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SEDAR26-DW-01

Date Submitted: 11 May 2011

SEDAR26 – DW - 01

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by

Meaghan D. Bryan[1], Maria del Mar Lopez[2], and Britni Tokotch[2]

U.S. Department of Commerce
National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)

[1]Southeast Fisheries Science Center (SFSC)
Sustainable Fisheries Division (SFD)
Gulf and Caribbean Fisheries Assessment Unit
75 Virginia Beach Drive
Miami, Florida 33149

[2]Southeast Regional Office
Sustainable Fisheries Division (SFD)
Caribbean Operations Branch
263 13th Avenue South
St. Petersburg, Florida 33701

May 2011

Caribbean Southeast Data Assessment Review Workshop Report
SEDAR26-DW-01
Sustainable Fisheries Division Contribution No. SFD-2011-008

Introduction

The purpose of this report is to review and assemble life history information for *Etelis oculatus* (queen snapper), *Lutjanus vivanus* (silk snapper), and *Sparisoma chrysopterum* (redtail parrotfish) in the US Caribbean. Photos of the three species can be found in Figures 1-3. Life history information for these species was synthesized from published work in the grey and primary literature, as well as FishBase (Froese and Pauly 2011). Given the paucity of available information for redtail parrotfish, the review was widened to include *Sparisoma viride* (stoplight parrotfish), *Sparisoma aurofrenatum* (redband parrotfish), *Sparisoma rubripinne* (redfin parrotfish), and *Scarus vetula* (queen parrotfish).

The report is organized by species and each section focuses on key aspects describing the relationships among age, growth and reproduction. Other descriptors such as geographic range, depth distribution, and habitat characteristics are also included. A previous review of silk and queen snapper biology by Cummings (2003) has been included as an appendix to provide additional information about these species. Lastly, Table 1 defines the symbols used throughout the report for various age, growth, and reproduction parameters.

***Lutjanus vivanus*, silk snapper**

Geographic range, depth distribution, and habitat

Silk snapper are found in the western Atlantic Ocean including the waters off Cape Hatteras, North Carolina and Bermuda and as far south as Brazil (Broadman and Weiler 1980, Sylvester et al. 1980, Parker and Mays 1996, South Atlantic SAFE Report 2005). They are also found in the Gulf of Mexico along the edge of the continental shelf (Sylvester 1980, Parker and Mays 1998). The reported depth range for silk snapper is between 64 meters and greater than 300 meters (Sylvester et al. 1980, Parker and Mays 1998, Cummings 2003, SAFE Report 2005, and references within). Depth distribution and ontogenetic stage are positively correlated, where younger and smaller fish are generally found in shallower depths than older and larger individuals (SAFE Report 2005, Boardman and Weiler 1980). Boardman and Weiler (1980) conducted a study throughout the waters of Puerto Rico between the depths of 70 meters and 270 meters. Although a wide size distribution was associated with a given depth class, the modal lengths of silk snapper at depths of 74-109m, 112-165m, and 166-274m were 210mm, 260mm, and 300mm, respectively (Boardman and Weiler 1980). Sylvester et al. (1980) suggest that juveniles and adults inhabit different depth distributions and point to the capture of smaller fish at shallower depths in Puerto Rico as evidence. Silk snapper are generally associated with rocky hard-bottom, however, adults can also be found over mud habitat (Sylvester and Dammann 1973).

Age and growth

Several studies have evaluated the age-length relationship for silk snapper and are summarized in Table 2. Length frequency data, as well as aged otoliths were used by most studies to estimate the von Bertalanffy growth parameters. The asymptotic length L_{inf} reported in Table 2 has a fairly large range, 600mm -1170mm. Sample size was not known for all studies, however, the largest estimate of L_{inf} was associated with the smallest sample size. The range of the von Bertalanffy growth coefficient k is quite large, 0.051-0.32, and indicates that silk snapper can be considered either a slow or relatively fast growing species. Estimates of the age at which length is equal to zero t_0 were also quite variable and ranges between -2.64 and -0.04. In terms of longevity, silk snapper is a relatively short lived species with a maximum observed age range of 3-6 years. The range of maximum observed length L_{max} reported in Table 2 is 512mm-830mm.

Natural mortality is often estimated as a function of L_{inf}, k, and temperature (Pauly 1980) or as an invariant relationship with k alone (Jensen 1995). The range of estimated natural mortality for silk snapper in the reviewed literature is 0.19-0.86.

The length-weight relationship of silk snapper has also been evaluated by several studies and is calculated as: $W = aL^b$, where W is weight, L is length, a is a scalar and b is a power parameter. The range of the estimated scalar and power parameters is $1e^{-5}$ - $9e^{-5}$ and 2.86-3.02, respectively (Table 2). The estimates of the power parameter are all close to 3, indicating isometric growth for silk snapper.

Reproduction

Silk snapper are gonochoristic (i.e., two distinct sexes). Spawning is expected to occur year round with peaks at various times of the year. Sylvester et al. (1980) found frequent occurrence of immature and mature ovaries in the same female, which was interpreted as an indication of year round spawning. Sylvester (1974) suggested that silk snapper may have two spawning periods, April-June and October-December. Similarly, Parker and Mays (1998) reported peak spawning periods in July through September and October through December along the southeastern coast of the US.

Estimates of length- and age-at-maturity from several studies are summarized in Table 2. Length-at-maturity represents 50% of population that is mature. Studies evaluating the maturity of gonad tissues in relation to length have provided a range of length-at-maturity estimates between 267mm and 600mm (Table 2). Thompson and Munro (1983) found that females and males were mature between 500mm and 555mm and 550mm and 600mm, respectively. A recent study in Puerto Rico found that length-at-maturity for females and males was much lower than that of Thompson and Munro, females and males were mature at 267mm and 296mm fork length (FL) (Rosario et al. 2006a). The range of estimated age-at-maturity is between 3 years and 6 years of age (Table 2).

***Etelis oculatus*, queen snapper**

Geographic range, depth distribution, and habitat

Less is known about the life history of queen snapper than silk snapper, however, they share a similar geographic range. Queen snapper are found throughout the western Atlantic as far north as North Carolina and Bermuda, throughout the Caribbean, as far south as Brazil, and are also found in the Gulf of Mexico (Cummings 2003, SAFE Report 2005, Rosario et al. 2006b, and references within). Fishing experiments to describe the biology of queen snapper conducted in the French West Indies, Dominica, Saint Lucia, and the Caribbean coast of Honduras were conducted in waters between 100m and 430m (Gobert et al. 2005). Queen snapper were generally not caught below 130m and not above 430m, however, fishermen have indicated that they can be caught from 100m to 500m (Gobert et al. 2005).

Age and growth

The age-length relationship for queen snapper has not been well studied. Two studies cited in Claro et al. (2001) and Martinez-Andrade (2003) are summarized in Table 3. The range for L_{inf} is between 1020mm and 1030mm and the range for k is 0.29 and 0.61 per year (Table 3). The original studies did not estimate a value for t_0, however Martinez-Andrade (2003) used the following equation to estimate t_0 from L_{inf} and k:

$$\log(-t_0) = -0.3922 - 0.2752 \log L_{inf} - 1.038 \log K$$ (Pauly 1980).

