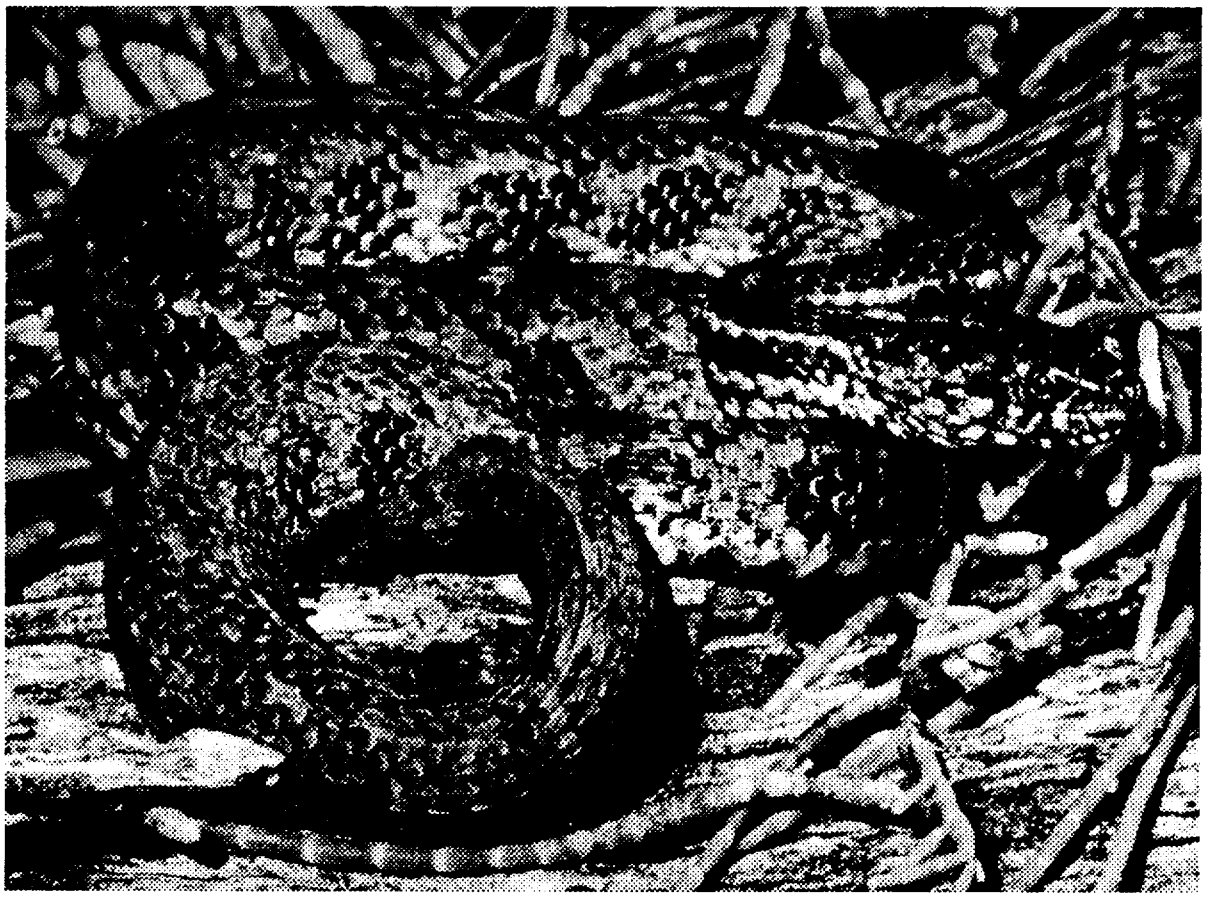
RECOVERY PLAN

Atlantic Salt Marsh Snake

(Nerodia clarkii taeniata)



U.S. Fish and Wildlife Service

RECOVERY PLAN FOR THE

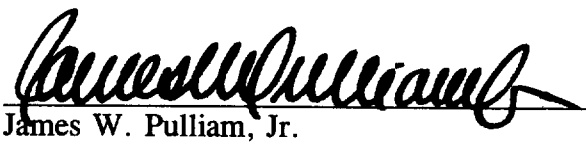
ATLANTIC SALT MARSH SNAKE
(Nerodia clarkii taeniata)

Prepared by

U.S. Department of the Interior
Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

with assistance from

Paul E. Moler
Florida Game and Fresh Water Fish Commission
Wildlife Research Laboratory
Gainesville, Florida

Approved: 

James W. Pulliam, Jr.
Regional Director, U.S. Fish and Wildlife Service

Date: December 15, 1993

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Literature Citations should read as follows:

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EXECUTIVE SUMMARY

Current Status: The Atlantic salt marsh snake is listed as a threatened species and is restricted to the salt marshes of Volusia, Brevard, and possibly Indian River Counties, Florida.

Habitat Requirements and Limiting Factors: The Atlantic salt marsh snake (*Nerodia clarkii taeniata*) inhabits brackish coastal marshes predominantly vegetated with glasswort (*Salicornia* spp.) and salt grass (*Distichlis spicata*). Black mangrove (*Avicennia germinans*) is typically present but not predominant. To the south, as mangroves become more prevalent, the Atlantic salt marsh snake is replaced by the conspecific mangrove water snake *(N. clarkii compressicauda)*.

