Vulnerability to Capture of Red Snapper (*Lutjanus campechanus*) in the Fisheries of the Southeast United States - a Preliminary look

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Abstract. Files of biological samples collected from 1992 through 2009 from the commercial and recreational sectors catching Red Snapper (*Lutjanus campechanus* were used to assess the distribution of size, age and depth in the Atlantic fishery. The data indicated that size and age of fish caught increase with depth. In addition, areas and depths fished varied among the recreational sectors and the commercial fishery. The evidence suggest that vulnerability to capture is variable over the size (or) age of the fish in each sector of the fishery, and dome shaped "selectivity" curves are appropriate as is the practice for the Gulf of Mexico stock.

Introduction. We define **Vulnerability** as the relative proportion of each age or size group of a species that is removed by the fishery or the separate fleets (sectors) of the fishery. (This should not be confused with catchability (q) of the catch equation; we use catchability in a different sense in this note.) Vulnerability can further be refined to include the effects of **Availability** of the fish to capture owing to their presence or absence in the area fished, **Catchabilty** in the sense of a behavioral effect such as restricted feeding during spawning, etc., and **Selectivity** to fishing methods and gear.

The question we address is how vulnerability (at size and age) in this fishery varies across time periods, areas, depth strata, and sectors of the fishery. What should the "selectivity" curves look like that will be used in the assessment. Our interest in this is prompted by the observations of one of us (**DN**) that these fish are not uniformly distributed along the shelf, that oceanic conditions and depth tend to restrict access to fish farther from port, and that in general the larger (older) fish tend to spend more time in deeper water. These circumstances would be expected to result in what is often called a "dome" shaped selectivity curve whereby younger and older animals are less vulnerable to capture than those of intermediate age. It also suggests that no age is 100% vulnerable. Our observations are qualitative and "anecdotal"; however, sufficient data was available it the SEDAR 24 Data Workshop to allow a preliminary examination of the issues.

Data. During the working session of the Recreational Catch Working Group data for catches by length and age were available together with the reported depth of capture. This information was used to quantify the distribution of fishing depth for three recreational sectors so as to assign discard mortalities. The distribution of size (or age) of the catches by depth and sector was not done; cursory examination by eye of the scatter plot of size and age against depth (Fig. 1a) was believed to show no relation between depth and the size of the fish. However, a regression line fitted to the points (Fig. 1b) indicates the size of the fish increases as the depth fished increases. The data are very noisy, but the relationship is significant (**N = 7416**, TL_mm = 546 + 0.496 Feet, P= 0.000).

