Ault-Smith Notes on Reef-fish Visual Census (RVC) Population Statistics Estimation for Black Grouper (*Mycteroperca bonaci*) and Red Grouper (*Epinephelus mori*) in the Florida Keys and Dry Tortugas Regions

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The reef-fish visual census (RVC) has been conducted in the Florida reef tract since 1979 to the present in a collaboration between NOAA Fisheries SEFSC and the University of Miami. The general statistical approach and sampling survey design are fully described in Ault et al. (2002, 2005a, 2006). Field methods are detailed in Brandt et al. (2009) and extended survey collaborators to include the Florida Fish & Wildlife Conservation Commission and the National Park Service.

The annual census is conducted using a two-stage stratified random survey design. Technical description and computational details of this statistical survey design are provided in Ault et al. (2002). The survey is conducted in two principal regions of the south Florida coral reef ecosystem: (1) the Florida Keys (Key Biscayne to west of Key West); and, (2) the Dry Tortugas region.

Notable milestones for the Florida Keys surveys:

- 1979-1993: sampling conducted along the Keys reef tract in various reef habitats, but limited in any particular year with respect to geographical coverage and habitats.

- 1994-2000: sampling coverage expanded to include all geographic regions of the Keys (Biscayne National Park, upper Keys, middle Keys, lower Keys), the full range of reef habitats less than 18 m in depth, and all no-take marine reserves (implemented prior to 1998 survey).

- 2001-2008: sampling coverage expanded to include forereef habitats ranging from 18-33 m in depth.

Notable milestones for the Dry Tortugas surveys:

- 1999-2000, 2004, 2006, 2008: sampling conducted in all reef habitats less than 33 m in depth in two principal areas, Tortugas Bank and Dry Tortugas National Park, including no-take marine reserves (implemented in 2001).

The survey domain and habitat strata for the Florida Keys surveys are described in Table 1. Sample sizes by strata and year are given in Table 2. Habitat strata for the Dry Tortugas surveys are described in Table 3, and corresponding sample sizes are given in Table 4.

Key population estimates provided from the RVC for black grouper and red grouper for the Florida Keys and Dry Tortugas regions are:

(1) abundance-at-length by year;
(2) total abundance and standard error by year;
(3) average length in the exploited phase by year (see Ault et al. 1998 & 2005b for computational details).

Abundance estimates are provided for the years in which the complete domain was surveyed. Average length estimates are provided for all sampling years. For the Florida Keys, the deep forereef stratum (18-33 m) was not surveyed prior to 2001.

Analysis of surveys from 2001-2008 showed a consistent relationship in density estimates between deep forereef and mid-depth forereef (6-18 m) strata (both strata are principally low-relief habitats) outside of no-take marine reserves. This relationship was used to estimate abundance in the deeper forereef stratum for the years 1994-2000. Thus, abundance estimates comprise the same survey domain in each year.

Table 1: Habitat-depth strata for the Florida Keys survey domain (a) prior to implementation of no-take marine reserves and (b) post-implementation of reserves. Nh is the number of primary sample units (dimensions 200 m by 200 m; 40,000 m^2) comprising a stratum; Wh is the corresponding proportion of the domain contained within a stratum.

(a)

Stratum Code	Description		Nh	Wh
PCHR	Hawk's Channel patch reefs		4914	0.3518
HRRF	High-relief habitat (reefs extend >3 m vertically, mostly occurs in shallow forereef)		345	0.0247
FRSH	Forereef, depth 0-6 m, low-relief (reefs extend <2 m vertically from sand base)		1489	0.1066
FRMD	Forereef, depth 6-18 m, low-relief		5845	0.4184
FRDP	Forereef, depth 18-33 m, low-relief		1376	0.0985
		Total	**13969**	**1**

(b)

Stratum Code	Protected	Nh	Wh
PCHR	0	4751	0.3401
PCHR	1	163	0.0117
HRRF	0	170	0.0122
HRRF	1	175	0.0125
FRSH	0	1374	0.0984
FRSH	1	115	0.0082
FRMD	0	5489	0.3929
FRMD	1	356	0.0255
FRDP	0	1376	0.0985
	Total	**13969**	**1**

Table 2: Sample sizes by strata and year for the Florida Keys survey.

	PCHR		HRRF		FRSH		FRMD		FRDP	
Year	Open	MPA	Open	MPA	Open	MPA	Open	MPA	Open	Total
1994	36		43		20		27		0	126
1995	76		106		35		74		0	291
1996	46		65		26		14		0	151
1997	127		117		60		104		0	408
1998	110	59	50	97	48	42	43	12	0	461
1999	62	22	23	88	26	6	168	45	0	440
2000	102	52	22	68	44	20	176	43	0	527
2001	145	28	94	134	93	40	138	45	25	742
2002	107	24	47	50	18	19	281	53	29	628
2003	92	24	53	62	40	21	95	37	24	448
2004	42	6	33	54	30	4	48	14	15	246
2005	123	19	34	55	49	14	110	48	46	498
2006	138	33	43	46	52	42	153	59	42	608
2007	137	24	32	62	50	22	204	41	47	619
2008	186	30	42	43	75	29	219	65	46	735

Table 3: Habitat-region strata for the Dry Tortugas survey domain: (a) prior to implementation of no-take marine reserves; and, (b) post-implementation of reserves. Nh is the number of primary sample units (dimensions 200 m by 200 m; 40,000 m^2) comprising a stratum; Wh is the corresponding proportion of the domain contained within a stratum.