The resulting range for t_0 was -0.41- -0.189 (Table 3). Natural mortality estimates were larger than for silk snapper, 0.33-0.76 (Table 3). The estimates of maximum observed length and maximum age are 715mm -1002mm and 5-10, respectively. Given the scarcity of studies evaluating the age-length relationship for queen snapper, the reported estimates should not be considered conclusive.

Several studies have evaluated the length-weight relationship for queen snapper (Bohnsack and Harper 1988, Murray and Moore 1992, Frota et al. 2004, Rosario et al. 2006b). The range for the scalar and power parameters estimated by the summarized studies are 0.012 – 0.0632 and 2.55-2.908, respectively (Table 3). The estimates of the power parameter are all close to 3, indicating isometric growth for queen snapper.

Reproduction

Very little is known about the spawning activity of queen snapper, however, they are apparently gonochronistic, like silk snapper and other snapper species (Thompson and Munro 1983). Rosario et al. (2006b) evaluated the reproductive cycle by calculating a gonadosomal index (GSI) for each maturation stage and month over an 18-month sampling period. The authors found that although queen snapper reproduce in all months and peaked in October and November. Queen snapper are expected reach maturity by age one or two and the reported range of length-at-maturity is 310mm and 536mm (Table 3). Rosario et al. (2006) distinguished length-at-maturity between males and females, where the length at maturity was 233mm and 310mm for males and females, respectively.

***Sparisoma chrysopterum*, redtail parrotfish**

Geographic range, depth distribution, and habitat

Redtail parrotfish are distributed in the southwest Atlantic, ranging from South Florida to Brazil and throughout the Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002).

Redtail are associated with a variety of habitats. Juveniles are mainly associated with seagrass beds, whereas adults are associated with coral reefs and the surrounding seagrass beds, sand, mudflats and mangroves.

Age and growth

Table 4 summarizes the information that was found describing the age-length and length-weight relationships for redtail parrotfish. There is a considerable lack of information. Choat and Robertson (2002) reviewed age-based studies for acanthurids and scarids in the tropical Atlantic and western Pacific. In their review they reported the von Bertlanffy growth parameters as well as maximum age for redtail parrotfish. Estimates of asymptotic length, the von Bertalanffy growth coefficient, and the length at age zero were 263mm, 1.176, and -0.04, respectively (Choat and Robertson 2002, Table 4). The maximum observed length of sampled fish was 347mm and maximum age was estimated to be 5 years (see Figure 2 in Choat and Robertson 2002). Evaluations of the length-weight relationship for redtail parrotfish reported estimated length-weight scalar and power parameters to be 0.0152 and 0.0154 and 3.0274 and 3.0423, respectively (Bouchon-Navaro et al. 2006, Molina-Urena 2009; Table 4).

Reproduction

Redtail parrotfish are protogynous hermaphrodites (i.e., they change from female to male), however, not all females change sex (Robertson and Warner 1978, De Loach 1999 cited by Molina-Urena (2009)). Some sparisomatines e.g., *Sp. chrysopterum, Sp. rubripinne, Sp. viride*, (Robertson and Warner 1978), and *Sp. cretense* (de-Girolamo et al. 1999) commonly display prematurational sex change. This character is also called secondary gonochorism because the small secondary males function in the same roles as primary males (Robertson and Warner 1978, Koltes 1993, Claro 1994). Redtails are thought to reproduce year round, however, spawning may decline between the months of May and August (Figuerola and Torres 1997). Reeson (1975) found that the highest proportion of ripe females in January and May. Paired spawning for this species has been observed (Robertson and Warner 1978).

Very little information about length-at-maturity is available for redtail parrotfish. Three estimates of length-at-first-maturity were found for redtail parrotfish, 140mm, 235mm, and 242mm (Table 4, Robertson and Warner 1978, Figuerola et al. 1998, Bouchon-Navarro et al. 2006). Wilson (2003) suggests that length-at-maturity for females is slightly larger at 250mm. Figuerola and Torres (1997) estimated length at 50% maturity for females in Puerto Rico to be 235mm.

Other parrotfish

Table 4 highlights the data limitations for redtail parrotfish. As such, age, growth, and reproduction information was gathered for similar scarid species. Tables 5 and 6 summarize the age, growth, and maturity parameters for stoplight parrotfish, as well as redfin and redband parrotfish, respectively. Commonalities among these species and redtail parrotfish include high growth rates (0.458-1.17 per year) and relatively short life spans (5-9 years, Tables 4-6). Figure 4 shows the relationship between estimated maximum age and standard length for parrotfish found throughout the Atlantic and Pacific oceans, as well as similarities in estimated maximum age for redtail, stoplight, redfin, and redband parrotfish. Figure 5b shows the von Bertalanffy growth curves for these same species. Although the asymptotic length varies among the species, growth rate is similar. These species also share common reproductive traits. All are protogynous hermaphrodites, with a terminal male phase. All spawn year-round in pairs, except for redfin parrotfish who form aggregations (Randall and Randall 1963, Robertson and Warner 1978, Colin 1978, Colin 1996).

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Table 1 Parameter symbols, descriptions, and units of measure which will be used throughout the report.

Parameter	Description	Units
Growth parameters		
L_{inf}	Asymptotic length (total length,TL, unless specified otherwise)	mm
k	von Bertalanffy growth coefficient	$years^{-1}$
t_0	Age at which length is 0	years
W_{inf}	Asymptotic weight	grams
a	Length-weight scalar	none
b	Length-weight power parameter	none
L_{max}	Maximum length (TL unless specified otherwise)	mm
Age		
t_{max}	Maximum reported age	years
Maturity		
L_{mat}	Length at which 50% of population are mature (TL unless specified otherwise)	mm
t_{mat}	Age at 50% maturity	years
Mortality		
M	Natural mortality rate	

Table 2 Summary of growth and maturity parameters for silk snapper, *Lutjanus vivanus*. Bold values are updates from Martinez-Andrade (2003). * indicates reference could not be found to corroborate the information. ‡ indicates length type is fork length. ζ from Froese and Pauly (2011).

