Virtual Population Analysis of the Gulf of Mexico Gag Grouper (*Mycteroperca microlepis*) Stock: The Continuity Case

by

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INTRODUCTION

As part of the collective effort to assess the status of the Gulf of Mexico gag grouper (*Mycteroperca microlepis*) stock, a virtual population analysis (VPA) model was constructed. The mode was constructed using the same basic formulation as in the previous assessment of this stocks (Turner et al. 2001, RFSAP 2001), but used updated data.

VPAs differ from other population models in that they rely predominantly on the age structure of the catch. If this information is available, it can be used to identify strong year classes and back-calculate abundance and fishing mortality rate histories. These exercises are usually aided through the use of life history information and indices of abundance. VPAs differ from statistical age-structured models in two important ways. First, VPAs are conditioned on catch-at-age data so these data are fit exactly, while indices of abundance and the selectivities of various fleets are estimated within the model. Second, VPAs typically identify stock-recruitment patterns post-analysis; whereas statistical age structured models often make this estimation in the model sometimes with penalties for using recruitments that deviate from the estimated relationship.

The principal purpose of these VPA analyses was to explore the influence of new data on our conclusions about the status of Gulf gag grouper. It was expected that the VPA would not be chosen to form the basis of our conclusions about stock status in this round of analysis, principally because the age structure of the catch is not well known. Nevertheless, it is helpful when interpreting a new model to know what the former model would have concluded with the updated data.

METHODS

Data

It was not possible to rely on directly observed catch at age information. Instead, age composition was inferred from size composition using an age-length key (SEDAR10-DW-2, SEDAR10-DW-Report). These data were combined with basic life history information and several indices of abundance. Although a number of indices were developed during the current assessment, this continuity case relied only on the four used in the previous assessment: commercial handline, commercial longline, and recreational headboats (all developed using reported catch and effort), and other recreational (MRFSS, which uses dock intercepts and interviews regarding effort).

Since the last assessment, the data on Gulf gag grouper has changed in two ways. First, the data timeframe was expanded. Five years have passed, which allowed ongoing data collection programs to add five years of data. Additionally, two earlier years (1984 and 1985) were made available in some of the datasets. Second, some data have been revised. Minor changes were made to the four indices of abundance as a result of new and improved standardization procedures (SEDAR10-DW-10, SEDAR10-DW-5, SEDAR10-DW-9, SEDAR10-DW-4; Fig. 1), while major changes were made to the age-length relationship. During the previous assessment, it was noted that limited sample sizes prevented the analysts to resolve ages of younger fish well (Turner et al. 2001). Consequently, an effort was made to sample small fish to provide better resolution. These efforts changed our perspective on the growth of Gulf gag grouper (SEDAR10-DW-2; Fig. 2), which in turn dramatically changed our estimates of catches at age (Fig. 3). Because of the central importance of catch at age data to VPA models, it was expected that the improvement in the age-length relationship could have a substantial influence on our conclusions about stock status.

VPA Construction

Principally, the VPA was constructed using the same conventions as in the previous assessment. Constant selectivities were used for each fishery-dependent index. These were all estimated within the model, with the exception of the longline fishery. As was recommended during the previous assessment (RFSAP 2001), initial estimates were converted into an asymptotic selectivity function for this fleet, which targets large individuals in relatively deep water.

To examine the effects of new years of data from changes in data (principally the age structure), two VPAs were constructed. One used updated data but only from the same timeframe as the original model, 1986-1999. The other VPA used updated data from all available years, 1984-2004.

