Length-weight relationships, location and depth distributions for select Gulf of Mexico reef fish species

Jeffrey R Pulver and Andrew Whatley
2016

## SEDAR58-RD20

30 January 2018


# Length-Weight Relationships, Location, and Depth Distributions for Select Gulf of Mexico Reef Fish Species 

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U.S. DEPARTMENT OF COMMERCE

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August 2016

# LENGTH-WEIGHT RELATIONSHIPS, LOCATION, AND DEPTH DISTRIBUTIONS FOR SELECT GULF OF MEXICO REEF FISH SPECIES 

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August 2016

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This report should be cited as follows:
Pulver, J.R., and A. Whatley. 2016. Length-weight relationships, location, and depth distributions for select Gulf of Mexico reef fish species. NOAA Technical Memorandum NMFS-SEFSC-693, 100 p.

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## Introduction

The NMFS Galveston Reef Fish Observer Program began mandatory coverage of the Gulf of Mexico commercial reef fish fishery in July 2006. Since that time the program has recorded catch data from vessels using multiple gear types (vertical line, bottom longline, spearfishing, and buoy fishing) across broad spatial and temporal scales (Scott-Denton et al., 2011; ScottDenton and Williams, 2013). While at-sea, fishery observers record characteristics of individual captured fish such as length, weight, discard disposition, location, and other environmental factors (NMFS, 2016). Length and weight data obtained from at-sea fishery observer programs are often useful because they include information about species not landed, e.g. non-target species, or for size ranges of target species typically discarded at-sea. Length-weight regression models are used extensively to estimate weight from length because of the technical difficulties in obtaining accurate weights while in the field. The purpose of this document is to provide length-weight relationships, location, and depth distributions for target and non-target reef fish species using data collected by the Galveston Reef Fish Observer Program from July 2006 through December 2015.

## Methods

The reef fish database contained catch information for $1,062,857$ individual captures of fish by all gear types representing 336 different taxonomic categories. Only taxonomic categories at the species level, e.g. not genus or family level, which had $\geq 5$ paired length-weight observations were included in this study. Total, fork, or standard lengths were recorded to the nearest mm and weights were primarily obtained using $10-\mathrm{kg}$ model $235-6 \mathrm{~S}^{\text {Salter }}{ }^{1}$ scales (accuracy $\pm 0.05 \mathrm{~kg}$ ),

[^0]but throughout the history of the program various brands of digital scales (accuracy $\pm 0.01 \mathrm{~kg}$ ) have also been used to obtain weights. Length-weight regression models were fit to species using the most common pairing observed between length measurement type and weight type (whole or gutted), e.g. fork and whole. Log-transformed length and weight data were fit using ordinary least squares with the following equation where $\ln =$ natural $\log , W=$ weight $(\mathrm{kg})$, $L=$ length (mm), $a=\mathrm{y}$-intercept, and $b=$ slope:
\[

$$
\begin{equation*}
\ln W=\ln a+b \ln L \tag{1}
\end{equation*}
$$

\]

For each species, the predicted fit from the resulting linear regression equations were plotted with $95 \%$ confidence intervals against a scatterplot of the observed data. Model fit information given in the results includes the number of observations used to fit the model, the adjusted $R^{2}$ coefficient of determination, and residual standard error (RSE). To predict weight from length using the model, the following equation is given for each species as:

$$
\begin{equation*}
\text { Weight }=\exp (\operatorname{Ln} a) * \text { Length }^{b} \tag{2}
\end{equation*}
$$

Also included is the most common final disposition (kept, discarded alive, discarded dead, used for bait, or unknown) for each species recorded by the program. The number of all captures observed in each statistical zone (Figure 1) for each species category was tabulated and included as a bar chart. Finally, a histogram of capture depths was generated with an estimated kernel density probability estimate included for each species. All analyses in this study were performed using R statistical software (version 3.3.0; R Development Core Team, 2016)

## Results/Discussion

Significant ( $p$-value $<0.05$ ) length-weight regression models were fit using 641,251 captures for 90 unique species (Table 1). Three species, red grouper (Epinephelus morio), vermilion
snapper (Rhomboplites aurorubens), and red snapper (Lutjanus campechanus) represented the majority ( $>75 \%$ ) of the paired length-weight observations available. The average number of paired observations used to fit each model was 7,125 and ranged from a minimum of five observations for red hogfish (Decodon puellaris) to a maximum of 254,416 for red grouper. The most common (65\%) paired measurements used to fit a model were fork lengths to predict whole weight. Lengths used to fit the models ranged from a minimum of 83 mm standard length for bank seabass (Centropristis ocyurus) to a maximum of 1683 mm total length for silky sharks (Carcharhinus falciformis). The mutton snapper (Lutjanus analis) regression model had the lowest RSE $(<0.09)$ of any species in this study with only five models having a RSE $>0.4$.

The average adjusted $R^{2}$ was 0.79 ( 0.22 S.D.) and ranged from a low of 0.05 to the highest value of 0.99 for dolphin (Coryphaena hippurus). The majority (60) of the species length-weight regression models had an adjusted $R^{2}>0.8$. The seven species that had $>10,000$ paired observations all had excellent fits with an adjusted $R^{2}>0.85$. Only 11 length-weight regression models had an adjusted $R^{2}<0.5$ with the lowest value ( 0.05 ) observed for tattler (Serranus phoebe); however, only 89 tattler paired measurements were available over a small length (123206 mm ) and weight ( $0.03-0.25 \mathrm{~kg}$ ) range. Generally, species with smaller mean lengths accounted for the smaller adjusted $R^{2}$ observed (Figure 2). The smaller adjusted $R^{2}$ observed were possibly due to increased variance at lighter weights caused by the resolution of the Salter scales ( accuracy $\pm 0.05 \mathrm{~kg}$ ).

