Vermilion Snapper Fishery-Independent Index of Abundance in US South Atlantic Waters Based on a Chevron Trap Survey (1990-2016)

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SEDAR55-WP02

Submitted: 8 November 2017

Please cite this document as:

Bubley, W. J. and T. I. Smart. 2017. Vermilion Snapper Fishery-Independent Index of Abundance in US South Atlantic Waters Based on a Chevron Trap Survey (1990-2016). SEDAR55-WP02. SEDAR, North Charleston, SC. 15 pp.

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SEDAR 55-WP02
MARMAP Technical Report # 2017-009

This work represents partial fulfillment of the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program contract (NA11NMF4540174) sponsored by the National Marine Fisheries Service (Southeast Fisheries Science Center) and the South Carolina Department of Natural Resources.

Background

The Marine Resources Monitoring, Assessment and Prediction program (MARMAP) has conducted fishery-independent research on reef fish species of the continental shelf and shelf edge between Cape Hatteras, North Carolina, and St. Lucie Inlet, Florida, for over 40 years. Although the MARMAP program has used various gear types and methods of deployment since its inception, since 1990 chevron traps have been the primary gear deployed to allow for analyses of long-term changes in relative abundance, age compositions, length frequencies, and other information regarding reef fish species on live-bottom and/or hard-bottom habitats. In 2008, with a first field season in 2009, the Southeast Area Monitoring and Assessment Program, South Atlantic Region (SEAMAP-SA) provided funding to a project called the "Reef Fish Complement" to assist with the expansion of the geographical sampling coverage of the MARMAP fishery-independent chevron trap survey. Again in 2010, with the formation of the Southeast Fishery-Independent Survey (SEFIS), additional funds were provided to, among other things, expand the geographical coverage and sampling intensity of the MARMAP fishery-independent chevron trap survey. Collectively, we now refer to these three surveys combined reef fish monitoring efforts from 2010 to present as the Southeast Reef Fish Survey (SERFS).

Objective

This report presents a standardized relative abundance index of Vermilion Snapper derived from the MARMAP/SERFS chevron trap survey during the years 1990-2016. The standardized index accounts for annual sampling distribution shifts with respect to covariates that affect catch of Vermilion Snapper in chevron traps.

Also provided are annual age compositions of Vermilion Snapper captured by chevron trap. This information is critical at informing the selectivity pattern at age of Vermilion Snapper by chevron traps.

Data presented in this report are based on the combined SERFS database accessed on January 06, 2017.

Methods

Survey Design and Gear
(see Smart et al. 2015 for full description)

Sampling area

- Cape Hatteras, NC, to St. Lucie Inlet, FL
  - General increase in sampling intensity (# of annual chevron trap deployments) through time
  - Gradual shift regarding the spatial coverage of samples through time
    - More geographic coverage in southern and northern latitudes in later years
- Sampling depths range from 13 to 218 m
  - Generally less than 100 m

Sampling season

- May through September
  - Limited earlier and later sampling in some years

Survey Design

- Simple random sample survey design
  - Annually, randomly selected stations from a chevron trap universe of confirmed live-bottom and/or hard-bottom habitat stations
  - No two stations are randomly selected that are closer than 200 m from each other
    - Minimum distance is typically closer to 400 m
- Traps deployed on suspected live-bottom and/or hard-bottom in a given year (reconnaissance) are evaluated based on catch and/or video or photographic evidence of bottom type for inclusion in the universe in subsequent years
  - If added to the known habitat universe, data from the reconnaissance deployment is included in index development

Sampling Gear – Chevron Traps

(see Collins 1990 and MARMAP 2009 for descriptions that are more complete)

- Arrowhead shaped, with a total interior volume of 0.91 m^3
- Constructed of 35 x 35 mm square mesh plastic-coated wire with a single entrance funnel ("horse neck")
- Baited with a combination of whole or cut clupeids (*Brevoortia* or *Alosa* spp., family Clupeidae), with *Brevoortia* spp. most often used
  - Four whole clupeids on each of four stringers suspended within the trap
  - Approximately 8 clupeids placed loose in the trap
- Soak time of approximately 90 minutes

