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Chelydra serpentina – Snapping Turtle

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Summary. – The snapping turtle, *Chelydra serpentina*, is a large and familiar freshwater species that is easily recognized by its large head, long tail, large claws, serrated rear carapace, and reduced plastron. It is a widely distributed species that represents an ancient lineage of turtles. We follow the current taxonomy in recognizing two subspecies in Florida: *C. s. serpentina* and *C. s. osceola*. We found intergrades of *C. s. serpentina* and *C. s. osceola* in northwestern Florida that showed considerable overlap in shape of neck tubercles and ratio of the width of the third vertebral scute to the height of the second pleural scute. We did not find evidence of intergradation in northeastern Florida, thus the intergrade zone between *C. s. osceola* and *C. s. serpentina* appears to extend from coastal southeast Georgia and the Okeefenokee Swamp to the Apalachicola River and northward into southwest Georgia. Although not abundant in Florida, *C. serpentina* is found throughout the state with the exception of the Florida Keys. In Florida, *C. serpentina* is most abundant in small creeks, spring fed streams, small ponds (< 5 ha), floodplain swamps, borrow pits, drainage ditches, and other small fresh waters with soft bottoms and aquatic vegetation. They are also regularly found in cypress dome ponds and strand swamps in wet pine flatwoods of the Florida panhandle. Overland movements of *C. serpentina* are common in Florida and are associated with dispersal, nesting, and migrations from wetlands during drying or refilling. There are few data on growth of *C. serpentina* in Florida, but growth rates may be higher than in northern populations because of a longer growing season. In a population from Leon County in northwestern Florida, early growth (1–6 yrs) was variable among individuals and ranged from 10–30 mm/year; females matured at about 22 cm CL (6–8 yrs) and males at 18–19 cm CL (4–6 yrs). In central and south Florida, the nesting season begins as early as February–March and continues until late June, whereas nesting occurs from mid-April through June in northern Florida. Aquatic plants and macroinvertebrates are major components of the diet of *C. serpentina* in Florida. This species is not currently considered rare or endangered in Florida, however, it suffers from several threats and populations should be monitored. Habitat loss and fragmentation are significant threats as Federal and State regulations are insufficient to protect many of the wetland habitats (e.g., small, isolated, and seasonal wetlands) that support *C. serpentina* populations in Florida. Mechanical removal of organic sediment ("muck") from lakes and ponds is an established wetland management technique in Florida and is a type of habitat alteration that is a serious threat to *C. serpentina* populations. There are currently no regulations in Florida that protect *C. serpentina* from excessive harvest and we lack adequate baseline data on the level of harvest of this species to properly assess population viability and set sustainable limits on use.

Conservation Status. – FNAI Global - G5 (Demonstrably Secure), State - S5 (Demonstrably Secure); ESA Federal - Not Listed; State - Not Listed; CITES - Not Listed; IUCN Red List - Not Listed (LC-Least Concern).

Species Recognition. — This large species (maximum size in Florida 42.4 cm carapace length (CL); FLMNH 66157) is recognized by a long tail with a dorsal ridge of large tuberculate scales (Figs. 1-1, 1-2). Average mass of adults in a northern Florida (Leon Co.) population was 5.5 kg (n = 43) with the largest individuals weighing 8–11 kg (Aresco and Gunzburger, unpubl. data). *Chelydra serpentina* has large claws, a small plastron, and large head. The neck is long and can be extended rapidly. The carapace is brown to black, relatively flattened and serrated in the rear, with three parallel rows of low ridges that become less pronounced with age. The carapace of large and presumably old adults is nearly smooth. The carapace of hatchlings and juveniles is darker and more rugose than those of adults (Fig. 1-2).

Figure 1-1. Adult male snapping turtle, *Chelydra serpentina,* from Leon Co., Florida. Photo by Matt Aresco.

The small, hingeless plastron is loosely attached by ligaments to the carapace at a narrow bridge (Fig. 1-3). It is cruciform-shaped, resulting in extensive areas of exposed skin with all four muscular limbs clearly visible. Skin on the undersides of the legs has many small tubercles. The plastron of hatchlings is black, often with light flecks (Fig. 1-4), but the black fades and the entire plastron becomes light brown, yellow-brown, or gray in adults (Fig. 1-3).

Chelydra serpentina is frequently mistaken for the alligator snapping turtle, *Macrochelys temminckii*. In contrast to *C. serpentina*, *M. temminckii* grows to a much larger size, has a larger head and more pointed snout with eyes facing laterally rather than dorsolaterally, a strongly hooked beak, a carapace with three rows of very well-developed longitudinal keels throughout life, and an extra row of scutes on the carapace between the marginals and costals (Figs. 1-1, 1-2).

Taxonomic History. — *Chelydra serpentina* was first described by Linnaeus (1758) as *Testudo serpentina*, and placed in the genus *Chelydra* by Schweigger (1812). Until recently the common name used for this turtle was the Common Snapping Turtle. Crother et al. (2000) recommended a change in the name to the Eastern Snapping Turtle because the term "common" might be misinterpreted to imply abundance.

Stejneger (1918) described the Florida snapping turtle, *Chelydra osceola*, as a separate species from peninsular Florida. He differentiated this species from *C. serpentina* based on much wider vertebral scutes (width of the third vertebral equal to or greater than one third of the length of all five vertebrals combined), knobs on dorsal keels of scutes located closer to the centers (rather than rear of scutes in *C. serpentina*), two pairs of small chin barbels (rather than only one pair in *C. serpentina*), and pronounced lateral scales on the tail. Stejneger (1918) also reported that the more anterior location of the dorsal keel knobs is most visible on the fifth vertebral and arises near the middle of that scute in *C. osceola*, instead of at the posterior edge in *C. serpentina*.

Subsequent to its description, *Chelydra osceola* was treated as a subspecies, *C. serpentina osceola* (Babcock, 1932; Carr, 1952; Feuer, 1971; Gibbons et al., 1988; Ernst et

Figure 1-2. Hatchling snapping turtle, *Chelydra serpentina,* from Pinellas Co., Florida. Photo by Dick Bartlett.

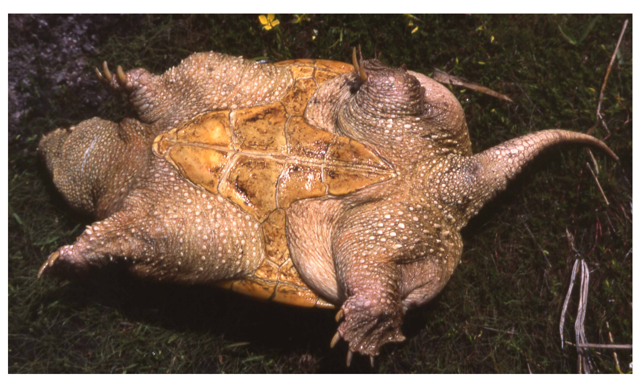

Figure 1-3. Adult female snapping turtle, *Chelydra serpentina,* from Leon Co., Florida. Photo by Matt Aresco.

