Mortality estimates for mutton snapper, *Lutjanus analis* inhabiting Florida waters

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1.0 Introduction

Recent concerns about the health of the mutton snapper population in Florida inspired state and federal officials to initiate a southeast data, assessment and review process, or SEDAR for the species. SEDAR-15a data workshop took place in Marathon, Florida April 18-20th, with the goals to compile the life history information, abundance indices and catch statistics, evaluate and critique available datasets, provide data for assessment analyses, and draft the Data Workshop Report.

Because of the substantial workload of the SEDAR process, and the limited time in which it is completed, members were divided into sub-groups or teams; stock assessment, life history, recreational fisheries, commercial fisheries, and fisheries independent indices. Each group was given a list of terms of reference that identify specific deliverables. This list for the life-history workgroup included providing estimates of (1) the natural mortality and (2) the recreational and commercial catch-and-release mortality. This working paper documents how these estimates were derived for SEDAR 15a.

2. Mortality estimates

2.1. Natural mortality

Prior to this assessment, the only natural mortality estimate of *L. analis* was provided by Burton (2002). Although fish up to 29 years were observed by Burton (2002), an examination of the age-frequency distributions revealed that no fish were observed between 18 and 29 years of age. For this reason Burton (2002) calculated two natural mortality estimates; one for fishes up to 17 years, and one for fishes up to the maximum age of 29. This is significant, because age-frequencies from this SEDAR also show fewer fishes over 18 years; however, fish were observed in all age classes including 40 years (Table 1). From these data, it was concluded that the *L. analis* population consists of two portions; one of individuals up to 18 years that reside where fishermen regularly harvest (hypothesized to be the Florida shelf less than 30 meters), and older fishes that are found in rarely fished locations, such as very deep or spatially remote locations. This second portion of the population is believed to represent a “virgin”, or relatively unexploited portion of the population. Since total mortality, Z, is equal to natural mortality (M) and fishing mortality (F) then examination of fishes older than 18 years of age would represent mostly M and not F. As evidence, consider that the recreational fishery for mutton snapper operates nearshore and 95% of their landings are fish aged 7 years or less while the commercial fishery operates in deeper water and 95% of their landings are fish aged 21 years old or less (Figures 1 and 2).

Burton (2002) estimated natural mortality equations derived from meta-analyses. One such example is provided by Hoenig (1983) who relates total longevity (t_{max}) to natural mortality (M) according to the relationship:

$\ln(\hat{M}) = 1.44 - 0.982 * \ln(t_{\max})$. According to this relationship, estimates of natural mortality from Burton (2002) became 0.26 for ages 1-17 and 0.14 for ages 1-29, and 0.11 for the t_{max}=40 yr in this assessment because fishes up to 40 years were observed (Table 1). By the nature of the equation, estimates of M will dramatically change with different t_{max} values. It is perhaps better then to estimate M based on multiple ages. For this reason we used a catch curve (Chapman and Robson 1960). To ensure that the data were as comparable as possible, we only included fish aged 18 years and older caught from the Dry Tortugas and southeast Florida shelf long-line fishery. There were 162 mutton snapper that met these criteria. The Chapman-Robson catch curve estimated total mortality at 0.13 per year- similar to the estimate from Hoenig (1983). Instead of assuming that a single natural mortality rate applies to all ages, we derived age-specific M values using Lorenzen's (2005) method. His approach uses the relationship between age and length and is scaled to a "target" mortality rate. Based on the above, and the age-and-growth information from Faunce et al. (2007), we scaled the calculated age-specific rates for ages 18-40 to 0.11 per year, the estimate that we obtained from Hoenig's (1983) regression (Figure 3).

2.2. Discard mortality

Discard mortality for mutton snapper has not been examined prior to this SEDAR, necessitating the inclusion and examination of alternative data. Data were obtained from two sources. First, the online search engine Cambridge Scientific Abstracts were culled for relevant articles from earliest to present within the default “Natural Resources” database using the following keywords: fishing mortality, grouper, snapper, mutton snapper, catch, release and mortality. Articles were deemed relevant if they focused on a species with similar body size to mutton snapper (< 1 m total length), with similar life history strategies (adults reside on marine reefs), collected with similar gear types (hook and line). Discard mortality from SEDAR 7 (Gulf of Mexico red snapper, *Lutjanus campechanus*, section 6.0) was selected as a second source (Table 2).