Oceanographic Data

- Hydrographic data collected via CTD during soaking of a "set" (typically 6 traps, but may be less) of chevron traps deployed at the same time
  - Bottom temperature (^oC) is defined as the temperature of the deepest recording within 5 m of the bottom

Data Filtering/Inclusion

Chevron trap data (Gear = 324) were limited to:

- Projects conducting monitoring efforts
  - P05 – MARMAP
  - T59 – SEAMAP-SA Reef Fish Complement
  - T60 – SEFIS
- Reef fish monitoring samples
  - Data source ≠ "Tag-MARMAP" – represents special historic MARMAP cruises that were used to tag various species of fish

        - Because standard sampling procedures were not used (e.g. not all fish were measured for length frequency) these samples are excluded from index development
- Traps that fished properly (i.e., appropriate catch IDs)
    - 0 – no catch
    - 1 – catch with finfish
    - 2 – catch without finfish
    - 8 - Species catch subsampled for Length Frequency
- Traps on live-bottom and/or hard-bottom habitat (i.e., appropriate station types)
    - Random –randomly-selected live-bottom stations
    - NonRandom – non-randomly sampled live-bottom station (a.k.a haphazard or opportunistic sample)
    - ReconConv – reconnaissance deployments that were subsequently converted into live-bottom chevron trap stations
    - Null – traps for which there is no station code value
        - Use of station codes is fairly new, with MARMAP historically using only the catch ID (see above) to indicate randomly-selected stations
    - N/A - Station type not assigned
    - Monitoring - Station whose sampling selection (random, nonrandom) is not known, but is part of overall station universe
- Traps with soak times that were neither extremely short nor long which often indicates an issue with the deployment not captured elsewhere (included 45-150 minutes)
    - SERFS targets a soak time of 90 minutes for all chevron trap deployments
- For Vermilion Snapper specifically, only the depths at which Vermilion Snapper have ever been captured by any of the monitoring programs (included 10-104 m)
- Excluded any chevron trap samples missing covariate information
- Excluded all traps sampled prior to 1990

Standardized Index Model Formulation

Model Basics

- Response variable – Catch/Trap hour (CPUE)
- Dependent variables
    - Year
    - Covariates
        - Depth, latitude (^{o}N), bottom temperature (^{o}C), and season
            - Summary of covariate bins and inclusion in sub-models available Table 1
- Model structure – Delta GLM
- Annual year effect coefficients of variation (CVs) and standard errors (SE) computed using bootstrapping
- Software used
    - R (Version 3.1.0; R Development Core Team 2014)

Age Composition

- Aging methods – sagittal otoliths were removed from Vermilion Snapper to serve as the aging structure
  - Ages presented here are calendar age based on increment counts with an estimated increment formation on September 1
  - Only fish with age samples taken are included in the age compositions
  - Prior to 2008, selection of fish retained for aging were sub-sampled based on length bins. From 2008 and on, selection of fish retained for aging was either complete (100% retained) or randomly sub-sampled. To correct age compositions prior to 2008, we corrected the number of fish in each age bin based on the abundance and length frequency in each trap according to the method developed for SEDAR 25 Black Sea Bass (Ballenger et al., 2011)

Results

Sampling Summary

A total of 14,713 chevron trap samples from 1990-2016 were retained and used in the development of the relative abundance index (Table 2)

- Proportion of traps positive for Vermilion Snapper averaged 0.275 per year
- On average 1,370 Vermilion Snapper caught annually from which age estimates were obtained

Model Selection

(see Table 3)

Final Index

(see Table 4 and Figure 1)

Diagnostics

- Residuals of covariates available in Figures 2 and 3

Age Composition

- Age composition by numbers and percentages in Tables 5 and 6, respectively

References

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R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

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Tables

Table 1: Delta-GLM covariates (and bins used) used in the development of standardized chevron trap CPUE indices. Only species for which delta-GLM standardized CPUE indices based on chevron trap catches are included.

				Bin #						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
				Latitude (°N)						
<=29	30	31	32	33	>=34					
				Depth (m)						
<20	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-69	>=70
				Bottom Temperature (°C)						
<=20	21-25	>25								
				Season						
Spring (April – June)	Summer (July – October)									

Table 2: Number of chevron trap collections made by the MARMAP/SERFS fishery-independent reef fish surveys, the number of included collections in the index development, and the average and range of the covariates depth, temperature, and latitude encountered by year. Please note that the SEAMAP-SA Reef Fish and SEFIS fishery-independent research projects did not begin until 2009 and 2010, respectively.

