Notice on SEDAR Working Papers

Marine Resources Monitoring, Assessment and Prediction Program:

Report on Atlantic Red Snapper, *Lutjanus campechanus*,

for the SEDAR 24 Data Workshop.

(vrs.1a)

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MARMAP REPORT 2010-02

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Introduction

Red snapper, *Lutjanus campechanus*, is a large, long lived, member of the family Lutjanidae. Red snappers are distributed in marine waters throughout the Gulf of Mexico south to the Yucatan Peninsula and in United States Atlantic waters north to North Carolina (Nelson and Manooch, 1982; Manooch and Potts, 1997). Adult red snapper are associated with structured habitats such as coral reefs, wrecks, gas and oil platforms, rocky outcroppings, and live-bottom habitats (Powles and Barans, 1980; Moseley, 1966; Nelson and Manooch, 1982). The mean maximum depth in the commercial red snapper fishery was 71 m (range 19 to 823 m) (SEDAR 15).

The periodicity of increment formation for red snapper otoliths in the Atlantic is by the month of April (McInerny, 2007). White and Palmer (2004) reported increment formation during June through August. The difference is probably related to sampling location, as 88% of McInerny's red snapper samples came from Florida.

The maximum recorded age for red snapper, using otolith opaque zone counts is 57 years for the Gulf of Mexico (Allman et al. 2002), and 54 years for the Atlantic (McInerny, 2007). Using measurements of nuclear-bomb ^{14}C in otoliths, Baker and Wilson (2001) confirmed that the longevity of red snapper in the Gulf of Mexico is at least 55 years.

White and Palmer (2004) is the only published reference on the reproductive biology of red snapper along the Atlantic coast of the southeastern U.S. Fishery-independent and fishery-dependent data collected by the MARMAP program during 2000-2009 were added to the White and Palmer (2004) data set (for a total of 1676 specimens) in preparation for SEDAR 24. In the data set, 56 percent (N=711) of the 1264 specimens examined histologically came from fishery-dependent sources, primarily the commercial snapper reel fishery. Overall, the majority of specimens were collected with snapper reels (53%) and chevron traps (27%).

The sexual pattern in red snapper is gonochorism. Red snapper from the Atlantic waters of the southeastern U.S. spawn during May through October with peak spawning occurring June through September (White and Palmer, 2004).

Information regarding young (age 1 or less) red snapper, from the Atlantic waters of the southeastern U.S., is practically nonexistent. Unlike the Gulf of Mexico, where young red snapper have been extensively studied (Workman & Foster, 1994; Szedlmayer & Howe, 1997; Workman et al., 2002; Bentley et al., 2005; Patterson & Wilson, 2005; Gallaway et al., 1999; Gazey et al., 2008), there are no published reports of young-of-year (YOY) red snapper in the Atlantic. Although White and Palmer (2004) comment on examining five YOY (59-133 TL mm) specimens to aid in the first annulus determination, they did not include those specimens in their data set for analysis. Those five specimens have also been added to the White and Palmer (2004) data set in preparation for SEDAR 24.

Materials and methods

Otoliths and gonadal tissue were taken from red snapper specimens collected from coastal and offshore waters between Cape Lookout, North Carolina, and Key West, Florida, between 1977-2009 (N=1676). Specimens were collected during standard sampling by the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program (fishery-independent, Project ID: P05, P55, & Q26) using chevron traps (gear code 324), Florida traps (gear coed 074), blackfish traps (gear code 053), mini-Antillean "S" traps (gear code 041), flatline otter trawl, 3/4 scale Yankee trawl (gear code 022), commercial High Rise roller trawl (gear code 226), short longline (gear code 061), snapper/bandit reel (gear code 043) and hook-and-line gear (gear code 014) (Collins, 1990; Harris and McGovern, 1997; Harris et al, 2004). Five juvenile red snapper were collected during standard sampling by the Southeast Atlantic Monitoring, Assessment, and Prediction (SEAMAP) program (fishery-independent, Project P94, using Mongoose-type Falcon trawl (gear code 233). Red snapper specimens were also obtained from commercial catches (fishery-dependent, Project ID: P50, T12) using speargun (gear code 065) and snapper/bandit reel (gear code 043) (See Appendix A & B).

Whole red snapper were weighed to the nearest gram (g) and total length (TL), fork length (FL), and standard length (SL) were measured to the nearest mm. The left and right (when possible) sagittal otoliths were removed from all fish and stored dry prior to processing.

In the laboratory, the left otolith was embedded in West System 105® epoxy resin, sectioned dorsoventrally to a slice of 0.4 mm, and mounted on glass microscope slides using Accu-mount 60 mounting medium (Baxter Scientific Products®). One to three otolith sections were examined with transmitted light under a dissecting microscope. Counts were made from the core of each otolith to the outer edge of each opaque zone and to the edge of the otolith. Sections were examined independently by two readers and re-examined jointly when differences in age estimation occurred. If disagreement persisted, the specimen was eliminated from age analyses. In addition, quality and edge type was recorded (Table 1).

A red snapper aging workshop was held in Charleston SC (August 2009) in preparation for SEDAR 24. To compare ageing accuracy and precision of assigning an age to otoliths, between different readers, the average percent error (APE) was calculated (Campana 2001) for a subsample (n=196) or "reference set" from fishery-independent and fishery-dependent sources (see Age Workshop Report for details).

A sample from the posterior portion of the gonad were fixed in 10% seawater formalin solution for 7-14 d and transferred to 50% isopropanol for 7-14 d. Tissue samples were processed in an Auto-Technicon 2A Tissue Processor® or automated (self-enclosed) tissue processor® and blocked in paraffin. Three transverse sections (6-8 μm) were cut from each sample with a rotary microtome, mounted on glass slides, stained with double-strength Gill hematoxylin, and counterstained with eosin-y.