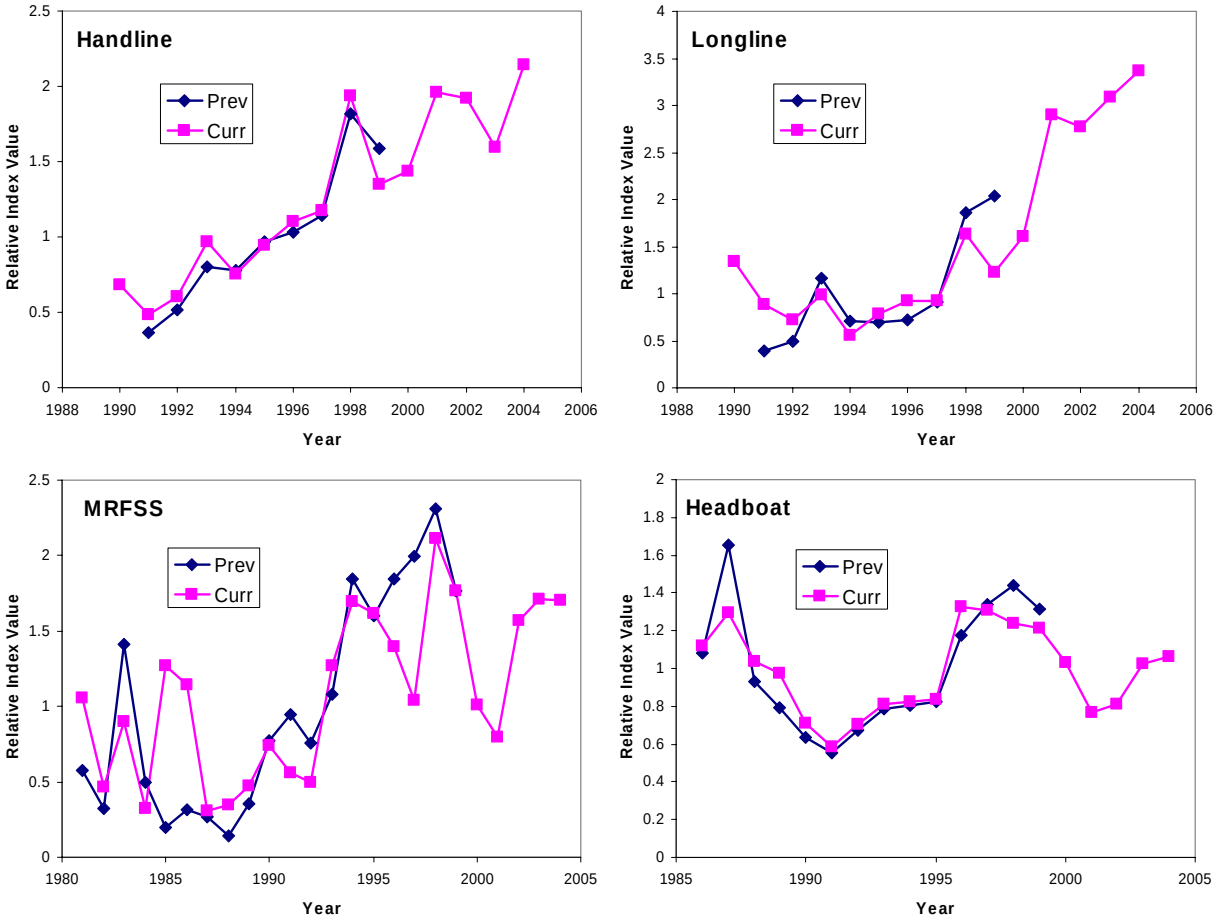


Fig. 1—Indices of Abundance.

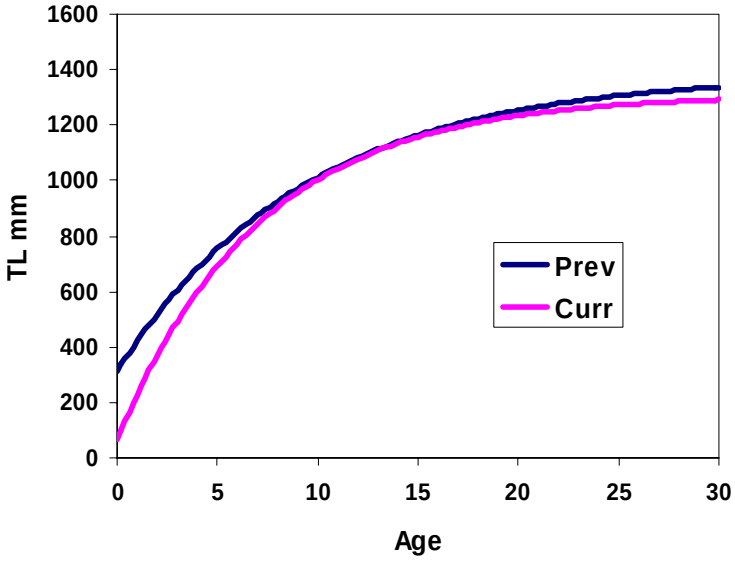
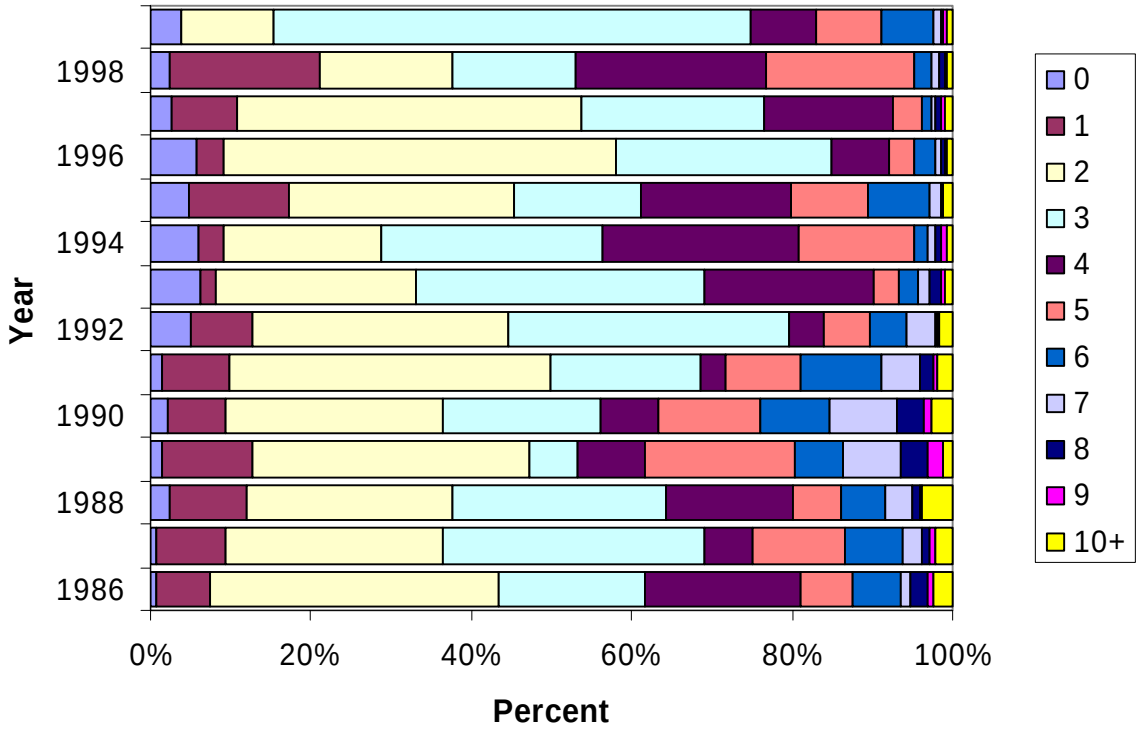