Figure 1-4. Hatchling snapping turtle, *Chelydra serpentina,* from Pinellas Co., Florida in ventral view. Photo by Dick Bartlett.

al., 1994). However, Richmond (1958) considered *Chelydra osceola* a full species based on an analysis of 20 morphological and osteological characters from a sample of several dozen specimens from peninsular Florida that he compared to a large sample from elsewhere in the USA. The primary characters that distinguished the two taxa were the shape of neck tubercles (pointed, papillate tubercles in *C. osceola* and flattened, rounded tubercles in *C. serpentina*) (Fig. 1-5), width of the third vertebral equal to or greater than 33% of the total length of the five vertebrals in *C. osceola*, and length of plastral forelobe < 40% of carapace length in *C. osceola*. Generally, in young turtles, the carapace of *C. s. osceola* is more rugose than that of *C. s. serpentina*.

Walker et al. (1998) and Walker and Avise (1998) examined geographic variation in mitochondrial DNA (control region) in 66 snapping turtles from across the southeastern USA. This sample demonstrated virtually no variation within or among populations in the portion of the genome that they studied. Furthermore, they found no evidence to support any distinction between *C. s. serpentina* and *C. s. osceola*. They proposed that *C. serpentina* had greater terrestrial dispersal capability across historical biogeographic barriers that limit gene flow in other freshwater turtles. Thus, moderate to high rates of gene flow among populations of *C. serpentina* probably reduced phylogeographic structure in the southeastern USA. However, because several morphological characters clearly support the current subspecies designations, we recommend that the current taxonomy recognizing *C. s. serpentina* and *C. s. osceola* be retained until additional portions of the genome are studied**.**

Figure 1-5. Adult Florida snapping turtle, *Chelydra serpentina osceola*, from Marion Co., Florida showing the distribution and length of tubercles on the neck of this subspecies. Photo by Steve Johnson.

DISTRIBUTION

Geographic Distribution.—*Chelydra serpentina* ranges across southern Canada from Nova Scotia to Saskatchewan and throughout the eastern and central United States, south to the Gulf of Mexico and west to the Rocky Mountains, including most of Texas. Populations of *Chelydra* in Central America and northwestern South America previously referred to the subspecies *C. s. rossignonii* and *C. s. acutirostris* are now considered to be full species distinct from *C. serpentina* (Gibbons et al., 1988; Phillips et al., 1996).

Chelydra serpentina is found throughout Florida with the exception of the Florida Keys. Gaps in the distribution of *C. serpentina* in Florida probably reflect incomplete collecting rather than the absence of this species (Fig. 1-6). Richmond (1958) found no intergrades in the area between north-central Florida and southeastern South Carolina and recommended that *C. s. osceola* be recognized as a full species unless it could be demonstrated that it interbreeds with *C. s. serpentina*. However, Feuer (1971) reported intergradation of *C. s. serpentina* and *C. s. osceola* in the vicinity of the Okeefenokee Swamp in southern Georgia and northeastern Florida and, thus, argued for subspecific status for the Florida snapping turtle. He also found that variation in neck tubercles was the best means of distinguishing the two subspecies and that the ratio of the width of the third vertebral scute to the height of the second pleural scute was significantly greater in *C. s. osceola* (mean = 0.973, *n* = 113) than in *C. s. serpentina* (mean = 0.838, *n* = 1097). Four of seven specimens from the Okeefenokee Swamp had neck tubercles that were intermediate between the long, pointed tubercles of *C. s. osceola*, and the rounded, wart-like tubercles of *C. s. serpentina*, and the average width of the third vertebral scute/height of the second pleural scute was intermediate between that in each subspecies (mean = 0.855, *n* = 7). Feuer (1971) proposed that the morphological variation between the subspecies likely occurred as a result of inundation of the northern peninsula of Florida during a Pleistocene interglacial period that isolated peninsular Florida and mainland populations.

Our examination of specimens in the Florida Museum of Natural History (FLMNH) collections (*n* = 70,

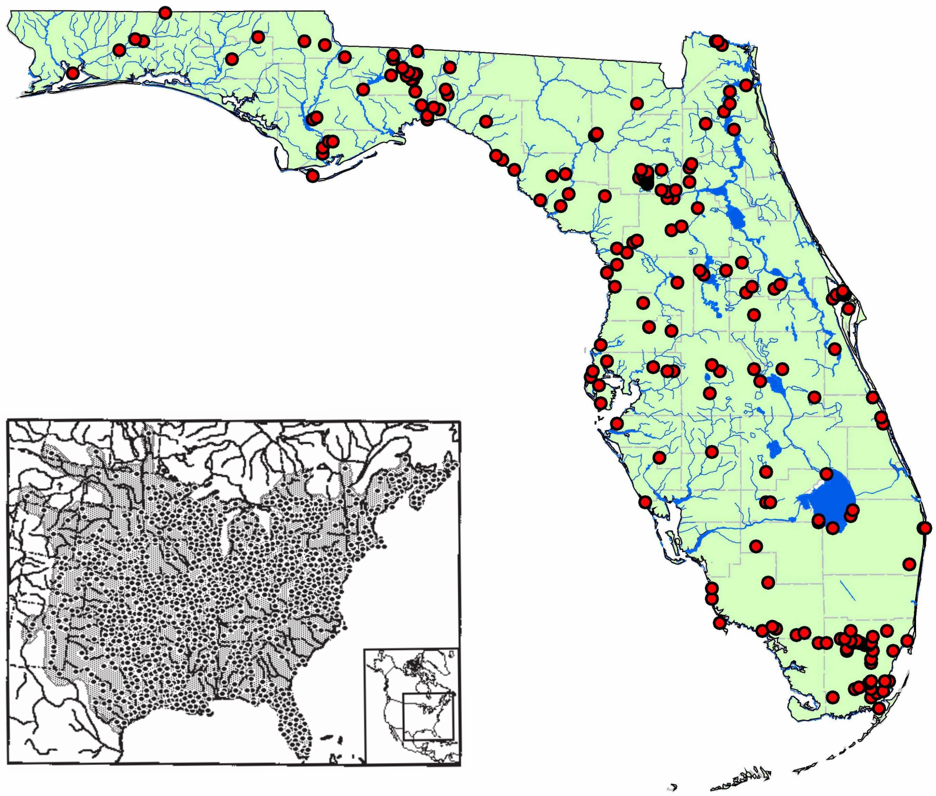

Figure 1-6. Available locality records for the snapping turtle, *Chelydra serpentina*, in Florida. Inset: distribution records from entire range of *C. serpentina* (adapted from Iverson, 1992; distribution in inset map not current for Florida as presented here).

all >10 cm SCL) has uncovered possible intergrades from Leon Co. (FLMNH 67790), Gadsden Co. (FLMNH 66141), Jefferson Co. (FLMNH 65107), and Bibb Co., GA (FLMNH 4167). A specimen from Grady Co., GA, also appeared to be an intergrade (Aresco, unpubl. data). Specimens from west of the Apalachicola River in the Florida Panhandle (Jackson Co., FLMNH 6523; Okaloosa Co., FLMNH 64730; and Santa Rosa Co., FLMNH 65106) all have short, rounded tubercles and appear to be *C. s. serpentina*. At a pond in Tallahassee, Leon Co., a sample of 35 *C. serpentina* shared characteristics of both subspecies suggesting that the population consisted of intergrades of *C. s. serpentina* and *C. s. osceola* (Table 1-1, Aresco and Gunzburger, unpubl. data). For example, the average ratio of the width of the third vertebral scute to the height of the second pleural scute was intermediate between that reported for *C. s. serpentina* and *C. s. osceola* (mean = 0.876, SD = 0.057, range 0.78–1.07, n = 35). In the lower Apalachicola River (Liberty and Franklin Co.), *C. serpentina* also shows the influence of *C. s. osceola* with pointed neck tubercles (although less pronounced than those in southern Florida) and moderately prominent lateral scale ridges on the tail (Ewert, unpubl. data); except for one individual from Liberty Co., FLMNH 10189, that exhibited features of *C. s. serpentina*. We did not find evidence of intergradation in northeast Florida, thus the intergrade zone between *C. s. osceola* and *C. s. serpentina* appears to extend from coastal SE Georgia and the Okeefenokee Swamp to the Apalachicola River and northward into southwest Georgia. An examination of variation in plastral forelobe length/carapace length to third vertebral width/second pleural height showed considerable overlap in these characters between *C. s. serpentina* and intergrades from Leon Co., Florida, but little overlap with *C. s. osceola* (Fig. 1-7).