Two readers independently determined sex and reproductive state using histological criteria (Table 2). When assignments differed, the readers re-examined the section simultaneously to determine reproductive state. Females were considered to be in spawning condition if they possessed hydrated oocytes and/or postovulatory follicles (POFs). Sex ratio data were analyzed using a Chi-square goodness of fit test to determine if these ratios differed among size classes from an expected 1:1 (Zar, 1984). To estimate length at 50% maturity (L_{50}) and age at 50% maturity (A_{50}) the PROBIT procedure (SAS Institute, Inc., 1990) was used. The LOGISTIC procedure was used to determine which model (Gompertz, Logistic, or Normal) provided the best fit to maturity data.

Table 1. Otolith Edge type and Quality

Otolith Edge Type

Code	Description	
1	Opaque zone on the edge.	
2	Narrow translucent zone on edge	Width less than about 30% of previous increment
3	Medium translucent zone on edge	Width about 30-60% of previous increment
4	Wide translucent zone on edge	Width more than about 60% of previous increment

Otolith Quality

Code	Description	Analysis consequence
A	Unreadable	Omit otolith from analysis
B	Very difficult to read	Age estimate between readers are expected to be >2 year for young, and > 4 yrs for old fish (>10 yrs) Agreement on age may be difficult to reach, in which case otoliths should be classified as A and omitted from the analysis.
C	Fair readability	Age estimates between readers should be within 2 year in young, and within 4 years in old fish (>10 yrs). Agreement after second reading is expected after some discussion.
D	Good readability	Age estimates between readers should be within 1 year for young, to 2 years in old fish (> 10 years). Agreement after second reading is expected without much discussion.
E	Excellent readability	Age estimates between readers should be the same.

Table 2. Histological criteria used to determine reproductive state in red snapper Lutjanus campechanus (modified from Wallace and Selman (1981); Hunter and Macewicz (1985); Hunter et al. (1986); Wenner et al. (1986); West (1990); Davis and West (1993)).

Reproductive stage	Male	Female
1-Immature	Small transverse section compared to resting male; spermatogonia & little or no spermatocyte development	Oogonia & primary growth oocytes only (< 60 μm), no evidence of atresia. Relative to resting female, area of transverse section of ovary is smaller, lamellae lack muscle and connective tissue bundles are not as elongate, oogonia are abundant along margin of lamellae, ovarian wall is thinner.
2-Developing	Development of cysts containing primary and secondary spermatocytes through some accumulation of spermatozoa in lobular lumina and ducts.	See below
3-Running ripe	Predominance of spermatozoa in lobules and ducts; little or no occurrence of spermatogenesis.	Completion of yolk coalescence and hydration in most advanced oocytes; zona radiata becomes thinner.
4-Spent	No spermatogenesis; some residual spermatozoa in shrunken lobules or ducts.	More than 50% of vitellogenic oocytes undergoing alpha or beta atresia.
5-Resting	Larger transverse section compared to immature male; little or no spermatocyte development; empty lobules and ducts; some recrudescence (spermatogonia through primary spermatocytes) possible at end of stage.	Oogonia & primary growth oocytes (> 60 μm), traces of all stages of atresia. Relative to immature female, area of transverse section of ovary is larger, lamellae more elongate, oogonia are less abundant along margin of lamellae, bundles of connective and muscle tissue present, ovarian wall is thicker.
2B-Developing, recent spawn		Vitellogenic oocytes predominant and POFs (postovulatory follicles) <12 h old (sensu Hunter et al.1986)
2C-Developing, recent spawn		Vitellogenic oocytes predominant and POFs 12-24 h old (sensu Hunter et al. 1986)
2D-Developing, recent spawn		Vitellogenic oocytes predominant and POFs >24 h old (sensu Hunter et al. 1986)
2E-Early developing, cortical alveoli		Most advanced oocytes in cortical-alveoli stage. Cortical alveoli form in peripheral cytoplasm. Oil droplets form around germinal vesicle.
2F-Developing, vitellogenesis		Most advanced oocytes in yolk-granule or yolk-globule stage.
2G-Final oocyte maturation		Most advanced oocytes in migratory-nucleus stage. Partial coalescence of yolk globules. Nucleus has moved away from center of cell, being replaced by coalescing oil droplets. By the time of ovulation, one large oil droplet is present.

Results

Red snapper were captured between latitude 24.34^o and 34.28^o (Fig. 1) and at a depth range of 7 to 212 meters. Specimens ranged in size from 59 to 976 mm TL. All red snapper < 150 mm TL (N=32) were captured at an average depth of 15 meters (7-18 m) (Fig.s 1 & 2).

Red snapper otoliths (N=196) in a 'reference set' of red snapper otoliths from fishery-independent and fishery-dependent sources were aged during an inter-lab aging workshop in 2009. The average percent error (APE) within SCDNR readers was 9.13%, with an associated CV of 12.91% (Beamish and Fournier 1981).

Additional red snapper otoliths (N=447), from fishery-independent and fishery-dependent sources, 2000-2009, were aged with an initial agreement of 67% and agreement within two annuli of 93%, between two readers. Otoliths that were determined to be unreadable were omitted from the analyses. Age ranged from 0 to 35 yr (Fig.3). Raw age data were provided to the SEDAR 24 Data Workshop in April of 2010.

The information presented in this report on spawning seasonality, sexual maturity, and sex ratio is based on the most accurate technique (histology) utilized to assess reproductive condition in fishes. There was little overlap in the length distributions of immature or resting red snapper and substantial overlap of resting and definitely mature individuals, indicating that maturity stages were assigned correctly for both sexes (Fig.s 4A & 4B). Although males were significantly more abundant than females at sizes ≤ 400mm TL, the overall sex ratio for red snapper was not significantly different from the expected 1:1 (Table 3). Sex ratio by year is close to the expected 1:1 (Table 4), although the number of red snapper specimens collected for 2002-2009 is small (N=127 total). Male red snapper were present in significantly larger numbers in age class 7 and were generally more abundant than females at ages < 5yrs (Table 5). Female red snapper were present in significantly larger numbers in age class 7 (Table 5) and were generally more abundant than males at ages >5yrs.

