Biscayne National Park Creel Survey index, 1978-2022

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SEDAR79-DW-15

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Introduction

Biscayne National Park is located south of Miami and north of Key Largo and is adjacent to the Florida Keys National Marine Sanctuary (Fig. 1). The Biscayne Creel Survey began in 1976, was discontinued in 1988, and resumed in 1992. Park personnel interview returning anglers about their fishing activity. Because the total catch, both the numbers kept and the numbers released, is recorded for each species, and the corresponding fork lengths are obtained from the retained fish, the creel survey is a good candidate for a fishery dependent index. Catch and length data from the park's creel survey were used in SEDAR 08 and the 08 Update to generate a fishery dependent index for spiny lobster (*Panulirus argus*); however, this analysis, SEDAR 79, is the first time that these survey data have been considered for finfish in the SEDAR process.

Sampling

Biscayne National Park provided an Access file containing the Biscayne National Park Creel Survey data and variable descriptions to FWC. At access points in the park, National Park samplers ask anglers where the anglers are from, whether they were fishing, how many persons were fishing, when they began fishing, how long did they spend fishing, where they spent most of their time fishing, their fishing experience, if they are aware of the fishing regulations, what they caught and whether they kept the fish or released their catch. The interviews are considered to represent a fishing trip. When additional interviewers were available, more than one access point could be sampled on the same day. In 1993, samplers began asking anglers if they may measure the angler's retained fish. The samplers measure the centerline length (fork length in cm) of the fish.

Prior to analyzing the data, the data were filtered for interyear comparability. The early survey data from 1976 and 1977 only identified Yellowtail Snapper (*Ocyurus chrysurus*) and Gray Snapper (*Lutjanus griseus*)) to species and grouped the other snapper species into Other Snappers (Lutjanus spp.); however, beginning in 1978 additional snapper species were identified to species including Mutton Snapper (*Lutjanus analis*); hence, the subsequent analyses used data from 1978 through 2022. Because most of the interviews were conducted on weekends (96%), the analyses restricted the data to weekend interviews. In 1999, there were 18 interviews but there was only one weekend interview. In 2019, there were 48 interviews but after selecting for trips believed to be in Mutton Snapper habitat based on cluster analyses (described below) there was only one weekend trip in 2019. Finally, there were no interviews conducted on weekends in 2020. Therefore, data from these three years (1999, 2019, and 2020) were omitted from further analyses.

Analysis

Because there is not a variable describing the habitat where the anglers fished, I thought that the suite of species caught together with Mutton Snapper would indicate angling trips that were fishing in suitable Mutton Snapper habitat, therefore, I used cluster analyses (Shertzer and Williams, 2008, Krebs 1989) to identify the other species that were frequently caught with Mutton Snapper. Catches that were not identified to species and those that were caught on less than 1% of the trips were omitted from the analysis. Given that the total catch was in numbers of fish, the cluster analysis used the Morisita similarity index with average linkage (Krebs 1989) and the number of clusters in the hierarchical analysis was determined based on the maximum silhouette width. Cluster analyses were initially run on the 1978-1987 data with a separate analysis on the 1993-2022 data. However, examination of the species in the same cluster as Mutton Snapper revealed that there were several species in the cluster with Mutton Snapper that were identified in both analyses. The combined dataset was also analyzed using Horn and Bray-Curtis similarity indices. In addition, the Bray-Curtis and Horn similarity indices were also run using the fourth root transformation of the total number caught per trip. All of the analyses used average linkage when generating the dendrograms of the clusters. Figure 2 shows the silhouette width plot and the dendrogram plot for the results of the run that used the Morisita index and average linkage. Table 1 lists the species in the Mutton Snapper cluster by configuration. Examination of the species clustered with Mutton Snapper identified by the runs with different similarity or data configurations revealed that seven species were included in every run and those species were Mutton Snapper, Gray Snapper, Yellowtail Snapper, Red Grouper, White Grunt, Bluestriped Grunt, and Jolthead porgy. Therefore, trips that caught any species in this group of species were included in the final data set.

Additional adjustments to the data included grouping some categories such as months were grouped into spawning (April – July, Lowerre-Barbieri and Friess 2022) and non-spawning (January – March, August – December) seasons, reducing the areas-fished to inside (1, 2, 3, 4, 20, 21, 22, and 23) and outside (5, 6, 17, 19, 26, and 36), combining high numbers of hours fished into an 11+ hour group, and if the number of anglers was greater than six then these anglers were put in the six-angler plus group. The anglers fishing experience or party composition was grouped into skilled, food (food and family), diving (spearfishing and diving), and other (novice, commercial, and other). The three commercial interviews were not included in the final data set. The fisherman's residence was grouped into Miami, Homestead, and north of there. The final data filtering was to eliminate any individual records that were missing data in any of the potential explanatory variables. There were 13,173 trips (interviews) in the final dataset.

Calculating the index

Beginning with king mackerel stock assessments in the 1990s, many abundance indices have been developed in the SE US using generalized linear models which are regression models that allow different statistical distributions. A common approach uses hurdle models (Cragg, 1971), usually a delta-lognormal modeling approach (Lo et al 1992). As the name implies, a delta-lognormal model combines two generalized linear submodels to calculate the index. The first submodel estimates the probability of catching a Mutton Snapper (the hurdle) using a binomial distribution with a logit link and a second submodel estimates the mean number of muttons caught on positive trips using a log-normal distribution with an identity link on the log transformed total number of muttons. Variations of this approach have used Poisson or gamma distributions in the second submodel instead of the log-normal distribution. Burton and Ingram (2005) used a delta-Poisson model when developing the Mutton Snapper fishery independent index for Riley's Hump. In addition to running hurdle models with each of the three distributions as the second submodel, I also fit two models that used single distributions: a negative binomial model with a log link which allows for extra zero catches and a Poisson model which also used a log link. The uncertainty in the annual estimates was derived from a Monte Carlo approach that used the least square means (LS means) and their standard errors. In each iteration of this method, a random normal deviate was drawn from a normal distribution ($\mu = 0$, $\alpha = 1$), and multiplied by the standard error and this error term was added to the LSmeans prior to back transforming the estimate to the arithmetic scale. The hurdle model did this for both submodels and the resulting back transformed LSmeans from each submodel were multiplied while the negative binomial and Poisson models were just back transformed from the log link. The Monte Carlo simulations were repeated 5000 times for each year.

