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Fisheries-independent data for Yellowtail Snapper (*Ocyurus chrysurus*) from reef-fish visual surveys in the Florida Keys and Dry Tortugas, 1999-2016.

Jennifer Herbig[1], Jeffrey Renchen[2], Alejandro Acosta[1]

[1]Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 2796 Overseas Highway, Suite 119, Marathon, FL 33050

[2]Florida Fish and Wildlife Conservation Commission, Farris Bryant Building, 620 S. Meridian St. 620, Tallahassee, FL, 32399

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Introduction:

The Florida Keys Reef ecosystem is one of the longest reefs in the world, stretching approximately 380 km from South Miami to the Dry Tortugas (Ault et al. 2006). This reef ecosystem is home to over 400 species of fish which support lucrative fisheries and tourism industries (Ault et al. 2005). To successfully manage this valuable resource, the reef visual census (RVC) was implemented in 1979 in the Florida Keys, Florida to monitor and provide long term data for reef fish populations in south Florida (Bohnsack et al. 1999). Surveys for the Dry Tortugas, Florida were implemented in 1999. The RVC is a multi-agency initiative that conducts underwater surveys with trained scientific divers that record abundance and size data of reef fishes in shallow water habitats (0-30m). Data from the RVC can be used to estimate abundance indices important for stock assessments. Therefore, these data were used to provide abundance indices for Yellowtail Snapper in the Florida Keys and the Dry Tortugas.

Methods:

Visual surveys in the Florida Keys (Biscayne National Park to Key West) and Dry Tortugas regions were typically conducted from May through October. Reef visual census (RVC) sites were focused on shallow water (<30m) hard bottom habitat and were chosen based on a two-stage stratified random sampling design. From 1999-2012, the hardbottom habitat of the Florida Keys and the Dry Tortugas was divided into 200x200m grid cells, or primary sampling units (PSUs), and assigned a habitat stratum based on depth, protection (open or closed to fishing), habitat type, and geographic sub-region (lower, middle, or upper Keys) (Brandt et al. 2009). After 2012, sampling was conducted biennially, and the PSUs were divided into 100x100m grids due to increasing accuracy in benthic habitat maps. The habitat strata in the Florida Keys were defined as inshore patch reef, mid-channel patch reef, offshore patch reef, high-relief reef, shallow forereef, mid-forereef, and deep forereef (Fig 1). Since there is not an inshore to offshore progression in the Dry Tortugas, habitat strata were defined as continuous low-relief reef, continuous mid-relief reef, continuous high-relief reef, isolated low-relief reef, isolated mid-relief reef, isolated high-relief reef, spur and grove low-relief reef, and spur and groove high-relief reef (Fig 2). The number of PSUs sampled in each stratum was based on the area of each strata within the sampling region and variance in abundance (Smith et al. 2011). Strata with higher variance were allocated more samples to increase survey accuracy. Once the estimated number of PSUs needed to achieve a 20% coefficient of variation (CV) were allocated to each stratum, PSUs were randomly chosen from the sampling domain.

Within each PSU, two secondary sampling units (SSUs) were selected based on the location of hard bottom habitat. At each SSU, a pair of divers would secure a GPS marker, swim 7.5m in opposite directions, and conduct their stationary point counts within an imaginary cylinder of water with a 7.5 m radius. Each point count survey recorded the abundance and lengths of fish species present and basic benthic demographics. Since diver cylinders at SSUs were adjacent and sometimes overlapped, the counts were not independent and were averaged for each SSU.

For this report, data from RVC surveys from 1999-2016 were used. Fish surveys have been collected in the Florida Keys from 1979-2016, however the methods outlined above were implemented in 1999 and have been consistently used since then. In addition, before the two-stage stratified random sampling design and the increased stratification, there was much higher variability in survey estimates (O'Hop et al. 2012). Data from the 1999-2016 surveys were used to estimate occurrence, occupancy, density, abundance, and length frequencies for the Florida Keys (Biscayne Bay through Key West) and the Dry

Tortugas. Occurrence was calculated as the percent of SSUs where Yellowtail Snapper was present. Occupancy was calculated as the weighted average of the strata occurrence. Density (fish/cylinder) was calculated by taking the average density per PSU, calculating a stratum density by averaging the PSU densities in that stratum, and calculating the final population density (within the sampling domain) by summing the weighted stratum densities. Stratum densities were weighted by the number of PSUs found within each stratum. The abundance estimates were extrapolated from the densities by multiplying the densities for each stratum by the number of PSUs per stratum and the number of SSUs possible in a PSU. More in-depth information about sampling design and analysis can be found in Ault et al. (2002, 2005, 2006), Brandt et al. (2009), and Smith et al. (2011).

Results/Discussion:

The Florida Keys were sampled yearly from 1999-2012, after which they were sampled biennially. During this time 5196 PSUs were sampled from Biscayne Bay to the Marquesas (Fig 3, Table 1). Except for the 2004 sampling year (when several hurricanes caused interruptions of the survey schedule), the minimum number of surveys were conducted within each of the strata for a representative sample of the fish community. Two strata (inshore patch reef and mid-channel patch reef) were not sampled in 2004. Therefore, data from 2003 and 2005 were averaged and used as a proxy for the missing strata values for 2004.

Occupancy for the Florida Keys was lower during the earlier time series (1999-2004) but increased for the remainder of the time series (Fig 4). In 2010, there was a cold front that was one of the longest and coldest events in the recorded history of the Florida Keys (Colella et al. 2012). This cold front was responsible for fish kills throughout the Keys and may have contributed to the decline in occurrence of Yellowtail Snapper (Fig 4). When occupancy was divided into occurrence by strata, adult fish (≥ 19cm FL) had their highest average occurrence at high relief reef and the deeper forereef (Fig 5), suggesting that adult Yellowtail Snapper may prefer this kind of habitat. Juvenile Yellowtail Snapper (<19cm FL) occurred more often at patch reef habitat (inshore to offshore) and high relief reef than forereef habitat (Fig 5).

Density of Yellowtail Snapper in the Florida Keys varied throughout the time series (Fig 6, Table 1). In general, the density of juvenile fish was higher than the density of adult fish (Fig 6, Table 1). Yellowtail Snapper is an important recreational and commercial fishery in the Florida Keys, which most likely reduces the adult density. In 2004, the decline in density could have been because fewer sites were sampled due to weather (Table 1, Fig 6). Since abundance is extrapolated from density, it followed the same pattern as density (Fig. 7, Table 2).

A breakdown of the recorded Yellowtail Snapper lengths in the Florida Keys suggested that there was some digit bias with multiples of five having higher counts (Fig 8). Binning lengths by 5cm bins would have included juvenile and adult fish in the same bins. Therefore, fish lengths were binned by 1cm for length frequency (Fig 9). The abundance of young of year Yellowtail Snapper (<10cm FL) was low throughout the time series (Table 3, Fig 9), mostly likely because these fish prefer seagrass habitat which is not surveyed in the RVCs.

The Dry Tortugas were sampled from 1999-2000, and then biennially beginning in 2004. During this time frame 2,691 PSUs were sampled (Fig 10, Table 4). Occupancy in the Dry Tortugas was higher throughout the time series than it was the in the Florida Keys (Fig 11). This could be due to its almost

pristine habitat and its remote location, which makes it more difficult for stakeholders to access. In addition, the Dry Tortugas is made up of a network of large marine reserves (Fig 10) which were established at different times throughout the time frame of these surveys. These reserves are closed to fishing or have limited fishing and most likely contributed to the continued increase in occupancy.

Unlike the Florida Keys, when occupancy was divided into occurrence by strata, both juvenile and adults had lower occurrence at high-relief spur and groove habitat (Fig 12). Yellowtail Snapper were also less frequently observed at continuous and isolated mid-relief habitats. Instead, they occurred more frequently at continuous and isolated high and low-relief reef habitat (Fig 12).

Density in the Dry Tortugas increased throughout the time series and was approximately two times greater in 2016 than in 1999 (Fig 13, Table 4). During several years, the density of adult snapper was greater than or approximately equal to juvenile snapper density. This could be because the larger fish, which are typically removed from the population in the Florida Keys, are protected in the Dry Tortugas. In addition, this added protection for larger fish may mean higher rates of predation on juvenile Yellowtail Snapper. Since abundance is extrapolated from density, it showed a similar trend to density throughout the time series (Fig 14, Table 5).

A breakdown of the recorded Yellowtail Snapper lengths in Dry Tortugas was similar to the Florida Keys and suggested that there was some digit bias with multiples of five (Fig 15). Therefore, for length frequency fish lengths were binned by 1cm (Fig 16). Similar to the Florida Keys, the RVC surveys in Dry Tortugas failed to capture the young of year Yellowtail Snapper (Table 6, Fig 16) most likely because these surveys focus on hardbottom habitat.

A comparison of the length frequencies between the Dry Tortugas and the Florida Keys during the most recent years (2012-2016), highlights the difference in the size structure between these two areas (Fig 17). The Florida Keys has a higher proportion of juvenile fish (< 19 cm) while the Dry Tortugas has a higher proportion of adult fish. It could be that the Florida Keys has more seagrass habitat for juvenile fish or it could be due to the different exploitation rate in the two areas.

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Table 1. The number of PSUs surveyed and the average densities (Yellowtail Snapper per cylinder) and their variance estimates by year for the Florida Keys.

Year	Number of PSU	Average Density	Average Density SE	Average Density CV (%)	Average Adult Density	Average Adult Density SE	Average Adult Density CV (%)	Average Juvenile Density	Average Juvenile Density SE	Average Juvenile Density CV (%)
1999	161	2.99	0.56	18.8	1.16	0.35	30.2	1.83	0.31	17.2
2000	221	3.70	0.42	11.4	1.33	0.22	16.9	2.37	0.31	13.1
2001	305	3.65	0.42	11.7	1.80	0.27	14.9	1.85	0.26	14.1
2002	343	4.94	0.74	14.9	1.72	0.31	18.1	3.22	0.59	18.5
2003	237	3.01	0.35	11.5	1.23	0.20	16.3	1.78	0.24	13.3
2004	127	2.66	0.43	16.2	1.34	0.35	26.0	1.32	0.24	17.9
2005	243	5.10	0.65	12.7	1.39	0.22	16.1	3.71	0.58	15.5
2006	319	4.75	0.81	17.1	1.70	0.60	35.4	3.05	0.43	14.0
2007	316	3.98	0.35	8.8	1.71	0.17	9.7	2.27	0.27	11.7
2008	376	5.47	0.43	7.8	2.32	0.25	11.0	3.16	0.26	8.1
2009	516	4.51	0.34	7.6	1.36	0.14	10.2	3.16	0.29	9.1
2010	379	3.62	0.51	14.0	1.29	0.29	22.6	2.32	0.34	14.5
2011	401	3.98	0.48	12.1	2.01	0.40	19.8	1.97	0.20	10.0
2012	416	4.69	0.43	9.1	1.68	0.25	15.0	3.01	0.31	10.3
2014	431	4.93	0.92	18.7	2.17	0.81	37.5	2.76	0.36	13.2
2016	405	4.85	0.60	12.4	2.04	0.42	20.4	2.82	0.33	11.6

Table 2. The extrapolated abundance estimates and their standard errors for Yellowtail Snapper in the Florida Keys.

Year	Abundance	Abundance SE	Adult Abundance	Adult Abundance SE	Juvenile Abundance	Juvenile Abundance SE
1999	11403698	2146743	4421116	1336798	6982582	1200430
2000	14127822	1607770	5073550	855960	9054272	1189624
2001	13922376	1621900	6871162	1022098	7051214	995378
2002	18856690	2812047	6559297	1189468	12297393	2270478
2003	11496521	1324596	4682796	761457	6813725	907393
2004	10146206	1646142	5101290	1326306	5044916	900863
2005	19474231	2474734	5320227	855314	14154004	2199984
2006	18152712	3101319	6507858	2301440	11644854	1628116
2007	15212570	1339088	6535673	636634	8676897	1013608
2008	20898301	1627043	8844537	968837	12053764	981468
2009	17225124	1306041	5177191	528239	12047932	1095830
2010	13815745	1931444	4940525	1115713	8875220	1288690
2011	15197230	1832585	7689764	1519398	7507466	747072
2012	17897189	1628422	6399773	957110	11497416	1183850
2014	18972606	3549077	8342734	3126655	10629872	1404421
2016	18694398	2312752	7852127	1603073	10842271	1257273

Table 3. The survey-estimated abundance (Abund.) of Yellowtail Snapper per 1cm length bins in the Florida Keys.

