Northern Red-bellied Cooter
(Pseudemys rubriventris)

5-Year Review:
Summary and Evaluation

May 3, 2007

U.S. Fish and Wildlife Service
New England Field Office
Concord, New Hampshire

5-YEAR REVIEW

Species reviewed: Northern Red-bellied Cooter, also known as Plymouth redbelly turtle/ *Pseudemys rubriventris bangsi*

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1. GENERAL INFORMATION

1.1 Reviewers

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1.2 Methodology used to complete the review

This review was completed by Michael Amaral, Sr. Endangered Species Specialist in the Service's New England Field Office, and lead recovery contact for the species. The Service solicited input and comments from an ad hoc recovery group for the cooter in Massachusetts. The recovery group consists of biologists familiar with this species from academia, MassWildlife, the Service's refuge program, and an environmental consultant. The most important sources of data informing this review include the 1994 recovery plan, published scientific literature, unpublished annual reports and consultations with species experts. Lloyd Gamble, Ph.D. candidate in the Department of Natural Resources, University of Massachusetts, Amherst developed the survival projections for the headstarted (HS) turtles discussed in section II.C.1.a and in Appendices A-H.

1.3 Background

1.3.1 FR Notice citation announcing initiation of this review:

77 FR 20717, April 21, 2006

1.3.2 Listing history:

FR notice: 65 FR 21828
Date listed: April 2, 1980
Entity listed: Subspecies *P. rubriventris bangsi*
Classification: Endangered

1.3.3 Associated rulemakings:

Critical habitat was designated concurrent with species listing, 65 FR 21828.

1.3.4 Review history:

The Plymouth red-bellied turtle was included in two cursory 5-year reviews conducted for all listed species between 1979 and 1991, as follows:

1. July 22, 1985 (50 FR 29901) – all species listed before 1976 and in 1979-80, resulting in a 1987 notice of completion (no change) on July 7, 1987 (52 FR 25522)

2. November 6, 1991 (56 FR 56882) – all species listed before 1991

No formal 5-year reviews have been conducted for the northern red-bellied cooter since then; however, a series of recovery plans has included assessments of this subspecies' status. The initial recovery plan for the species was completed in 1981. The 1981 plan was updated and revised in 1985. In 1990, the State of Massachusetts, Division of Fisheries and Wildlife, in cooperation with others, prepared an action plan for the species (French 1990). In 1994, the Service's 1985 recovery plan was again revised, and this revision included an updated assessment of the species status and a discussion on the revision to the subspecific taxonomy of *P. rubriventris*.

In February 1997, the Service received a petition to delist the species due to taxonomic error. In October 2006, we published a "substantial" 90-day finding that opened a 60-day public comment period and announced the initiation of a status review (191 FR 58363).

1.3.5 Species' Recovery Priority Number at start of review:

Recovery priority number is 9, indicative of a moderate degree of threat and high recovery potential for a subspecies.

1.3.6 Recovery plan:

Name of plan: Plymouth Redbelly Turtle (*Pseudemys rubriventris*) Recovery Plan, Second Revision
Date issued: May 6, 1994
Previous plans: 1981 and September 26, 1985

2. REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review listed as a DPS? No

2.1.2 Was the DPS listed prior to 1996? N/A

2.1.3 Is there relevant new information regarding application of the DPS policy to this DPS listing that indicates a need for splitting out, combining or otherwise re-configuring DPSs, or that the listed entity is no longer consistent with the DPS policy? N/A

2.1.4 Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy?

Yes. The Plymouth red-bellied turtle was listed in 1980, well prior to the February 7, 1996 DPS policy. Because the Plymouth population at the time of listing was recognized as a distinct subspecies, little consideration was given to a vertebrate population listing at that time. However, herpetologists have long questioned the subspecific status of *Pseudemys rubriventris bangsi*, the red-bellied cooters restricted to Plymouth County, Massachusetts, and morphometric studies alternately corroborated and invalidated the subspecies designation (reviewed in USFWS 1978, 1980). For example, in 1978, Graham corroborated Babcock's 1937 designation of the subspecies *bangsi* when, after completing "an in-depth analysis of the shell dimensions of both subspecies of *Chrysemys rubriventris* [= *Pseudemys rubriventris*] concluded *bangsi* as morphometrically distinct from *rubriventris*" (cited in 46 FR 21702, 1980). The Service's 1978 proposed listing rule for this turtle acknowledged the dynamic nature of freshwater turtle taxonomy and noted

> "The Plymouth red-bellied turtle was described in 1937 on the basis of measurements of the shell. Subsequent work by Roger Conant revealed that the measurements used by Babcock were invalid and, as such, the subspecific status of '*bangsi*' is in doubt. Ernst and Barbour ('The Turtles of the United States,' Univ. Press, Kentucky, 1971), in the [then] most recent review of U.S. turtle biology, retain the subspecies '*bangsi*'; letters from Dr. T. Graham and R. Conant, authorities on this turtle, also recommend retention of the name '*bangsi*'. Turtle biologists generally feel that, given the isolation of the Plymouth red-bellied turtle, future study will reveal valid reasons for recognizing *C. r. bangsi*. As such, the Service feels justified in proposing this turtle under the trinomial designation."

Iverson and Graham (1990) examined more than 200 red-bellied cooters from throughout the species range and concluded that the single morphological character (shell height) used by Babcock (1937) to differentiate the subspecies *bangsi* was insufficient to warrant retaining the subspecies designation. From 1990 until this 5-year review, only limited research examining the differences between Massachusetts red-bellied cooters and those in the mid-Atlantic states has been undertaken (Haskell 1993; Brown *et al.* 1996; USFWS unpubl. data).

The Service addressed the recommended change in taxonomy in the 1994 recovery plan revision, which was provided to interested agencies and the public for comment. The recovery plan reported that the endangered Plymouth population of the red-bellied cooter would likely meet the then-interim criteria for retention on the threatened and endangered

species list as a DPS (USFWS 1994). None of the public comments received addressed the taxonomic change.

Discussion of DPS Criteria

Discreteness

The DPS policy (61 FR 4722) states that a vertebrate population segment may be considered discrete if it satisfies either of the following two conditions:

1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation; or
2. It is delimited by international governmental boundaries…

The red-bellied cooter (*P. rubriventris*) has a relatively continuous coastal plain distribution across seven mid-Atlantic states from eastern North Carolina to central New Jersey (Mitchell 1994). The population in Plymouth County, Massachusetts is separated from the southern range of the species by approximately 250 miles (Iverson and Graham 1990, USFWS 1994) and has apparently been isolated for hundreds of years (Rhodin and Largy 1984; Rhodin 1992). In fact, some turtle researchers describe the species as "represented by two disjunct populations: the southern population…and the federally endangered northern population found only in Massachusetts" (Haskell 1993, Browne et al. 1996).

There is no dispersal of individuals (LeConte 1830, cited in Iverson and Graham 1990) and therefore no evidence of genetic exchange between northern and mid-Atlantic red-bellied cooters (Haskell 1993; USFWS 1994). Bartron and Julian (2007) examined 12 microsatellite loci for red-bellied cooters from Federal Pond in Massachusetts, New Jersey (46 samples from Bass Lake plus 5 samples from 3 nearby lakes), Blackwater National Wildlife Refuge in Maryland and Virginia (5 sites). Allelic richness was substantially lower in the Massachusetts collection, compared with those from New Jersey, Maryland, and Virginia. While restricted sampling locations limit the scope of inference from this study, significant genetic differences between all collections were supported through multiple analyses of allele frequencies, including estimates of F_{ST}, Cavalli-Sforza and Edwards chord distances, and maximum likelihood assignment. Individuals from the Massachusetts (Federal Pond) population were assigned back to the collection of origin 100% of the time.

On the basis of the marked, physical separation of Massachusetts cooters from cooters elsewhere in the species' range, and available genetic evidence, the Massachusetts population of the red-bellied cooter meets the Service's discreteness criterion.

Significance

Under DPS policy (61 FR 4722), once a population segment is determined to be discrete, we consider its biological and ecological significance to the larger taxon to which it belongs. This consideration may include, but is not limited to, the following factors:

1. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon,
2. Evidence that loss of the discrete population segment would result in a significant gap in the range of the taxon,
3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range, or
4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

In Massachusetts, the cooter is primarily a resident of isolated coastal plain ponds fed by groundwater and springs (Barbour et al. 1998), whereas from New Jersey south, it is primarily a species of large rivers, slow moving creeks, brackish water systems or interconnected pond habitat (Compton *et al. in litt.* 2006; Graham *in litt.* 2006; Graham 1991, Mitchell 1994). This difference in habitat occurrence will likely result in the northern and mid-Atlantic populations having different dispersal strategies, differential exposure to terrestrial mammals and road mortality, differential tolerances and possibly adaptations to climatic conditions, and dissimilar patterns of genetic variability within and across subpopulations. In particular, the Massachusetts population occurs at the northern extremity of the species' range and is subject to environmental stresses not experienced by mid-Atlantic and more southern cooters.

An example of an adaptation of the northern population to the unique ecological setting in which it occurs is the ability to overwinter, submerged under solid ice cover, sleeping on the pond bottom, while respiring for the most part aerobically via cutaneous and buccopharyngeal gas exchange with the surrounding water (Graham and Guimond 1995; Graham *in litt.* 2006). In addition, Iverson and Grahams (1990) conducted a morphometric study of over 150 large red-bellied cooters from throughout the species' range. Highest or lowest means for eight (of 17) morphometric characters among Massachusetts male cooters and six among Massachusetts female cooters are potential indicators of adaptations to the unique ecological setting in the northern portion of the species' range. Thus, the northern population occupies an ecological setting different from conspecifics farther south and exhibits some behavioral and morphometric differences from mid-Atlantic cooter populations. We therefore find that the Massachusetts population segment meets significance criterion 1.