Discard mortality is influenced by the factors of hook type, hook placement, time of handling, and depth of capture (the latter being the result of barotrauma caused by the super-inflation of the swim bladder upon ascent). Of these factors, depth of capture is best represented in the available data. In order to identify general trends in the data, it was assumed that the average depth and mortality of fish captured could be adequately represented by the midpoint between the minimum and maximum reported values in each study (e.g., the data were normally distributed and that the mode=mean)- an assumption substantiated by Wilson et al. (2005). Two groups of data could be easily discerned from the data; those collected in less than 30 m depth, and those collected at greater depths. This division point of 30 m also has significance since a large proportion of the Florida shelf is near or below this depth (Figure 4). Therefore the shallow depth group can be considered a proxy for fishes collected nearshore and available to recreational anglers. This assumption is substantiated by the fact that trapping efforts for snappers that simulate recreational fishery locations, including *L. analis* made during 2000-2003 by the Florida Fish and Wildlife Conservation Commission (Barbieri & Colvocoresses 2003) on the Atlantic Florida shelf, averaged 22.6 meters, and 95% confidence intervals (1.96 * 1 standard deviation) place boundaries between 14.5 and 30.7 m deep (n=485). Mortality rates were drastically different between depth groups, and averaged 15% (range 1-58 %) for the shallow group and 66% (range 44 – 86%) for the second group. These values were statistically different based on t-test comparison of means ($p<0.001$), and provide the first method to assign discard mortality rates to *L. analis*.

Limited data were available on *Lutjanus analis* discard mortality in the form of headboat observations made in eastern and western Florida during 2005-06 (Beverly Sauls, FWC unpublished; Table 3). Comparison of these limited data with *Lutjanus campechanus* data reveals that discard mortality rates were neither consistently greater or lower than red snapper mortality rates for the two depth classes (Figure 5). However, discard mortality for *L. analis* was lower than for *L. campechanus* in three of four instances, suggesting that discard mortality rates for *L. analis* may be lower than for *L. campechanus* at all depths. However, the high mortality of *L. analis* in shallow (< 60' or ca. 20 m) depths on the east coast of Florida cannot be easily explained nor discounted.

Because of these differences, a more attractive method to assigning release mortality would be to examine how rates change with depth as a continuous variable rather than within discrete depth bins. This type of data are only available for *L. campechanus*, and when available information was combined, it was revealed that discard rates could be effectively modeled using a logistic regression (Figure 6). The final form of this model was:

$$y = \frac{79.12}{1 + \left(\frac{x}{34.10}\right)^{-5.55}}$$

where *x* is discard depth and *y* is the discard mortality rate (%). Examination of residuals and test results revealed that the model was adequate and statistically significant ($p<0.001$). Because this model can be used to estimate discard mortality for a variety of depths, it is the recommended as the preferable option to assign discard mortality rates for *L. analis*. An important assumption is that the relationship between mortality and depth for *Lutjanus campachanus* can be applied to *L. analis*. Examination of limited data from headboat surveys indicate that this assumption may not be correct, and that its acceptance adopts a more conservative approach to discard mortality rates for *L. analis*.

3. Synopsis

Natural mortality rates were estimated from two methods focusing on the lightly fished proportion of the population (ages 18-40). Rates were determined to be 0.11-0.13 for the unfished proportion of the population and greater rates back-calculated for younger ages. We recommend using the age-specific estimates of Lorenzen (2005) scaled to a M of 0.11 per year.

Discard mortality was estimated according to depth using both a static bin approach and a logistic regression with depth. Both methods revealed greater mortality rates with greater depths, although models using depth as a continuous variable revealed mortality rarely reaches 100%. The dynamic logistic relationship between release mortality and depth is recommended for *L. analis*.