Fig. 2—Age-Length Relationships. Previous assessment: TL (mm) = $1381.5(1-e^{-0.1061(Age+2.4359)})$; Current assessment: TL (mm) = $1310(1-e^{-0.14(Age+0.37)})$

Previous



Current

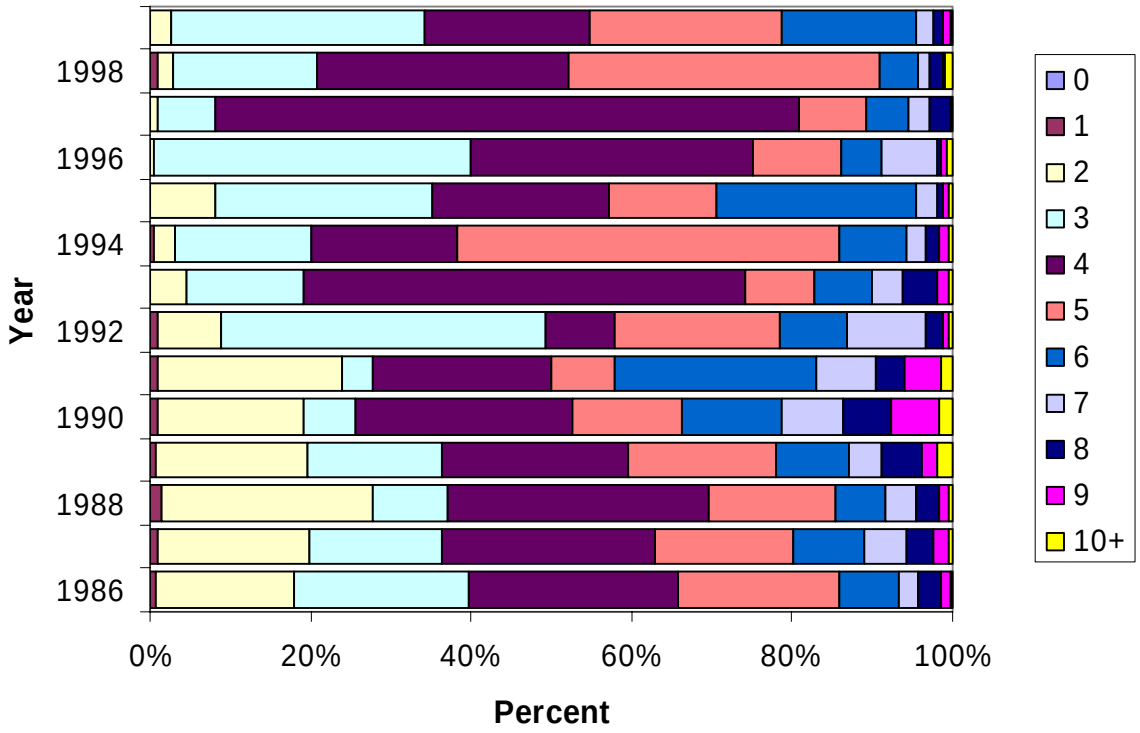


Fig. 3—Catch at Age Estimates.

RESULTS

Parameter Estimates

Estimates of fishing mortality rates at age were surprisingly consistent across runs despite the dramatic changes in inferred age structure (Table 1, Fig. 4). As would be expected, the two new VPAs did not differ in their early year estimates. They only diverged in the late 1990s, where the full timeframe provided additional information on cohorts represented in these years. There were a few spikes in F at age in each of the series. These were not always consistent between the old and new models (e.g., 1994), as a result of the differences in inferred age structure. Interestingly, the results from the new model using the old timeframe were more consistent with the old assessment than with the new assessment using the full timeframe. This observation suggests that the new years of data were more influential than the shift in the age-length key.

Estimates of numbers at age were even more consistent across the old and new models (Table 2, Fig. 5). Some differences included a 1989-born cohort that shows up in the new models but not the old. However, both models suggest a strong year class born in the early 1990s, although the old model suggested a 1993 birthday while the new model indicates 1994. This change was expected because the new age-length key predicted older ages, especially for the youngest fish.

Other Fits and Estimates

Fits to indices changes a bit across the three models tested (Fig. 6). Fits were fairly consistent between the old model and the new one limited to the same time frame. This consistency was not terribly surprising since the change in age-length key affected both the catch at ages and also the selectivities of the different fleets. Note that selectivities generally shifted so that older age classes were more vulnerable (Fig. 7).

CONCLUSIONS

The new assessment for the Gulf of Mexico gag grouper stock included two new or improved sources of information. First, we had an improved age-length key. This change led to an interpretation that fish were caught at older ages than had previously believed. But, it also led to a shift in the reproductive schedule and the selectivity of various fisheries, minimizing the effects of this change on the model as a whole. Second, we had data from recent years, which suggested a growing stock. Despite these changes, the estimates of abundance and fishing mortality rates were mostly quite consistent between the old and new models. When differences did exist, they were primarily in recent years, and apparently influenced more by additional years of data than by the revised age-length key.

REFERENCES

Reef Fish Stock Assessment Panel (RFSAP). 2001. *October 2001 Report of the Reef Fish Stock Assessment Panel, Final Draft—November 26, 2001*. Gulf of Mexico Fishery Management Council, Tampa, FL.

