Probability <10% in 100 years.	LC

* Endangered only if two of three subcriteria Ba-c are satisfied.

Table 8. Okaloosa darter numbers and status relative to one of the demographic recovery criteria. $\bar{X}$ is the cumulative long-term mean at each monitoring site. X is the number of Okaloosa darters collected that year. CRIT is the threshold for satisfying part of the operational definition of "stable or increasing" ($\bar{X}$ - 1.75 times the standard deviation of $\bar{X}$). CRIT values highlighted denote instances that did not satisfy this definition (i.e., $X < \bar{X} - 1.75sd$). NS indicates that the site was not sampled in that year.

Stream	2000			2001			2002			2003			2004			2005		
	$\bar{X}$	X	CRIT	$\bar{X}$	X	CRIT	$\bar{X}$	X	CRIT	$\bar{X}$	X	CRIT	$\bar{X}$	X	CRIT	$\bar{X}$	X	CRIT
Bens Cr. at E 619	18.9	19.5	6.3	19.2	22.0	7.1	19.2	19.0	7.6	19.2	20.0	8.1	19.0	16.0	8.2	18.8	16.0	8.3
East Long Cr. at E 192	2.7	2.5	1.0	2.5	0.50	0.52	2.5	1.5	0.5	2.3	0.5	0.2	2.2	1.0	0.1	2.1	0.0	-0.2
Juniper Cr. at E 221	21.1	30.5	7.8	21.1	21.5	8.4	21.3	24	9.1	22.4	36	8.8	23.0	31	9.3	24.8	53	6.2
Little Rocky Cr. at E 477	10.6	11.0	2.5	10.3	6.0	2.1	10.9	19.0	2.1	11.5	19.0	2.2	12.3	24.0	1.7	12.3	11.0	2.0
Rocky Cr. at E 200	4.7	4.0	1.0	4.4	1.0	0.4	4.5	6.0	0.6	4.6	6.5	0.8	5.0	10.0	0.6	4.7	0.0	-0.1
Turkey Cr. at E 232	29.2	28.0	8.0	31.3	54.5	7.4	31.3	31.0	8.4	31.3	31.5	9.3	33.2	60.0	8.4	34.3	50.0	9.2
Rogue Cr. at E 233	41.0	64.0	11.1	41.8	50.5	12.9	42.7	53.5	14.4	44.4	66.5	15.1	46.6	77.0	14.7	52.0	134.0	2.9
Tenmile Cr. at E 231	27.6	26.0	12.4	28.0	32.5	13.3	27.3	19.5	12.7	26.5	15.0	11.2	27.4	41.0	11.3	31.2	88.0	0.5
Little Rocky Cr. at E 200	14.3	10.5	3.7	14.9	21.0	4.2	14.8	13.5	4.5	15.6	26.5	4.3	16.1	23.0	4.7	17.6	40.0	2.4
Rocky Cr. at E 201	14.1	19.0	6.0	14.0	12.5	6.2	15.1	28.0	5.0	17.4	47.5	-0.6	19.4	48.0	-2.7	23.1	78.0	-10.3
Turkey Cr. at E 637	48.5	96.0	0.3	50.4	72.0	3.0	50.5	51.5	5.1	50.9	56.5	7.2	55.4	118.0	3.5	59.3	118.0	2.2
W. Long Cr. at E 406	14.1	7.5	4.9	13.8	10.0	4.8	13.9	15.0	5.2	14.9	27.5	4.4	15.5	24.0	4.6	15.8	21.0	5.0
Toms Cr. at SR 85	48.0	12.0	-7.6	41.8	23.0	-8.6	36.4	15.0	-12.0	35.3	30.0	-8.2	35.4	36.0	-4.3	NS	NS	NS
Mill Cr. at SR 190	NS	NS	NS	11.5	3.0	-13.2	11.1	6.0	-12.9	NS	NS	NS	10.6	2.0	-13.0	NS	NS	NS
E. Turkey Cr. at R. Bayou	1.7	3.0	-1.9	1.6	5.0	-2.0	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.5	1.0	-2.0
E. Turkey Cr. at E 285	NS	NS	NS	8.3	0.0	0.2	7.8	2.0	-0.6	7.2	0.0	-1.6	NS	NS	NS	NS	NS	NS
E. Turkey Cr. At E 473	21.7	9.0	1.8	21.0	13.0	1.5	19.5	2.0	-1.2	18.4	4.0	-2.8	17.6	6.0	-3.6	16.9	6.0	-4.3
E. Turkey Cr. at Baseline	NS	NS	NS	22.3	17.0	6.6	21.2	7.0	4.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
Shaw Still Branch at 190	NS	NS	NS	14.1	2.0	-4.7	12.9	0.0	-6.3	11.9	0.0	-7.5	11.1	1.0	-8.2	NS	NS	NS
Swift Cr. at SR 190	NS	NS	NS	NS	NS	NS	0.2	0.0	-0.9	NS	NS	NS	NS	NS	NS	0.2	0.0	-0.8
Swift Cr. at SR 20	NS	NS	NS	NS	NS	NS	0.0	0.0	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
Swift Cr. at SR 285	NS	NS	NS	NS	NS	NS	0.0	0.0	0.0	NS	NS	NS	0.0	0.0	0.0	NS	NS	NS
Swift Cr. at No # Rd	37.6	12.0	8.1	35.8	18.0	6.0	33.6	9.0	2.1	32.5	19.0	1.5	NS	NS	NS	NS	NS	NS
Swift Cr. at Railroad	18.5	26.0	2.7	18.4	18.0	3.4	17.7	9.0	2.6	17.3	12.0	2.6	NS	NS	NS	NS	NS	NS
W. Long Cr. at E 406	31.2	11.0	13.4	29.5	11.0	9.8	27.6	5.0	5.3	26.4	11.0	3.6	25.3	10.0	2.1	NS	NS	NS
W. Long Cr. at E 469	NS	NS	NS	NS	NS	NS	12.8	0.0	-9.0	12.0	1.0	-9.7	12.9	26.0	-8.9	12.6	8.0	-8.6
W. Long Cr. at No # Rd	NS	NS	NS	4.8	1.0	-0.3	4.4	0.0	-1.0	NS	NS	NS	4.1	0.0	-1.5	NS	NS	NS