			Depth (m)		Temperature (°C)		Latitude (°N)		Date	
Year	Total Collections	Included Collections	Avg	Range	Avg	Range	Avg	Range	Avg	Range
1990	354	313	33.9	17-93	22	18.2-27.8	32.4	30-34	5/28	4/23-8/9
1991	305	272	34.1	17-95	24.9	15.9-27.5	32.62	31-35	8/3	6/11-9/24
1992	324	288	34	17-62	21.3	15.3-24.5	32.74	30-34	6/2	3/31-8/13
1993	542	392	34.9	16-94	22.8	17.7-28.5	32.34	30-34	6/23	5/10-8/13
1994	468	390	39.1	16-93	22.8	18.1-26.9	32.27	31-34	6/23	5/9-10/26
1995	545	383	32.9	16-60	24.5	20.1-28.3	31.86	30-34	7/21	5/3-10/25
1996	642	361	38.2	14-100	22	14.2-27	32.28	28-34	7/4	4/29-9/16
1997	533	401	39.5	15-97	22.8	16.8-28	31.95	28-35	7/11	5/5-9/29
1998	523	426	39.6	14-92	21.5	9.5-28.6	32.02	27-35	6/26	5/5-8/18
1999	347	215	36.8	15-75	22.9	17.9-28.8	31.68	27-34	7/20	6/2-9/28
2000	383	299	36.3	15-101	23.9	18-28.5	32.22	29-34	7/18	5/16-10/19
2001	325	252	37.8	14-91	23.5	16-29.2	32.29	28-34	7/24	5/23-10/24
2002	336	244	37.7	13-94	24.2	15.2-28.3	31.85	28-34	7/25	6/17-9/24
2003	286	224	39.8	16-92	18.9	13.4-25.1	32.04	27-34	7/21	6/3-9/22
2004	341	282	40.6	14-91	20.9	16.7-25.8	32.2	29-34	6/22	5/5-10/28
2005	357	315	37.6	15-69	22.9	18-28.5	32	27-34	7/13	5/3-10/19
2006	332	297	38.1	15-94	22.4	15-26.6	32.22	27-34	7/20	6/6-9/28
2007	361	337	38	15-92	23.2	15.3-28.9	32.13	27-34	7/18	5/21-9/24
2008	354	303	38	15-92	21.9	15.2-27.2	32.13	27-35	7/11	5/5-9/30
2009	464	404	36.3	14-91	22.6	15.4-27.2	32.19	27-35	7/21	5/6-10/8
2010	1051	705	38.5	14-92	22.1	12.3-29.4	31.44	27-35	8/6	5/4-10/27
2011	1014	699	40.5	14-93	21.6	14.8-28.8	30.88	27-35	7/27	5/19-10/26
2012	1393	1153	40.5	15-98	22.1	12.9-27.8	31.88	27-35	7/12	4/24-10/10
2013	1561	1360	38.2	15-100	22.1	12.4-28.1	31.25	27-35	7/15	4/24-10/4
2014	1520	1470	39.2	15-103	23.4	16.1-29.3	31.91	27-35	7/10	4/23-10/21
2015	1523	1448	39.1	16-104	22.6	13.6-28.4	31.87	27-35	7/4	4/21-10/22
2016	1537	1480	40.6	17-104	23.9	15.5-29.3	32.11	27-35	8/3	5/4-10/26

Table 3: Summary of the backwards selection of covariates from Bernoulli Sub-model and Lognormal Sub-model, including degrees of freedom, deviance, and Akaike's Information Criteria (AIC) values for Vermilion Snapper.