Acknowledgements

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Table 1: Observed age-frequency data for *Lutjanus analis*.

	N				
Age	FWRI St. Petersburg	M. Burton	FWRI Tequesta Independent Study	FWRI Keys Independent Study	TOTAL
0	4		107		111
1	11	7	49	5	72
2	315	143	67	81	606
3	1346	326	245	98	2015
4	1147	295	91	54	1587
5	587	247	34	34	902
6	352	145	12	22	531
7	272	105	7	10	394
8	162	67	7	7	243
9	90	32	1	2	125
10	55	13	2	2	72
11	65	9		2	76
12	42	7			49
13	32	2			34
14	34	3		1	38
15	30	1		1	32
16	31	1			32
17	26	4		1	31
18	24				24
19	24				24
20	24				24
21	18	1			19
22	16				16
23	7	1			8
24	10	1			11
25	11	1			12
26	11				11
27	12				12
28	9				9
29	6	1			7
30	3				3
31	9	1			10
32	4				4
33	7				7
34	8				8
35	3				3
36	3				3
37	2				2
38	1				1
39	2				2
40	3				3
TOTAL	4818	1413	622	320	7173

Table 2. Discard mortality information from literature and SEDAR 7 sources. Depth bin 1 = < 30 m, depth bin 2 = > 30 m depth.

Source	Species	Mean depth(m)	30m depth bins	Average M*
CSA				
Wilson and Burns, 1996[1]	*E. morio* and *M. phenax*	22.0	1	7.0
Wilson and Burns, 1996[2]	*E. morio* and *M. phenax*	59.5	2	67.0
St. John and Syers, 2005[3]	*Glaucosoma hebraicum*	7.0	1	21.0
St. John and Syers, 2005[4]	*Glaucosoma hebraicum*	52.0	2	86.0
Broadhurst et al., 2005[5]	*Pagrus auratus*	.	1	18.0
Wilson et al., 2005[6]	*Lutjanus campechanus*	46.0	2	69.0
SEDAR 7				
Parker, 1985	*Lutjanus campechanus*	22.0	1	21.0
Parker, 1985	*Lutjanus campechanus*	30.0	1	11.0
Gitschlag and Renaud, 1994[7]	*Lutjanus campechanus*	22.5	1	1.0
Gitschlag and Renaud, 1994[8]	*Lutjanus campechanus*	28.5	1	10.0
Gitschlag and Renaud, 1994[9]	*Lutjanus campechanus*	38.5	2	44.0
Render and Wilson, 1994	*Lutjanus campechanus*	21.0	1	20.0
Patterson et al., 2002	*Lutjanus campechanus*	21.0	1	9.0
Patterson et al., 2002	*Lutjanus campechanus*	27.0	1	14.0
Patterson et al., 2002	*Lutjanus campechanus*	32.0	1	18.0
Diamond et at., 2004[10]	*Lutjanus campechanus*	30.0	2	53.0
Diamond et at., 2004[11]	*Lutjanus campechanus*	40.0	2	71.0
Diamond et at., 2004[12]	*Lutjanus campechanus*	50.0	2	69.0
Wilson and Nieland, 2004[13]	*Lutjanus campechanus*	60.0	2	69.5

* estimated from mid-point in range of mortality estimates

(1) In-situ study 0-14% < 44 m
(2) In-situ study on depth and mortality 67% >44m
(3) Demersal reef fish hook catch and release condition 0-14 m
(4) Demersal reef fish hook catch and release condition 45-59 m
(5) Estuarine hook and line tournament
(6) Commercial Multi-hook gear -9 -85m (ave. = 46m)
(7) 21-24m -for fish <32 cm
(8) 27-30m – for fish <32 cm
(9) 37-40m – for fish <32 cm
(10) 30m - oil platform study (Texas)
(11) 40m - oil platform study (Texas)
(12) 50m - oil platform study (Texas)
(13) Commercial 30-90m

Table 3. 2005-06 At-sea headboat observer data for mutton snapper, *Lutjanus analis*; release conditions from east (EFL) and west (WFL) Florida.

