Florida Brown Snake (Lower Keys Population) Biological Status Review Report

March 31, 2011

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION
620 South Meridian Street
Tallahassee, Florida 32399-1600

Biological Status Review
for the
Florida Brown Snake (Lower Keys Population)
(*Storeria victa*)
March 31, 2011

EXECUTIVE SUMMARY

The Florida Fish and Wildlife Conservation Commission (FWC) directed staff to evaluate all species listed as Threatened or Species of Special Concern as of November 1, 2010 that had not undergone a status review in the past decade. Public information on the status of the Lower Keys population of the Florida brown snake was sought from September 17 through November 1, 2010, but no information was received. The 3-member Biological Review Group (BRG) met on November 19, 2010. Group members were Kevin Enge (FWC lead), Steve Johnson (University of Florida), and Paul Moler (independent consultant) (Appendix 1). In accordance with rule 68A-27.0012, Florida Administrative Code (F.A.C), the BRG was charged with evaluating the biological status of the Lower Keys population of the Florida brown snake using criteria included in definitions in 68A-27.001, F.A.C., and following protocols in the *Guidelines for Application of the IUCN Red List Criteria at Regional Levels (Version 3.0)* and *Guidelines for Using the IUCN Red List Categories and Criteria (Version 8.1)*. Please visit http://myfwc.com/wildlifehabitats/imperiled/listing-action-petitions/ to view the listing process rule and the criteria found in the definitions.

In late 2010, staff developed the initial draft of this report which included BRG findings and a preliminary listing recommendation from staff. The draft was sent out for peer review and the reviewers' input has been incorporated to create this final report. The draft report, peer reviews, and information received from the public are available as supplemental materials at http://myfwc.com/wildlifehabitats/imperiled/biological-status/.

The BRG concluded from the biological assessment that the Lower Keys population of the Florida brown snake met 2 listing criteria. The Lower Keys population of the Florida brown snake meets the definition of an isolated population (significant and discrete population of a species) because of its significant morphological distinctiveness from the peninsular Florida population. Therefore, FWC staff recommends that the Lower Keys population of the Florida brown snake be listed as a Threatened species.

This work was supported by a Conserve Wildlife Tag grant from the Wildlife Foundation of Florida. FWC staff gratefully acknowledges the assistance of the biological review group members and peer reviewers. Staff would also like to thank Dr. Joseph Mitchell who served as a data compiler for the species.

BIOLOGICAL INFORMATION

Taxonomic Classification – Although Christman (1980) presented evidence suggesting the Florida brown snake (*Storeria victa* Hay, 1892) warranted status as a distinct species, it was generally considered a subspecies of the brown snake (*Storeria dekayi*) until Crother (2000)

concurred with Christman. The herpetological community has yet to completely accept this distinction. Christman (1980) found that most snakes in peninsular Florida had 15 instead of 17 dorsal scale rows at mid-body, 2 instead of 3 preocular scales on each side of the head, and the wider end of the dark, tear-shaped blotch on the temporal scale directed anteriorly. Duellman and Schwartz (1958) noted a phenotypic resemblance in ventral and subcaudal counts between brown snakes from the Lower Keys and northern Florida, and Christman (1980) found a similar phenomenon in regards to preocular counts and ventral dark pigmentation. The fact that Florida brown snakes in the Keys are more similar to brown snakes in northern Florida, not the nearer mainland population, is evidence of the distinctiveness of the Lower Keys population. Duellman and Schwarz (1958) and Christman (1980) contend that the Lower Keys were once connected to the central Florida mainland when the Upper Keys were still submerged, and when southern Florida and the Upper Keys later emerged, they were colonized by populations from the north and diverged from the original stock, many of whose characteristics have been retained by populations of some reptile species on the isolated Lower Keys. Christman (1980) suggested that the Lower Keys population could realistically be assigned sub-specific status (this has not occurred) because it is differentiated even less than peninsular snakes. The Lower Keys population should thus be considered representative of an ancient gene pool that differs slightly but uniquely from mainland populations.

