

# Abundance Indices of Red Hind Collected in Caribbean SEAMAP Surveys from Southwest Puerto Rico

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## **Abundance Indices of Red Hind Collected in Caribbean SEAMAP Surveys from Southwest Puerto Rico**

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Since 1991 a fishery-independent survey under the support of the Southeast Area Monitoring and Assessment Program – Caribbean (SEAMAP-C) has been carried out in the southwest coast of Puerto Rico (P.R.). Pagán (2002) summarized these data, which are intended to be used for long-term monitoring of local fisheries, including abundances and ecology. Here this information was used to ascertain abundance trends of red hind to be used as input to stock assessment models.

For the SEDAR 35, the time series of data between 1991 and 2011 were used to develop abundance indices for red hind for the U.S. Caribbean off the southwest coast of Puerto Rico. Initially, SEAMAP-C data were evaluated to determine the efficacy of their use for development of abundance indices of areas around both Puerto Rico and the U.S. Virgin Islands, using multiple gear-types (handline and traps) and catch data-types (catch in numbers or weight). Preliminary analyses indicated a sparseness of complete catch and effort for red hind in the USVI area, sparseness in the continuity of the time series of the trap data, and a higher variability in the weight data. Therefore, handline catch-per-unit-effort (CPUE) data in numbers of red hind collected off the southwest coast of Puerto Rico were used to develop abundance indices. Figure 1 shows the distribution of CPUE.

The delta-lognormal index of relative abundance ( $I_y$ ) as described by Lo *et al.* (1992) was estimated as

$$(1) \quad I_y = c_y p_y,$$

where  $c_y$  is the estimate of mean CPUE for positive catches only for year  $y$ ;  $p_y$  is the estimate of mean probability of occurrence during year  $y$ . Both  $c_y$  and  $p_y$  were estimated using generalized linear models. Data used to estimate abundance for positive catches ( $c$ ) and probability of occurrence ( $p$ ) were assumed to have a lognormal distribution and a binomial distribution, respectively, and modeled using the following equations:

$$(2) \quad \ln(\mathbf{c}) = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}$$

and

$$(3) \quad \mathbf{p} = \frac{e^{\mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}}}{1 + e^{\mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}}}, \text{ respectively,}$$

where  $\mathbf{c}$  is a vector of the positive catch data,  $\mathbf{p}$  is a vector of the presence/absence data,  $\mathbf{X}$  is the design matrix for main effects,  $\boldsymbol{\beta}$  is the parameter vector for main effects, and  $\boldsymbol{\varepsilon}$  is a vector of independent normally distributed errors with expectation zero and variance  $\sigma^2$ .

The GLIMMIX and MIXED procedures in SAS (v. 9.1, 2004) were used to develop the binomial and lognormal submodels, respectively. Similar covariates were tested for inclusion for both submodels: water depth (m), geographic spawning aggregation marine protected area (MPA) variable (“0” for outside MPA and “1” for inside MPA), spawning season variable [if month in (12, 1, 2) then spawning season is “1”, otherwise spawning season is “0”], and year. A backward selection procedure was used to determine which variables were to be included into each submodel based on type 3 analyses with a level of significance for inclusion of  $\alpha = 0.05$ . If year was not significant then it was forced into each submodel in order to estimate least-squares means for each year, which are predicted annual population margins (i.e., they estimate the marginal annual means as if over a balanced population).

Therefore,  $c_y$  and  $p_y$  were estimated as least-squares means for each year along with their corresponding standard errors,  $SE(c_y)$  and  $SE(p_y)$ , respectively. From these estimates,  $I_y$  was calculated, as in equation (5), and its variance calculated as

$$(4) \quad V(I_y) \approx V(c_y)p_y^2 + c_y^2V(p_y) + 2c_y p_y \text{Cov}(c, p),$$

where,

$$(5) \quad \text{Cov}(c, p) \approx \rho_{c,p} [SE(c_y)SE(p_y)],$$

and  $\rho_{c,p}$  denotes correlation of  $c$  and  $p$  among years.