		Release Condition					
Region	Median Depth	Good	Fair	Poor	Dead	Total	Proportion*
EFL	<60'	2	1	1		4	0.50
	>60'	50	10	13	3	76	0.38
WFL	<60'	37	1			38	0.03
	>60'	14	2	2		18	0.22

*assumes all fishes not in good condition suffer complete mortality following a precautionary approach.

Figure 1. Proportion of *Lutjanus analis* captured by the recreational (pink line, squares) and commercial (blue line, diamonds) sectors.

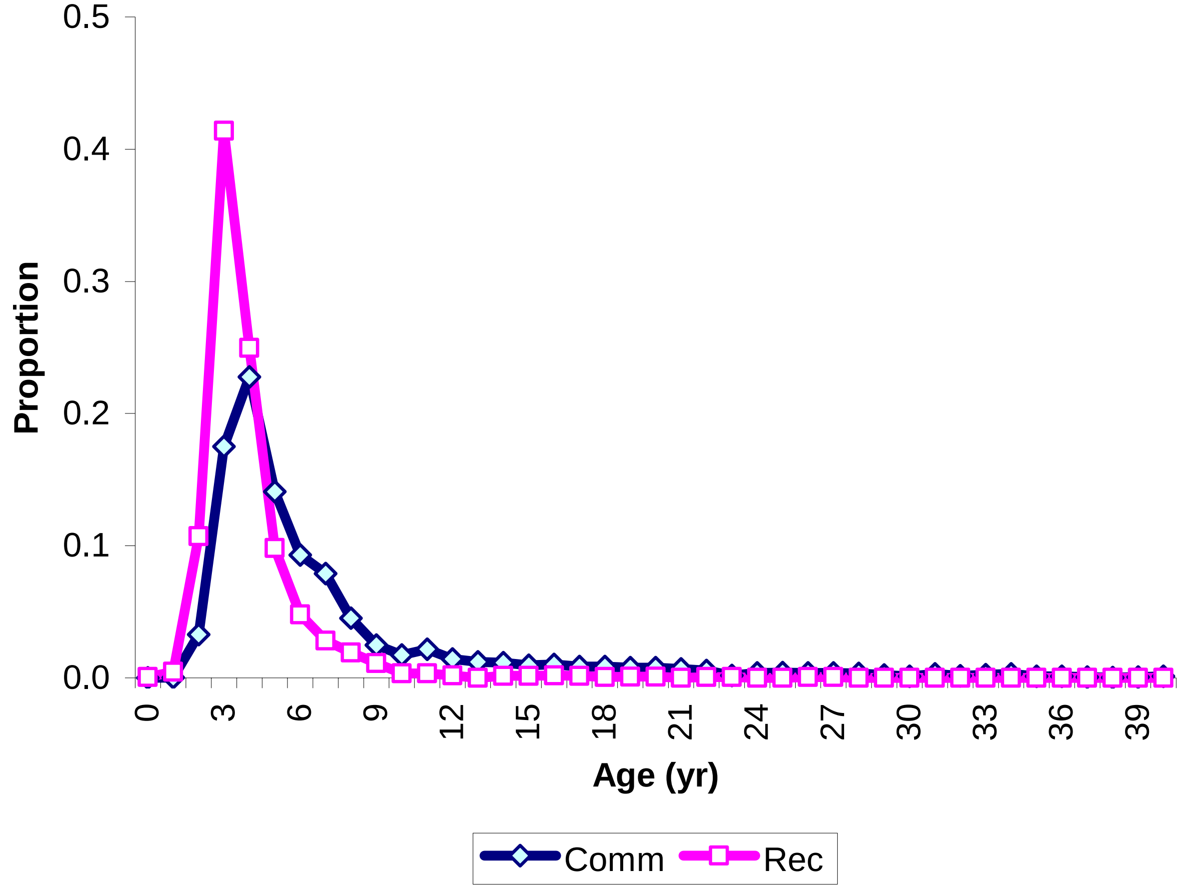

Figure 2. Cumulative distribution of *Lutjanus analis* catch by the recreational and commercial fishery sectors.