Turner, SC, CE Porch, D Heinemann, GP Scott, and M Ortiz. 2001. *Status of Gag in the Gulf of Mexico, Assessment 3.0*. Sustainable Fisheries Division Contribution SFD 01/02-134. Department of Commerce, National Marine Fisheries Service, Miami, FL.

Table 1—Fishing mortality rates at age by year from the previous assessment and a new VPA run with data from 1986-1999 and with data from 1984-2004.

Previous Assessment

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1986	0.01	0.055	0.34	0.465	0.517	0.261	0.303	0.601	0.411	0.277	0.277
1987	0.005	0.098	0.21	0.357	0.179	0.391	0.324	0.121	0.6	0.193	0.193
1988	0.022	0.1	0.482	0.344	0.305	0.266	0.354	0.264	0.065	0.412	0.412
1989	0.006	0.11	0.498	0.162	0.144	0.571	0.405	0.823	0.365	0.156	0.156
1990	0.005	0.021	0.252	0.343	0.184	0.201	0.339	0.744	0.632	0.119	0.119
1991	0.006	0.036	0.234	0.434	0.128	0.602	0.387	0.504	0.534	0.132	0.132
1992	0.025	0.037	0.165	0.295	0.145	0.316	0.603	0.198	0.027	0.126	0.126
1993	0.014	0.017	0.225	0.404	0.426	0.201	0.291	0.644	0.169	0.114	0.114
1994	0.014	0.009	0.252	0.456	0.581	0.633	0.182	0.187	0.948	0.101	0.101
1995	0.035	0.041	0.119	0.375	0.744	0.538	1.017	0.258	0.117	0.115	0.115
1996	0.014	0.023	0.158	0.113	0.205	0.189	0.192	0.161	0.096	0.067	0.067
1997		0.029	0.556	0.126	0.111	0.182	0.102	0.078	0.268	0.123	0.123
1998			0.093	0.502	0.232	0.223	0.188	0.174	0.14	0.109	0.109
1999				0.402	0.402	0.087	0.087	0.087	0.087	0.087	0.087

New Assessment --> 1999

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1986	0	0.004	0.139	0.299	0.42	0.39	0.36	0.247	0.265	0.208	0.208
1987	0	0.005	0.106	0.117	0.403	0.314	0.18	0.272	0.37	0.174	0.174
1988	0	0.011	0.258	0.086	0.456	0.574	0.221	0.14	0.3	0.231	0.231
1989	0	0.008	0.152	0.193	0.235	0.369	0.549	0.157	0.204	0.265	0.265
1990	0	0.001	0.162	0.04	0.28	0.118	0.246	0.556	0.21	0.211	0.211
1991	0	0.005	0.057	0.064	0.277	0.177	0.493	0.317	0.914	0.372	0.372
1992	0	0.004	0.044	0.118	0.175	0.382	0.247	0.312	0.131	0.321	0.321
1993	0	0.001	0.037	0.165	0.373	0.426	0.351	0.274	0.358	0.182	0.182
1994	0	0.001	0.018	0.193	0.32	0.653	1.051	0.188	0.177	0.152	0.152
1995	0	0	0.019	0.291	0.471	0.487	1.066	1.652	0.085	0.117	0.117
1996	0	0	0.001	0.092	0.526	0.333	0.243	0.708	0.978	0.106	0.106
1997		0	0.007	0.026	0.286	0.261	0.312	0.218	0.818	0.064	0.064
1998			0.017	0.231	0.19	0.315	0.307	0.166	0.297	0.252	0.252
1999				0.346	0.346	0.174	0.174	0.174	0.174	0.174	0.174

Table 1 (cont.)—Fishing mortality rates at age by year from the previous assessment and a new VPA run with data from 1986-1999 and with data from 1984-2004.

New Assessment --> 2004

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1984	0	0.003	0.073	0.046	0.173	0.335	0.164	0.208	0.355	0.158	0.158
1985	0	0.004	0.137	0.195	0.323	0.936	0.381	0.369	0.261	0.349	0.349
1986	0	0.004	0.137	0.299	0.415	0.384	0.356	0.245	0.261	0.206	0.206
1987	0	0.005	0.104	0.115	0.401	0.309	0.177	0.268	0.364	0.171	0.171
1988	0	0.011	0.252	0.084	0.447	0.571	0.216	0.137	0.294	0.226	0.226
1989	0	0.008	0.148	0.188	0.23	0.358	0.544	0.153	0.199	0.259	0.259
1990	0	0.001	0.162	0.039	0.271	0.115	0.236	0.547	0.204	0.204	0.204
1991	0	0.005	0.057	0.064	0.268	0.17	0.477	0.301	0.884	0.357	0.357
1992	0	0.004	0.043	0.118	0.175	0.364	0.234	0.297	0.123	0.303	0.303
1993	0	0.001	0.042	0.16	0.371	0.425	0.327	0.255	0.334	0.169	0.169
1994	0	0.001	0.02	0.226	0.307	0.648	1.045	0.172	0.162	0.139	0.139
1995	0	0	0.027	0.34	0.592	0.458	1.047	1.615	0.077	0.106	0.106
1996	0	0	0.002	0.134	0.67	0.478	0.223	0.679	0.906	0.095	0.095
1997	0	0	0.008	0.048	0.457	0.382	0.536	0.196	0.751	0.057	0.057
1998	0	0.005	0.007	0.286	0.395	0.639	0.531	0.352	0.258	0.219	0.219
1999	0	0	0.014	0.122	0.467	0.463	0.489	0.374	0.468	0.147	0.147
2000	0	0.002	0.127	0.1	0.328	0.197	0.481	0.285	0.35	0.167	0.167
2001	0	0.002	0.003	0.091	0.202	0.501	0.506	0.657	0.299	0.305	0.305
2002		0.004	0.028	0.103	0.186	0.385	0.412	0.422	0.256	0.332	0.332
2003			0.034	0.361	0.186	0.162	0.348	0.346	0.328	0.302	0.302
2004				0.995	0.995	0.236	0.236	0.236	0.236	0.236	0.236