Length Bin	Abund. 1999	Abund. 2000	Abund. 2001	Abund. 2002	Abund. 2003	Abund. 2004	Abund. 2005	Abund. 2006	Abund. 2007	Abund. 2008	Abund. 2009	Abund. 2010	Abund. 2011	Abund. 2012	Abund. 2014	Abund. 2016
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	65111	0	12579	1491	0	0	0	0	0
2	247	12401	1951	0	0	0	33658	494	421	6413	7727	16007	319	11972	7909	0
3	1304	10986	18466	0	27265	3281	0	13621	64283	57736	60787	14174	15048	17060	1507	28149
4	92459	6201	101059	10096	29184	97583	32019	13645	9859	51567	150752	59984	75391	95598	38975	63127
5	273253	38022	154564	25116	78623	184534	109569	83739	225769	125879	415300	136616	75653	173335	138582	337188
6	161862	106664	231345	160025	258023	376352	520813	876881	93990	211127	416258	125979	99148	671587	522990	492922
7	97330	176687	201740	367446	133182	109097	543707	369496	96025	316625	416143	82163	201291	552714	643807	788900
8	366942	558914	242044	1041083	341326	372187	1082344	1160184	144603	394053	901327	148958	359462	693515	765591	784621
9	467026	390086	365186	921622	346748	305192	588639	641606	182043	339451	704259	63445	255793	626299	631934	519493
10	336831	1107224	898916	928147	765781	411735	1249105	1480984	399253	912947	1251624	416185	327414	1253235	834865	665393
11	310620	583725	287580	578088	250240	513372	396901	170489	457801	605390	426098	193946	299046	580187	766570	438999
12	539801	936503	517200	1772798	573614	757258	1248304	864981	973200	1221354	1153812	623538	526116	1010226	784592	720332
13	421062	952342	517793	1255160	470032	64438	1646500	817278	548300	1048843	779649	663702	252020	595308	788950	458527
14	705388	850122	821320	710914	647541	248092	1116648	686785	1034472	1028837	1044571	845546	671870	854977	775379	799675
15	1004370	1511912	790171	1688381	1090537	733771	2278663	1945386	1683761	1935165	1994513	1627225	1378804	1226050	1581938	1187285
16	777568	656413	872446	785704	600260	285878	1251685	474497	1040866	892494	784357	1299535	1022155	840948	870302	1325913
17	590343	410629	329370	957351	491759	310716	1151103	940969	824625	973561	783960	1198265	710453	922977	694234	1126704
18	836176	745443	700061	1095461	709610	205484	904347	1038708	897626	1919745	755304	1359952	1237482	1371428	781747	1105043
19	606878	197612	292361	242682	271583	37887	305151	359797	320235	650526	418256	554957	787816	641373	859163	1047966
20	1421994	1436298	1450855	2250550	1323426	560986	1851560	1444545	1163759	1728776	1079586	1454365	1536825	1343673	972053	2013905
21	386551	145738	49086	196988	197638	82764	248919	141671	128079	372428	226563	102307	896316	435800	442983	648017
22	365048	260794	148203	410613	214606	96065	460953	356976	471160	818568	477304	377048	899870	667789	807460	782731
23	538623	296668	335082	431980	410367	395260	589650	690895	321738	600908	498051	553253	770469	442710	525494	1129739
24	150517	213450	153605	225608	259321	204433	273353	142331	344081	631757	364290	295108	393842	364269	499755	438062
25	448780	754404	797568	744547	811169	705943	650829	1891910	1046799	999141	493083	625517	1017472	406483	277810	368565
26	135437	70648	252191	208698	31949	62684	161438	67132	207962	374365	159851	63606	274123	287302	325110	367981
27	31647	56965	71211	432205	272329	77043	108148	86766	335657	437851	278520	96730	152304	175849	291939	186951
28	70219	467515	613619	117741	125402	396889	268942	856252	505019	603893	364012	146580	442610	319878	156133	236483
29	55923	36709	63624	187667	47917	166507	107097	72715	235852	291185	127931	1546	88137	57325	136212	49223
30	81653	573549	646595	248092	274677	437955	200900	177427	439578	566985	300274	449018	241920	408206	684535	202301
31	6195	83414	175099	24989	24995	7998	13442	1163	87568	135129	156742	4733	29358	71511	1254974	32115
32	6189	249336	187076	141788	102625	18910	15927	91856	178877	287494	72104	16576	83430	412437	90111	103135
33	53767	95249	339973	265162	112265	363446	14250	54236	125431	71909	58738	137088	1628	55119	93459	142517
34	6538	8877	219212	118690	27935	12092	652	11769	131413	48414	30407	367	13903	25846	768706	18445
35	33018	58333	219207	187472	116397	514405	34488	47351	299678	97720	35071	38048	16322	218049	7283	48119

Lenth Bin	Abund. 1999	Abund. 2000	Abund. 2001	Abund. 2002	Abund. 2003	Abund. 2004	Abund. 2005	Abund. 2006	Abund. 2007	Abund. 2008	Abund. 2009	Abund. 2010	Abund. 2011	Abund. 2012	Abund. 2014	Abund. 2016
36	856	16582	350093	16872	10064	7516	0	4891	131379	4585	9450	0	4671	16153	135024	6552
37	1223	0	183702	920	7171	176003	0	149	16360	42300	2869	2945	273	7190	0	0
38	3954	2260	181349	69530	33659	376282	1086	6657	31577	23568	4002	0	11895	8823	11380	12530
39	0	13075	64527	0	2844	291618	0	149	5584	21374	277	0	427	3350	345	0
40	6224	32183	61824	36503	3721	38242	579	1220	5790	9020	17275	3497	17029	24756	1682	0
41	448	0	12434	0	0	0	0	0	802	0	0	0	0	0	0	13235
42	0	0	1841	0	0	0	0	0	495	0	0	0	427	2941	778	0
43	326	1381	150	0	0	0	0	0	0	0	0	1014	6124	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	0	2941	0	0
45	163	490	526	0	736	18814	0	0	802	568	0	4055	1750	0	0	0
46	0	0	150	0	0	0	0	0	0	0	0	0	0	0	0	286
47	0	0	0	0	0	0	0	0	0	20277	0	0	0	0	0	286
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	345	2985
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	8944	2019	0	0	0	0	0	0	0	0	0	8110	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	823	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	12863	0	0	0	0	4055	0	0	0	0
61	0	0	0	0	0	0	0	0	0	5794	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	2537	0	0	0	0	0

Table 4. The number of PSUs surveyed, and the average densities of Yellowtail Snapper and their variance estimates by year for the Dry Tortugas.

Year	Number of PSU	Average Density	Average Density SE	Average Density CV (%)	Average Adult Density	Average Adult Density SE	Average Adult Density CV (%)	Average Juvenile Density	Average Juvenile Density SE	Average Juvenile Density CV (%)
1999	170	4.16	0.72	17.2	2.29	0.61	26.6	1.87	0.32	17.4
2000	207	5.24	0.42	8.0	1.62	0.26	15.9	3.62	0.34	9.3
2004	310	7.58	0.67	8.8	3.45	0.47	13.7	4.13	0.36	8.8
2006	249	4.15	0.50	12.1	1.83	0.35	18.9	2.32	0.28	12.0
2008	338	9.51	1.57	16.5	5.71	1.39	24.3	3.80	0.44	11.4
2010	364	9.59	1.05	10.9	5.21	0.71	13.7	4.38	0.69	15.8
2012	416	8.43	0.83	9.8	4.80	0.56	11.7	3.64	0.34	9.5
2014	351	14.43	1.47	10.2	8.67	1.04	11.9	5.75	0.70	12.2
2016	286	8.75	0.83	9.5	4.42	0.43	9.7	4.33	0.61	14.0

Table 5. The extrapolated abundance estimates and their standard errors for Yellowtail Snapper in the Dry Tortugas.

Year	Abundance	Abundance SE	Adult Abundance	Adult Abundance SE	Juvenile Abundance	Juvenile Abundance SE
1999	8279344	1427669	4558840	1211799	3720504	645670
2000	10439119	840192	3220143	513354	7218977	669010
2004	15107244	1326727	6878729	940635	8228514	722371
2006	8267556	996718	3639805	689266	4627751	553276
2008	18956851	3128212	11385675	2762496	7571176	866856
2010	19109686	2086525	10386634	1423279	8723052	1378233
2012	16803997	1650112	9554883	1117748	7249114	686908
2014	25580538	2613028	15375946	1835444	10204592	1243903
2016	15516880	1471969	7842301	764002	7674578	1076423

Table 6. The survey-estimated abundances (Abund.) of Yellowtail Snapper per 1cm length bins by year in the Dry Tortugas.

Length Bin	Abund. 1999	Abund. 2000	Abund. 2004	Abund. 2006	Abund. 2008	Abund. 2010	Abund. 2012	Abund. 2014	Abund. 2016
0	0	0	0	0	0	0	0	0	0
1	12476	0	0	712	6722	0	0	478	0
2	73207	21943	3037	42993	12754	0	10999	11481	0
3	64725	12577	3505	170045	19476	7494	46958	71204	0
4	32049	12356	4759	228689	15075	54269	105429	112696	8356
5	31937	38958	20141	188878	20456	12644	133148	169939	7492
6	55930	26982	26159	132295	47330	34899	218313	174897	22959
7	158486	88581	15206	104108	39701	103255	281548	169518	153259
8	71244	327336	137812	73975	167373	53342	282569	464719	74321
9	97823	282150	44688	52918	172047	82380	161420	180166	368733
10	608459	799346	583173	249558	429259	230116	569005	297034	218976
11	71015	485442	305327	74092	404766	187664	248650	301545	717302
12	193957	725284	1106343	421917	905132	561194	432658	765758	380873
13	328938	545082	779586	339284	647070	559800	772862	574575	440759
14	336147	823485	540208	498916	662081	1240093	406388	825311	568571
15	499037	1228119	2156858	746757	1133913	1940799	1021015	1190535	1578805
16	354477	538116	912977	422233	1134155	1338456	786529	1686960	859173
17	363767	582880	450739	462303	703476	1042558	717029	1513584	1230304
18	366829	680339	1137997	418078	1050389	1274090	1054594	1694193	1044694
19	630310	226314	346304	145922	494536	653739	739441	1415090	967066
20	820566	677774	2031620	919210	3300594	1549129	2155396	1393522	1019571
21	146681	265665	200779	89258	627300	1358036	610721	1054883	951256
22	210580	180799	280514	317873	920212	1462668	988000	1063849	814521
23	477368	324074	392611	174375	667705	752701	755892	1348842	716767
24	366101	117681	243083	196007	1091804	654083	633829	1699307	636211
25	260666	320708	1356879	463837	911693	1027723	1014031	1062843	631802
26	58195	60142	522040	175268	347110	750830	307226	1836691	452937
27	498463	33974	398746	21405	558403	394977	281535	673698	281771
28	255295	153582	299858	223690	612403	539484	637362	1084144	369588
29	39316	104424	203136	44010	245322	211434	201817	705152	114501
30	263487	191669	177996	265908	593870	514046	738357	656200	360034
31	13627	82027	22958	6125	75597	178923	53625	342077	138495
32	71557	89333	64154	218553	320360	119224	122730	203578	103740
33	65337	121905	31955	47364	94424	66666	134596	267710	113892
34	12044	47463	223203	37777	312992	13310	28040	198232	26515
35	112524	61082	48268	123276	56292	73860	85688	96185	40660
36	186098	64163	3623	2988	85518	17684	7454	99510	40056
37	0	30608	4300	328	31186	4262	11151	57828	23222
38	5571	16549	3080	69830	11372	8254	16796	23577	5246
39	0	9457	0	37059	1301	0	0	6258	6384
40	43094	35076	19169	14913	18385	29700	15751	40818	1002
41	0	0	0	18204	2427	0	0	648	5568
42	0	0	0	0	763	732	8868	2057	3205
43	0	3783	795	1428	0	2200	2077	2955	12949

Length Bin	Abund. 1999	Abund. 2000	Abund. 2004	Abund. 2006	Abund. 2008	Abund. 2010	Abund. 2012	Abund. 2014	Abund. 2016
44	0	0	0	0	675	0	0	1559	1392
45	13243	1891	3536	25196	696	2778	2920	1527	3531
46	0	0	0	0	0	0	0	699	0
47	0	0	0	0	0	0	0	2017	0
48	0	0	0	0	0	0	0	1080	420
49	0	0	0	0	0	0	0	0	0
50	5810	0	122	0	2734	191	1582	0	0
51	0	0	0	0	0	0	0	508	0
52	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0
55	2324	0	0	0	0	0	0	1645	0
56	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	6580	0
59	0	0	0	0	0	0	0	0	0
60	581	0	0	0	0	0	0	16450	0
61	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	6580	0
64	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	1645	0

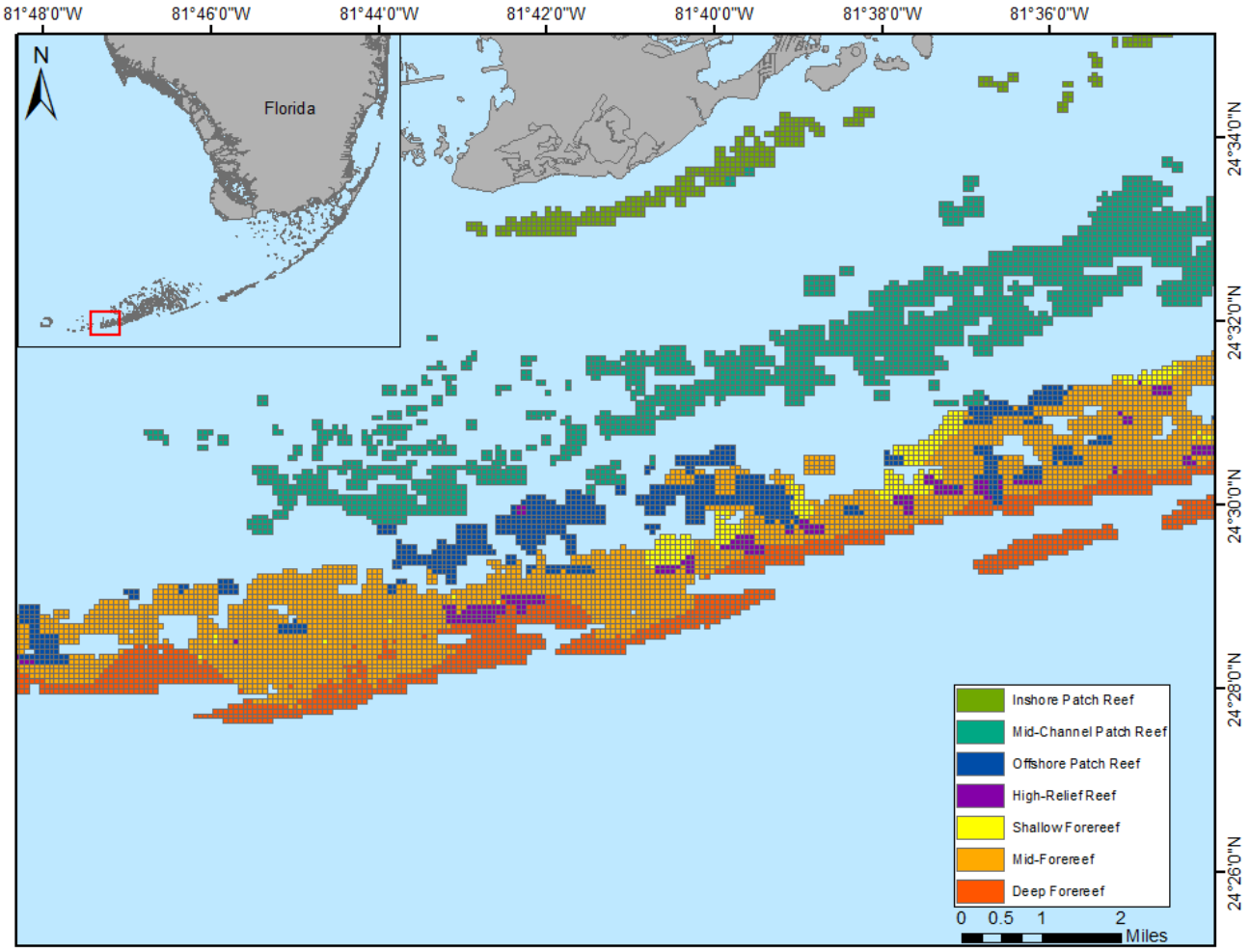

Figure 1: Habitat strata within the 100x100m grid for the RVC Florida Keys sampling scheme.