Despite the difficulties in obtaining accurate weights in the at-sea environment, the Galveston Reef Fish Observer Program has collected high quality length and weight data for a large number of commercially important fish species in the Gulf of Mexico. These length-weight and additional data should be useful to other researchers wishing to explore temporal or spatial
variations in the reef fish fishery to derive conclusions benefitting the long-term management of the fishery.

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Table 1. Regression model information for the 90 reef fish species including the number of observations $(\mathrm{N})$, minimum length in mm (Min) and maximum length in mm (Max), mean length in mm, length standard deviation (S.D.), y-intercept (Ln $a$ ), slope (b), standard error of the slope (SE $b$ ), residual standard error (RSE), adjusted $R^{2}, R^{2}$, and overall regression model significance ( $p$-value).

| Common Name | Scientific Name | N | $\begin{gathered} \text { Min } \\ (\mathbf{m m}) \end{gathered}$ | $\begin{gathered} \text { Max } \\ (\mathbf{m m}) \end{gathered}$ | $\begin{aligned} & \text { Mean } \\ & (\mathrm{mm}) \end{aligned}$ | S.D. | Ln ${ }^{\text {a }}$ | $b$ | SE b | RSE | $\begin{gathered} \text { Adjusted } \\ R^{2} \end{gathered}$ | $R^{2}$ | $p$-value |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Grouper, Black | Mycteroperca bonaci | 182 | 633 | 1,410 | 964.8 | 168.2 | -18.3 | 3.04 | 0.06 | 0.14 | 0.93 | 0.93 | $<0.01$ |
| Gag | Mycteroperca microlepis | 13,669 | 236 | 1,399 | 675.5 | 144.2 | -17.9 | 2.96 | 0.01 | 0.13 | 0.96 | 0.96 | $<0.01$ |
| Grouper, Yellowfin | Mycteroperca venenosa | 6 | 425 | 858 | 646.3 | 173.4 | -18.1 | 3.01 | 0.21 | $0.13$ | $0.98$ | $0.98$ | $<0.01$ |
| Grouper, Yellowmouth | Mycteroperca interstitialis | 21 | 398 | 668 | 567.8 | 76.9 | -16.5 | 2.74 | 0.26 | 0.17 | 0.85 | 0.86 | $<0.01$ |
| Scamp | Mycteroperca phenax | 6,385 | 221 | 951 | 554.9 | 103.9 | -17.1 | 2.80 | 0.01 | 0.18 | 0.90 | 0.90 | $<0.01$ |
| Grouper, Red | Epinephelus morio | 254,416 | 199 | 924 | 475.2 | 95.5 | -18.8 | 3.13 | 0.00 | 0.13 | 0.96 | 0.96 | $<0.01$ |
| Grouper, Snowy | Epinephelus niveatus | 3,600 | 284 | 1,233 | 637.5 | 124.2 | -18.2 | 3.01 | 0.01 | 0.13 | 0.95 | $0.95$ | $<0.01$ |
| Grouper, Yellowedge | Epinephelus flavolimbatus | 18,986 | 284 | 1,153 | 652.7 | 115.9 | -18.1 | 2.99 | 0.00 | 0.12 | 0.95 | 0.95 | $<0.01$ |
| Grouper, Marbled | Epinephelus inermis | 16 | 519 | 877 | 677.6 | 111.6 | -19.7 | 3.27 | 0.24 | 0.15 | 0.92 | 0.93 | $<0.01$ |
| Hind, Speckled | Epinephelus drummondhayi | 1,077 | 241 | 1,092 | 528.9 | 148.0 | -18.5 | 3.11 | 0.02 | 0.16 | 0.97 | 0.97 | $<0.01$ |
| Graysby | Cephalopholis cruentata | 53 | 178 | 518 | 273.4 | 52.7 | -13.4 | 2.21 | 0.24 | 0.31 | 0.62 | 0.62 | $<0.01$ |
| Hind, Red | Epinephelus guttatus | 17 | 231 | 546 | 384.6 | 83.0 | -16.7 | 2.78 | 0.29 | 0.26 | 0.85 | 0.86 | $<0.01$ |
| Hind, Rock | Epinephelus adscensionis | 88 | 229 | 426 | 355.3 | 42.4 | -19.1 | 3.20 | 0.16 | 0.19 | 0.82 | 0.82 | $<0.01$ |
| Perch, Sand | Diplectrum formosum | 364 | 126 | 320 | 212.3 | 28.4 | -10.1 | 1.56 | 0.13 | 0.34 | 0.27 | 0.27 | $<0.01$ |
| Seabass, Black | Centropristis striata | 642 | 134 | 457 | 266.2 | 51.1 | -14.4 | 2.42 | 0.07 | 0.34 | 0.66 | 0.66 | $<0.01$ |
| Seabass, Rock | Centropristis philadelphica | 247 | 106 | 318 | 201.1 | 38.2 | -15.2 | 2.53 | 0.18 | 0.56 | 0.44 | 0.44 | $<0.01$ |
| Seabass, Bank | Centropristis ocyurus | 175 | 83 | 470 | 205.7 | 46.8 | -9.2 | 1.45 | 0.11 | 0.32 | 0.48 | 0.48 | $<0.01$ |
| Tattler | Serranus phoebe | 89 | 123 | 206 | 174.6 | 14.1 | -10.0 | 1.47 | 0.60 | 0.47 | 0.05 | 0.06 | 0.02 |
| Bass, Longtail | Hemanthias leptus | 84 | 248 | 555 | 411.0 | 65.3 | -15.5 | 2.55 | 0.10 | 0.16 | 0.88 | 0.88 | $<0.01$ |
| Flag, Spanish | Gonioplectrus hispanus | 18 | 216 | 278 | 246.1 | 21.4 | -13.0 | 2.14 | 0.66 | 0.24 | 0.36 | 0.40 | $<0.01$ |
| Creole-Fish | Paranthias furcifer | 639 | 215 | 403 | 296.2 | 35.3 | -11.9 | 1.93 | 0.09 | 0.27 | 0.41 | 0.41 | $<0.01$ |
| Snapper, Red | Lutjanus campechanus | 110,897 | 172 | 990 | 460.4 | 112.4 | -17.7 | 2.96 | 0.00 | 0.14 | 0.96 | 0.96 | $<0.01$ |