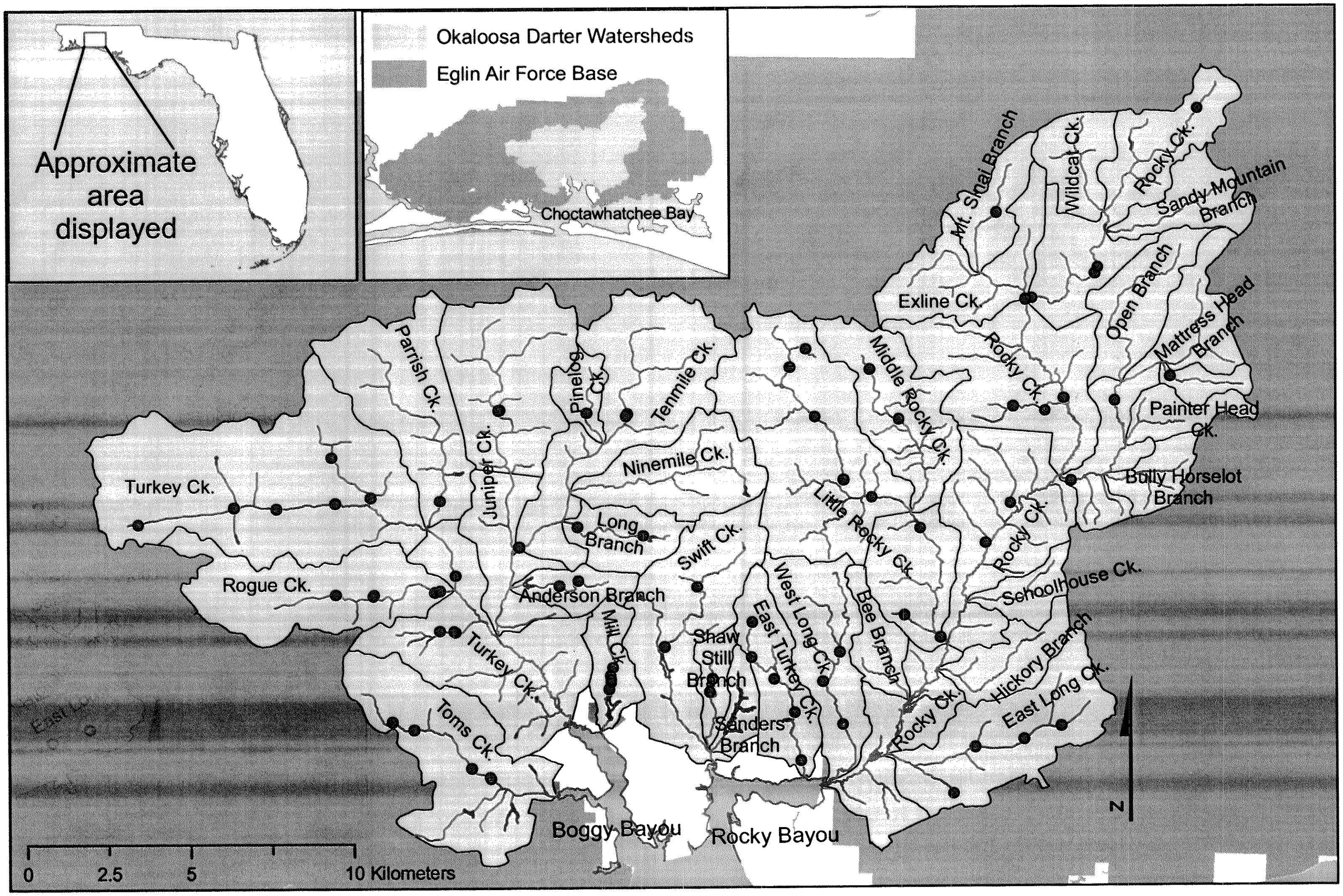

Figure 1. Watersheds encompassing the range of the Okaloosa darter. Red dots show where Okaloosa darters have been observed since 1998. The watersheds of the longest streams, Turkey Creek, Juniper Creek, Rocky Creek, and Little Rocky Creek, are divided longitudinally into two or more units that are of roughly comparable size.