Recovery Objective: Delist the Atlantic salt marsh snake when recovery criteria are met.

Recovery Criteria: This snake may be considered for delisting if (1) there is no evidence of significant genetic introgression (genetic exchange limited to a very narrow hybrid zone) from the Florida banded water snake (*Nerodia fasciata pictiventris*) into adjacent populations of the Atlantic salt marsh snake (*Nerodia clarkii taeniata*), (2) adequate habitat protection is maintained, and (3) self-sustaining populations of 100-200 adult snakes at each of 10 secure, discrete sites are established throughout Volusia County. These numerical goals are subject to revision as more information becomes available on the biology of the Atlantic salt marsh snake.

Actions Needed:

1. Conduct basic ecological studies.
2. Determine and map distribution.
3. Identify habitat protection measures.
4. Conduct taxonomic assessment.
5. Determine relative abundance within occupied habitats.
6. Determine extent of genetic introgression.
7. Develop a contingency plan for catastrophic events.
8. Disseminate information about Atlantic salt marsh snakes.

Costs ($000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Need 7	Need 8	Total
FY1	25	15	8	5		4			57
FY2	25	15		5		3			48
FY3		10		7			2		19
FY4				2	10			6	18
FY5	—	—	—	—	10	—	—	—	10
Total	50	40	8	19	20	7	2	6	152

Date of Recovery: Delisting should be initiated in 2000 if recovery criteria are met.

RECOVERY PLAN OUTLINE

I. INTRODUCTION

Description

The Atlantic salt marsh snake (*Nerodia clarkii taeniata*) was listed as a threatened species on November 29, 1977 (U.S. Fish and Wildlife Service 1977). It was described by E. D. Cope in 1895 as a subspecies of the mangrove water snake, *Natrix compressicauda* (New World water snakes are now assigned to the genus *Nerodia*). It has a complex taxonomic history which is addressed in the next section.

There are three subspecies of salt marsh snakes, the Gulf salt marsh snake (*Nerodia clarkii clarkii),* mangrove water snake (*N. c. compressicauda*), and Atlantic salt marsh snake (*N. c. taeniata*). Their dorsal patterns are formed from a basic pattern of four rows of dark blotches running from head to tail (two lateral and two dorsolateral rows) on a lighter background. In the striped forms, the blotches fuse linearly to form stripes; in the banded forms, the blotches fuse across the back to form bands. In partially striped individuals, it is invariably the anterior portion of the body that is striped, with the pattern posteriorly consisting of bands or rows of unfused blotches. The lateral stripes have a greater tendency than do the dorsolateral stripes to break down posteriorly into rows of blotches. The Gulf salt marsh snake (*Nerodia clarkii clarkii*) has a dorsal pattern that is completely striped, or nearly so, with dark brown to black stripes on a tan background. It is not unusual for the lateral stripes in this form to break down posteriorly into rows of blotches. The mangrove water snake (*N. clarkii compressicauda*) may be uniformly orange in color, but it more often has a pattern of dark bands on a lighter background. Individuals from throughout the range of the mangrove water snake may be partially striped; in these specimens the striping is typically limited to the neck region, but occasional specimens may be more extensively striped. Coloration in the mangrove water snake is extremely variable, with the background being gray, straw, or reddish and the bands being black, brown, or red. Populations of mangrove water snakes characteristically include at least some individuals that exhibit reddish or orange pigmentation.

The Atlantic salt marsh snake (*N. c. taeniata*) is a partially striped salt marsh snake that reaches a maximum length of at least 82 cm (32 in.), although it is typically less than 65 cm (26 in.) in length. The pattern consists of a gray to pale olive background with black to dark brown stripes anteriorly, the stripes breaking up into rows of spots posteriorly. The extent of the striping is variable, but most individuals from the coastal marshes of Volusia County are striped on at least the anterior 30 percent of the body. The venter is black with a central row of large cream to yellowish spots. As in the case of the dorsal striping, this ventral pattern is best developed anteriorly and tends to break down posteriorly. The red pigmentation characteristic of mangrove water snakes is conspicuously lacking in Atlantic salt marsh snakes from the vicinity of Edgewater, Volusia County, and northward (i.e., the area from which the form was described).

Hebrard (1979) reported coloration for 23 specimens from the southern Indian River Lagoon, near the Volusia-Brevard county line. Of these, 7 (30 percent) exhibited orange or reddish pigmentation either dorsally or ventrally. It is unclear at this time whether the reddish pigmentation reported by Hebrard should be interpreted as indicating intergradation with the

mangrove water snake. The series of 25 specimens for which Hebrard provided pattern descriptions had dorsal stripes on 0 to 100 percent of the body; only 8 (32 percent) had dorsal stripes on more than 30 percent of the body, but 3 (12 percent) reportedly had dorsal stripes on 100 percent of the body. (In terms of pattern formation, the vertebral stripe is actually the lighter background color which is visible between the two dark, dorsolateral stripes.)