(a)

Stratum Code	Location	Habitat	Nh	Wh
BANK_CONT_LR	Tortugas Bank	Contiguous reef, low-relief	2584	0.3172
BANK_CONT_HR	Tortugas Bank	Contiguous reef, high-relief	359	0.0441
BANK_ISOL_LR	Tortugas Bank	Isolated reef structures, low-relief	45	0.0055
BANK_ISOL_MR	Tortugas Bank	Isolated reef structures, medium-relief	422	0.0518
BANK_ISOL_HR	Tortugas Bank	Isolated reef structures, high-relief	20	0.0025
PARK_CONT_LR	Dry Tortugas National Park	Contiguous reef, low-relief	2403	0.2950
PARK_CONT_MR	Dry Tortugas National Park	Contiguous reef, medium-relief	211	0.0259
PARK_CONT_HR	Dry Tortugas National Park	Contiguous reef, high-relief	39	0.0048
PARK_ISOL_LR	Dry Tortugas National Park	Isolated reef structures, low-relief	905	0.1111
PARK_ISOL_MR	Dry Tortugas National Park	Isolated reef structures, medium-relief	736	0.0903
PARK_ISOL_HR	Dry Tortugas National Park	Isolated reef structures, high-relief	21	0.0026
PARK_SPGR_LR	Dry Tortugas National Park	Spur-groove reef, low-relief	283	0.0347
PARK_SPGR_HR	Dry Tortugas National Park	Spur-groove reef, high-relief	119	0.0146
		Total	**8147**	**1**

(b)

Stratum Code	Protected	Nh	Wh
BANK_CONT_LR	0	1120	0.1375
BANK_CONT_LR	1	1464	0.1797
BANK_CONT_HR	0	37	0.0045
BANK_CONT_HR	1	322	0.0395
BANK_ISOL_LR	0	28	0.0034
BANK_ISOL_LR	1	17	0.0021
BANK_ISOL_MR	0	133	0.0163
BANK_ISOL_MR	1	289	0.0355
BANK_ISOL_HR	1	20	0.0025
PARK_CONT_LR	0	2403	0.2950
PARK_CONT_MR	0	211	0.0259
PARK_CONT_HR	0	39	0.0048
PARK_ISOL_LR	0	905	0.1111
PARK_ISOL_MR	0	736	0.0903
PARK_ISOL_HR	0	21	0.0026
PARK_SPGR_LR	0	283	0.0347
PARK_SPGR_HR	0	119	0.0146
	Total	**8147**	**1**

Table 4: Sample sizes by strata and year for the Dry Tortugas survey.

	BANK_CONT_LR		BANK_CONT_HR		BANK_ISOL_LR		BANK_ISOL_MR		BANK_ISOL_HR		PARK CONT_LR	PARK CONT_MR	PARK CONT_HR	PARK ISOL_LR	PARK ISOL_MR	PARK ISOL_HR	PARK SPGR_LR	PARK SPGR_HR	
Year	**Open**	**MPA**	**Open**	**MPA**	**Open**	**MPA**	**Open**	**MPA**	**Open**	**MPA**	**Open**	**Open**	**Open**	**Open**	**Open**	**Open**	**Open**	**Open**	**Total**
1999	51		61		17		31		16		47	8	10	12	14	6	30	24	327
2000	51		31		40		21		10		64	17	12	45	52	7	9	22	381
2004	41	18	9	32	19	4	19	54		18	146	39	33	44	45	14	26	8	569
2006	43	23	6	32	4	6	15	55		8	117	43	24	14	60	14	18	8	490
2008	56	47	10	18	10	14	22	48		23	108	87	31	56	51	22	36	14	653