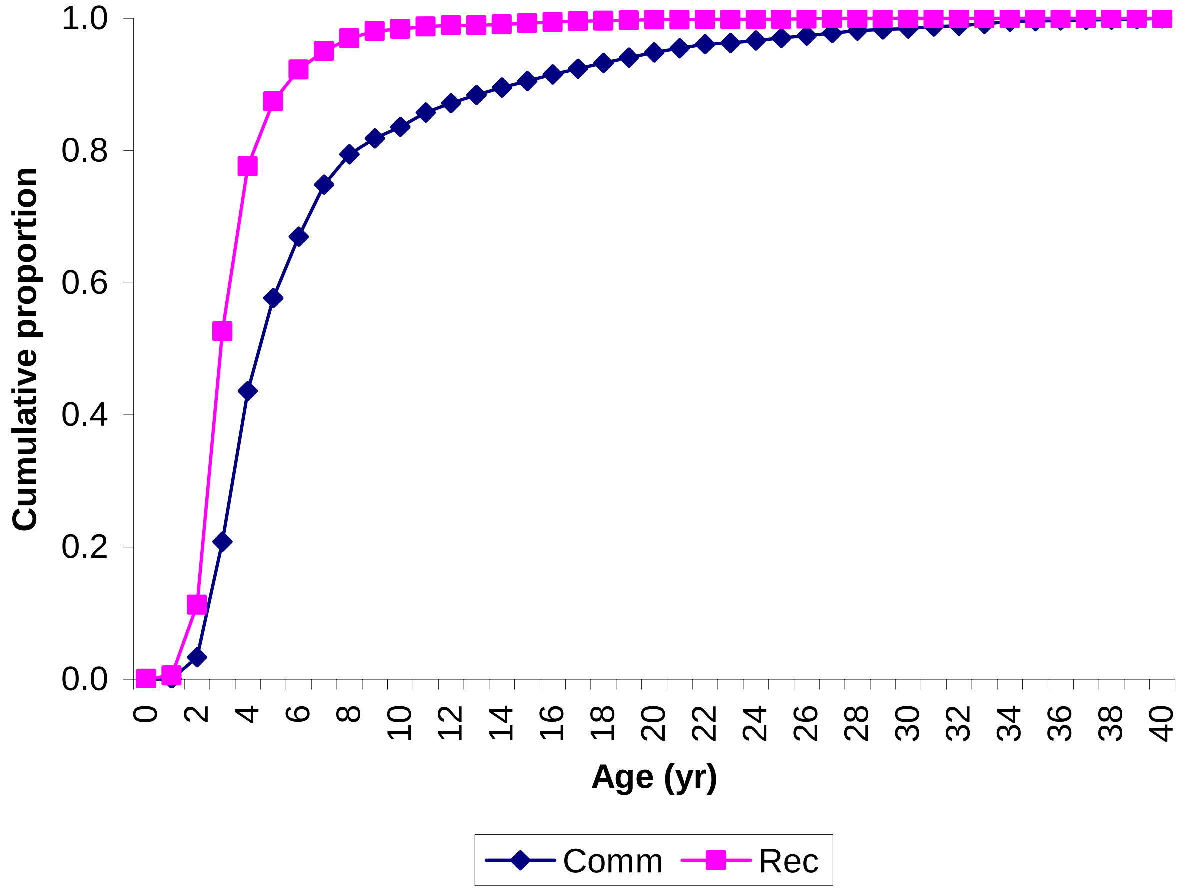

Figure 3. Age-specific natural mortality rates for *Lutjanus analis*.