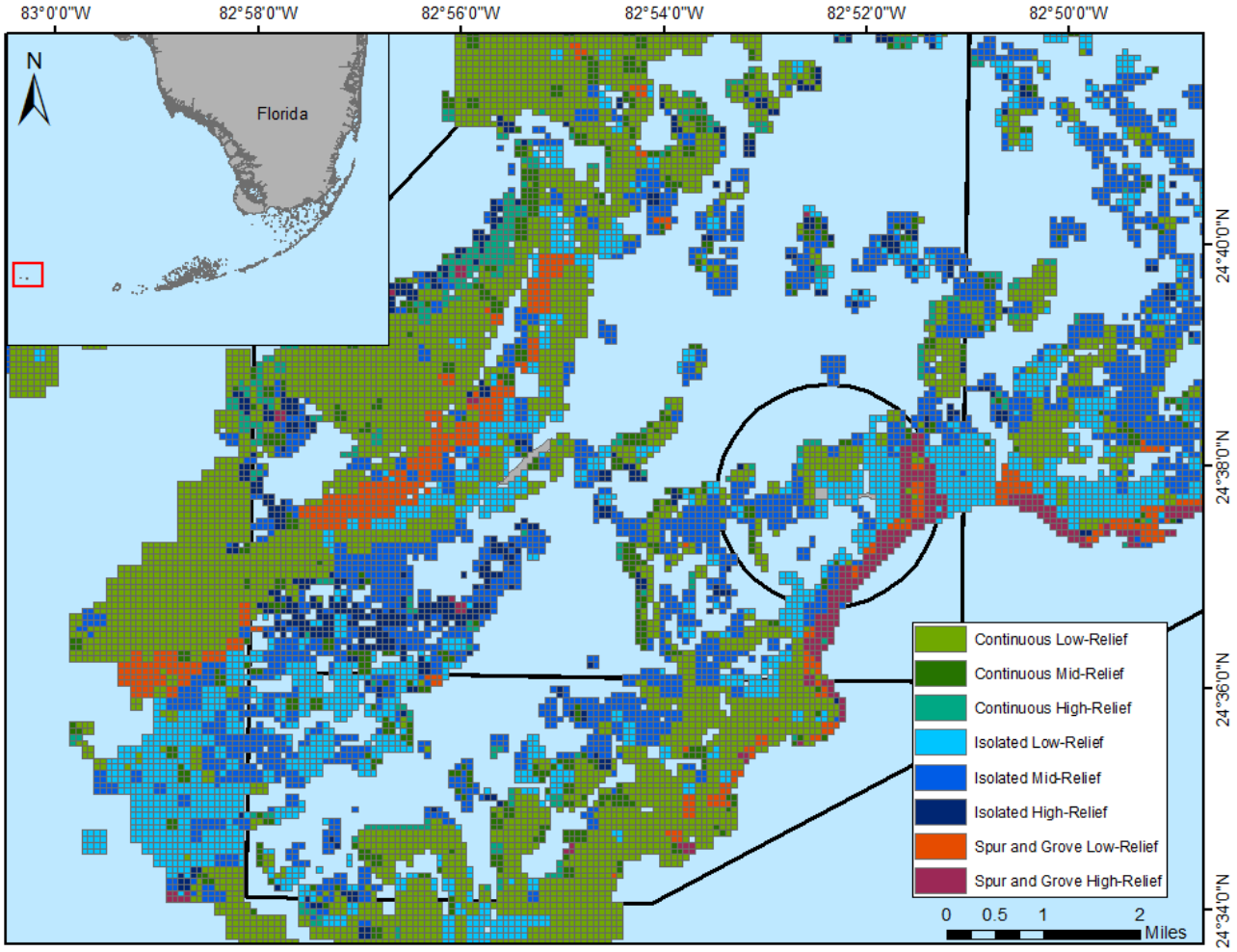

Figure 2. Habitat strata within the 100x100m grid for RVC Dry Tortugas sampling scheme.

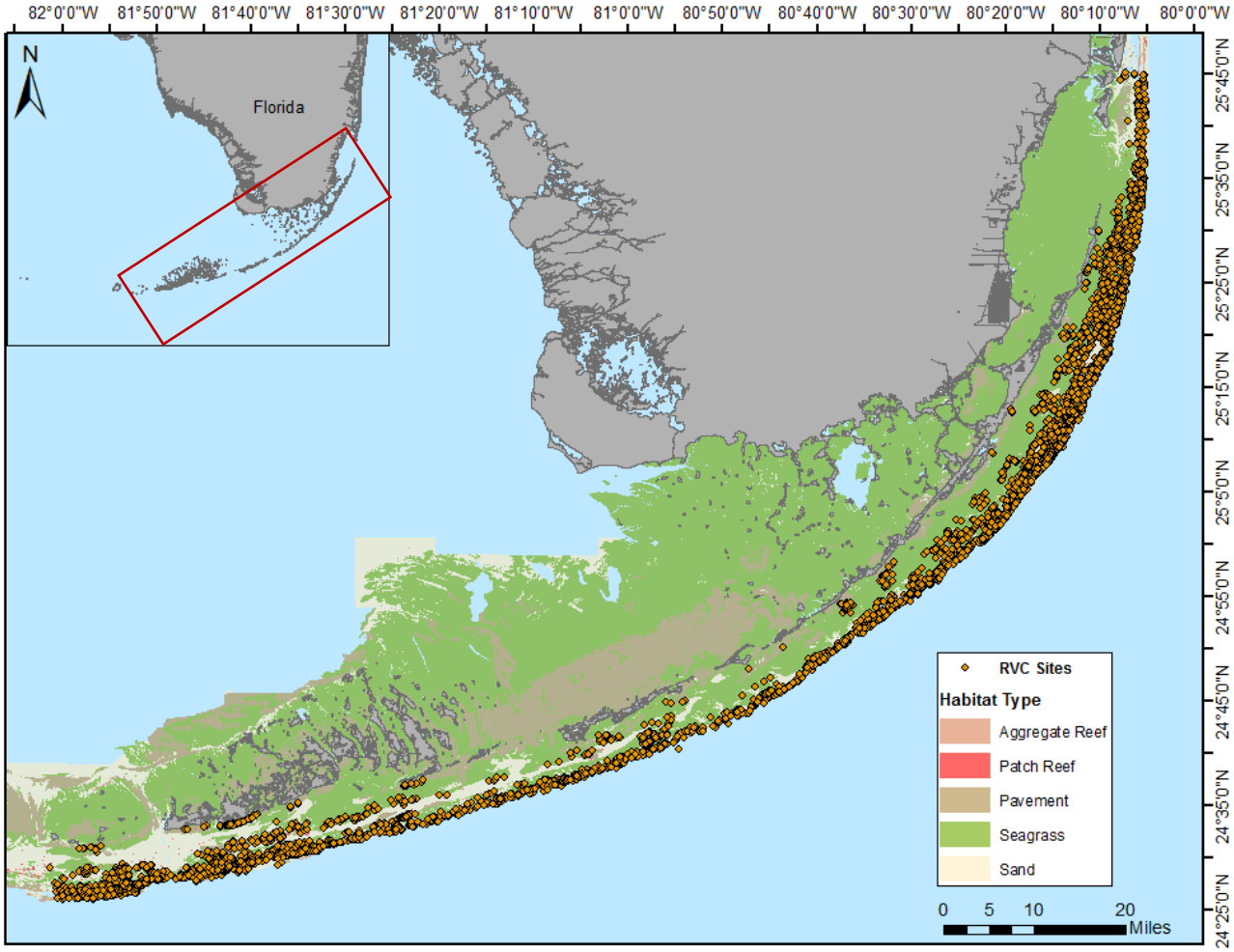

Figure 3. A map of the RVC primary sampling units (PSUs) surveyed from Biscayne Bay to the Marquesas from 1999 through 2016.

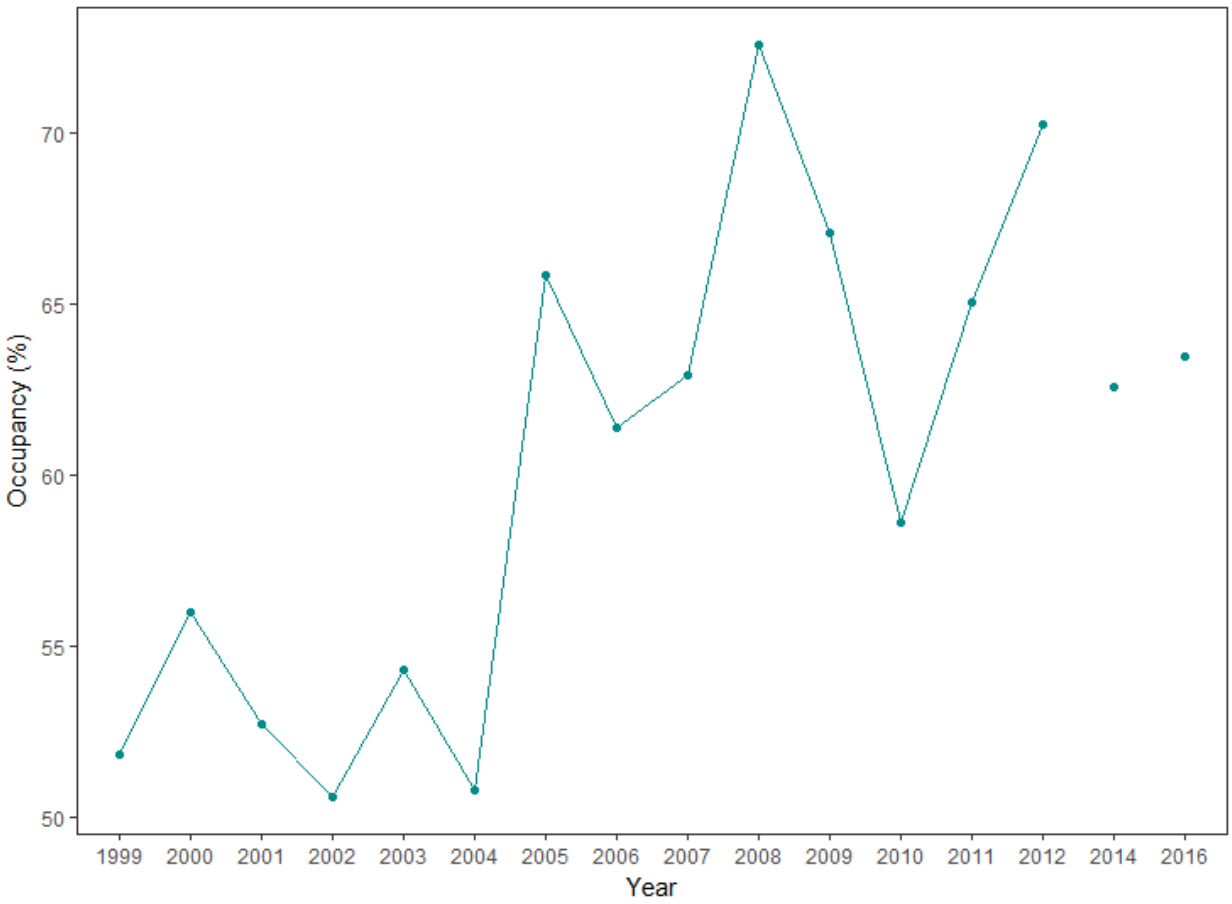

Figure 4. The occupancy rate of Yellowtail Snapper (both juvenile and adult) over time in the Florida Keys.