Removed	df	Deviance	AIC
Bernoulli Sub-model			
<none>		13852	13972
season	1	13932	14020
temperature	2	13989	14075
latitude	5	14450	14530
depth	10	14824	14894
Lognormal Sub-Model			
season	1	5231.6	11445
<none>		5230.4	11446
latitude	5	5285.8	11473
temperature	2	5282.7	11477
depth	10	5418.9	11550

Table 4: Chevron trap nominal CPUE and Delta-GLM standardized CPUE for Vermilion Snapper and information associated with chevron trap sets included in standardized CPUE calculation. Both indices were normalized to the long-term average. CV = coefficient of variation, Positive = proportion of included collections positive for the species of interest, n = number of collections which captured individuals, Normalized = CPUE (number of fish*trap-1*hr-1) normalized to its mean value over the time series, and the lower and upper 95% confidence intervals (CI) calculated from the normalized standard error.

	Nominal CPUE			Delta-GLM Standardized CPUE						
Year	CPUE	CV	Normalized	Positive	n	CPUE	CV	Normalized	Lower CI	Upper CI
1990	1.13	0.20	0.51	0.27	86	0.55	0.18	0.54	0.35	0.73
1991	7.28	0.13	3.26	0.52	142	3.44	0.15	3.36	2.37	4.35
1992	3.29	0.20	1.48	0.36	105	1.14	0.17	1.11	0.73	1.49
1993	2.05	0.12	0.92	0.32	126	1.31	0.14	1.28	0.93	1.64
1994	5.12	0.11	2.30	0.45	175	2.44	0.14	2.38	1.74	3.02
1995	2.81	0.13	1.26	0.35	135	1.72	0.15	1.68	1.20	2.16
1996	4.17	0.20	1.87	0.34	121	1.14	0.17	1.11	0.73	1.49
1997	2.03	0.22	0.91	0.24	96	0.72	0.18	0.71	0.46	0.96
1998	1.66	0.18	0.75	0.26	110	0.71	0.16	0.69	0.47	0.92
1999	1.93	0.19	0.87	0.33	70	1.10	0.2	1.08	0.66	1.49
2000	3.47	0.16	1.56	0.35	104	1.45	0.18	1.41	0.91	1.92
2001	3.00	0.20	1.34	0.33	83	1.35	0.18	1.32	0.85	1.78
2002	3.99	0.15	1.79	0.42	102	1.95	0.17	1.91	1.26	2.55
2003	0.43	0.26	0.19	0.14	31	0.45	0.25	0.44	0.22	0.66
2004	0.77	0.18	0.34	0.24	67	0.65	0.18	0.63	0.41	0.85
2005	1.41	0.20	0.63	0.25	79	0.68	0.18	0.66	0.43	0.90
2006	0.76	0.23	0.34	0.18	54	0.40	0.21	0.39	0.23	0.56
2007	2.34	0.19	1.05	0.24	80	1.02	0.19	0.99	0.63	1.36
2008	2.17	0.18	0.97	0.24	74	0.96	0.2	0.94	0.57	1.31
2009	2.32	0.18	1.04	0.24	97	1.03	0.18	1	0.65	1.36
2010	1.84	0.14	0.83	0.27	187	0.59	0.14	0.58	0.43	0.73
2011	1.70	0.15	0.76	0.2	137	0.61	0.15	0.59	0.42	0.76
2012	0.56	0.13	0.25	0.15	171	0.34	0.12	0.33	0.25	0.41
2013	0.52	0.15	0.23	0.13	178	0.21	0.13	0.21	0.16	0.26
2014	0.6	0.13	0.27	0.15	222	0.29	0.11	0.28	0.22	0.34
2015	0.9	0.12	0.4	0.2	288	0.50	0.11	0.48	0.38	0.59
2016	1.91	0.09	0.86	0.26	387	0.92	0.1	0.9	0.73	1.07

Table 5: Age composition of Vermilion Snapper collected by the MARMAP/SERFS chevron trap survey from 1990-2016. Ages are calendar ages and composition is in number of fish in each year corresponding to a given age. The total number of fish per year (Fish) and the number of traps which caught fish that had age samples taken (Traps) are also included.