## (Table 1, continued)

| Common Name | Scientific Name | N | $\begin{gathered} \operatorname{Min} \\ (\mathrm{mm}) \end{gathered}$ | $\begin{gathered} \text { Max } \\ \text { (mm) } \end{gathered}$ | $\begin{aligned} & \text { Mean } \\ & (\mathrm{mm}) \end{aligned}$ | S.D. | Ln a | $b$ | SE b | RSE | $\begin{gathered} \text { Adjusted } \\ R^{2} \end{gathered}$ | $R^{2}$ | $p$-value |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Snapper, Lane | Lutjanus synagris | 2,330 | 162 | 513 | 322.0 | 47.7 | -16.8 | 2.80 | 0.03 | 0.25 | 0.74 | 0.74 | $<0.01$ |
| Snapper, Mutton | Lutjanus analis | 2,502 | 378 | 864 | 598.0 | 88.7 | -17.7 | 2.96 | 0.01 | 0.09 | 0.96 | 0.96 | $<0.01$ |
| Snapper, Gray | Lutjanus griseus | 4,001 | 219 | 714 | 426.2 | 76.1 | -17.5 | 2.92 | 0.01 | 0.16 | 0.92 | 0.92 | $<0.01$ |
| Snapper, Cubera | Lutjanus cyanopterus | 7 | 597 | 1,037 | 805.3 | 160.0 | -16.5 | 2.78 | 0.17 | 0.09 | 0.98 | 0.98 | $<0.01$ |
| Snapper, Silk | Lutjanus vivanus | 785 | 220 | 810 | 440.4 | 72.3 | -18.6 | 3.11 | 0.02 | 0.11 | 0.95 | 0.95 | $<0.01$ |
| Snapper, Vermilion | Rhomboplites aurorubens | 117,080 | 106 | 624 | 291.0 | 51.0 | -17.8 | 2.98 | 0.00 | 0.21 | 0.85 | 0.85 | $<0.01$ |
| Wenchman | Pristipomoides aquilonaris | 146 | 155 | 365 | 218.1 | 24.5 | -15.2 | 2.51 | 0.30 | 0.39 | 0.32 | 0.33 | $<0.01$ |
| Snapper, Queen | Etelis Oculatus | 328 | 200 | 912 | 549.9 | 119.2 | -16.1 | 2.69 | 0.04 | 0.17 | 0.94 | 0.93 | $<0.01$ |
| Snapper, Yellowtail | Ocyurus chrysurus | 7,740 | 168 | 512 | 300.0 | 42.7 | -17.6 | 2.95 | 0.01 | 0.18 | 0.84 | 0.84 | $<0.01$ |
| Tilefish | Lopholatilus chamaeleonticeps | 11,304 | 316 | 1,023 | 631.8 | 123.0 | -20.2 | 3.29 | 0.01 | 0.15 | 0.95 | 0.94 | $<0.01$ |
| Tilefish, Blueline | Caulolatilus microps | 6,558 | 319 | 810 | 553.6 | 63.2 | -18.8 | 3.09 | 0.01 | 0.10 | 0.92 | 0.92 | $<0.01$ |
| Tilefish, Goldface | Caulolatilus chrysops | 70 | 243 | 602 | 448.8 | 75.6 | -19.8 | 3.27 | 0.15 | 0.23 | 0.87 | 0.88 | $<0.01$ |
| Tilefish, Sand | Malacanthus plumieri | 144 | 313 | 632 | 504.4 | 61.2 | -19.6 | 3.15 | 0.10 | 0.16 | 0.87 | 0.87 | $<0.01$ |
| Grunt, White | Haemulon plumieri | 2,463 | 162 | 743 | 283.6 | 41.9 | -18.3 | 3.09 | 0.03 | 0.22 | 0.78 | 0.78 | $<0.01$ |
| Tomtate | Haemulon aurolineatum | 1,306 | 121 | 427 | 205.2 | 25.0 | -17.2 | 2.86 | 0.10 | 0.43 | 0.38 | 0.38 | $<0.01$ |
| Porgy, Red | Pagrus pagrus | 35,784 | 114 | 651 | 287.3 | 47.7 | -17.0 | 2.88 | 0.01 | 0.19 | 0.86 | 0.86 | $<0.01$ |
| Porgy, Knobbed | Calamus nodosus | 1,135 | 205 | 548 | 307.6 | 35.4 | -16.4 | 2.79 | 0.04 | 0.15 | 0.81 | 0.81 | $<0.01$ |
| Porgy, Saucereye | Calamus calamus | 414 | 189 | 549 | 300.0 | 36.6 | -16.2 | 2.75 | 0.06 | 0.14 | 0.86 | 0.86 | $<0.01$ |
| Porgy, Jolthead | Calamus bajonado | 1,097 | 192 | 700 | 422.9 | 111.2 | -17.2 | 2.93 | 0.02 | 0.15 | 0.97 | 0.97 | $<0.01$ |
| Porgy, Littlehead | Calamus proridens | 490 | 191 | 410 | 290.6 | 38.9 | -17.2 | 2.92 | 0.07 | 0.22 | 0.76 | 0.76 | $<0.01$ |
| Sheepshead | Archosargus probatocephalus | 238 | 277 | 562 | 399.8 | 57.4 | -19.7 | 3.36 | 0.08 | 0.17 | 0.89 | 0.89 | $<0.01$ |
| Porgy, Whitebone | Calamus leucosteus | 123 | 200 | 578 | 311.0 | 58.2 | -17.6 | 2.97 | 0.16 | 0.31 | 0.73 | 0.74 | $<0.01$ |
| Rudderfish, Banded | Seriola zonata | 1,657 | 241 | 752 | 427.4 | 70.8 | -16.3 | 2.72 | 0.02 | 0.15 | 0.91 | 0.91 | $<0.01$ |
| Amberjack, Lesser | Seriola fasciata | 286 | 186 | 950 | 409.9 | 105.6 | -15.7 | 2.63 | 0.04 | 0.17 | 0.93 | 0.93 | $<0.01$ |
| Amberjack, Greater | Seriola dumerili | 2,323 | 222 | 1,600 | 787.4 | 287.4 | -16.0 | 2.69 | 0.01 | 0.16 | 0.98 | 0.98 | $<0.01$ |