There are several characters of morphology and color pattern that distinguish the salt marsh snakes from the related freshwater species of *Nerodia*, but one of the most reliable is the number of dorsal scale rows. The salt marsh snakes have the dorsal scales in 21 rows at midbody, whereas the freshwater banded water snake has the scales in 23 rows. Also, those populations of salt marsh snakes that are at least partially striped are easily distinguished from the freshwater form, which is completely banded.

Taxonomy

The Atlantic salt marsh snake has a complex taxonomic history, having been known under various combinations of generic, specific, and subspecific names. The North American water snakes were long included within the genus *Natrix*, but Rossman and Eberle (1977) restricted that genus to Eurasia and erected the genus *Nerodia* to include many of the North American species previously included within *Natrix*.

At the species level, the salt marsh snakes have at various times been treated as a separate species or as subspecies of two related freshwater species. Both the Gulf salt marsh snake (*Nerodia clarkii clarkii*) and the mangrove water snake (*N. clarkii compressicauda*) were initially described as separate species. Based at least partly on reports of hybrids between *N. c. clarkii* and the freshwater broad-banded water snake (*N. fasciata confluens*), Clay (1938) reduced the salt marsh snakes to subspecies of *N. sipedon*, a name that at the time applied to all of the banded water snakes of eastern North America. Subsequently, Conant (1963) elevated the subspecies of *N. fasciata* to species status to include the three salt marsh snakes and the three southern freshwater subspecies: *N. f. fasciata*, *N. f. confluens*, and *N. f. pictiventris*. At the time that the Atlantic salt marsh snake was listed as threatened, it was regarded as a subspecies of the southern water snake, *N. fasciata* (fide Conant, 1963). More recently, Lawson et al. (1991) conducted an extensive electrophoretic analysis of the *N. fasciata* - *N. clarkii* complex, including specimens from three hybrid swarms. They found no genetic introgression between the salt marsh snakes and the adjacent freshwater snakes and concluded that the salt marsh snakes warrant recognition as a separate species, *N. clarkii*. Hence, the appropriate name for the Atlantic salt marsh snake is now *Nerodia clarkii taeniata*.

At the subspecific level, the Atlantic salt marsh snake has alternately been treated as a separate subspecies or synonymized with the mangrove water snake. It was described by Cope (1895) as *Natrix compressicauda taeniata*, a subspecies of the mangrove water snake. It was synonymized with *N. compressicauda* by Barbour and Noble (1915), but then resurrected as a separate subspecies by Carr and Goin (1942). Dunson (1979) again

proposed that *taeniata* should be relegated to synonymy with *compressicauda,* although he never examined any specimens of *taeniata* nor visited the *taeniata* localities. The form that the U.S. Fish and Wildlife Service (Service) listed as threatened is the Atlantic salt marsh snake, *Nerodia fasciata taeniata* (now *N. clarkii taeniata*).

The taxonomic status of the Atlantic salt marsh snake will remain controversial until a thorough, rigorous systematic assessment is conducted. The Endangered Species Act (Act) defines the term species as including ". . . any subspecies of fish or wildlife or plants, and any distinct population or segment of any species or vertebrate fish or wildlife which interbreeds when mature." Final resolution of the taxonomic status of the Atlantic salt marsh snake will provide further insight into proper management but continued protection under the Act appears justified whether it remains a distinct subspecies or a distinct population. Regardless of its taxonomic status, the Atlantic salt marsh snake is a relict of historical and/or ecological processes unique to Florida and should be preserved (Kochman 1992).

Distribution

The species to which the Atlantic salt marsh snake belongs, *N. clarkii*, is found in a narrow coastal strip from southern Texas, east along the Gulf coast, around the Florida peninsula, and up the east coast of Florida at least as far as the Halifax River, Volusia County. It is also known from the north coast of Cuba (Jaume 1974).

The threatened designation applies only to the Atlantic salt marsh snake, *N. c. taeniata* (Figure 1). Both Cope's (1895) type series and the specimens used by Carr and Goin (1942) to resurrect *N. c. taeniata* came from the brackish coastal marshes of Volusia County, Florida. There is some uncertainty about the precise locality from which Cope's specimens came, but Carr and Goin restricted the type locality to the vicinity of National Gardens, which lies near the north end of the Halifax River. Salt marsh snakes have not been documented to the north in southern Flagler County. The Carr and Goin series was collected on the barrier island at New Smyrna Beach. Recent records for populations identifiable as Atlantic salt marsh snakes are available from (1) the barrier island a short distance north of Ponce Inlet, (2) the mainland shoreline east of the New Smyrna Beach airport, (3) two localities on the barrier island at New Smyrna Beach (Florida Game and Fresh Water Fish Commission (FGFWFC) records), (4) an island in the Indian River east of Edgewater (G. Goode, East Volusia Co. Mosquito Control, pers. comm.) and (5) a single specimen identified as *N. c. taeniata* was captured just south of the Flagler County line (G. Goode pers. comm.). It is not known if a viable population exists in this area or to the north in Flagler County but if so, these Atlantic salt marsh snakes are now isolated from populations in the northern Indian River Lagoon by the Ormond Beach-Daytona metropolitan area.