Ecological Distribution. — In Florida, *C. serpentina* is most abundant in small creeks, spring fed streams, small ponds (< 5 ha), floodplain swamps, borrow pits, drainage ditches, and other small fresh waters with soft bottoms. They are also regularly found in cypress dome ponds and strand swamps in wet pine flatwoods of the Florida Panhandle (authors, unpubl.). Given that females have frequently nested on Forbes Island and elsewhere along the west bank of the lower Apalachicola River, the species appears to be widespread in waters of the large, wooded floodplain (Ewert and Jackson, 1994 and unpubl.). In eastern Sarasota Co., Punzo (1975) found *C. s. osceola* in swamps, woodland ponds, and streams. In the eastern Everglades (Dade Co.), *C. s. osceola* occurs at least locally in small ditches with clear water and abundant vegetation (Ewert, unpubl.). In a survey of turtle populations in Leon Co., *C. serpentina* was most abundant in small, eutrophic ponds (0.5–1.5 ha) with relatively shallow water, thick muck bottoms (muck depth of 0.5–1.5 m), and an abundance of duckweed (*Spirodela* sp.) and emergent macrophytes (Aresco and James, 2005).

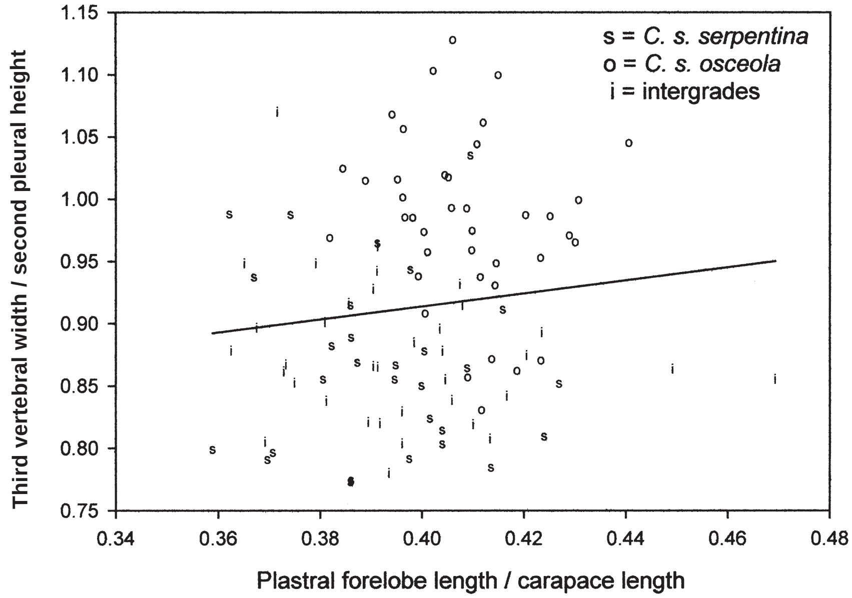

Figure 1-7. Variation in plastral forelobe length/carapace length versus third vertebral width/second pleural height among *C. s. serpentina* (including individuals from northwestern Florida, Georgia, Tennessee, Arkansas, and the Carolinas) (n = 29), *C. s. osceola* (peninsular Florida) (n = 39), and intergrades from Leon County, Florida (n = 35). Subspecies and intergrades are assigned based on length and shape of neck tubercles.

In Florida, *C. serpentina* appears to occur at lower densities in large lakes than in small ponds and creeks. For example, only 9 *C. serpentina* were found among 4896 turtles at Lake Jackson, a 1620 ha sinkhole lake in Leon Co., during a natural dry-down event (Aresco, 2005). Similarly, at Lake Conway in central Florida, only 21 snapping turtles were among 4817 turtles captured during a three-year study (Bancroft et al., 1983). Recapture of six of these snapping turtles suggested that the population was small. Within Lake Conway, *C. serpentina* was associated with shallow water with an abundance of aquatic vegetation and a mud substrate. The physiology of *C. serpentina* includes apparent adaptations for burying in mud and muck and surviving under low oxygen conditions (Jackson et al., 1984). *Chelydra serpentina* is also tolerant of brackish water and inhabits coastal estuaries (Dunson, 1986).

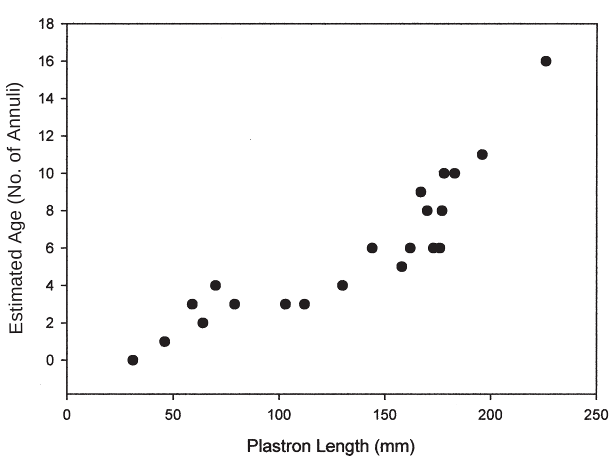

Figure 1-8. Relationship of size and age of *Chelydra serpentina* (n = 22) in Leon County, Florida. Age was estimated using counts of growth annuli on the 2nd pleural scute and included only those turtles with complete sets of clearly visible annuli.

HABITAT RELATIONS

Activity. — This species is a "bottom-walker" and prefers shallow water where it can breathe by extending its long neck to the surface. When active, individuals typically move slowly along the bottom or remain hidden in dense aquatic vegetation. In Florida, when *C. serpentina* is inactive during hot summer days or winter months, it may hide under submerged logs or bury into deep mud, muck, or leaf litter (Aresco, *pers. obs.*).

Chelydra serpentina may be active during day or night (Aresco, unpubl. data). In Tallahassee, Leon Co., a 34.7 cm CL male was observed foraging at the edge of a pond in 20 cm of water in mid-morning, an 8.3 cm CL juvenile active in shallow water at night (2345 hrs), and a large adult in shallow water with neck fully extended at night (2230 hrs), possibly foraging on crayfish (Gunzburger and Aresco, unpubl. data). Individuals were observed both basking and crawling slowly through submergent aquatic vegetation during mid-day on the Wacissa River, Jefferson Co. (Aresco and Gunzburger, unpubl. data). At Rainbow Run, Marion Co., this species is infrequently encountered during daytime surveys (1 of 2500 turtle captures) but is more abundant according to data from overnight trapping (Meylan, unpubl. data). Adults have been encountered moving during the morning and after sundown in ditches in Dade Co. in March (Ewert, unpubl. data). *Chelydra serpentina* has often been seen moving on land during the day (Aresco, unpubl. data). At an ephemeral cypress dome pond in Liberty Co., both juveniles and adults were typically captured at drift fences in the morning following moderate to heavy rain during the night (Palis, Aresco, and Kilpatrick, unpubl. data). Individuals were observed moving overland into a cypress dome pond when it refilled, remaining

Table 1-1. Variation in morphological features of *Chelydra serpentina serpentina* x *Chelydra serpentina osceola* ($n = 35$) from a population at McCord Pond, Tallahassee, Leon County, Florida.