Compton *et al. in litt.* (2006) point out that the loss of the Massachusetts population would reduce the latitudinal extent of the species' range by approximately one third; the depiction of the species range in Iverson and Graham (1990) suggests that loss of the Massachusetts population would reduce the species range by closer to 40%. In either case, this would create a significant gap in the range of *P. rubriventris*. On this basis, the Massachusetts population meets significance criterion 2. Furthermore, Nielsen et al. (2001) discuss the significance of some peripheral populations, citing that populations at the northern extremity of their ranges may survive in refugia that later, with different environmental conditions, serve as source populations for an expanded range. Moreover, Channell and Lomolino (2000) found that peripheral populations survive more frequently than core populations when species undergo dramatic reductions in their range (>75 percent).

Bartron and Julian (2007) found that there were significant genetic differences between the Federal Pond, Massachusetts and mid-Atlantic cooter populations from New Jersey (as well as Maryland and Virginia). This result, based on differences in allele frequencies at 12 microsatellite loci, is in contrast to previous allozyme-based genetic studies (Haskell 1993; Browne *et al.* 1996), perhaps due to the limited number of polymorphic loci and low variability of markers sampled in the earlier studies. Of the four populations Bartron and Julian examined, the Massachusetts population exhibited the lowest mean number of alleles per locus and allelic richness.

In view of the above, it is determined that the Massachusetts population is significant to the status of the species as a whole. Finally, this population's status as an endangered species is discussed in sections II.B.3. and II.C.2.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes. The 1994 recovery plan is being used as a general guide to recovery. Although the plan is more than a decade old, the factors contributing to endangered status have not changed appreciably. Also, red-bellied cooters are long-lived animals and there is no evidence that the population in Plymouth County, Massachusetts undergoes wide or abrupt population fluctuations. The actions recommended to achieve recovery, habitat protection and increased turtle survival are still pertinent, and the recovery criteria are measurable. With increased financial support, they are also attainable.

2.2.2 Adequacy of recovery criteria

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

Generally yes, but appropriateness of introductions to riverine habitats should be re-evaluated.

2.2.2.2 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)?

5 Factors	Relevant
1) Present or threatened destruction, modification or curtailment of its habitat or range	Yes
2) Overutilization for commercial, recreational, scientific or educational purposes	No
3) Disease or predation	Yes - Predation
4) Inadequacy of existing regulatory mechanisms	Yes
5) Other natural or manmade factors affecting its continued existence	Yes

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information and noting which of the 5 listing factors are addressed by that criterion.

"Reclassification to threatened status will be considered when:

- the Plymouth redbelly turtle [cooter] population increases from the current population level of approximately 300 breeding-age individuals to a total of 600 breeding-age individuals distributed among a minimum of 15 self-sustaining populations.

Although the turtle's restricted range may remain a limiting factor, delisting will be considered when:

- the distribution of the species is expanded to 20 or more self-sustaining populations (in lakes, ponds, and possibly rivers) and numbers are increased to a total of 1,000 or more breeding-age individuals;
- sufficient habitat is protected to allow long-term maintenance of the populations;
- knowledge about their life history, habitat requirements, and limiting factors is sufficient to effectively protect and manage the turtles and their habitat."

Discussion/Recovery Criteria for Reclassification from E to T:

- The Plymouth redbelly turtle [cooter] population increases from the current population level of approximately 300 breeding-age individuals to a total of 600 breeding-age individuals distributed among a minimum of 15 self-sustaining populations.

  This criterion addresses the curtailment of the species' range and addresses the need for increasing the number of pond populations to reduce the likelihood of extinction (listing factor 1 above). It also addresses the critically low number of individuals that represent the total population of this species in Massachusetts (listing factor 5). The low number of individuals in each pond population increases the vulnerability of the species to extirpation from chance events such as high egg or hatchling predation rates that result over time in inadequate recruitment, and increases the likelihood that the species may be affected by loss of genetic fitness through inbreeding depression (factors 3 and 5). This criterion also addresses the conservation biology principle of redundancy, as it specifies that 15 self-sustaining populations are needed to ensure persistence over time (factor 5).

  While progress has been made, this criterion has not been met. Largely through headstarting, it is estimated that many hundreds more turtles now occur within Plymouth County coastal plain ponds than in the early 1980s. However, subpopulations numbering 50 or more cooters are only likely to occur in about 10 ponds (see Table 1), and most of these animals will not have reached sexual maturity yet, and thus have not entered the breeding population. We do not know if these pond populations newly-established with or enhanced by releases of headstarted turtles are self-sustaining.

Discussion/Delisting Criteria:

- The distribution of the species is expanded to 20 or more self-sustaining populations (in lakes, ponds, and possibly rivers) and numbers are increased to a total of 1,000 or more breeding-age individuals.

  As above, this criterion addresses listing factors 1, 3 and 5. In particular, the cooter population is less likely to be susceptible to high predation rates on eggs and hatchlings (factor 3) if the breeding population is distributed over many, i.e., 20 or more, ponds.

  This criterion has not been met. See comment above.

- Sufficient habitat is protected to allow long-term maintenance of the populations.

  This criterion directly addresses factor 1, the need to protect aquatic feeding, resting, breeding, and over wintering habitats and adjacent upland habitats, used for nesting and dispersal. Since upland nesting habitats adjacent to ponds may or may not be protected depending on distance from the water edge, this criterion also addresses listing factor 4.

  This factor has not been met. Of the 20 or so ponds supporting red-bellied cooters, about four ponds are protected in part or in their entirety through conservation ownership, permanent easement, or other conservation instrument. All aquatic and surrounding upland habitat of the largest pond population, Federal Pond, except for a small portion, is owned by the Federal Furnace Cranberry Company, a private company that is currently reviewing opportunities for non-agricultural development. Only East Head Pond (Myles Standish State Forest) and Crooked Pond (Massasoit National Wildlife Refuge) are entirely within state or federal conservation ownership. A portion of Gunner's Exchange Pond and a nesting beach on Island Pond are also within the NWR system.

- Knowledge about their life history, habitat requirements, and limiting factors is sufficient to effectively protect and manage the turtles and their habitat.

  This criterion addresses all relevant listing factors (1, 3, 4 and 5).

  Progress has been made on this criterion, and the red-bellied cooters at Federal Pond, in particular, have been studied in some detail (e.g., T.E. Graham *in litt.* 2006; Haskell 1993; J. Crane 2003, 2004, 2005, 2006). However, many aspects of red-bellied cooter natural history and ecology remain poorly known. For example, it is not known how far cooters will travel from the ponds, whether there is genetic interchange between pond populations, how many headstarted hatchlings are sufficient to establish a population, what effect fire suppression is having on the quality of cooter nesting habitat and on the sex ratio of cooter hatchlings, if hatching success of cooter nests at Federal Pond will be sufficient to sustain this pond population after nest protection efforts are terminated, and what

the survival rate of non-headstarted hatchlings is. Until more is learned about the limiting factors for this species in Plymouth County, Massachusetts, it will not be possible to ensure that its recovery will be sustainable over time.

2.3 Updated Information and Current Species Status

2.3.1 Biology and habitat

2.3.1.1 Abundance, population trends, demographic features, or demographic trends:

At the time of listing in 1980, fewer than 50 Plymouth red-bellied cooters were thought to exist, only 12 were documented as being female, and their distribution was limited to about 12 ponds in Plymouth County, Massachusetts (45 FR 21828). Following the discovery of a "large" population of cooters in Federal Pond and a program initiated in 1984 of rearing (or headstarting) hatchlings for nine months and releasing them, the number and distribution of red-bellied cooters in Massachusetts had increased to an estimated 300 breeding age individuals in 17 ponds (USFWS 1994). The headstarting of 100-200+ hatchlings per year has continued from 1994 to the present, and as a result, there are now an estimated 400-600 breeding-age individuals occurring in about 20 ponds (Figure 1). However, fewer than half of those ponds are likely to contain more than 20 breeding age animals. Some headstarted turtles have also been released into two rivers.[1] It should be noted that population estimates are based primarily on estimated high survival rates of known numbers of released, HS turtles, and actual survey data are available in only a few instances for the number of wild (non-HS) and HS turtles present in ponds (e.g., Haskell 1993) for Federal, Gunner's Exchange-Hoyts, Crooked and Island Ponds, and Great South and Boot Ponds (Graham and Graham 2001). These estimates and the year of survey are as follows: Crooked Pond, 40 animals (1991); Island Pond, 70 animals (1991); Gunners Exchange-Hoyts Pond, 67 animals (1991); Federal Pond, 171 animals (1991); Great South Pond, 63 animals (2001) and Boot Pond, 31 (2001). In most cases, these estimates include HS and non-HS juvenile, sub-adult and adult cooters.

Although sexual dimorphism is apparent in 5-7 years, female red-bellied cooters are not believed to reach sexual maturity until 15-20 years of age, perhaps less in males (T.E. Graham in USFWS 1994). Headstarting is believed to accelerate breeding by a few years, as a 12-year HS female was recorded breeding (T.E. Graham, pers. comm.). The life expectancy of this species is thought to be 40-45 years (MA NH&ESP 1995). Graham and Graham (2001) reported an estimated 50-year-old female turtle in Boot Pond that had been marked as an adult in 1969.