Life History and Habitat Requirements – Information on the species has been summarized by Lazell (1989), Weaver et al. (1992), Ernst and Ernst (2003), and Rossi and Rossi (2003). In the peninsula, Florida brown snakes are rarely found far from water (often near ponds and marshes) or in upland hammocks, sheltering under detritus, logs, and in mats of floating water hyacinth (*Eichornia crassipes*) roots (Carr 1940; Gibbons and Dorcas 2005). Ashton and Ashton (1981) claimed that it is common in parks and near homes that are near ponds and drainage ditches. In the Lower Keys, brown snakes are apparently found in more terrestrial habitats (Weaver et al. 1992). Lazell (1989) found them regularly in hardwood hammocks on Middle Torch Key. He found them most often where there was “no open fresh water.” However, in Florida Natural Areas Inventory (FNAI) records, snakes were found in hardwood hammocks containing freshwater and brackish marshes or very small freshwater ponds. It is tolerant of some habitat disturbance and has been found in an old suburban development on Little Torch Key (FNAI record). Snakes in Everglades National Park gave birth from June through September to 6–13 young (mean 8.6) (Dalrymple et al. 1991), and a road-killed large female from Little Torch Key had 6 large embryos in mid-July (Lazell 1989). Florida brown snakes are primarily nocturnal and have been found crossing roads at night in the Keys (Lazell 1989, Weaver et al. 1992). They are more terrestrial than their mainland counterparts (Christman 1980). Slugs and earthworms are the most common prey for *Storeria dekayi*, but snakes, insects, isopods, spiders, and small fish and amphibians are sometimes eaten (*see* Ernst and Ernst 2003). Brown snakes are preyed upon by spiders, toads (*Anaxyrus* sp.), Cuban treefrogs (*Osteopilus septentrionalis*), and a variety of mammals, birds, and snakes (Ernst and Ernst 2003, Maskell et al. 2003). Specific predators of snakes in the Lower Keys are unknown, but feral and domestic cats, dogs, raccoons (*Procyon lotor*), crabs, large anurans, and raptors eat small snakes and may be a threat.

Population Status and Trend – The Lower Keys population of the Florida brown snake is assumed to have declined due to development of suitable upland habitat. According to Lazell

(1989), the taxon is encountered regularly in 1 small area of hardwood hammock on Middle Torch Key, but "the Lower Keys populations seem widely disjunct and genuinely scarce." The most recent record from Big Pine Key is 1975, Little Torch Key is 1984, Middle Torch Key is 1984, No Name Key is 1895, and Sugarloaf Key is prior to 1958. The lack of recent records makes the status of the Lower Keys population unknown. We are aware of only 10 records from Big Pine Key, 2 records from Little Torch Key, and 1 record each from Middle Torch, No Name, and Sugarloaf keys. However, Lazell reportedly considered it "common" at a site on Middle Torch Key (FNAI Element Occurrence Record 17672) and noted "road-killed specimens but plenty of live ones around" at a site on Little Torch Key (FNAI Element Occurrence Record 25745).