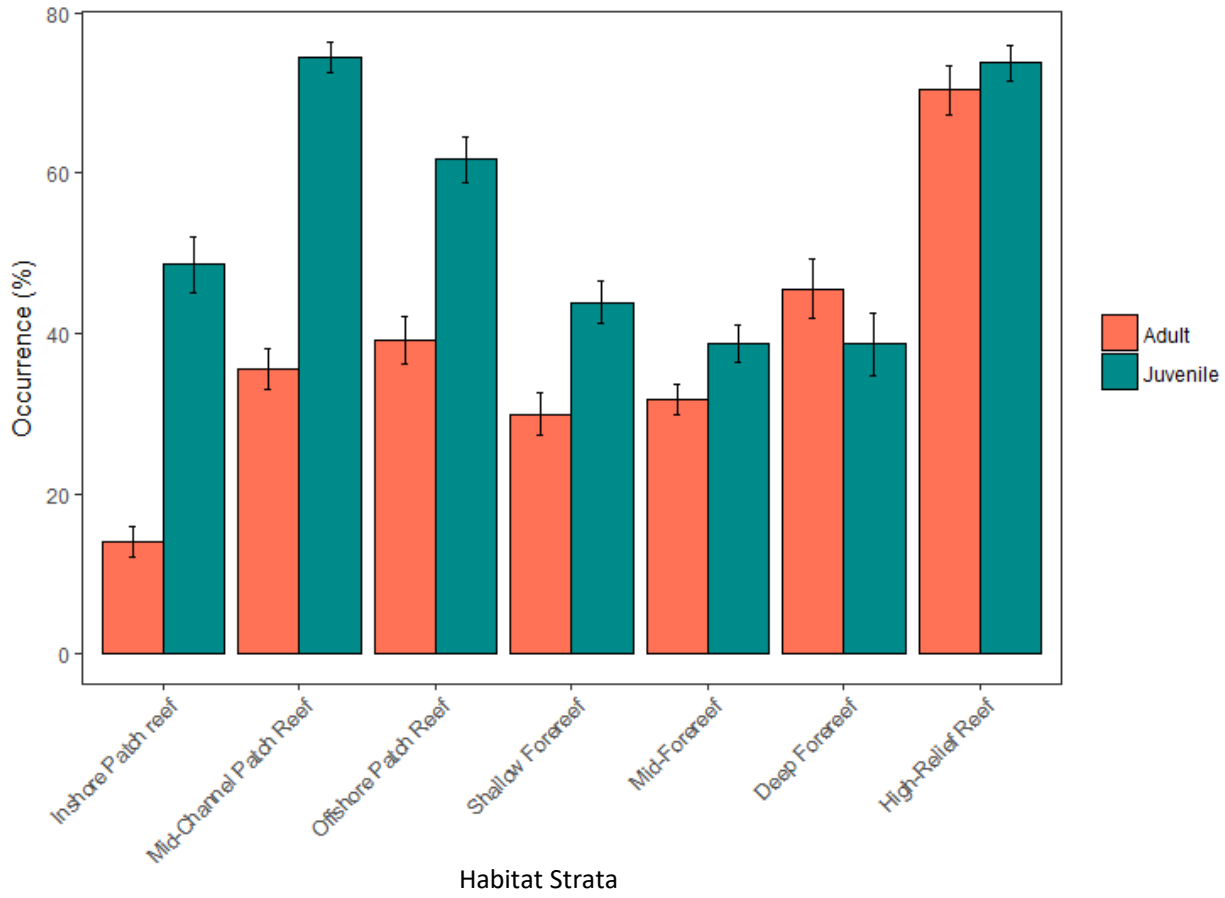

Figure 5. Occurrence by life stage and strata for Yellowtail Snapper in the Florida Keys. Error bars represent the standard error.

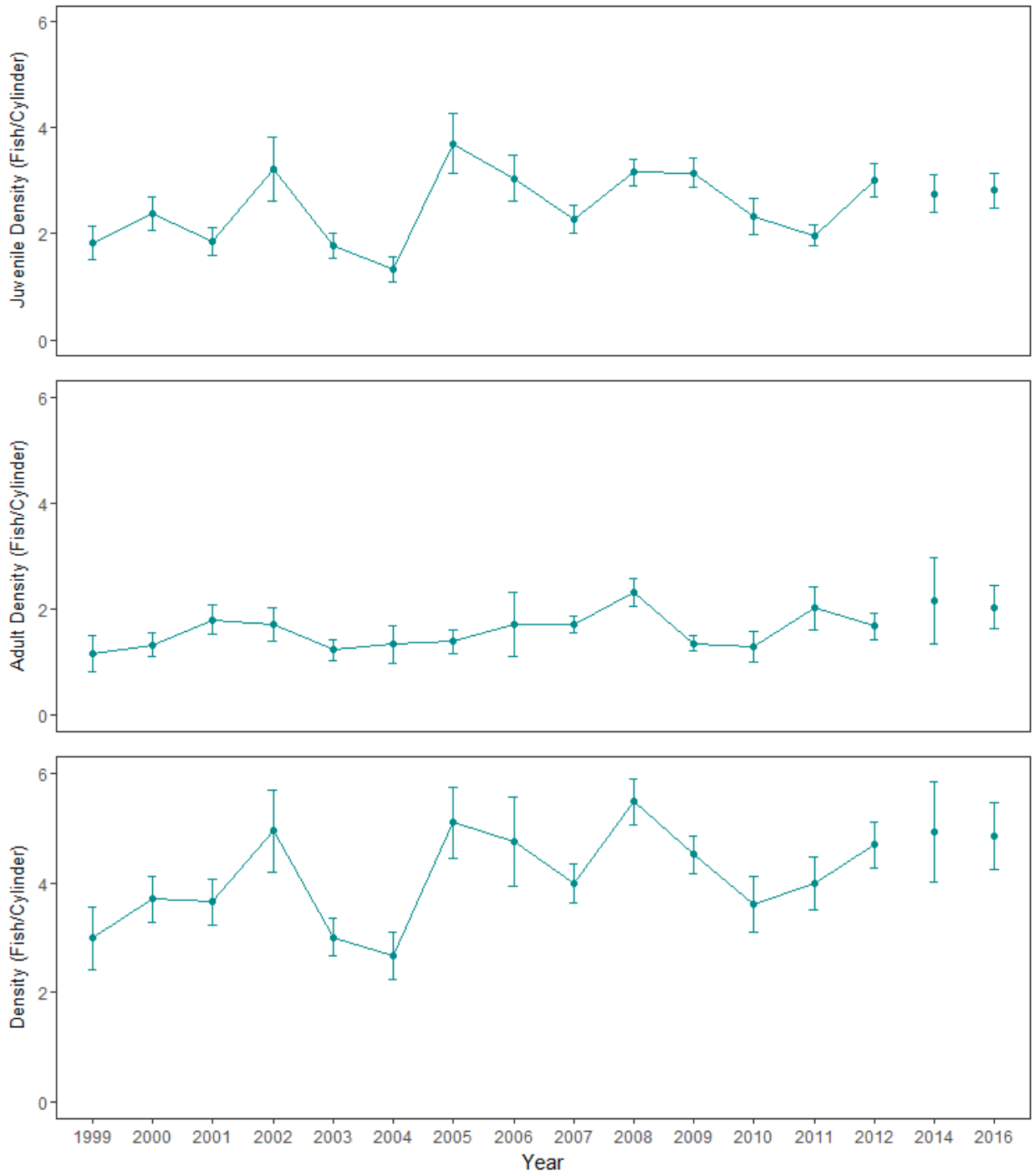

Figure 6. Survey densities of Yellowtail Snapper (juvenile, adult, and all life stages combined) in the Florida Keys. Error bars represent the standard error.

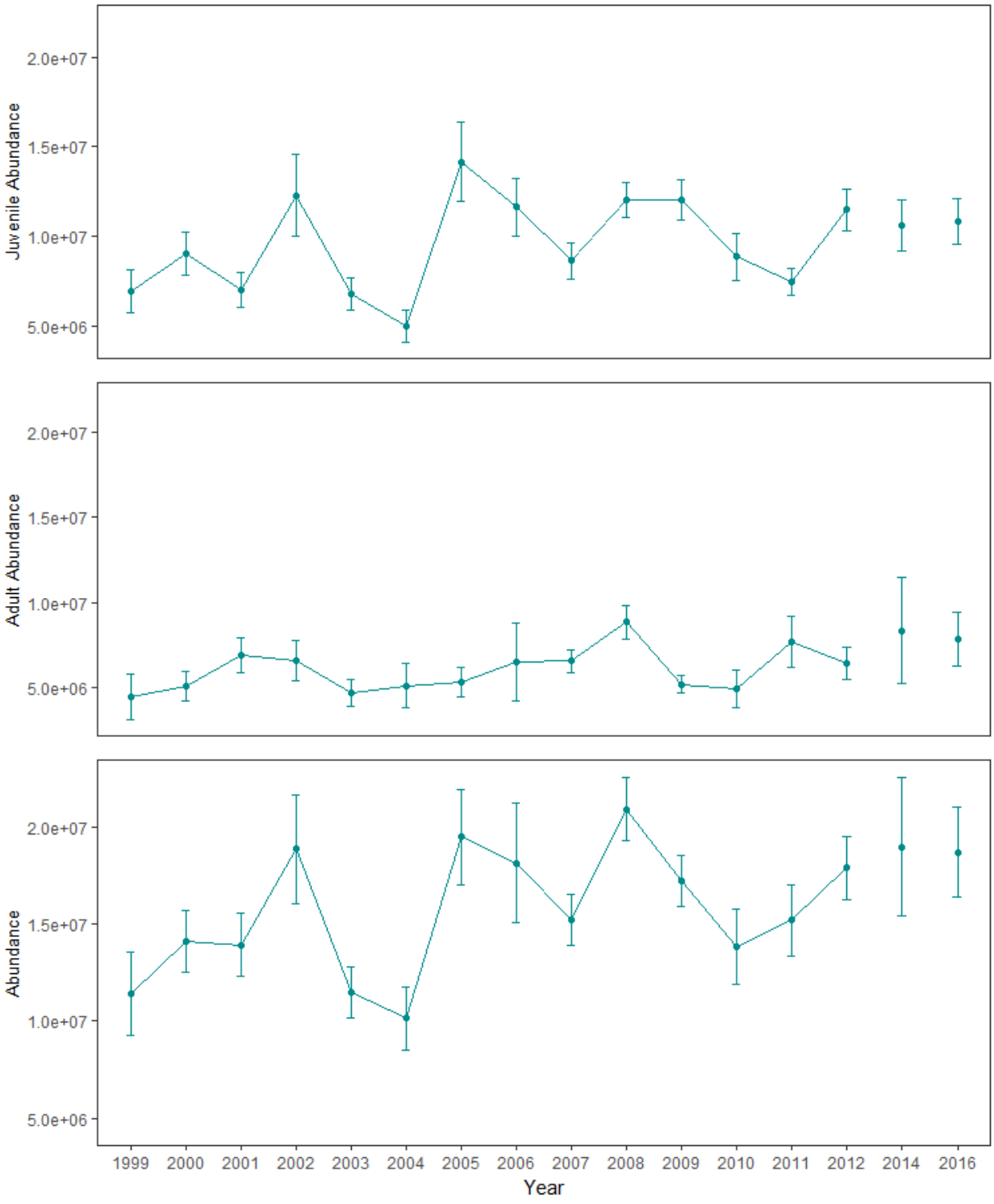

Figure 7. Survey-estimates of abundance of Yellowtail Snapper (juvenile, adult, and all life stages combined) in the Florida Keys. Error bars represent the standard error.

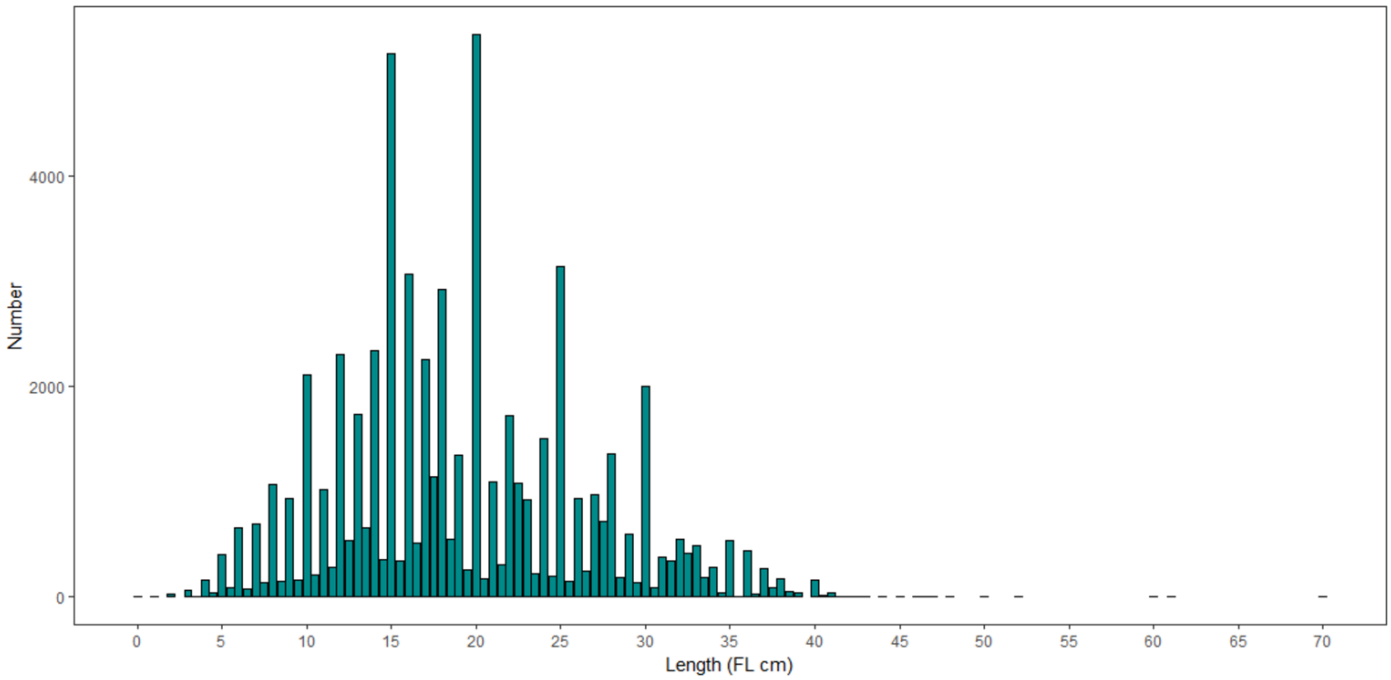

Figure 8. Diver-estimated lengths (FL) for Yellowtail Snapper in the Florida Keys, 1999-2016.