Character	Mean (SD, Range)	% with *osceola* trait
vertebral 3 width/ total length of vertebrals	0.32 (0.02, 0.30-0.37)	12%
plastral forelobe length/ carapace length	0.40 (0.02, 0.36-0.47)	66%
vertebral 3 width/ pleural 2 height	0.88 (0.06, 0.78-1.07)	31%
no. pairs chin barbels	9% two pairs (*osceola*)	
lateral tail scales	11% moderately prominent ridges (*osceola*)	
dorsal keel knobs	100% at rear of scute (*serpentina*)	
neck tubercles	100% moderately pointed (intermediate)	

in the pond for relatively short time periods, and leaving when the pond dried (3–4 wks).

Seasonality. — From November to early March, individuals in a Leon Co. pond were inactive and buried in a deep muck bottom under shallow water (< 0.5 m) (Aresco and Gunzburger, 2004). *Chelydra serpentina* was captured in baited hoop traps as late as October in Leon Co. (Aresco, unpubl. data). At Lake Jackson in Leon Co., individuals were found moving overland as early as 15 March and as late as 15 September (Aresco, unpubl. data). Individuals were found migrating into or out of an ephemeral cypress dome pond located in pine flatwoods of the Apalachicola National Forest in Liberty Co. on 2 November (male), 3 March (male), 20 March (adult female), 4 April (subadult female), 10 April (male), 15 April (2 juveniles), and 25 April (juvenile) (Palis, Aresco, and Kilpatrick, unpubl. data). Seasonal variation in activity of *C. s. osceola* was not apparent at Lake Conway in central Florida (Bancroft et al., 1983).

Movements and Terrestrial Activity. — Overland movements of *C. serpentina* are common in Florida and are associated with dispersal, nesting, and migrations from wetlands during drying or refilling. Carr (1952) reported that both sexes may move overland between water bodies after emerging from hibernation and cover distances of > 0.5 km. In northwestern Florida, subadult and adult males and females (independent of nesting movements) are frequently observed moving overland in pine flatwoods between permanent water in swamps and ephemeral cypress dome ponds (with and without water) (Palis, Aresco, and Kilpatrick, unpubl. data). Males, females, and immatures are often found attempting to cross roads 0.5 km or more from the nearest wetland. During the dry-down of Lake Jackson, Leon Co., two juveniles (4.0 cm CL) were found at a drift fence moving directly towards nearby permanent water after apparently migrating at least 0.5 km from the nearest remaining pool on the lake bottom during the final days of drying (Aresco, unpubl. data). A large male (34.6 cm CL) migrated from a drying pool at Lake Jackson on 20 April 2000 to Little Lake Jackson on the opposite side of U.S. Highway 27 and was captured migrating back to Lake Jackson on 15 March 2001 as the lake refilled. These observations suggest that *C. serpentina* has the ability to detect water from relatively long distances and may prefer moving to new water rather than attempting to burrow and aestivate in a dry lake bottom. Several juveniles apparently moved overland and quickly re-colonized a portion of Lake Jackson, which had recently refilled with shallow water after being completely dry for 5–6 months.

Home Range. —Home range size has not been determined in Florida. In more northern populations, home range size may be highly variable among individuals of the same sex in adjacent lakes, even when those lakes have similar densities and biomass of snapping turtles (Obbard and Brooks, 1981; Galbraith et al., 1987).

Temperature Relationships. — Aerial basking by adult *C. serpentina* was observed in April on the Wacissa River in Jefferson Co. and in September on the Sante Fe River in Columbia Co. (Ewert, 1976; Gunzburger and Aresco, unpubl. data).

GROWTH AND REPRODUCTION

Growth. — There are few data on growth of *C. serpentina* in Florida, but growth rates may be greater than in northern populations because of a longer growing season, depending on habitat productivity. In a population from Leon County in northwestern Florida, early growth (1–6 yrs) was variable among individuals and ranged from 10–30 mm/year (Fig. 1-8) (Aresco, unpubl. data). In contrast, a juvenile from Lake Conway in central Florida grew only 4.3 mm/year (Bancroft et al., 1983). Jackson and Ewert (1997) suggested that female *C. s. osceola* have the potential to grow to large sizes based on a series of large specimens (e.g., 36.8, 35.2, 34.8 cm CL) collected from Lake Apopka, Orange County, in 1928–29.

Christiansen and Burken (1979) used growth rings to calculate annual growth increments and found that *C. serpentina* in Iowa grew 25–35 mm/yr for the first 3 or 4 years. Female *C. serpentina* in Ontario grew 15–20 mm/yr for the first 11 years of life (Galbraith et al., 1989). In all populations studied, growth of *C. serpentina* began to slow when individuals approached size at sexual maturity and most individuals stopped growing once they had attained maturity. For example, a radio-tracked adult male (32.7 cm CL) from Lake Conway in central Florida grew only 1 mm in 15 months and most large adults (> 30 cm CL) from Leon County in northwestern Florida showed no evidence of recent growth (Aresco, unpubl. data).

Sexual Dimorphism. — In a population of *C. serpentina* in Leon Co., carapace length of males (mean = 29.6 cm, range = 18.4–37.0, $n = 28$) was significantly larger than that of females (mean = 26.8 cm, range = 22.0–33.0, $n = 25$) (Aresco and Gunzburger, unpubl. data). The sexual dimorphism index (SDI) in this population is 1.11. A similar pattern of sexual size dimorphism was reported in populations outside of Florida, where males typically also grow to larger sizes than females (reviewed in Gibbons and Lovich, 1990). In individuals > 20 cm CL, the distance from the plastron to the cloaca is relatively longer in males than in females.

Size and Age at Sexual Maturity. — Size and age at sexual maturity of *C. serpentina* has not been well studied in Florida. In a sample of *C. serpentina* from Leon County, females matured at about 22 cm CL (6–8 yrs) and males at 18–19 cm CL (4–6 yrs) (Aresco and Gunzburger, unpubl. data). For example, a road-killed gravid female *C. serpentina* from Leon Co. measured 22.5 cm CL and 16.2 cm PL with 6 growth rings (Aresco, unpubl. data). In a sample from Dade Co., the smallest gravid female was 18.5 cm CL, 13.8 cm PL, 1.4 kg, and had 4 large growth rings. Other gravid females in the population had 4 large rings plus a few much smaller ones. This suggests achievement of sexual maturity in less than 6 yrs (Ewert, unpubl. data). In contrast, a dissected female from the Wacissa River in Jefferson Co. was 24.6 cm CL, 17.3 cm PL, and 3.3 kg but had tiny, immature gonads and 10 growth rings (Ewert, unpubl. data).

Longevity. — In the north, at least, *C. serpentina* has the potential for long life, as some individuals probably exceed 50 yrs in age (Congdon et al., 1987; Congdon and Gibbons, 1989).