The backward selection procedure used to develop the delta-lognormal model is summarized in Table 1. All variables were retained in each submodel as highly significant (i.e.  $p < 0.0001$ ). Figure 2 summarizes indices of red hind, developed using a delta-lognormal model. Figures 3 and 4 provide diagnostics for each of the submodels in the index development. In Figures 3 and 4, the approximately normal distribution of the residuals of the submodels is indicated. Finally, a length-frequency histogram for red hind (Figure 5) collected during this survey was developed.

## ***Literature Cited***

- LO, N. C. H., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. *Can. J. Fish. Aquat. Sci.* 49: 2515-1526.
- PAGÁN, F. E. 2002. Caribbean-SEAMAP Program Reef Fish Data Analysis Survey, Final Report. Prepared for UPR Sea Grant College Program/NMFS Cooperative Southeast Area Monitoring and Assessment Program – Caribbean (SEAMAP-C), University of Puerto Rico Sea Grant College Program, Mayagüez, Puerto Rico. 66 pages.

Figure 1. Distribution of CPUE (# per 5 hook hours) for handlines in the SEAMAP-C Survey from 1991 - 2011. Nonzero CPUEs ranged from 0.77 to 70.72 red hind per 5 hook hours (white to red = lowest to greatest CPUE). Note: numerous stations have the same latitude and longitude over the course of the time series, resulting in some stations being masked by others.

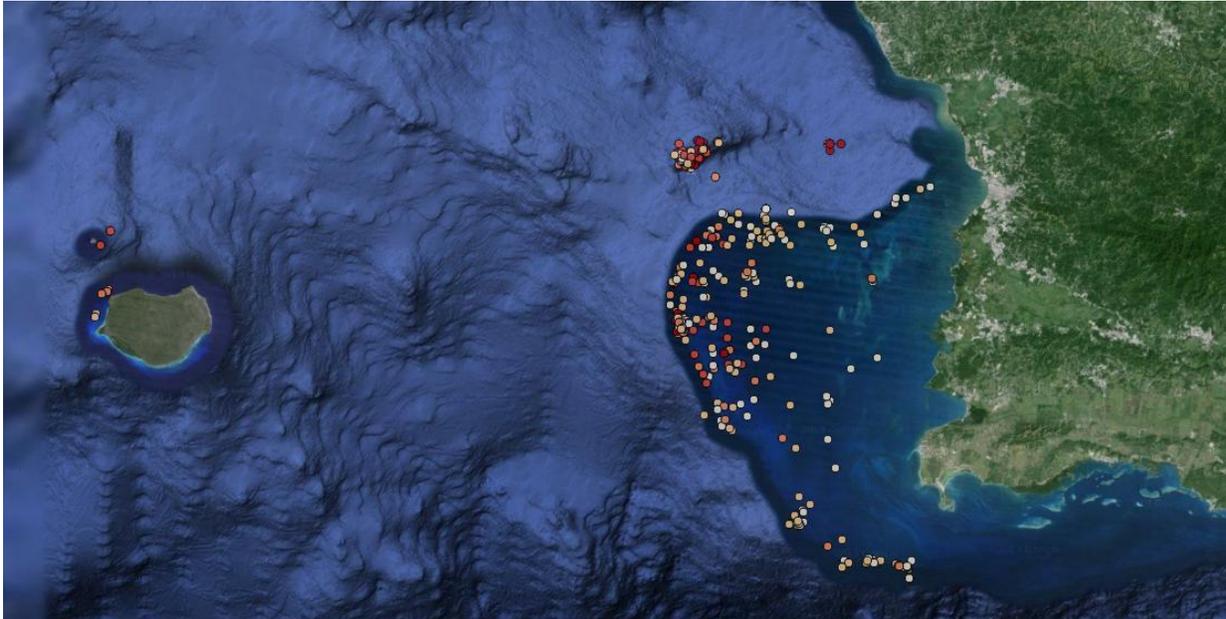
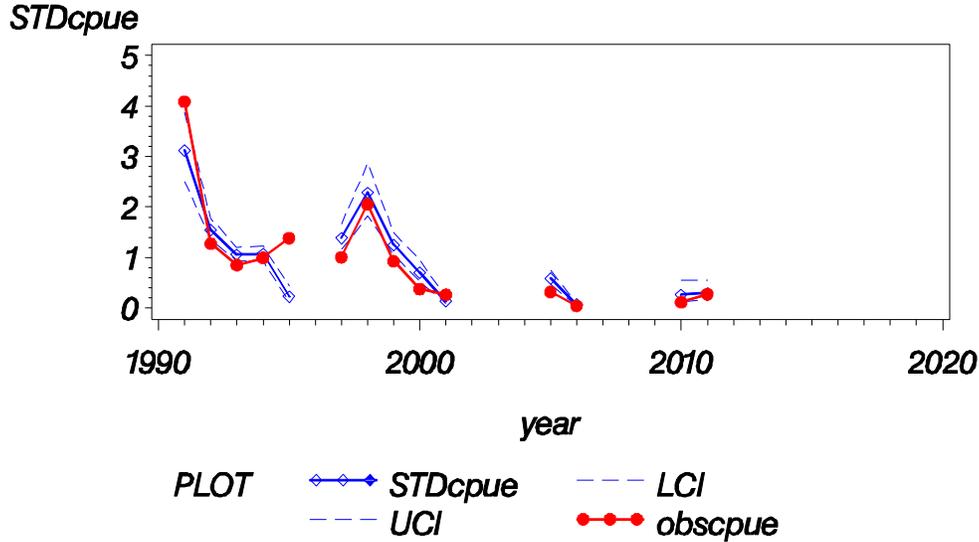