				Age-length relationship						Length-weight relationship			Maturity	
Location	Reference	n	Sex	t_0	L_{inf}	k	M	L_{max}	t_{max}	a	b	W_{inf}	L_{mat}	t_{mat}
South Florida	Ault et al. (1998)	-	U	-2.309	781	0.09	0.23	512	9	1e-5	3.1	9300	**418**	3
SE Cuba	Pozo and Espinosa (1982)*ζ	-	U	-2.08	812	0.1	**0.54**	600	**30**	1.7e-5	3.03	8735	**433**	5.5
NE Cuba	Pozo et al.(1983 &1984)* ζ	-	M&F	-2.64	782	0.09	**0.56**	**757**	**33**	-	-	7837	**419**	6
Costa Rica	Tabash and Sierra (1996)	200	U	-0.04	620	0.32	0.86	**598**	9	9e-5	2.9	3405	340	2
Venezuela	Gomez et al. (1996)	300	M	**-1.317**	**816**	0.1	0.19	790	9	1.1e-5	3.02	8320	565	6
Venezuela	Gomez et al. (1996)	292	F	**-1.336**	**775**	0.1	0.19	760	9	1.1e-5	3.02	7500	540	6
Pooled	Froese & Pauly (2000)	-	U	-1.32	812	0.1	0.21	830	29	-	-	9167	433	6
USVI	Sylvester et al. (1980)	95	M&F	-	1170	0.08	-	-	-	-	-	-	-	-
PR	Boardman & Weiler (1980)	-	M&F	-	-	-	-	710	-	-	-	-	380 & 500‡	-

Table continued on next page

Table 2 Continued

				Age-length relationship						Length-weight relationship			Maturity	
Location	Reference	n	Sex	t_0	L_{inf}	k	M	L_{max}	t_{max}	a	b	W_{inf}	L_{mat}	t_{mat}
South Atlantic	SAFE Report (2005)	-		-	-	-	-	830	-	-	-	-	434	6.3
	Thompson & Munro (1983)	-	F	-	-	-	-	-	-	-	-	-	500-555	-
	Thompson & Munro (1983)	-	M	-	-	-	-	-	-	-	-	-	555-600	-
Brazil	Lessa et al. (2004)*[ζ]	-	U	-2.30	600[‡]	0.051	-	-	-	-	-	-	225[‡]	-
PR	Rosario et al. (2006)	108	M	-	-	-	-	-	-	-	-	-	296[‡]	-
PR	Rosario et al. (2006)	127	F	-	-	-	-	-	-	-	-	-	267[‡]	-
PR	Rosario et al. (2006)	235	M&F	-	-	-	-	-	-	0.117	2.86[‡]	-	-	-

Table 3 Age, growth, and maturity parameters for queen snapper, *Etelis oculatus*. Bold values are updates from Martinez-Andrade (2003). * indicates reference could not be found to corroborate the information. ‡ indicates length type is fork length. ζ from Froese and Pauly (2011).

				Age-length relationship						Length-weight relationship			Maturity	
Location	Reference	n	Sex	t_0	L_{inf}	K	M	L_{max}	t_{max}	a	b	W_{inf}	L_{mat}	t_{mat}
St Lucia	Murray & Moore (1992a) *$^{\zeta}$	-	U	**-0.41**	1020	0.29	0.33	930	**10**	-	-	23300	**531**	**2**
St Lucia	Murray et al. (1992)*$^{\zeta}$	-	U	**-0.189**	1030	0.61	**0.76**	**1002**	**5**	-	**-**	23900	**536**	**1**
St. Lucia	Murray & Moore (1992b)	62	-	-	-	-	-	-	-	0.0632	2.771	-	-	-
South Atlantic	SAFE Report (2005)	-	U	-	-	-	-	1000	-	-	-	-	536	1
St Thomas	Bohnsack & Harper (1988)$^{\zeta}$	21	U	-	-	-	-	-	-	0.0233	2.55‡	-	-	-
St. Croix	Bohnsack & Harper (1988)$^{\zeta}$	48	U	-	-	-	-	-	-	0.0173	2.578	-	-	-
Brazil	Frota et al. (2004)	27	U	-	-	-	-	-	-	0.0128	2.908	-	-	-
PR	Rosario et al. (2006)	187	M	-	-	-	-	-	-	-	-	-	233‡	-
PR	Rosario et al. (2006)	187	F	-	-	-	-	-	-	-	-	-	310‡	1
PR	Rosario et al. (2006)	419	M&F	-	-	-	-	715‡	-	0.012	2.84‡	-	-	-

Table 4 Age, growth, and maturity parameters for redtail parrotfish *Sparisoma chrysopterum*. † indicates standard length (SL), ͻ indicates length at first maturity, ‡ indicates fork length (FL).

				Age-length relationship						Length-weight relationship			Maturity	
Location	Reference	n	Sex	t_0	L_{inf}	K	M	L_{max}	t_{max}	a	b	W_{inf}	L_{mat}	t_{mat}
Central Western Atlantic	Choat & Robertson (2002)	-	-	-0.04	263	1.176	-	347	5	-	-	-	-	-
Guadeloupe, Martinique	Bouchon-Navarro et al. (2006)	38	-	-	-	-	-	406	-	0.0154	3.0423	-	242 ͻ	-
Panama	Robertson & Warner (1978)	-	-	-	-	-	-	-	-	-	-	-	140 † ͻ	-
Puerto Rico	Figuerola et al. (1998)	-	-	-	-	-	-	-	-	-	-	-	235 † ͻ	-
South Florida	Molina-Urena (2009)	105	-	-	-	-	-	-	-	0.0152	3.0274	-	-	-

Table 5 Age, growth, and maturity parameters for stoplight parrotfish *Sparisoma viride*. † indicates standard length (SL).

				Age-length relationship						Length-weight relationship			Maturity	
Location	Reference	n	Sex	t_0	L_{inf}	K	M	L_{max}	t_{max}	a	b	W_{inf}	L_{mat}	t_{mat}
Bahamas	Choat et al. (2003)	108	-	-0.06	472	0.458	-	490	9	-	-	-	-	-
Los Roques, Venezuela	same as above	118	-	-0.06	280.6	0.6	-	-	9	-	-	-	-	-
Barbados	same as above	109	-	-0.05	274.5	0.71	-	-	9	-	-	-	-	-
San Blas, Panama	same as above	82	-	-0.05	263.7	0.82	-	-	7	-	-	-	-	-
Upper FL Keys	Paddack et al. (2009)	176	-	-0.06	335	0.84	-	390	8	-	-	-	-	-
South Florida	Molina-Urena (2009)	53	-	-	-	-	-	-	-	0.0226	2.929	-	-	-
Turks & Caicos	Koltes (1993)	142	F	-	-	-	-	-	-	-	-	-	170-270†	-
Turks & Caicos	same as above	50	M	-	-	-	-	-	-	-	-	-	>270†	-

Table 6 Age, growth, and maturity parameters for redfin parrotfish *S. rubripinne* and redband parrotfish *S. aurofrenatum*. † indicates standard length (SL). ‡ Found from FishBase.org

				Age-length relationship						Length-weight relationship			Maturity	
Location	Reference	n	Sex	t_0	L_{inf}	K	M	L_{max}	t_{max}	a	b	W_{inf}	L_{mat}	t_{mat}
S. rubripinne, redfin parrotfish														
Central western Atlantic	Choat & Robertson (2002)	-	-	-	238†	0.811	-	-	7	-	-	-	-	-
St. Thomas/St. John	Bohnsack & Harper (1988)‡	25	-	-	-	-	-	-	-	0.0774	2.336	-	-	-
St. Croix	same as above	434	-	-	-	-	-	-	-	0.0206	3	-	-	-
South Florida	same as above	17	-	-	-	-	-	-	-	0.0047	3.429	-	-	-
Jamaica	Reeson (1983) ‡	100	-	-	-	-	-	-	-	0.0129	3.110	-	-	-
Panama	Robertson & Warner (1978)	-	F	-	-	-	-	-	-	-	-	-	160†	-
Virgin Islands	Randall (1963)	-	F	-	-	-	-	-	-	-	-	-	220†	-
Virgin Islands	same as above	-	M	-	-	-	-	-	-	-	-	-	194†	-