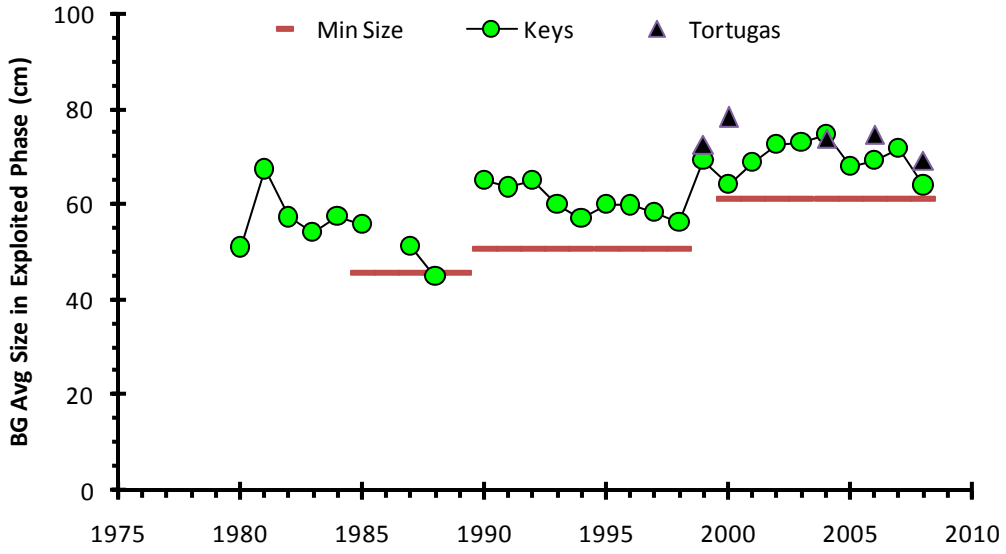

Figure BG.1- Time-series of black grouper (*Myctoperca bonaci*) average length (cm) in the exploitable phase (see Ault et al. 1998, 2005b) for the Florida Keys (open green circles, 1980-2008) and Dry Tortugas (solid black triangles, 1999-2008) regions. The solid (red) line shows the minimum size limit imposed by fishery management.

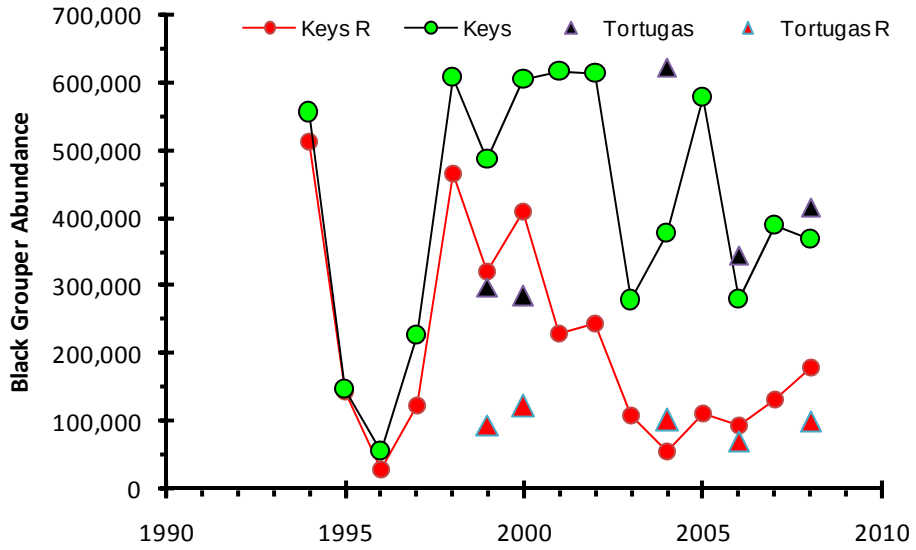

Figure BG.2.- Time-series of black grouper (*Myctoperca bonaci*) population abundance (numbers of fish) by survey region: Florida Keys (green circles, 1980-2008); and, Dry Tortugas (solid black triangles, 1999-2008) regions. Recruit abundance for the same time periods is shown for the two regions: Keys (red circles) and Tortugas (red triangles).

Table 5.- Florida Keys black grouper (*Mycteroperca bonaci*) abundance by 1 cm length categories estimated from the RVC survey for the period 1994-2008.