	Year																										
Age	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	1	1	1
1	0	4	0	8	0	0	33	0	18	15	99	76	46	20	4	67	57	35	6	0	7	1	5	7	109	20	83
2	110	536	190	378	1335	392	645	575	562	321	602	501	708	90	67	217	73	761	161	117	39	42	84	46	190	448	412
3	280	1322	140	352	862	623	637	395	338	190	654	255	454	79	150	143	102	136	313	287	279	93	81	131	81	340	485
4	343	490	450	134	682	349	975	255	127	85	131	336	227	42	76	199	61	72	42	336	130	469	43	69	170	136	365
5	40	393	276	218	293	203	301	377	67	23	126	115	255	17	51	77	81	67	28	29	106	185	170	41	109	375	148
6	35	99	172	94	208	59	338	95	98	37	45	48	73	22	24	40	22	119	39	31	15	74	46	120	73	161	228
7	16	111	64	77	98	70	86	132	45	52	36	24	32	2	20	14	11	49	51	39	12	36	55	26	210	156	98
8	10	64	35	35	78	46	100	12	67	26	41	23	21	2	10	24	4	14	26	71	11	18	4	23	96	282	113
9	4	46	6	23	25	28	36	31	22	18	17	14	11	0	2	1	5	5	6	42	8	20	7	4	42	87	168
10	4	10	11	8	15	12	29	17	14	8	11	3	5	0	2	2	0	12	3	7	3	20	6	3	5	40	44
11	1	2	0	9	1	8	8	2	13	2	8	6	1	1	2	1	0	4	1	6	1	7	4	0	5	17	22
12	0	0	1	0	4	4	2	6	10	1	2	3	0	0	2	0	0	0	0	5	0	1	3	2	7	3	4
13	0	2	0	3	3	0	0	1	0	3	0	0	0	1	1	2	0	0	0	3	0	1	3	0	3	5	1
14	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Fish	843	3079	1345	1339	3604	1795	3191	1898	1381	781	1772	1404	1833	276	411	791	416	1274	676	973	611	967	511	472	1103	2072	2174
Traps	108	153	111	128	177	135	170	119	113	80	114	95	121	41	70	80	57	83	70	85	114	115	140	107	165	295	394

Table 6: Age composition of Vermilion Snapper collected by the MARMAP/SERFS chevron trap survey from 1990-2016. Ages are calendar ages and composition is in percentage of fish in each year corresponding to a given age. The total number of fish per year (Fish) and the number of traps which caught fish that had age samples taken (Traps) are also included.

	Year																										
Age	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
1	0.0	0.1	0.0	0.6	0.0	0.0	1.0	0.0	1.3	1.9	5.6	5.4	2.5	7.3	1.0	8.5	13.7	2.8	0.9	0.0	1.2	0.1	1.0	1.5	9.9	1.0	3.8
2	13.1	17.4	14.1	28.2	37.0	21.8	20.2	30.3	40.7	41.1	34.0	35.7	38.6	32.6	16.3	27.4	17.6	59.7	23.8	12.0	6.4	4.3	16.4	9.8	17.2	21.6	19.0
3	33.2	42.9	10.4	26.3	23.9	34.7	20.0	20.8	24.5	24.3	36.9	18.2	24.8	28.6	36.5	18.1	24.5	10.7	46.3	29.5	45.7	9.6	15.9	27.8	7.3	16.4	22.3
4	40.7	15.9	33.5	10.0	18.9	19.4	30.6	13.4	9.2	10.9	7.4	23.9	12.4	15.2	18.5	25.2	14.7	5.7	6.2	34.5	21.3	48.5	8.4	14.6	15.4	6.6	16.8
5	4.7	12.8	20.5	16.3	8.1	11.3	9.4	19.9	4.9	2.9	7.1	8.2	13.9	6.2	12.4	9.7	19.5	5.3	4.1	3.0	17.4	19.1	33.3	8.7	9.9	18.1	6.8
6	4.2	3.2	12.8	7.0	5.8	3.3	10.6	5.0	7.1	4.7	2.5	3.4	4.0	8.0	5.8	5.1	5.3	9.3	5.8	3.2	2.5	7.7	9.0	25.4	6.6	7.8	10.5
7	1.9	3.6	4.8	5.8	2.7	3.9	2.7	7.0	3.3	6.7	2.0	1.7	1.8	0.7	4.9	1.8	2.6	3.9	7.5	4.0	2.0	3.7	10.8	5.5	19.0	7.5	4.5
8	1.2	2.1	2.6	2.6	2.2	2.6	3.1	0.6	4.9	3.3	2.3	1.6	1.2	0.7	2.4	3.0	1.0	1.1	3.9	7.3	1.8	1.9	0.8	4.9	8.7	13.6	5.2
9	0.5	1.5	0.5	1.7	0.7	1.6	1.1	1.6	1.6	2.3	1.0	1.0	0.6	0.0	0.5	0.1	1.2	0.4	0.9	4.3	1.3	2.1	1.4	0.9	3.8	4.2	7.7
10	0.5	0.3	0.8	0.6	0.4	0.7	0.9	0.9	1.0	1.0	0.6	0.2	0.3	0.0	0.5	0.3	0.0	0.9	0.4	0.7	0.5	2.1	1.2	0.6	0.5	1.9	2.0
11	0.1	0.1	0.0	0.7	0.0	0.5	0.3	0.1	0.9	0.3	0.5	0.4	0.1	0.4	0.5	0.1	0.0	0.3	0.2	0.6	0.2	0.7	0.8	0.0	0.5	0.8	1.0
12	0.0	0.0	0.1	0.0	0.1	0.2	0.1	0.3	0.7	0.1	0.1	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5	0.0	0.1	0.6	0.4	0.6	0.1	0.2
13	0.0	0.1	0.0	0.2	0.1	0.0	0.0	0.1	0.0	0.4	0.0	0.0	0.0	0.4	0.2	0.3	0.0	0.0	0.0	0.3	0.0	0.1	0.6	0.0	0.3	0.2	0.1
14	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Fish	843	3079	1345	1339	3604	1795	3191	1898	1381	781	1772	1404	1833	276	411	791	416	1274	676	973	611	967	511	472	1103	2072	2174
Traps	108	153	111	128	177	135	170	119	113	80	114	95	121	41	70	80	57	83	70	85	114	115	140	107	165	295	394

