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Growth rates of juvenile smalltooth sawfish *Pristis pectinata* Latham in the western Atlantic

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The growth rates of juvenile smalltooth sawfish *Pristis pectinata* collected in Florida waters between 1999 and 2006 were investigated using length-frequency and tag-recapture data. Stretched total length (L_{ST}) data from 144 smalltooth sawfish (690–4960 mm) and 28 recaptures (775–2150 mm) were used for the analyses. Both methods indicated that growth was rapid during the first 2 years after birth. The L_{ST} increased by 650–850 mm in the first year, and by 480–680 mm in the second year. Data for animals >2200 mm were limited, so growth beyond 2 years of age was uncertain. The von Bertalanffy growth parameters estimated from L_{ST} frequency data were $L_\infty = 6000$ mm, $K = 0{\cdot}140$ year^{-1} and $t_0 = -0{\cdot}863$ years. Growth rates over the size range for which tag-recapture data were available were similar to that from L_{ST} frequency data. The growth rates reported are substantially faster than those previously assumed for this species and may have important implications for the recovery of this endangered species. There are conflicting data regarding the growth rates of older *P. pectinata* which need to be resolved with more data from the wild population before a complete understanding of the conservation implications can be obtained.

Key words: age and growth; endangered species; length frequency; Pristidae; tag recapture.

INTRODUCTION

The ability to predict the recovery (or continued decline) of an endangered species depends on a sound understanding of its life-history, including growth, reproduction and mortality. Field, and possibly captive, research is therefore important, despite the inherent rarity of endangered species, to provide data for planning recovery. In the absence of these data, life-history correlates and information from closely related species can produce estimates, but provide less certainty.

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The smalltooth sawfish *Pristis pectinata* Latham, 1794, was a common inhabitant of tropical and subtropical Atlantic coastal waters before decades of fishing and habitat modification resulted in substantial declines in the population (Simpfendorfer, 2000*a*). These declines have occurred throughout the species' range, and there are reports of it being extirpated from parts of its former range (Snelson & Williams, 1981). Within U.S. waters, the majority of the remaining population occurs in south and south-west Florida (Seitz & Poulakis, 2002; Poulakis & Seitz, 2004). As a result, this species is listed by the IUCN as Critically Endangered and it was listed under the U.S. Endangered Species Act in 2003 (USNMFS, 2003; Adams *et al.*, 2006).

Pristis pectinata is a large species of batoid elasmobranch, growing to >6000 mm in stretched total length (L_{ST}) (Simpfendorfer, 2002). The young are born in spring (March and April) between *c.* 690 and 810 mm and may reach maturity between 2700 and 3600 mm (Simpfendorfer, 2005; Mote Marine Laboratory and Florida Fish and Wildlife Conservation Commission, unpubl. data). In Florida, the young occupy nursery areas in shallow estuaries and shallow coastal bays (Seitz & Poulakis, 2002; Poulakis & Seitz, 2004). Juveniles as large as 2500 mm have been recorded in these nursery habitats (unpubl. data), at sizes larger than this they appear to move to more open-water coastal habitats (Simpfendorfer, 2005). Adults have been recorded in a variety of coastal and shelf habitats from shallow estuarine areas to at least 122 m (Seitz & Poulakis, 2002; Poulakis & Seitz, 2004; Simpfendorfer, 2006).

Simpfendorfer (2000*a*) estimated the population recovery rates of Atlantic sawfish (smalltooth sawfish *P. pectinata* and largetooth sawfish *Pristis perotteti* Müller & Henle, 1841) using life-history tables constructed with data available in the literature, life-history correlates and data from related species. He estimated that the *P. pectinata* population had an intrinsic rate of population increase of 0·081–0·130 year^{-1}, and based on these data the population would take at least several decades to recover if all sources of external mortality were eliminated. Since no age and growth data were available for this species, a range of situations with different growth rates were tested, resulting in the wide range of estimates. Previous research on the age and growth of sawfishes is limited to freshwater habitats. Tanaka (1991) produced a growth curve for the freshwater sawfish (*Pristis microdon* Latham, 1794) from northern Australia and Papua New Guinea using vertebral ageing that indicated relatively slow growth and late maturity ($K = 0{\cdot}066$ year^{-1}, where K is from the von Bertalanffy growth equation). In contrast, Thorburn *et al.* (2007) working in north-western Australia reported similar first year growth rates, but continued rapid growth, with growth to 2500 mm approximately four times faster than reported by Tanaka (1991). Thorson (1982) provided growth information for the largetooth sawfish from tag-recapture data, noting slow growth in adults (mean annual growth = 44 mm). There are also some limited observations from captive *P. pectinata* specimens. Growth of the group as a whole is poorly understood and limits the ability to model populations for the purposes of developing and evaluating recovery strategies.