A problem attendant to the listing of any subspecies that is distributionally continuous and intergradient with another subspecies is the difficulty of defining the limit(s) of the listed form's distribution in the area where it contacts the related, unlisted subspecies. To the

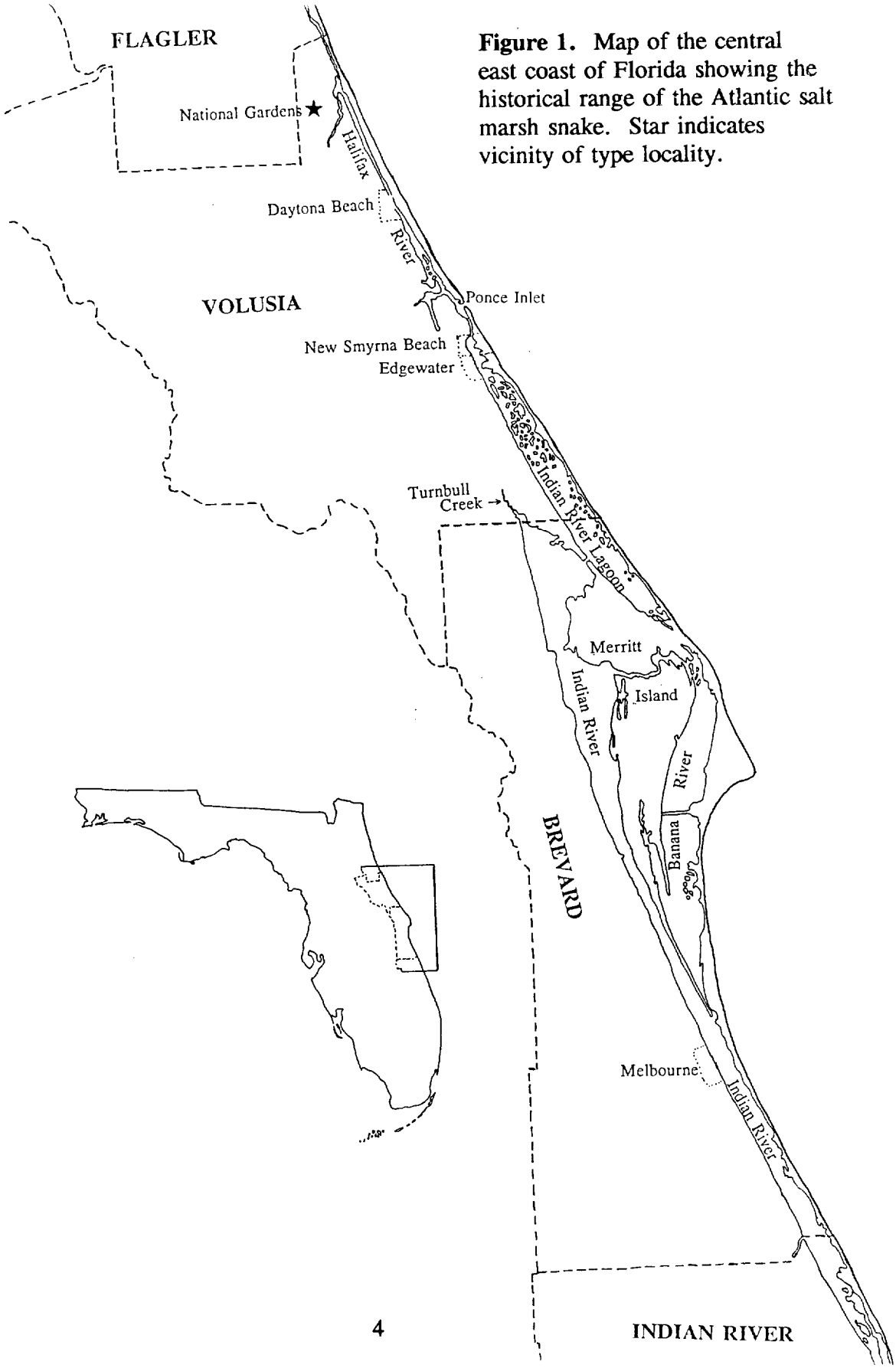

Figure 1. Map of the central east coast of Florida showing the historical range of the Atlantic salt marsh snake. Star indicates vicinity of type locality.