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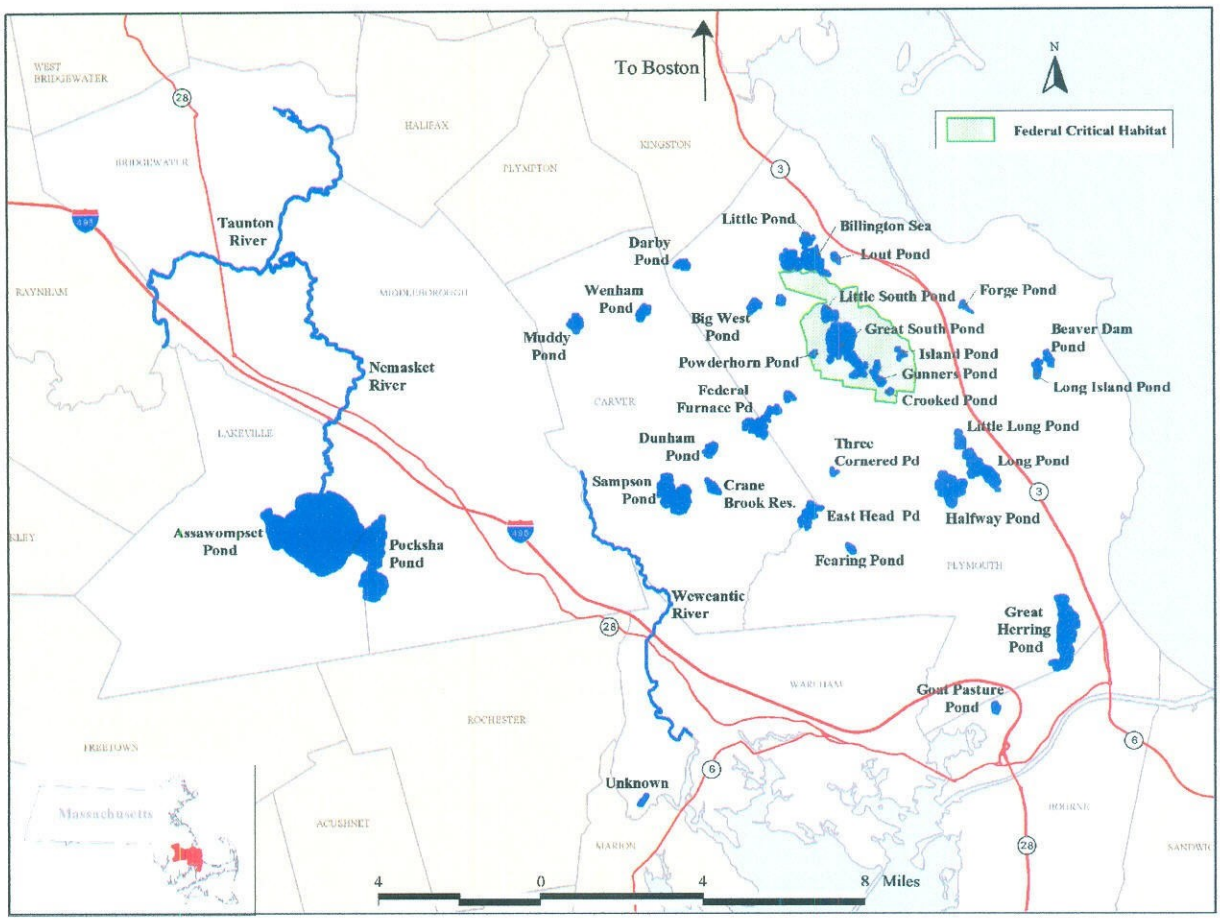
[1] Although the red-bellied cooter is a coastal plain pond species in southeastern Massachusetts, HS hatchlings were released experimentally in two river systems in order to take advantage of the availability of these long linear aquatic habitats and the dispersal corridor they provide to the turtles.

Figure1. Current Distribution of the Plymouth Population of the Northern Red-bellied Cooter.



Females excavate a shallow nest in sandy soil, usually within 100 meters of the pond, and lay an average of 12 eggs (range 5-17). A small number of females may lay two clutches per year (Graham 1993), and incubation requires about 73-80 days at 25°C. Hatchlings measure about 32 mm (1¼ inches) in length, and either move directly into ponds following emergence or over winter in nests. The microclimate at nest sites can affect the sex ratio of hatchlings (temperature-dependent sex determination) (USFWS 1994). Nests in shady and cool sites will produce more males and those in warm sunny locations more females. Since the majority of hatchlings used for headstarting for several years during the period 1985-1998 were selected from nests where the hatchlings emerged late in the season or would have overwintered in the nests, the sex ratio of HS hatchlings for this period is believed to be heavily skewed toward males (T. French, pers. comm.). In fact, Graham and Graham (2001), in a survey of Great South and Boot Ponds, found that of 86 cooters that were captured and sexed, 52 were males

and 34 were females. In Boot Pond, males outnumbered females by a ratio of about 2.5 to 1 (21:8).

It is well known that the survival rate of many vertebrate species is related to size differences within age groups, with smaller individuals being more vulnerable to predation. Predators of newly-emerged red-bellied cooters include the bull frog (Graham 1984) and may also include chain pickerel, largemouth bass, great blue heron, and raccoon (Haskell *et al.* 1996; unpubl. USFWS data). The survival rate of non-HS red-bellied cooter hatchlings is not known; however, it is believed to be very low. For example, the survival rate of hatchlings of the similarly long-lived fresh water species, Blanding's turtle, is estimated to be as low as 1% (Compton *in litt.* 2006). Of the more than a thousand marked (shell-notched) red-bellied cooter hatchlings that emerged from caged nests and were released directly into their natal pond, very few have ever been encountered again (T.E. Graham, pers. comm.; MassWildlife unpubl. data). This suggests that hatchling survival is either extremely low or very difficult to estimate if older turtles that were shell-notched as hatchlings no longer exhibit the marking.

Due to their much larger size when released, the survival rate of HS cooters is believed to be much greater than non-HS hatchlings, with perhaps as many as 50% reaching sexual maturity (Haskell 1993; Haskell *et al.* 1996). Graham (pers. comm.) noted shell damage in HS turtles released into Crooked Pond. Bites had been taken from the rear carapace and plastron margins, most probably by snapping turtles, suggesting that these turtles are predators of released HS cooters.

While >2,700 is a robust number of cooters, annual survival estimates for ages 1-3 (0.73, 0.85, 0.89) and ≥4 (0.90) (Haskell *et al.* 1996) appreciably reduce the number of surviving HS turtles in each pond over time (Table 2). For example, of the 1,006 HS turtles released into the Assawompsett Pond complex, only about 600 would have survived in 2006 and none would have yet reached breeding age. For Big West Pond, which received 36 headstarts during 1987-1889, about four breeding age turtles may have survived to 2006.

Thus, of the 2,725 HS turtles released in Massachusetts ponds, this simplistic survival projection estimates that approximately 168 (sd = 17.2) reached potential breeding age and survived to 2007 (Gamble *in litt.* 2007). Corresponding pond-specific estimates range from 0-28 surviving turtles in 2007. If no further HS releases occur, it is estimated that 130 (sd = 24.6) potential breeding-age cooters will survive to 2026, and that pond-specific estimates will range from 0-75 (see Appendices A-G). No allowance for recruitment was made in this simplistic survival model and the actual survival rate of cooters ≥ age 4 may well be greater than 90% (T.E. Graham, pers. comm. 2007). Other assumptions and limitations are listed in Appendix H.

Table 1 summarizes the numbers and locations of HS hatchling releases in Plymouth County, Massachusetts from 1984 to 2006 (courtesy of Dave Taylor and Tom French, MassWildlife).

Table 1. Release Sites of Headstart Hatchling Red-bellied Cooters, 1985-2006.

	Release pond	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Subtotal
1	Assawompset Great Quittacus Lakeview Pocksha														28	86	119	98	82	184	121	148	140	1006
2	Big West			11	10	15																		36
3	Billington						20	11	16															47
4	Boot			21	20	15		10																66
5	Crooked	13	29	12	11	9	5	5							1		4	4						93
6	East Head			31	29	25	11	10								18	10	22	36	41			10	243
7	Fearing																	14						14
8	Federal			29	32	24	16	10	16						15			4	10					156
9	Forge									13														13
10	Goat Pasture												24			22								46
11	Great Herring															1								1
12	Great South		1						30	26	23							8		2	6	6		102
13	Halfway								20	25	23													68
14	Hoyts Gunners			26	27	15												12	14					94
15	Island		9		10	7			3															29
16	Little Long									25	23													48
17	Louts						21	6	14															41
18	Muddy					15	19	10																44
19	near Three Corner																	2						2
20	Nemasket River												12	106	22									140
21	No Name								6															6
22	Powderhorn											37												37
23	Rocky Pond																2							2
24	Sampson											38	28	24	20									110
25	Three Corner Pond																18							18
26	Wenham			11	9	15																		35
27	Weweantic River									37	25	36	31											129
28	Unknown											13	9	16	32	29								99
	TOTAL	13	39	141	148	140	92	62	105	126	94	124	104	146	118	156	153	164	142	227	127	154	150	2725

Table 2. *Pseudemys rubriventris* Headstart to Breeding Age Survival Projections.