## (Table 1, continued)

| Common Name | Scientific Name | N | $\begin{gathered} \operatorname{Min} \\ (\mathrm{mm}) \end{gathered}$ | $\begin{gathered} \text { Max } \\ \text { (mm) } \end{gathered}$ | Mean (mm) | S.D. | Ln a | $b$ | SE b | RSE | $\begin{gathered} \text { Adjusted } \\ R^{2} \end{gathered}$ | $R^{2}$ | $p$-value |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Jack, Almaco | Seriola rivoliana | 2,058 | 165 | 1,302 | 516.9 | 170.5 | -16.2 | 2.73 | 0.01 | 0.16 | 0.97 | 0.97 | $<0.01$ |
| Runner, Blue | Caranx crysos | 1,165 | 157 | 532 | 329.6 | 53.0 | -17.3 | 2.90 | 0.03 | 0.19 | 0.87 | 0.87 | $<0.01$ |
| Jack, Common Crevalle | Caranx hippos | 81 | 242 | 957 | 594.7 | 226.0 | -15.2 | 2.59 | 0.04 | 0.15 | 0.98 | 0.98 | $<0.01$ |
| Rainbow Runner | Elagatis bipinnulata | 26 | 272 | 663 | 465.2 | 108.6 | -16.2 | 2.69 | 0.16 | 0.20 | 0.91 | 0.92 | $<0.01$ |
| Pompano, Florida | Trachinotus carolinus | 111 | 300 | 426 | 357.8 | 30.4 | -20.3 | 3.45 | 0.15 | 0.13 | 0.84 | 0.84 | $<0.01$ |
| Barrelfish | Hyperoglyphe perciferomis | 256 | 277 | 815 | 630.0 | 99.1 | -17.0 | 2.87 | 0.03 | 0.09 | 0.97 | 0.97 | $<0.01$ |
| Dolphin | Coryphaena hippurus | 329 | 292 | 1,227 | 573.5 | 289.2 | -17.0 | 2.74 | 0.02 | 0.13 | 0.99 | 0.99 | $<0.01$ |
| Bluefish | Pomatomus saltatrix | 224 | 266 | 803 | 418.6 | 64.4 | -18.1 | 2.99 | 0.06 | 0.13 | 0.92 | 0.92 | $<0.01$ |
| Cobia, Ling | Rachycentron canadum | 165 | 400 | 1,330 | 824.1 | 173.3 | -20.1 | 3.26 | 0.06 | 0.15 | 0.96 | 0.96 | $<0.01$ |
| Tuna, Blackfin | Thunnus atlanticus | 255 | 499 | 890 | 724.5 | 71.9 | -16.6 | 2.83 | 0.06 | $0.09$ | 0.91 | $0.91$ | $<0.01$ |
| Bonito | Euthynnus alletteratus | 821 | 277 | 837 | 643.3 | 91.2 | -17.0 | 2.84 | 0.03 | 0.12 | 0.94 | 0.94 | $<0.01$ |
| Mackerel, Spanish | Scomberomorus maculatus | 62 | 337 | 678 | 512.3 | 80.0 | -18.9 | 3.04 | 0.13 | 0.16 | 0.90 | 0.91 | $<0.01$ |
| Mackerel, King | Scomberomorus cavalla | 2,585 | 476 | 1,309 | 813.8 | 114.0 | -18.6 | 2.98 | 0.02 | 0.11 | 0.93 | 0.93 | $<0.01$ |
| Mackerel, Cero | Scomberomorus regalis | 24 | 337 | 710 | 463.1 | 85.9 | -20.1 | 3.25 | 0.31 | 0.26 | 0.83 | 0.83 | $<0.01$ |
| Wahoo | Acanthocybium solandri | 24 | 925 | 1,591 | 1278.4 | 188.2 | -21.2 | 3.32 | 0.33 | 0.24 | 0.82 | 0.83 | $<0.01$ |
| Barracuda, Great | Sphyraena barracuda | 350 | 346 | 1,478 | 907.2 | 164.9 | -18.4 | 2.94 | 0.05 | 0.20 | 0.90 | 0.90 | $<0.01$ |
| Triggerfish, Gray | Balistes capriscus | 3,211 | 178 | 694 | 379.0 | 64.3 | -16.8 | 2.85 | 0.02 | 0.17 | 0.88 | 0.88 | $<0.01$ |
| Sharksucker | Echeneis naucrates | 896 | 257 | 984 | 704.6 | 95.2 | -16.3 | 2.53 | 0.04 | 0.21 | 0.80 | 0.80 | $<0.01$ |
| Drum, Red | Sciaenops ocellatus | 100 | 538 | 1,143 | 795.6 | 133.2 | -19.2 | 3.14 | 0.09 | 0.15 | 0.93 | 0.93 | $<0.01$ |
| Bigeye | Priacanthus arenatus | 90 | 191 | 572 | 336.2 | 60.0 | -16.2 | 2.68 | 0.12 | 0.19 | 0.85 | 0.86 | $<0.01$ |
| Bigeye, Short | Pristigenys alta | 124 | 181 | 326 | 259.7 | 24.4 | -16.2 | 2.75 | 0.22 | 0.25 | 0.55 | 0.55 | $<0.01$ |
| Squirrelfish | Holocentrus adscensionis | 237 | 178 | 386 | 281.4 | 28.5 | -11.3 | 1.86 | 0.18 | 0.30 | 0.30 | 0.30 | $<0.01$ |
| Scorpionfish, Spinycheek | Neomerinthe hemingwayi | 346 | 216 | 602 | 426.8 | 47.6 | -18.0 | 2.97 | 0.10 | 0.21 | 0.74 | 0.74 | $<0.01$ |
| Rosefish, Blackbelly | Helicolenus dactylopterus | 34 | 261 | 492 | 374.9 | 57.8 | -14.8 | 2.46 | 0.20 | 0.18 | 0.82 | 0.82 | $<0.01$ |
| Lionfish, Red | Pterois volitans | 71 | 169 | 407 | 295.0 | 59.3 | -16.5 | 2.71 | 0.16 | 0.29 | 0.81 | 0.81 | $<0.01$ |