Table continued on next page

Table 6 Continued

					Age-length relationship					Length-weight relationship			Maturity	
Location	Reference	n	Sex	t_0	L_{inf}	K	M	L_{max}	t_{max}	a	b	W_{inf}	L_{mat}	t_{mat}
S. aurofrenatum, redband parrotfish														
Central western Atlantic	Choat & Robertston (2002)	-	-	-	182	-0.04	-	255	7	-	-	-	-	-
South Florida	Molina-Urena (2009)	7	-	-	-	-	-	-	-	0.0128	3.0857	-	-	-

Figures

Figure 1 Photo of *Lutjanus vivanus*, silk snapper. Photo credit D. Bryan (2006).

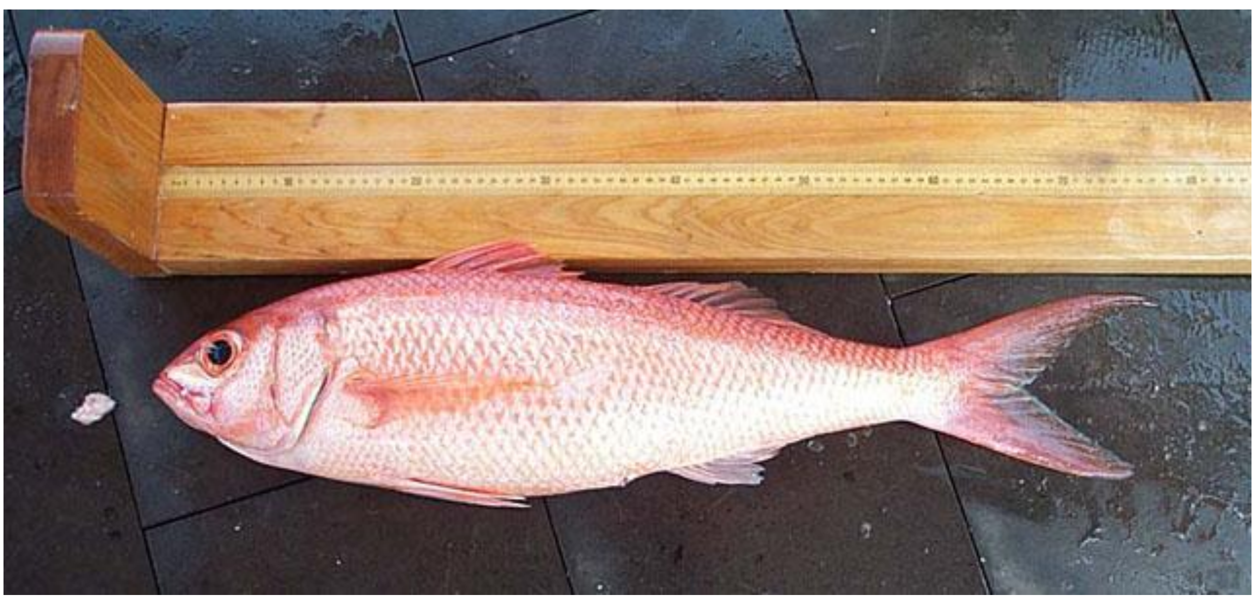

Figure 2 Photo of *Etelis oculatus*, queen snapper. Photo credit J.G. Romine (2004).

Figure 3 Photo of *Sparisoma chrysopterum*, redtail parrotfish. Photo credit J.E. Randall (1997).

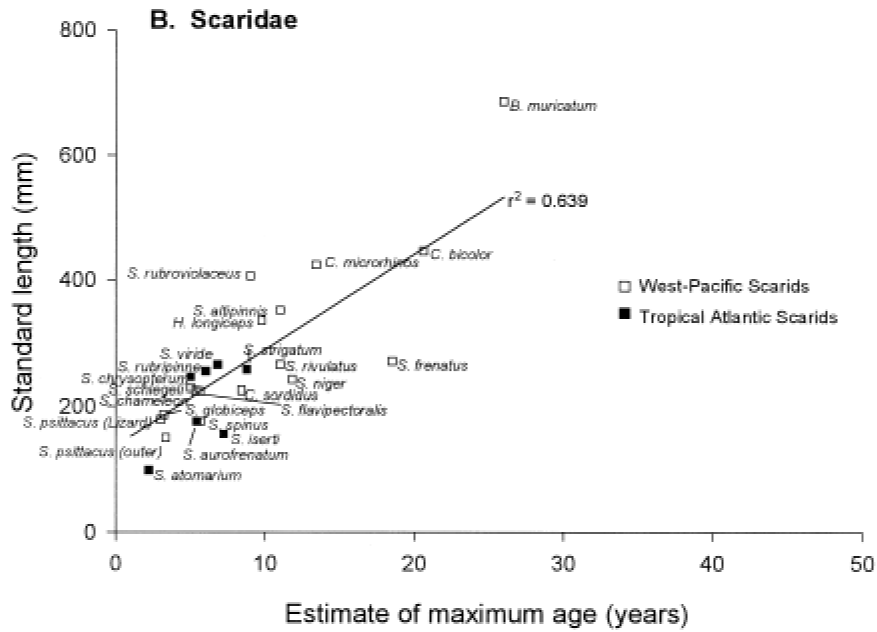

FIGURE 3 The relationship between maximum length and maximum age in 50 taxa of acanthurid and scarid fishes. Lines are least-squares regressions. (A) West Pacific and tropical Atlantic Acanthuridae. (B) West Pacific and tropical Atlantic Scaridae.

Figure 4 The relationship between standard length and maximum age for the family Scaridae plotted in Figure 3from Choat and Robertson (2002).