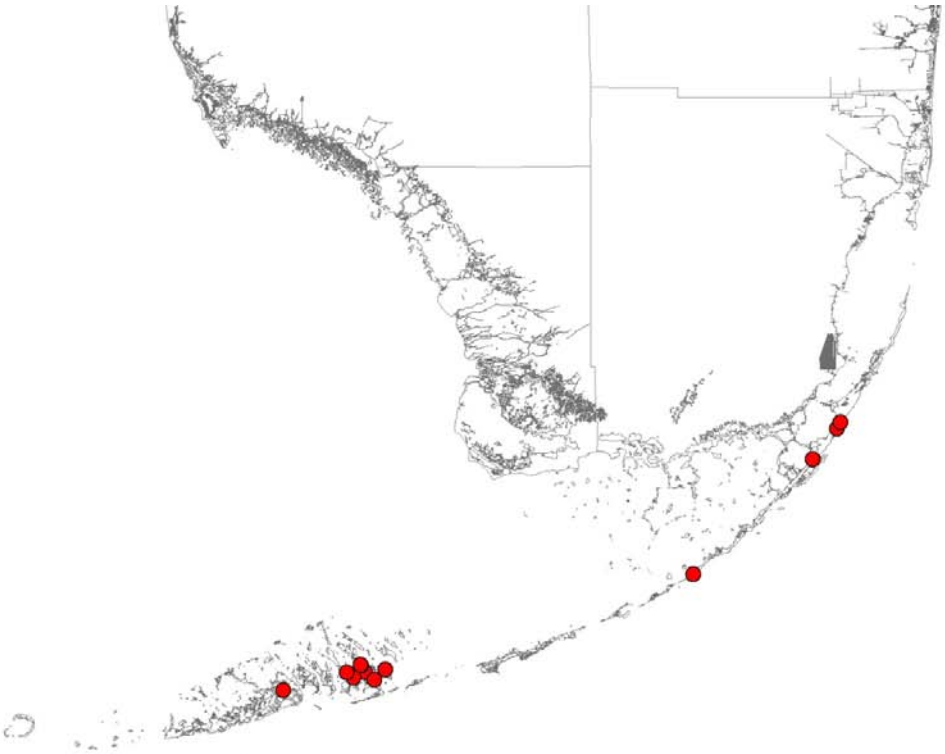

Fig. 1. Locality records from museums and FNAI for the Florida brown snake in the Florida Keys (the Lower Keys population does not include the 4 easternmost records).

Geographic Range and Distribution – The Florida brown snake occurs from extreme southeastern Georgia south through the Florida peninsula to the Lower Keys. In the Lower Keys, brown snakes have been found on Big Pine, Little Torch, Middle Torch, No Name, and Sugarloaf keys (Duellman and Schwartz 1958, Lazell 1989, Weaver et al. 1992, museum and FNAI records) (Fig. 1). The only other records of the species in the Keys are from Key Largo and Upper Matecumbe Key in the Upper Keys (museum records) (Fig. 1).

Quantitative Analyses – We are not aware of a population viability analysis conducted for the Lower Keys population of the Florida brown snake or for this species range wide. Loss of habitat due to sea level rise over the next 100 years is likely to reduce its preferred habitat. Thus, population decline is expected to occur in the future. A baseline population estimate would greatly enhance the accuracy of future estimates.

BIOLOGICAL STATUS ASSESSMENT

Threats – Clearing of hammocks and areas around wetlands has probably eliminated Florida brown snakes from some areas, particularly if snakes are restricted to habitats in proximity to sources of fresh water with surrounding grass and shrub vegetation. However, populations may persist in areas where the landscape has been cleared and left vacant to undergo ecological succession, especially where freshwater sources remain. Road mortality removes adults from the population, as indicated by literature, museum, and FNAI records (*see* Paulson 1968, Lazell 1989, museum and FNAI records). Big Pine Key with its dense network of roads may be a prime area for road mortality. The Florida brown snake was the most commonly killed snake species on a highway crossing Paynes Prairie in northern Florida (Dodd et al. 2004). The nonnative cane toad (*Rhinella marina*) and Cuban treefrog are known to eat small snakes (Maskell et al. 2003, Meshaka et al. 2004) and may be a threat to brown snakes. Hurricanes strike south Florida about every 3 years (Gentry 1974), and associated seawater surges and short-term flooding of upland habitats in the Keys may kill some snakes and their prey. A Category 3 hurricane storm surge of 4 m (13 feet) would result in the complete submersion of Big Pine Key and No Name Key, which provide ca. 51% of the 276 freshwater sources for the Key Deer (*Odocoileus viriginanus clavium*) (Lopez et al. 2003). In 2005, Hurricane Wilma (Category 3) passed just north of the Florida Keys, causing 2 storm surges. The second storm surge caused maximum storm tides 1.5–1.8 m (5–6 feet) above mean sea level in Key West (60% of the city was flooded) and 1.5–2.4 m (5–8 feet) between Boca Chica and Big Pine keys (Kasper n.d.). The Florida Keys have been hit with more intense hurricanes, such as the Labor Day Hurricane of 1935 (Category 5) and Hurricane Donna (Category 4) in 1960. A sea level rise due to climate change could significantly impact this taxon. In the best-case scenario, a sea level rise of 18 cm (7 inches) by Year 2100 would inundate 34% of Big Pine Key, resulting in the loss of 11% of the island's upland habitat (http://frrp.org/SLR%20documents/FINAL%20-%20Aug%2021%20-WITH%20COVER.pdf) and inundating coastal habitats used by the species. In the worst-case scenario, a sea level rise of 140 cm (4.6 feet) by Year 2100 would inundate 96% of Big Pine Key.