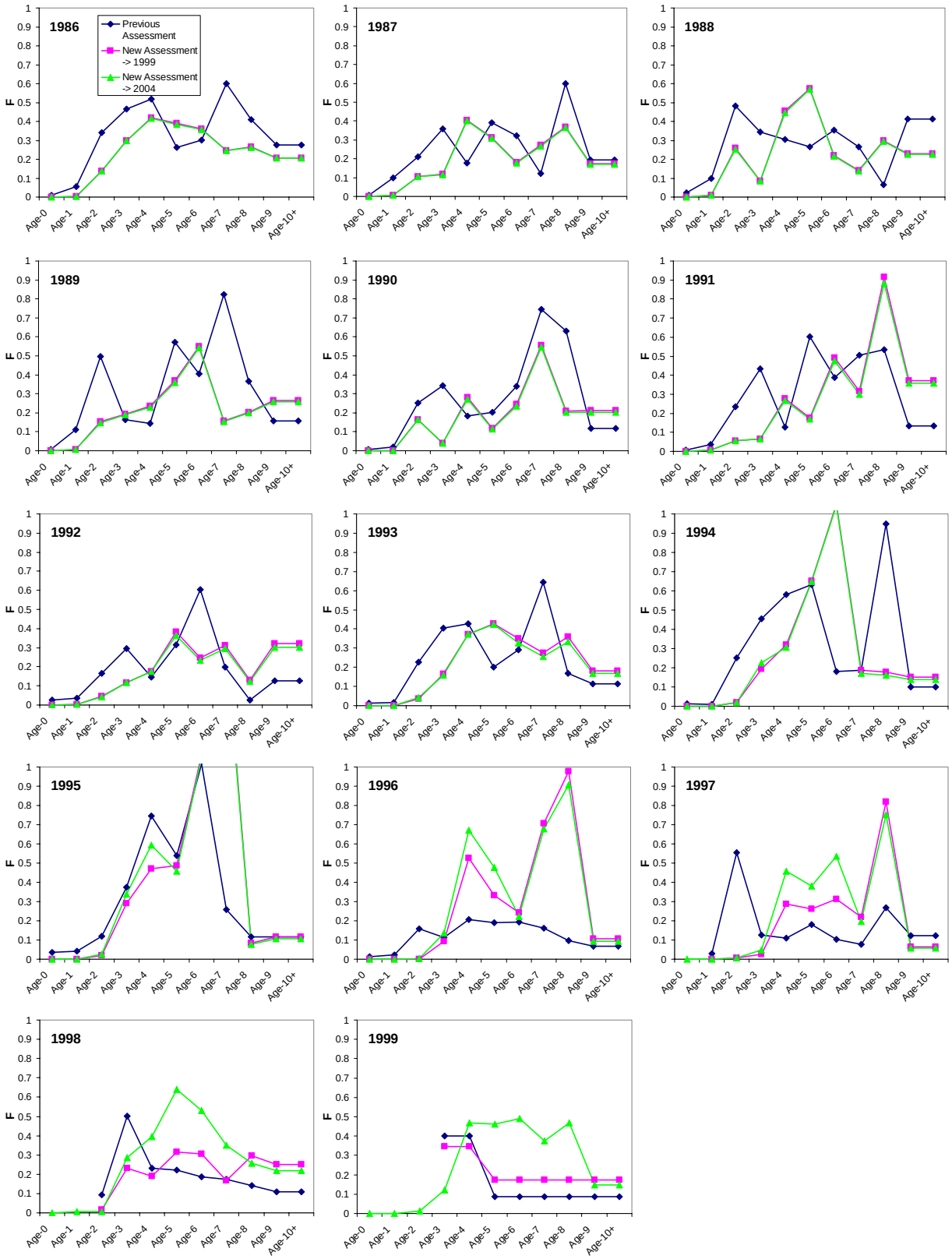


Fig. 4—Fishing mortality rates at age by year from the previous assessment (blue diamonds) and a new VPA run with data from 1986-1999 (pink squares) and with data from 1984-2004 (green triangles).

Table 2—Numbers at age (in millions) by year from the previous assessment and a new VPA run with data from 1986-1999 and with data from 1984-2004.

Previous Assessment

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1986	0.808	1.288	1.303	0.512	0.501	0.294	0.249	0.027	0.065	0.029	0.104
1987	0.939	0.689	1.049	0.798	0.277	0.257	0.195	0.158	0.013	0.037	0.087
1988	0.909	0.804	0.537	0.732	0.481	0.199	0.149	0.121	0.121	0.006	0.088
1989	1.965	0.765	0.626	0.286	0.446	0.305	0.131	0.09	0.08	0.097	0.054
1990	2.096	1.682	0.59	0.328	0.209	0.333	0.148	0.076	0.034	0.048	0.111
1991	1.758	1.795	1.417	0.395	0.2	0.15	0.234	0.091	0.031	0.016	0.121
1992	1.413	1.504	1.491	0.965	0.22	0.152	0.071	0.137	0.047	0.016	0.103
1993	4.609	1.186	1.248	1.088	0.619	0.164	0.095	0.033	0.097	0.04	0.09
1994	4.834	3.912	1.004	0.857	0.626	0.348	0.115	0.061	0.015	0.07	0.1
1995	1.832	4.101	3.337	0.672	0.468	0.301	0.159	0.083	0.044	0.005	0.132
1996	4.316	1.524	3.386	2.551	0.397	0.191	0.151	0.05	0.055	0.033	0.105
1997		3.664	1.281	2.488	1.961	0.279	0.136	0.107	0.036	0.043	0.112
1998			3.062	0.632	1.889	1.51	0.2	0.106	0.086	0.024	0.118
1999				2.402	0.329	1.29	1.04	0.143	0.077	0.064	0.109
2000					1.383	0.19	1.017	0.82	0.112	0.06	0.137