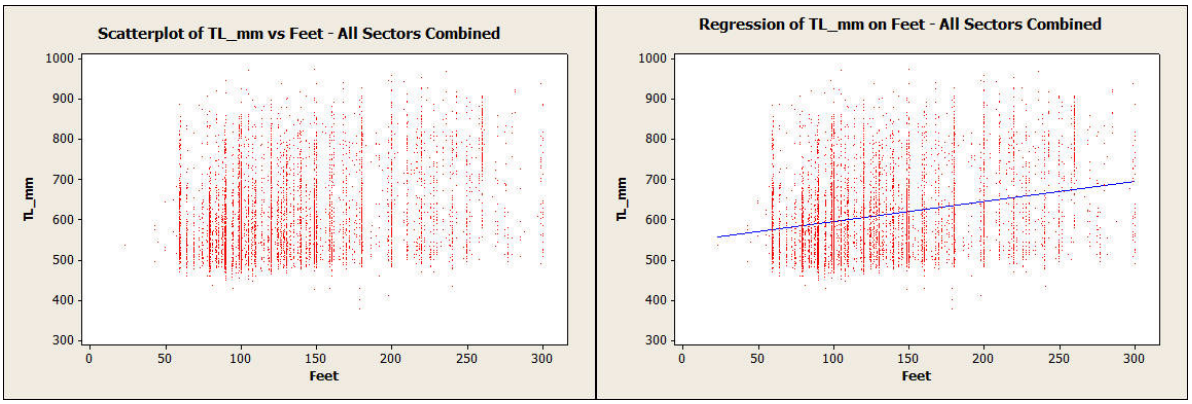

Figure 1a

Figure 1b

Two files were supplied by Dr. Jennifer Potts, leader of the Life History Working Group. These comprise entries from several sources collected from 1992 through 2009. The entries are: Month, Year, Fishery (four sectors – CM=Commercial, CB=Charter Boat, HB=Head boat and PR= Private Recreational), State (Florida to Virginia),Area Fished(block number),Minimum Depth, Maximum Depth, Units of Depth (feet, meters, fathoms), Sex, Total Length mm, Fork Length mm and Calendar age.

The depth data were edited to convert all unit of depth to feet. Seven hundred fifty nine entries gave both a maximum and a minimum depth. Each was converted to a single depth; the arithmetic average of the two values. A further edit of the depth data removed 186 trips with averaged values greater than 350 feet. There were a minor number of missing values for of age, total length or fork length and depth. Except for fork length, none were greater than about 200 so the sample size remains large.

We had two data files because of confidentiality issues. One file contains data by fishery sector and State; the other combines the three recreational sectors into one category, and gives catch location by map block. This was to prevent us from assigning areas and dates to the recreational data – the commercial data are so numerous for all areas that confidentiality is not an issue.

All sectors have several hundred entries except Private Recreational (PR). Here the entries are too few (25) to allow a meaningful assessment as a separate sector; they are included in the combined Recreational Sector (RC) data analysis. Total samples sizes are: Commercial 3871, Combined Recreational 3358.

One of us (DN) from personal knowledge and with information furnished by his For Hire Sector colleagues assembled an information table that describes the main structures offshore the principal ports and inlets from Cape Canaveral north. The coverage is for most of the landing areas used by the Charter and Head Boat fisheries that catch red snapper (Table 1). These locations were classified into three areas according to the width of the coastal shelf (Fig. 3).