Male Reproductive Cycle. — The male reproductive cycle has not been studied in Florida. In Tennessee and Wisconsin, *C. serpentina* has a post-mating or dissociated spermatic cycle in which sperm are produced primarily during summer and stored until mating in the following spring (White and Murphy, 1973; Mahmoud and Cyrus, 1992). In Tennessee, sperm is produced from late June to November with a peak in mid-September, whereas epididymides are largest from November to May (White and Murphy, 1973).

Female Reproductive Cycle. — The reproductive cycle of female *C. serpentina* has not been studied in Florida. In Tennessee, this species has a pronounced ovarian cycle with follicles growing in summer and fall and reaching maximum size in May and June of the following year just before ovulation (White and Murphy, 1973). In Iowa, Christiansen and Burken (1979) found that subadult females had enlarged follicles which they did not ovulate during the two years prior to reaching maturity, thus suggesting that the criterion for maturity in *C. serpentina* should be either the presence of eggs in the oviducts or corpora lutea in the ovaries.

Courtship and Mating. — Mating and copulation may occur throughout the year in southern Florida. In northern Florida, mating has a late fall to early spring hiatus (Ernst et al., 1994). In indoor captivity, one male *C. s. osceola* (Highlands Co.) mounted introduced females during all months. Females attempted to escape by snapping or "butting" with nearly closed mouths. The mounted male rubbed female heads with its chin and a closed mouth (Ewert, unpubl. data). Female *C. serpentina* are known to store sperm in storage tubules in the posterior albumen region of the oviduct (Gist and Jones, 1989).

Nesting Season. — Nesting begins earlier in Florida than in states further north, resulting in a longer nesting season (reviewed in Iverson et al., 1997). In central and south Florida, the nesting season may begin as early as February–March and continues until late June. For example, *C. serpentina* was observed nesting on 7 February at Lake Maggiore in Pinellas Co. (Heinrich, unpubl. data). Nesting probably commences in February in Dade Co., based on the presence of fresh corpora lutea, shelled oviductal eggs, or both (Ewert, 1976, 2000). Near Gainesville in north-central Florida, nests were observed on 18 May, 3 June, and 9 June (Iverson, 1977). At Lake Jackson in Leon County, nesting occurs from April–June and nesting females were observed on 4 April, 28 April, and 14 June (Aresco, unpubl. data). Also, nesting along the lower Apalachicola River has occurred mainly from mid-April to May but extending to mid-May during several years (Ewert, unpubl. data).

Nest Sites and Nesting Behavior. — Range-wide, nest sites for *C. serpentina* vary from open, sunny sites to shaded sites (Ewert, 1976; Ewert et al., 1994; Ernst et al., 1994). Along the lower Apalachicola River, only three of 91 nests were fully open to sunlight and 75 nests were mostly shaded (Ewert, unpubl. data). *Chelydra serpentina* may prefer more shaded nest sites with a decrease in latitude. Selected sites are often in broad-leaved forest or under bushes (Ewert, 1976; Ewert et al., 1994; unpubl. data). In Sarasota Co., however, *C. s. osceola* nests were somewhat less shaded (Punzo, 1975).

In Florida, nests are constructed moderately close to water in some habitats (e.g., lakes, rivers). Along the lower Apalachicola River, most females nested < 10 m from water in a high water year (Ewert, 1976) but averaged about 19 m (range 1.5–50 m, *n* = 12 nests) from water in more normal years (Ewert, unpubl. data). In Sarasota Co. seven nests ranged from 38–141 m from water with an average of 94 m (Punzo, 1975). These females nested between 0600 and 0800 hrs. Further north, in Leon and Franklin Co., females were found nesting in the mid-morning (1000–1200 hrs) (Aresco and Ewert, unpubl. data).

Nest depth to top and bottom eggs in 17 nests along the lower Apalachicola River averaged 9.5 and 20.3 cm, respectively, with an overall range of 5–25 cm. In horizontal aspect, seven egg cavities were approximately round and 11.5–16 cm across (Ewert, unpubl. data).

Clutch Size. — Clutch sizes in peninsular Florida are rather small for the species (2–28 eggs, Dade Co., Ewert, 2000; 6–21 eggs, Sarasota Co., Punzo, 1975; 14–20 eggs, Alachua Co., Iverson, 1977). Jackson and Ewert (1997) reported "large" clutches for *C. s. osceola* at 30 and 31 eggs in Dixie County and 23 eggs in Seminole County. The current maximum clutch size in Florida is 54 eggs from a female found nesting near Goose Pond in Tallahassee, Leon County (Jackson and Ewert, 1997). A radiographed 36.7 cm CL *C. s. osceola* x *serpentina* from the same locality contained 49 eggs (Aresco, unpubl. data). In Leon Co., a radiographed 28.5 cm CL female *C. s. osceola* x *serpentina* contained 34 shelled eggs and a fresh road-killed 22.5 cm CL female *C. s. serpentina* at the outset of nesting season in early April contained only 5 shelled eggs, suggesting that this was a full clutch for this small individual (Aresco, unpubl. data). Along the lower Apalachicola River in Franklin Co., the average size of 46 clutches of *C. s. serpentina* x *osceola* was 33.2 eggs (range 17–52; Ewert and Jackson, 1994). Clutch sizes in northern Florida are similar in size to those northward along the Atlantic Coastal Plain into Nova Scotia, but smaller than those in the upper Midwest and northern Plains (reviewed in Iverson et al., 1997).

Reproductive Potential. — This species produces only one clutch per year in the northern portion of its range and females may not reproduce every year (Congdon et al., 1987). Iverson (1977) suggested that *C. serpentina* in the Gainesville area produced only a single clutch per year, and certain individuals may follow this pattern. However, combined counts of multiple sets of corpora lutea and enlarged follicles indicate that females in Dade Co. can produce two to three, and possibly four clutches per season (Ewert, 2000). The estimated annual output was 27.6 eggs (range 19–36) per female**.** Females in this population tended to be quite small in size for adult *C. serpentina* (Ewert, 2000, unpubl. data). Some of the south Florida females retained in a heated laboratory produced clutches in the fall as well as two or more in the winter and spring. This observation begs the question of whether the reproductive cycle in *C. s. osceola* is entrained differently to the annual seasonal cycle than that of *C. s. serpentina*. There are only indirect data to suggest multiple clutching in central and northern Florida. In these samples, a proportion of dissected gravid females had many enlarged, perhaps pre-ovulatory, ovarian follicles (Dixie and Franklin Co.). Additionally, the broad range in dates of nesting in northern Florida allows that an early nesting female might also produce a late season clutch (Ewert, 2000, unpubl. data).

Eggs. — Eggs of *C. serpentina* in Florida and elsewhere are approximately spherical and have pliable to rigid eggshells that become turgid during early incubation (Ewert, 1979, unpubl. data). A sample of 490 normal eggs from 34 clutches from along the lower Apalachicola River averaged 14.1 ± 2.6 g (range 10.1–17.5 g). Smaller normal eggs (to 7.2 g) have come from Dade County. Linear measurements of eggs have ranged from 23.4 x 23.0 mm to 31.8 x 30.1 mm (Ewert, unpubl.). Egg masses from Sarasota Co. ranged from 5–13 g (Punzo, 1975). Egg diameters from Alachua Co. ranged from 24.9 to 30.8 mm (Iverson, 1977).