The response variable in the first submodel that estimated the probability of catching a mutton was 1.0 if at least one Mutton Snapper was caught on that trip or a 0.0 if not; the response variable for the second submodel was the total number of Mutton Snappers caught per trip with the Poisson or Gamma distributions or the log of the total number of Mutton Snappers caught in the log-normal distribution. The negative binomial and Poisson models also used the total number of Mutton Snapper caught as the response variable. Potential explanatory variables included year, season, area fished, party experience, angler's residence, hours fished, and the number of anglers. The criteria for including a variable in the final submodel were whether the variable was statistically significant at the 0.05 level in a X^2 distribution and whether adding the variable reduced the mean deviance (a measure of uncertainty) by at least 0.5%. The idea was to avoid over-parameterizing the model with variables that were statistically significant but did not reduce the deviance. The uncertainty in the annual estimates was derived through Monte Carlo simulation as described above.

Because the alternative model configurations used different statistical distributions, the final model configuration was the configuration with the lowest root mean square error (RMSE) of the standardized residuals to the second submodels or to the positive trips in the negative binomial and Poisson models.

Length frequency

There were 1,067 retained Mutton Snapper lengths available from the 1993-2022 data set. These lengths were recorded in fork length (cm) and were converted to maximum total length in cm using Eq. 1, SEDAR 79 morphometrics:

$$TLmax\_cm = (1.072*(FL\_cm*10) + 14.71)/10 \qquad (1)$$

Given the range of total lengths (12.7-93.7 cm), the lengths were grouped into 2-cm length bins. Anglers in Biscayne National Park have access to deeper water offshore and also larger fish; therefore, the selectivity was assumed to be flat-topped (Eq. 2). The logistic equation was:

$$sel = \frac{1}{1+\exp\left((L50-L)/slope\right)} \qquad (2)$$

where *sel* was selectivity, *L50* was the length at which 50% of the fish were selected (inflection point) , and the *slope* was a shape coefficient. A dome-shaped selectivity curve (double logistic, Eq. 3) is also included in case the data workshop decides that the larger fish are not completely available to anglers fishing in the park's offshore waters (Eq 3.)

$$sel = \left(\frac{1}{1+\exp\left((L50_1-L)/slope_1\right)}\right)*\left(1-\frac{1}{1+\exp\left((L50_2-L)/slope_2\right)}\right) \qquad (3)$$

where *sel* was selectivity, $L50_1$ was the ascending length at which 50% of the fish were selected and $L50_2$ was the corresponding descending length, and the $slope_1$ *and* $slope_2$ were shape coefficients. Non-linear regressions were used to estimate the coefficients.

Results and discussion

The final set of trips that occurred in suitable Mutton Snapper habitat were identified by their species composition. Forty species were caught on at least 1% of the 21,427 interviews, however, conch was omitted from the analyses leaving 39 species and those 39 species were grouped into between 15 and 24 clusters (Table 1). When the members of the clusters identified by the different similarity indices and data configurations that contained Mutton Snapper were compared, there were seven species that were identified among the species by every configuration and those species were Mutton Snapper, Gray Snapper, Yellowtail Snapper, Red Grouper, Jolthead Porgy, Bluestriped Grunt, and White Grunt; essentially species that were frequently observed on hard bottom habitats such as coral reefs with some topography (Table 1). The final data set was composed of those interviews that caught at least one of these species. There were 13,173 angler interviews included in the final data set, and, of those interviews, anglers caught Mutton Snapper on 1,878 interviews, i.e., anglers caught Mutton Snapper on 14% of the trips.

The nominal catch rates were quite variable with generally higher values after 2006 (Fig. 3, Table 3). Mutton Snapper are not caught frequently. The range of number of Mutton Snapper caught per trip was 0 – 90 with the 75th percentile being zero and the 90th percentile being 1 fish.

The model fits of the different configurations are shown in Table 1 and the configuration with the lowest Root Mean Square Error (RMSE) was the Hurdle-Poisson model. The binomial submodel estimating the probability of catching a Mutton Snapper selected the year, party experience hours fished, and area fished to include in the final model and those variables explained 6.1% of the deviance. The standard residuals in the binomial submodel were balanced (Fig. 4a and b). Because the binomial model dependent variable only has two values, 0, and 1, there are no outliers. The while the submodel with the Gamma distribution reduced the deviance more than the submodel with the Poisson distribution (9.9% vs. 7.8%) the submodel with the Poisson distribution had a lower mean square error (MSE, 18.3 vs. 19.1) indicating a better overall fit to the data. The submodel with the log-normal distribution submodel only explained 2.3% pf the deviance and had a larger MSE of 20.6. In SEDAR 15A, Burton and Ingram (2008) also used a delta-Poisson model in generating the Riley Hump index. The Poisson submodel selected the same four variables (year, area fished, hours fished, and party experience) as the binomial submodel, albeit in a different order. There were 34 outliers out of 1,878 trips identified in the final submodel (Fig. 4d and e). The outliers were trips with total catches greater than 3 Mutton Snapper per trip, most of which were 3 - 8 fish with two trips with large catches of 38 and 90 fish per trip. The catch of 90 retained Mutton Snapper came from three anglers in December 1987, fishing for eight hours offshore.

The standardized index, like the nominal catch rates, was variable with a slightly increasing trend (Fig. 5, Table 1). The index was low in the early years except for in increase 1987; when the data resume in 1993, the index is at the same level as in 1987 it then declined reaching a low in 1997 and then stayed low until 2001 when it increased a little until an increase in 2007 after which a gradual decline until 2012 then stable until an increase in 2017. Overall, the index since 2007 has been higher than in earlier years. The majority (86%) of the coefficients of variation of the annual index values were less than 0.30. (Table 3).