Release pond	Headstarts Released (1985-2006)	Headstarts Projected to Survive to 12+ Years							
		2007 (year 22)				2026 (year 41)			
		mean	std	min	max	mean	std	min	max
Assawompset/⊓Great Quittacus/⊓Lakeview/⊓Pocksha	1006	0	0.0	0	0	75	23.1	15	157
Big West	36	4	2.4	0	12	1	0.8	0	4
Billington	47	7	3.3	0	17	1	1.1	0	5
Boot	66	8	3.5	0	21	1	1.2	0	8
Crooked	93	9	3.9	0	22	2	1.4	0	7
East Head	243	13	5.2	0	32	11	4.7	2	30
Fearing	14	0	0.0	0	0	1	1.0	0	5
Federal	156	16	5.6	4	33	4	2.1	0	11
Forge	13	3	1.6	0	8	0	0.6	0	3
Goat Pasture	46	0	0.0	0	0	2	1.5	0	7
Great Herring	1	0	0.0	0	0	0	0.2	0	1
Great South	102	15	5.2	2	30	4	2.2	0	15
Halfway	68	13	4.9	1	31	2	1.5	0	12
Hoyts⊓Gunners	94	8	3.4	0	21	3	1.9	0	12
Island	29	3	2.0	0	11	0	0.7	0	4
Little Long	48	10	3.6	1	21	1	1.2	0	6
Louts	41	6	2.9	0	16	1	1.0	0	5
Muddy	44	6	2.9	0	16	1	0.9	0	5
near Three Corner	2	0	0.0	0	0	0	0.3	0	2
Nemasket River	140	0	0.0	0	0	6	3.1	0	17
No Name	6	1	1.0	0	5	0	0.4	0	3
Powderhorn	37	8	3.5	0	19	1	1.2	0	7
Rocky Pond	2	0	0.0	0	0	0	0.4	0	2
Sampson	110	9	3.6	0	19	4	2.6	0	13
Three Corner Pond	18	0	0.0	0	0	1	1.1	0	5
Wenham	35	4	2.1	0	13	1	0.8	0	4
Weweantic River	129	21	6.8	1	42	4	2.3	0	14
Unknown	99	3	1.8	0	9	4	2.4	0	12
ALL COMBINED	2725	168	17.2	111	233	130	24.6	64	214

2.3.1.2 Genetics, genetic variation, or trends in genetic variation:

***Genetic Uniqueness*:** Haskell (1993) and Browne *et al.* (1996) conducted a study investigating the genetic divergence between northern and mid-Atlantic red-bellied cooter populations. Non-lethal blood and muscle samples were collected from Massachusetts and New Jersey individuals. Enzymes encoded for 12 genetic loci were examined for polymorphism using starch gel electrophoresis (Haskell 1993). Four of the 12 loci examined exhibited slight variation while the other eight had no variability, and little genetic variability between the two populations was observed.

In contrast to the studies noted above, Bartron and Julian (2007) examined allele frequencies at 12 microsatellite loci of four cooter populations, and found that 11 loci were polymorphic in one or more of the populations. At most loci, the Massachusetts cooter samples (all from Federal Pond) exhibited a decreased number of alleles per locus in comparison to the populations sampled from New Jersey, Maryland, and Virginia. Significant genetic differences were observed

between all collections, based on estimates of allelic richness, F_{ST} values, F-statistics, maximum likelihood assignment and Cavalli-Sforza Edwards chord distances (CSE) between populations (Bartron and Julian 2007). The largest pairwise F_{ST} differences were between the Massachusetts and New Jersey populations; the largest Cavalli-Sforza and Edwards chord distances were between Massachusetts and Virginia. Evidence for a relatively recent genetic bottleneck (consistent with the current low population size and particularly, low population size at the time of listing) was observed for the Massachusetts population, but overall population relatedness was not higher in the Massachusetts population relative to the other populations (NJ, MD and VA).

In light of the above, additional investigation of red-bellied cooter genetics may reveal further evidence on the extent to which the northern population has diverged genetically from cooters in mid-Atlantic states. Melanism offers an example of a character that may be adaptive. Melanism occurs in four levels of expression: permanent, seasonal, ontogenetic, and reticulate, with reticulate melanism being the form of interest. Reticulate melanism results in the loss of the yellow lines on the soft parts and the loss of patterning and darkening of the carapace. Reticulate melanism differs from the other forms of melanism in that the process is progressive, is believed to be under hormonal control, and once established will likely continue for the life of the turtle (Lovich *et al.* 1990). This phenomenon has been reported in the northern populations of several species, *Chrysemys picta* (Lovich *et al.* 1990; Smith *et al.* 1969), *Gopherus flavomarginatus* (Morafka and McCoy 1988 in Gibbons 1993), *Gopherus polyphemus* (Landers *et al.* 1980), *Heterodon platirhinos* (Michener *et al.* 1989), *Crotalus horridus* (Ernst and Ernst 2003), including *P. rubriventris* (Agassiz 1857; Babcock 1938; Lovich *et al.* 1990). Moreover, not only does this particular form of melanism have the propensity to occur in the northern portion of these species' ranges, but it also appears to be limited to those populations (Seidel and Palmer 1991; Mitchell 1994). Such is the case for red-bellies, as no melanistic individuals have been reported from the Virginia populations (Mitchell 1994).

Possible adaptive functions of reticulate melanism have been investigated, with protection from radiation (McGuinness and Proctor 1973 in Gibbons 1993), gamete protection (Neill 1974 in Gibbons 1993), and thermoregulation efficiency (Boyer 1965 in Gibbons 1993) being plausible hypotheses. Current studies have demonstrated that melanism did inhibit the penetration of ultraviolet radiation (Neill 1974; Cloudsley-Thompson *et al.* 1985 in Gibbons 1993); however, it provided no thermoregulatory advantage (Boyer 1965 in Gibbons 1993; Terrell and Garstka 1984 in Gibbons 1993; Lovich *et al.* 1990). These physiological, histological, and hormonal differences associated with melanism could prove significant to Plymouth red-bellied cooters, if shown to be an adaptation for survival of this northern population. In any event, the propensity for melanism in the northern population is a characteristic unique for the species.

T.E Graham *in litt.* (2006) points out that genetic variation within a species is the raw material upon which natural selection acts to foster evolution. Outlier populations found at the extremity of a species' geographic range, such as the

Massachusetts red-bellied cooter, are widely viewed by biologists and geneticists as likely to contain important genetic variation due to the unique selection pressures in force at the limit of a species' range (this is particularly so along a north-south gradient). For example, the adaptation that allows Plymouth County cooters to survive over winter under ice—an ability researchers have not demonstrated for conspecifics farther south— may be a heritable characteristic of the northern population.

2.3.1.3 Taxonomic classification or changes in nomenclature:

The red-bellied cooter (*Pseudemys rubriventris*) was originally described by J. LeConte in 1830 as *Testudo rubriventris*, based on a specimen that was collected near Trenton, New Jersey (Mitchell 1994). F. Lucas was the first to recognize the existence of these turtles within the State of Massachusetts in 1869 (USFWS 1994). By 1894, Lonnberg transferred the species to the genus *Pseudemys* where it remains today (Mitchell 1994). Other scientific names previously applied to this species in the literature are *Emys rubriventris, Ptchemys rugosa, Pseudemys rugosa*, and *Chrysemmys rubriventris* (Mitchell 1994). Additional common names include Plymouth turtle, Plymouth terrapin, Plymouth red-belly turtle, and Plymouth red-bellied terrapin (Schmidt 1953).

As discussed in section II.A.4. Babcock (1937) utilized differences in carapace height as a means to differentiate the Massachusetts red-bellied turtles as the distinct subspecies *bangsi*. This distinction was subsequently disputed by Iverson and Graham (1990). Accordingly, Crother (2000) reported that the proper common and scientific name of the endangered population of this species should be referred to as the "Plymouth population of the Northern Red-bellied Cooter, *Pseudemys rubriventris*."

2.3.1.4 Spatial distribution, trends in spatial distribution, or historic range:

The Plymouth red-bellied cooter is restricted to about 20 coastal plain ponds in four towns: Plymouth, Kingston, Carver and Middleborough, within Plymouth County, Massachusetts. Ten of the ponds occur within a 1,500-acre area, and as much as 50% of this northern population occurs in a single privately-owned pond. The majority of all known sites occur on private lands, with less than 10% occurring on state forest and national wildlife refuge system lands. As a direct result of the release of HS hatchling turtles, the number and distribution of the species in Massachusetts has been expanded significantly since listing in 1980. However, the majority of these HS individuals have not reached breeding age, and this northern population of cooters remains restricted to a relatively small number of ponds within one county.

2.3.1.5 Habitat or ecosystem conditions:

The freshwater, coastal plain ponds that provide habitat for the red-bellied cooter are distributed in a narrow band in coastal southeastern Massachusetts and are of

varying size. The ponds form in depressions that are connected hydrologically to the underground aquifer, and thus pond levels rise and fall with the water table. For nesting, the cooter needs sandy soil on uplands surrounding the pond. In Massachusetts, many species that inhabit the coastal plain pond community are globally rare and highly endangered (Barbour *et al.* 1998).

Historically, these ponds occurred in a landscape of pitch pine/scrub oak barrens that periodically burned due to lightning strikes and fires set by Native Americans (Cronon 1983). As a result, the forest and some pond shores were dotted with openings and grasslands, areas where the sun penetrated to the ground absent a forest over story. Sandy openings adjacent to ponds were optimum cooter nesting sites because the sun warmed the eggs during incubation.