Incubation and Hatching. — Under identical laboratory conditions for incubation, the eggs of *C. serpentina* from Florida (Dade, Dixie, Franklin and Seminole Cos.) take longer to develop and hatch than similar sized eggs from northern populations (Ewert, 1979, 1985, unpubl. data). Mean incubation periods of Florida eggs range from 74–78 days at 30°C to 145 days at 21.5°C. Probable incubation times in natural nests would be intermediate, ca. 80 to 102 days. *Chelydra serpentina* exhibits a pattern of environmental sex determination where eggs incubated at very warm or very cool temperatures produce mostly females, while those at moderate temperatures produce mostly males (Yntema, 1976; Wilhoft et al., 1983). This also holds true for the subspecies *C. s. osceola* (Ewert, unpubl. data). There is no evidence that hatchling *C. serpentina* overwinter on land in Florida.

Hatchlings. — Hatchlings of *C. serpentina* from the Gainesville area ranged from 24–30 mm CL (Iverson, 1977), but have frequently measured 35 mm CL from along the lower Apalachicola River and elsewhere in Florida (Ewert, unpubl. data). The fresh mass of a hatchling developed in a damp substrate averages near or slightly over 75 % of the mass of its original egg. There is no indication that hatchlings of *C. s. serpentina* and *C. s. osceola* differ from each other in size. However, hatchlings of *C. s. osceola* from the eastern Everglades differ by having neutral gray coloration dominating the carapace, with a few mid-dorsal black marks. The plastron is black with white flecks. From Dixie Co. northward, hatchlings of both *C. s. serpentina* and *C. s. osceola* are uniformly black except for some white dots on the plastron (Ewert, unpubl. data).

POPULATION BIOLOGY

Density and Biomass. — Data on population density and biomass of this species in Florida are only available from four populations in Leon County in the panhandle. They demonstrate considerable variation in density among sites (Aresco, unpubl. data; Table 1-2). In northern populations, this species also shows significant variation in density (0–66 adults/ha) and biomass (9–340 kg/ha) (Froese and Burghardt, 1975; Major, 1975; Iverson, 1982; Iverson et al., 2000; Galbraith et al., 1988; Congdon and Gibbons, 1989).

From available accounts of commercial harvest of *C. serpentina* in the Midwest, this species must have occurred at very high densities in Midwestern rivers in the early 1900s (Clark and Southall, 1920). For example, a single fish company at La Crosse, Wisconsin, handled almost 30,000 snapping turtles between November 1917 and May 1918.

Population Dynamics. — Survivorship schedules of adult snapping turtles in Florida are unknown.

Population and Community Structure. — Sex ratio of adult males: adult females was not significantly different from 1:1 at McCord Pond, a natural suburban pond/marsh in Tallahassee, Leon Co. (25 females, 30 males) (Aresco and Gunzburger, unpubl. data). Similarly, sex ratios were 1:1 in some northern populations (Lagler and Applegate, 1943; Mosimann and Bider, 1960; Major, 1975).

In a determination of absolute abundance at McCord Pond, turtles were initially trapped with aquatic hoop traps prior to a mechanical muck removal project. Then all remaining turtles were hand-collected while heavy machinery was removing muck (Aug 1999–March 2000) (Aresco and Gunzburger, 2004). The size distribution was dominated by large adults, but with sufficient numbers of juveniles and subadults to indicate low levels of recruitment (Fig. 1-9). In Leon County, *C. serpentina* represented only 0.18% of the

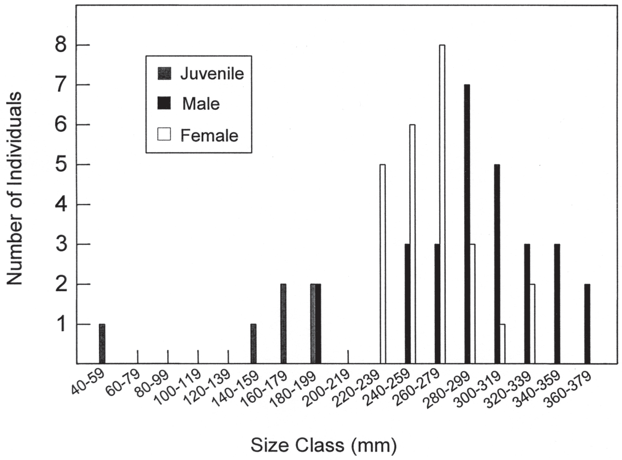

Figure 1-9. Size distribution of *Chelydra serpentina* at McCord Pond, Tallahassee, Leon Co., Florida.

turtle community at Lake Jackson, whereas it represented 18% of the turtle community at the 1.5 ha muck-bottomed McCord Pond (Table 1-2) (Aresco and Gunzburger, 2004; Aresco, unpubl. data).

INTERSPECIFIC INTERACTIONS

Diet. — *Chelydra serpentina* is omnivorous and is known to feed on a wide variety of aquatic invertebrates, fish, amphibians, and plants. This species can complete a feeding strike in 78 milliseconds and has the ability to capture fast-moving prey items such as fish, crayfish, and amphibians (Lauder and Prendergast, 1992). There is only one quantitative diet study of this species in Florida. Punzo (1975) examined the digestive tracts of 59 *C. s. osceola* from several habitats in west-central Florida and found that earthworms, insects, isopods, and plant material were present in all individuals. The remains of amphibians were present in 95% of tracts, amphipods in 92% (probably eaten incidentally with plants), and crayfish in 83%. Bone fragments were present in 100% of individuals but most were not identified, thus the relative importance of fish, birds, and mammals in the diet of snapping turtles could not be evaluated in that study. At McCord Pond in Tallahassee, Leon Co. with a high density of *C. serpentina*, 5.1% of adult yellow-bellied sliders (*Trachemys scripta*) and Florida cooters (*Pseudemys floridana*) were missing one or more limbs, possibly the result of attacks by snapping turtles (Aresco and Gunzburger, unpubl. data).

Aquatic plants are a major component of the diet of snapping turtles. Three adult *C. serpentina* collected in Leon Co. contained plant material. A fecal sample of an adult male (31 cm CL) captured in July contained 95% duckweed (*Spirodela polyrhiza*) and 5% stems of American lotus (*Nelumbo lutea*), the stomach of a 37 cm CL male found in August contained 100% wild taro (*Colocasia esculenta*), an exotic emergent plant, and the stomach of a 28.2 cm CL female found in July contained 100% bladderwort (*Utricularia* sp.) (Aresco, unpubl. data). Other studies have reported herbivory by snapping turtles throughout their range. In Illinois, Budhabhatti and Moll (1990) observed the same 33 cm adult grazing on duckweed (*Lemna minor*) on 10 occasions between late May and early August.

Predation. — Depredation of nests of *C. serpentina* can be significant, especially by mammalian predators such as raccoons and foxes, but also by fish crows. Rates of nest depredation appear to be > 90% along the lower Apalachicola River. When nesting was simultaneous with *Macrochelys temminckii*, nests of *C. serpentina* have been depredated within a day, whereas nests of *M. temminckii* have lasted 1–2 days (Ewert and Jackson, 1994; Ewert, unpubl. data). In the northern part of the range, nests are often destroyed within a few days of oviposition but after two or three weeks nest survivorship increases to almost 100% (Robinson and Bider, 1988). Rates of nest depredation may vary among years at the same site (Hammer, 1969; Congdon et al., 1987) suggesting variation in predator abundance or environmental conditions (e.g., nesting during rain).