FLen (cm)		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2		0	0	0	0	0	0	9171	0	0	0	0	0	0	0	0
3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4		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
6		0	0	640	0	0	0	0	4464	0	658	0	0	0	0	0
7		0	0	0	0	0	0	0	4464	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	688	0	5592	0	0	0	0	0
9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10		0	0	0	0	6058	0	844	4464	0	5592	0	0	512	0	0
11		0	0	0	0	0	0	0	4464	0	0	0	0	0	0	0
12		0	0	0	5467	0	0	6463	4464	5577	0	0	0	3887	0	0
13		0	0	0	0	0	0	0	0	0	0	0	9299	4295	0	0
14		0	0	0	0	42010	15047	0	0	0	0	0	0	0	0	0
15		0	0	0	0	12525	0	20028	643	4454	11842	0	0	0	0	5828
16		0	0	0	0	1113	0	0	8928	0	0	12202	4330	0	0	0
17		0	0	0	0	6058	2251	0	0	0	0	0	0	4295	0	2914
18		17138	3893	0	0	54535	24566	0	0	9093	0	0	0	0	0	7871
19		0	0	0	0	0	6410	0	0	5376	0	0	0	4295	0	5639
20		35135	0	13013	8272	7042	70246	35864	23331	32730	0	24968	9587	5697	0	8553
21		0	0	0	10935	408	0	0	0	9619	0	0	0	4544	0	0
22		0	0	0	0	6058	437	24384	9486	3375	658	0	4330	0	6868	0
23		0	0	0	0	42010	6562	59599	0	8626	0	0	0	4295	0	0
24		0	0	0	0	408	0	45432	0	6098	0	0	0	4033	14543	5733
25		0	137621	640	5467	48644	30363	25645	21649	12333	14548	3070	5416	10597	23861	14381
26		17138	0	0	5467	3113	54663	16056	0	10031	1032	0	0	0	4147	0
27		0	0	13013	36861	6058	4840	2195	4464	0	0	0	394	0	6868	3989
28		17138	0	0	0	42010	3033	18658	874	7037	11184	0	805	4786	7492	9676
29		0	0	0	0	408	1126	0	5680	0	0	0	0	0	309	0
30		408277	4006	0	6232	42010	15047	67330	41122	49917	6250	366	9515	15152	20236	43039
31		0	0	0	0	0	3033	1098	0	0	5592	0	6210	0	3433	6437
32		0	0	0	459	4077	2038	0	23903	12987	5920	732	3764	512	3743	12533
33		0	0	0	0	0	0	18612	0	4809	10212	0	11502	0	3838	2819
34		0	0	0	459	90252	12283	6463	6368	3828	7233	0	0	0	309	5639
35		18427	0	426	43093	52350	68254	52478	58903	59577	21466	15560	46232	26741	35983	43818
36		1289	0	640	36861	296	31697	1098	4464	2227	0	0	0	0	0	2504
37		1402	0	0	0	296	0	844	0	2227	165	366	14712	0	565	5733
38		0	0	0	459	0	0	10863	17015	6681	5592	366	12490	4328	8007	5566
39		0	0	0	0	45419	0	0	10144	283	0	0	0	0	0	2819
40		18540	0	1921	12313	47012	1516	23365	98485	57464	7613	732	76180	29494	25000	27431
41		0	0	0	0	0	1601	0	0	7515	1654	0	0	8065	618	2914
42		0	0	0	459	796	24566	3714	6424	7515	5592	0	11502	4033	3433	6814
43		0	684	0	6386	0	1516	0	11847	3755	0	0	0	0	874	1832
44		0	0	640	0	0	0	0	688	11972	1032	0	8421	0	309	609
45		19830	0	8667	43706	46179	28447	87136	47984	20976	11510	11222	77030	23091	11853	29201
46		0	0	0	0	0	0	0	688	2227	0	0	0	0	309	0
47		0	0	0	0	0	291	0	16799	0	0	0	0	649	0	0
48		0	0	0	0	0	0	2343	2110	17710	5980	732	0	0	0	2819
49		0	0	0	459	0	0	0	5840	1915	0	0	0	0	0	461
50		0	0	1921	459	0	2623	19881	46089	38014	46567	24781	65393	18396	29173	35138
51		0	0	0	0	0	0	1098	7104	2227	0	0	0	0	0	0
52		0	0	0	0	0	0	0	186	14422	343	732	842	0	958	2819
53		0	0	0	0	0	0	0	5914	2227	0	0	0	0	0	2819
54		0	0	0	0	0	0	0	279	0	0	0	0	0	0	3380
55		0	0	0	459	888	30096	15969	13837	15848	7639	3972	3764	7149	14946	8190
56		0	0	0	0	0	0	0	0	4454	165	366	0	0	0	609
57		1402	0	0	0	0	0	0	1375	0	0	0	0	0	0	0
58		0	0	0	0	0	0	0	372	6023	0	0	3369	0	759	3374
59		0	0	0	0	0	0	320	0	2510	0	0	0	0	0	0
60		0	684	640	0	296	10022	13443	33479	34725	24432	35421	70659	38916	35011	23138
61		0	0	0	0	0	0	0	172	0	0	0	8332	0	3037	0
62		0	0	0	0	0	0	0	0	0	1316	0	0	0	3037	457
63		0	0	640	0	0	0	1646	0	0	0	366	0	0	309	0
64		0	0	640	0	0	0	0	0	0	0	0	0	0	0	0
65		0	0	640	3264	0	0	2700	15402	18076	5051	43175	25585	10200	5627	12146
66		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67		0	0	0	0	0	0	0	186	0	0	0	0	0	0	0
68		0	0	0	0	0	0	0	186	0	328	565	0	0	309	461
69		0	0	0	0	0	0	0	0	947	0	0	0	0	0	3380
70		0	0	1281	0	0	30533	2059	12688	9915	15933	55458	50576	12067	48818	2139
71		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73		0	0	0	0	0	0	0	172	0	0	0	0	0	0	0
74		0	0	0	0	0	0	0	0	0	328	565	0	0	0	0
75		0	0	0	0	0	0	0	4471	23833	3737	7774	9759	13197	31247	3841
76		0	0	0	0	0	0	0	0	0	0	0	0	0	3037	0
77		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80		0	0	0	0	0	0	2059	9102	22506	9250	27452	21920	7775	14120	0
81		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83		0	0	0	0	0	0	0	0	380	328	21470	0	0	0	0
84		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85		0	0	0	0	0	874	0	2813	6098	2391	10856	0	649	0	0
86		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88		0	0	0	0	0	0	0	0	0	0	0	0	0	759	0
89		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90		0	0	0	0	0	3250	0	0	380	1976	32326	1839	491	7088	0
91		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
92		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95		0	0	0	0	0	0	0	0	6098	9401	366	0	0	0	0
96		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100		0	0	0	0	0	0	320	12335	15773	1643	42449	1199	0	6074	0
101		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
106		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
109		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110		0	0	0	0	0	0	0	0	0	1314	0	3369	7775	3346	0
111		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
112		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
114		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115		0	0	0	0	0	0	0	0	1667	0	0	0	0	0	0
116		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
117		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
122		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	**Population**	**555,718**	**146,888**	**45,364**	**227,540**	**608,335**	**487,232**	**599,178**	**617,011**	**614,058**	**279,060**	**378,412**	**578,326**	**279,913**	**390,255**	**369,463**
	Recruits	**513,254**	**145,520**	**27,734**	**122,714**	**467,151**	**320,198**	**410,320**	**228,360**	**245,467**	**107,779**	**56,898**	**111,383**	**93,639**	**131,631**	**178,869**