The aim of this research was to provide estimates of the growth rates of juvenile *P. pectinata*. The study combined data from three organizations that have collected this species, either in directed research, or as part of sampling habitats in which it occurs. Accurate species-specific estimates of growth rates will provide greater certainty in the determination of population recovery rates and aid in recovery planning. Two sources of growth data, length-frequency data and tag-recapture data, were used to provide for comparison of results between methods.

MATERIALS AND METHODS

FIELD SAMPLING

Sampling occurred from June 1999 to December 2006 throughout south-west Florida and the Florida Keys (Tampa Bay to Marquesas Keys). Habitats sampled in this region included mangrove shorelines, sheltered bays, mangrove backwaters, seagrass beds, deep channels, the lower reaches of rivers, river mouths, drainage ditches and man-made canals. Four sampling methods were used: longlines, gillnets, haul seines and rod and reel. Longlines consisted of a 100–800 m bottom set mainline of 8 mm braided nylon rope anchored at both ends. Gangions were constructed of either 1 m of 5 mm braided nylon cord and 1 m of stainless steel wire or 1 m of 136·1 kg monofilament. Hooks were either Mustad® tuna circle hooks (10/0–16/0), 3·5/0 Mustad® 'J'style shark hooks or 9/0 Eagle Claw® straight O'Shaughnessy hooks. Hooks were baited with frozen mullet (*Mugil* spp.) or other fresh teleost species when available. Gangions were spaced *c.* 10 m apart along the mainline. Set times ranged from 30 to 300 min, but were mostly <150 min. Gillnets were 46–183 m of 76 mm (3 inch), 127 mm (5 inch) or 152 mm (6 inch) stretch mesh monofilament anchored at both ends. Surface buoys were used to mark the location of nets every 10 m. Gillnets were monitored continuously to allow removal of animals as they were captured. Set times were normally 30 to 90 min. Centre-bag haul seines (183 m, 38 mm stretch mesh) were set in a rectangle along the shoreline and pulled in by hand. Rod and reel fishing used 18·1 kg monofilament line and a 10/0 Mustad® tuna circle hook with *c.* 0·5 m of plastic coated wire leader. Hooks were baited with the same baits used on the longlines.

Captured smalltooth sawfish were sexed and at least three measurements of length [precaudal (L_{PC}), natural total (L_{NT}) and L_{ST} (from the tip of the rostrum to the tip of the tail, with the tail extended to its maximum extent)] were taken with measuring boards or measuring tapes to the nearest 5 mm or 1·0 mm. In general, measuring boards were used for smaller smalltooth sawfish and tapes were used for large fish. Measurement error was minimized because a small group of scientists measured all of the smalltooth sawfish at release and recapture. L_{ST} rounded to the nearest 5 mm was used for all analyses. All smalltooth sawfish were tagged with plastic cattle ear tags (Dalton® Rototag or Jumbo Rototag, Henley-on-Thames, U.K.) through the first or second dorsal fin. Some fish were also tagged with plastic headed dart tags (Hallprint®, Victor Harbor, Australia). Beginning in 2002, all smalltooth sawfish captured were also tagged with an 11 mm passive integrated transponder (PIT) tag (Biomark®, Boise, ID, U.S.A.) that was injected into the muscle below the first dorsal fin. All smalltooth sawfish captured from 2002 onward were scanned with a PIT tag reader to determine if they had been previously captured.

DATA ANALYSIS

Length-frequency data

Length-frequency data from the three organizations were combined, with all years and both sexes pooled. Sexes were pooled due to small sample sizes and because early growth is usually indistinguishable between the sexes in other elasmobranchs (Simpfendorfer, 2000*b*). The data were then divided into monthly samples and analysed using the ELEFAN II (Pauly, 1987) and PROJMAT (Rosenberg *et al.*, 1986; Basson *et al.*,

1988) methods implemented in the computer programme LFDA (version 5) (Fisheries Management Science Program, http://www.fmsp.org.uk/software.htm). These methods were used to fit non-seasonal and seasonal von Bertalanffy growth functions to the data: $L_t = L_\infty(1 - e^{-q})$, where L_t is the length at age t, L_∞ is the asymptotic length, and q is dependent on whether the seasonal or non-seasonal form of the equation is used. For the non-seasonal form: $q = K(t - t_0)$, where K is the growth rate and t_0 is the age at which length is zero. For seasonal growth the Hoenig & Hanumara (1982) function was used: $q = K(t - t_0) + S{\cdot}\sin 2\pi\ (t - t_0) - S{\cdot}\sin 2\pi\ (t - t_s)$, where t_s defines the start of the convex segment of a sinusoid oscillation with respect to t_0 and $S = CK\ (2\pi)^{-1}$, where C is the relative amplitude of the seasonal oscillation.