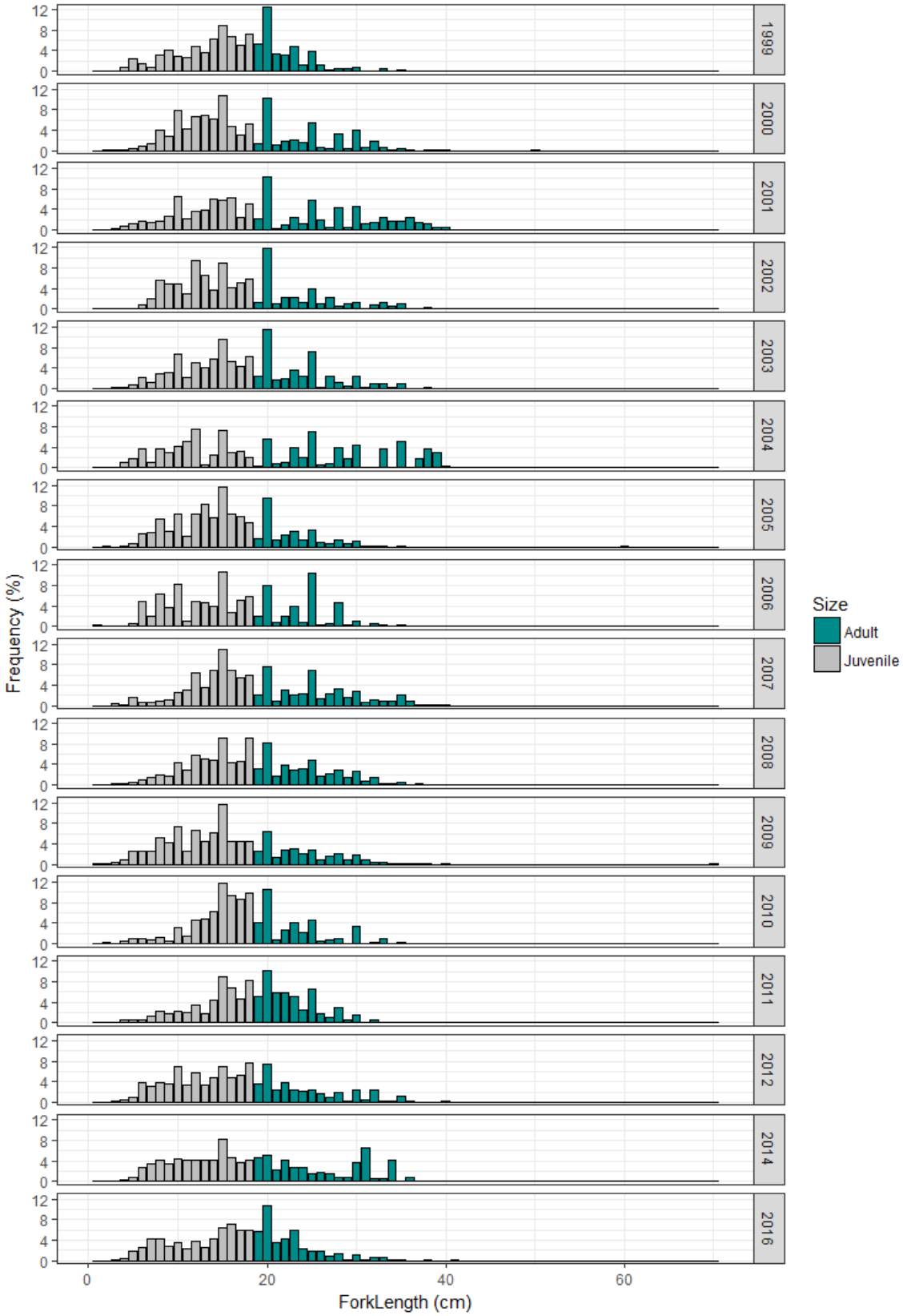

Figure 9. Length composition of Yellowtail Snapper in the Florida Keys.

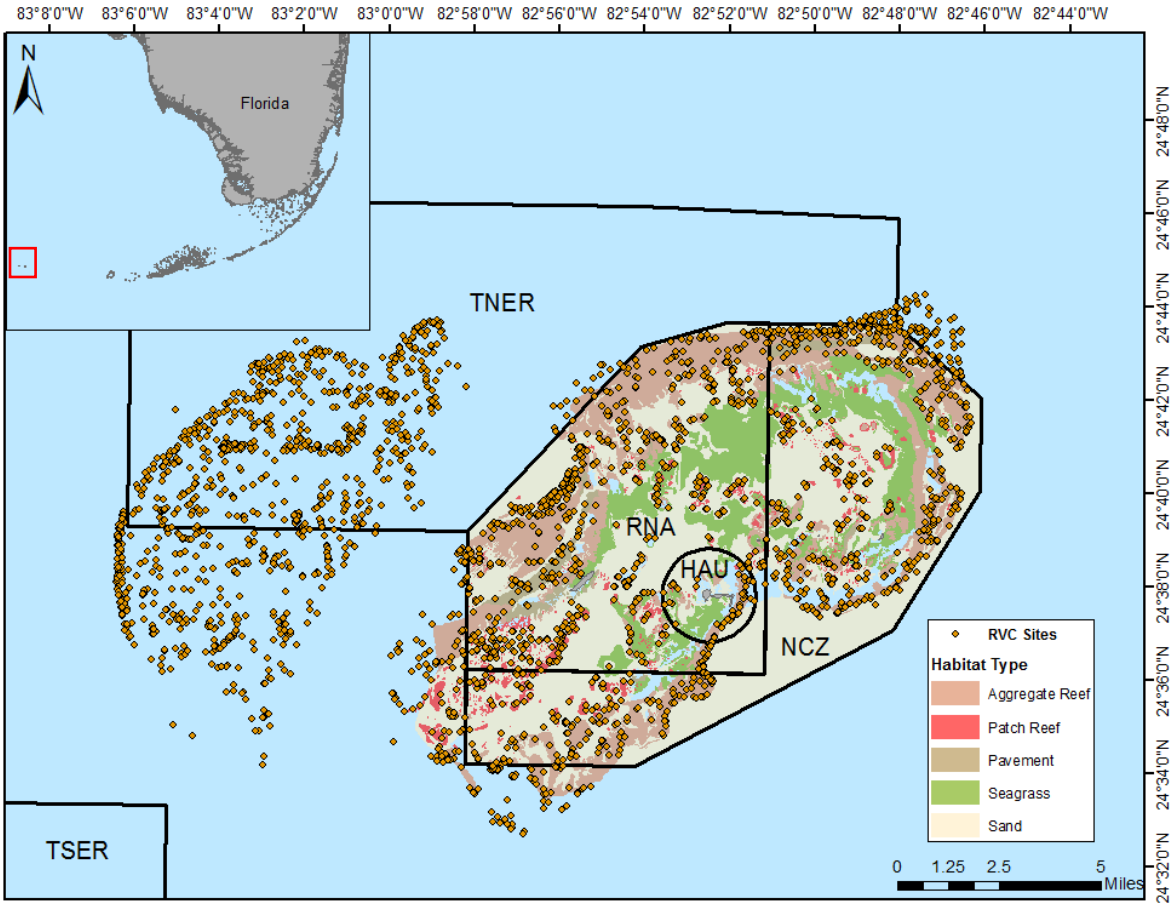

Figure 10: A map of the RVC primary sampling units (PSUs) surveyed from the Dry Tortugas from 1999-2016. The South Ecological Reserve (TSER), North Ecological Reserve (TNER), the Research Natural Area (RNA), the Historic Preservation and Adaptive Use area, and the Natural Cultural Zone are all marine reserves with closed or limited fishing. Areas outside these reserves are open to fishing.

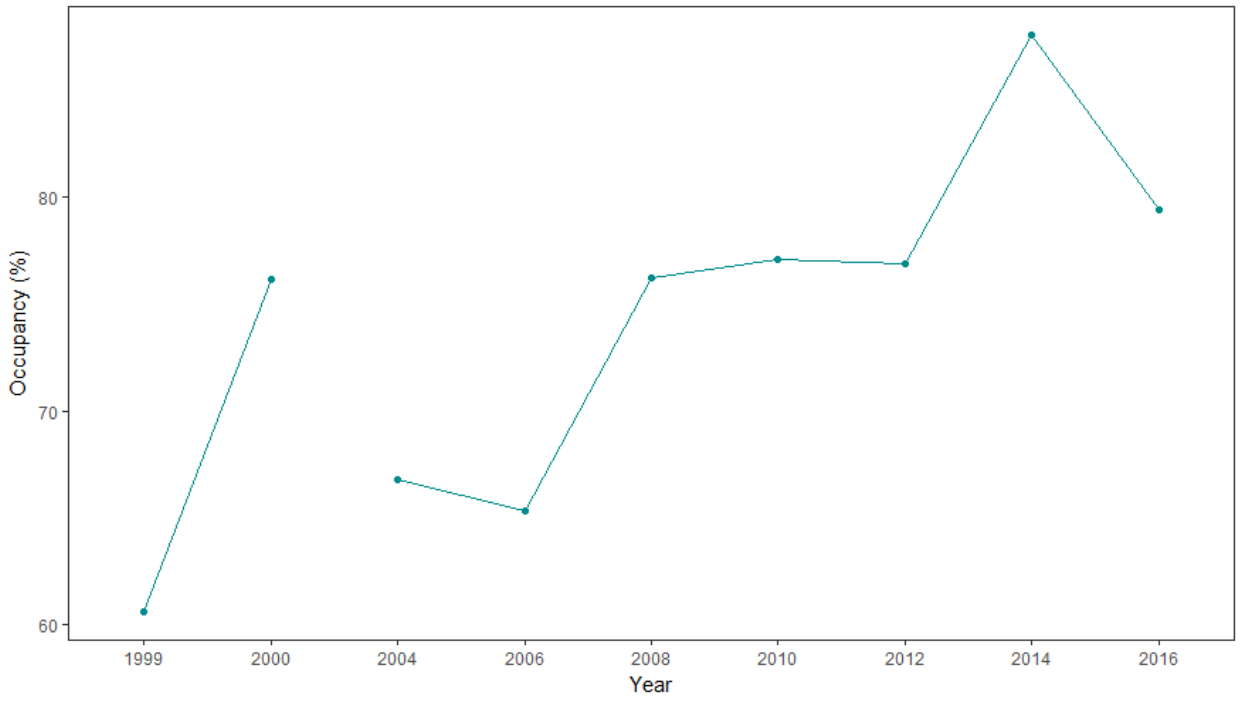

Figure 11. The occupancy rate of Yellowtail Snapper (both juvenile and adult) over time in the Dry Tortugas.

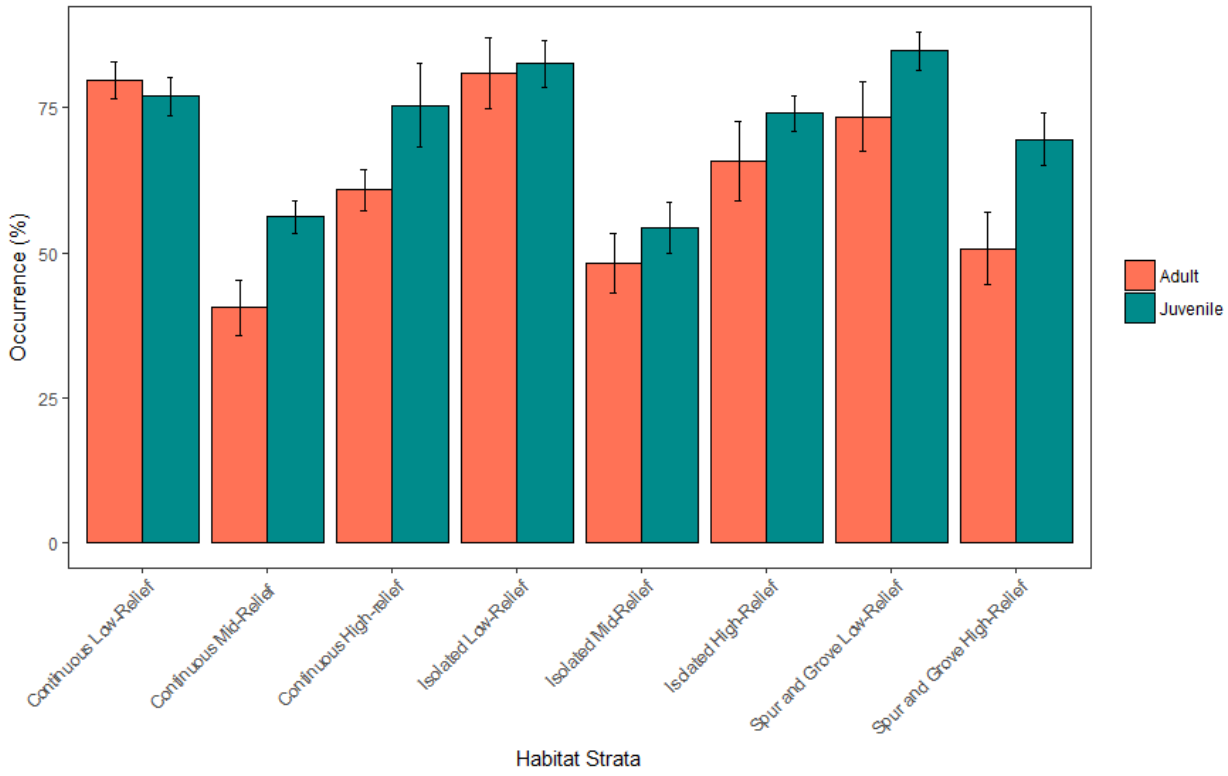

Figure 12. Occurrence by life stage and strata for Yellowtail Snapper in the Dry Tortugas. Error bars represent the standard error.