Population Assessment – Findings from the BRG are included in the Biological Status Review Information Findings table, below. They found the Lower Keys population of the Florida brown snake met sub-criteria B1, B2, and D2 for listing as a Threatened species. The taxon has a restricted geographic distribution in both extent of occurrence and area of occupancy, and it meets 2 of the other 3 requirements. It occurs in only 1 or 2 locations where subpopulations and their prey could be rapidly affected by the storm surge of an intense hurricane, and a continuing decline in extent of habitat is projected because of development of vacant lots. The taxon also meets the criterion for a very small or restricted population by having both a small area of occupancy and a few locations.

LISTING RECOMMENDATION

The Lower Keys population of the Florida brown snake meets the definition of an isolated population (significant and discrete population of a species) because of its significant morphological distinctiveness from the peninsular Florida population. For this reason, FWC staff recommends that the Lower Keys population of the Florida brown snake be listed as a Threatened species in Florida.

SUMMARY OF THE INDEPENDENT REVIEW

Comments were received from 3 reviewers: Mr. Kenneth P. Wray (Florida State University), Mr. E. Pierson Hill (Florida State University), and Mr. Richard D. Owen (Florida Department of Environmental Protection). No changes were recommended that would affect the findings or staff recommendations. All reviewers concurred with the staff recommendation. Peer reviews are available at MyFWC.com.

LITERATURE CITED

Ashton, R. E., Jr., and P. S. Ashton. 1981. Handbook of reptiles and amphibians of Florida. Part one: the snakes. Windward, Miami, Florida, USA. 176pp.

Carr, A. F., Jr. 1940. A contribution to the herpetology of Florida. University of Florida Publications, Biological Sciences 3:1–118.

Christman, S. P. 1980. Patterns of geographic variation in Florida snakes. Bulletin of the Florida State Museum, Biological Sciences 25:157–256.

Crother, B. I., Committee Chair. 2000. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. Society for the Study of Amphibians and Reptiles Herpetological Circular No. 29. 82pp.

Dalrymple, G. H., T. M. Steiner, R. J. Nodell, and F. S. Bernardino, Jr. 1991. Seasonal activity of the snakes of Long Pine Key, Everglades National Park. Copeia 1991:294–302.

Dodd, C. K., Jr., W. J. Barichivich, and L. L. Smith. 2004. Effectiveness of a barrier wall and culverts in reducing wildlife mortality on a heavily traveled highway in Florida. Biological Conservation 118:619–631.

Duellman, W. E., and A. Schwartz. 1958. Amphibians and reptiles of southern Florida. Bulletin of the Florida State Museum, Biological Sciences 3:181–324.

Ernst, C. H., and R. W. Barbour. 1989. Snakes of eastern North America. George Mason University Press, Fairfax, Virginia, USA. 282pp.

Ernst, C. H., and E. M. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington, D.C., USA. 668pp.

Fitch, H. S. 1993. Relative abundance of snakes in Kansas. Transactions of the Kansas Academy of Science 96:213–224.

Fitch, H. S. 2003. Reproduction in snakes of the Fitch Natural History Reservation in northeastern Kansas. Journal of Kansas Herpetology 6:21–24.

Gentry, R. C. 1974. Hurricanes in South Florida. Pages 73–81 *in* P. J. Gleason, editor. Environments of South Florida: Present and Past. Miami Geological Society Memoirs No. 2, Miami, Florida, USA.

Gibbons, W., and M. Dorcas. 2005. Snakes of the Southeast. University of Georgia Press, Athens, Georgia, USA. 253pp.