Table 6.- Dry Tortugas region black grouper (*Mycteroperca bonaci*) abundance by 1 cm length categories estimated from the RVC survey for the period 1999-2008.

FLen (cm)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1						0	0				0		0		0
2						0	1821				0		0		0
3						0	0				0		1605		0
4						0	0				0		2296		0
5						0	0				0		3901		961
6						0	0				0		9071		0
7						0	0				0		2373		0
8						0	0				0		8022		0
9						0	0				0		3901		0
10						770	0				5344		0		0
11						0	0				0		0		0
12						6011	0				0		0		0
13						0	0				0		0		0
14						0	0				0		0		0
15						396	1821				574		0		0
16						0	1821				0		0		0
17						6406	0				752		3209		274
18						0	7547				0		0		1644
19						396	0				0		0		143
20						881	17329				5297		580		2688
21						0	0				0		0		2500
22						6781	1821				0		0		2773
23						881	10681				0		0		274
24						0	0				2876		1605		3499
25						23217	20527				11069		0		5142
26						1260	0				0		0		4144
27						6011	1821				574		0		2063
28						7147	4742				884		1681		6839
29						0	1402				1733		0		0
30						3974	27616				25615		8737		12007
31						14541	0				0		145		1287
32						1260	4370				1142		6040		7361
33						792	3641				0		0		331
34						0	1821				2547		145		2813
35						14369	14798				44545		17633		43910
36						0	367				133		0		1918
37						441	1821				2690		2818		4419
38						13950	14508				9436		580		7918
39						0	1821				6874		580		0
40						86207	27391				63963		22773		46493
41						0	4742				2263		0		3288
42						0	4642				4992		0		11452
43						792	4742				4301		3977		9424
44						0	0				866		0		8044
45						26054	22222				55151		16758		44489
46						0	0				0		0		1921
47						513	0				2010		0		4160
48						792	2148				5564		2184		4824
49						0	10139				3750		0		0
50						35734	10838				84499		41463		52321
51						0	0				0		0		1645
52						0	0				2876		1137		2061
53						0	728				0		0		0
54						0	0				0		0		2642
55						5700	5586				36236		14486		12524
56						13409	0				0		0		4144
57						0	0				0		0		1644
58						198	551				2263		4591		3295
59						0	0				0		0		143
60						2773	734				64377		20328		39680
61						0	0				0		0		2642
62						0	367				3148		2296		2323
63						0	3641				2614		1343		0
64						0	0				0		0		143
65						792	8458				19821		28193		8486
66						198	0				1832		0		1079
67						0	0				2284		4016		0
68						0	0				4842		184		683
69						0	0				0		4591		0
70						0	728				43501		11708		7398
71						0	0				0		565		0
72						792	0				0		0		0
73						0	1485				0		0		0
74						0	0				0		0		0
75						0	4194				8154		21142		2830
76						0	0				0		0		0
77						0	0				3663		0		0
78						0	113				0		0		1645
79						0	0				0		0		0
80						0	17140				25099		13665		5600
81						0	0				0		0		0
82						0	0				0		0		1855
83						0	0				0		184		188
84						0	0				0		0		0
85						0	1821				3901		3606		2995
86						0	0				0		0		0
87						0	0				0		0		0
88						0	1485				0		0		0
89						0	0				0		0		0
90						792	678				20830		11519		4161
91						0	0				299		0		0
92						0	0				0		0		0
93						0	0				0		0		143
94						0	0				0		0		0
95						12617	7760				2585		0		462
96						0	0				0		0		0
97						0	0				0		0		869
98						0	0				0		0		0
99						0	0				0		0		0
100						792	0				14975		25019		2021
101						0	0				0		0		0
102						0	0				0		0		0
103						0	0				0		0		0
104						0	0				0		0		0
105						0	113				1832		0		0
106						0	0				0		0		1645
107						0	0				0		0		211
108						0	0				0		0		0
109						0	0				0		0		0
110						0	226				2152		9054		0
111						0	0				0		0		0
112						0	0				0		0		0
113						0	0				0		0		0
114						0	0				0		0		0
115						0	0				0		0		0
116						0	0				0		0		0
117						0	0				0		0		0
118						0	0				0		0		0
119						0	0				0		0		0
120						0	226				5633		3045		0
121						0	0				0		0		0
122						0	0				0		0		0
123						0	0				0		0		0
124						0	0				0		0		0
125						0	0				0		2296		0
Totals	**Population**					**297,639**	**284,994**				**622,361**		**345,045**		**416,481**
	Recruits					**95,093**	**123,579**				**102,952**		**70,944**		**100,653**