LFDA fits the growth functions by first exploring the parameter space to approximate the best values, and then uses a non-linear optimizer to maximize a scoring function. The scoring function for PROJMAT is an unweighted least squares value based on forward projected values of a matrix. The scoring function for ELEFAN first restructured the length-frequency data using the method of Brey *et al.* (1988) and then calculated the ratio between the sum of modal peak values to which a curve was fit.

Tag-recapture data

Tag-recapture data were analysed using the GROTAG method described by Francis (1988). This method uses a maximum likelihood approach to fitting a growth function that included estimated growth rates (g_α and g_β) at two selected lengths ($\alpha = 800$ mm L_{ST} and $\beta = 2000$ mm L_{ST}) based on the available data, the coefficient of growth variability (v), measurement error (assumed to be normally distributed with a mean, m, and S.D., s), and outlier probability (p). The estimated growth increment for an individual, i, is given by: $\Delta L_i = [(\beta g_\alpha - \alpha g_\beta)(g_\alpha - g_\beta)^{-1} - L_i]\{1 - [(1 + (g_\alpha - g_\beta)(\alpha - \beta)^{-1})^{\Delta T_i}]\}$, where L_i is the length at release and ΔT_i is the period at liberty. The likelihood function is: $\lambda = \sum_i \log[(1-p)\lambda_i + pR^{-1}]$, where $\lambda_i = [e - 0{\cdot}5(\Delta L_i - \mu_i - m)^2 (\sigma_i^2 + s^2)^{-1}][2\pi(\sigma_i^2 + s^2)]^{-0{\cdot}5}$. R is the range of the observed growth increments, μ_i is the expected value of growth increment of the ith individual and σ_i is the S.D. of the growth variability. In the present study, σ_i was assumed to be proportional to the predicted growth increment (*i.e.* $\sigma_i = v\mu_i$).

The Solver function in Microsoft® Excel was used to maximize the likelihood value of the model. Although the growth model allowed the use of six parameters, the number of parameters used was determined using the likelihood ratio test (LRT). In its simplest form, growth was assumed to be linear ($g_\alpha = g_\beta$) and include s. The addition of more parameters [non-linear growth ($g_\alpha \neq g_\beta$), v, m and p] was significant if the likelihood increased by $>1{\cdot}92$ per parameter (Francis, 1988). The final model used for each group was the one with the least number of significant parameters.

Bootstrapping was used to estimate 95% CI for parameter estimates. New growth increment values were generated by adding randomly selected points from two normal distributions (Simpfendorfer, 2000*b*). The first distribution had a mean of the predicted growth increment and a S.D. equal to $v\mu$, and represented growth and growth variability. The second distribution represented the measurement error and had a mean of m and a S.D. of s. Five hundred bootstrapped data sets were created using each method and fitted using the technique described above. Ninety-five per cent CI were calculated from the 2·5th percentile and the 97·5th percentile of the resulting parameter distributions.

RESULTS

LENGTH-FREQUENCY DATA

Length data from 144 smalltooth sawfish, ranging from 690 to 4960 mm, were used for length-frequency analysis (Fig. 1). The majority of data were from individuals <2000 mm, with two modes, one at 800–1100 mm and the

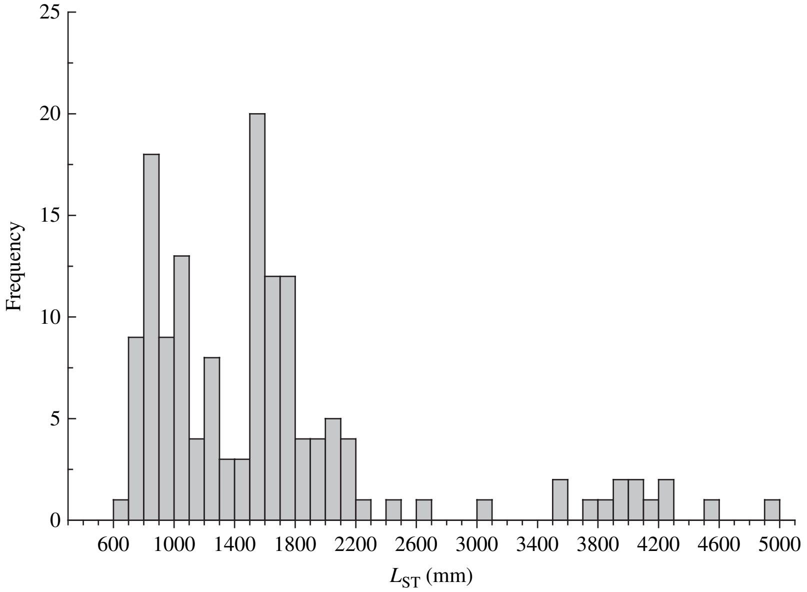

FIG. 1. Stretched total length (L_{ST}) frequency of *Pristis pectinata* captured in research surveys in Florida waters from 1999 to 2006.