Kasper, K. n.d. Hurricane Wilma in the Florida Keys. NOAA/National Weather Service Forecast Office, Key West, Florida, USA. 20pp. (http://www.srh.noaa.gov/media/key/Research/wilma.pdf)

Lazell, J. D., Jr. 1989. Wildlife of the Florida Keys: a Natural History. Island Press, Covelo, California, USA. 254pp.

Lopez, R. R., N. J. Silvy, R. F. Labisky, and P. A. Frank. 2003. Hurricane impacts on Key deer in the Florida Keys. Journal of Wildlife Management 67:280–288.

Meshaka, W. E., Jr., B. P. Butterfield, and J. B. Hauge. 2004. The exotic amphibians and reptiles of Florida. Krieger, Melbourne, Florida, USA. 166pp.

Maskell, A. J., J. H. Waddle, and K. G. Rice. 2003. *Osteopilus septentrionalis*. Diet. Herpetological Review 34:137.

Mitchell, J. C. 1994. The Reptiles of Virginia. Smithsonian Institution Press, Washington, D.C., USA. 352pp.

Monroe County. 1999. Future land use element. Pages 2-1–2-147 *in* Technical document – Monroe County Year 2010 Comprehensive Plan. (http://www.monroecounty-fl.gov/pages/MonroeCoFL_Growth/CompPlan2010/technical/02.0%20Future%20Land%20Use%20Element.pdf)

Morgenstern, C. S. 1997. Managing Monroe County's unbridled growth. Florida Naturalist 70(2):18.

Paulson, D. R. 1968. Variation in some snakes from the Florida Keys. Quarterly Journal of the Florida Academy of Sciences 29:295–308.

Rossi, J. V., and R. Rossi. 2003. Snakes of the United States and Canada: natural history and care in captivity. Krieger, Malabar, Florida, USA. 520pp.

Weaver, W. G., S. P. Christman, and P. E. Moler. 1992. Florida brown snake, lower Keys population, *Storeria dekayi victa* Hay. Pages 154–157 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Zwick, P. D., and M. H. Carr. 2006. Florida 2060: a population distribution scenario for the State of Florida. A research project prepared for 1000 Friends of Florida. GeoPlan Center, University of Florida, Gainesville, Florida, USA. 25pp.

Biological Status Review Information
Findings

Species/taxon: Florida Brown Snake, Lower Keys population
Date: 11/19/10
Assessors: Enge, Johnson, Moler

Generation length: 4 years

Criterion/Listing Measure	Data/Information	Data Type*	Sub-Criterion Met?	References
*Data Types - observed (O), estimated (E), inferred (I), suspected (S), or projected (P). Sub-Criterion met - yes (Y) or no (N).				
(A) Population Size Reduction, ANY of				
(a)1. An observed, estimated, inferred or suspected population size reduction of at least 50% over the last 10 years or 3 generations, whichever is longer, where the causes of the reduction are clearly reversible and understood and ceased[1]	Causes of reduction have not ceased (c)	S	N	
(a)2. An observed, estimated, inferred or suspected population size reduction of at least 30% over the last 10 years or 3 generations, whichever is longer, where the reduction or its causes may not have ceased or may not be understood or may not be reversible[1]	<30% population size reduction because of reduced rate of habitat loss; 8.1% decline in human population in Keys since 2000 and limits on development	S	N	Monroe County (1999), U.S. Census Bureau
(a)3. A population size reduction of at least 30% projected or suspected to be met within the next 10 years or 3 generations, whichever is longer (up to a maximum of 100 years) [1]	<30% population size reduction because habitat loss will be restricted by limits on development; projected 2.2% human population increase in Keys in next 10 years	S	N	Monroe County (1999), Zwick and Carr (2006)
(a)4. An observed, estimated, inferred, projected or suspected population size reduction of at least 30% over any 10 year or 3 generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased or may not be understood or may not be reversible.[1]	<30% population size reduction (*see* A2 and A3)	S	N	Monroe County (1999), Zwick and Carr (2006)
[1] based on (and specifying) any of the following: (a) direct observation; (b) an index of abundance appropriate to the taxon; (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat; (d) actual or potential levels of exploitation; (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.				
(B) Geographic Range, EITHER				
(b)1. Extent of occurrence < 20,000 km^2 (7,722 mi^2) OR	137.3 km^2	E	Y	Monroe County (1999)
(b)2. Area of occupancy < 2,000 km^2 (772 mi^2)	18.5 km^2	E	Y	GIS analysis of potential habitat by B. Stys (FWC), excluding saltwater habitats
AND at least 2 of the following:				