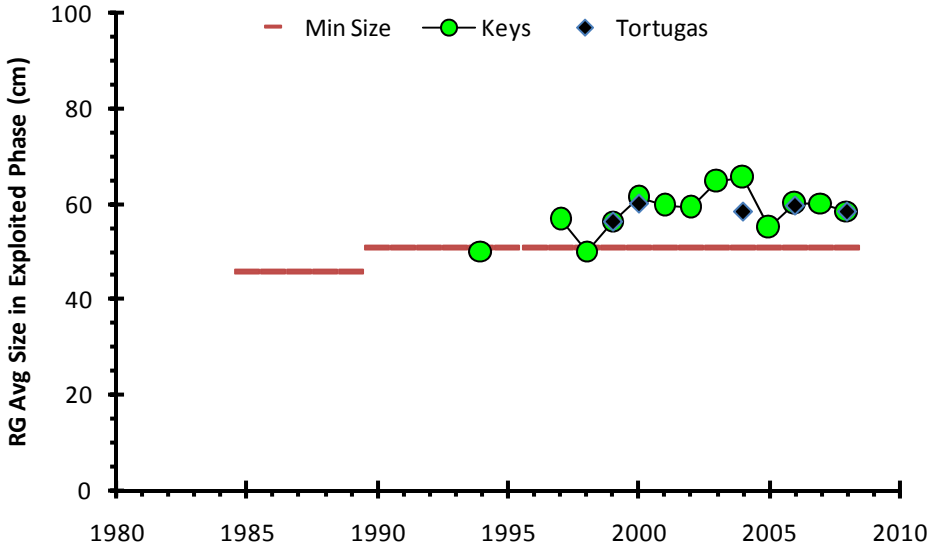

Figure RG.1.- Time-series of red grouper (*Epinephelus morio*) average length (cm) in the exploitable phase (see Ault et al. 1998, 2005b) for the Florida Keys (open green circles, 1980-2008) and Dry Tortugas (solid black diamonds, 1999-2008) regions. The solid (red) line shows the minimum size limit imposed by fishery management.

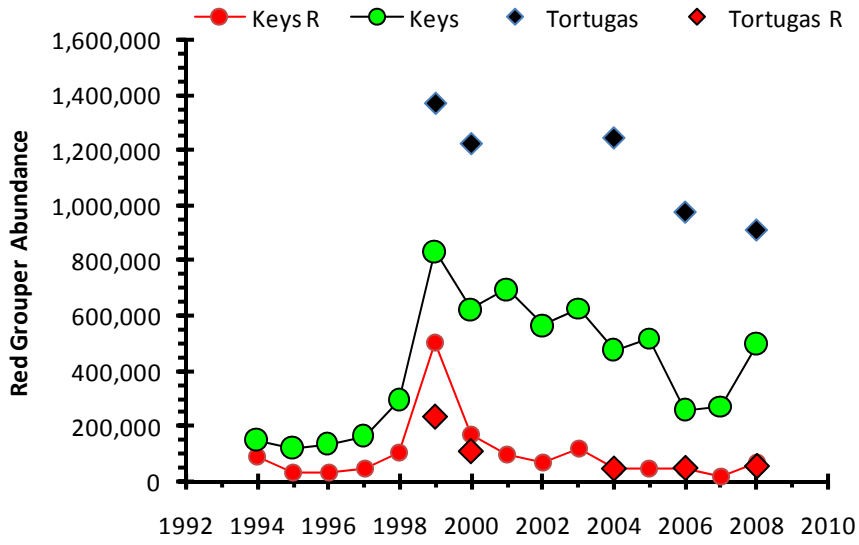

Figure RG.2.- Time-series of red grouper (*Epinephelus morio*) population abundance (numbers of fish) by survey region: Florida Keys (green circles, 1980-2008); and, Dry Tortugas (solid black squares, 1999-2008) regions. Recruit abundance for the same time periods is shown for the two regions: Keys (red circles) and Tortugas (red squares).

Table 7.- Florida Keys red grouper (*Epinephelus morio*) abundance by 1 cm length categories estimated from the RVC survey for the period 1994-2008.