The youngest mature female red snapper was age two and the oldest was age four. The smallest mature female red snapper was 265 mm TL, and the largest immature female was 435 mm TL. Age at 50% maturity (A_{50}) was 1.87 yr (Logistic, proportion mature = 1 - 1/(1 + exp(a+b*age)); with a = -2.71 and b = 1.45, 95% CI = 1.48-2.12) and length at 50% maturity (L_{50}) was 370 mm TL (Gompertz, proportion mature = 1 - exp(-exp(a+b*age)); with a = -8.11 and b = 0.02, 95% CI = 354-381 mm). Mature females were present in 0% of the age 1 class, 54% of the age 2 class, 86% of the age 3 class, 93% of the age 4 class, and 100% of females age 5 or older . Mature males were present in 50% of the age 1 class, 93% of the age 2 class, 97% of the age 3 class, 100% of the age 4 class, 97% of the age 5 class, and 100% of males age 6 or older. All red snapper were mature at 451 mm TL and larger (Table 6).

Spawning red snapper were found at depths 23-72 meters and latitudes 27^o-33^o (Fig. 1).

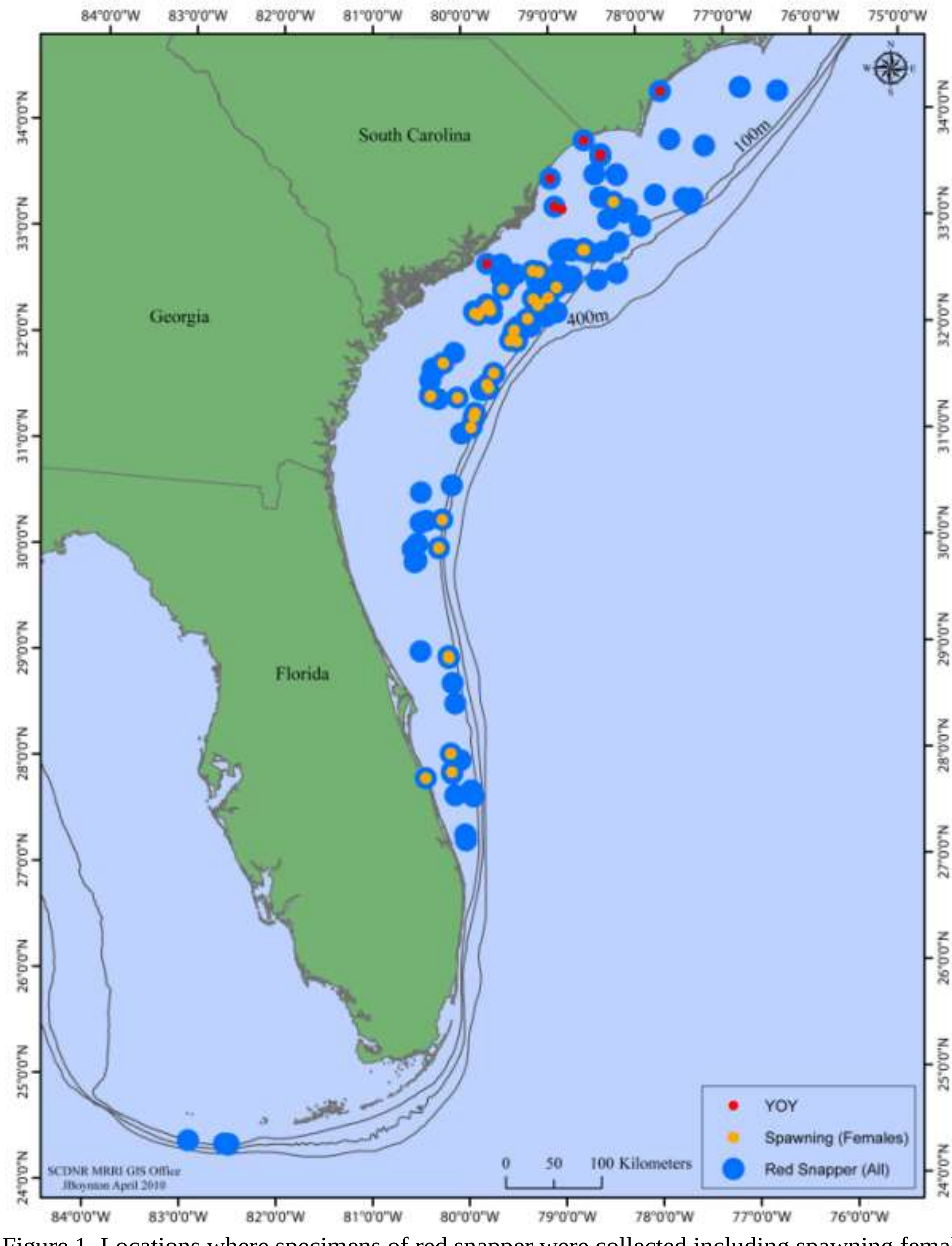

Figure 1. Locations where specimens of red snapper were collected including spawning females and young-of-the-year (YOY). Spawning females defined as hydrated oocytes or postovulatory follicles. Based on all MARMAP data collected 1977 - 2009.