other at 1500–1800 mm. Larger individuals were included to aid in the estimation of L_∞. Individuals were caught in all months, with most captured between March and July. The ELEFAN method produced a slightly higher value of K and lower value of L_∞ than the PROJMAT method for the non-seasonal growth models (Table I). The results indicated that growth of juvenile sawfish was rapid, but that it slows at $L_{ST} > 2000$ mm (Fig. 2). Both the PROJMAT and ELEFAN methods yielded seasonal growth models, but the parameters defining the seasonal pattern differed substantially (Table I). The seasonal change in growth was minor for both fitting methods (Fig. 3). The ELEFAN seasonal growth model showed higher growth rates in the period from June to September, and provided a higher score value than the non-seasonal model, indicating that it provided a good fit to the data. The PROJMAT seasonal model only produced a 0·02 increase in the score value, suggesting that its non-seasonal model adequately described the data.

TABLE I. The von Bertalanffy growth function parameter estimates for *Pristis pectinata* based on length-frequency data. Two methods of calculation (ELEFAN and PROJMAT), and both non-seasonal and seasonal functions, were used. Score functions are not comparable between the ELEFAN and PROJMAT methods

Model	K (year^{-1})	L_∞ (mm)	t_0 (year)	t_s (year)	C	Score
ELEFAN non-seasonal	0·189	5270	−0·590	—	—	0·568
PROJMAT non-seasonal	0·140	6000	−0·863	—	—	−2·790
ELEFAN seasonal	0·189	5270	−0·530	−0·334	0·687	0·664
PROJMAT seasonal	0·134	6250	−0·828	0·433	0·182	−2·775