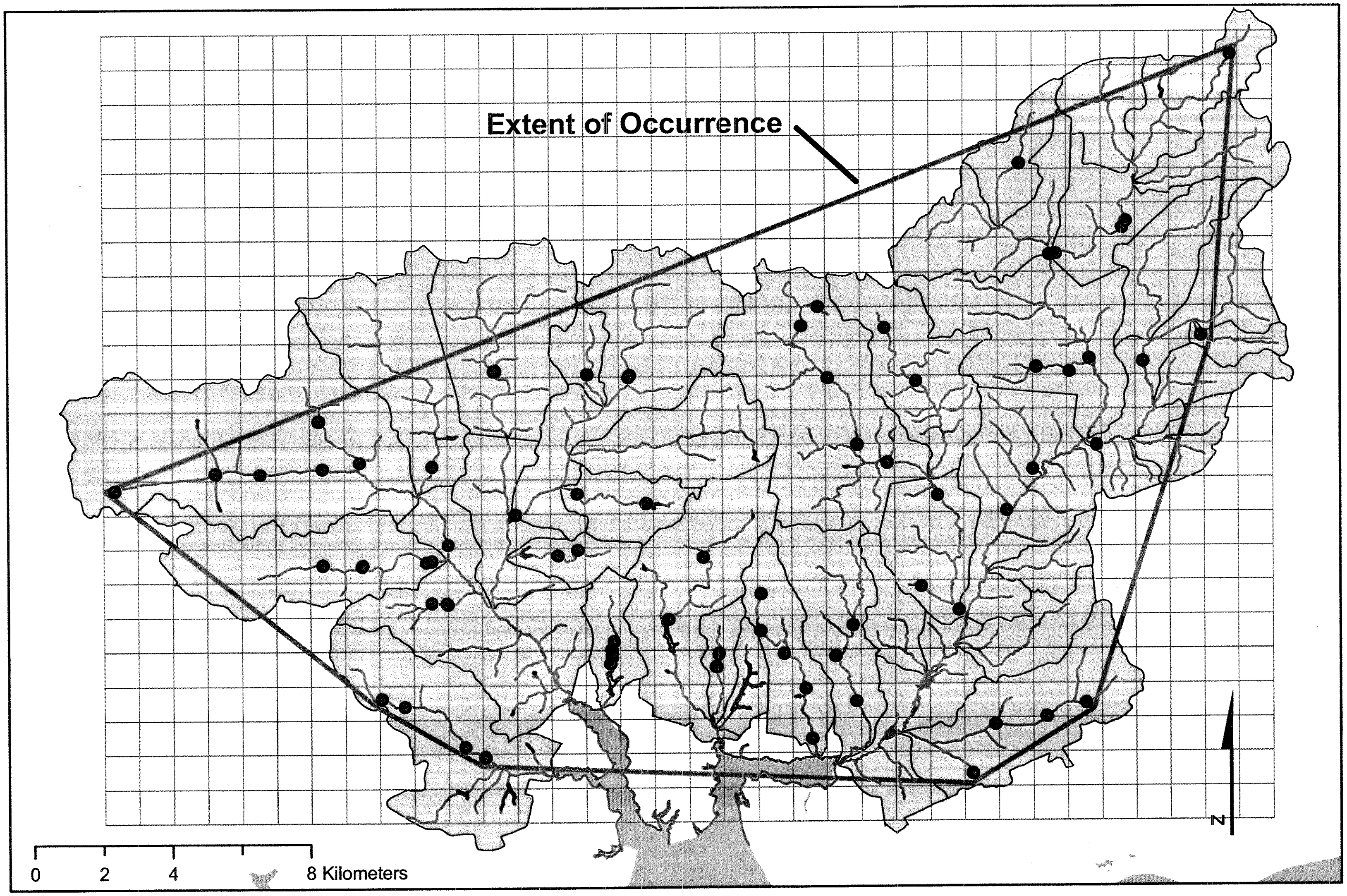

Figure 2. Extent of occurrence of the Okaloosa darter and 1-km grid used for measuring the species' area of occupancy. Red dots show where Okaloosa darters have been observed since 1998.