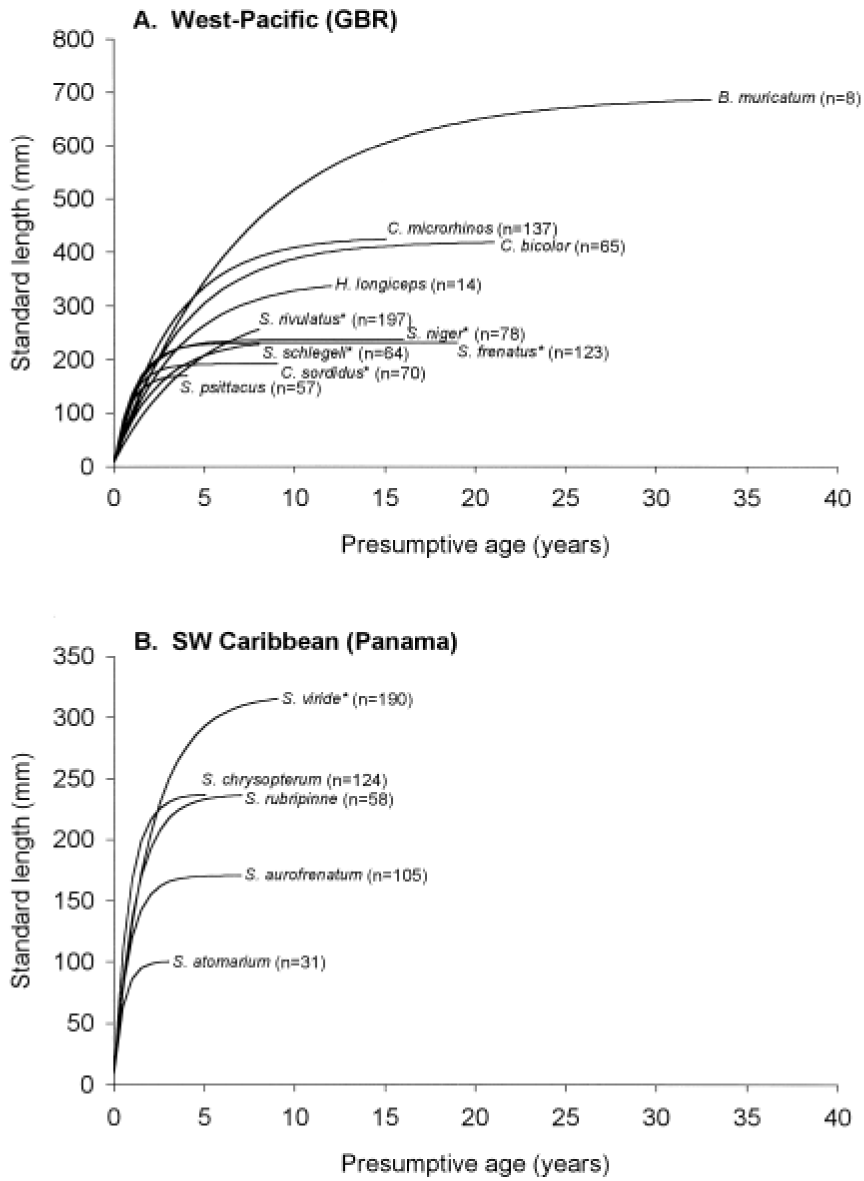

FIGURE 5 von Bertalanffy growth curves fitted to size-at-age data for 15 scarid taxa (von Bertalanffy parameters in Table 1; size-at-age data available from J. H. Choat). (A) West Pacific (northern GBR) taxa of *Bolbometopon*, *Chlorurus*, *Hipposcarus*, and *Scarus*. (B) Caribbean taxa of *Sparisoma* from the San Blas sampling locality.

Figure 5 Age-length relationship for five scarid taxa plotted in Figure 5 from Choat and Robertson (2002). Species include redtail parrotfish *S. chrysopterum*, stoplight parrotfish *S. viride*, redfin parrotfish *S. rubripinne*, redband parrotfish *S. aurofrenatum*, and greenblotch parrotfish *S. atomarium*.

Appendix

SEDAR 4 Doc-7
Information on the general biology of silk and Queen snapper in the Caribbean

By

Nancie J. Cummings

U.S. Department of Commerce
National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Southeast Fisheries Science Center (SFSC)
Sustainable Fisheries Division (SFD)
175 Virginia Beach Drive
Miami, Florida 33149

November 2003
Sustainable Fisheries Division Contribution No. SFD 2003-0024
and
Caribbean Deepwater SEDAR Data Workshop Report Doc-7

Final Draft

Introduction

Commercial fishing has been occurring off Puerto Rico since the late 1800's (Jarvis 1932). Kawaguchi (1974), Nelson and Carptener (1968), Brownell and Rainey (1971), and Sylvester and Dammann (1974) previously noted the importance of silk snapper in the Caribbean reef fish fisheries as early as the 1970's. Sylvester et al. (1980) and Tabash and Sierra (1996) emphasized the importance of documenting the species biology in order to determine adequate management strategies. In response to a request for information in 2003 on deep water snapper fisheries of Puerto Rico and the U.S. Virgin Islands by the Caribbean Fishery Management Council, biological information on silk and queen snapper was reviewed. The silk and queen snapper, members of the Lutjanide are one of the largest teleostan families, which includes 4 sub families, 17 genera, and 103 species (Allen 1985, Chow et al. 1993). This report presents a summary of the scientific literature on the general biology of silk, *Lutjanus vivanus* (Cuvier 1828) and queen (*Etelis oculatus)* (Valenciennes 1828) snappers, two species that are commonly observed in the commercial deep water reef fish fisheries of the Virgin Islands and Puerto Rico. Herein is provided summary information on their distribution, stock structure, growth, and reproduction.

Methods

Published and non-published publications were reviewed to obtain biological information for silk and queen snapper. In addition electronic computer databases of summary biological reference material was accessed including Fishbase (ICLARM 2000).

Summary Biological Information

Silk Snapper (Lutjanus vivanus)

Distribution, Habitat, Association with other species, and Stock Structure

The silk snapper is a commonly caught lutjanid in the Western Atlantic, occurring as far north as North Carolina, including off Bermuda, the Gulf of Mexico to northern South America as far south as Trinidad and northern Brazil (Bohlke and Chaplin 1968, Struhsaker 1969, and Allen1985). The species, common near the edge of the continental and island shelves, inhabits waters mainly between 90 and 140 m although it has been observed up to about 300 m (Carpenter 1965,Rivas 1970, Sylvester and Dammann 1973, Allen 1985). Off the Carolinas and the Florida Keys the species mainly occurs between 25 and 72 m (Bullis and Thompson 1965) while in the Gulf of Mexico it has been found at depths between 162 and 216 m. Rivas (1970) reported on silk snapper which were sampled using bottom gear at depths from 30 m to 360 m, from 1950 through 1968between Cape Hatteras, North Carolina and Fortaleza, Brazil by the Bureau of Commercial Fisheries(Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi) in conjunction with the U.S.Fish and Wildlife service. Sylvester and Dammann (1973) found silk snapper at depths from 81 to378 m Sylvester et al. (1980) noted the possibility of different habitats for silk snapper adults and juveniles as supported by the fishery in Puerto Rico. Using electric reels in the early 1970's,Sylvester and Dammann reported that silk snapper were caught over irregular substrates with adults found mainly over mud bottom. According to Rivas (1970) silk snapper are the only deep water snappers found over mud substrate in the Western Atlantic in particular the region referred to as'lower-shelf habitat' by Struhsaker (1969). The studies of Brownell and Rainey (1971), Sylvester (1974), Boardman and Weiler (1979) suggest that silk snapper are commonly associated with blackfin and voraz snapper as well as several other species of groupers and jacks. Sylvester and Dammann (1974) observed silk snapper from 80 to 350 m (average 200 m) while blackfin were more common from 48 m to 82m. Boardman and Weiler also observed silk snapper associated with vermilion snapper (off Puerto Rico). These studies also suggested that silk were more frequent at the greater depths up to 175 m while blackfin and vermillion at the shallower depths (<100 m) (Boardman and Weiler 1979). Sylvester's studies were conducted off the U.S. Virgin Islands or nearby off Anegada and/or Virgin Gorda. Rivas (1970) suggested that bottom type could be an important factor in determining the actual vertical depth distribution of snappers. It is especially interesting to note that the tendency to school by size was observed in some of the studies (Dammann et al. 1970). In 111 bottom long sets made by the National Marine Fisheries Service (NMFS) from 76 m to 644 m, off St. Thomas and Puerto Rico (including Culebra Island) in August 1982 (Russell 1982) silk snapper were observed occurring from 200 m to 322 m somewhat shallower than were queen snapper which were captured from 206 m to 484 m. In 90 bottom longline sets made in April 1984 (Russell 1984) by the NMFS off Puerto Rico, Culebra and St. Thomas silk snapper were captured most frequently between 200m and 298 m. Similar surveys were conducted during 1980 and 1983 by the NMFS and those results could provide additional knowledge regarding the distribution of this species.