south, the Atlantic salt marsh snake intergrades with the mangrove water snake along the central Atlantic coast of Florida. As noted above, both the description and the resurrection of the subspecies were based on specimens from Volusia County, although Carr and Goin (1942) considered a single specimen from Indian River County also to be *N. c. taeniata*. They also mentioned a specimen of salt marsh snake from Melbourne, Brevard County, but did not indicate whether they considered that specimen to be *N. c. taeniata*. Wright and Wright (1957) considered *N. c. taeniata* to extend only as far south as the lower end of Mosquito Lagoon, in northern Brevard County, and Neill (1958) indicated that *N. c. taeniata* intergraded with the mangrove water snake on Merritt Island. In the final listing of the Atlantic salt marsh snake (FR 42:60743-60745), the Service indicated that "The Atlantic salt marsh snake is known only from coastal areas of Brevard, Volusia, and Indian River counties." However, Hebrard and Lee (1981) examined a large series of salt marsh snakes from southern Mosquito Lagoon near the Volusia-Brevard county line and reported that they "resembled *Nerodia fasciata compressicauda* quite closely." Hebrard and Lee further noted that their specimens differed markedly in coloration and pattern from specimens of *N. c. taeniata* from further north in Volusia County. It is also worth noting that the snakes examined by Hebrard and Lee were collected in mangroves (species not indicated), whereas only about 10 miles farther north, where populations of typical Atlantic salt marsh snakes are found, the habitat consists primarily of glasswort (*Salicornia* spp.) flats and salt grass (*Distichlis spicata*)-bordered tidal creeks with only scattered black mangroves (*Avicennnia germinans*). The zone of intergradation appears to coincide with the increasing dominance of mangrove swamps, eventually as mangrove swamps become predominant so does *N. c. compressicauda*. Kochman (1992) concluded that "salt marsh snakes from farther south in Brevard and Indian River counties, although occasionally striped, appear to comprise a zone of intergradation with *N. c. compressicauda*."

Until a survey and taxonomic assessment have been conducted, it will not be possible to determine the southern distributional limit of the Atlantic salt marsh snake. Nonetheless, it appears that the subspecies may be restricted to the brackish, coastal marshes of Volusia County, from the Halifax River south to the northern portions of the Indian River Lagoon.

Habitat

Atlantic salt marsh snakes are restricted to brackish, tidal marshes. They most often have been found in association with saltwort flats and salt grass-bordered tidal creeks. It is not known if they occur in the adjacent black needlerush (*Juncus roemerianus*) habitat. Atlantic salt marsh snake use of marsh habitats may be limited by water level; with extreme fluctuations making the marsh too hydric or xeric (G. Goode pers. comm.). When inactive or pursued, they frequently retreat into one of the numerous fiddler crab (*Uca pugilator*) burrows that riddle the edge of the marsh and the banks of the tidal creeks (Carr and Goin 1942, Kochman 1992, P. Moler pers. obs.).

Life History/Ecology

Although the Atlantic salt marsh snake is most easily observed at night, it may be active at any time of day. Its activity is influenced by tidal cycles, which strongly influence the

availability of food (Neill 1958). Although Carr and Goin (1942) indicated that all of their specimens were collected "just as the tide was beginning to overflow the flats," Kochman (1992) indicated that it was observed most often "during low tidal stages, when it apparently feeds on small fishes that become trapped in the shallow water." It feeds primarily on small fish, but it readily takes frogs when available.

This species is ovoviviparous. Captive individuals have given birth to 3 to 9 young from August to October (Kochman 1992). Fecundity is low relative to the adjacent freshwater species, *N. fasciata*, which may give birth to 50 or more young.

Most snakes adapted to life in salt water (families Hydrophiidae, Achrocordidae, and Homalopsidae) possess salt glands, through which they excrete excess salts (Dunson 1975). The salt marsh snakes apparently lack salt glands (Schmidt-Nielsen and Fange 1958), but they nonetheless exhibit very low dehydration rates in seawater (Pettus 1963, Dunson 1978, 1980). Salt marsh snakes are apparently able to survive in seawater through their reduced rates of cutaneous water and salt exchange and their refusal to drink seawater even when they become dehydrated. By contrast, when held in seawater, their freshwater congeners quickly become dehydrated, which prompts them to drink. This merely exacerbates their dehydration and leads to death (Pettus 1963). Salt marsh snakes readily drink fresh water when it becomes available from rain or dew (Kochman 1992).

Reasons for Listing

The Atlantic salt marsh snake was listed on the basis of two primary concerns, intensive drainage and development in coastal salt marshes resulting in loss of habitat and the accompanying disruption of reproductive isolating mechanisms, leading to hybridization with the Florida banded water snake and potential swamping of the Atlantic salt marsh snake gene pool by the much larger Florida banded water snake gene pool.

At the time of its listing, the Atlantic salt marsh snake was thought to include salt marsh snakes as far south as Indian River County (U.S. Fish Wildlife Service 1977). As suggested above, it may actually be much more restricted, occurring only in the brackish, coastal marshes of Volusia County. If so, then given its highly restricted distribution, the Atlantic salt marsh snake's vulnerability to habitat destruction and modification is even greater than previously realized.

It is well known that salt marsh snakes occasionally hybridize with the closely related freshwater species, *Nerodia fasciata*, especially in areas of habitat disturbance (Kochman 1977, Dunson 1979, Lawson et al. 1991). Lawson et al. (1991) demonstrated that, despite the reproductive compatibility of the two forms, there appears to be little or no genetic introgression between them in areas of undisturbed habitat. The extent of genetic introgression associated with the local breakdown of reproductive isolation between the two species has not yet been examined.

Rising sea levels are not an immediate threat but in the long term may reduce the amount of habitat available to the Atlantic salt marsh snake. As sea levels rise, salinity in the estuaries will also rise correspondingly and possibly change the vegetation of the marsh, eventually flooding the area and making it inhospitable for the snake.