New Assessment --> 1999

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1986	1.167	1.268	1.145	0.724	0.648	0.53	0.21	0.096	0.106	0.058	0.116
1987	1.102	1.004	1.087	0.858	0.462	0.366	0.309	0.126	0.065	0.07	0.122
1988	0.608	0.948	0.86	0.841	0.657	0.266	0.23	0.222	0.083	0.039	0.138
1989	3.014	0.524	0.808	0.572	0.665	0.358	0.129	0.159	0.166	0.053	0.121
1990	1.232	2.594	0.447	0.597	0.406	0.452	0.213	0.064	0.117	0.117	0.115
1991	1.327	1.06	2.23	0.327	0.494	0.264	0.346	0.144	0.032	0.081	0.161
1992	1.681	1.142	0.908	1.813	0.264	0.322	0.19	0.182	0.09	0.011	0.144
1993	5.685	1.447	0.979	0.748	1.386	0.191	0.189	0.128	0.115	0.068	0.097
1994	4.299	4.894	1.244	0.812	0.546	0.821	0.107	0.115	0.084	0.069	0.118
1995	1.752	3.701	4.209	1.052	0.577	0.341	0.368	0.032	0.082	0.06	0.138
1996	1.874	1.508	3.185	3.554	0.677	0.31	0.18	0.109	0.005	0.065	0.152
1997		1.613	1.298	2.739	2.789	0.344	0.191	0.122	0.046	0.002	0.168
1998			1.389	1.11	2.297	1.804	0.228	0.12	0.084	0.018	0.137
1999				1.175	0.758	1.635	1.133	0.144	0.088	0.054	0.103
2000					0.715	0.462	1.182	0.819	0.104	0.063	0.114

New Assessment --> 2004

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1984	1.571	1.126	1.154	1.047	0.868	0.269	0.246	0.126	0.062	0.053	0.16
1985	1.496	1.352	0.966	0.923	0.86	0.628	0.165	0.179	0.088	0.037	0.157
1986	1.19	1.288	1.159	0.726	0.654	0.536	0.212	0.097	0.107	0.058	0.118
1987	1.13	1.024	1.104	0.87	0.463	0.372	0.314	0.128	0.066	0.071	0.123
1988	0.609	0.973	0.877	0.856	0.667	0.267	0.235	0.227	0.084	0.039	0.141
1989	3.024	0.524	0.828	0.587	0.677	0.367	0.13	0.163	0.17	0.054	0.124
1990	1.268	2.603	0.448	0.615	0.419	0.463	0.221	0.065	0.12	0.12	0.118
1991	1.158	1.091	2.237	0.328	0.509	0.275	0.355	0.15	0.032	0.084	0.167
1992	1.478	0.997	0.935	1.819	0.265	0.335	0.2	0.19	0.096	0.011	0.151
1993	4.04	1.272	0.854	0.771	1.391	0.191	0.201	0.136	0.121	0.073	0.104
1994	2.326	3.478	1.094	0.705	0.565	0.826	0.108	0.124	0.091	0.075	0.128
1995	1.453	2.002	2.99	0.923	0.484	0.358	0.372	0.033	0.09	0.066	0.152
1996	4.753	1.251	1.723	2.505	0.565	0.231	0.195	0.112	0.006	0.072	0.169
1997	2.707	4.091	1.077	1.481	1.887	0.249	0.123	0.134	0.049	0.002	0.189
1998	1.908	2.33	3.521	0.919	1.214	1.028	0.146	0.062	0.095	0.02	0.155
1999	7.647	1.643	1.996	3.01	0.594	0.704	0.467	0.074	0.037	0.063	0.121
2000	1.968	6.582	1.414	1.693	2.294	0.321	0.382	0.246	0.044	0.02	0.137
2001	1.009	1.694	5.654	1.072	1.319	1.422	0.227	0.203	0.16	0.027	0.114
2002		0.868	1.455	4.852	0.842	0.928	0.741	0.118	0.091	0.102	0.089
2003			0.744	1.218	3.769	0.602	0.544	0.423	0.066	0.06	0.118
2004				0.619	0.731	2.693	0.441	0.33	0.257	0.041	0.114
2005					0.197	0.233	1.831	0.3	0.225	0.175	0.105