Today's landscape around coastal plain ponds in Plymouth County is rural residential, with some ponds having many shoreline homes, such as Island and Boot Ponds and others, such as Federal Pond, where no residential development has occurred. In many cases, commercial cranberry production occurs in close association with these pond habitats. In most cases, the ponds are not connected by surface waters such as streams, thus movement of cooters from one location to another requires movement over land.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

Based on archaeological data, the pre-colonial distribution of this species in Massachusetts extended as far north as Essex County and Middlesex County; as far west as Westborough, Worcester County; and as far south as Martha's Vineyard, Dukes County. It is believed to have become restricted to Plymouth County because of human predation (Rhodin and Largy 1984).

Presently, the two predominant land uses in the general areas within red-bellied cooter habitat are commercial cranberry production and rural residential. Cranberry production is the largest agricultural industry in Plymouth County, Massachusetts. Many aspects of cranberry agriculture are compatible with maintaining the aquatic and nesting habitats used by cooters. For example, the turtles reside in the natural ponds and human-enhanced reservoirs used as the water sources for cranberry bog irrigation and harvest, and they also nest on certain water control structures, such as sandy levees, if the vegetation is managed. However, the cranberry industry is also the single largest water user on Cape Cod and in southeastern Massachusetts (3.5 billion gallons annually) (Barbour *et al.* 1998), and many of the cooter populations in close association with commercial cranberry bog operations are dependent on the same water used by the growers. The sale of agricultural land and conversion of commercial cranberry operations into residential developments is in many ways a greater threat to the cooter because of the increased habitat effects on pond shorelines and

surrounding uplands, increased recreational use of ponds by residents, and threat of mortality due to the increase in vehicular speed and traffic volumes on area roads.

Considered Boston's "south shore," southeastern Massachusetts is now one of the fastest growing regions in the northeastern United States (Cavanagh 2004; Barbour *et al.* 1998), and Plymouth County is in the epicenter of this rapid human population growth. According to the U.S. Census Bureau (2000 and 2006), the human population in Plymouth County increased 4.1% between April 2000 and July 2005; statewide, Massachusetts only increased 0.8% during the same period. Between 1990 and 2000, Plymouth County's human population rose 8.6%, while statewide, Massachusetts grew 5.5%.

Increased residential development and human activity near ponds where red-bellied cooters occur adversely affect this turtle in many ways. In the proposal to list the species (98 FR 21702 1978), habitat modification and vandalism were cited as two primary threats. Another threat identified in the proposed listing was widening of roads. Water withdrawals are necessary to support residential development and may affect the underlying water table and the level of water in coastal plain ponds and associated wetlands (Barbour *et al.* 1998). Cavanagh (2004) notes that many of Massachusetts coastal plain ponds are "being loved to death" due to the universal appeal of pond-shore housing. He notes that many ponds are completely surrounded by dense residential development, resulting in trampling of vegetation, disturbance of basking turtles, and nutrient loading from failed septic systems and lawn fertilizers. Other studies have shown that the populations of certain wildlife species, such as raccoons, striped skunks and red fox, known nest predators of fresh water turtles (Mitchell 1994), increase in rural residential and agricultural landscapes due to the extra food resources found in those areas (Oehler and Litvaitis 1996).

Of the 22-25 ponds that comprise the total range of the Massachusetts red-bellied cooter, only Crooked Pond (Massasoit National Wildlife Refuge) and East Head Pond (Myles Standish State Forest) are entirely within federal and state conservation status. Although East Head Pond is surrounded by state forest, the water rights to the pond are held by an adjacent cranberry grower. In addition, the northern corner of Federal Pond is within state forest land, and part of Gunner's Exchange Pond is in Massasoit Refuge, as is one nesting beach on Island Pond. The majority of cooter pond habitat (>90%) is not in state, federal or conservation ownership.

Periodic wild fires and fire set by indigenous people once set back forest succession and maintained open, sunny areas within southeastern Massachusetts coastal plain forests. When these disturbances occurred along pond shores, they created excellent nesting sites for the cooter. With wild fire suppression, and in the absence of prescribed fire, undeveloped pond shores have become surrounded by closed canopy forests with a dense understory of blueberry and huckleberry. As a result, nesting site quality has declined.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

The cooter is not believed to be a species taken (illegally) for the commercial pet trade in freshwater turtles. Massachusetts red-bellied cooters are protected from take by both the Endangered Species Act of 1973, as amended, and by Massachusetts state law. While vandalism (shooting) of turtles was identified as a threat in the 1978 listing proposal, educational efforts since then are believed to have all but eliminated this threat. In view of the above, overutilization is not believed to be a factor in the decline or recovery of the red-bellied cooter.

2.3.2.2 Disease or predation:

Disease is not believed to be a factor in the decline or recovery of the red-bellied cooter in Massachusetts. However, it is standard procedure for a veterinarian to examine HS turtles after a fall-winter-spring in captivity to ensure they are free of obvious pathology before being released to target ponds.

Predation at certain life stages, however, is an important factor thought to limit this population (Haskell 1993). Once red-bellied cooters reach maturity, they are large turtles (250 to 400 mm, 10-16 inches in total carapace length) and predation is not considered a likely mortality factor. However, cooter eggs and hatchlings are much more vulnerable. Nest predation by raccoons and skunks (USFWS 1994), red fox and coyotes (J. Crane *in litt.* 2005) and crows (Babcock 1938) results in the loss of many nests. At Federal Pond, the largest pond population in Massachusetts, nest predation is thought to approach 100% of unprotected nests in some years at the main nesting location (locally referred to as short dike) (USFWS; MassWildlife unpubl. data).

Predators of newly-emerged red-bellied cooters include the bull frog (Graham 1984) and may also include chain pickerel, largemouth bass, great blue heron and raccoon (Haskell *et al.* 1996; unpubl. USFWS data). The survival rate of non-HS red-bellied cooter hatchlings is not known, however it is believed to be very low. For example, the survival rate of hatchlings of the similarly long-lived fresh water species, Blanding's turtle, is estimated to be as low as 1% (Compton *in litt.* 2006). Of the thousands of marked (shell notched), red-bellied cooter hatchlings that emerged from marked nests and were released directly into their natal pond, very few have ever been encountered again (Graham 1984; T. French, pers. comm.). Because of their much larger size when released, the survival rate of HS cooters is believed to be much greater than non-HS hatchlings, with perhaps as many as 50% reaching sexual maturity (Haskell 1993; Haskell *et al.* 1996).

2.3.2.4 Inadequacy of existing regulatory mechanisms:

In addition to federal listing as endangered and the designation of about 10 ponds and 3,269 acres as critical habitat, the red-bellied cooter is also listed as an endangered species by the Commonwealth of Massachusetts (Mass. General Law, chapter 131 A, and Code of Massachusetts Regulations 321 CMR 10.00). This

state designation prohibits the taking and possession of cooters without a permit. In 1986, an amendment to the Massachusetts Wetland Protection Act (Mass. General Law, chapter 131, sections 40 and 40A), and subsequent regulations (1987), provided relatively strong protection to all the ponds known to be inhabited currently or during the past 25 years by cooters and other state-listed species (French 1990). This amendment provides protection from alteration to ponds occupied by red-bellied cooters, and proposed development that is within the surrounding uplands to a distance of 61 meters (200 feet) (M.G.L. c131A) will require environmental review by MassWildlife's Natural Heritage and Endangered Species program.

The lack of protection to more of the uplands surrounding cooter ponds is a major concern, because turtles sometimes leave the water and traverse uplands in search of nesting sites and occasionally for dispersal to other ponds (Haskell 1993). It is also important because development of the uplands can lead to direct mortality of turtles due to vehicles striking turtles on roads or pet dogs digging up turtle nests. Upland development may have more subtle deleterious effects such as degradation of water quality and displacement of turtles from favored basking and nesting sites by increased levels of human presence.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

The headstarting program is believed to have successfully established or enhanced the population of cooters in many coastal plain ponds (see Table 1), and a small number of HS animals have now been confirmed to be breeding at Federal and East Head Ponds. However, as a recovery action, headstarting is treating the symptoms of high nest predation rates rather than their cause. This approach was undertaken notwithstanding the obvious shortcoming noted above, because managers lack the means and ability to permanently decrease the number of generalist, egg predator species that occur along 20+ coastal plain ponds in Plymouth County, Massachusetts. This is considered infeasible, particularly so given Massachusetts State law, the Wildlife Protection Act of 1996 that prohibits the use of most types of animal traps (e.g., legholds, snares, and Conibear) in the Commonwealth (MassWildlife *in litt.* 2006). In view of the above, high nest predation rates will continue to be a factor limiting the red-bellied cooter population at most ponds.

Federal Pond serves as the near-sole source for all the HS hatchlings used in the effort to increase the number of cooters in Plymouth County and their distribution among area ponds. Federal Pond is used as this source because the breeding population of turtles there is much more robust than in any other pond. However, the little data available on the degree of genetic variability among subpopulations of the cooter in Massachusetts (Haskell 1993) suggest that there is less heterozygosity of sampled allozymes within Federal Pond turtles than within Island Pond, another pond population nearby. Therefore, it is possible that the vast majority of cooters in the Massachusetts population today (Federal Pond cooters and virtually all of the HS animals released in other ponds) may be genetically less diverse, and possibly less fit, than the non-HS turtles present in

the ponds. In addition, because most Massachusetts coastal plain ponds in which red-bellied cooters reside are groundwater or spring-fed and are not interconnected by surface waters or streams, there may be little interchange of turtles between pond populations. The paucity of gene flow between pond populations may be detrimental to the persistence of the species in Massachusetts if some populations have limited ability to respond to a new disease, environmental stresses, or other challenges. Similarly, with minimal movement of animals between ponds, there is limited opportunity for dwindling populations to be "rescued" by immigration. An additional factor is the likelihood that many of the HS turtles released during a multi-year period, from 1985-1998, are likely to be males. For example, Boot Pond received 66 HS hatchlings from 1987-1991 and Graham and Graham (2001) found that 72% that were captured there in 2001 were males. Thus, the effective population size (the number of animals contributing gametes) of ponds receiving these HS cooters is much less than if the sex ratio of headstarts was 1:1.