## (Table 1, continued)

| Common Name | Scientific Name | N | $\underset{(\mathrm{mm})}{(\mathrm{Min}}$ | $\begin{aligned} & \text { Max } \\ & (\mathrm{mm}) \end{aligned}$ | $\begin{aligned} & \text { Mean } \\ & (\mathrm{mm}) \end{aligned}$ | S.D. | Ln a | $b$ | SE $b$ | RSE | $\begin{gathered} \text { Adjusted } \\ R^{2} \end{gathered}$ | $R^{2}$ | $p$-value |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Hogfish | Lachnolaimus maximus | 723 | 234 | 733 | 392.0 | 65.6 | -14.5 | 2.44 | 0.05 | 0.20 | 0.78 | 0.78 | $<0.01$ |
| Hogfish, Red | Decodon puellaris | 5 | 219 | 406 | 277.2 | 73.9 | -18.3 | 3.06 | 0.36 | 0.17 | 0.95 | 0.96 | $<0.01$ |
| Toadfish, Leopard | Opsanus pardus | 564 | 193 | 583 | 340.6 | 51.3 | -14.5 | 2.45 | 0.09 | 0.32 | 0.57 | 0.57 | $<0.01$ |
| Lizardfish, Inshore | Synodus foetens | 256 | 235 | 475 | 348.5 | 42.5 | -17.1 | 2.72 | 0.15 | 0.30 | 0.55 | 0.55 | $<0.01$ |
| Snakefish | Trachinocephalus myops | 230 | 184 | 403 | 249.0 | 41.2 | -8.5 | 1.21 | 0.20 | 0.47 | 0.14 | 0.14 | $<0.01$ |
| Sand Diver | Synodus intermedius | 650 | 210 | 471 | 328.2 | 50.6 | -15.7 | 2.51 | 0.09 | 0.34 | 0.57 | 0.57 | $<0.01$ |
| Shark, Bonnethead | Sphyrna tiburo | 12 | 621 | 1,010 | 850.0 | 100.7 | -12.9 | 2.06 | 0.47 | 0.20 | 0.62 | 0.66 | $<0.01$ |
| Shark, Bigeye Sixgill | Hexanchus vitulus | 134 | 474 | 1,251 | 796.4 | 156.8 | -15.8 | 2.48 | 0.13 | 0.31 | 0.73 | 0.73 | $<0.01$ |
| Shark, Sevengill | Heptranchias perlo | 62 | 701 | 1,074 | 887.6 | 98.5 | -18.8 | 2.89 | 0.21 | 0.18 | 0.76 | 0.76 | $<0.01$ |
| Dogfish, Chain | Scyliorhinus retifer | 46 | 345 | 557 | 476.0 | 53.1 | -9.4 | 1.45 | 0.56 | 0.44 | 0.11 | 0.13 | 0.01 |
| Dogfish, Roughskin | Cirrhigaleus asper | 20 | 421 | 1,113 | 834.7 | 185.6 | -19.1 | 3.02 | 0.15 | 0.17 | 0.96 | 0.96 | $<0.01$ |
| Dogfish, Cuban | Squalus cubensis | 2,981 | 269 | 1,136 | 538.3 | 82.7 | -17.6 | 2.77 | 0.03 | 0.23 | 0.74 | 0.74 | $<0.01$ |
| Dogfish, Shortspine | Squalus mitsukurii | 106 | 433 | 814 | 707.1 | 57.5 | -18.9 | 2.98 | 0.11 | 0.10 | 0.89 | 0.89 | $<0.01$ |
| Shark, Smooth Dogfish | Mustelus canis | 1,929 | 460 | 1,460 | 1023.2 | 183.4 | -21.6 | 3.33 | 0.02 | 0.21 | 0.90 | 0.90 | $<0.01$ |
| Shark, Atlantic Sharpnose | Rhizoprionodon terraenovae | 6,540 | 269 | 1,300 | 814.5 | 99.9 | -18.7 | 2.91 | 0.02 | 0.19 | 0.79 | 0.79 | $<0.01$ |
| Shark, Blacknose | Carcharhinus acronotus | 1,045 | 552 | 1,294 | 864.9 | 149.2 | -19.0 | 3.00 | 0.03 | 0.19 | 0.88 | 0.88 | $<0.01$ |
| Shark, Finetooth | Carcharhinus isodon | 10 | 661 | 1,167 | 902.5 | 155.2 | -14.5 | 2.33 | 0.64 | 0.34 | 0.57 | 0.62 | 0.01 |
| Shark, Silky | Carcharhinus falciformis | 311 | 652 | 1,683 | 934.2 | 147.3 | -19.0 | 2.98 | 0.07 | 0.18 | 0.86 | 0.86 | $<0.01$ |