Conservation Measures

Conservation measures have consisted of limited survey work, genetic comparison with other salt marsh snakes and southern banded water snakes, use of the provisions under Section 7 of the Act, Section 404 of the Clean Water Act (CWA), and the Fish and Wildlife Coordination Act (FWCA), and proposals for creation of habitat to mitigate for areas impacted by permitted dredge-and-fill activities.

Sporadic surveys conducted from 1978 to 1988 by personnel of the FGFWFC and the Service confirmed the continued presence of the Atlantic salt marsh snake at several localities in Volusia County, Florida. Personnel of the East Volusia County Mosquito Control District are currently conducting surveys for Atlantic salt marsh snakes associated with mosquito control impoundments on islands in the northern portions of the Indian River Lagoon (G. Goode pers. comm.). A survey was conducted on Merritt Island National Wildlife Refuge in the late 1970's, and a large population of salt marsh snakes was identified in the vicinity of the Volusia-Brevard county line, but this population seemed to show signs of intergradation with the mangrove water snake (Hebrard and Lee 1981).

Localities in the vicinity of New Smyrna Beach were sampled by FGFWFC for genetic studies (Lawson et al. 1991). Electrophoretic analyses indicated that the salt marsh snakes are closely related to but specifically distinct from the southern banded water snake (*Nerodia fasciata*), and that the three subspecies of the salt marsh snake are electrophoretically indistinguishable from each other (Lawson et al. 1991). Tissues were saved for possible comparison of mitochondrial DNA variation in the salt marsh snakes, but that work has not yet been performed.

The Atlantic salt marsh snake is protected as a threatened species under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). The Act places an affirmative mandate on Federal agencies to carry out programs for the conservation of federally listed endangered and threatened species. Further, the Act requires all Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of any federally listed endangered or threatened species. Federal agency actions that can directly or indirectly affect endangered or threatened species include any activity that is authorized, funded, or carried out by such agency. Compliance with theses standards is ensured under Section 7 of the Act because agencies must consult with the Service or National Marine Fisheries Service on actions that may affect listed species or critical habitat.

In addition to Section 7 consultations, protection and conservation of salt marsh habitat is provided by CWA and FWCA. The Service and U.S. Army Corps of Engineers review proposed dredge-and-fill activities and construction projects in waters of the United States

where projects may affect the Atlantic salt marsh snake or its habitat. During a 10-year period (1983-1992) a minimum of 36 various projects were permitted in Volusia County's salt marsh habitat. These projects included dredge-and-fill, shoreline protection projects, construction of piers and marinas, mosquito ditching, and water control structures. However, only 32 acres of salt marsh were destroyed by these projects, most (29.44 acres, 18 projects) before 1988. Loss of salt marsh habitat appears to have slowed since 1988 (2.56 acres, 18 projects) indicating improved protection. If the Atlantic salt marsh snake is limited to Volusia County, any project destroying salt marsh habitat may be detrimental to the species.

II. RECOVERY

A. Objective and Criteria

Atlantic salt marsh snakes are restricted to brackish, tidal marshes primarily composed of saltwort flats and salt grass-bordered tidal creeks. Historically, this habitat probably represented a small portion of the salt marsh and changed periodically from recurring tropical storms. However with development of Florida's Atlantic coast, habitat has been permanently lost. This development, coupled with narrow habitat flexibility and a limited range (primarily Volusia County), has resulted in reduced populations of Atlantic salt marsh snakes.

At the time of listing, habitat loss was cited as a threat to the Atlantic salt marsh snake. Current habitat protection appears to be adequate under existing regulatory mechanisms and habitat loss must remain at or below current levels for the near future to aid in recovering this snake. Additionally, to avoid risks of genetic and/or catastrophic events, an attempt should be made to establish self-sustaining populations throughout the subspecies range.

The recovery goal for the Atlantic salt marsh snake is to delist it. Delisting can be considered if the following conditions are met:

1. If there is no evidence of significant genetic introgression (genetic exchange limited to a very narrow hybrid zone) from the Florida banded water snake (*Nerodia fasciata pictiventris*) into adjacent populations of the Atlantic salt marsh snake (*Nerodia clarkii taeniata*).

2. Maintain adequate habitat protection and maintain habitat loss at or below current levels for the next 5 years.

3. Establish self-sustaining populations of 100-200 adult snakes at each of 10 secure, discrete sites dispersed throughout Volusia County. These numerical goals are subject to revision as more information becomes available on the biology of the Atlantic salt marsh snake.

4. These populations should be monitored for at least 5 years before considering delisting. If delisted, these populations will continue to be periodically monitored as required by the Act.

B. Narrative Outline for Recovery Actions Addressing Threats

1.0 Conduct basic ecological studies of the Atlantic salt marsh snake population in the northern Indian River Lagoon of Volusia County. A better understanding of the basic ecology of the Atlantic salt marsh snake is needed to assure that management decisions are based on a full knowledge of the species' requirements. Specific information is needed on home range size and habitat requirements, population

density, movements and activity patterns, and minimum area needed for a viable population.