Given that the Plymouth County, Massachusetts, population of the red-bellied cooter is a northern outlier of what is otherwise a mid-Atlantic to southern coastal occurring species, warming of the earth's climate could have several effects on the northern population. Warmer weather in spring and summer may provide more favorable conditions for Massachusetts turtles to bask, feed and nest. Hatching success (absent predation) may be higher during warmer summers and a more equal sex ratio of hatchlings could result. On the other hand, the ranges of other species will be similarly influenced to some degree and new competitors, pathogens, and introduced invasive species (e.g., an aquatic plant that out-competes native cooter plant foods) could become established.

2.4 Synthesis

The Massachusetts population of the northern red-bellied cooter is now moderately more numerous and is distributed in more ponds than when it was listed in 1980. Most numerical and distributional gains have been accomplished through the rearing and release of more than 2,700 HS hatchling turtles during the period 1984-present. However, because the HS program only addresses the population limiting factors of high egg and hatchling predation rates symptomatically, it does not ensure that the population will be able to sustain itself over the long term.

Increasing turtle numbers alone will not prevent a population from declining, because survivorship, reproductive output, and growth all contribute to the maintenance of viable populations (Crouse *et al.* 1987 in Haskell 1993). With the best data available at the time, modeling by Haskell (1993) suggested that a stable or slowly increasing cooter population in Massachusetts may occur only under optimal feasible conditions. Haskell cautioned against using headstarting as a singular long-term strategy in sustaining Massachusetts cooters, suggesting instead that research to identify—and management to mitigate—the mortality factors of hatchling and juvenile turtles is clearly needed.

Coastal plain pond shore communities are vulnerable to several immediate and long-term threats caused by human activities. Withdrawal of surface water and ground water can

affect the water level in ponds and influence both aquatic fauna and the shoreline plant community. Demand for freshwater increases in direct proportion to residential growth, which has been "explosive" on Cape Cod and in Plymouth County (Barbour *et al.* 1998). As residential development along pond shores increases, water-based recreation on the ponds increases, and shy turtles such as the cooter are displaced from favored basking and nesting sites. Also, as pond shores become inhabited, wildfire suppression becomes a necessity and the opportunity to use prescribed fire as a management tool is lost. Undeveloped portions of the shorelines then become closed canopy forest, and nesting habitats open to the sun that are favored by the cooter become scarce. The use of shaded nesting sites prolongs incubation, resulting in an increase in the likelihood of nest predation and the tendency for hatchling sex ratios to be skewed toward males.

Thus, loss and alteration of habitat remains a serious threat to the red-bellied cooters in Massachusetts. Human population growth in Plymouth County has resulted in direct and indirect effects on the cooter population there, and only the regulatory protections in place through the federal Endangered Species Act and the Massachusetts Endangered Species and Wetlands Protection Acts have prevented further habitat losses. Protection of habitat through conservation acquisition has occurred only on a very limited scale.

The cooter presents a special case where the original taxonomic basis for listing the subspecies in 1980 has changed, but a contemporary review of information on the discreteness, significance, and status of the Massachusetts population supports the retention of this population as an endangered DPS.

3. RESULTS

3.1 Recommended Classification

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
____ No change is needed
__X_ Other

The findings of this review support retention of the red-bellied cooter (*Pseudemys rubriventris*) in Massachusetts on the list of threatened and endangered species through an amended listing that identifies this population as an endangered DPS. This finding is supported by the Service's review of the best information available and by the following agencies and individuals that commented on the Service's 90-day notice to delist the species (191 FR 58363): State of Massachusetts, Endangered Species Natural Heritage Program (French *in litt.* 2006); University of Massachusetts - nine herpetologists and ecologists associated with the Natural Resources Department and other agencies (Compton *in litt.* 2006); the Massachusetts Chapter of The Nature Conservancy (Bowden *in litt.* 2006); Dr. Terry Graham, who researched these animals for nearly 40 years (Graham *in litt.* 2006); Dr. Sylvia Fallon, Conservation Genetics Fellow, National Resource Defense Council, *in litt.* (2006); and John Crane, environmental consulting biologist currently working with the species in Plymouth County, Massachusetts, *in litt.*

(2006). None of the comments received by the Service during the comment period on the 90-day notice of petition finding supported delisting the species.

3.2 New Recovery Priority Number: 9, unchanged from current RPN.

3.3 If a reclassification is recommended, indicate the Listing and Reclassification Priority Number: N/A

4. RECOMMENDATIONS FOR FUTURE ACTIONS

- Protect through fee acquisition, conservation easement, purchase of development rights or any other means, the most important pond shore habitats supporting the species in Plymouth County.

- Conduct population estimate surveys of selected ponds and rivers, such as Federal Pond, Assawompsett Pond, East Head Pond, Great South Pond, Hoyts-Gunners Exchange Pond, Island Pond, Sampson Pond, and the Nemasket and Weweantic Rivers. These waters are likely to support the greatest number of cooters in the Massachusetts population and have not been recently surveyed.

- Prioritize and conduct basking site and nest site enhancement activities at ponds supporting the largest cooter populations.

- Utilize the survival data provided in Table 2 to review the number of released turtles through the HS program and supplement selected ponds as appropriate.

- Conduct research and identify if feasible means to mitigate high nest/egg and hatchling predation rates can be implemented.

- Develop a monitoring plan that will efficiently track the status of the population both during the process of recovery and post-delisting.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Pseudemys rubriventris,* northern red-bellied cooter

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:
Retain as endangered but amend listing to identify Plymouth County, Massachusetts, population as a DPS.

Appropriate Listing/Reclassification Priority Number, if applicable: N/A

Review conducted by:
Michael Amaral, New England Field Office
Celine Goulet, graduate student University of New Hampshire Lloyd Gamble, graduate student, University of Massachusetts, and Meredith Bartron and Shannon Julian, USFWS Northeast Fishery Center Conservation Genetics Lab, made significant contributions to this review.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date_____

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve Thomas J. Healy Acting Date 9.10.07

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Pseudemys rubriventris*, northern red-bellied cooter

Current Classification: Endangered

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Celine Goulet, graduate student University of New Hampshire, Lloyd Gamble, graduate student, University of Massachusetts, and Meredith Bartron and Shannon Julian, USFWS Northeast Fishery Center Conservation Genetics Lab, made significant contributions to this review.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 3/12/07

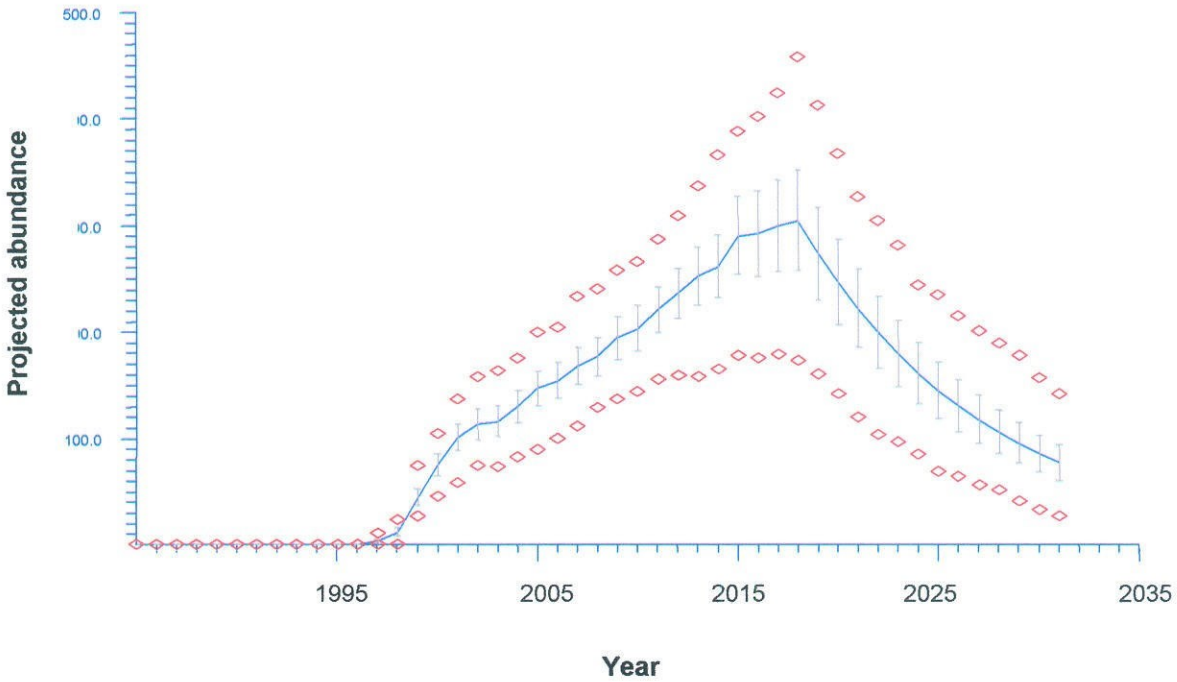
REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