FLen (cm)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	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
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	2408	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	10247	4290	9804	2408	0	0	0	0	0	614
11	0	0	0	0	0	0	0	1134	0	0	0	0	0	0	1685
12	0	0	0	0	0	0	0	899	9632	0	10224	0	0	0	614
13	0	0	0	0	0	30742	0	2044	0	0	0	0	0	0	0
14	0	5132	0	0	0	30742	0	4107	0	0	0	0	0	0	0
15	0	0	0	0	0	81983	468	6502	3943	15066	0	0	8072	3728	0
16	30849	0	24496	0	5810	23164	9985	5920	2408	0	12201	0	0	0	0
17	15425	0	0	0	0	94792	0	1253	0	0	0	0	0	0	542
18	0	0	0	0	0	5231	32533	1584	838	11185	0	0	11943	0	5101
19	0	0	0	0	5810	41205	10916	5697	2408	0	0	0	8072	0	2930
20	0	5132	0	20129	0	46226	29950	11144	16039	11185	12201	25840	0	3728	6399
21	15425	0	12249	0	33031	8716	935	4107	0	0	0	0	0	0	614
22	30849	5132	0	0	38033	20494	8623	13804	0	22370	10224	0	15980	3728	13721
23	0	0	0	0	21737	1796	11302	0	0	0	0	0	0	0	9160
24	0	15411	0	10064	5973	56473	20433	4107	5603	5591	0	10604	0	6714	8788
25	0	8170	0	19548	326	56122	44154	30286	26131	56660	5175	12702	2986	3728	25487
26	0	0	0	0	38074	0	13338	0	4835	0	0	0	4333	3262	8459
27	0	1548	24496	0	326	15478	4290	0	8062	0	0	0	0	0	3544
28	0	0	0	0	5484	5124	18257	18532	5583	23105	52004	0	4633	5971	14500
29	0	464	0	0	653	10463	4333	11182	5627	5591	12201	0	597	2986	2820
30	0	20543	12249	40257	41693	36189	99075	37702	52209	44156	30144	65084	3583	22279	43823
31	0	0	0	0	0	20494	25617	0	4835	11185	0	5303	0	6523	14536
32	15425	5132	0	6516	5484	42791	46850	48489	27600	6413	0	5303	11152	3728	22849
33	0	0	0	455	16451	14641	18262	9810	9632	19072	0	15572	0	6990	13129
34	0	0	0	0	0	9410	5652	14654	6492	0	13473	18596	0	3262	17477
35	0	23117	44902	20584	18570	31174	64013	142291	48016	44302	30321	17908	33322	17432	61231
36	0	11141	0	0	21779	0	8663	8213	1676	1129	12201	33225	0	0	4063
37	0	0	0	0	0	184	8580	0	5627	822	5175	0	9563	11551	592
38	0	7706	0	20129	653	0	4333	23075	7604	18643	12201	13962	13001	0	7363
39	15425	7548	0	0	0	0	4290	4107	4816	0	0	4330	0	0	2930
40	0	6009	12249	6516	26428	81046	56884	68197	51881	65319	85600	71952	28385	50146	32871
41	0	0	0	0	0	10247	0	0	2408	0	0	0	0	0	6342
42	0	0	0	0	0	0	16178	17911	18993	6330	10224	25403	27498	1523	9160
43	0	0	0	0	0	0	0	0	4835	6330	0	534	4036	3262	7063
44	0	0	0	0	0	0	8663	283	0	0	10224	0	0	0	6472
45	15425	464	8157	17490	6136	0	14181	71112	51827	45651	29309	63389	19125	10718	23871
46	0	0	0	0	0	5231	0	9698	3175	5591	5175	837	0	0	5858
47	0	0	0	0	0	0	0	914	0	0	0	8659	4825	7457	5750
48	0	0	0	0	0	15478	9985	6365	1676	6330	366	0	4036	0	9884
49	0	0	0	0	0	0	0	914	0	0	0	0	0	0	0
50	15425	0	0	455	5029	10463	7055	35786	42130	46642	12396	50106	5282	15612	23212
51	0	0	0	0	0	0	0	0	0	0	0	4864	0	0	0
52	0	0	0	0	0	0	0	0	380	0	0	4330	4333	3728	0
53	0	0	0	0	0	0	0	1548	9668	1129	0	0	0	3728	0
54	0	0	0	0	0	0	0	0	2514	0	0	0	0	0	0
55	0	0	0	0	0	10463	4333	9162	20554	20594	8424	18122	5894	4279	14930
56	0	0	0	0	0	0	0	0	0	0	0	0	1298	0	0
57	0	0	0	0	0	0	0	0	2408	0	0	0	0	3262	2820
58	0	0	0	0	0	0	0	1688	6115	5591	0	0	8369	6990	5858
59	0	0	0	0	0	0	0	0	0	0	0	9937	0	0	2930
60	0	0	0	0	0	0	0	11208	30272	21822	8621	20925	8721	21011	28012
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	5652	11182	0	1129	0	0	0	0	614
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	0	0	0	6516	0	0	0	0	0	5980	0	0	0	0	0
65	0	0	0	0	0	10463	0	7588	14874	2601	44188	8252	1947	26893	8184
66	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
68	0	0	0	0	0	0	0	0	761	0	0	4330	0	0	3544
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	12495	11186	20507	10590	0	4529	1273	614
71	0	0	0	0	0	0	0	0	0	6330	0	0	0	0	0
72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	27439	30344	12201	0	5101	6523	6472
76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2930
78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	11751	0	11748	10224	837	0	0	0
81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	4290	914	0	2258	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	15000	12567	0	0	708	0
91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95	0	0	0	0	0	0	0	0	0	6330	0	0	0	0	0
96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.- Dry Tortugas region red grouper (*Epinephelus morio*) abundance by 1 cm length categories estimated from the RVC survey for the period 1999-2008.