2.0 Determine and map distribution of the Atlantic salt marsh snake. Surveys of suitable habitats in Volusia, Brevard, and Indian River counties will determine the extent of suitable habitat that is occupied and the distributional limits of the Atlantic salt marsh snake. Surveys also should be conducted in salt marshes from the Flagler-Volusia County line north to St. Augustine to determine the northern extent of the species range. They also may identify additional areas of hybridization with *N. fasciata*. Delineation of the distribution will allow habitat protection efforts to be focused on areas actually occupied by the Atlantic salt marsh snake.

3.0 Identify and implement appropriate habitat protection measures. Identify and implement habitat protection measures. Determine the extent of existing habitat protection and if additional measures are needed, identify and implement preferred option(s).

3.1 Habitat protection measures. Use existing regulatory measures such as Section 7 of the Act, Section 404 of CWA, and FWCA to provide protection to salt marsh habitat. Strict application of Section 7 (consultation) and 404 regulations within the range of the Atlantic salt marsh snake should reduce loss of existing habitat. Require mitigation proposals from permitted dredge-and-fill projects to obtain conservation easements for protecting existing salt marsh habitat or to create and/or restore such habitats.

3.2 Identify specific beneficial habitat management practices. Specific management techniques need to be identified through research and applied to appropriate salt marsh habitats. The effects of open water marsh management (rotary ditching less than 42 in. wide to increase water flow) need to be documented. The applicability of salt marsh restoration activities needs to be evaluated in relation to Atlantic salt marsh snakes. Additionally, burning of mangroves (in areas where mangroves have been killed by freezes) may create additional habitat if the burns revert to the *Salicornia* spp. - *Distichlis spicata* habitat type.

3.3 Habitat acquisition. Identify essential habitats for the Atlantic salt marsh snake and pursue public ownership of these areas. An existing system is the State's Conservation and Recreation Lands (CARL) program.

3.4 Contaminants monitoring. Periodic water quality monitoring in salt marsh habitat should be done to determine possible contamination. Urban runoff, including pesticides and fertilizers applied to lawns and mosquito spraying, may degrade salt marsh habitats making them unsuitable for Atlantic salt marsh snakes.

4.0 Conduct a taxonomic assessment of the salt marsh snakes in Volusia, Brevard, and Indian River Counties. A taxonomic assessment is required to determine diagnostic criteria to use in evaluating populations identified in the distributional survey. Approaches should include traditional morphometric and meristic analyses and an examination of mitochondrial DNA polymorphisms.

4.1 Morphometric and meristic analyses. This subspecies was described at a time when little was known about salt marsh snakes elsewhere on the Atlantic coast, and available diagnoses do not permit an adequate determination of the geographical limits of the taxon. An initial assessment will be needed to determine data to be collected from snakes encountered in the distributional survey. Thereafter, the survey should proceed concurrently, in order to make additional material available for a taxonomic analysis.

4.2 Analysis of mitochondrial DNA polymorphisms. This work will further assist in determining the relationship between this form and the mangrove water snake.

5.0 Determine relative abundance within occupied habitats, identify the most important populations and habitat, and develop a population censusing technique. Based on populations identified in the distributional survey, determine relative abundance in different habitats (e.g. *Juncus roemerianus* marsh). This will provide additional direction in identifying habitat protection needs. Populations will need to be monitored to detect population trends. A population indices technique is needed to obtain trend data. Systematic searches of the potholes in the salt flats at low tide to observe snakes or find snake tracks in the mud may be developed into a population index.

6.0 Determine extent of genetic introgression at one or more sites where hybridization with *N. fasciata* is known to have occurred. This task is one of the recovery criteria and upon completion may determine future management activities. Existing electrophoretic data provide a ready means for determining the extent of genetic introgression between *N. fasciata* and *N. clarkii* ssp. A hybrid population is known to occur in southern Volusia County at the point where U.S. Hwy. 1 crosses Turnbull Creek. A transect should be established through this hybrid zone and the adjacent brackish marsh, and snakes from this transect should be examined electrophoretically to determine the degree of introgression of *N. fasciata* genes into the adjacent population of salt marsh snakes. If additional areas of hybridization are identified in the distributional survey, then the assessment of genetic introgression should be expanded to at least one of these additional sites. If genetic exchange is limited to a very narrow hybrid zone and does not extend into the adjacent salt marsh snake population, then genetic swamping may not be a significant concern. Determine if hybridization occurs naturally or from habitat alterations.

7.0 Development of a contingency plan. If the distributional surveys and ecological studies indicate a very depressed Atlantic salt marsh snake population, a captive breeding program may be warranted. Salt marshes that are isolated and protected have been identified and offer the possibility of propagating *N. c. taeniata* in a relatively natural condition.

8.0 Disseminate information about Atlantic salt marsh snakes. Although intentional killing is not thought to be a significant factor contributing to the threatened status of this form, an effort should be made to minimize take by informing the public of the protected status.

8.1 Produce and distribute educational posters about the identification and protected status of the Atlantic salt marsh snake. The public needs to be informed about the protected status of the Atlantic salt marsh snake. These posters should be displayed at marinas, bait shops, and schools within the range of the Atlantic salt marsh snake.