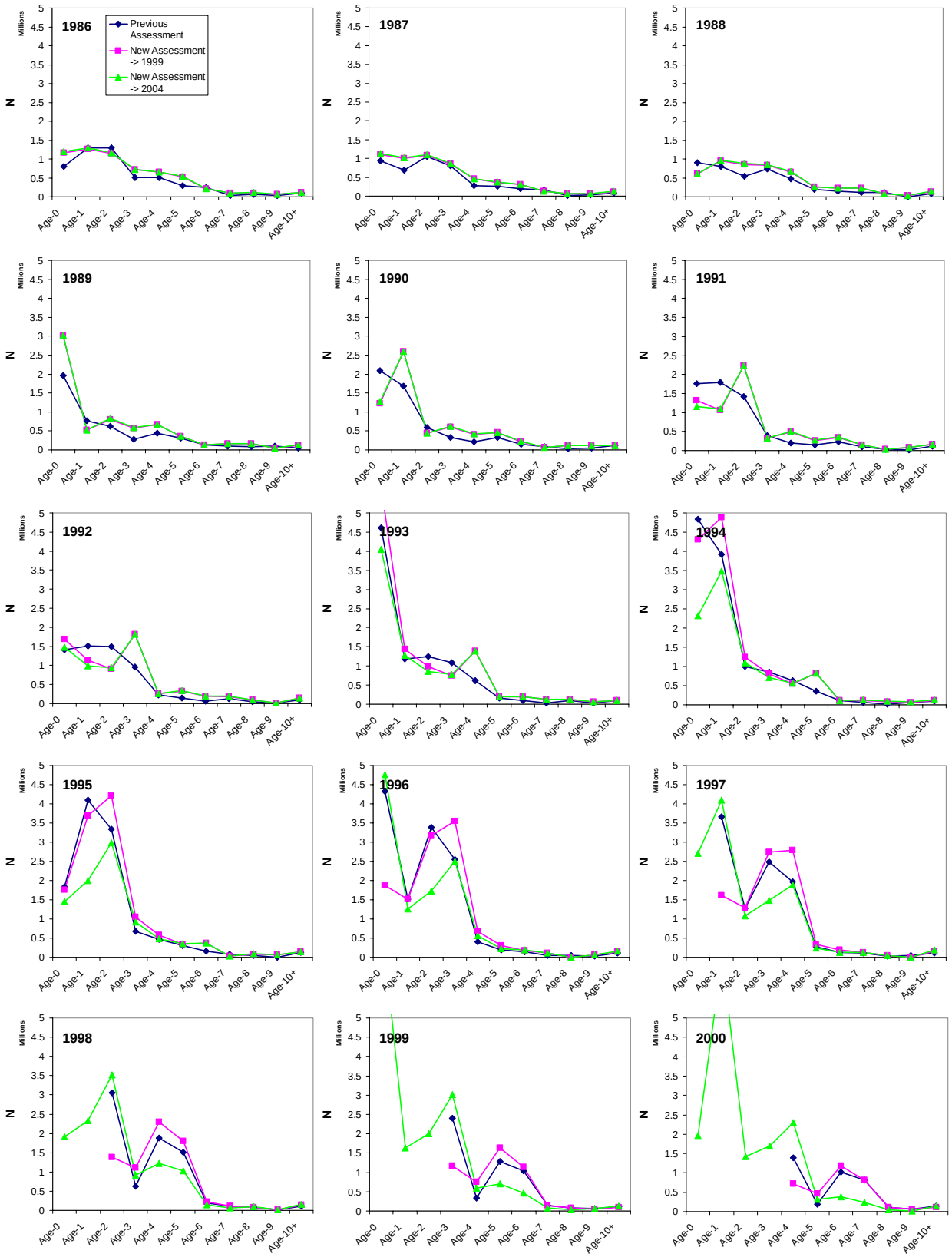


Fig. 5—Numbers at age by year from the previous assessment (blue diamonds) and a new VPA run with data from 1986-1999 (pink squares) and with data from 1984-2004 (green triangles).