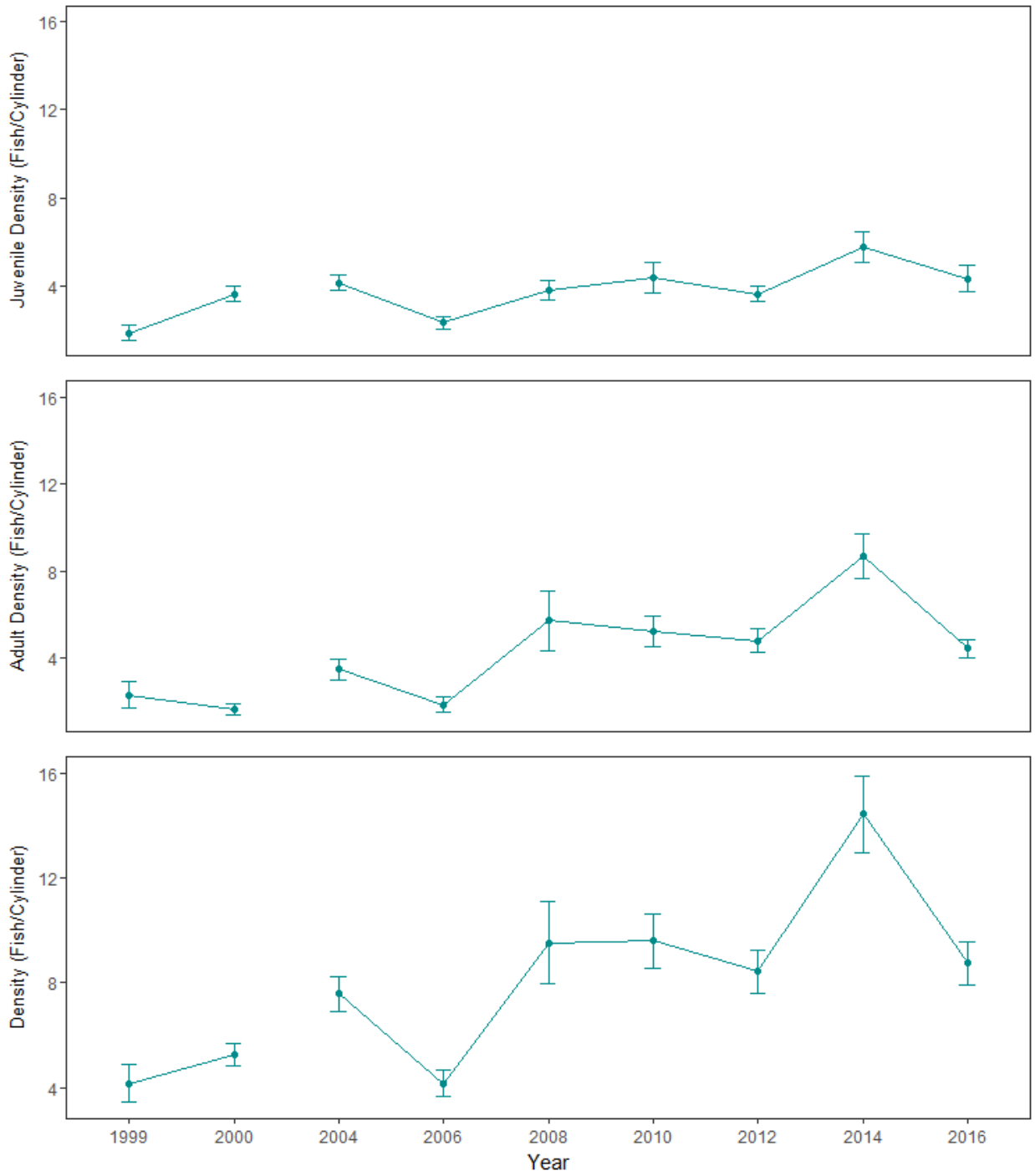

Figure 13. Survey densities of Yellowtail Snapper (juvenile, adult, and all life stages combined) in the Dry Tortugas. Error bars represent the standard error.

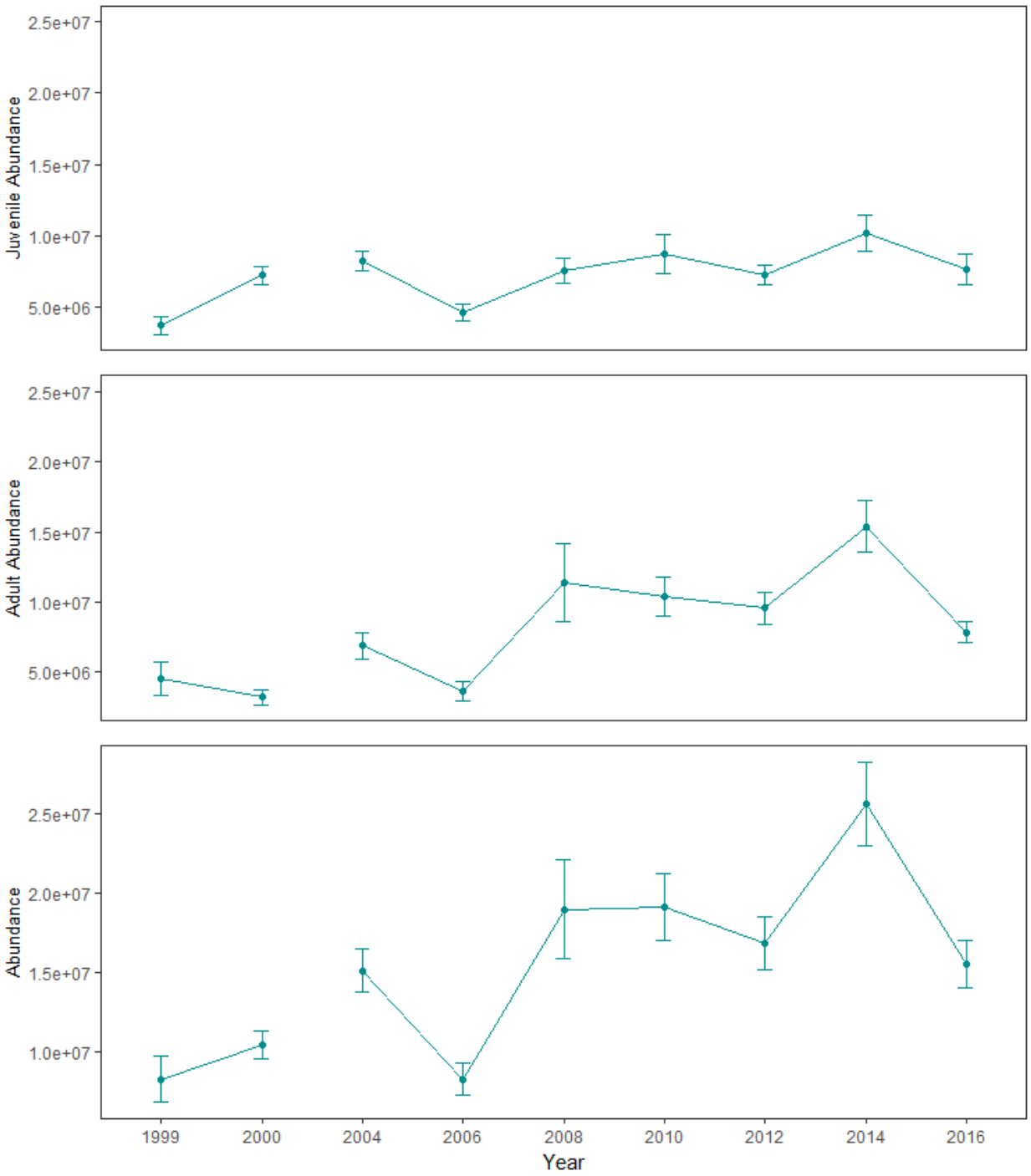

Figure 14. Survey-estimated abundances of Yellowtail Snapper (juvenile, adult, and all life stages combined) in the Dry Tortugas. Error bars represent the standard error.

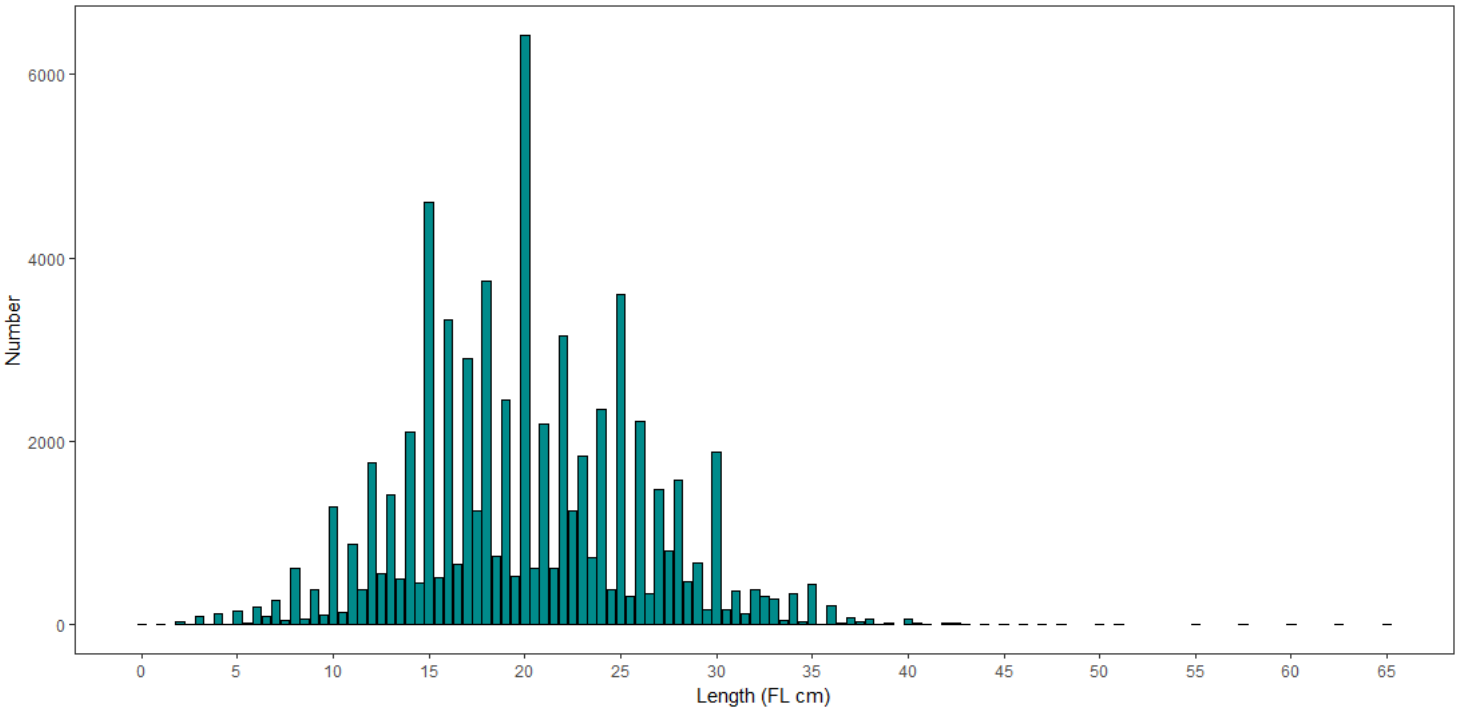

Figure 15. Diver-estimated lengths (FL) for Yellowtail Snapper in the Dry Tortugas.