8.2 Produce and distribute pamphlets to inform landowners about the protected status of the Atlantic salt marsh snake. Those people owning property that includes or adjoins Atlantic salt marsh snake habitat are the ones most likely to encounter this snake. These property owners should be informed of the potential presence of this snake and its protected status.

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III. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated costs for the recovery program. It is a guide for meeting the objectives discussed in part II of this Plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs. These actions, when accomplished, should bring about the recovery of the Atlantic salt marsh snake and protect its habitat. It should be noted that not all the estimated monetary needs for all parties involved in recovery are identified and, therefore, Part III reflects only the estimated financial requirements for the recovery of this species.

While the U.S. Fish and Wildlife Service has no power to require other Federal and State agencies to carry out specific actions for endangered species recovery, we believe the designated agencies have the necessary authority to carry out the identified tasks. The implementation schedule serves to alert those agencies to the need for these actions and to justify seeking funds to carry out the actions.

Priorities in column one of the following implementation schedule are assigned as follows:

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

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

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

Key to Acronyms Used in Implementation Schedule

FDEP	Florida Department of Environmental Protection
FGFC	Florida Game and Fresh Water Fish Commission
TNC/F	The Nature Conservancy, Florida Chapter
NBS	National Biological Survey
TE-FWS	Division of Endangered Species, U.S. Fish and Wildlife Service
EVCMC	East Volusia County Mosquito Control

RECOVERY PLAN IMPLEMENTATION SCHEDULE

Priority	Task #	Task Description	Task Duration	Responsible Agency	Cost Estimates ($000s) FY1	FY2	FY3	FY4	FY5	Comments
2	1.0	Basic ecological research	2 years	TE-FWS, NBS	25	25				
2	2.0	Distribution survey	3 years	NBS, EVCMC	15	15	10			
2	3.1	Habitat protection	ongoing	TE-FWS						
2	3.2	Habitat management	ongoing	TE-FWS, TNC/F, FGFC, EVCMC, FDEP	8					
2	3.3	Habitat acquisition	ongoing	TE-FWS, TNC/F, FGFC, FDEP						Whenever funding is available.
2	3.4	Contaminants monitoring	ongoing	FDEP						
2	4.1	Taxonomic assessment	3 years	NBS	5	5	5			
2	5.0	Determine relative abundance	2 years	TE-FWS				10	10	

Priority	Task #	Task Description	Task Duration	Responsible Agency	Cost Estimates ($000s) FY1	FY2	FY3	FY4	FY5	Comments
2	6.0	Determine extent of genetic introgression	2 years	FGFC	4	3				
3	7.0	Develop a contingency plan	1 year	TE-FWS, FGFC			2			
3	8.1	Produce and distribute posters	ongoing	FGFC				2		
3	8.2	Produce and distribute pamphlets	ongoing	FGFC				4		
3	4.2	Mitochondrial DNA assessment	2 years	FGFC			2	2		

IV. LIST OF REVIEWERS

Review copies of the Technical/Agency draft of this recovery plan were sent to the following organizations, state agencies, and individuals. Written comments were received from those marked by an asterisk (*).

Ray Ashton, Chairman*
FCREPA
611 NW 79th Drive
Gainesville, FL 32607

Steve Christman*
Rt. 3, Box 2831
Quincy, FL 32351

Division of State Lands*
Florida Department of Environmental Protection - Mail Station 45
3900 Commonwealth Blvd.
Tallahassee, FL 32399-3000

Division of Recreation and Parks*
Florida Department of Environmental Protection
3900 Commonwealth Blvd.
Tallahassee, FL 32399-3000

C. Kenneth Dodd*
National Biological Survey
412 NE 16th Avenue, Room 250
Gainesville, FL 32601

Lew Ehrhart
Department of Biology
University of Central Florida
P.O. Box 25000
Orlando, FL 32816

Gary Goode*
East Volusia Mosquito Control District
1600 Aviation Center Parkway
Daytona Beach, FL 32114

Dave Breininger*
Bionetics
Mail Code BIO-2
Kennedy Space Center, FL 32899

Judy Hancock
Florida Chapter Sierra Club
1010 Alamo Drive
Lake City, FL 32055

Dale Jackson*
Florida Natural Areas Inventory
1018 Thomasville Road, Suite 200-C
Tallahassee, FL 32303

F. Wayne King
Florida Museum of Natural History
University of Florida
Gainesville, FL 32611

Howard Kochman*
National Biological Survey
412 NE 16th Avenue, Room 250
Gainesville, FL 32601

Robin Lawson
Osher Laboratory
California Academy of Sciences
Golden Gate Park
San Francisco, CA 94118

Barry Mansell
2826 Rosselle Street
Jacksonville, FL 32205

Roy McDiarmid
Department of Herpetology
U.S. National Museum
Smithsonian Institution
Washington, D.C. 20560

Peter Meylan
National Audubon Society
Eckerd College
St. Petersburg, FL 33733

Wendy Whitlock
106 Finley Street
Clemson, SC 29631

Refuge Manager
Merritt Island National Wildlife Refuge
P.O. Box 6504
Titusville, FL 32780

Mr. Wendell Simpson
Superintendent
Canaveral National Seashore
308 Julia Street
Titusville, FL 32780