Fish lengths began to be measured in 1993 and Figure 6 contains both the unweighted and weighted length frequencies of 1,067 Mutton Snapper with a length range of 12.7-93.7 cm total length; the weighted frequencies were weighted by the corresponding year's standardized hurdle Poisson index value. Given the range of lengths observed in the retained catch, and, given that many anglers fished in the deeper waters offshore from Elliot Key, anglers may have had access to all ages of fish and that a flat-topped selectivity curve would be appropriate (Fig. 7a). The coefficients of the selectivity curve as determined by SAS version 9.4 (proc nlin) were 46.1 cm (SE = 0.15 cm) for 50% inflection and 7.15 cm (SE = 0.13 cm) for the slope. However, if the data workshop decides that all ages of fish are not available to the park's anglers, then a dome-shaped selectivity would be appropriate. The coefficients for the dome-shaped curve were 38.2 cm (SE = 1.58 cm) and 55.7 cm (SE = 1.52 cm) for the inflection points and 6.32 cm (SE = 1.50 cm) and 5.67 cm (SE = 1.39 cm) for the slopes.

Acknowledgments

Many thanks to Biscayne National Park's Supervisory Wildlife Biologist, Dr. Vanessa McDonough, for providing the creel survey data and their updates and for resolving my many questions on the data and how they were collected.

Literature Cited

Burton, M.L. and W. Ingram. 2008. Visual census Surveys at Riley's Hump, Tortugas South Ecological Reserve. SEDAR-15A-DW_10. SEDAR, North Charleston, SC. 4p.

Cragg, J. G. 1971. Some statistical models for limited dependent variables with application to the demand for durable goods. Econometrica 39(5):829-844.

Krebs, C.J. 1989. Ecological methodology. HarperCollinsPublishers. New York. 654 p.

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.

Lowerre-Barbieri, S. and C. Friess. 2022. Mutton Snapper reproduction. SEDAR 79-DW (in prep).

Shertzer, K.W., and E.H. Williams. 2008. Fish assemblages and indicator species: reef fishes of the southeastern United States. Fish. Bull. 106:257–269.

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Table 1. Comparison of the species identified in the same cluster as Mutton Snapper estimated with Morisita, Bray-Curtis, and Horn similarity indices using either the number of Mutton Snapper caught per trip or the fourth root of the number of Mutton Snapper caught per trip. The shaded species are the seven species that were identified on every run.

Similarity	Morisita	Bray-Curtis	Bray - Curtis	Horn	Horn
Data	Number caught	Number caught	Fourth root of number caught	Number caught	Fourth root of number caught
Number of clusters	k = 24	k = 15	k = 18	k = 20	k = 20
Species	Mutton snapper	Mutton snapper	Mutton snapper	Mutton snapper	Mutton snapper
	Yellowtail snapper	Yellowtail snapper	Yellowtail snapper	Yellowtail snapper	Yellowtail snapper
	Gray snapper	Gray snapper	Gray snapper	Gray snapper	Gray snapper
	Red grouper	Red grouper	Red grouper	Red grouper	Red grouper
	Jolthead porgy	Jolthead porgy	Jolthead porgy	Jolthead porgy	Jolthead porgy
	Bluestriped grunt	Bluestriped grunt	Bluestriped grunt	Bluestriped grunt	Bluestriped grunt
	White grunt	White grunt	White grunt	White grunt	White grunt
		Black grouper	Black grouper		Black grouper
		Nassau grouper	Nassau grouper		Nassau grouper
	Gag	Gag		Gag	
		Hogfish	Hogfish		Hogfish
		Saucereye porgy			
		Yellow jack			
		Great barracuda	Great barracuda		Great barracuda
		Cero	Cero	Cero	Cero
	Blue runner			Blue runner	Blue runner

Table 2. Fits of different model configurations evaluated by the root mean square error based on the observed and predicted total catches for the 1,878 positive trips.

Configuration	Variables selected	Number of positive trips	Model degrees of freedom	Total degrees of freedom	Root mean square error
Hurdle Poisson	year, party_comp, hrs_fished, season , and area_x	1878	46	1831	1.67
Hurdle Gamma	year, party_comp, hrs_fished, and season	1878	45	1832	1.672
Hurdle log-normal	party_comp, year, and hrs_fished	1878	44	1833	1.708
Poisson	year, party_comp, hrs_fished, and season	1878	45	1832	1.711
Negative binomial	year, party_comp, hrs_fished, and season	1878	45	1832	1.719

Table 3. The number of trips, nominal and the standardized indices and their coefficients of variation (CV) of Mutton Snapper from Biscayne National Park by year.

Year	Number of interviews	Nominal index	CV	Delta-Poisson index	CV	Index scaled to mean
1978	471	0.08	0.216	0.08	0.248	0.18
1979	1492	0.32	0.124	0.35	0.092	0.79
1980	1291	0.33	0.111	0.34	0.095	0.77
1981	1129	0.32	0.110	0.31	0.096	0.71
1982	1469	0.21	0.126	0.23	0.105	0.53
1983	919	0.28	0.124	0.28	0.109	0.64
1984	197	0.23	0.290	0.19	0.263	0.44
1985	591	0.13	0.160	0.12	0.178	0.28
1986	488	0.21	0.176	0.19	0.166	0.44
1987	427	0.72	0.335	0.77	0.135	1.76
1988						
1989						
1990						
1991						
1992						
1993	345	0.61	0.171	0.70	0.123	1.60
1994	493	0.58	0.186	0.73	0.113	1.67
1995	219	0.40	0.284	0.51	0.185	1.16
1996	317	0.22	0.301	0.34	0.196	0.78
1997	146	0.06	0.359	0.08	0.515	0.18
1998	172	0.37	0.287	0.47	0.243	1.06
1999						
2000	101	0.20	0.300	0.26	0.339	0.59
2001	89	0.38	0.409	0.62	0.289	1.42
2002	351	0.39	0.269	0.61	0.152	1.38
2003	431	0.32	0.239	0.53	0.150	1.20
2004	103	0.36	0.542	0.64	0.316	1.47
2005	84	0.18	0.473	0.35	0.486	0.79
2006	126	0.37	0.199	0.54	0.209	1.23
2007	105	0.82	0.200	1.05	0.155	2.40
2008	152	1.06	0.272	1.55	0.137	3.52
2009	134	0.84	0.296	1.25	0.137	2.84
2010	172	0.61	0.264	0.84	0.159	1.92
2011	161	0.70	0.301	0.95	0.154	2.16
2012	103	0.26	0.347	0.51	0.304	1.15
2013	111	0.43	0.288	0.87	0.221	1.98
2014	80	0.43	0.355	0.72	0.297	1.63
2015	126	0.48	0.318	0.70	0.239	1.60

Table 3 continued. Nominal and the standardized indices and their coefficients of variation (CV) of Mutton Snapper from Biscayne National Park.