Figures

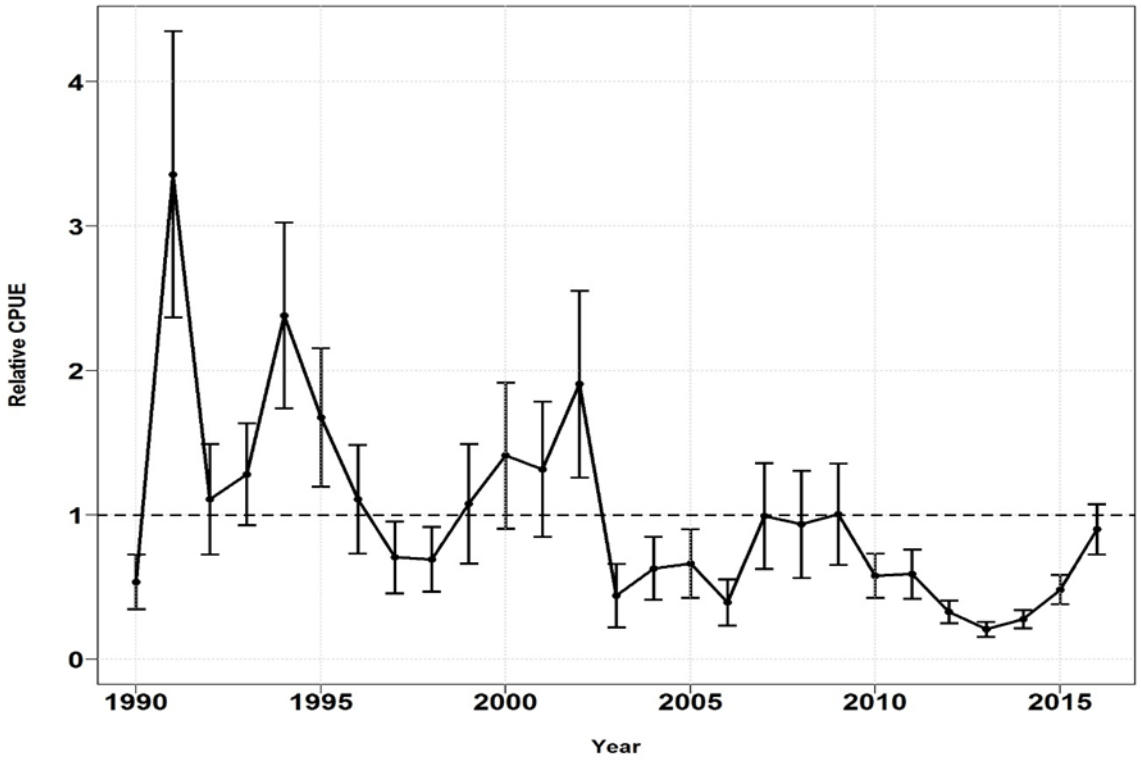

Figure 1: Chevron trap normalized Delta-GLM standardized CPUE (error bars = 95% CI) for Vermilion Snapper from 1990 - 2016. The dotted line represents the mean value for the time series.