Table 1. Backward selection procedure for building delta-lognormal submodels for red snapper collected during Bottom Longline Surveys in the Gulf of Mexico.

<i>Model Run #1</i>	<i>Binomial Submodel Type 3 Tests (AIC = 9542.2)</i>						<i>Lognormal Submodel Type 3 Tests (AIC = 3040.7)</i>			
<i>Effect</i>	<i>Num DF</i>	<i>Den DF</i>	<i>Chi-Square</i>	<i>F Value</i>	<i>Pr &gt; ChiSq</i>	<i>Pr &gt; F</i>	<i>Num DF</i>	<i>Den DF</i>	<i>F Value</i>	<i>Pr &gt; F</i>
<i>year</i>	12	2065	172.39	14.37	<.0001	<.0001	13	1196	15.59	<.0001
<i>spawning season</i>	1	2065	31.48	31.48	<.0001	<.0001	1	1196	51.70	<.0001
<i>spawning aggregation area</i>	1	2065	146.61	146.61	<.0001	<.0001	1	1196	111.88	<.0001
<i>depth</i>	1	2065	66.79	66.79	<.0001	<.0001	1	1196	220.96	<.0001

Figure 2. Abundance indices for red hind collected during SEAMAP-C Surveys using handlines off southwest Puerto Rico. *STDcpue* is the index scaled to a mean of one over the time series. *Obscpue* is the average nominal CPUE, and LCI and UCI are 95% confidence limits. In the table below, the *frequency* listed is nominal frequency, *N* is the number of bottom longline stations, *Index* is the abundance index in CPUE units, *Scaled Index* is the index scaled to a mean of one over the time series, *CV* is the coefficient of variation on the index value, and *LCL* and *UCL* are 95% confidence limits.



<i>Survey Year</i>	<i>Frequency</i>	<i>N</i>	<i>Index</i>	<i>Scaled Index</i>	<i>CV</i>	<i>LCL</i>	<i>UCL</i>
1991	1.00000	94	11.4812	3.12356	0.10921	2.51231	3.88352
1992	0.55807	353	5.6761	1.54423	0.06933	1.34451	1.77361
1993	0.63683	391	3.8949	1.05965	0.06174	0.93668	1.19878
1994	0.58960	346	3.9435	1.07286	0.06935	0.93408	1.23226
1995	0.34091	21	0.8398	0.22847	0.32135	0.12205	0.42768
1997	0.50926	216	5.0971	1.38672	0.09161	1.15500	1.66493
1998	0.71739	92	8.3987	2.28494	0.11251	1.82580	2.85954
1999	0.68508	181	4.6077	1.25357	0.08556	1.05674	1.48706
2000	0.42000	100	2.5857	0.70347	0.15401	0.51791	0.95551
2001	0.29268	82	0.4921	0.13387	0.20469	0.08927	0.20074
2005	0.39412	170	2.1517	0.58540	0.12060	0.46034	0.74443
2006	0.10526	57	0.2496	0.06790	0.10875	0.05466	0.08435
2010	0.19444	36	0.9580	0.26065	0.38386	0.12417	0.54711
2011	0.61538	13	1.0833	0.29471	0.32526	0.15630	0.55570