Year	Number of interviews	Nominal index	CV	Delta-Poisson index	CV	Index scaled to mean
2016	105	0.74	0.325	1.06	0.188	2.42
2017	169	0.48	0.196	0.71	0.171	1.62
2018	207	0.84	0.200	1.09	0.136	2.48
2019						
2020						
2021	62	0.98	0.403	1.17	0.243	2.67
2022	38	1.61	0.259	1.96	0.218	4.47
Total	17223					

Table 4. Length frequencies (maximum total length, 5 cm length bins) of Mutton Snapper retained by Biscayne National Park anglers 1993 – 2022.

	Maximum total length (cm, midpoint)																	
year	**12.5**	**17.5**	**22.5**	**27.5**	**32.5**	**37.5**	**42.5**	**47.5**	**52.5**	**57.5**	**62.5**	**67.5**	**72.5**	**77.5**	**82.5**	**87.5**	**92.5**	**Total**
1993	0	0	1	12	14	22	20	11	6	4	5	5	2	1	0	1	0	104
1994	0	1	0	8	22	24	24	12	6	10	9	6	3	1	0	0	0	126
1995	0	0	0	4	1	5	10	5	4	2	2	1	0	0	0	0	0	34
1996	0	0	0	1	3	5	9	2	2	3	1	2	1	1	0	0	0	30
1997	0	0	1	3	0	3	5	3	0	0	0	1	0	0	1	0	0	17
1998	0	0	1	3	2	3	4	11	3	2	1	0	0	0	3	0	0	33
1999																		
2000	0	0	0	1	1	1	5	2	2	2	0	1	0	0	0	0	0	15
2001	0	0	0	0	0	0	2	2	3	1	0	0	0	0	0	0	0	8
2002	0	0	0	4	1	8	9	14	2	5	5	1	2	2	0	0	0	53
2003	0	0	0	3	2	3	16	22	13	4	5	2	0	1	0	0	0	71
2004	0	0	0	1	1	1	3	1	1	1	0	2	0	0	0	0	0	11
2005	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
2006	0	0	1	2	3	8	3	1	2	3	2	1	0	0	1	0	0	27
2007	0	0	1	1	5	1	10	16	2	4	3	3	3	0	0	0	1	50
2008	0	3	6	12	15	2	8	11	8	10	4	1	2	1	1	0	0	84
2009	0	0	0	7	10	8	15	4	8	0	1	0	0	0	0	0	0	53
2010	0	0	0	0	1	4	16	31	11	8	8	4	1	0	0	0	0	84
2011	0	0	0	4	1	0	13	33	11	11	4	1	1	2	0	0	0	81
2012	0	0	0	0	1	0	1	5	5	7	2	1	0	0	0	0	0	22
2013	0	0	0	1	0	0	2	2	4	5	3	2	3	0	0	0	0	22
2014	0	0	0	3	3	3	3	3	1	0	0	0	0	0	0	0	0	16
2015	0	0	0	9	0	1	2	1	1	0	0	0	2	0	1	0	0	17
2016	0	0	0	0	1	0	5	6	2	1	0	1	0	0	0	0	0	16
2017	0	0	0	0	1	1	4	7	5	2	3	2	0	1	0	0	0	26

Table 4 continued. Length frequencies (maximum total length, 5 cm length bins) of Mutton Snapper retained by Biscayne National Park anglers 1993 – 2022.

	Maximum total length (cm, midpoint)																	
year	12.5	**17.5**	**22.5**	**27.5**	**32.5**	**37.5**	**42.5**	**47.5**	**52.5**	**57.5**	**62.5**	**67.5**	**72.5**	**77.5**	**82.5**	**87.5**	**92.5**	**Total**
2018	0	0	0	0	0	0	2	7	7	1	2	3	1	0	0	0	0	23
2019																		
2020																		
2021	0	0	0	0	0	0	0	2	1	2	1	1	0	1	0	0	0	8
2022	1	0	2	3	7	0	5	4	6	1	1	0	4	1	0	0	0	35
Total	1	4	13	82	95	103	196	219	116	89	62	41	25	12	7	1	1	1067
Prop	0.001	0.004	0.012	0.077	0.089	0.097	0.184	0.205	0.109	0.083	0.058	0.038	0.023	0.011	0.007	0.001	0.001	