a. Severely fragmented or exist in ≤ 10 locations	1 or 2 locations; known from 5 islands in close proximity (within 25 km) that could be severely impacted by the storm surge from an intense hurricane	O	Y	
b. Continuing decline, observed, inferred or projected in any of the following: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent, and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals	Continuing decline in iii	P	Y	Monroe County (1999)
c. Extreme fluctuations in any of the following: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals	No evidence of extreme fluctuations	S	N	
(C) Population Size and Trend				
Population size estimate to number fewer than 10,000 mature individuals AND EITHER	Uncertain of population size but suspected to be less than10,000; rarely found, although may be under reported	S	N	Fitch (1953), Ernst and Barbour (1989), GIS analysis of potential habitat by B. Stys (FWC)
(c)1. An estimated continuing decline of at least 10% in 10 years or 3 generations, whichever is longer (up to a maximum of 100 years in the future) OR	Projected 2.2% human population increase is unlikely to cause a 10% decline in snake populations from habitat loss	S	N	
(c)2. A continuing decline, observed, projected, or inferred in numbers of mature individuals AND at least one of the following:	Some decline is likely due to development and habitat loss	P	Y	
a. Population structure in the form of EITHER	Not enough data to assess	S	N	
(i) No subpopulation estimated to contain more than 1000 mature individuals; OR				
(ii) All mature individuals are in one subpopulation		I	N	
b. Extreme fluctuations in number of mature individuals		S	N	
(D) Population Very Small or Restricted, EITHER				
(d)1. Population estimated to number fewer than 1,000 mature individuals; OR	Uncertain of population size, but likely more than 1,000	S	N	
(d)2. Population with a very restricted area of occupancy (typically less than 20 km^2 [8 mi^2]) or number of locations (typically 5 or fewer) such that it is prone to the effects of human activities or stochastic events within a short time period in an uncertain future	18.5 km^2 and in 1or 2 locations	E	Y	GIS analysis of potential habitat by B. Stys (FWC), excluding saltwater habitats
(E) Quantitative Analyses				
e1. Showing the probability of extinction in the wild is at least 10% within 100 years	No PVA		N	

Initial Finding (Meets at least one of the criteria OR Does not meet any of the criteria)	Reason (which criteria/sub-criteria are met)
Threatened	B1+B2ab(iii); D2
Is species/taxon endemic to Florida? (Y/N)	N

If Yes, your initial finding is your final finding. Copy the initial finding and reason to the final finding space below. If No, complete the regional assessment sheet and copy the final finding from that sheet to the space below.	
Final Finding (Meets at least one of the criteria OR Does not meet any of the criteria)	Reason (which criteria/sub-criteria are met)
Threatened	B1+ B2ab(iii); D2