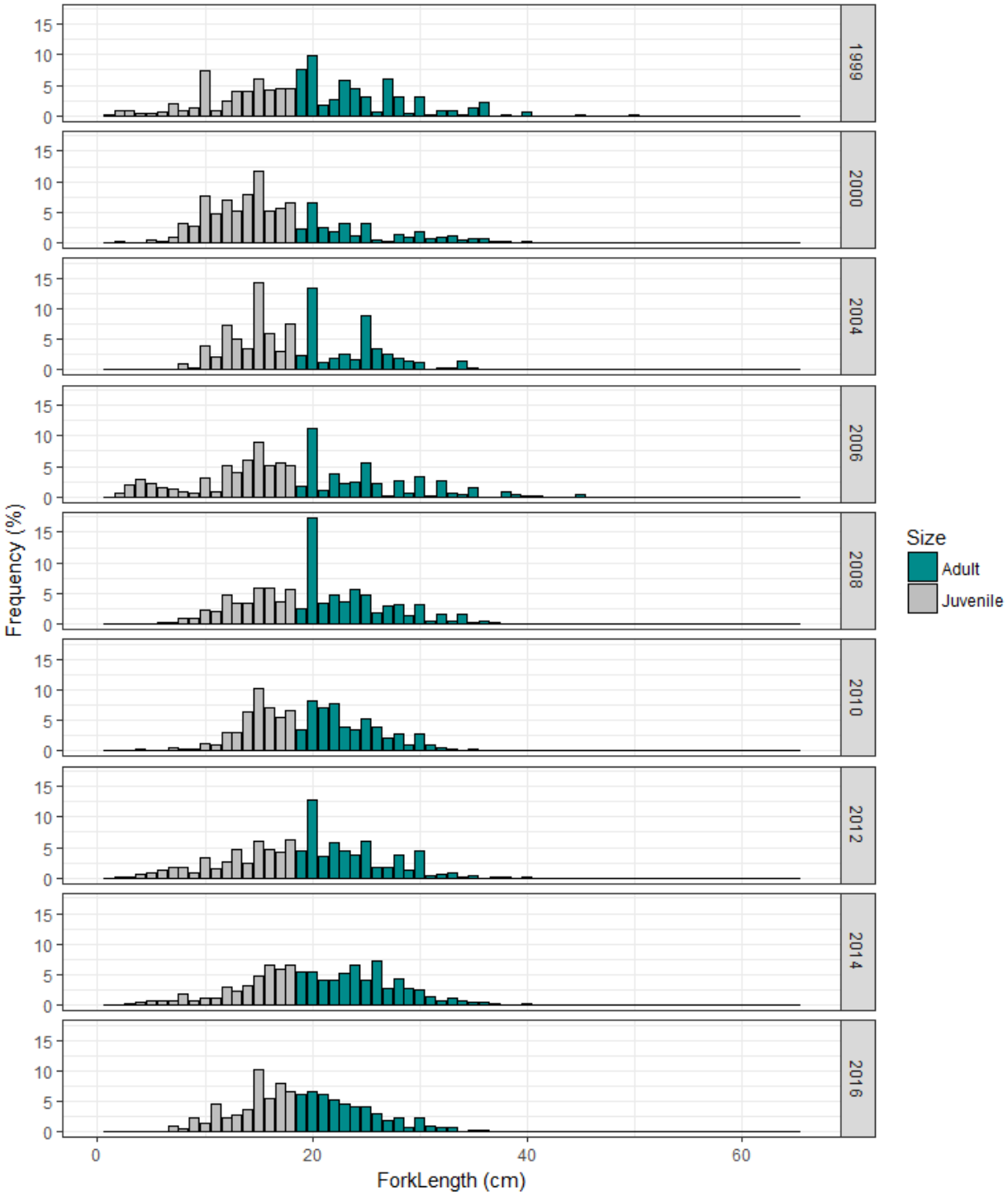

Figure 16. Length composition of Yellowtail Snapper in the Dry Tortugas.

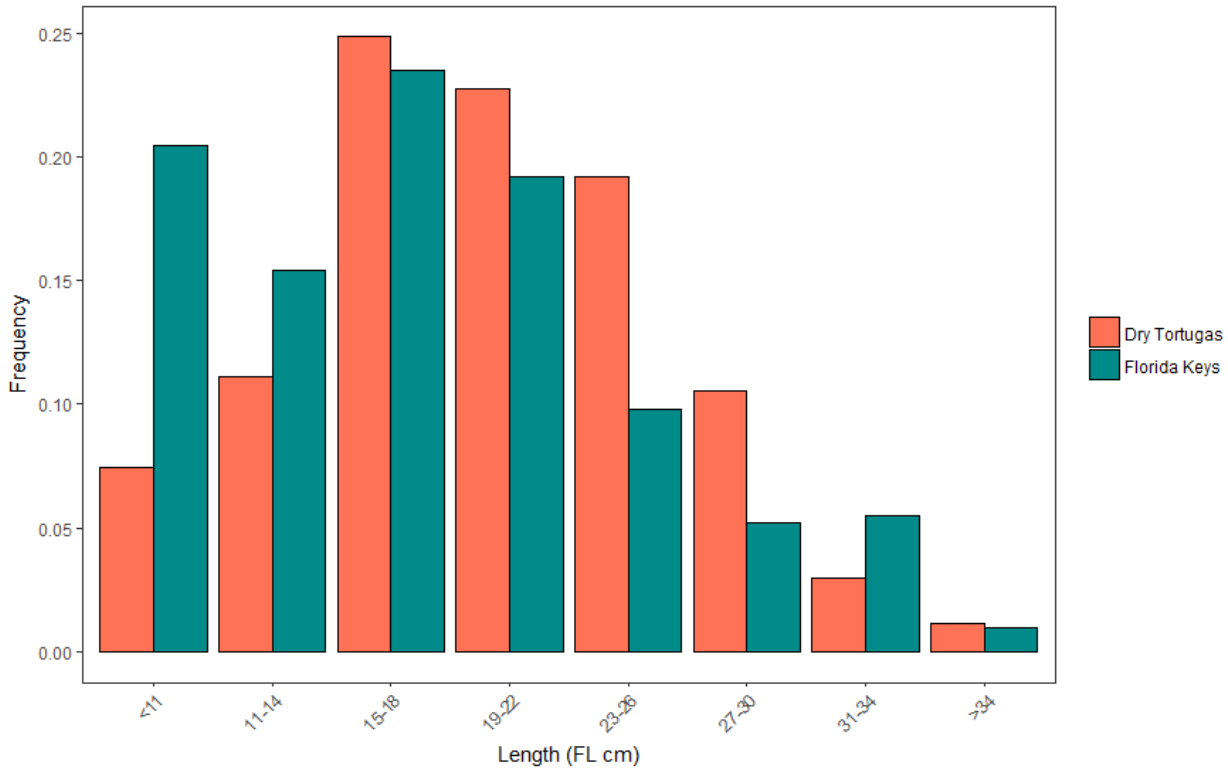

Figure 17. A comparison of the combined length frequencies of Yellowtail Snapper for 2012-2016.

Addendum : Fisheries-independent data for Yellowtail Snapper (*Ocyurus chrysurus*) from reef-fish visual surveys in the Florida Keys and Dry Tortugas, 1999-2016.

Jennifer Herbig[1], Jeffrey Renchen[2], Alejandro Acosta[1]

[1]Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 2796 Overseas Highway, Suite 119, Marathon, FL 33050

[2]Florida Fish and Wildlife Conservation Commission, Farris Bryant Building, 620 S. Meridian St. 620, Tallahassee, FL, 32399

Data Working Paper Addendum

June 2019

- The workgroup decided to combine the Florida Keys and the Dry Tortugas for the index. Steve Smith sent new habitat strata codes so that the regions could be combined. Below are the updated figures and tables.

Table 1. The number of PSUs surveyed and the average densities (Yellowtail Snapper per cylinder) and their variance estimates by year.

Year	Number of PSU	Average Density	Average Density SE	Average Density CV (%)	Average Adult Density	Average Adult Density SE	Average Adult Density CV (%)	Average Juvenile Density	Average Juvenile Density SE	Average Juvenile Density CV (%)
1999	331	2.94	0.37	12.5	1.35	0.26	19.4	1.59	0.20	12.6
2000	428	4.00	0.30	7.5	1.33	0.16	12.2	2.67	0.22	8.4
2004	437	4.78	0.53	11.1	2.40	0.42	17.6	2.38	0.28	11.7
2006	568	4.78	0.61	12.7	1.82	0.46	25.1	2.96	0.32	10.8
2008	714	6.83	0.56	8.2	3.38	0.45	13.3	3.45	0.22	6.5
2010	743	5.45	0.48	8.7	2.51	0.30	11.8	2.94	0.31	10.5
2012	832	6.01	0.39	6.6	2.75	0.25	9.2	3.26	0.24	7.4
2014	782	8.28	0.90	10.9	4.44	0.76	17.1	3.85	0.37	9.6
2016	691	6.57	0.56	8.5	3.01	0.37	12.2	3.55	0.34	9.5

Table 2. The extrapolated abundance estimates and their standard errors for Yellowtail Snapper.

Year	Abundance	Abundance SE	Adult Abundance	Adult Abundance SE	Juvenile Abundance	Juvenile Abundance SE
1999	16386638	2050003	7534862	1461267	8851776	1114692
2000	22318383	1669364	7438522	910568	14879861	1246308
2004	26656000	2962512	13387374	2350544	13268626	1553693
2006	26666632	3374911	10144673	2544595	16521958	1777290
2008	38069356	3105702	18851033	2510607	19218323	1245799
2010	30383773	2653086	14005586	1653985	16378187	1726150
2012	33506477	2195695	15315587	1406334	18190890	1337756
2014	46572786	5056989	24943560	4269571	21629226	2068410
2016	36943848	3152759	16955847	2070135	19988002	1891598

Table 3. The survey-estimated abundance (Abund.) of Yellowtail Snapper per 1cm length bins in the Florida Keys.

Length Bin	Abund. 1999	Abund. 2000	Abund. 2004	Abund. 2006	Abund. 2008	Abund. 2010	Abund. 2012	Abund. 2014	Abund. 2016
0	0	0	0	0	0	0	0	0	0
1	10541	0	0	76804	21219	0	0	404	0
2	63784	26601	2449	36588	17644	17660	23937	21366	0
3	53025	21582	8598	161735	85228	20808	59360	72565	31487
4	95976	13874	120812	208268	68507	102444	194131	151191	91678
5	224237	72090	289199	254693	157251	149137	295591	293367	318327
6	168047	124397	471189	1067243	240741	164928	890156	746934	504218
7	198388	240949	145010	507889	347331	173917	793989	835347	979539
8	332589	812031	408760	1399964	585755	200990	959846	1254870	922971
9	481574	631095	389420	810581	487139	137129	785421	781912	991627
10	857360	1759317	1009960	1891902	1345164	600692	1794116	1131082	884266
11	338764	978813	940210	224500	1014839	361482	779707	1142694	1218132
12	610622	1490285	1775380	1242342	2070296	1121790	1425546	1582915	1245151
13	609693	1408355	753387	1100368	1665750	1146372	1267796	1472310	993501
14	852269	1500419	792811	1100492	1635948	1904778	1231566	1704087	1531310
15	1215293	2487240	2711411	2644397	2994977	3279899	2167523	3013079	2941053
16	949493	1082692	1200354	855795	1918562	2393217	1588874	2641561	2430701
17	806715	913310	860398	1451218	1648140	2099563	1599317	2257966	2563127
18	983406	1316812	1323444	1487180	2913831	2503380	2334016	2525577	2340915
19	1014039	373300	363970	518399	1105376	1072428	1330249	2364724	2196752
20	1808221	1903812	2621807	2266570	4594696	2838460	3332862	2422065	3439873
21	476766	359996	289792	244387	936770	1219303	1013945	1538538	1696014
22	479643	368385	372351	682924	1576135	1626761	1599179	1960959	1670447
23	827738	555741	941731	903898	1227434	1279778	1153772	1944722	2023327
24	444849	291020	486846	347806	1578949	876652	956261	2251178	1121735
25	623394	939317	2209973	2457234	1863549	1514544	1349906	1365653	1034175
26	156414	110841	520432	240728	685013	736461	569675	2193297	883809
27	440109	77964	411155	102329	915554	483839	438200	1010401	500959
28	285700	586423	824912	1095084	1142173	613592	900372	1254352	637736
29	85408	132349	428860	102209	496056	203036	248880	862231	171595
30	310030	698204	526979	434136	1098445	878227	1099509	1493108	599454
31	19134	152476	31647	6621	191575	158293	123695	1893437	177635
32	63603	321984	81990	283063	553074	121450	534685	293081	228847
33	113610	197210	645846	100298	155342	188739	176862	383892	289764

Length Bin	Abund. 1999	Abund. 2000	Abund. 2004	Abund. 2006	Abund. 2008	Abund. 2010	Abund. 2012	Abund. 2014	Abund. 2016
34	17572	51008	195938	46828	312177	12312	50381	1148442	49114
35	136090	108799	749483	157158	144042	102535	312140	105414	88775
36	150378	71252	10792	5900	79852	14795	23334	267065	47915
37	1214	28224	314407	553	71050	6611	17488	58752	23329
38	8808	17010	673353	67110	35121	7387	22626	36538	20946
39	0	21457	519640	30147	25186	0	3418	6553	6442
40	45086	62825	75809	13314	25918	28498	39099	42242	1017
41	445	0	0	16243	2996	0	0	568	21339
42	0	0	0	0	707	589	10338	2820	3223
43	324	4747	981	1274	0	3650	2077	2954	12971
44	0	0	0	0	672	0	3031	1553	1393
45	12009	2174	37120	20460	1245	6201	2305	1458	3552
46	0	0	0	0	0	0	0	680	284
47	0	0	0	0	23118	0	0	1984	284
48	0	0	0	0	0	0	0	1421	3141
49	0	0	0	0	0	0	0	0	0
50	12154	2005	151	0	2205	7710	1298	0	0
51	0	0	0	0	0	0	0	494	0
52	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0
55	1701	0	0	0	0	0	0	1649	0
56	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	6597	0
59	0	0	0	0	0	0	0	0	0
60	425	0	0	0	0	3737	0	16492	0
61	0	0	0	0	6605	0	0	0	0
62	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	6597	0
64	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	1649	0

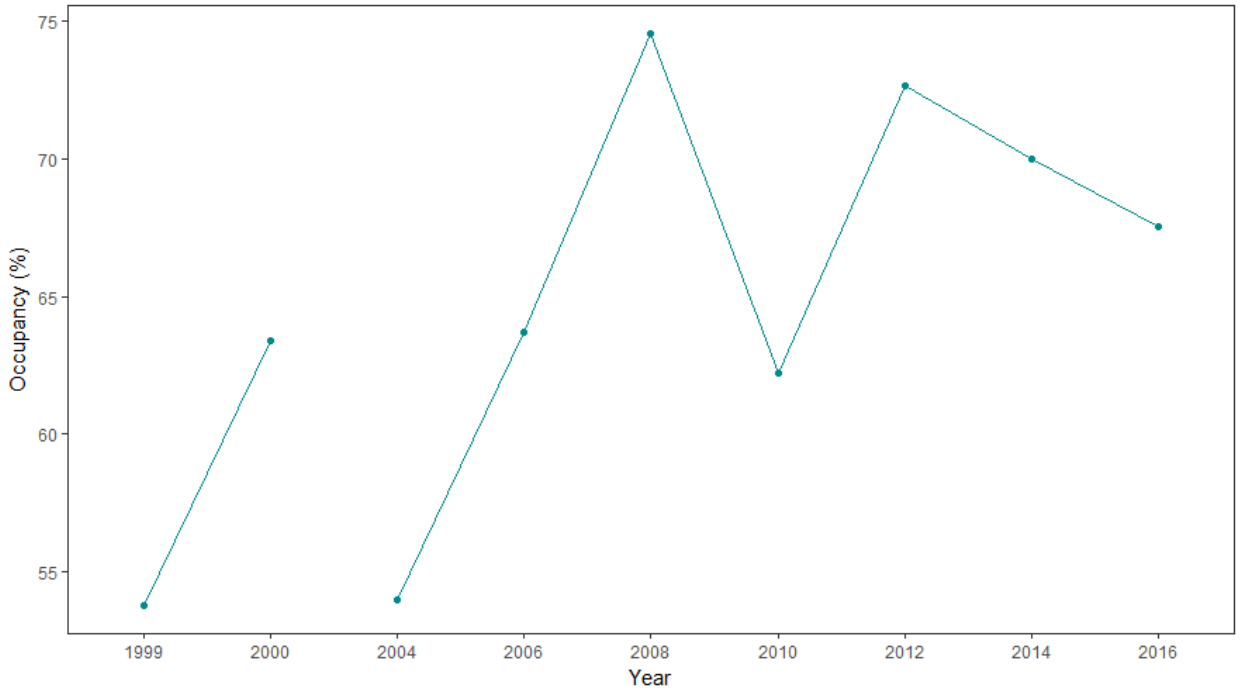

Figure 1. The occupancy rate of Yellowtail Snapper (both juvenile and adult) over time.