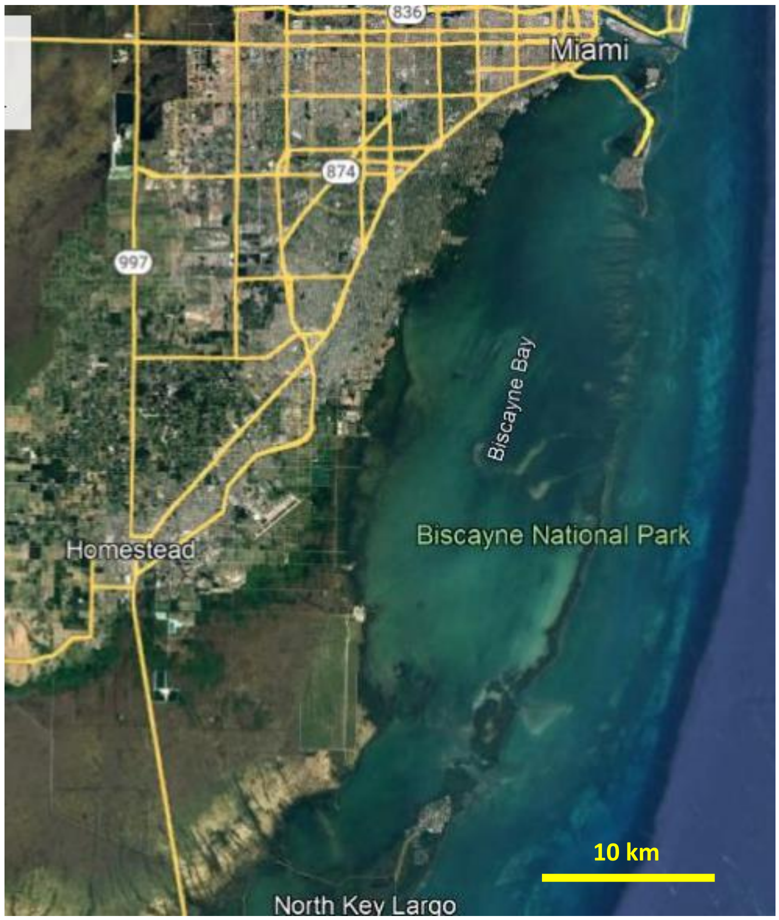
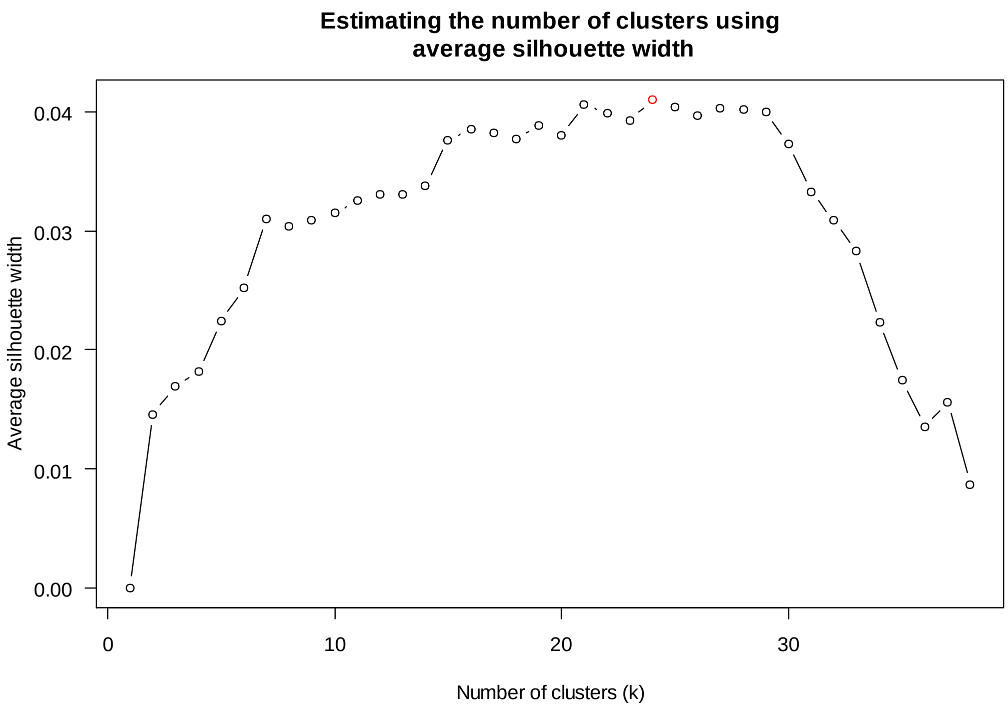


Figure 1. Biscayne National Park (Google Earth image).

a.



b.

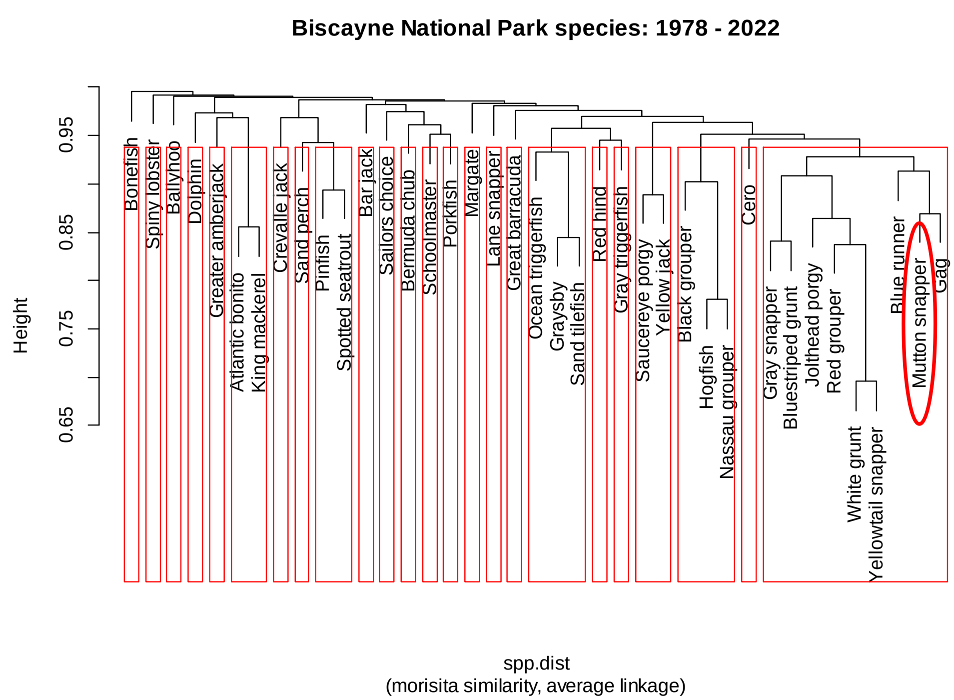


Figure 2. Cluster silhouette plot (a) and the cluster dendrogram (b) for the combined data set: 1978 - 2022.