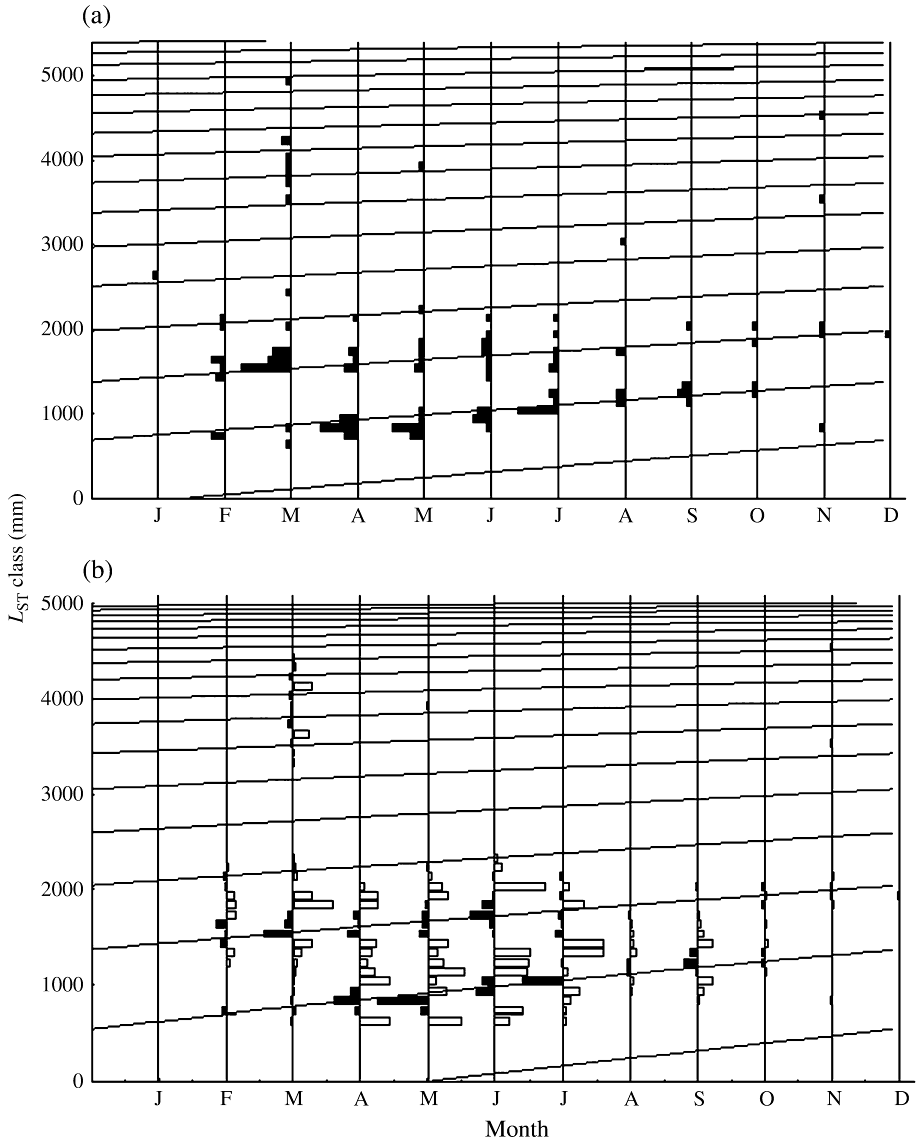

FIG. 2. Monthly stretched total length (L_{ST})-frequency data for *Pristis pectinata* caught in Florida waters. Upward sloping horizontal lines indicate non-seasonal von Bertalanffy growth curves fitted using (a) PROJMAT (■, raw L_{ST} frequency data) and (b) ELEFAN (■ and □, restructured data).

TAG-RECAPTURE DATA

Twenty-eight recaptures of smalltooth sawfish (12 males and 16 females) occurred during the study period and all were made within 20 km of release locations. Periods at liberty varied from 1 to 652 days, with most <100 days. At release L_{ST} ranged from 775 to 1811 mm, and at recapture L_{ST} ranged from 775 to 2150 mm. Growth increments ranged from 0 to 1130 mm and showed

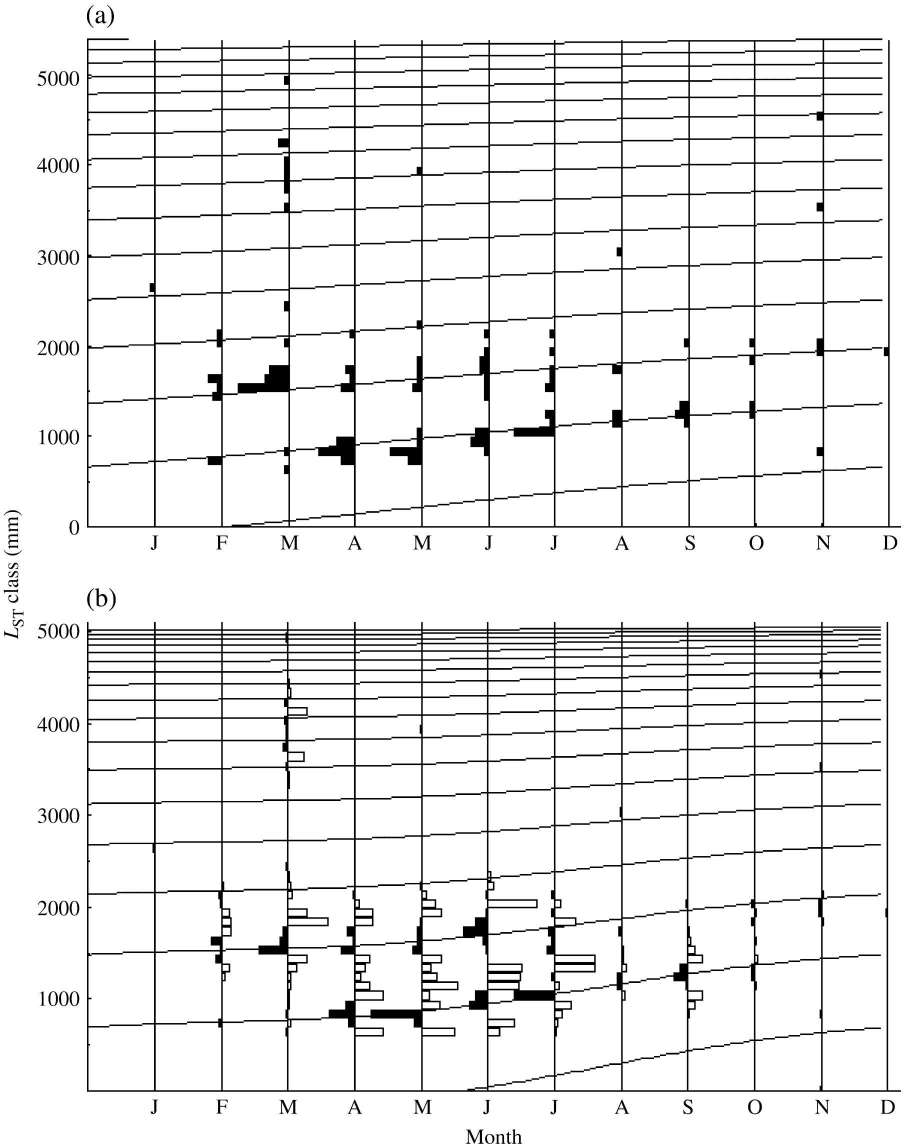

FIG. 3. Monthly stretched total length (L_{ST})-frequency data for *Pristis pectinata* caught in Florida waters. Upward sloping horizontal lines indicate seasonal von Bertalanffy growth curves fitted using (a) PROJMAT (■, raw L_{ST} frequency data) and (b) ELEFAN (■ and □, restructured data).