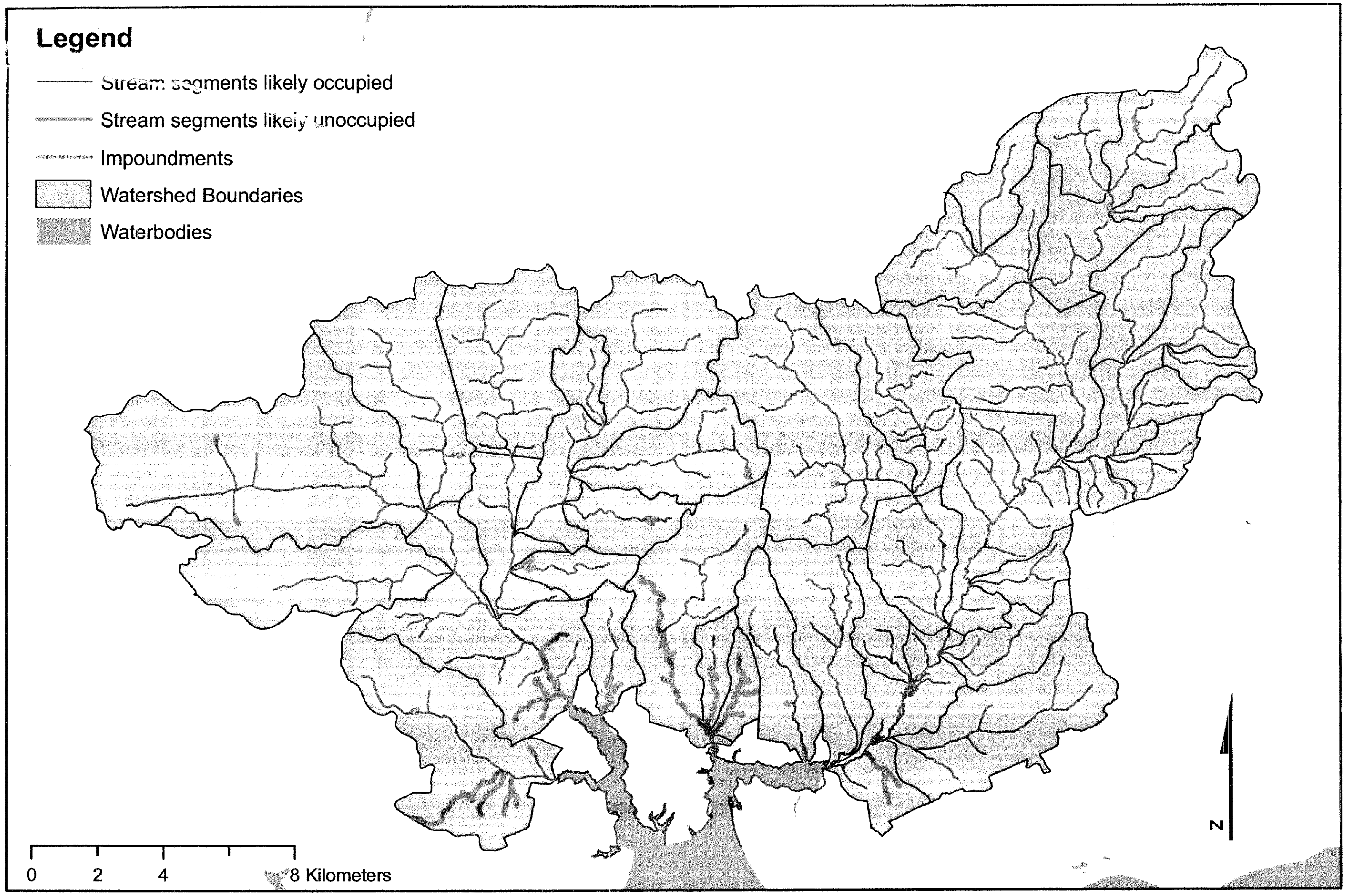

Figure 3. Range of the Okaloosa darter showing stream segments that are likely occupied and unoccupied and impoundments that appear on 1:24000-scale maps.

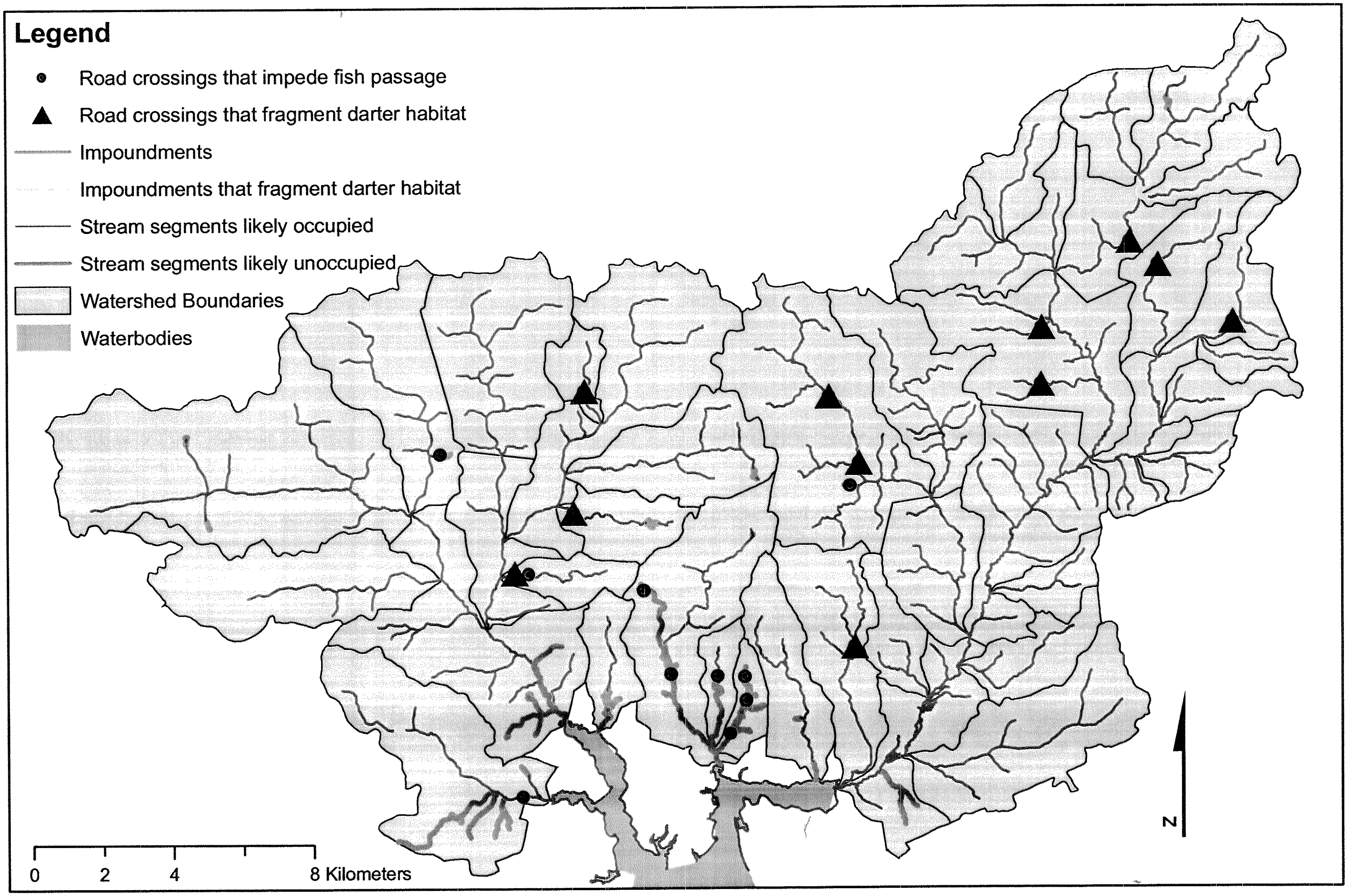

Figure 4. Fragmentation of the range of the Okaloosa darter by impoundments and road crossings. Several barriers to fish passage displayed do not have a fragmenting effect because they are located at the margins of the stream network that is likely occupied by the darter or are adjacent to other barriers.