NMFS Statistical Zones of the Southeast Region


Figure 1. NMFS statistical zones used by the observer program for the Gulf of Mexico and South Atlantic.


Figure 2. Mean lengths ( $\pm$ S.D.) for 90 reef fish species compared to its corresponding adjusted $R^{2}$ given by the length-weight regression model.

## Grouper, Black



More common in the Eastern Gulf


Figure 3 . Regression model, location, and depth information for grouper, black ( Mycteroperca bonaci ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=19,696$


Depth (Feet)

Figure 4 . Regression model, location, and depth information for gag ( Mycteroperca microlepis).

# Grouper, Yellowfin 



More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=9$
Depth (Feet)

Figure 5 . Regression model, location, and depth information for grouper, yellowfin ( Mycteroperca venenosa).

# Grouper, Yellowmouth 



More common in the Eastern Gulf


Figure 6 . Regression model, location, and depth information for grouper, yellowmouth ( Mycteroperca interstitialis ).


More common in the Eastern Gulf


Figure 7 . Regression model, location, and depth information for scamp ( Mycteroperca phenax ).

## Grouper, Red



More common in the Eastern Gulf


Figure 8 . Regression model, location, and depth information for grouper, red ( Epinephelus morio ).


More common in the Eastern Gulf


Statistical Zones, $N=5,510$


Depth (Feet)

Figure 9 . Regression model, location, and depth information for grouper, snowy (Epinephelus niveatus).

Grouper, Yellowedge


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=30,451$


Depth (Feet)

Figure 10 . Regression model, location, and depth information for grouper, yellowedge ( Epinephelus flavolimbatus ).


More common in the Western Gulf


Figure 11 . Regression model, location, and depth information for grouper, marbled (Epinephelus inermis ).


More common in the Eastern Gulf


Figure 12 . Regression model, location, and depth information for hind, speckled (Epinephelus drummondhayi).

Graysby


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=111$
Figure 13 . Regression model, location, and depth information for graysby ( Cephalopholis cruentata).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=22$

Figure 14 . Regression model, location, and depth information for hind, red (strawberry grouper) (Epinephelus guttatus ).

Hind, Rock


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=121$


Depth (Feet)

Figure 15 . Regression model, location, and depth information for hind, rock ( Epinephelus adscensionis ).


More common in the Eastern Gulf


Figure 16 . Regression model, location, and depth information for perch, sand (Diplectrum formosum ).


More common in the Eastern Gulf


Figure 17 . Regression model, location, and depth information for seabass, black ( Centropristis striata ).


More common in the Eastern Gulf



Figure 18 . Regression model, location, and depth information for seabass, rock ( Centropristis philadelphica ).


More common in the Eastern Gulf


Figure 19 . Regression model, location, and depth information for seabass, bank ( Centropristis ocyurus ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=147$


Depth (Feet)

Figure 20 . Regression model, location, and depth information for tattler (Serranus phoebe ).

# Bass, Longtail 



More common in the Western Gulf


Figure 21 . Regression model, location, and depth information for bass, longtail (Hemanthias leptus ).


More common in the Eastern Gulf


Figure 22 . Regression model, location, and depth information for flag, spanish ( Gonioplectrus hispanus ).

## Creole-Fish



More common in the Western Gulf


Figure 23 . Regression model, location, and depth information for creole-fish ( Paranthias furcifer ).

## Snapper, Red



$$
\mathrm{W}=\exp (-17.7) \mathrm{L}^{2.96}
$$

Fork Length (mm)
Mean Length $=460 \mathrm{~mm}$
Mean Weight $=1.96 \mathrm{~kg}$
More common in the Western Gulf


Statistical Zones, $N=163,606$


Depth (Feet)

Figure 24 . Regression model, location, and depth information for snapper, red (Lutjanus campechanus ).


More common in the Eastern Gulf

$\begin{array}{llllllllllllllllllll}1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 13 & 14 & 15 & 16 & 17 & 18 & 19 & 20 & 21\end{array}$

Statistical Zones, $N=3,465$


Depth (Feet)

Figure 25 . Regression model, location, and depth information for snapper, lane (Lutjanus synagris ).


More common in the Eastern Gulf


Figure 26 . Regression model, location, and depth information for snapper, mutton (Lutjanus analis ).


More common in the Eastern Gulf


Statistical Zones, $N=5,642$


Depth (Feet)

Figure 27 . Regression model, location, and depth information for snapper, gray (Lutjanus griseus ).

## Snapper, Cubera



More common in the Eastern Gulf


Figure 28 . Regression model, location, and depth information for snapper, cubera ( Lutjanus cyanopterus ).