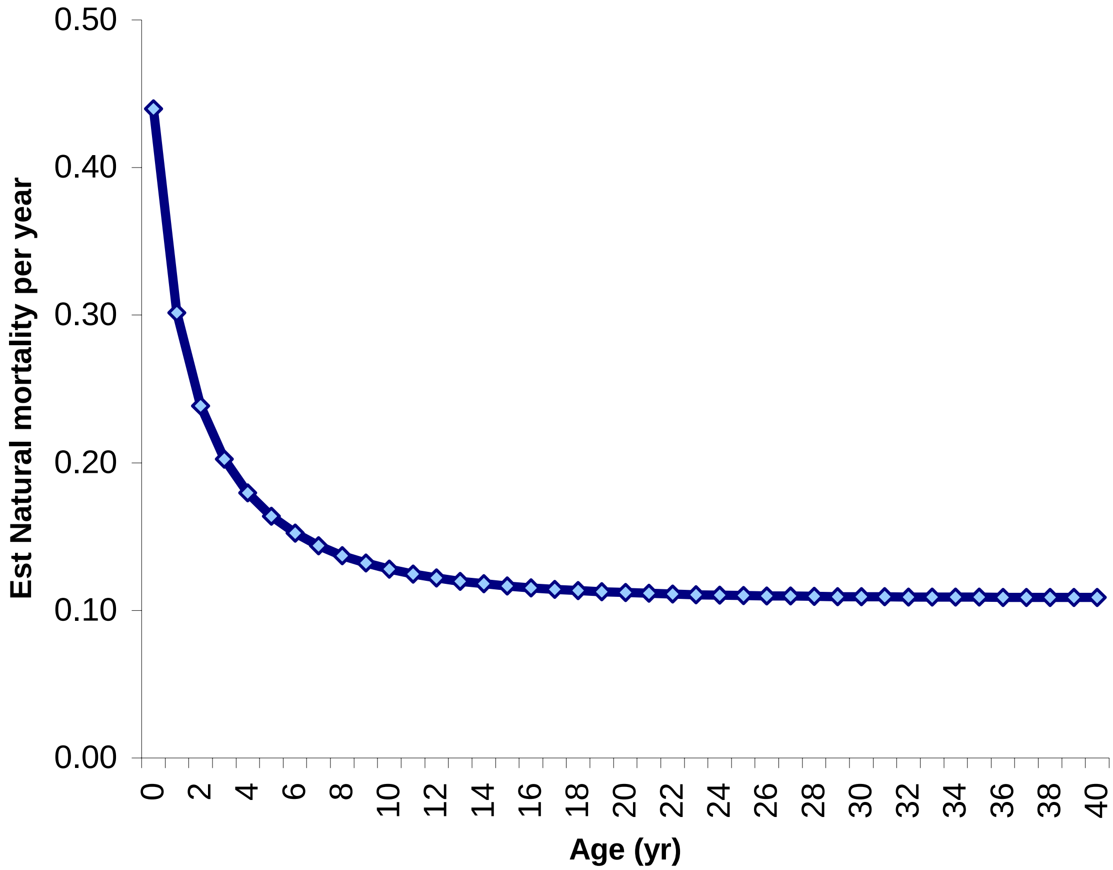

Figure 4. Satellite image and color enhancement of Florida bathymetry illustrating the preponderance of red and orange (depths less than 30 m) on the majority of the Florida shelf. Image courtesy of Google earth, while layer produced by USGS.