a consistent increasing trend with time at liberty (Fig. 4). The likelihood values for the growth models with three to six parameters were all very similar, with the more complex models providing no significant improvement in the fit of the models (Table II). Thus, the three parameter model was used to best describe the growth of juvenile smalltooth sawfish. The growth rate of 863·9 mm year^{-1} at 800 mm indicated very rapid growth early in life. Bootstrapped estimates of

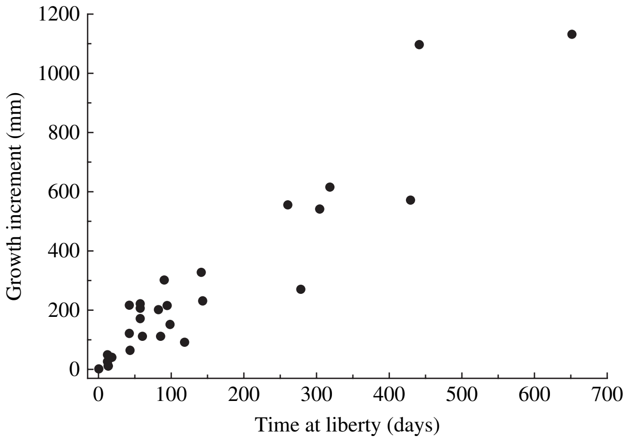

FIG. 4. Growth increment as a function of time at liberty for 28 juvenile *Pristis pectinata* recaptured from Florida waters. Two male sawfish had the same increment (10 mm) over the same time at liberty (14 days).

95% CI intervals for the g_α were relatively tight (805·0–923·1 mm year^{-1}), while those for g_β were 215·0–410·1 mm year^{-1} and the S.D. of measurement error (3·94–7·05) was more variable.

COMPARISON OF METHODS

Over the size range for which most of the L_{ST} data and all of the tag-recapture data were available (690–2200 mm), the growth curves produced were similar (Fig. 5). Statistical comparison of the different growth functions was not possible because the length-frequency analysis did not produce likelihood estimates.

DISCUSSION

The results of this study demonstrate that the growth rates of early juvenile smalltooth sawfish are rapid. Length-frequency and tag-recapture data both indicated that growth from birth (*c.* 690–810 mm, estimated from the presence

TABLE II. Estimated *Pristis pectinata* growth parameters based on tag-recapture data using the Francis (1988) method. Significance of additional parameters was tested using the likelihood ratio test

Parameters	g_α (mm year^{-1})	g_β (mm year^{-1})	v	s	m (cm)	p	Likelihood
2 (linear)	683·3	—	—	9·67	—	—	−95·874
3	863·9	399·2	—	5·71	—	—	−82·176
4	855·6	279·3	0·09	4·71	—	—	−81·041
5	860·9	279·6	0·09	4·71	−0·217	—	−81·033
6	860·9	279·6	0·09	4·71	−0·217	0·00	−81·033

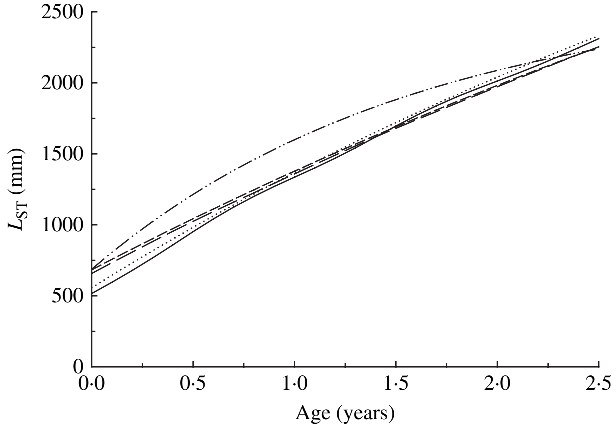

FIG. 5. Comparison of growth functions for juvenile *Pristis pectinata* in Florida waters from tag-recapture (GROTAG, -··-) and stretched total length (L_{ST})-frequency data (ELEFAN non-seasonal, ·····; ELEFAN seasonal, ——; PROJMAT non-seasonal, ---; PROJMAT seasonal, – –).