More common in the Eastern Gulf


Statistical Zones, N = 950


Depth (Feet)

Figure 29 . Regression model, location, and depth information for snapper, silk (Lutjanus vivanus ).

Snapper, Vermilion


More common in the Eastern Gulf


Figure 30 . Regression model, location, and depth information for snapper, vermilion ( Rhomboplites aurorubens ).

## Wenchman



More common in the Western Gulf


Statistical Zones, $\mathrm{N}=191$


Depth (Feet)

Figure 31 . Regression model, location, and depth information for wenchman ( Pristipomoides aquilonaris ).


More common in the Western Gulf


Figure 32 . Regression model, location, and depth information for snapper, queen ( Etelis Oculatus ).


More common in the Eastern Gulf


Figure 33 . Regression model, location, and depth information for snapper, yellowtail ( Ocyurus chrysurus ).

Tilefish


More common in the Eastern Gulf


Figure 34 . Regression model, location, and depth information for tilefish (Lopholatilus chamaeleonticeps ).

# Tilefish, Blueline 



More common in the Eastern Gulf


Figure 35 . Regression model, location, and depth information for tilefish, blueline ( Caulolatilus microps ).

# Tilefish, Goldface 



More common in the Western Gulf


Statistical Zones, $N=97$


Depth (Feet)

Figure 36 . Regression model, location, and depth information for tilefish, goldface ( Caulolatilus chrysops ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=211$
Depth (Feet)

Figure 37 . Regression model, location, and depth information for tilefish, sand ( Malacanthus plumieri).

# Grunt, White 



More common in the Eastern Gulf


Figure 38 . Regression model, location, and depth information for grunt, white ( Haemulon plumieri ).

## Tomtate



More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=3,539$


Depth (Feet)

Figure 39 . Regression model, location, and depth information for tomtate ( Haemulon aurolineatum ).


More common in the Eastern Gulf

$\begin{array}{llllllllllllllllll}1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 13 & 14 & 15 & 16 & 17 & 18 & 20\end{array}$

Statistical Zones, $N=44,644$


Depth (Feet)

Figure 40 . Regression model, location, and depth information for porgy, red ( Pagrus pagrus ).


More common in the Eastern Gulf


Figure 41 . Regression model, location, and depth information for porgy, knobbed ( Calamus nodosus ).


More common in the Eastern Gulf


Figure 42 . Regression model, location, and depth information for porgy, saucereye ( Calamus calamus ).

## Porgy, Jolthead



More common in the Eastern Gulf


Figure 43 . Regression model, location, and depth information for porgy, jolthead ( Calamus bajonado ).


More common in the Eastern Gulf


Figure 44 . Regression model, location, and depth information for porgy, littlehead ( Calamus proridens ).

Sheepshead


More common in the Western Gulf


Statistical Zones, $\mathrm{N}=270$
Depth (Feet)
Figure 45 . Regression model, location, and depth information for sheepshead (Archosargus probatocephalus ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=170$


Depth (Feet)

Figure 46 . Regression model, location, and depth information for porgy, whitebone ( Calamus leucosteus ).


More common in the Eastern Gulf

$\begin{array}{lllllllllllllll}1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 15 & 16 & 17 & 18\end{array}$
Statistical Zones, $\mathrm{N}=2,603$


Depth (Feet)

Figure 47 . Regression model, location, and depth information for rudderfish, banded ( Seriola zonata ).


More common in the Eastern Gulf



Statistical Zones, $\mathrm{N}=395$
Depth (Feet)
Figure 48 . Regression model, location, and depth information for amberjack, lesser (Seriola fasciata ).

$$
R^{2}=0.981
$$



More common in the Eastern Gulf


234567891011131415161718192021
Statistical Zones, $\mathrm{N}=5,366$


Depth (Feet)

Figure 49 . Regression model, location, and depth information for amberjack, greater (Seriola dumerili ).


More common in the Eastern Gulf


Statistical Zones, N = 2,962


Depth (Feet)

Figure 50 . Regression model, location, and depth information for jack, almaco ( Seriola rivoliana).


More common in the Western Gulf


Figure 51 . Regression model, location, and depth information for runner, blue ( Caranx crysos ).


More common in the Western Gulf


Statistical Zones, $\mathrm{N}=208$


Depth (Feet)

Figure 52 . Regression model, location, and depth information for jack, common crevalle ( Caranx hippos ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=50$
Depth (Feet)
Figure 53 . Regression model, location, and depth information for rainbow runner ( Elagatis bipinnulata ).


More common in the Western Gulf


Figure 54 . Regression model, location, and depth information for pompano, florida ( Trachinotus carolinus ).


More common in the Western Gulf


Figure 55 . Regression model, location, and depth information for barrelfish ( Hyperoglyphe perciferomis ).

## Dolphin



More common in the Eastern Gulf


Figure 56 . Regression model, location, and depth information for dolphin ( Coryphaena hippurus ).


More common in the Western Gulf

$\begin{array}{llllllllllllll}4 & 6 & 7 & 8 & 9 & 10 & 11 & 13 & 14 & 15 & 16 & 17 & 18 & 20\end{array}$


Statistical Zones, $\mathrm{N}=310$
Depth (Feet)

Figure 57 . Regression model, location, and depth information for bluefish ( Pomatomus saltatrix ).

Cobia, Ling


More common in the Eastern Gulf


Figure 58 . Regression model, location, and depth information for cobia, ling (Rachycentron canadum ).