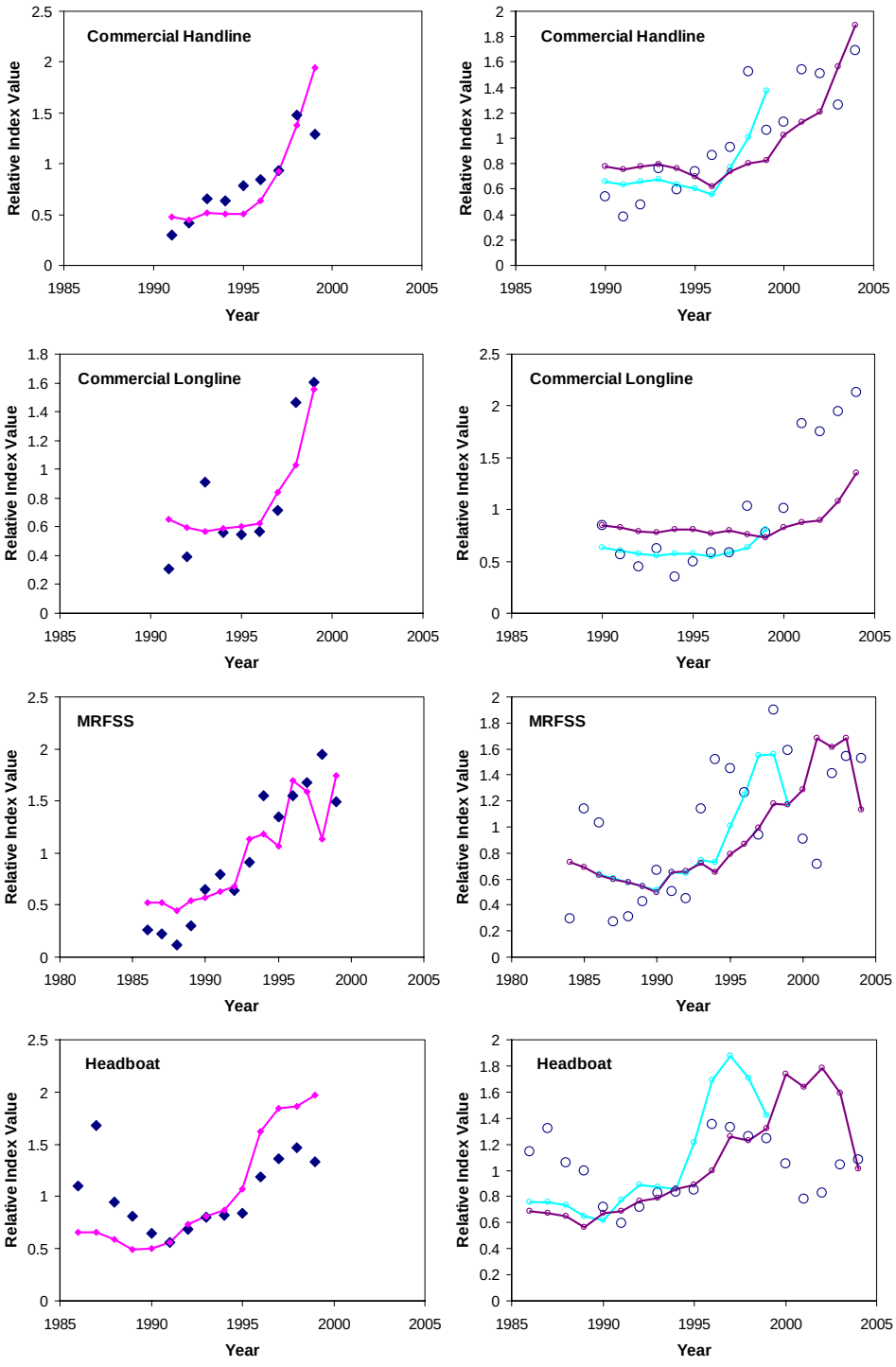


Fig. 6—Fits to indices from the previous assessment (left column) and a new VPA run with data from 1986-1999 (light blue) and with data from 1984-2004 (purple).

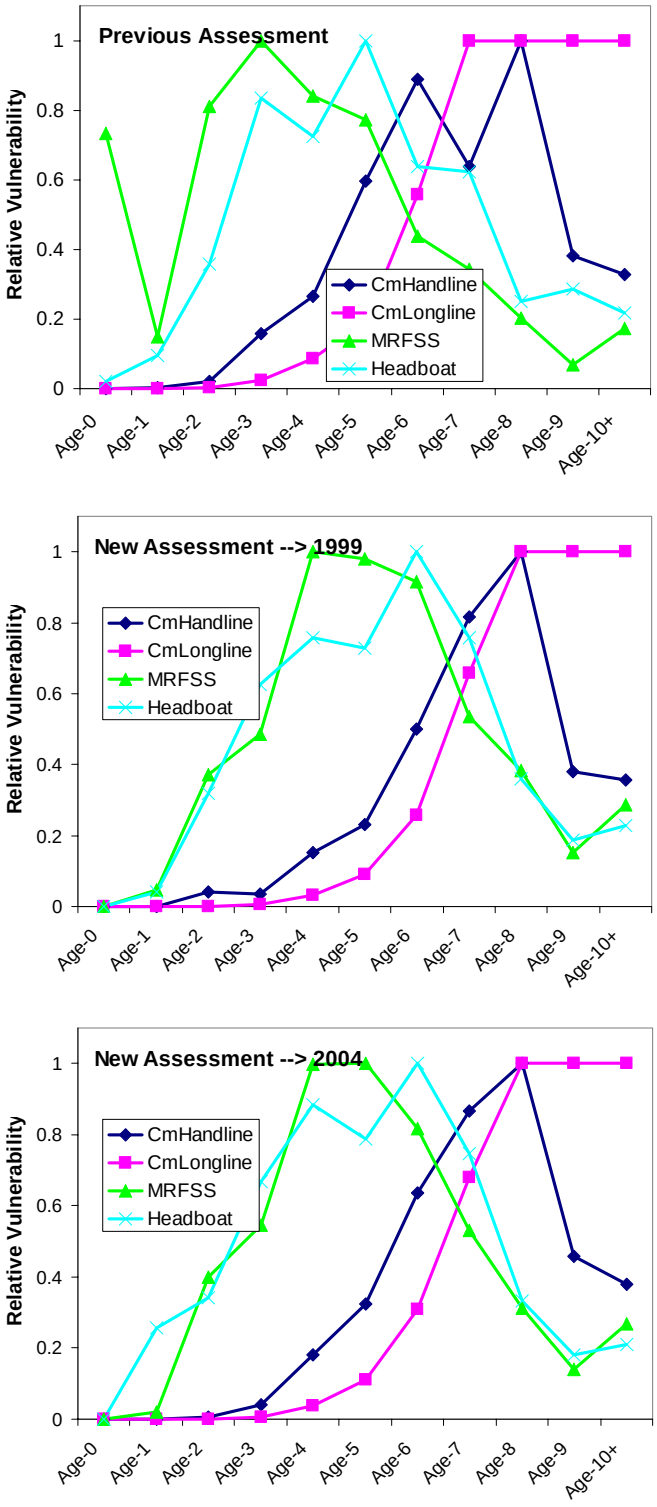


Fig. 7—Selectivity patterns by fleet from the previous assessment (top) and and a new VPA run with data from 1986-1999 (middle) and with data from 1984-2004 (bottom). Note that selectivity in the longline fleet was assumed asymptotic and set by assigning full selectivity to all ages above the estimated age at full selectivity.