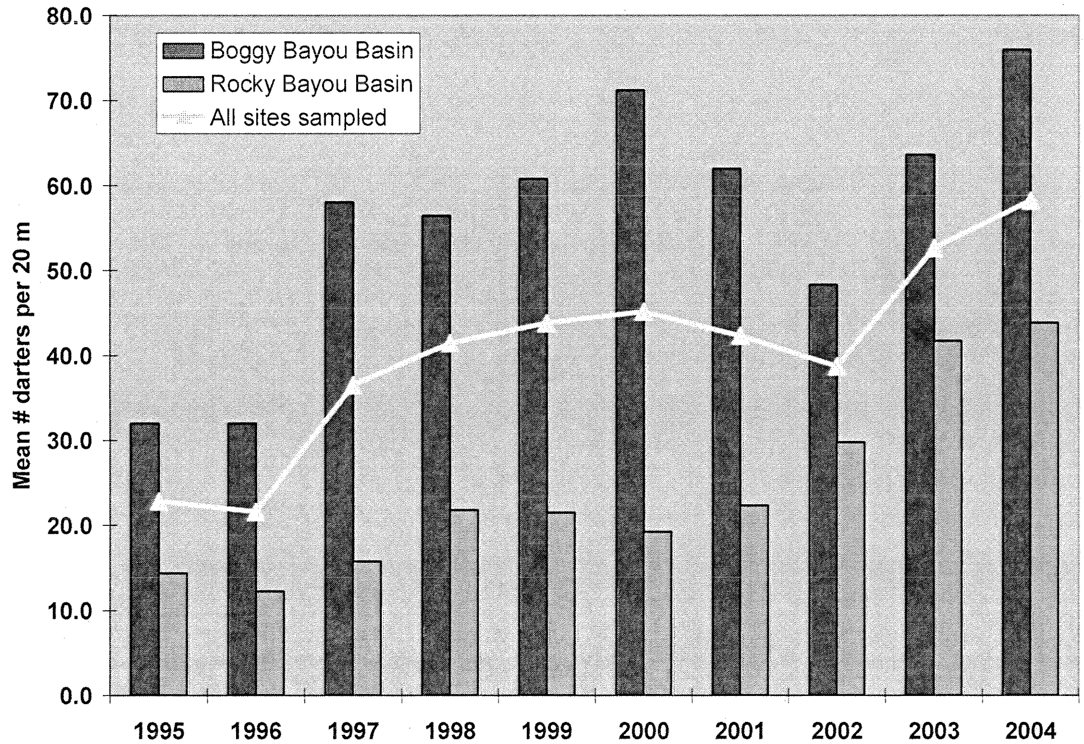

Figure 5. Mean number of Okaloosa darters at all 20-m stream segments surveyed 1995 through 2004 (source: Jordan and Jelks 2004).