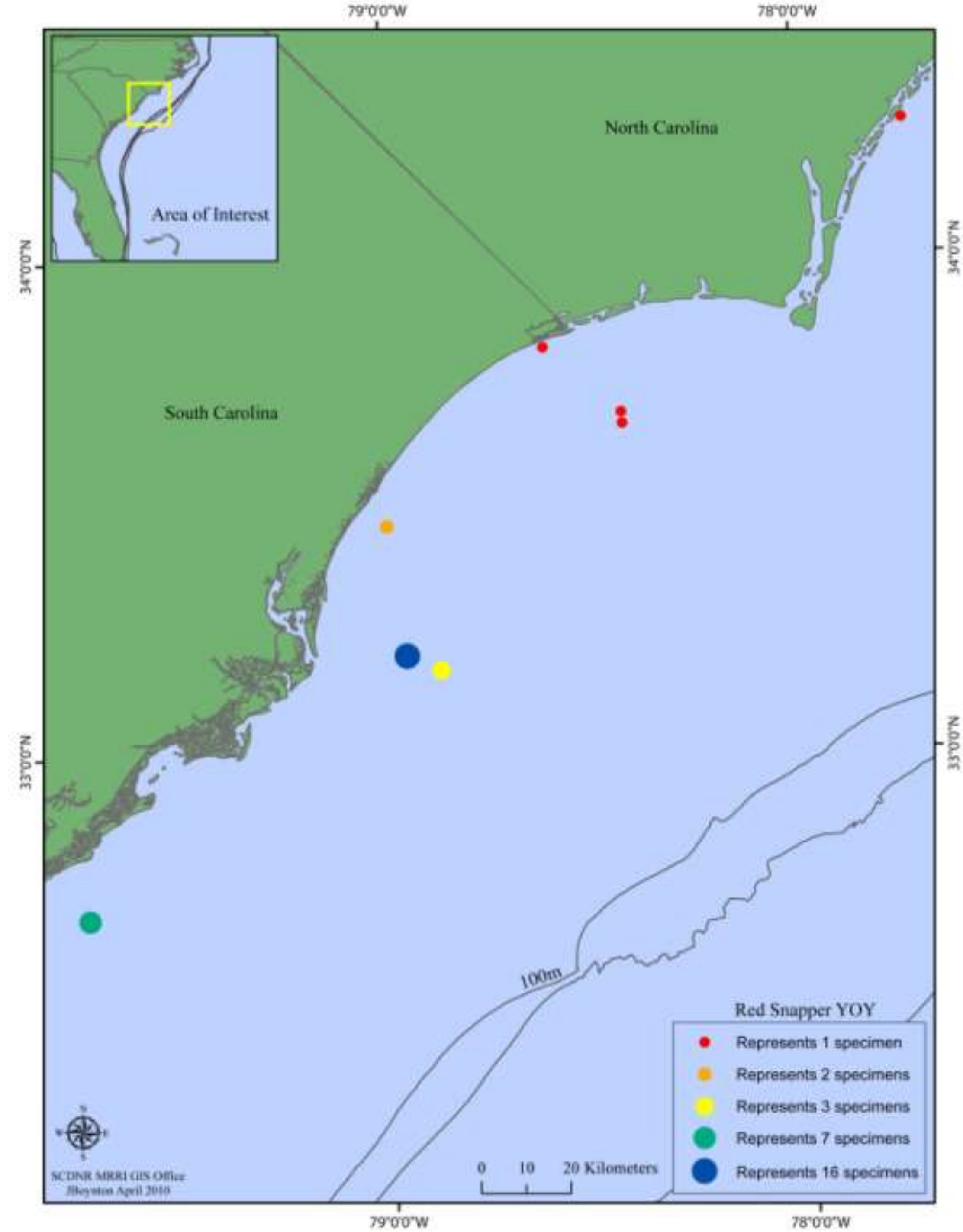

Figure 2. Locations where specimens of young-of-the-year (YOY) red snapper, <150 mm TL, collected with trawls (1979, 1986, 1999, 2000).

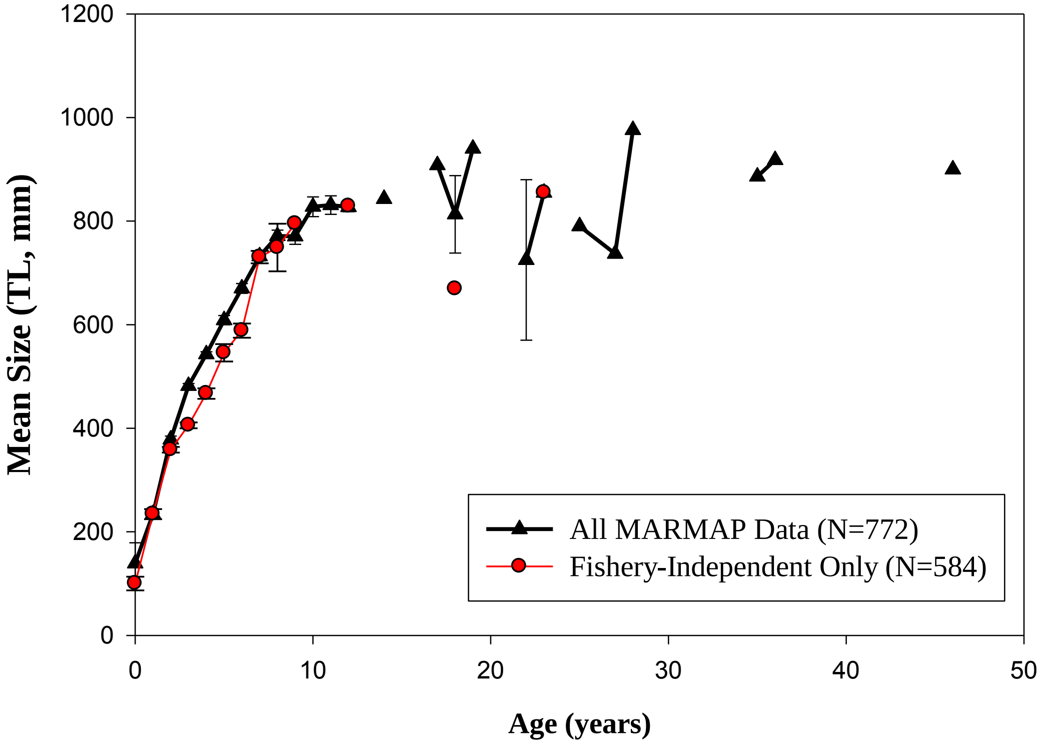

Figure 3. Mean observed size at age of red snapper,
all MARMAP data vs Fishery-Independent data (1977-2009).