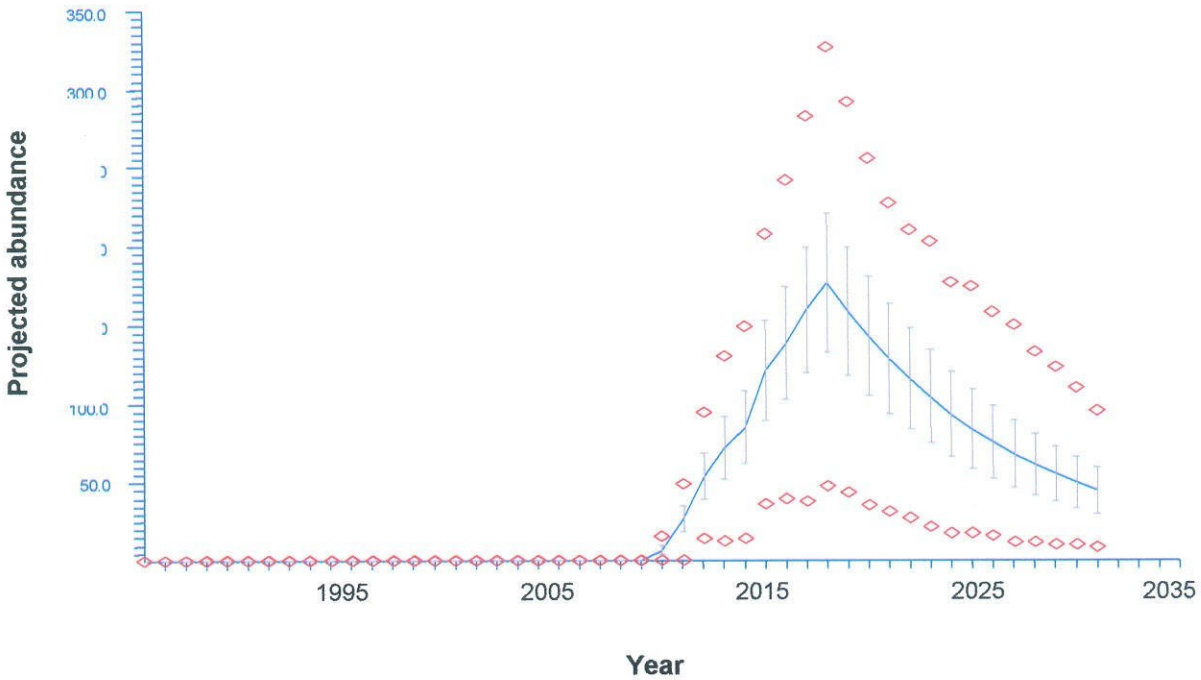
Approve_____ Date_____

APPENDICES

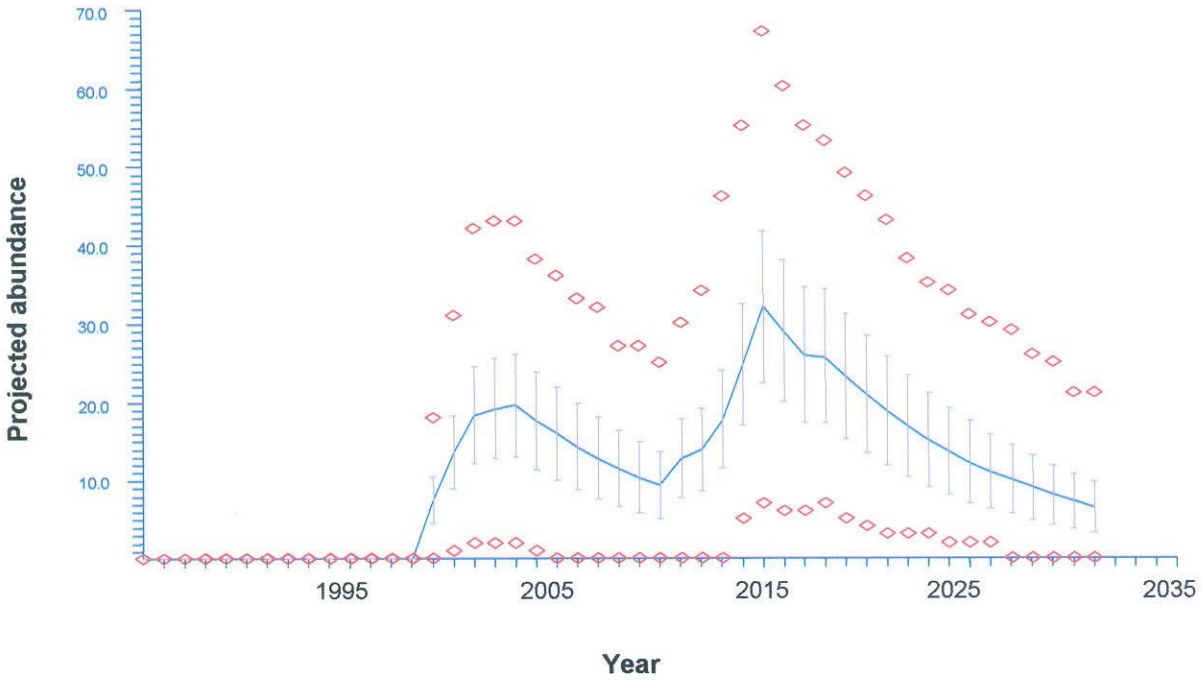
Appendix A. Estimated HS Population Size Projections (including breeding age adults only) for All Ponds Combined. Bars depict +/- 1 STD and diamonds show min and max values from all iterations.



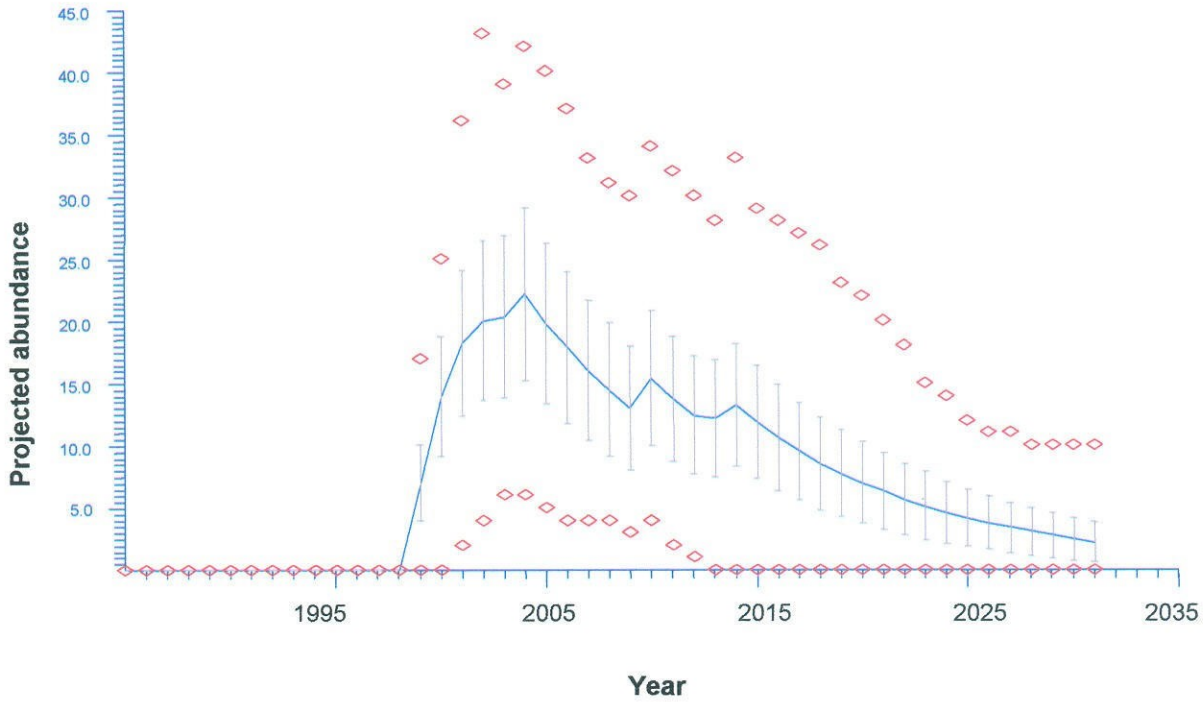
Appendix B. Estimated HS Population Size Projections (including breeding age adults only) for AGLP Complex. Bars depict +/- 1 STD and diamonds show min and max values from all iterations.