Tuna, Blackfin


$$
\mathrm{W}=\exp (-16.6) \mathrm{L}^{2.83}
$$

Fork Length (mm)
Mean Length $=724 \mathrm{~mm}$
Mean Weight $=7.81 \mathrm{~kg}$
More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=453$


Figure 59 . Regression model, location, and depth information for tuna, blackfin (Thunnus atlanticus ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=1,271$


Depth (Feet)

Figure 60 . Regression model, location, and depth information for bonito (Euthynnus alletteratus ).


More common in the Western Gulf


Figure 61 . Regression model, location, and depth information for mackerel, spanish (Scomberomorus maculatus ).


More common in the Eastern Gulf


Statistical Zones, $N=4,507$
Depth (Feet)
Figure 62 . Regression model, location, and depth information for mackerel, king ( Scomberomorus cavalla ).


More common in the Eastern Gulf


Depth (Feet)

Figure 63 . Regression model, location, and depth information for mackerel, cero (Scomberomorus regalis ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=60$


Depth (Feet)

Figure 64 . Regression model, location, and depth information for wahoo ( Acanthocybium solandri ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=745$


Depth (Feet)

Figure 65 . Regression model, location, and depth information for barracuda, great (Sphyraena barracuda ).


More common in the Eastern Gulf


Statistical Zones, $N=5,159$


Depth (Feet)

Figure 66 . Regression model, location, and depth information for triggerfish, gray (Balistes capriscus ).

## Sharksucker



More common in the Eastern Gulf


$$
\begin{array}{llllllllllllllllll}
1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 13 & 15 & 16 & 17 & 18 & 19 & 20
\end{array}
$$

Statistical Zones, $N=2,157$


Depth (Feet)

Figure 67 . Regression model, location, and depth information for sharksucker (Echeneis naucrates ).


More common in the Western Gulf


Statistical Zones, $\mathrm{N}=285$


Depth (Feet)

Figure 68 . Regression model, location, and depth information for drum, red (Sciaenops ocellatus ).

# Bigeye 



More common in the Western Gulf


Statistical Zones, $\mathrm{N}=124$


Depth (Feet)

Figure 69 . Regression model, location, and depth information for bigeye ( Priacanthus arenatus ).


More common in the Eastern Gulf



Statistical Zones, $\mathrm{N}=157$
Depth (Feet)

Figure 70 . Regression model, location, and depth information for bigeye, short ( Pristigenys alta ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=393$


Depth (Feet)

Figure 71 . Regression model, location, and depth information for squirrelfish (Holocentrus adscensionis ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=888$


Depth (Feet)

Figure 72 . Regression model, location, and depth information for scorpionfish, spinycheek ( Neomerinthe hemingwayi ).

Rosefish, Blackbelly


More common in the Eastern Gulf


Figure 73 . Regression model, location, and depth information for rosefish, blackbelly ( Helicolenus dactylopterus ).


More common in the Eastern Gulf


Figure 74 . Regression model, location, and depth information for lionfish, red ( Pterois volitans ).


More common in the Eastern Gulf


Figure 75 . Regression model, location, and depth information for hogfish ( Lachnolaimus maximus ).

## Hogfish, Red



More common in the Eastern Gulf



Figure 76 . Regression model, location, and depth information for hogfish, red ( Decodon puellaris).


More common in the Eastern Gulf


Statistical Zones, $N=867$


Depth (Feet)

Figure 77 . Regression model, location, and depth information for toadfish, leopard ( Opsanus pardus ).

# Lizardfish, Inshore 



More common in the Eastern Gulf


Figure 78 . Regression model, location, and depth information for lizardfish, inshore (Synodus foetens ).


More common in the Eastern Gulf


Figure 79 . Regression model, location, and depth information for snakefish (Trachinocephalus myops ).

## Sand Diver



More common in the Eastern Gulf


Figure 80 . Regression model, location, and depth information for sand diver (Synodus intermedius ).


More common in the Eastern Gulf


Figure 81 . Regression model, location, and depth information for shark, bonnethead (Sphyrna tiburo ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=208$


Depth (Feet)

Figure 82 . Regression model, location, and depth information for shark, bigeye sixgill (Hexanchus vitulus ).


More common in the Western Gulf


Figure 83 . Regression model, location, and depth information for shark, sevengill (Heptranchias perlo ).


More common in the Eastern Gulf


Figure 84 . Regression model, location, and depth information for dogfish, chain (Scyliorhinus retifer ).

Dogfish, Roughskin


More common in the Eastern Gulf


Figure 85 . Regression model, location, and depth information for dogfish, roughskin (Cirrhigaleus asper ).


More common in the Eastern Gulf


Figure 86 . Regression model, location, and depth information for dogfish, cuban (Squalus cubensis ).


More common in the Eastern Gulf


Figure 87 . Regression model, location, and depth information for dogfish, shortspine ( Squalus mitsukurii).

Shark, Smooth Dogfish


More common in the Western Gulf


Figure 88 . Regression model, location, and depth information for shark, smooth dogfish ( Mustelus canis ).


More common in the Eastern Gulf


Figure 89 . Regression model, location, and depth information for shark, atlantic sharpnose ( Rhizoprionodon terraenovae ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=2,885$


Depth (Feet)

Figure 90 . Regression model, location, and depth information for shark, blacknose ( Carcharhinus acronotus ).


More common in the Eastern Gulf


Figure 91 . Regression model, location, and depth information for shark, finetooth ( Carcharhinus isodon ).


More common in the Eastern Gulf


Statistical Zones, $\mathrm{N}=890$


Depth (Feet)

Figure 92 . Regression model, location, and depth information for shark, silky ( Carcharhinus falciformis ).


[^0]:    ${ }^{1}$ Mention of trade names or commercial companies is for identification purposes only and does not imply endorsement by the National Marine Fisheries Service, NOAA.