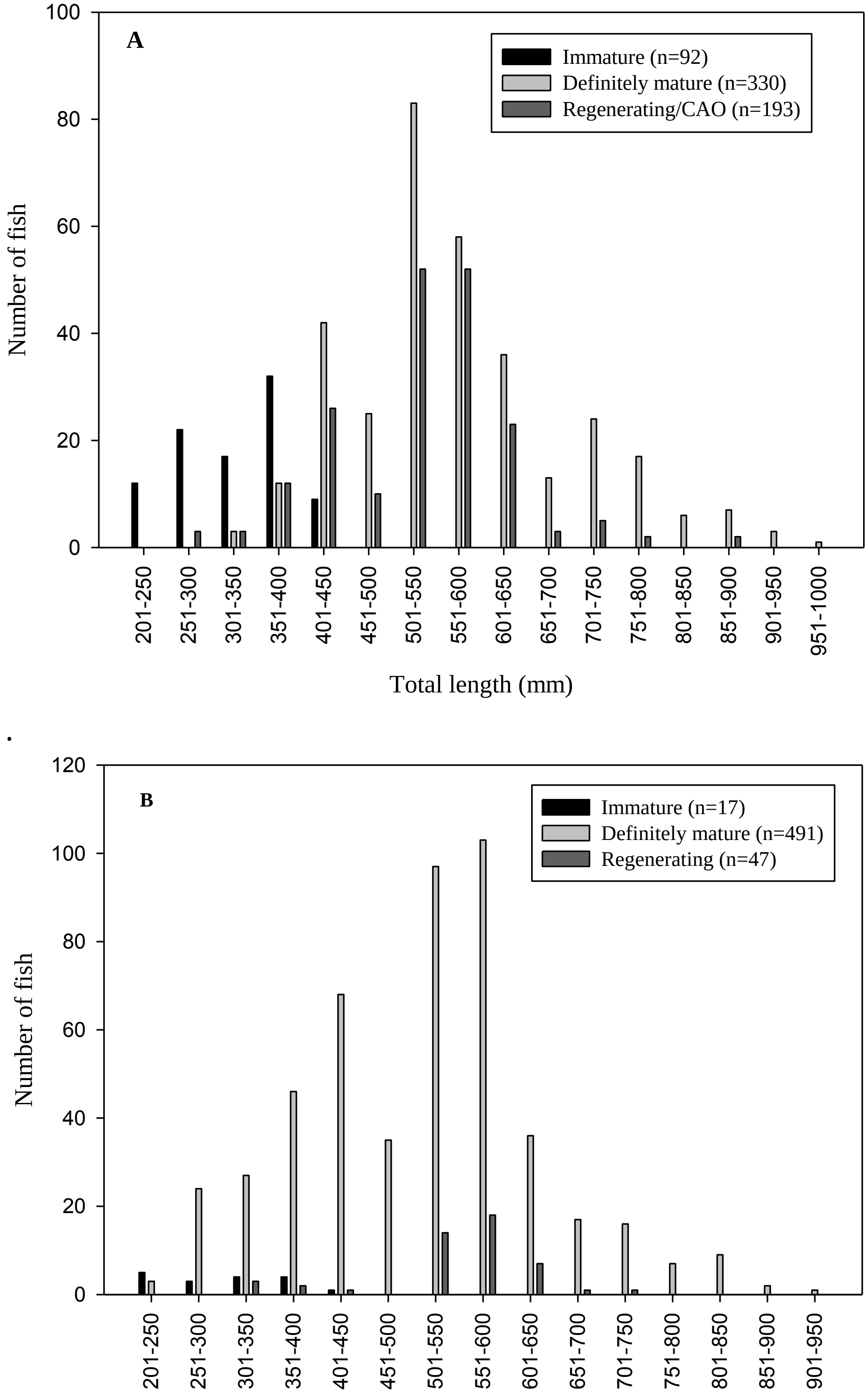

Figure 4. Length histogram for immature, confirmed mature, and resting red snapper from 1977 - 2009. A) Female B) Male.

Table 3. Chi-square analysis of sex ratios for adult red snapper by Total Length (TL, mm) from 1977 - 2009. H_o: Male to Female is 1:1. *p < 0.01, **p < 0.05

TL	Female	Male	Sex Ratio (M:F)	X^2
<=250	0	5		
251-300	3	25	1:0.1	8.64*
301-350	9	28	1:0.3	4.88**
351-400	34	61	1:0.6	3.84**
401-450	64	61	1:1.1	0.04
451-500	48	39	1:1.2	0.47
501-550	144	131	1:1.1	0.31
551-600	105	110	1:1	0.06
601-650	54	41	1:1.3	0.89
651-700	22	18	1:1.2	0.20
701-750	29	17	1:1.7	1.57
751-800	17	13	1:1.3	0.27
801-850	5	5	1:1	0
851-900	8	3	1:2.7	1.14
901-950	3	1		
951-1000	1	0		
Total	**546**	**558**	**1:1**	**0.07**

Table 4. Chi-square analysis of sex ratios for adult red snapper by year, 1977 – 2009. H_o:Male to Female is 1:1.

Year	Female	Male	Sex Ratio (M:F)	X^2
1977	0	0		
1978	2	1		
1979	8	2	1:4	1.80
1980	9	4	1:2.3	0.96
1981	3	5	1:0.6	0.25
1982	1	0		
1983	0	0		
1984	9	9	1:1	0
1985	0	0		
1986	1	0		
1987	0	1		
1988	17	20	1:0.9	0.12
1989	4	3	1:1.3	0.07
1990	7	16	1:0.4	1.76
1991	0	12		
1992	12	13	1:0.9	0.02
1993	18	12	1:1.5	0.60
1994	23	28	1:0.8	0.25
1995	8	6	1:1.3	0.14
1996	17	10	1:1.7	0.91
1997	39	28	1:1.4	0.90
1998	21	23	1:0.9	0.05
1999	75	87	1:0.9	0.44
2000	197	186	1:1.1	0.16
2001	26	23	1:1.1	0.09
2002	9	19	1:0.5	1.79
2003	0	0		
2004	0	4		
2005	7	6	1:1.2	0.04
2006	1	4	1:0.3	0.90
2007	15	17	1:0.9	0.06
2008	12	14	1:0.9	0.08
2009	10	9	1:1.1	0.03
Total	**551**	**562**	**1:1**	**0.05**

Table 5. Chi-square analysis of sex ratios for red snapper by age (year), 1977 – 2009. H_o: Male to Female is 1:1. * $p < 0.10$, ** $p < 0.05$

Age	Female	Male	Sex Ratio (M:F)	X^2
0	0	0		
1	0	1		
2	44	75	1:0.6	4.04**
3	194	197	1:1.0	0.01
4	144	163	1:0.9	0.59
5	51	36	1:1.4	1.29
6	24	18	1:1.3	0.43
7	17	5	1:3.4	3.27*
8	4	6	1:0.7	0.20
9	5	3	1:1.7	0.25
10	5	3	1:1.7	0.25
11	2	0		
12	1	0		
18	1	0		
19	1	0		
22	1	0		
23	1	0		
27	0	1		
28	1	0		
35	0	1		
36	1	0		
38	1	0		
46	0	1		
Total	**498**	**510**	**1:1**	**0.07**

Table 6. Percentage of mature red snapper by size class from 1977-2009.