of a rostral sheath) to 1 year of age resulted in an approximate doubling in size (1350–1550 mm). Slightly lower growth rates were estimated for the second year. Such rapid growth rates have rarely been reported in elasmobranchs, which are typically considered to be slow growing, as shown in the elasmobranch age and growth summary table in Cailliet & Goldman (2004). Most fast growing elasmobranchs have relatively small maximum sizes and rapid growth lasts only a year or two. For example, Simpfendorfer (1993) reported that the Australian sharpnose shark *Rhizoprionodon taylori* (Ogilby, 1915), which has a maximum total length (L_T) of 790 mm, almost doubled in length in its first year of growth, but in the second added only 100 mm. Larger species that grow rapidly are less common. Tiger sharks *Galeocerdo cuvier* (Péron & Lesueur, 1822), which have a maximum L_T of 5500 mm (Randall, 1992), have rapid growth, increasing from 610 to 1060 mm in their first year (Natanson *et al.*, 1999). The growth rates of young smalltooth sawfish are therefore among the most rapid within the elasmobranchs.

There are few published studies on growth in other species of sawfishes. Tanaka (1991) reported von Bertalanffy growth parameters for *P. microdon* in northern Australia and Papua New Guinea. Growth was relatively slow, with $K = 0{\cdot}066$ year^{-1} and growth from birth (800 mm) to 1500 mm took *c.* 4 years. In contrast, Thorburn *et al.* (2007) reported more rapid growth for the same population, with a 4 year old animal estimated to be 2500 mm. Neither study on *P. microdon* provided validation of the periodicity of growth band formation in the vertebrae on which they were based. Thorson (1982) reported growth data for *P. perotteti* from a tagging study in Lake Nicaragua that showed the average growth rate of adults to be *c.* 44 mm year^{-1}. A von Bertalanffy growth curve used to approximate Thorson's data by Simpfendorfer (2000*a*) had a K value of 0·089 year^{-1}. Based on published data, the growth rates for juvenile smalltooth sawfish are substantially greater than those reported for other sawfish species, all of which are based on freshwater habitats. Whether this difference is the result of species-specific growth rates, or differences in productivity between freshwater and estuarine habitats is unknown. The likelihood that measurement error was responsible for the observed results was low since a small number of trained scientists measured all of the animals in this study. The small degree of measurement error was also demonstrated by the results of the GROTAG analysis.

Using tag-recapture data from relatively small individuals, the GROTAG method produced the highest rates of juvenile growth. Because of the lack of recaptures of large smalltooth sawfish this method was only able to provide growth rate estimates for animals up to *c.* 2 years old and was not used to estimate von Bertalanffy parameters. The length-frequency methods was able to estimate von Bertalanffy parameters that appeared to provide a good representation of the growth of this species. This may have been the result of including data from large smalltooth sawfish. Although both length-frequency methods yielded similar results, ELEFAN under-estimated the size at birth, while PROJMAT provided more accurate estimates. In addition, simulation studies have shown that in some situations ELEFAN is less robust than PROJMAT (Basson *et al.*, 1988). Thus, the PROJMAT results probably best represent the non-seasonal growth of juvenile smalltooth sawfish based on the data available.

The addition of seasonal growth parameters to the length-frequency models produced conflicting results. ELEFAN indicated that growth was more rapid from June to September, while PROJMAT indicated February to July. Neither seasonal growth model indicated a strong seasonal change in growth rate, with ELEFAN estimating the greater change in growth. The PROJMAT seasonal growth model did not appear to substantially increase the fit to the data and was considered to add little information. The ELEFAN model did improve model fit, and is likely to provide the best representation of seasonal growth. The period of most rapid seasonal growth estimated by ELEFAN corresponds to the highest water temperatures during summer. Increased growth rates may be facilitated by these high temperatures.

Gear selectivity can cause problems for the interpretation of length-frequency data by creating artificial modes (or truncating them) in the length-frequency data. In this study, however, the use of several different sampling gears in different habitats (*e.g.* mangrove shorelines, seagrass beds, deep channels, main river stems, tributaries and man-made canals), including gillnets with three different mesh-sizes, longlines with a variety of hook sizes and haul seines, meant that sawfish over a wide range of sizes could be sampled. Thus gear selectivity was not considered to be an issue. Another factor that can influence the interpretation of data is movement of animals at different stages of their life history. This can cause similar effects to gear selectivity. Given that smalltooth sawfish use estuarine nursery areas at sizes *c.* < 2500 mm, this may be a concern in the current study in truncating the right hand limb of the second age class. Habitats outside of nursery areas, however, were extensively surveyed, reducing the likelihood of this effect. In addition, the similarity of growth rates estimated by the tag-recapture data over this same size range suggests that the second age class was adequately identified.