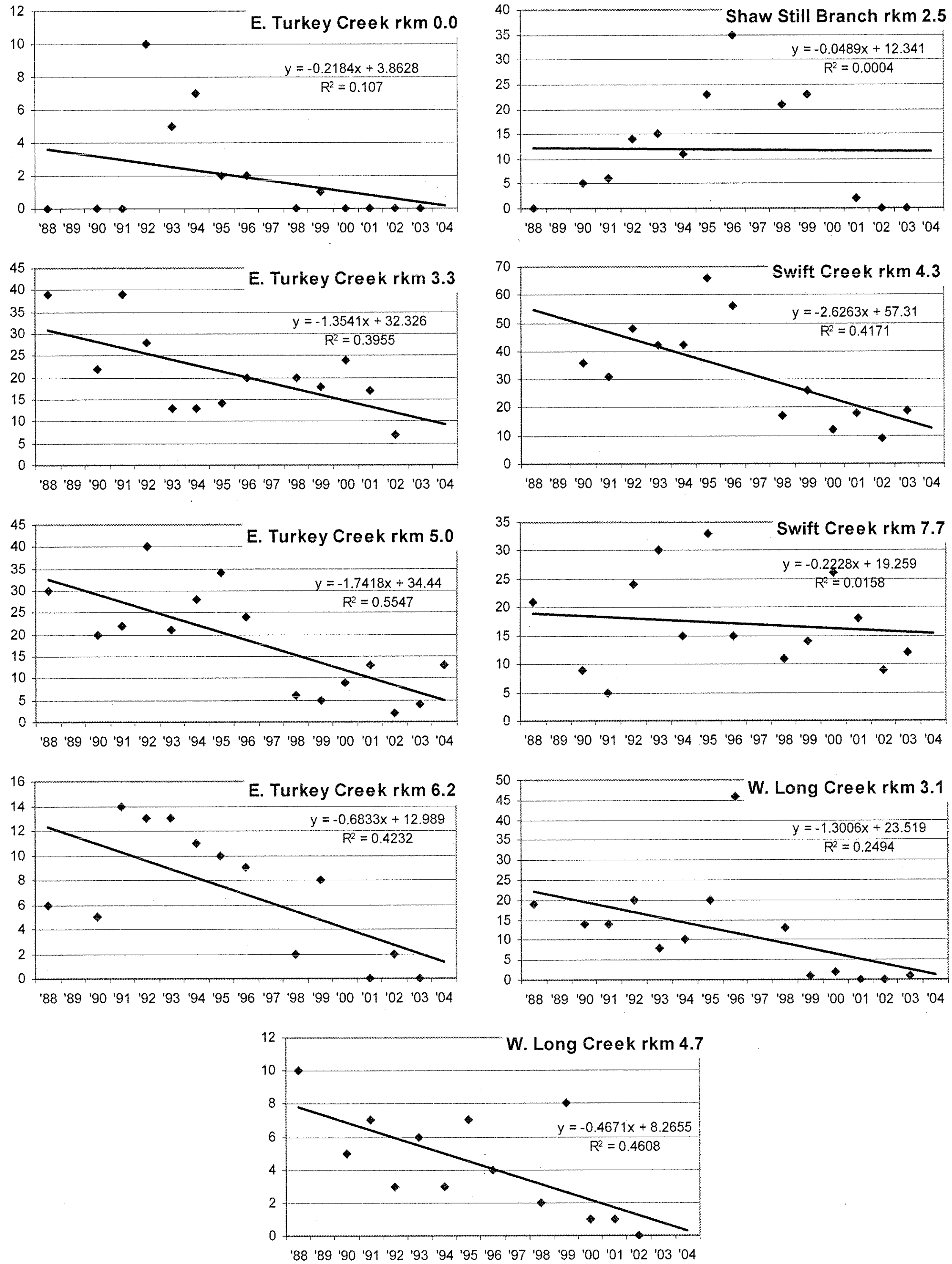

Figure 6. Okaloosa darter counts at nine sites ("rkm" = kilometers upstream of the stream mouth) monitored by Bortone (1999) from 1988 through 1999, and by USFWS or USGS 2000 through 2004, using 60-minute seine surveys. In all charts, the vertical axis is the number of darters collected and the horizontal axis is the year of the collection (e.g., "'88" = 1988).

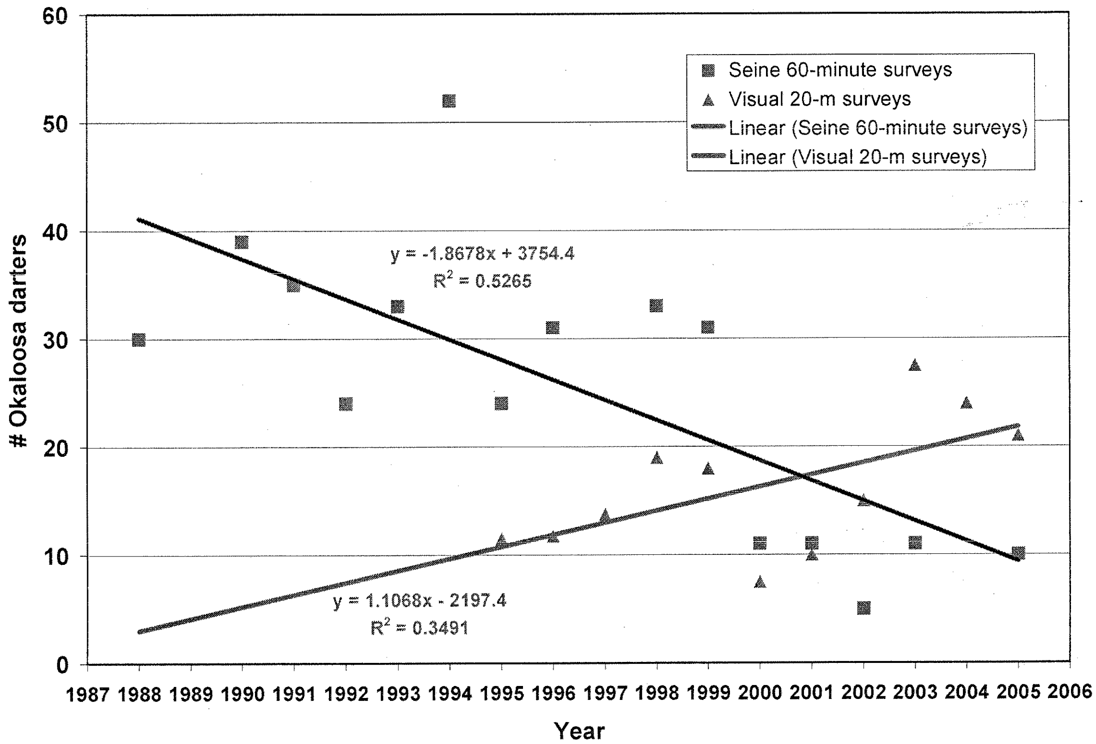

Figure 7. Contrasting trends (least-squares model) of Okaloosa darter counts by visual and seine surveys of site at Eglin Range Road 406 crossing of West Long Creek, which is 5.5 km upstream from its confluence with Rocky Creek.