FLen (cm)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1						0	0				0		0		0
2						0	0				0		0		0
3						0	0				0		2258		0
4						0	0				0		0		0
5						6388	346				1173		4519		0
6						0	0				0		0		0
7						12061	2312				0		0		0
8						6030	4437				0		0		0
9						0	0				0		0		0
10						0	2312				0		0		1701
11						12061	0				0		556		0
12						8400	11187				2284		0		1701
13						0	0				0		0		2428
14						16436	6228				151		2258		0
15						2203	13165				4069		2877		4129
16						0	6749				0		0		12386
17						12061	2312				0		2852		1701
18						14072	4624				0		2258		5694
19						6030	2312				4069		0		3047
20						18547	16889				12378		5752		4580
21						0	4437				0		0		6111
22						0	6890				1800		1777		3148
23						3948	2312				4069		0		0
24						18907	4765				605		6640		1844
25						97717	18849				17166		18037		8084
26						15003	0				0		594		7789
27						12105	10679				12790		3395		4272
28						41974	17049				13680		23339		5649
29						26840	10471				1800		2258		4853
30						109161	57380				74842		62727		40417
31						12061	19502				3596		0		3270
32						66060	23471				22014		16255		9433
33						21041	30234				13580		23115		10017
34						33740	21233				5055		11987		8266
35						109928	102367				111172		96483		49015
36						24644	35936				14009		5518		9351
37						16855	13198				7138		7257		10944
38						44688	24611				12206		24135		33132
39						1352	7655				4550		184		6630
40						139335	178754				193757		169380		67812
41						12786	15234				0		0		13170
42						16663	28994				15679		23501		25459
43						12296	26844				10419		4703		14933
44						13058	14333				169		923		2126
45						121069	96533				137096		97582		71513
46						4018	2965				5127		556		11047
47						2883	16070				3858		1296		15579
48						8808	15266				7956		20043		19912
49						12061	0				0		7305		3562
50						82564	45863				148139		85015		88106
51						0	6242				151		0		5987
52						0	0				11786		1666		27429
53						6701	6242				2404		1334		10573
54						622	7105				0		2428		4043
55						62775	92129				70182		49680		54413
56						1113	382				9191		6640		6275
57						0	0				20649		0		4765
58						19639	2870				12737		8794		9270
59						4491	0				0		0		7412
60						65042	46282				121173		76205		66543
61						0	2073				3255		2258		3283
62						1651	6934				4806		0		7060
63						626	5034				126		1783		3615
64						939	1342				1142		594		10327
65						6559	55894				44730		35588		42602
66						0	0				0		0		5142
67						0	4437				0		0		869
68						0	301				1137		0		1519
69						0	4437				1800		0		0
70						3205	16178				42150		16344		15996
71						0	0				0		0		0
72						0	10679				0		0		1738
73						0	5546				0		4519		0
74						0	0				0		2274		0
75						1651	13434				15118		9140		5007
76						0	0				0		0		0
77						0	0				0		0		0
78						0	4437				0		0		4853
79						0	0				0		0		0
80						0	3883				8729		4599		15280
81						0	0				0		0		0
82						0	0				0		0		0
83						0	0				0		0		0
84						0	0				0		0		0
85						0	3416				4220		3001		2049
86						0	0				0		0		0
87						0	0				0		0		0
88						0	0				0		0		0
89						0	0				0		0		0
90						0	0				3071		10307		1990
91						0	0				135		0		0
92						0	0				0		0		0
93						0	0				0		0		0
94						0	0				0		0		0
95						0	0				0		0		0
96						0	0				0		0		0
97						0	0				0		0		0
98						0	0				0		0		0
99						0	0				0		0		0
100						0	346				135		1189		0
Population	**0**	**0**	**0**	**0**	**0**	**1,370,868**	**1,224,391**	**0**	**0**	**0**	**1,245,223**	**0**	**975,678**	**0**	**910,851**
Recruits	**0**	**0**	**0**	**0**	**0**	**234,861**	**110,126**	**0**	**0**	**0**	**47,764**	**0**	**49,784**	**0**	**56,554**

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