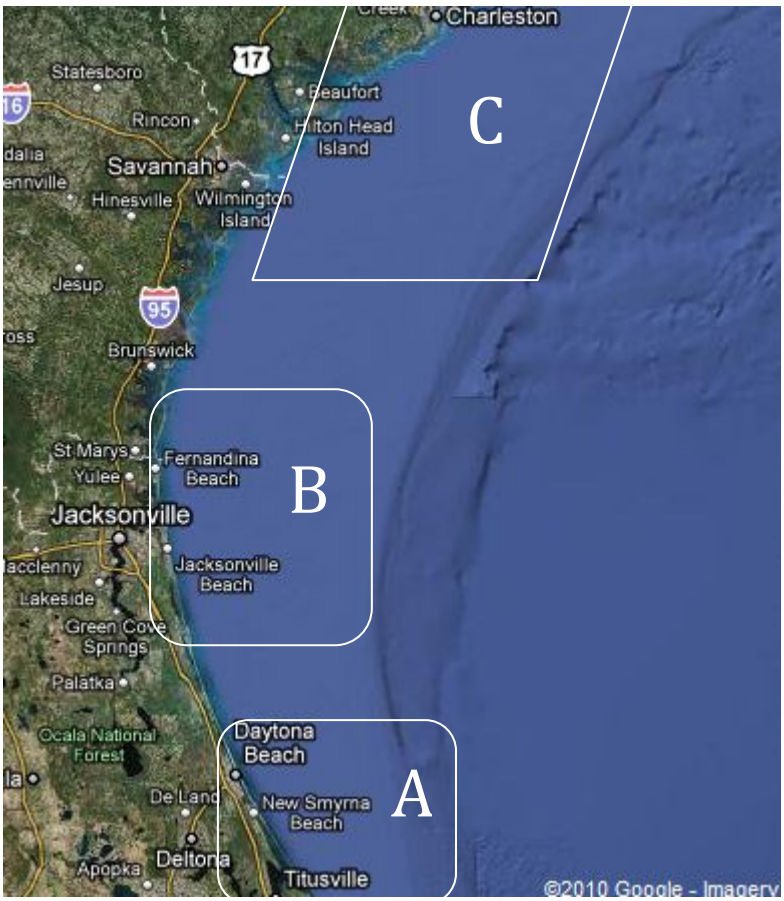

Figure 3. Three main fishing areas for Atlantic red snapper. Areas are based on shelf width from Narrow (A), medium (B) and wide (C)

Table 1

AREA	PORT or INLET
A	Cape Canaveral – Titusville (Captain Russell Sinclair) 1. Closest reef is 10 miles and 55 feet of water, called Canaveral Reef. Closest recreational bottom fishing area - Pelican Flats – 18 miles at 110 degrees compass heading and depths of 80-90 feet of water. 2. Most popular recreational bottom fishing area-21-23 fathom bottom -26 miles at 60-70 degrees and depths of 126-138 feet. 3. Furthest recreational bottom fishing area is the 27 fathom ledge or bottom- 26-30 miles from Cape Canaveral- 160-165 feet. Anglers are very often adversely affected by the Gulf Stream current.
A	Ponce Inlet (Daytona Beach) (Captain Paul Nelson) 1. Closest recreational bottom fishing area – Bridge reef to Cracker Reef 5 miles to 12 miles at 55 degrees to 110 degrees and depths of 60 to 75 feet of water. 2. Most popular recreational bottom fishing area – Party Grounds and Ridge south to Turtle Mound and Horseshoe- 17 to 26 miles at 68 to 107 degrees compass course and 60 to 85 feet of water. 3. Furthest recreational bottom fishing area is the 21-23 fathom bottom- 32-36 miles at 60 degrees to 110 degrees and is 126-138 feet deep. Anglers are often adversely affected by the Gulf Stream current.
B	Jacksonville (Captain George Strait) 1. Closest recreational bottom fishing area- Montgomery's Reef at 8 miles and 65 feet of water. 2. Most popular recreational bottom fishing area – Black Mars Reef and East 18 and it is 24 miles and 100 feet of water. 3. Furthest recreational bottom fishing area –Elton Bottom- 38 miles and 115 feet.
C	Savannah (Captain Steve Amick) 1. Closest recreational bottom fishing reef is 5 miles offshore at 40 feet deep. 2. Most Popular is J reef and Grays Reef both are 18-20 miles and 55-65 feet of water. 3. The Triple Ledge is about 75 miles offshore and is rarely fished recreationally.
C	Charleston (Captain Mark Brown) 1. Closest recreational bottom fishing reef is the "Near-shore Reef" 5 miles offshore and in thirty feet of water. 2. Most popular bottom fishing reef is the Y-73 and the Comanche Reef- both at 30 miles and 90-105 feet of water. 3. Furthest recreational bottom fishing area is called the Red Banks – at 35 miles and 90 feet of water.
C	North Carolina to be added

Table 1. Major Reef Areas – Florida to North Carolina*

*The information was gathered from local captains from each of the inlets named and applies to headboats and private recreational boats, charter boats range farther offshore.

Results. For an initial analysis we looked at the distribution of length and depth data by sector (Fig. 4).