Figure 3. Diagnostic residual QQplot of the binomial submodel.

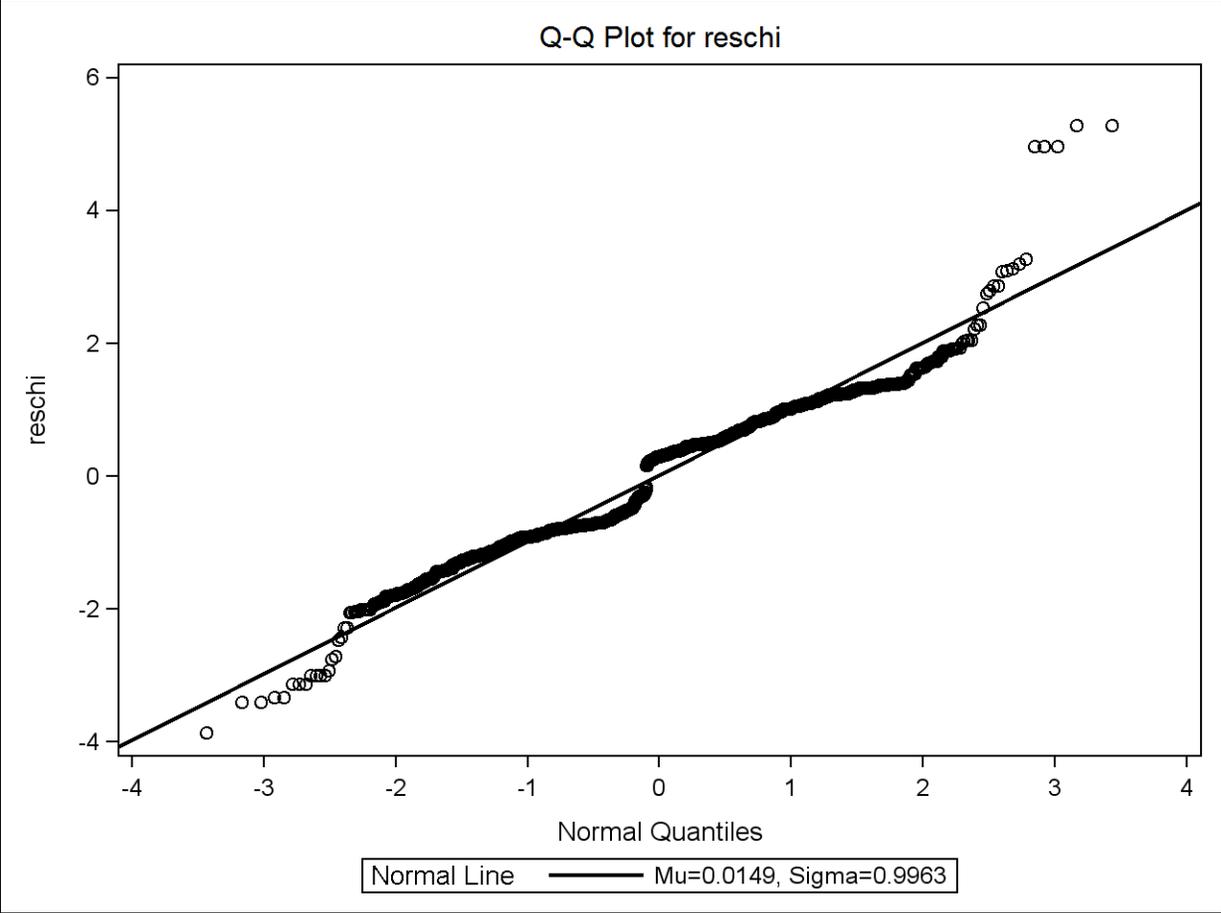


Figure 4. Diagnostic residual QQplot of the lognormal submodel.