Morphometrics

Silk snapper is characterized by a normal fusiform body shape, weak preopercular notch and knob and long pectoral fins that reach the level of the anus. Individuals have pink to red coloration on the back and upper sides often appearing as a silvery sheen along the lower abdominal region. The fins of individuals are usually reddish or pale yellow. Small or young individuals (<25 cm) individuals usually have a blackish spot on the upper side below the anterior dorsal soft rays. Maximum size observed in the field was 83 cm (total length) and 8.3 kg (IGFA 2001, Allen 1985). Chow et al. (1993) noted the close similarity morphologically among members of the Lutjanidae family, reported by previous ichthyologists (Richards 1985, Leis 1987, Richards and Lindeman 1987) making it especially difficult to differentiate between identification of larvae. Using restriction fragment length polymorphism (RFLP) analysis, silk snapper could be identified (Chow et al. 1993).

Food Habits

The silk snapper are considered mainly carnivorous by most researchers as are most members of the Lutjanidae. Randall (1968) noted that the larger species of the Lutjanidae eat mostly fishes. The stomachs of silk snapper sampled off the U.S. Virgin Islands in the early 1970's included fish (51%), isopods (8%), invertebrates (31%). The species is reported to ascend to shallower waters at night for feeding (Bohlke and Chaplin 1993). Parrish noted that most snappers tend to feed more actively at night. Allen (1985) reported silk snapper also feeding occassionally on some pelagic items such as urochordates.

Reproduction

The species is dioecious with no known tendency to change sex, and fertilization is external
(Allen 1985). Spawning is thought to be year round in the more tropical latitudes with two predominant peaks. Silk snapper are thought to spawn in late spring through early summer in the temperate regions (e.g., Carolinas, Gulf of Mexico). Munro et al. (1973) reported on spawning of silk snapper from observations made off the reefs adjacent to Port Royal, on the south coast of

Jamaica and on Pedro Bank and on Morant Bank, 50 NM southwest and southeast of Jamaica. Silk snapper were observed in ripe condition during March, September and November, suggesting year round spawning. Munro et al. (1973) also suggested two maxima in spawning timing, in April and September-October, for silk snapper off Jamaica. Leis (1987) reported on the early life history of tropical snappers from a review of the literature. Leis noted that based on the available information from larval abundance that most lutjanids spawn year-round and with an apparent maximum reproductive activity in the spring and summer. Grimes's (1987) reviewed Lutjanidae reproduction and he put forth the idea that the seasonality pattern in spawning (i.e., a restricted spawning period during late spring/summer vs spawning year round) was related to geographical location with populations occurring on oceanic islands being characterized by year-round spawning while those occurring along the continental areas had more restrictive spawning periods. Grimes (1987) further noted that some specific populations did not seem to conform to this pattern and gave as examples those off Cuba, new Caledonia, and the deep water *Egelis carbunculus* off Hawaii and provided some reasoning based on continental production volume allied to high rainfall.

Sex Ratio

Boardman and Weiler (1979) reported a sex ratio for males to females of 0.8:1 (1.25:1) for fish sampled by traps off Puerto Rico. Sylvester et al. (1980) observed sampled silk snappers off the US Virgin Islands between July and September 1973 using bottom fishing gear, set lines, and traps. From some 27 sampling trips a sex ratio if 1.16 (male:female) was observed from 141 individual fish. Boardman and Weiler (1979) noted difficulty in identifying males in certain developmental stages which had large deposits of fat in the body cavity. Grimes (1987) reviewed the reproductive biology of the Lutjanide and commented on sexual dimorphism and hermaphroditism in the Lutjanidae. Analyses of sex ratios in species of this family from geographically diverse locations did not suggest any trend towards variation in sex ratio at size that would indicate hermaphroditism. Grimes (1987) further noted that from the data of the more thorough studies (i.e., those in which a wide range of sizes were observed) suggested a tendency for females to be more prevalent at the larger sizes and suggested a differential longevity of the sexes.

Maturation Timing and Fecundity

Summarized information on silk snapper maturity and fecundity is presented in Table 1. Boardman and Weiler (1979) observed silk snapper off Puerto Rico maturing at abut 38 cm and 50 cm respectively for males and females. Silk snapper off Cuba matured at 48 cm (females) and 50 cm (males) while silk snapper off Jamaica matured at 52 cm (females) and 57 cm (males) similar to fish from Puerto Rico. Grimes (1987)'s review of reproduction in Lutjanidae suggested that for deep reef (>91 m in that review) snappers, individuals matured at about 49% of the maximum length while the shallow-water species matured at about 43% of the maximum length. This would suggest that the silk snapper could mature at about 37 cm somewhat smaller than that observed in the field for fish sampled off the U.S. Virgin Islands, off Cuba, or off Jamaica.

Sylvester (1970) suggested two spawning periods for silk snapper, one from April - June, and another from October-December, based on the presence of two abundance peaks for fish sampled off the U.S. Virgin Islands between July 1970 and December 1972. That study suggested a spawning maxima occurring in March and another around September-October.

Collazo (1983 or 1984) from examination of some 2200 fish off Puerto Rico between 1979 and 1980 reported silk snapper spawning year round with two peaks in the percentage of ripe females occurring between April and June and October-December. Sylvester et al. (1980) examined fish off the U.S. Virgin Islands also for fecundity information. They noted the occurrence of a large number of immature eggs in mature ovaries suggesting greater than one spawn per year. The fecundity information shows large individual variation for this species. Sylvester et al. (1980) noted that eggs of silk snapper were smaller and more numerous than those of another snapper inhabiting deep waters, the blackfin snapper, *L. buccanela.* Very little information exists regarding the duration of the larval period. Leis (1987). The results of three studies (Richards 1982, Starck 1970, and Brothers et al. 1983) suggest empirical estimates ranging from 25 to 47 days for the pelagic phase for shallow water Lutjanids..