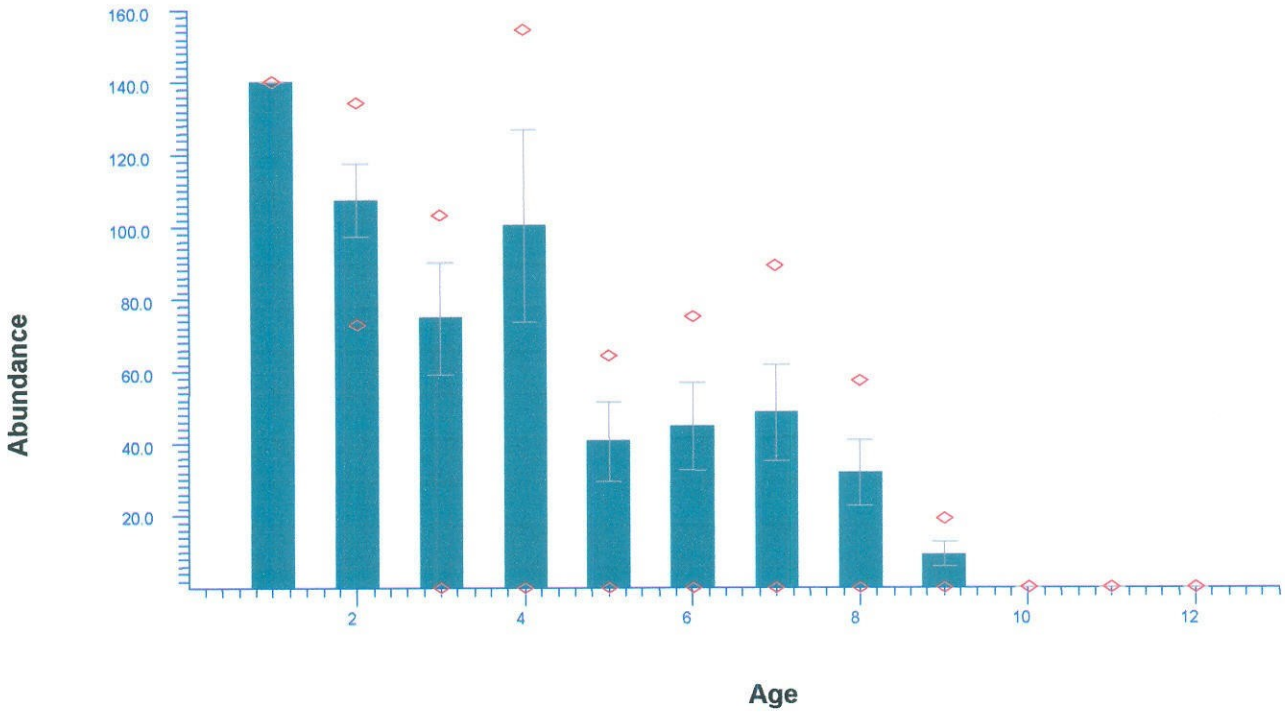
Appendix C. Estimated HS Population Size Projections (including breeding age adults only) for East Head Pond. Bars depict +/- 1 STD and diamonds show min and max values from all iterations.



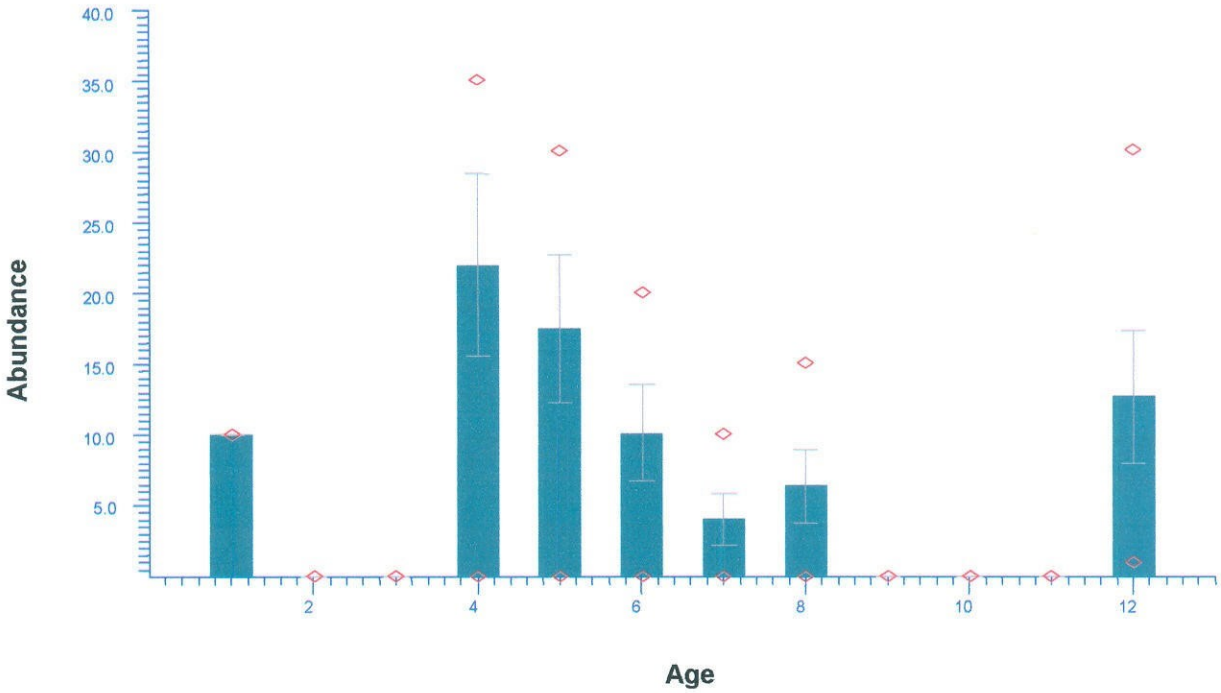
Appendix D. Estimated HS Population Size Projections (including breeding age adults only) for Federal Pond. Bars depict +/- 1 STD and diamonds show min and max values from all iterations.



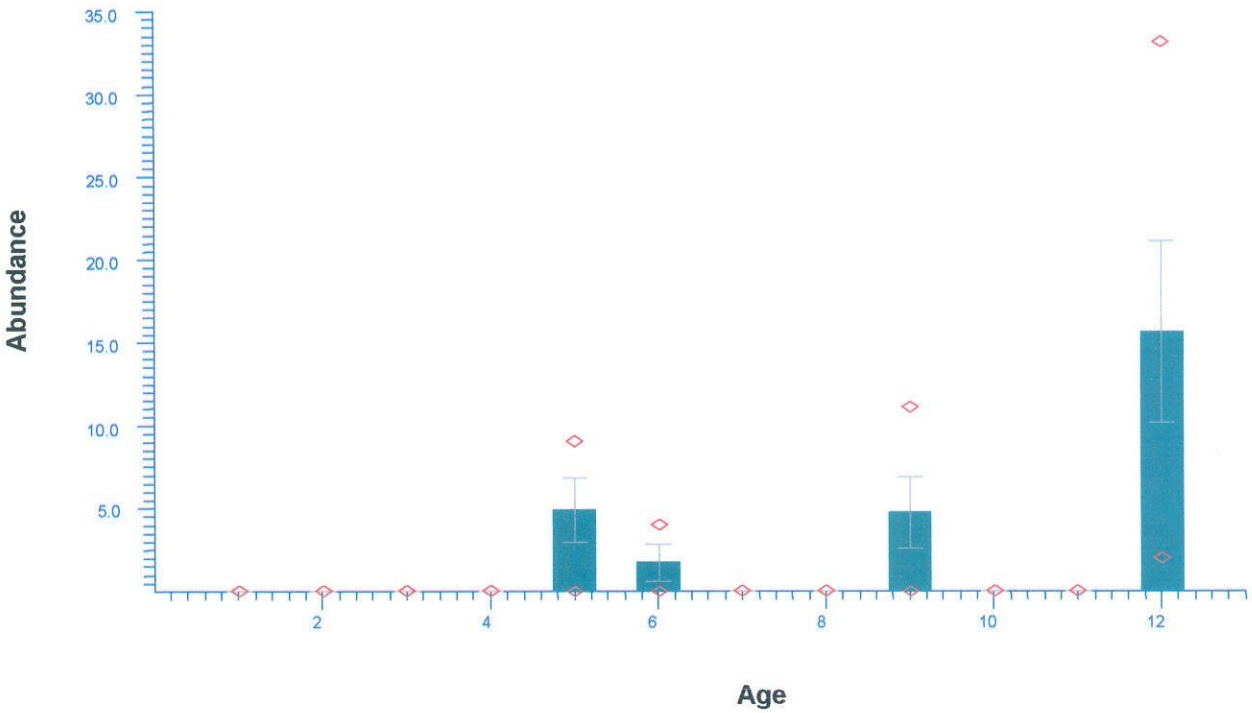
Appendix E. Estimated HS 2007 Age Structure for AGLP Complex. Bars depict +/- 1 STD and diamonds show min and max values from all iterations. Age 12+ individuals are pooled.



Appendix F. Estimated HS 2007 Age Structure for East Head Pond. Bars depict +/- 1 STD and diamonds show min and max values from all iterations. Age 12+ individuals are pooled.



Appendix G. Estimated HS 2007 Age Structure for Federal Pond. Bars depict +/- 1 STD and diamonds show min and max values from all iterations. Age 12+ individuals are pooled.



Appendix H. Assumptions and Limitations of the HS Survival Model.

Assumptions and Limitations:

Numerous assumptions pertain to the survival projections presented. They include:

- Estimates pertain to headstarted turtles only.
- The accuracy of projections depends on how well the estimates for survival and their associated levels of variability reflect reality. Data for parameter estimates were collected primarily from 1984 to 1988 and are applied to the period from 1985 to 2026.
- No potential deleterious effects of catastrophes (e.g., extraordinarily bad survival years) or inbreeding depression were incorporated.
- Size-specific variability in survival of headstarts was not incorporated.
- All individuals were assumed to reach potential sexual maturity at age 12.
- Males and females were not distinguished in the models.
- Year-to-year variation in survival was represented by randomly drawing from a lognormal distribution with parameter estimates listed above. The lognormal distribution was used to minimize truncation bias from parameters that approach a (0,1) boundary.