	Female		**Male**	
TL	**% Mature**	*n*	**% Mature**	*n*
<=250	0	19	50	10
251-300	15.79	19	86.21	29
301-350	28.57	28	87.5	32
351-400	50.82	61	95.16	62
401-450	90	70	98.39	62
451-500	100	47	100	39
501-550	100	144	100	130
551-600	100	101	100	109
601-650	100	49	100	39
651-700	100	20	100	17
701-750	100	29	100	17
751-800	100	16	100	12
801-850	100	5	100	5
851-900	100	8	100	3
901-950	100	3	100	0
951-1000	100	1	100	0
Totals		**620**		**566**

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Appendix A: Project Codes and descriptions

The following projects represent the source of red snapper for SCDNR - MARMAP program:

Fishery Independent Projects
Project **P05**: MARMAP, 1973-2009. Long-term (38 years) reef fish monitoring project.
Project **P55**: MARMAP, 1984. Reef fish monitoring project aboard commercial vessels.
Project **P94**: SEAMAP, 1986-2009. Long-term (24 years) coastal water (trawl) survey project.
Project **Q26**: MARFIN /MARMAP (Gag spawning project), 1995. MARFIN grant funded project to verify gag spawning areas/aggregations.

Fishery Dependent Projects
Project **P50**: Commercial Fishery, 1980-2009, Red snapper otoliths and gonads collected by SCDNR personnel from the commercial fishery. There were no regulations for red snapper 1980-1983. Commercial regulations for red snapper from 1984-1992 include a size limit of 12" TL (305 mm). Commercial regulations for red snapper during 1993-2009 include a size limit of 20" TL (508 mm).

Project **T12**: Commercial Fishery/MARFIN (Red grouper project- Florida Keys), 2000-2001, Red snapper otoliths and gonads collected by commercial fishermen from the commercial fishery, provided to SCDNR personnel. Commercial regulations for red snapper during 2000-2001 include a size limit of 20" TL (508 mm). However, fishermen possessed a LOA (Letter of Amendment) or "permit" to collect undersize specimens.

Appendix B

Gear types utilized to collect red snapper specimen from fishery independent and fishery dependent sources.

Fishery Independent Sources (SCDNR –MARMAP/SEAMAP)

Gears	Gear Code
Blackfish Traps	053
Chevron Trap	324
Experimental Trap	073
Florida Antillean Trap	074
Mini-Antillean "S" Trap	041
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Gear descriptions & deployment protocol

TRAPS

Blackfish Traps

Construction and Design

Blackfish trap (Fig. B-1, B-2, & B-11) were nearly cubic (0.6 m x 0.6 m x 0.5 m; 0.16 m^3 volume) and constructed of 38-mm (1.5-inch) octagonal mesh ("chicken wire"). Each trap consisted of two entrances (0.13 m diameter, 0.09 m length) and one bait well (0.10 m diameter, 0.25 m length). See trap schematics in Fig. B-11. Blackfish traps were used from 1977 to 1989, and in 2006, 2007 and 2008 (for a trap comparison study)

Deployment and Retrieval

Blackfish traps were baited with cut herrings (*Brevoortia* or *Alosa* spp., family Clupeidae), placed in the bait wells. Traps were deployed on buoyed lines (2 to a buoy or individually) usually separated by 30.5-m line, or tied off to an anchored vessel (1988 – 1989). Traps were generally set on live-bottom reef areas at depths < 50 m. Each trap soaked for approximately 90 minutes and was retrieved using a hydraulic pot hauler.

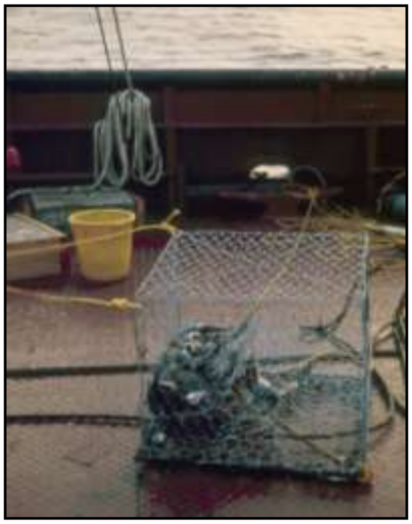

Fig. B-1. Blackfish trap with catch.

Fig. B-2. Blackfish trap being retrieved with catch. Note the brick to weigh the trap down.

<u>Florida Antillean Traps</u>

Construction and Design

Florida Antillean traps (Fig. B-3 & B-11) were rectangular (0.9 m x 1.1 m x 0.6 m; 0.59 m^3 volume) and constructed of 38 x 51 mm (1.5 x 2.0 inch) plastic-coated wire mesh. Each trap had one entrance and one bait well (0.13-m diameter, 0.6-m length). Florida Antillean Traps were used from 1980 through 1989, and in 2006, 2007 and 2008 (for a trap comparison study). See trap schematics in Fig. B-11.

Deployment and Retrieval

Florida Antillean traps were baited with cut herrings (*Brevoortia* or *Alosa* spp., family Clupeidae) placed in the bait wells. Traps were deployed individually with 8-mm (5/16-inch) polypropylene line attached to a Hi-Flyer buoy or tied off an anchored vessel (1988-1989). Traps were generally set on live-bottom reef areas on the continental shelf and upper slope. Each trap soaked between 90 and 120 minutes and retrieved with a hydraulic pot hauler.