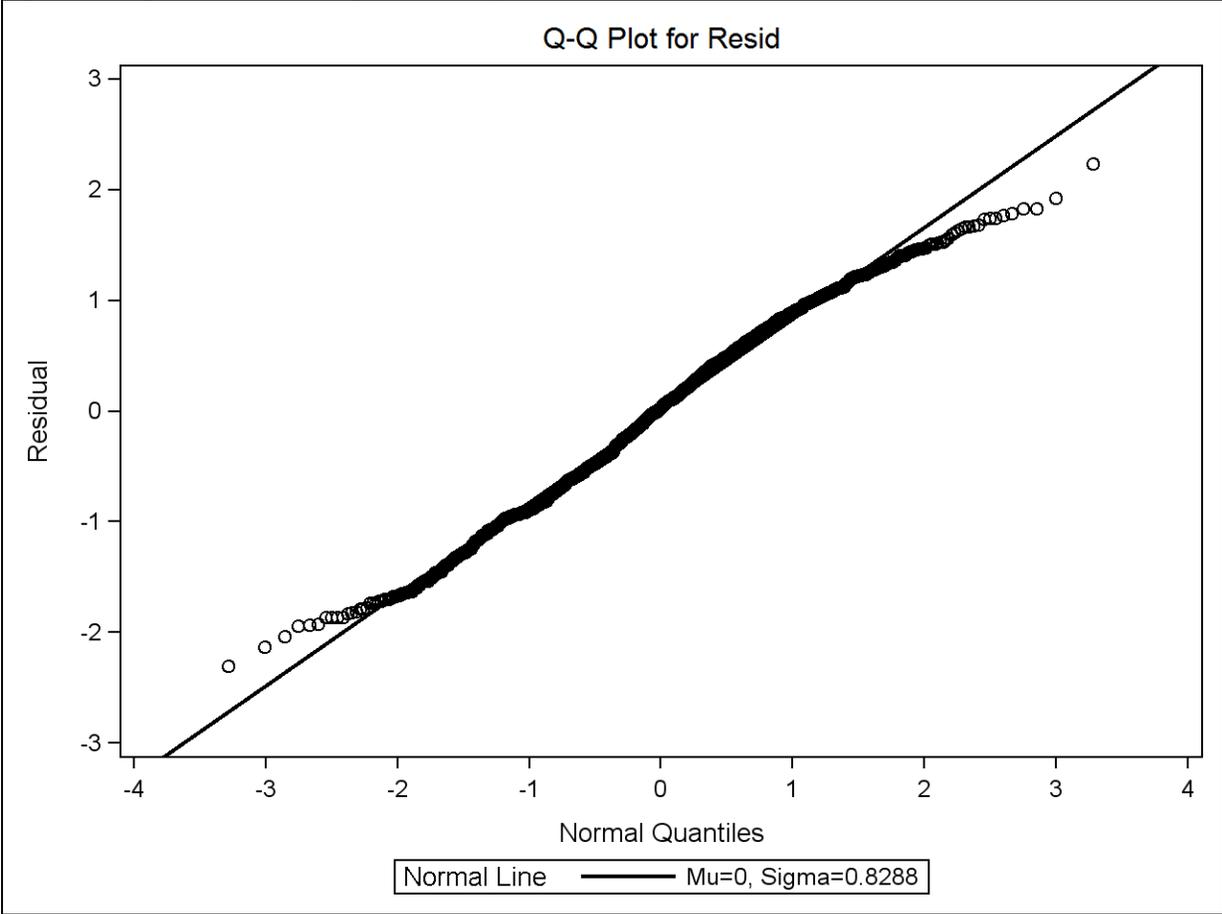


Figure 5. Length frequency of red hind collected during SEAMAP-C Surveys using handlines off southwest Puerto Rico. N = 8598.