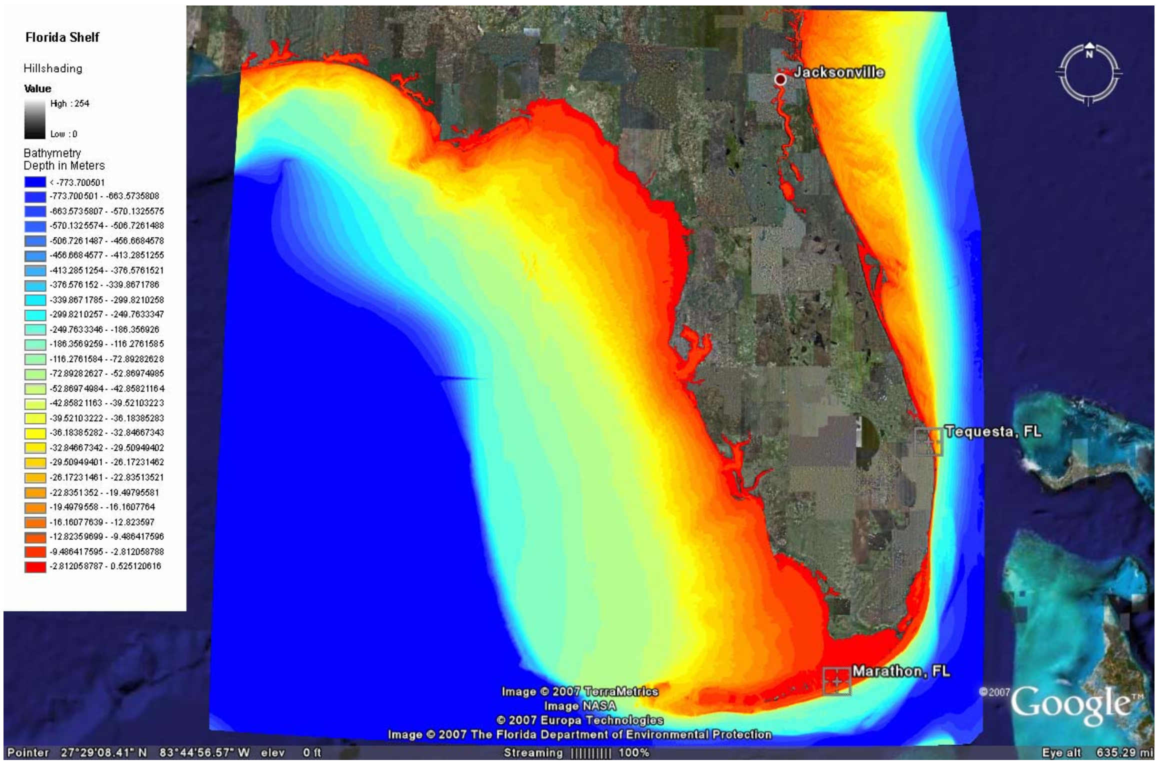

Figure 5. Discard mortality rates for two depth classes; <30m = depth class 1, and > 30 m = depth class 2.

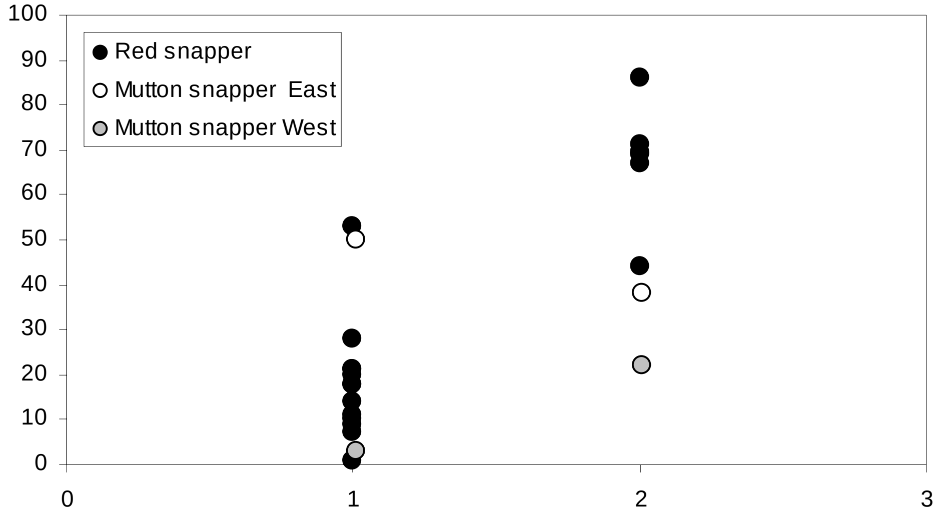

Figure 6. Discard mortality as a function of depth of capture (top figure) and associated residuals with fitted logistic curve (bottom).