During the dry-down of Lake Jackson, Leon Co., under severe drought conditions, two *C. serpentina* were found dead on the dry lake bottom, a 14.0 cm CL juvenile and 26.8 cm CL adult, both probably killed by raccoons (Aresco, unpubl. data). Despite speculation that alligators cause the low densities of *C. serpentina* in Florida lakes, *C. serpentina* was not reported in a diet study of alligators in north-central Florida although Florida red-bellied turtles (*Pseudemys nelsoni*), peninsula cooters (*Pseudemys floridana*), striped mud turtles (*Kinosternon baurii*), and common musk turtles (*Sternotherus odoratus*) were present in alligator stomachs in this study (Delany and Abercrombie, 1986).

Parasites and Disease. — Leeches (*Placobdella parasitica*) are commonly found on the soft parts of *C. serpentina* (Brooks et al., 1990, Aresco and Gunzburger, unpubl. data). Plastral shell lesions (shell rot) infected several adult *C. serpentina* from a suburban pond in Tallahassee, Leon Co. (Aresco and Gunzburger, unpubl. data).

THREATS

Documented Threats. — Habitat loss and fragmentation are significant threats to snapping turtle populations in Florida. Many small, isolated wetlands that support populations of *C. serpentina* are destroyed or altered because they receive little or no legal protection in Florida. Terrestrial habitats associated with wetlands that are vital to *C. serpentina* for nesting and linkage to other wetlands are afforded no protection as they are outside of the wetland delineation boundaries (Gibbons, 2003). Direct loss of natural wetlands

Table 1-2. Variation in density, biomass, and percent composition in the turtle community of *Chelydra serpentina* among four sites in Leon County, Florida.

Site (ha)	*n*	Density (turtles/ha)	Biomass (kg/ha)	% composition
McCord Pond (1.5)	64	43.0	201.0	18.0
Harriman Pond (0.5)	11	22.0	69.5	10.0
Chapman Pond (1.0)	3	3.0	10.6	3.5
NW Lake Jackson (405)	17	0.04	0.1	0.2

as a result of residential and commercial development and conversion of natural wetlands to stormwater retention ponds associated with urbanization can eliminate snapping turtle populations (Aresco, unpubl. data).

Even without commercial land development, diversions of natural water flows appear to have adversely affected *C. s. osceola* populations in dedicated natural areas, such as the eastern part of Everglades National Park. Water diversion has aggravated drought conditions leading to deaths following complete drying (Koschman, 1966).

Mechanical removal of organic sediment ("muck") from lakes and ponds is an established wetland management technique in Florida and is a type of habitat alteration that is a serious threat to *C. serpentina* populations (Aresco and Gunzburger, 2004). Mechanical muck removal is conducted by the Florida Fish and Wildlife Conservation Commission (FFWCC) in attempts to enhance sport fisheries and improve boater access, and by local municipalities to increase stormwater capacity of wetlands that serve as stormwater retention ponds in suburban areas. In most cases, the ponds are pumped dry and heavy machinery (large backhoes and bulldozers) remove all organic sediment to a depth at which sand or clay is reached, or much deeper in the case of the stormwater ponds. Organic sediment is either piled on the shore and allowed to dry before transport to off-site landfills or immediately loaded onto trucks as it is removed. In the process, *C. serpentina* are either killed by suffocation in excavated piles of sediment or crushed by heavy machinery, with virtually no chance to escape (Aresco and Gunzburger, 2004). In some cases, turtles found by workers during pumping or excavating are taken for human consumption (Mitchell Brothers Construction Co., Tallahassee, *pers. comm.*). During cold weather, turtles are inactive and often buried in organic sediment and are incapable of escaping mechanical excavation or digging themselves out from muck piles. For example, at McCord and Harriman Ponds in Tallahassee, Leon Co., populations of 64 and 11 individuals, respectively, were completely eliminated from these ponds and many additional sediment removal projects are planned in the next few years throughout Florida (Aresco and Gunzburger, 2004). In cases where entire wetlands are drained and dredged, local extinction of *C. serpentina* populations is likely with no foreseeable recovery. In suburban landscapes, the probability of successful recolonization by *C. serpentina* of stormwater ponds is greatly reduced by a road-fragmented landscape (Aresco, 2005). Large-scale sediment removal operations leave lakes and ponds with a hard, graded sand or clay substrate devoid of any organic material and aquatic plants. Therefore, habitat alteration resulting from sediment removal reduces the likelihood of population recovery of species such as *C. serpentina* that are primarily associated with habitats of thick organic sediment and dense macrophytes.

Roads built through or near wetlands are significant sources of mortality of turtle populations in Florida (Aresco, 2005). *Chelydra serpentina* is frequently observed attempting to cross roads when females emerge from water to nest or when adults or juveniles move overland between aquatic habitats. During drought conditions in Florida, lakes, ponds, and swamps may dry completely, causing *C. serpentina* to migrate in search of water (Aresco, 2005). Thus, roads are barriers to both normal seasonal movements and mass migrations during periodic drought conditions. Highway roadsides also create artificial disturbed and open habitats that may be attractive to nesting females but may cause significant annual road mortality. In central Ontario, a 3-yr study found 86 *C. serpentina* killed on roads during the nesting season, of which 24% were mature females (Haxton, 2000). In a 4-yr survey on the 3.6 km Long Point Causeway at Lake Erie, Ontario, 272 *C. serpentina* were found road-killed (Ashley and Robinson, 1996). Unfortunately, there are few quantitative data on road mortality of *C. serpentina* in Florida. Smith and Dodd (2003) reported 8 *C. serpentina* killed in one year on a 3.2 km section of U. S. Highway 441 at Paynes Prairie. Although *C. serpentina* was at low density (0.04 turtles/ha) at Lake Jackson, Leon Co., it had the greatest level of road mortality relative to abundance compared to other turtle species (11 road-killed individuals on 1.2 km of U.S. Highway 27 in four years) (Aresco, 2005). Without careful monitoring of turtle populations, the effects of road mortality on *C. serpentina* populations might not be detected until after population declines have occurred.

Potential Threats. — Historically, snapping turtles were harvested for their meat throughout their range (Clark and Southall, 1920; Harding and Holman, 1987). In colder climates, much of the commercial collecting of this species was done with long, recurved hooks that were used to probe muddy bottoms and undercut riverbanks at resting and/or hibernation sites (Clark and Southall, 1920). During World War II Americans were encouraged to consider snapping turtles as an alternative meat supply (Lagler, 1943). In the early 1970s, commercial harvest of *C. serpentina* in New York resulted in an average take of 2.4 adults/ha/year, a level of harvest that was not sustainable and a fourth-year yield that was half of that in the first year (Kiviat, 1980).