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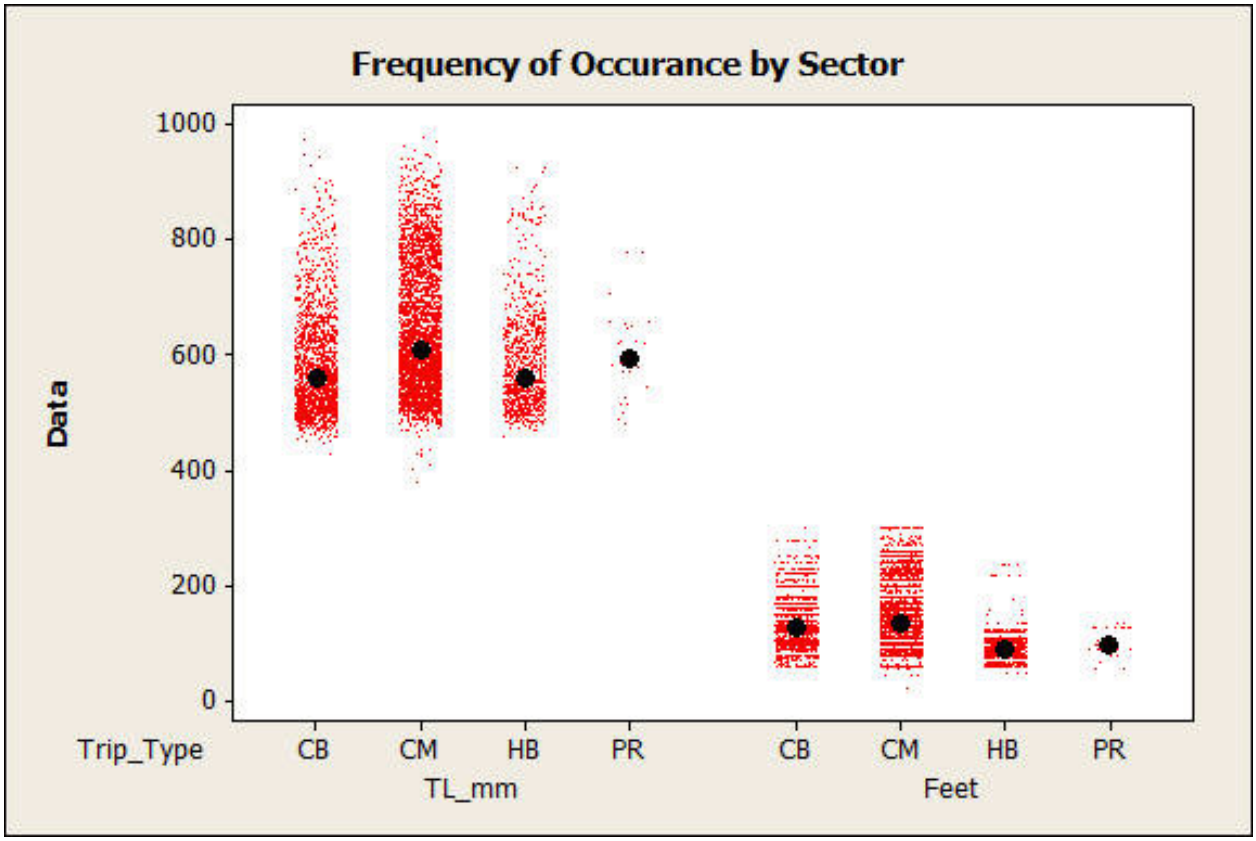

Figure 4. Individual data plots with median symbol (black circles) for total length (TL-mm) and depth (fee) for each of the four sectors: Charter Boat (CB), Commercial Boat (CM) Head Boat (HB) and Private Recreational (PR).

Sector	Median size Tl_mm	Median Depth in feet
Charter Boat	558.0	127.5
Commercial Boat	607.0	135
Head Boat	561.5	89

Table 2. Median values for Fig. 4.