The lack of tag-recapture data >2150 mm made it impossible to validate growth rates above this size. In addition, the limited quantity of data meant that it was impossible to separate out data for each sex to produce estimates of growth for each. The results of research on captive smalltooth sawfish, however, suggest that growth of larger juvenile and adult fish is much slower than suggested by the data presented in this paper. Using data mostly from individuals >1500 mm, 16 smalltooth sawfish from five aquaria, much slower growth was estimated (S. Clark, G. Violetta, A. Henningsen, V. Reischuk, P. Mohan, J. Keyon and G. Kelly, unpubl. data) than reported here for ages 0 and 1 years, with estimates of K from 0·042 to 0·067 year^{-1}, and ages at maturity of at least 17 years for males and 20 years for females. The estimated mean growth rate of three captive animals from the Oceanario Islas Rosario, Columbia, was 196 mm year^{-1}, with growth from 845 to 3200 mm in 12 years (C. Borhorquez, unpubl. data). It is unclear, however, how comparable captive growth rates are to those in the wild because of artificial living and feeding conditions (Cailliet & Goldman, 2004; Mohan *et al.*, 2004). The field data show that early growth of juvenile smalltooth sawfish is rapid, and the captive data suggest that growth slows significantly before maturity. Thus, further research on wild populations will be required to provide accurate estimates of growth rates of larger juvenile and adult smalltooth sawfish for each sex, and to estimate the ages at which they mature. Previous estimates of growth that yielded ages at maturity on the order of 20 years are unlikely to be accurate, however, given the high early growth rates.

The rapid growth of juvenile smalltooth sawfish reduces the risk of predation from large predators, such as sharks which occur in the same habitats. The relatively small size at birth means that predation may be significant, and rapid growth would minimize the predation risk. Evidence from acoustic tracking of juvenile smalltooth sawfish has suggested that they employ behaviours that would also minimize predation risk (*e.g.* use of extremely shallow banks and red mangrove *Rhizophora mangle* L. shoreline habitats) (Simpfendorfer, 2006). Development of these predator avoidance mechanisms to minimize predation risk has probably been important in the evolution of the early life history of the smalltooth sawfish.

Another possible reason for the rapid growth observed is density-dependent compensation. Density-dependent changes in growth rates of elasmobranchs have been hypothesized for species that have been heavily exploited, but have yet to be unequivocally demonstrated. For example, Sminkey & Musick (1995) observed a slight increase in growth rates of sandbar sharks *Carcharhinus plumbeus* (Nardo, 1827) after exploitation. Cassoff *et al.* (2007) have also hypothesized that density-dependent increases in growth of overfished porbeagle sharks *Lamna nasus* (Bonnaterre, 1788) may have occurred, including a reduction in the age at maturity. It is unlikely that density-dependent growth will be unequivocally demonstrated for smalltooth sawfish due to the lack of data on the pre-exploited population, unless the population recovers to a level that the increased density limits growth.

The results of this study have potentially important implications for conservation of the smalltooth sawfish in the western Atlantic as well as other sawfish species worldwide. Previous estimates of growth rates used in population assessments have been assumed to be relatively slow, consistent with most other large elasmobranch species (Cortes, 2000; Cailliet & Goldman, 2004). Simpfendorfer (2000*a*) used demographic techniques to examine potential recovery rates and tested ages at maturity from 10 to 24 years. The results of the current study suggest that age at maturity may be substantially lower than this range of estimates. There are limited data available, however, on the size at maturity from which ages at maturity could be estimated for either sex. Males at 1900 and 1930 mm had short uncalcified claspers (35 and 40 mm, respectively), one at 2530 mm had claspers that were beginning to elongate (70 mm), and specimens at 3810 and 4020 mm had fully calcified elongate claspers (370 and 520 mm, respectively) (Mote Marine Laboratory and Florida Fish and Wildlife Conservation Commission, unpubl. data; M. Michel, pers. comm.). On the basis of these preliminary data, males appear to mature between 2530 and 3810 mm. Accurate estimates of size or age at maturity for females are unavailable at this time, but if they follow the pattern demonstrated by most elasmobranchs they are likely to be larger than for males. If ages at maturity for both sexes prove to be lower than those previously used in demographic assessments, then rates of population growth rates are likely to be greater and recovery times shorter. Since growth rates typically slow at different rates for males and females as maturity is approached, more data on smalltooth sawfish of both sexes larger than used in this study are needed to permit analysis of the recovery rates of the population.

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