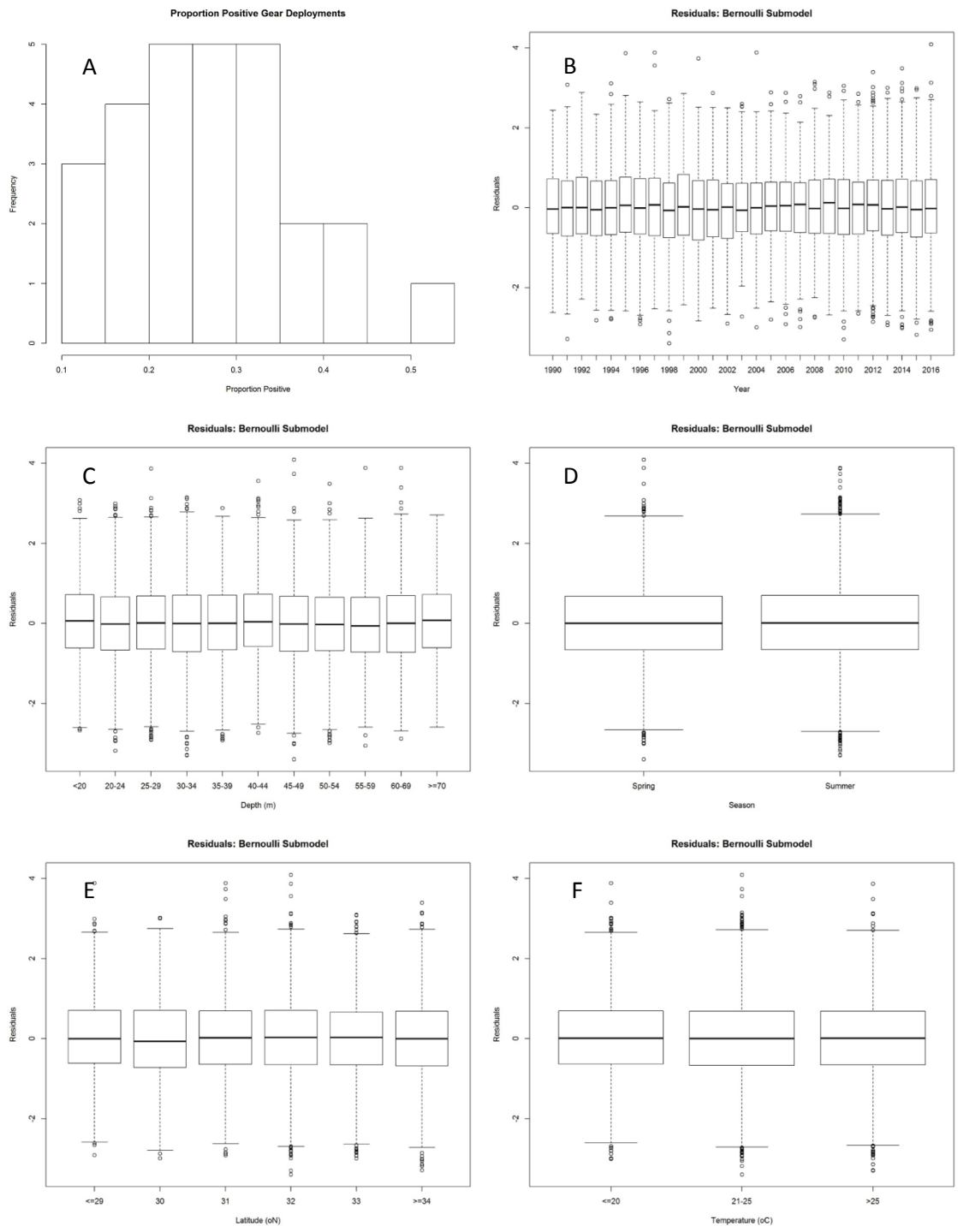

Figure 2: Diagnostic plots for the Bernouli submodel of the Delta-GLM standardized chevron trap CPUE index of Vermillion Snapper. A) Frequency of proportion positive trap sets over the time series and residuals are plotted for the covariates B) Year; C) Depth; D) Season; E) Latitude; F) Temperature.