Fig. B-3. Florida Antillean Trap (Florida Snapper Trap)

Mini-Antillean "S" traps

Construction and Design

Mini-Antillean "S" traps (Fig. B-4 & B-5), were small versions of S-shaped traps used in Caribbean Reef fisheries (1.22 m x 1.22 m x 0.61 m) and constructed of galvanized wire netting with hexagonal mesh (5 cm x 4 cm x 4.5 cm). The trap had two large funnels on opposite sides of the trap. The Mini-Antillean "S" trap was used from 1977 through 1980.

Deployment and Retrieval

Mini-Antillean "S" traps were baited with cut herrings (*Brevoortia* or *Alosa* spp., family Clupeidae), placed in the bait well. Traps were deployed individually on buoyed lines. Mini-Antillean "S" traps were generally fished in depths less than 100 m. Each trap soaked for 90 minutes and was retrieved using a hydraulic pot hauler.

Fig. B-4. Mini Antillean S Trap.

Fig. B-5. Mini-Antillean "S" Trap full with catch.

Chevron Traps

Construction and Design

Chevron traps (Fig. B-6 - B-11) were arrowhead shaped (maximum dimensions of 1.5 m x 1.7 m x 0.6 m.; 0.91 m^3 volume) and constructed of 35 mm x 35 mm square mesh plastic-coated wire. Chevron traps had one entrance funnel ("horseneck"), and one release panel to remove the catch. Chevron traps have been used by MARMAP since 1988 (consistent use and deployment since 1990). See trap schematics in Fig. B-11.

Traps had still cameras (taking 1 picture per deployment) in 1999. Starting in 2007, traps were outfitted with digital cameras taking one image per 5 minutes during deployment. In 2007 some traps had a camera, in 2008 roughly 50% of the traps had a camera, and starting in 2009, all traps had a camera attached. The cameras are mounted above the trap opening facing away from the trap opening (see figure B-11).

Deployment and Retrieval

Chevron traps were baited with a combination of whole or cut herrings (*Brevoortia* or *Alosa* spp., family Clupeidae). Bait was suspended on 4 stringers (approximately 4 herrings per string) within the trap and also placed loosely in the trap (approximately 8 additional herrings). The traps were tethered individually using 8-mm (5/16 inch) polypropylene line to a polyball buoy and a Hi-Flyer buoy attached to a 10-m trailer line or tied off to an anchored vessel (1988-1989). Traps were generally set on live-bottom reef areas on the continental shelf and upper slope. Each trap soaked for approximately 90 minutes. Up to six traps were fished at the same time and all were retrieved with a hydraulic pot-hauler.

Fig. B-6. Chevron traps baited with menhaden; ready for deployment. Iron sashes weigh trap down.

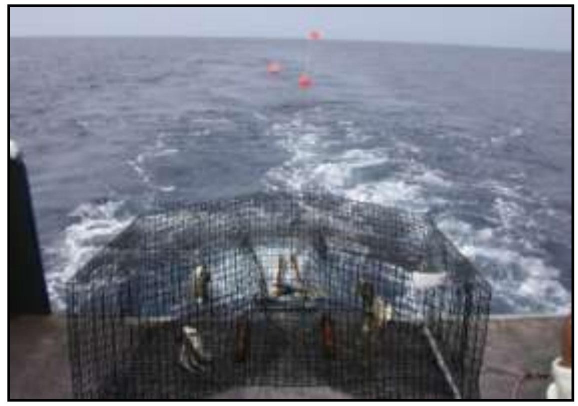

Fig. B-7. Chevron traps, baited, waiting to be deployed. Buoys mark location of a deployed trap.

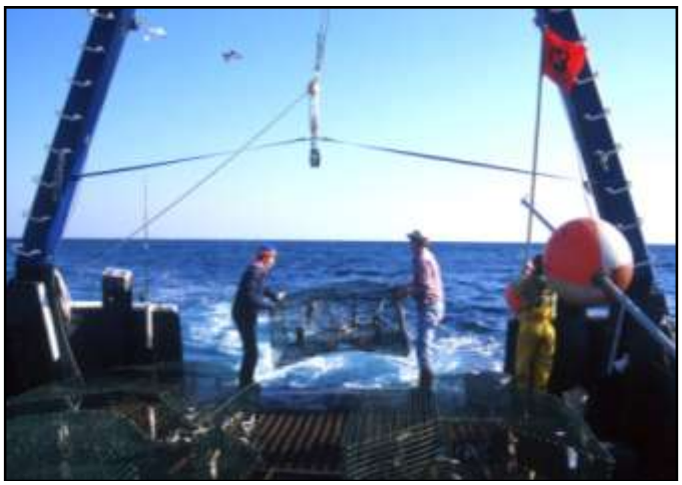

Fig. B-8. Chevron trap being deployed off the R/V Palmetto.

Fig. B-9. Chevron trap retrieval, with catch.

Fig B-10. Emptying Chevron trap on deck.