These simple plots support four conclusions:

1. The Private Recreational (PR) observations are too few to be statistically significant.
2. Commercial Boats (CM) catch larger fish and fish deeper than do the other two sectors
3. Head Boats and Charter boats take fish of similar size, but HB fish the shallowest areas.
4. It may not be valid to pool Head Boat data with Charter Boat data as was done by the data workshop when considering discard mortality. (SEDAR 24 SAR Section II, p124)

This differences among sectors of sample depths is more obvious with Fig. 5a, which compares the recreational sectors directly. The Private Recreational samples are included but they are so few they are

hidden at the bottom of the figure. Figure 5b compares the recreational sector (the three combined for confidentiality) and the Commercial sector

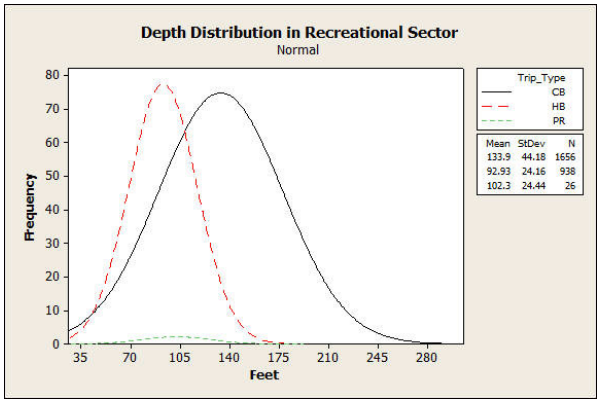

Figure 5a

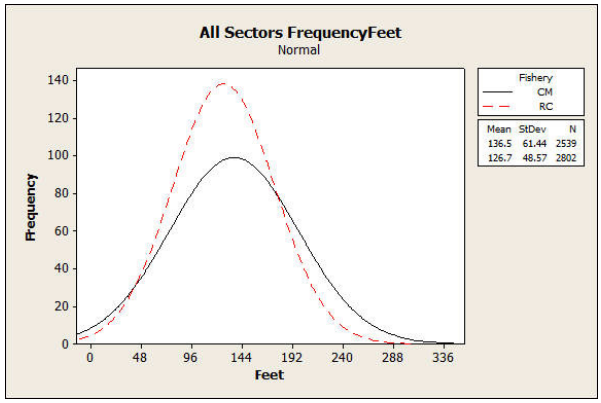

Figure 5b.

Figure 5a. Comparison of distribution of samples (proxy for effort) between Head Boat and Charter Boat, and

Figure 5b. Recreational Boats (three recreational sectors combined) and Commercial Boats for all year and areas.

The separation in depth between the Head Boat and Charter Boat fleets is clear. The three recreational sectors are combined in the comparison with the commercial sector in Fig. 5b.and should be separated when the confidentiality issue is resolved. However, the commercial sector appears to extend its fishing effort into deeper water than does the combined recreational sector. The degree of separation is biased due to including the Head Boat data with the Charter Boat data.

It is clear that there are differences in depth fished by the various sectors. What is also of interest is how the size or age of the fish is related to the depth fished. Figures 6a and 6b look at the relation of catch at age and length caught as depth increases.