Growth

Age Length Relations

Several investigators have evaluated the relation between length and age from length frequency statistics and otoliths for different regions (Table 2). Records from angling reports suggest that the maximum size achieved by this species is about 76 cm and 6 kilograms. Thompson and Munro (1974) reported the maximum observed size in trap catches off Jamaica to be 72 cm FL and 68 cm FL for females and males respectively. From the summarized growth information estimates of the annual growth rate parameter, k, ranged from about 0.1 to 0.32 while estimates of the asymptotic size, L infinity, ranged from 53 cm (FL) to 76 cm (FL) for fish from Cuba, Costa Rica and the U.S. Virgin Islands. Claro and Garcia-Arteaga (2001) noted that the growth rate parameter, k, derived by Thompson and Munro (1983) for silk snapper may be excessively high. Thompson and Munro (1983) reported that otoliths of silk snapper did not reveal regular clear bands easily interpretable as annuli. In general this species is characterized as relatively fast growing and showing some trend for a pattern of linear growth in the early years (Musa et al. 1979). Several studies exist describing other important meristic conversions such as length to length and weight to length formulae (Tables 3 and 4.).

Longevity

Tabash and Sierra's (1996) study off Costa Rica suggested a maximum life span of about seven years for silk snapper. These authors estimated size at first capture for 50% of the population to the hook and line fishery to be 25.5 cm or about 1.9 years of age.

Recruitment timing and size

Sylvester (1974) and Sylvester et al. (1980) studied silk snapper off the U.S. Virgin Islands and reported recruitment to the fisheries began at age 2 and full recruitment occurred by age 4. Sylvester (1974) observed individuals as small as 10-19 cm occurring during October through December.

Natural Morality

Tabash and Sierra (1996) estimated natural mortality for silk snapper using Ralston's (1987) method to be 0.86.

Queen Snapper (Etelis oculatus)

Very little scientific information exists for this species . A few investigators have reported on the occurrence of the queen snapper in local fisheries. Thompson and Munro (1974) and Mahon et al. (1981) noted the importance in the Jamaican and Barbados fisheries respectively. The queen snapper is known in the St. Lucian fisheries as the 'Red Snapper' and makes up about 98% of the demersal landings between August and November annually from south of the island. Small individuals are apparently taken as by-catch in some trawl fisheries (Cervigón et al. 1992).

Distribution, Habitat, Association with other species, and Stock Structure

This species has a similar distribution as the silk snapper and is found in the Western Atlantic: Bermuda and North Carolina, USA, Gulf of Mexico southward through the Caribbean to Brazil. The queen snapper is reported to be particularly abundant in the Bahamas and the Antilles (Anderson, pers. comm as cited in ICLARM Fishbase) . Queen snapper commonly is found in areas characterized by rocky bottoms and is abundant near oceanic islands. Direct observations of vertical distribution of the queen snapper are available from bottom longline sets made during scientific research cruises in August 1982 and April of 1984 by the NMFS off Puerto Rico , Culebra Island and St. Thomas (Russell 1982, 1984). Queen snapper were observed most frequently at depths of 206 m to 484 m from bottom longline sets made during the 1982 NMFS cruise and at depths of 300 m to 398 m during the 1984 NMFS cruise. Similar cruises were conducted during 1980 and 1983 and those results may add further insight into the vertical distribution of this species.

Morphometrics

The queen snapper has a small head and distinct large eye with a short snout. The body is generally fusiform. The maxilla is covered with small scales, a slight protrusion of the lower jaw. The dorsal and anal fin bases are scaleless and the caudal fin deeply forked with the scale rows on the back running parallel with the lateral line. The coloration in the queen is distinct as in the silk snapper. The back and upper sides are deep pink to red; lower sides and belly pink; fins pink except the spinous portion of the dorsal fin and the entire caudal fin brilliant red (ICLARM Fishbase)

Food Habits

As does other Lutjanidae the queen snapper eats animals and feeds and mostly on small fishes and squids as an adult. Younger queen snapper individuals also take crustraceans.

Reproduction

The queen snapper like the silk snapper exhibits dioecism. Spawning is probably year round (see below), and fertilization is external however detailed information on reproduction in this species is not available.in the literature.

Growth

Growth characteristics of the queen snapper are available from a very restricted geographical area. Maximum size of 100.0 cm TL and maximum published weight of about 5.3 kg has been observed from sport fishing angling records. Relationships for length to length and/or weight to length conversions were described from fish off Saint Lucia (Tables 5 and 6). Little information exist for converting lengths to ages and in particular from the U.S. Virgin Islands and Puerto Rico fish, the area of concern to the CFMC/SEFSC Caribbean Deep Water SEDAR data workshop (Table 7) The initial examinations of fish off Saint Lucia suggest the need for more detailed and comprehensive field collections of queen snapper ageing observations to better evaluate growth in this species. Murray and Neilson (2002) emphasize the need to confirm the estimates of queen snapper growth rate and to further evaluate their method (i.e.., pooling growth increments from several segments) of analysis. Furthermore, Murray and Neilson (2002) noted that an overestimation of the growth rate parameter, k, would not be surprising from their approach. Murray and Neilson's (2002) estimate of k was 0.621

Recruitment timing and size

Murray et al. (1992) suggested this species had two pulses of entrance into the local fisheries based on examination of landings records. Murray et al. suggested that when taking into account the seasonality in reproduction this pattern of recruitment resembled that suggested by Grimes (1977) of "more or less continuous year round spawning with peaks of reproductive activity in the spring and fall." These authors however pointed out that queen snapper were probably available to the Saint Lucian fisheries year round but were fished exclusively only during the fishing when tuna catch rates we low in St. Lucia.

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Figure 1. *Lutjanus vivanus*, Silk snapper (Valenciennes, 1828). Taken from FishBase drawing set by Robbie Cada].

Figure 2. *Etelis oculat*us, Queen snapper, (Valenciennes, 1828). [Taken from FishBase drawing set by Robbie Cada].

Table 1. Summary information on the fecundity of silk snapper from the published literature.
Study Study area Study Period Maturity and Fecundity information Spawning Period or Season
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1. Thompson and Munro (1973) Jamaica November 1969 - March 1973 50% maturity 50-55 cm females, 55-60 cm fl males Spawning year round.
2. Erdman 1976 cited in (2) Puerto Rico 1976 Spawned year round
3. Grimes et. al. 1977 North Carolina 1970's Spawned year round with two peaks (July-September) October-December
4. Boardman and Weiler 1979 Puerto Rico 1978 50% maturity 50cm females,38 cm males Spawning year round
5. Sylvester et al. 1980 U.S. Virgin Islands July 1972 - September 1973 Range in length 25.5 cm to 63.0 cm, n=24 Not clearly identified in the study
mean # eggs = 108,000 range = 9,000 to 299,000 Authors suggested fish may spawn throughout the year
6. Collaxo 1983 or 1984 Puerto Rico (San Juan, Mayaguez, Ponce) n=2201 fish Spawning observed year round (Table 7 that
Comment: Copy of report read an in author’s possession however, no year given of publishing. report) with peaks observed in 2 periods
(April-June, October-December).