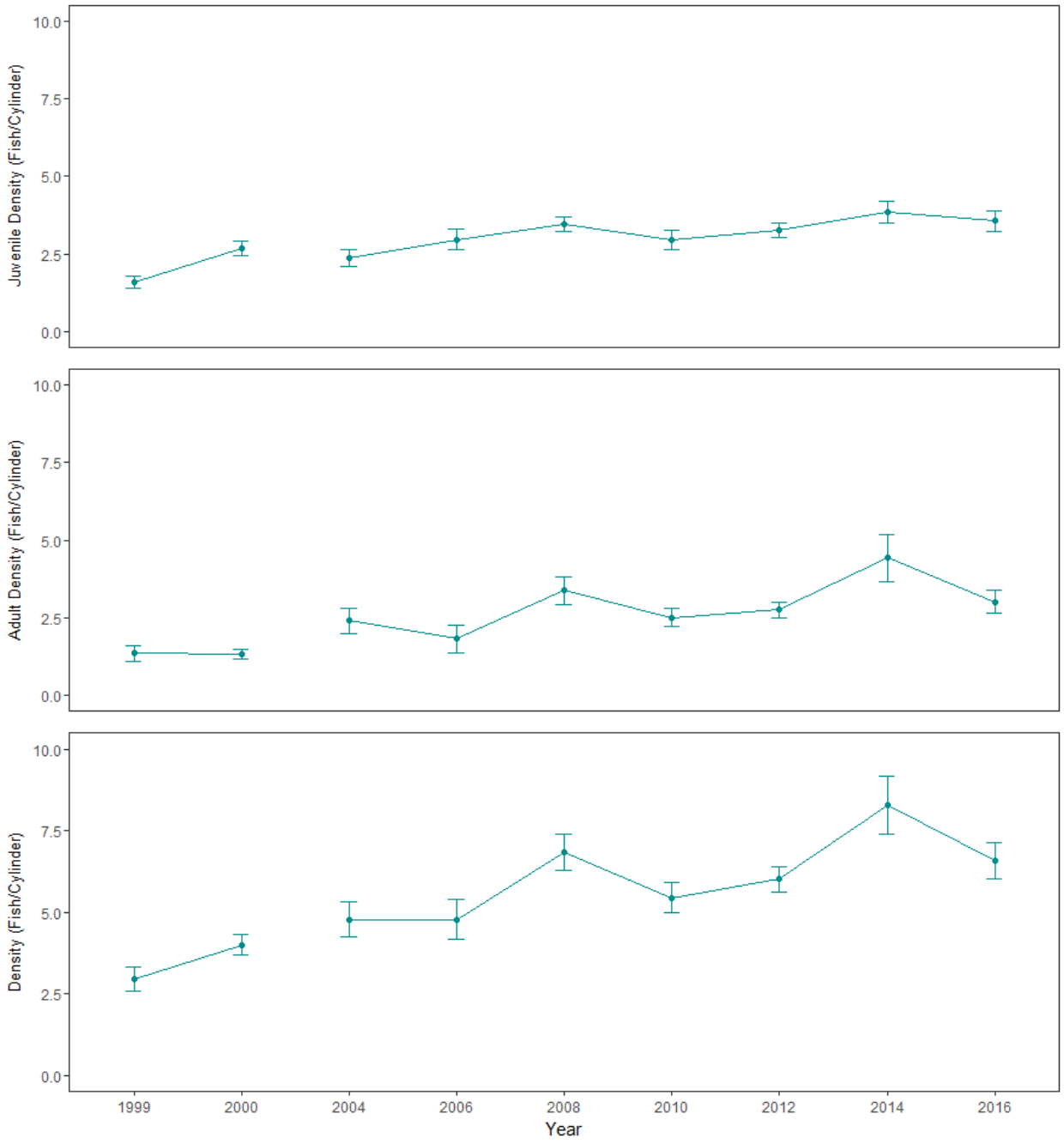

Figure 2. Survey densities of Yellowtail Snapper (juvenile, adult, and all life stages combined). Error bars represent the standard error.

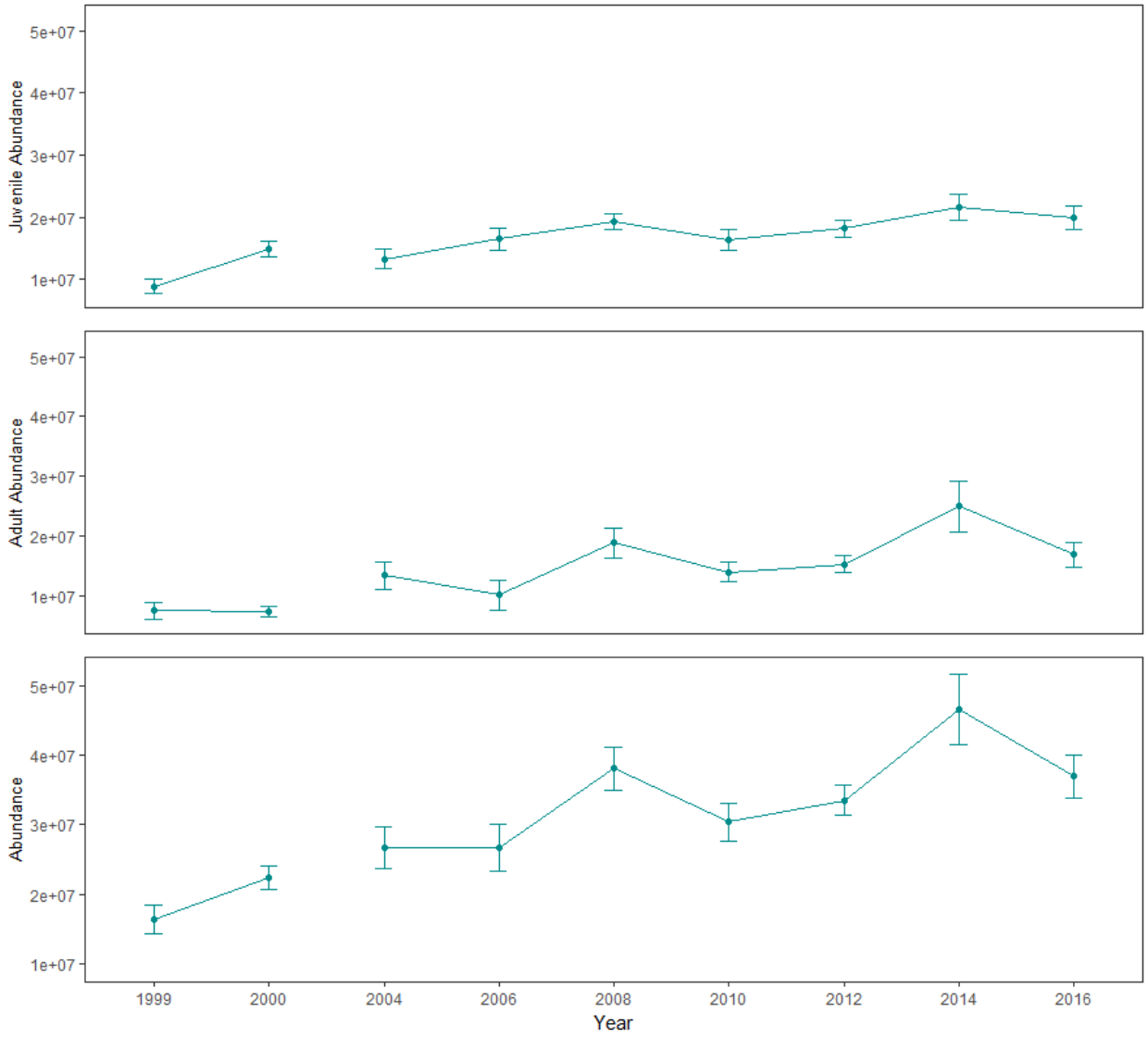

Figure 3. Survey-estimates of abundance of Yellowtail Snapper (juvenile, adult, and all life stages combined). Error bars represent the standard error.

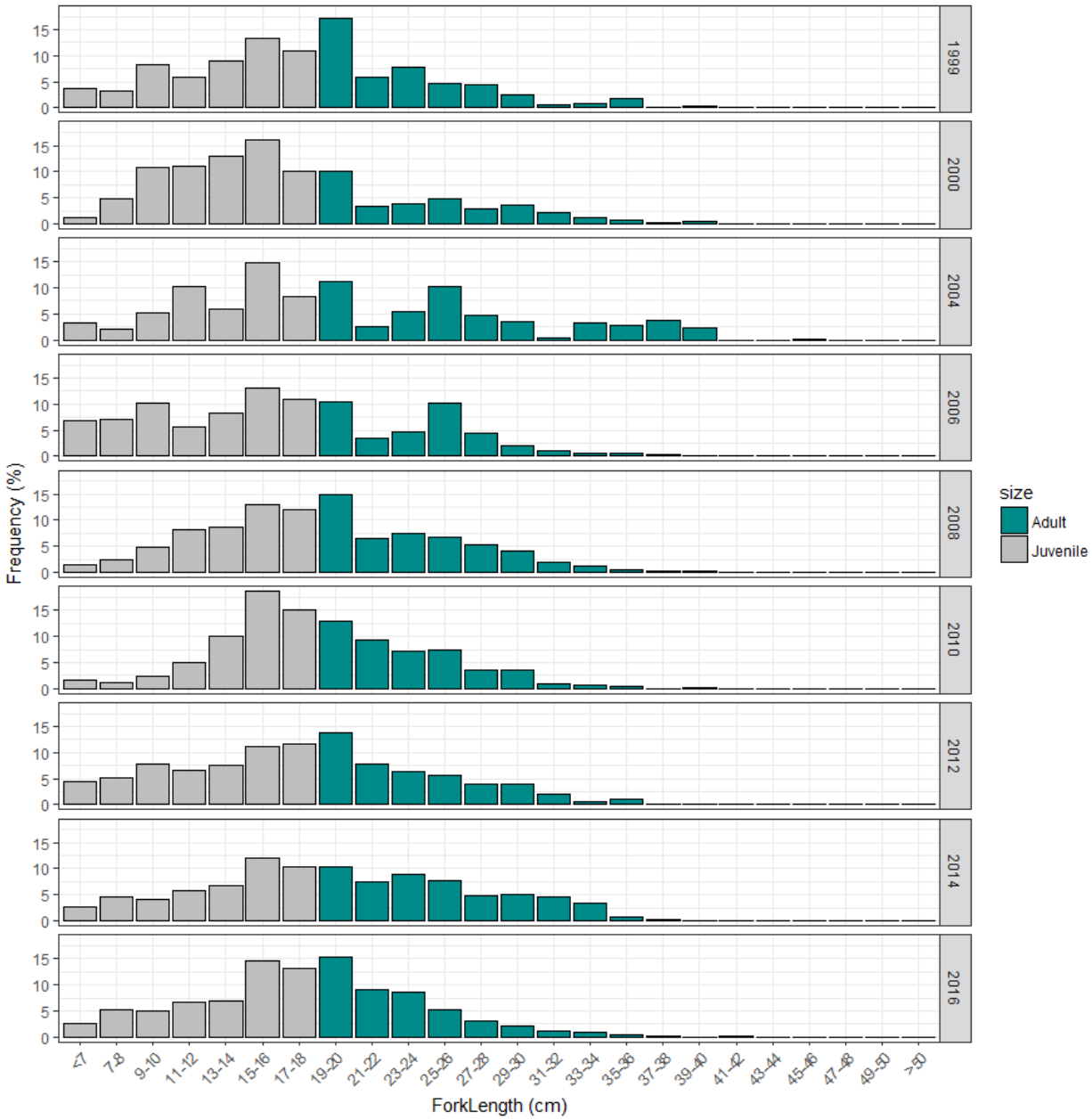

Figure 4. Length composition of Yellowtail Snapper.