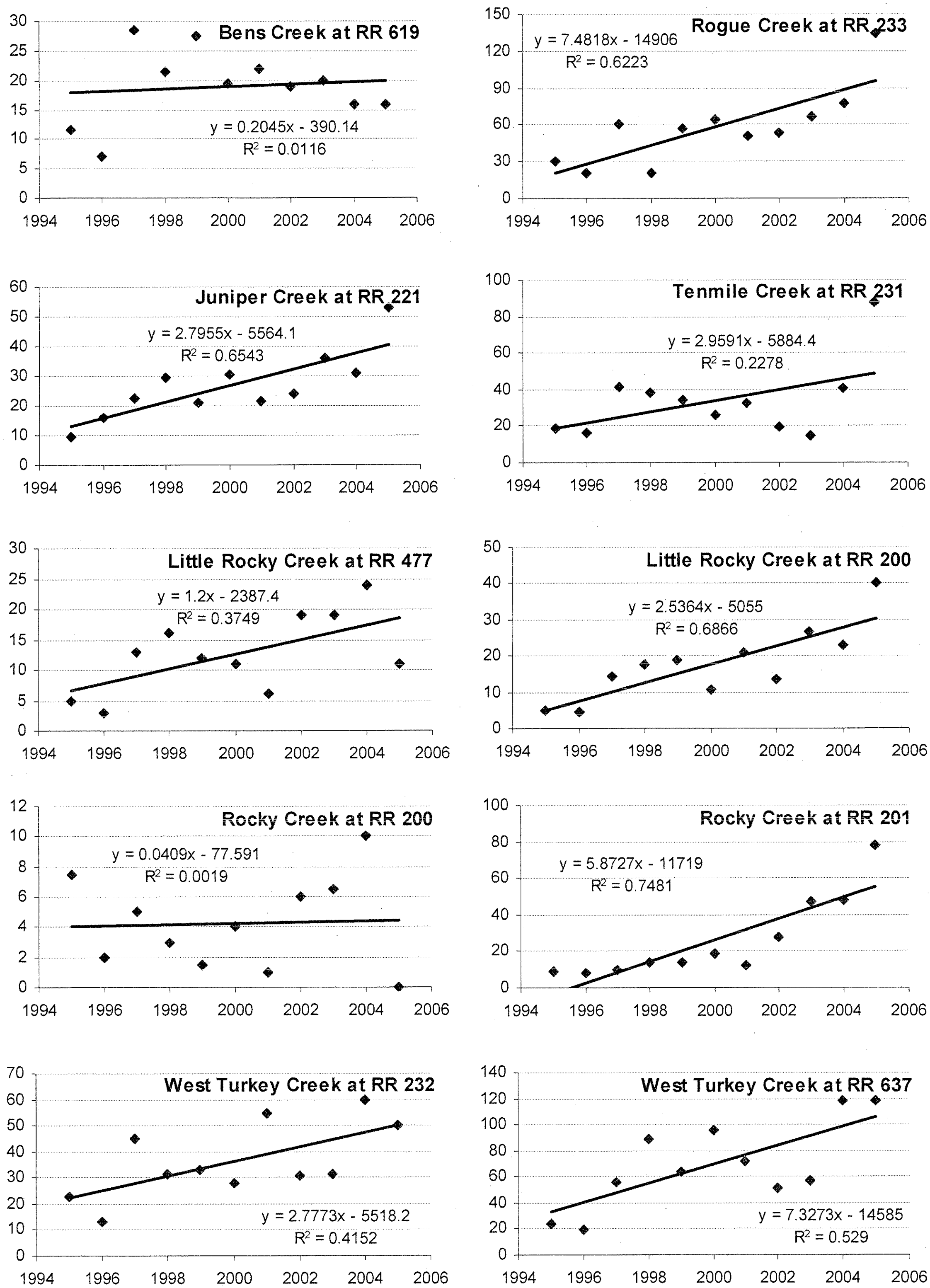

Figure 8. The long-term trend in the number of Okaloosa darters (count) at each site. These counts represent visual surveys taken in the summer only, since spring sampling was discontinued after 1999. In all charts, the vertical axis is the number of darters collected and the horizontal axis is the year of the collection.