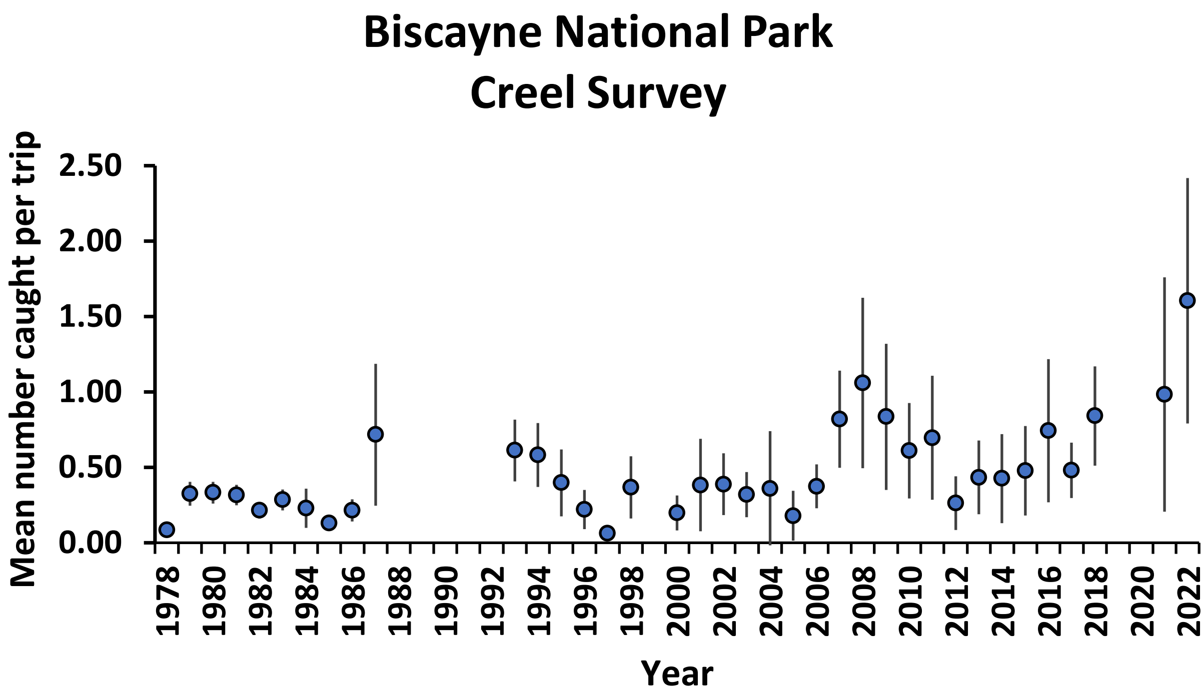


Figure 3. Annual mean number of Mutton Snapper caught per interview (trip) at Biscayne National Park (nominal catch rate).

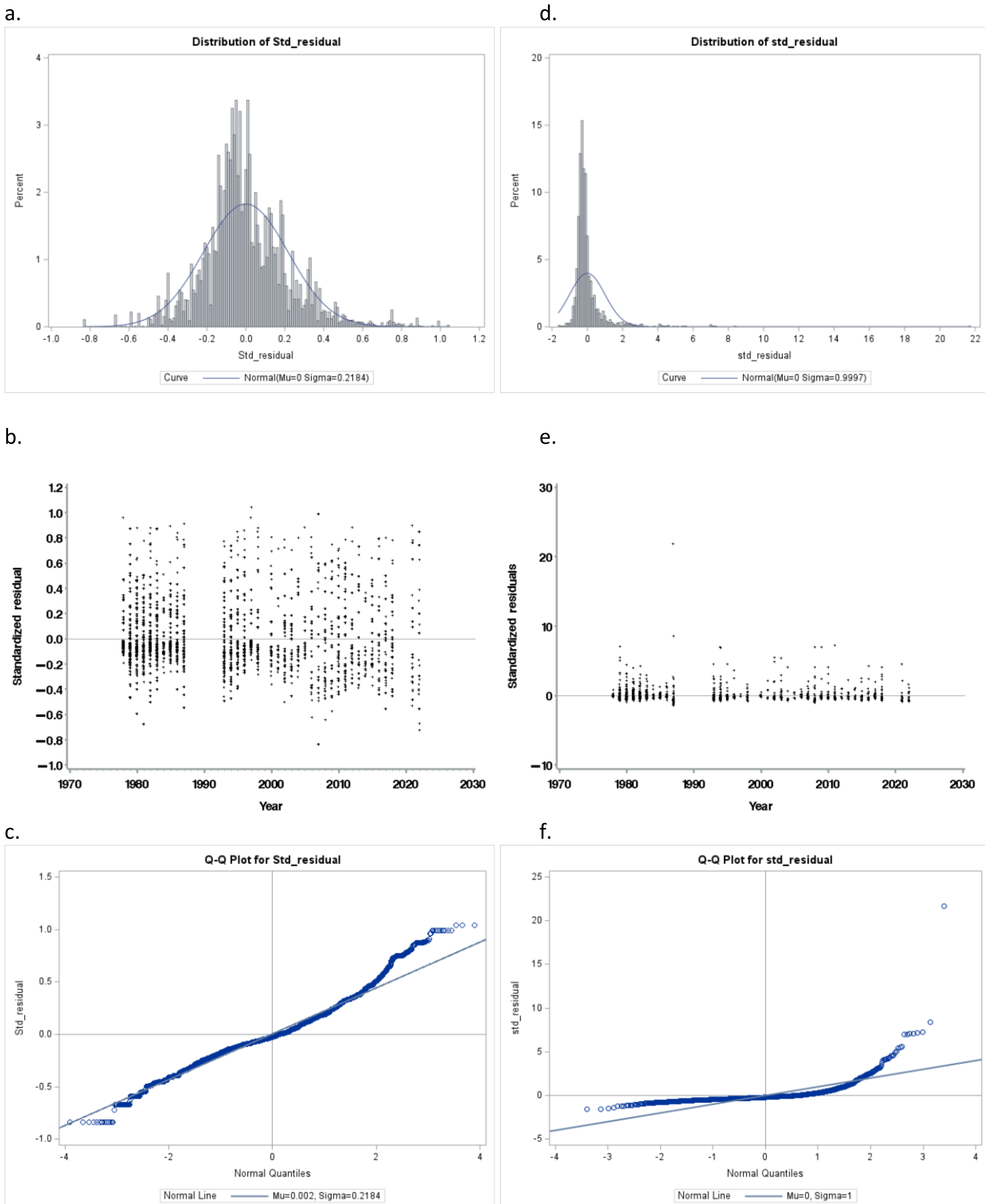


Figure 4. Distribution of standard residuals from the binomial submodel (a b) and a QQ plot of the standard residuals and the normal quantiles (c) and similar plots for the Poisson submodel (d-f).