1	Biological Status Review Information Regional Assessment	Species/taxon: Florida Brown Snake, Lower Keys population
2		Date: 11/19/10
3		Assessors: Enge, Johnson, Moler
4		
5		
6		
7		
8	Initial finding	
9		
10	2a. Is the species/taxon a non-breeding visitor? (Y/N/DK). If 2a is YES, go to line 18. If 2a is NO or DO NOT KNOW, go to line 11.	No
11	2b. Does the Florida population experience any significant immigration of propagules capable of reproducing in Florida? (Y/N/DK). If 2b is YES, go to line 12. If 2b is NO or DO NOT KNOW, go to line 17.	No
12	2c. Is the immigration expected to decrease? (Y/N/DK). If 2c is YES or DO NOT KNOW, go to line 13. If 2c is NO go to line 16.	
13	2d. Is the regional population a sink? (Y/N/DK). If 2d is YES, go to line 14. If 2d is NO or DO NOT KNOW, go to line 15.	
14	If 2d is YES - Upgrade from initial finding (more imperiled)	
15	If 2d is NO or DO NOT KNOW - No change from initial finding	
16	If 2c is NO or DO NOT KNOW- Downgrade from initial finding (less imperiled)	
17	If 2b is NO or DO NOT KNOW - No change from initial finding	
18	2e. Are the conditions outside Florida deteriorating? (Y/N/DK). If 2e is YES or DO NOT KNOW, go to line 24. If 2e is NO go to line 19.	
19	2f. Are the conditions within Florida deteriorating? (Y/N/DK). If 2f is YES or DO NOT KNOW, go to line 23. If 2f is NO, go to line 20.	
20	2g. Can the breeding population rescue the Florida population should it decline? (Y/N/DK). If 2g is YES, go to line 21. If 2g is NO or DO NOT KNOW, go to line 22.	
21	If 2g is YES - Downgrade from initial finding (less imperiled)	
22	If 2g is NO or DO NOT KNOW - No change from initial finding	
23	If 2f is YES or DO NOT KNOW - No change from initial finding	
24	If 2e is YES or DO NOT KNOW - No change from initial finding	
25		
26	Final finding	Threatened

Additional notes – Generation length is defined as the average age of parents of the current cohort, which is greater than the age at first breeding and less than the age of the oldest breeding individual. No demographic data exist. Mitchell (1994) and Ernst and Ernst (2003) reported that a *Storeria dekayi* lived at least 7 years in captivity, and females become sexually mature at 2 or 3 years of age. However, we suspect that female sexual maturity is attained by at least 2 years of age in the Florida Keys because of its longer activity season. We infer a generation length of 4 years.

Sub-criterion A2. – Actual estimates of brown snake populations and trends do not exist, but we suspect that loss and degradation of habitat probably have resulted in population decline within the past 12 years. Urbanization resulted in extensive destruction of rockland and other habitats in the past, but vigorous litigation has slowed the previous uncontrolled rate of growth in the Keys (Morgenstern 1997). According to the U.S. Census Bureau, Monroe County's population decreased by 8.1% from 2000 through 2009.

Sub-criterion A3. – Three generations from 2010 would be 2022. By the Year 2020, Monroe County's population is projected to increase by 2.2% (Zwick and Carr 2006). However, Monroe County's population has been decreasing, and according to the U.S. Census Bureau, the population in 2009 was only 73,165, not the 82,414 that was projected (http://quickfacts.census.gov/qfd/states/12/12087.html). Of the potential habitat identified using GIS analysis, 61.1% is protected in conservation lands, preserves, or easements (B. Stys, FWC, pers. commun. 2010), and there are restrictions on clearing rockland habitat on private lands.

Sub-criterion B1. – The land area of the Lower Keys, not including offshore islands, is ca. 137.3 km^2 (53.0 mi^2) (Monroe County 1999). A GIS estimate using 2003 FWC land-cover classes of the total land area of the Florida Keys, which consists of ca. 1,700 islands, is 642 km^2 (248 mi^2) (B. Stys, FWC, pers. commun. 2010).

Sub-criterion B2. – A GIS analysis of potential habitat for the Lower Keys brown snake population identified 51.4 km^2 (19.9 mi^2) of potential habitat on 6 keys (B. Stys, FWC, pers. commun. 2010), which we will assume is equivalent to the area of occupancy. The GIS analysis included 566 ha (1,398 acres) of potential habitat on Big Torch Key, where brown snakes have not been reported. The FWC 2003 land-cover classes that comprised most of the potential habitat were mangrove swamp (14.8 km^2; 5.7 mi^2), tropical hardwood hammock (10.0 km^2, 3.9 mi^2), salt marsh (9.3 km^2, 3.6 mi^2), scrub mangrove (8.8 km^2; 3.4 mi^2), pinelands (8.1 km^2; 3.1 mi^2), and freshwater marsh and wet prairie (0.4 km^2; 0.1 mi^2). Based upon the literature and museum and FNAI records, there is no evidence that snakes occur in mangrove swamp, scrub mangrove, or salt marsh. If we delete these saltwater habitats, the area of occupancy is only 18.5 km^2 (7.2 mi^2). Based upon future development and clearing of habitat, we project a continuing decline in area of occupancy, extent of habitat, and number of mature individuals. The taxon is known from 5 islands in the Lower Keys, but we are uncertain whether the population can be considered severely fragmented. Many of these keys are separated by narrow channels that are sometimes <1 km wide, and "subpopulations" on these islands may experience demographic or genetic exchange (i.e., >1 migrant individual per year). However, the Lower Keys inhabited by brown snakes could all be considered 1 or 2 locations (Sugarloaf Key is separated from the other 4 keys and could be considered a second location). A "location" is a geographically or

ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The 5 inhabited keys extend across an area of only ca. 24 km (15 miles). A storm surge of salt water from a severe hurricane (Category 3 or higher) could completely overwash these 5 islands (*see* Threats section), killing individuals, increasing the salinity of freshwater wetlands, and affecting prey populations. There is no evidence that the brown snake experiences extreme fluctuations.

Criterion C. – No data on population densities exist for the brown snake in the Lower Keys or elsewhere in Florida. During a road survey in Long Pine Key, Everglades National Park, 135 brown snakes were found (7.6% of all snake captures) (Dalrymple et al. 1991). Population density estimates for *Storeria dekayi* range from 13/ha in Kansas grasslands (Fitch 1993) to 300/ha in Pennsylvania (Ernst and Barbour 1989). If there is only 18.5 km^2 of potential habitat (excluding saltwater habitats), then densities would have to be <5.4 snakes/ha in order for the population to number <10,000 individuals. Based upon population studies elsewhere, this density estimate seems low, but the wide variation in published population densities, lack of any density data from Florida, and paucity of records from the Lower Keys make any population estimates questionable.

Sub-criterion D2. – The GIS analysis, excluding saltwater habitats, estimated only 18.5 km^2 (7.2 mi^2) of potential habitat on the 5 inhabited keys. This estimate of area of occupancy is just below the threshold, and if the taxon is found on another key, the threshold will probably no longer be met. However, the taxon (Lower Keys populations) meets the threshold because it can be considered to occur in only 1 or 2 locations in the Lower Keys (*see* Sub-criterion B2).

APPENDIX 1. Brief biographies of the Florida brown snake Biological Review Group members.

Kevin M. Enge received his M.S. in Wildlife Ecology and Conservation from the University of Florida and B.S. degrees in Wildlife and Biology from the University of Wisconsin–Stevens Point. He is currently an Associate Research Scientist in the Reptile and Amphibian Subsection of the Wildlife Research Section, Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission (FWC). He has worked for FWC since 1989, serving as a nongame survey and monitoring biologist and the Herp Taxa Coordinator. He has conducted numerous surveys of both native and exotic amphibians and reptiles, and he has published >60 scientific papers and 25 reports.

Steve A. Johnson received his Ph.D. from the University of Florida and M.S. and B.S. degrees from the University of Central Florida. He is an Assistant Professor of Urban Wildlife Ecology at the University of Florida, and he holds a teaching and extension position in the Department of Wildlife Ecology and Conservation, Gulf Coast Research and Education Center. His area of expertise is natural history and conservation of amphibians and reptiles, especially those using isolated wetlands, and he has >60 publications.

Paul E. Moler received his M.S. in Zoology from the University of Florida in 1970 and his B.A. in Biology from Emory University in 1967. He retired in 2006 after working for 29 years as a herpetologist with FWC, including serving as administrator of the Reptile and Amphibian Subsection of the Wildlife Research Section. He has conducted research on the systematics, ecology, reproduction, genetics, and conservation biology of a variety of herpetofaunal species in Florida, with primary emphasis on the biology and management of endangered and threatened species. He served as Chair for the Florida Committee on Rare and Endangered Plants and Animals in 1992–94, Chair of the Committee on Amphibians and Reptiles since 1986, and editor of the 1992 volume on amphibians and reptiles. Paul has >90 publications on amphibians and reptiles.

APPENDIX 2. Summary of letters and emails received during the solicitation of information from the public period of September 17, 2010 through November 1, 2010.

No comments were received on this species during the public solicitation for information period.