Commercial exploitation of snapping turtles has recently increased in many states because of a new demand from Asian markets (both in the U. S. and in China) for turtle meat, organs, and bones for food and traditional medicines. The wholesale value of hatchling *C. serpentina* increased to $6 each in 2002–03. Photographs accompanying Internet sales clearly show offerings of hatchling *C. s. osceola* from south Florida (Ewert, *pers. obs.*). Although turtle farms in China are attempting to produce their own *C. serpentina* (P. Moler, FFWCC, *pers. comm.*), China continues to import them from North America. A turtle trapper in Maine reported an Asian buyer who had solicited 5,000 pounds of small female snapping turtles. In North Carolina, 23,000 turtles were harvested in 2002, many of which were snapping turtles that were shipped to China or U. S. Asian markets (North Carolina Division of Wildlife Management, *pers. comm.*). The Maine Department of Inland Fisheries and Wildlife banned commercial harvest of snapping turtles in 2002 because of decades of overexploitation and the potential increase in harvest from Asian buyers offering high prices. In Florida the level of harvest of *C. serpentina* is unknown as the FFWCC does not require permits or reporting for turtles harvested for personal consumption and most commercial turtle harvest (65-85%) goes unreported (Enge, 1993). Enge (1993) reported that 83 lb (37 kg) of dressed snapping turtle meat was sold to one fish market in the Lake Okeechobee area from 1990–92, prior to the considerable increase in Asian demand for U.S. turtles in the last several years. Conversations with local turtle trappers in north Florida indicate that *C. serpentina* are often captured on trotlines, set lines, and bush hooks, both intentionally and as bycatch while trapping Florida softshells (*Apalone ferox*). According to trappers, snapping turtle meat is kept for personal consumption or sold locally. In the 1980s–1990s, baited trotlines set to catch Florida softshells were prevalent on Lake Jackson, Leon Co. (M. Hill, FFWCC, *pers. comm.*). Although *C. serpentina* may naturally be less abundant in large lakes, long-term exploitation of *C. serpentina* both directly or as bycatch to Florida softshell harvest may at least partially explain the very low density of this species at Lake Jackson compared to nearby ponds, which have relatively high densities of *C. serpentina* but no harvest pressure. A series of very large *C. s. osceola* collected in the 1920s from Lake Apopka, Orange Co. (FLMNH 53698, 66157, 66158; CL's 40.5, 42.5, and 39.9 cm) suggests the historic presence of large individuals in lake populations that are rarely observed today. Therefore, although levels of unreported harvest for personal consumption or local sales may be relatively low, some *C. serpentina* populations may be adversely affected if population densities are naturally low and the same populations are exploited over time.

Population viability models derived for northern populations demonstrate that low levels of harvest (less than 10%) of adult *C. serpentina* can lead to rapid depletion of populations (Galbraith and Brooks, 1987; Congdon et al., 1994), and even light conventional harvest is not sustainable **(**Galbraith et al., 1997)**.** Without close monitoring of the population status of this species, the effects of overharvesting may not be recognized until they become severe. Consumption of this species by humans might be tempered by the observation that it is high on the food chain, long lived, and has been shown to concentrate organochlorine toxicants (e.g., from pesticides in agricultural areas) to a degree considered unsafe for humans under USDA standards (Stone et al., 1980; Golet and Haines, 2001).

Incidental killing of all species of turtles, including *C. serpentina*, by bank fishermen continues in north Florida and is especially problematic during drought conditions when turtles become concentrated in relatively small areas (Aresco, unpubl. data). Turtles are killed due to a misconception that they compete with humans for fish and because they may take bait (e.g., worms, chicken parts) or tackle that fishermen retrieve by destroying the turtle (Aresco, *pers. obs.*). Juvenile snapping turtles are more vulnerable to this threat than adults. Some government and private managers of fisheries ponds, sport fish stocks, and waterfowl at both private and public water bodies continue to employ lethal methods of predator control on perceived fish and waterfowl predators such as turtles. Although there is no scientific evidence that *C. serpentina* reduces populations of fish or waterfowl, this species is often trapped and killed for this reason throughout its range (J. Birdsley, *pers. comm.*, Aresco, *pers. obs.*).

Despite Federal regulations that prohibit sale of turtles less than four inches in length, hatchling and small juvenile *C. serpentina* are commonly sold in pet stores (e.g., at three pet stores in Tallahassee in 2003) (Aresco, *pers. obs.*). From 1990–92, 262 *C. serpentina* taken from the wild were sold in pet stores, but clearly the actual numbers collected were far greater than reported (Enge, 1993).

STATUS

The status of *C. serpentina* is unknown in most of Florida, but is generally considered secure. The species is not currently listed by CITES, USFWS, FCREPA, or FFWCC.

CONSERVATION OPTIONS AND SOLUTIONS

Chelydra serpentina is not State or Federally listed as threatened or endangered. However, Federal and state regulations are insufficient to protect many of the wetland habitats (e.g., small, isolated, and seasonal wetlands) that support snapping turtle populations in Florida. Therefore, state legislative regulations should be passed to protect these wetlands (not connected with U.S. navigable waters) that are no longer protected due to a recent Supreme Court decision (Gibbons, 2003). Additional regulations should extend wetland conservation boundaries to include the terrestrial periphery and terrestrial corridors between isolated wetlands (Buhlmann and Gibbons, 2001).

The negative effects of sediment removal on populations of *C. serpentina* and other herpetofauna should be carefully considered prior to the permitting of future projects by regulatory agencies and, if possible, mitigation efforts such as capturing and relocating turtles to nearby ponds prior to and during these projects should be undertaken.

Reducing or eliminating road mortality of *C. serpentina* can be accomplished by constructing diversion fencing or barriers along the road in combination with under-highway culverts at key crossing locations (Dodd et al., 2004; Aresco, 2005; M. Papin, NYDOT, *pers. comm.*). Areas where road-kills are concentrated along defined stretches of road, such as where highways bisect wetlands or at important nesting sites, should be identified for mitigation (Aresco, 2005). In Florida, such projects typically originate at the county level (e.g., Metropolitan Planning Organization) and involve cooperation with the Florida Department of Transportation (FDOT), with potential funding sources such as Federal transportation enhancement funds under TEA-21 (Transportation Equity Act for the 21st Century) or FDOT environmental mitigation funds (Transportation Research Board, 2002). New road projects should be carefully evaluated for their environmental impacts during the PD&E phase (Project Development and Environmental) and wildlife crossing and diversion structures designed into such projects beforehand. For *C. serpentina* and other turtles with good climbing ability, diversion structures should be at least 1 m tall, have an inward facing lip, and buried to at least 30 cm. Wire exclusion fencing typically installed along major highways in Florida to prevent wildlife-vehicle collisions does not work for all size classes of turtles. There are numerous large gaps under fencing, especially at watercourses and wetlands, and standard wire size only excludes larger turtles (greater than $4^1/_2$ inches shell width, Aresco, *pers. obs.*).

There are currently no regulations in Florida that protect *C. serpentina* from excessive harvest and we lack adequate baseline data on the level of harvest of this species to properly assess population viability and set sustainable limits on use. We recommend that the Florida Fish and Wildlife Conservation Commission consider a moratorium on harvest of *C. serpentina* until baseline data are collected. If other states follow North Carolina and ban commercial turtle harvest, commercial turtle trapping will probably increase in Florida over the next several years. At a minimum, all turtle harvest (personal and commercial) should require a specific trapping permit and mandatory reporting of size, sex, and number of harvested turtles. This strategy should be implemented immediately in order to closely track the status of harvested populations and the activities of turtle trappers throughout the state.

Fishermen and fisheries and waterfowl managers should be educated that *C. serpentina* does not significantly affect fish and waterfowl populations, but in fact, provide important ecological functions as scavengers and herbivores. Needless eradication of *C. serpentina* from public and private ponds and lakes should be specifically prohibited by the FFWCC. In areas where bank fishermen continually kill turtles that are incidentally caught on fishing lines, those individuals should be prosecuted under the FFWCC general regulation prohibiting "wanton and willful destruction of wildlife." Trotlines, setlines, and bush hooks should be prohibited in Florida as they indiscriminately capture non-target species and incidental mortality of turtles can occur from abandoned bush hooks in Panhandle rivers (e.g., Ochlockonee River, Apalachicola River, and Wacissa River).

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