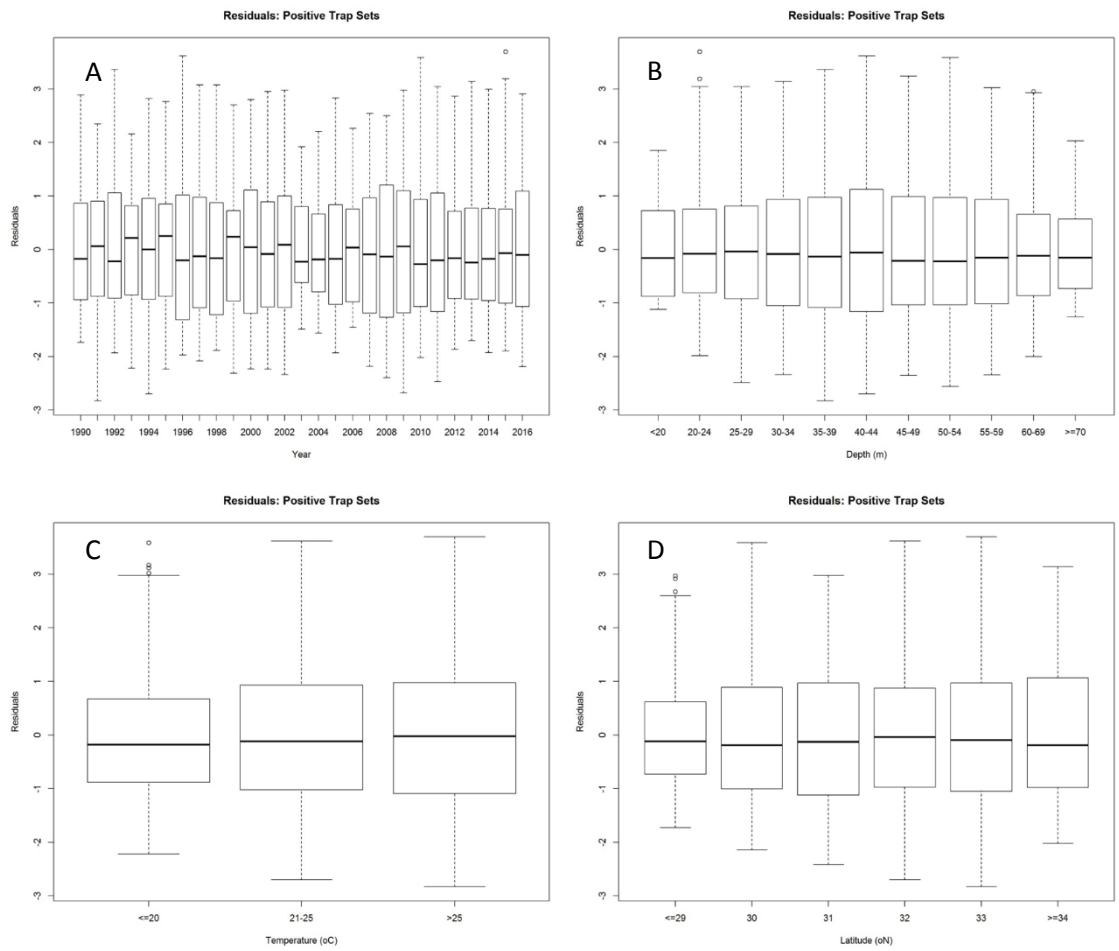

Figure 3: Diagnostic plots for positive trap sets of the Delta-GLM standardized chevron trap CPUE index of Vermillion Snapper. Residuals are plotted for the covariates A) Year; B) Depth; C) Temperature; D) Latitude.