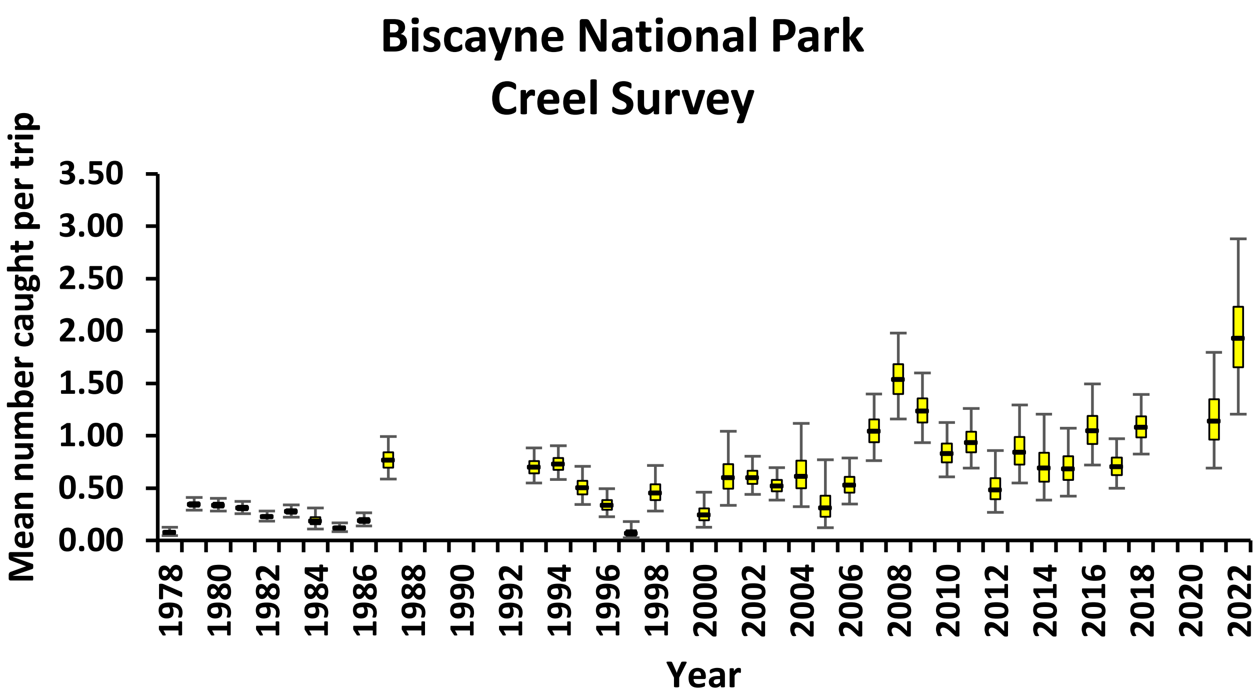
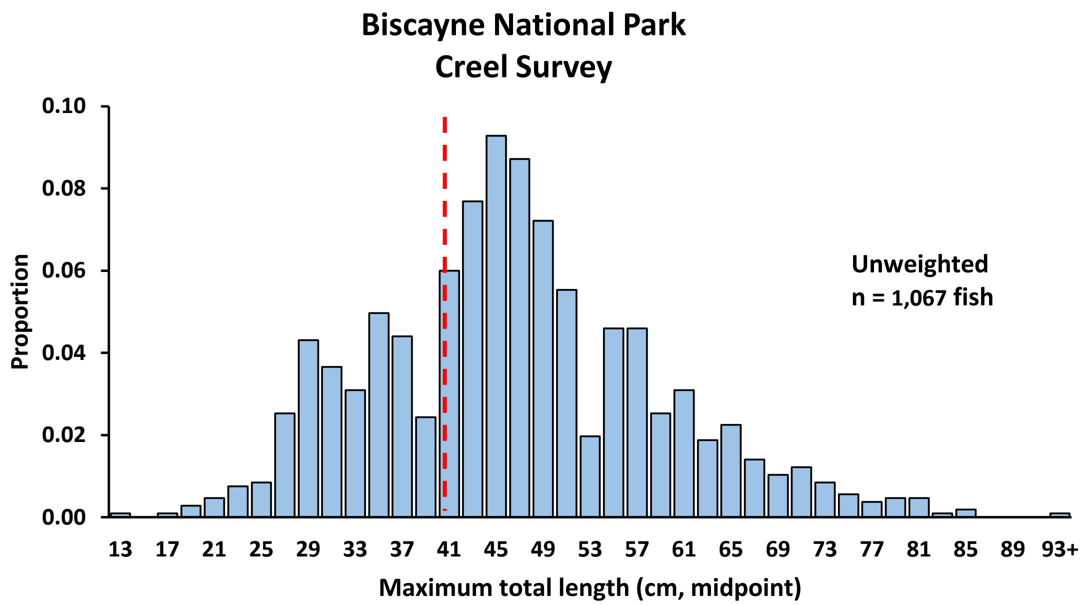


Figure 5. Standardized catch rates (number of Mutton Snapper caught per trip) from Biscayne National Park. The numbers of interviews by year are in Table3.

a.



b.