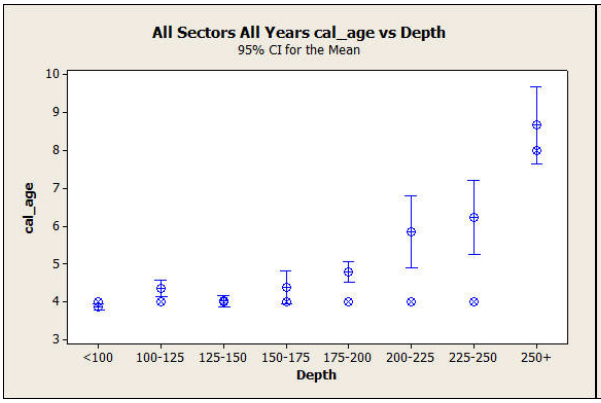

Figure 6a

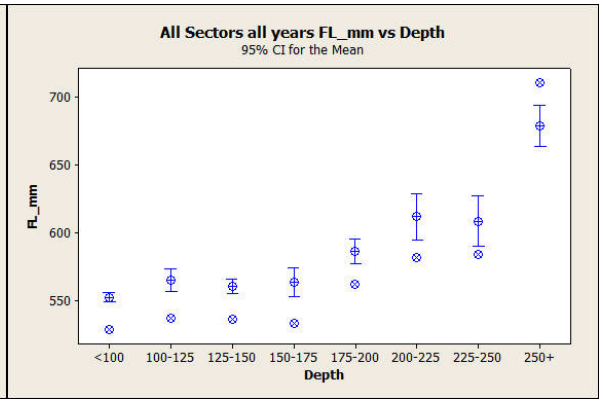

Figure 6b

Figures 6a and 6b. Relation of depth and catch at age and size (FL_mm) for all sectors and all years. Means have the C.I Bar, the other symbols are the median values.

The distribution of catches is not normal, but the composite information from all sectors combines is interesting. Because of the confidentiality issue we did not attempt to refine these results in terms of area fished for the separate entities in the recreational sector. However we did find some difference for the commercial sector and the composite recreational sector among the areas (Fig 7).

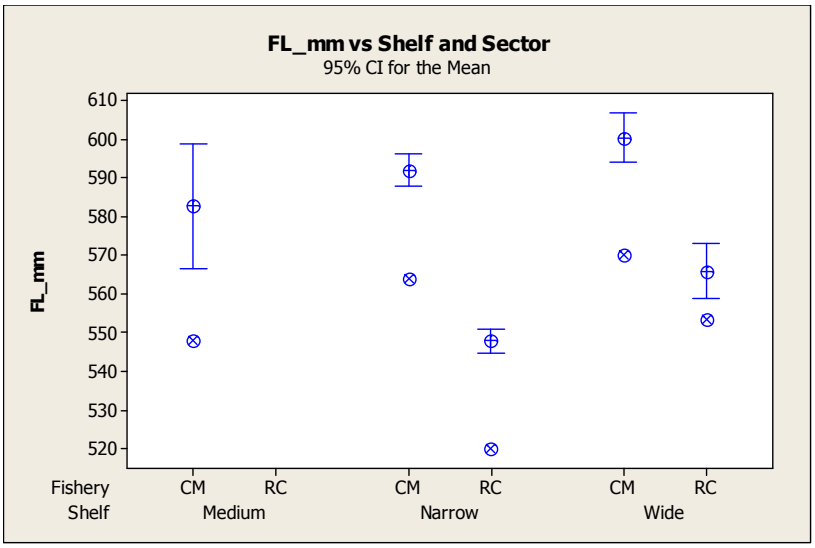

Figure 7. Mean (with C.I. bars) and median (circle with X) fish size for the three sections of shelf (Fig. 1) The medium shelf area sample is small – 132 and so it cannot be differentiated from the Narrow shelf.

Discussion. This exercise has been instructive in that it makes it clear that the various sectors of the fishery operate in different ways to such a degree that the issue of vulnerability (selectivity as used in the modeling) needs to be evaluated. The fact that there are differences in size for the larger fish taken among the several sectors indicates that a flat topped selectivity curve as was used in SEDAR 15 is inappropriate. Second, since fishing is restricted in the case of head boats and probably most private boats to the areas closer to shore, they do not have access to the portion of the stock in deeper – more distant – water. Thus, unless we consider the fish are a fungible product with the complete mixing over the entire range, availability becomes a factor for consideration. (The fungibility argument is weak because there is evidence for a cline with larger fish in deeper water.) Third, the apparent size at capture difference between the recreation and the commercial sectors (Fig 5a) has another possible interpretation. It may indicate gear selectivity with the commercial sector employing stronger gear and techniques that allows larger fish to be landed in deeper water than is the case with charter boats.

All the evidence presented so far indicates that there are fish that live outside the center of the fishery and that these fish do not mix completely (hence differences in average size among sectors). This implies that the sensitivity curve for every sector of the fishery is dome shaped, with larger/older fish being less vulnerable (for several reasons) to capture. The quantitative aspects have to be determined.

Acknowledgements.

We wish to thank Dr. Potts for providing us with the data file.