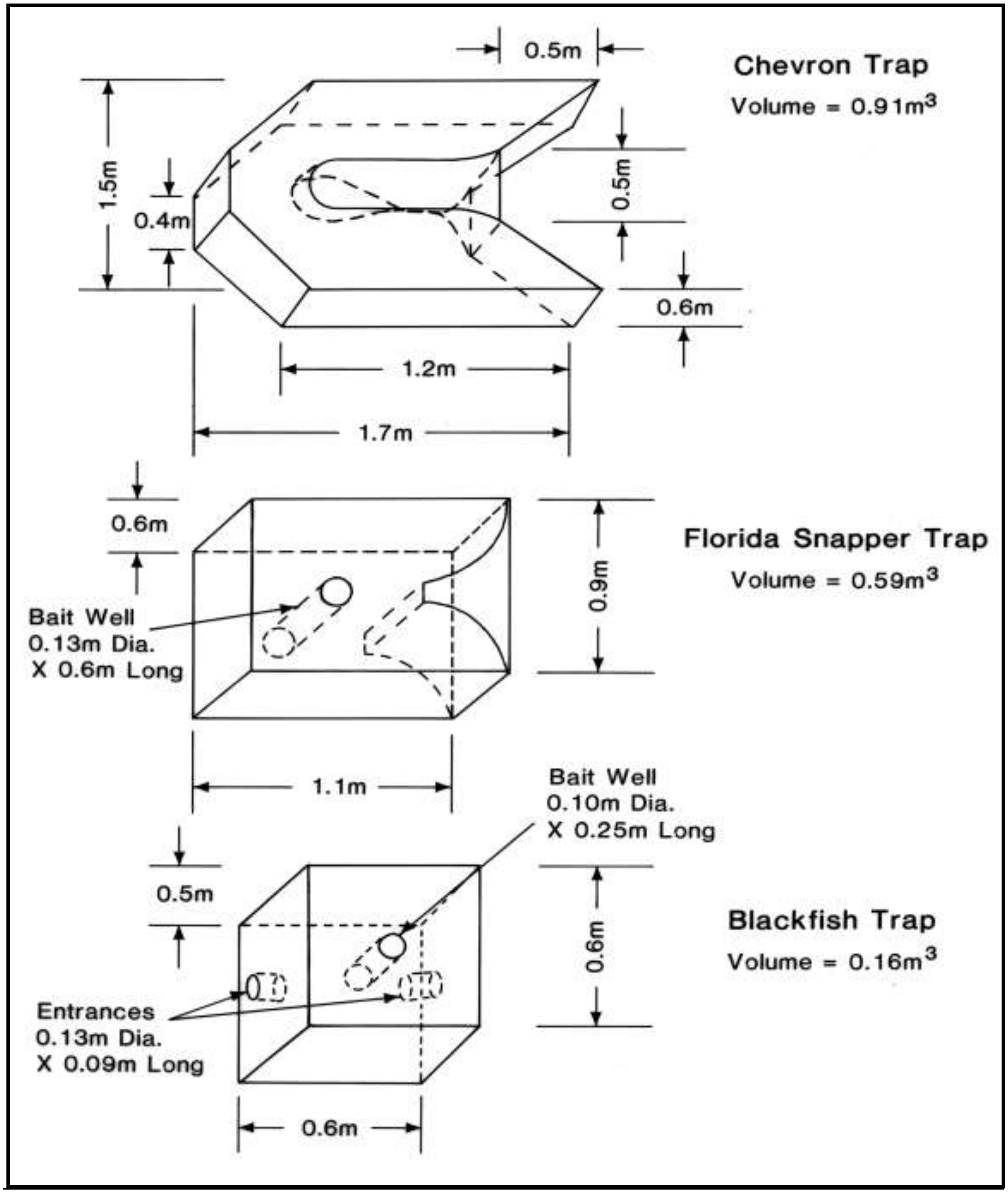

Fig. B-11. Diagram with dimensions of Chevron, Florida, Blackfish, & traps (from Collins, 1990).

HOOK AND LINE

Hook and Line (or Rod and Reel, or Personal Hook and Line)

Hook and line collections were any haphazardly deployed angling gear (e.g. Electramate or manual rod and reel) used by either the scientific party or boat crew. There was much variation in fishing times, number of anglers, configuration of terminal tackle and bait (live and artificial) used. MARMAP is currently (2009) developing a standard hook and line procedure that can be used to develop an index of abundance for collected species. This method will be introduced in the 2010 sampling season.

Construction and Design

Electramate Rod and Reel

Hook and line collections used 6/0 Penn Senator high speed reels on 1.83-m boat rods, sometimes equipped with Electramate electric motors. Terminal tackle consisted of 36-kg test (former) or 23-kg test monofilament mainline, three 4/0 or 5/0 (manufacturer dependent) non-offset "J" hooks on 23-kg test monofilament leaders 0.25 m long and 0.3 to 0.5 m apart, above one or two 0.5 kg lead sinkers.

Deployment and Retrieval

Electramate Rod and Reels

Top and bottom hooks were usually baited with cut squid and the middle hook with one-half round scad (*Decapterus punctatus*). Other combinations of squid and miscellaneous cut fishes were also used. Hook and line collections were usually made at dusk and dawn with the vessel either anchored or drifting. There was much variation in fishing times, number of anglers, configuration of terminal tackle and bait used.

Snapper Reel (or Vertical Lines or Baited Hooks)

Snapper reels (Fig. B-12) have been used by MARMAP in the past. Recently (2009) a snapper reel has been placed on board the R/V Palmetto again. A consistent sampling method for an index of abundance for collected species is being developed for use in the near future.

Construction and Design

Snapper Reels

Snapper reels were manual or electrically operated commercial snapper reel with a 30-cm (12-inch) diameter reel, 3.2-mm (1/8-inch) stainless steel cable. Terminal tackle consisted of a 2.2-kg (5-pound) weight and two or three 4/0 hooks.

Deployment and Retrieval

Snapper Reels

Snapper reels were baited with squid or cut fish. There was much variation in fishing times, number of anglers, configuration of terminal tackle and bait used.

Fig. B-12. Snapper Reel.

TRAWL

<u>¾ –scale Yankee Trawl</u>

Construction and Design

The Yankee trawl (Fig. B-13) was a bottom trawl that #72 flat nylon thread, 1.3 cm stretched mesh nylon liner, 16.5-m footrope sweep, #500 New England otter trawl doors, and 11 aluminum floats (20.3 cm diameter) spaced equally along the headrope. The footrope was equipped with 9-cm (3.5-inch) rubber rollers ("cookies"). The net had a 16.5-m footrope, 11.9-m headrope and the following stretched mesh dimensions: 11.4 cm in the wings, 10.2 cm then to 8.9 cm in the body, 5.1 cm in the cod end, and 1.3 cm in the cod end liner.

Deployment and Retrieval

Yankee trawls were towed for 30 minutes at 6.5 km/h (3.5 knots). This gear was primarily used on regional sand-bottom surveys of the continental shelf and upper slope. The sweep of the Yankee Trawl was 8.748 m, and 3.241 km was the distance covered during a standard 30-min tow (Wenner et al. 1979a), resulting in a swept area of 2.835 ha/tow.

Fig. B-13. Yankee Trawl deployed.