Table 2. Summary information on length to age relationship for silk snapper from the literature.
Parameter Units Estimate Reference Sample Size Study Area Sampling Dates Analysis Method
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1. L infinity cm 62.0 Tabash and Sierra 1996 1,867 Costa Rica Sampled 8/1992-11/1994 ELEFAN I as implement in FiSAT (Gayanilo et al. 1996)
k year 0.32 monthly samples taken
tzero year -0.04
theta 0.85
theta-prime 3.09
2. L infinity cm 70.0 Thompson and Munro (1974) Jamaica
3. L infinity cm 53.0 Reshetnikov and Claro 1974 Cuba From otoliths and urohyal bones
k year 0.35
tzero year
theta 2.99
theta-hat
4. L infinity cm 76.0 Garcia 1979 Cubs Length based
k year 0.14
tzero year
theta 3.30
theta-hat
5. Maximum size cm 115.0 Sylvester et al. 1980. Virgin Islands Sampled 7/1972 - 8/1973 Walford Plot
(Tobago Cay and south of Frenchcap Cay)

Table 2. Continued
6. L infinity cm 59.25 Musa et al. 1983. Puerto Rico
k year 0004.00 (4.0*10**-4)
tzero year -522.02
n=45 otoliths; 3 separate redions taken
Comments: 1) Fitting method not given; estimates of growth rate parameter (k) and tzero are suspect.
2) Authors noted difficulty in making mesuremetns in this species.
3) sample set did not contain fish at younger/smaller sizes below 12 cm FL.
7. L infinity cm 72.9 Claro and Garcia-Arteaga 1994 Northeast Zone Hardpart Analysis
k year 0.09 Cuba
tzero year -2.64
theta 2.68
theta-hat
rings not annual
8. L infinity cm 75.7 Claro and Garcia-Arteaga 1994 Southeast Zone Hardpart Analysis
k year 0.1 Cuba
tzero year -2.08
theta 2.76
theta-hat
rings not annual
9. Maximum size cm 76 Bolkle and Chaplin 1968 Bahamas

Table 3. Summary information on length to length relationships for silk snapper from the literature.
1. Unsexed Fish
Regression: SL = 0.7 + 0.86 x FL
Number of fish: 47 r:
Length range (cm): 23.0-52.0 Data Ref.: Manooch and Mason 1984
Units : cm
2. Unsexed Fish
Regression: TL = 0.9 + 1.04 x FL
Number of fish: 47 r:
Length range (cm): 23.0-52.0 Data Ref.: Thompson and Munro 1974
Units : cm
3. Regression: TL = 0.0 + 1.072222 x FL
Comments: Based on measurement of picture, in MORPHMET table from ICLARM Fishbase.
Units : Cm
4Regression: TL = 0.0 + 1.229299 x SL
Comments: Based on measurement of picture, in MORPHMET table from ICLARM Fishbase.

Table 4. Summary information on weight to length relations for Silk snapper from the literature.
Equation Sample Size Study Area Length Range(cm) Sampling Dates
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1. Tabash and Sierra(1996): Weight (grams)= 0.00009 * Fl (mm)** 2.91 n=200 fish Costa Rica 18-54 9/1992 to 11/1994
r-square =0.90
2. Sylvester and Dammann 1973: Log Weight(kg) = -3.47058 + (2.41350*Log(Fl cm) n=35 fish U.S. Virgin Islands,
Anegada, Virgin Gorda
3. Boardman and Weiler 1979 Log Weight(grams)= 3.10 * Log (Fl mm) - 5.00 n=30; r=0.99 Puerto Rico
4. Sylvester et al. (1980): No equation given, tables of raw lenth data presented n=95 U.S. Virgin Islands
figures of w-l equation presented
5. Musa et al. 1983 Log Weight(grams)= 2.92 * log (FL Cm) - 4.60 n=121 Puerto Rico 12-39 1977-1979
Parameter estimates are suspect
6a. Bohnsack and Harper 1988 Log Weight(grams)= -4.2096 + (2.781 * log (Fl mm)) n=165 St. Croix 22-65
6b. Bohnsack and Harper 1988 Log Weight(grams)= -4.6001 + (2.913 * log (Fl cm)) n=36 St. Thomas/St. John 20-64
6c. Bohnsack and Harper 1988 Log Weight(grams)= -5.3646 + (3.237 * log (Fl cm)) n=181 Puerto Rico 15-40
Log Weight(grams)= log a + b(log FL (mm) from Bohnsack and Harper 1988, pg. 9
7. Claro and GarcNa-Arteaga 1994 Log Weight(grams)=0.0166* log (Fl cm) - 3.03 Cuba (Southeast) 19-56
8. Duarte et al. 1999 Log Weight(grams)=0.0456* log (Fl cm) - 2.8 n=18 Colombia 10.2-31 1995-1998

Table 5. Summary information on length to length relationships for queen snapper from the literature
Sex of fish: unsexed
Regression: SL(cm)= 0.0 + 0.7664233 x TL (cm)
Number of fish: 2 r:
Length (cm): 42.0-95.0 TL Data Ref.:
Comments: Derived from data in the BRAINS table in Fishbase.
Units : cm
Sex of fish: unsexed
Regression: TL(cm) = -0.986 + 1.159 x FL(cm)
Number of fish: 394 r:0.964
Length (cm): Data Ref.: Murray and Moore 1992 .
Comment: 1987 samples off Saint Lucia between August and November.
Units : cm

Table 6. Summary information on weight to length relations for queen snapper from the published literature.
Equation: log(Total weight (grams)) = log a + b (log Fl cm)

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a b Length range n Country Location Reference

0.0233 2.55 36.0 - 89.0 FL 21 US Virgin Is St. Thomas/St. John Bohnsack and Harper 1994
0.0173 2.578 20.0 - 70.0 FL 48 US Virgin Is St. Croix Bohnsack and Harper 1994
0.0632 2.771 62 Saint Lucia Murray and Moore 1992

Table 7. Summary information on length to age relationship for queen snapper from the literature.
1. Parameter unit Value Referemce Country Sampling Dates Analytical Methods
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L infinity cm 102.0 Murray and Moore 1992 Saint Lucia Sampled 1/1987-12/1987 ELEFAN I as implement in FiSAT (Gayanilo et al. 1996)
k year 0.29 monthly samples taken
theta-prime 3.48
2. L infinity cm 103.2 Murray 1992 Saint Lucia
k year 0.61
tzero year
Comment: Reference not found but as cited in Murray and Nelson 2002.
3. Reference: Murray and Neilson 2002
k year 1.078 +/- 0.687 Saint Lucia Modification of method of Murray 1989 (quasi-Gulland and Holt (1959) plot method) where:
k year 0.621 +/- 0.076 regression of daily growth incremetns on mid-point of otolith segment (increment) to focus
Notes: This study did not derive estimates of the asymptotic size, L Infinity.
4. k year 0.71 Murray 1989 Saint Lucia Elefan
Notes: This study did not derive estimates of the asymptotic size, L Infinity.