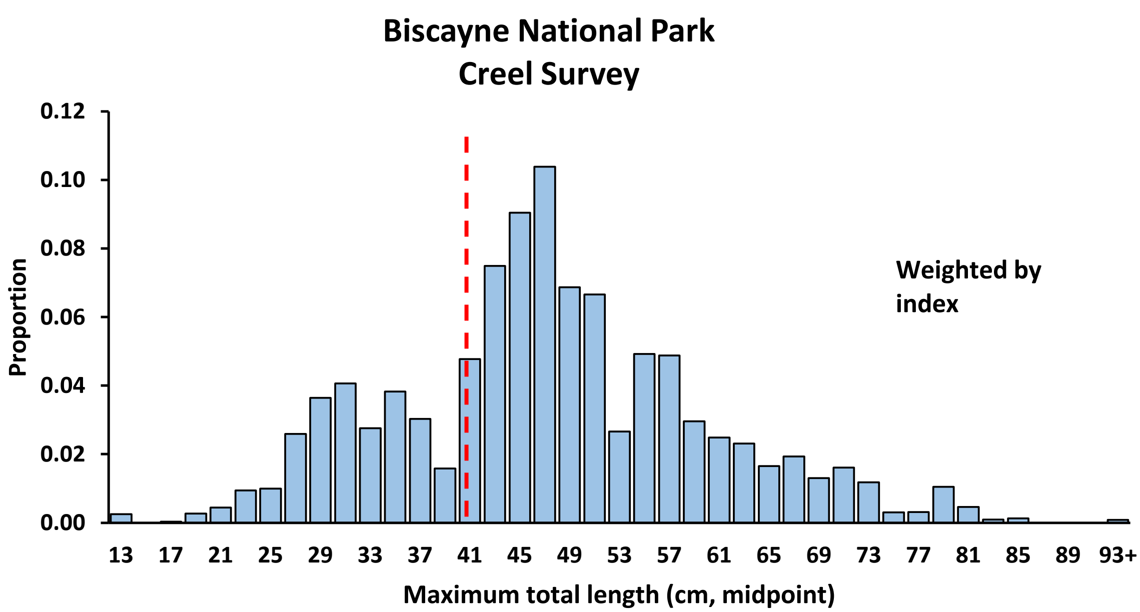
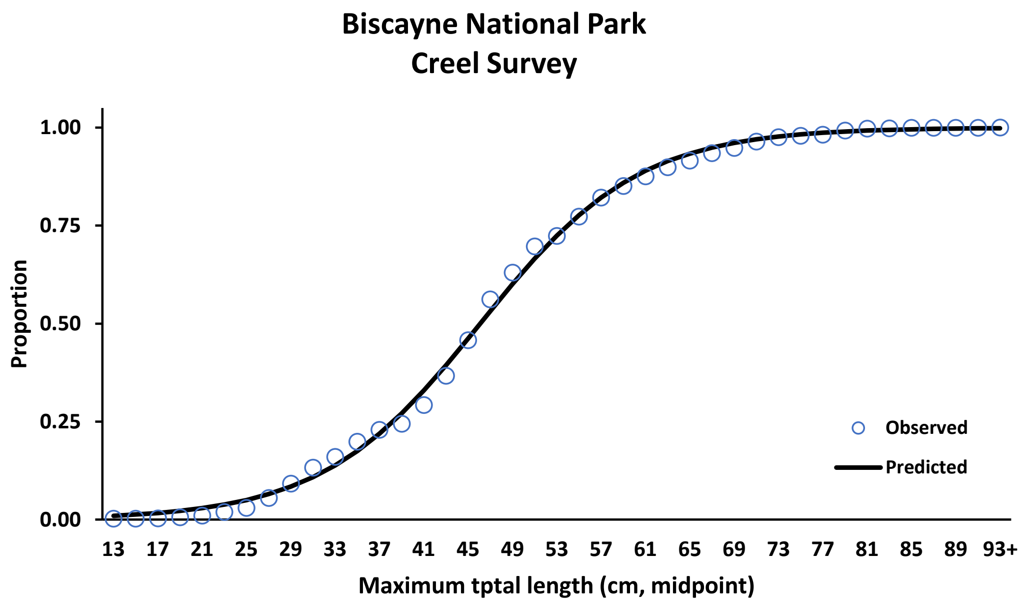


Figure 6. Unweighted (a) and weighted by index (b) length frequencies of retained Mutton Snapper from Biscayne National Park 1993-2022. Red dashed line is 1995-2017 minimum size of 16 inches (40.6 cm).

a.



b.

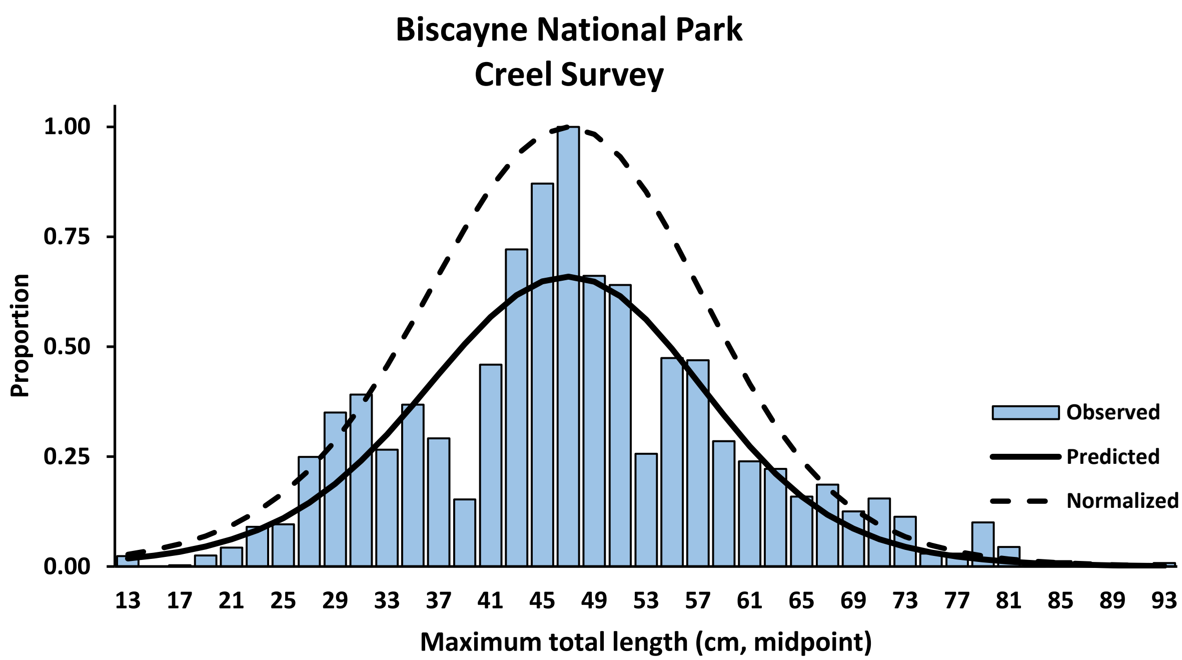


Figure 7. Selectivity of Mutton Snapper in Biscayne National Park Creel Survey; flat-topped (a) or dome-shaped (b).