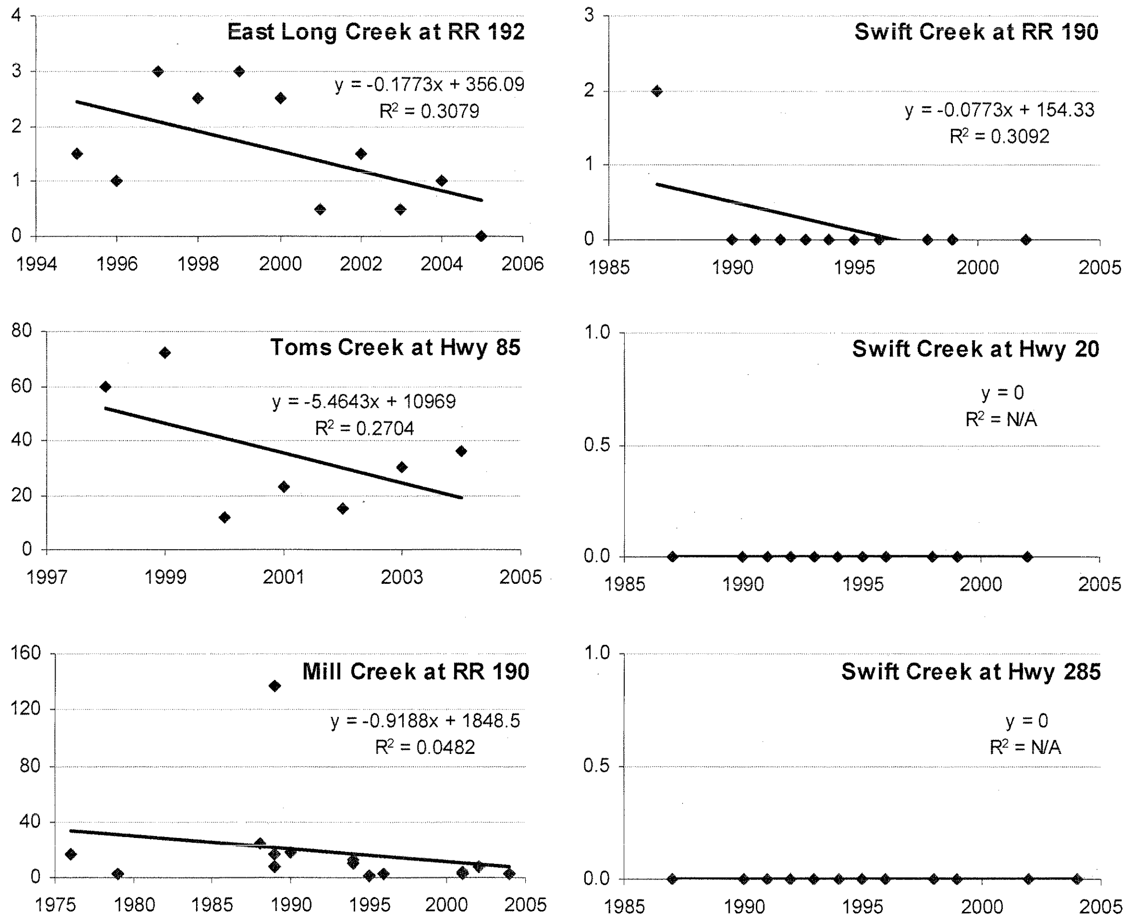

Figure 9. The long-term trend in the number of Okaloosa darters (count) at each site. The counts from East Long Creek represent visual surveys taken in the summer only, since spring sampling was discontinued after 1999. In all charts, the vertical axis is the number of darters collected and the horizontal axis is the year of the collection.

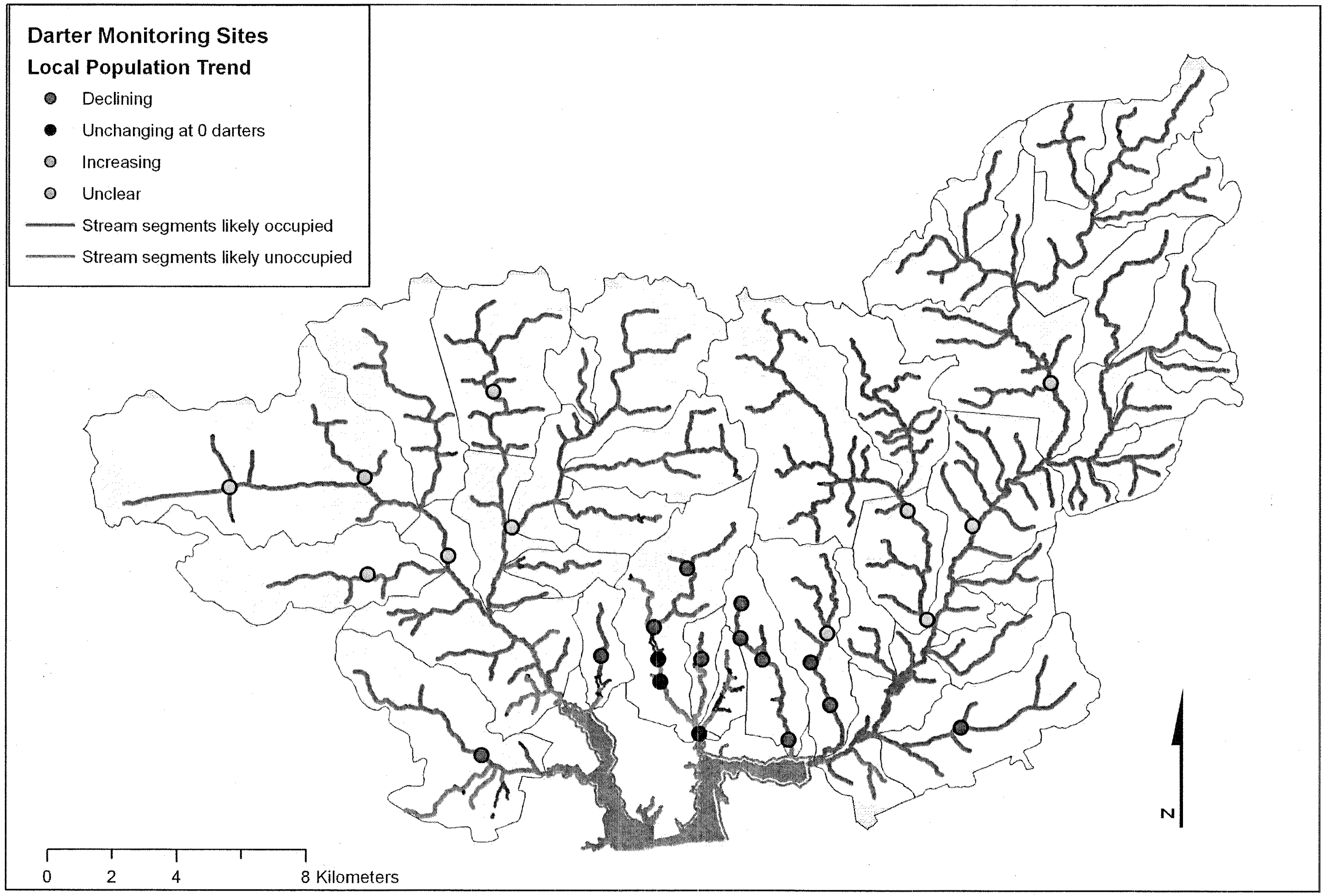

Figure 10. Map showing locations of the 26 Okaloosa darter monitoring sites listed in Appendix A of the 1998 Recovery Plan and the local population trend apparent at each site.