Modeled age composition of Gulf of Mexico Red Snapper 1984-2003

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Introduction

For several assessments (including Goodyear 1995 and Schirripa and Legault 1999) the age composition of Gulf of Mexico red snapper catches from the commercial and recreational finfish fisheries (not including the shrimp bycatch) has been derived using a probabilistic modeling approach developed by Goodyear (1997). The approach uses information on recruitment patterns, historical mortality rates, the frequency distributions of length at age to create probability distributions from observed length samples.

The purpose of this paper is to describe the application of that method for the SEDAR 7 stock assessment of red snapper in 2004. Age composition from the finfish fisheries was calculated for multiple geographic and fishery strata under two different assumptions about the stock structure of red snapper in the Gulf of Mexico: 1) that there is one stock with different fisheries in the eastern and western Gulf and 2) that there are two stocks, one in the eastern Gulf and one in the western Gulf.

The Goodyear procedure was used to calculate both the age composition of the landed catches as well as the age composition of the discarded catches from the finfish fisheries (It was not used to calculate the age composition of the shrimp bycatch which was estimated by Nichols 2004c). In addition to calculating the abundance of discards from the directed commercial and recreational fisheries as has been done in previous assessments, a procedure was added to permit calculation of the amount and age composition of discards from the non-directed (closed season) commercial fishery identified in the SEDAR7 Data Workshop report. The procedure involves iteration between two processes, the first is the aging program in which sizes are converted to age composition and the second is a virtual population analysis (VPA) which is used to derive estimates of fishing mortality rates which are then used in the next iteration of the aging program. Turner (2004) described the equations involved in calculating the age composition of the landed and discarded catches from directed fisheries; that information is not repeated here. The methods used to calculate the numbers of dead discards from the closed season commercial fishery are described.

Inputs

age assignment phase parameters

Diaz *et. al.* (2004) reviewed growth of Gulf of Mexico red snapper using more than 40,000 age observations which had not been available when Goodyear examined red snapper growth. They examined the data for geographic (east, west) and fishery specific (recreational, handline, longline) growth rates; they concluded that there were only small differences in growth rates between fisheries and between regions. Therefore one growth curve was used for all regions and fisheries under both stock structure assumptions (Table 1). Their estimate of the coefficient of variation of length at age (0.16) was also used.

Ages were standardized to January 1 for use in assessments by adding half a year to t_0 which effectively converted the size at annulus formation from the assumed date of July 1 (Alman *et al.* 2004) earlier to the start of the year.

Diaz (2004) examined allometric relationships of Gulf of Mexico red snapper and concluded that there were only very small differences from those estimated by Goodyear and used in recent assessments. Therefore the equations used in previous assessments were retained (Table 1).

All lengths from the finfish fisheries were converted to total length and all weights to whole weight. In general the equations used in recent assessments (Goodyear 1995, Schirripa and Legault 1999) were used; Texas Parks and Wildlife Department (TPWD) biologists reported that all lengths recorded by TPWD personnel are the equivalent of what the Gulf States Marine Fisheries Commission's Gulf FIN program describes as maximum length. Therefore a maximum length to total length equation was developed with linear regression using data collected by Florida Marine Fisheries Institute personnel and reported to Gulf FIN. All lengths reported by TPWD were converted from maximum length to total length as defined by GulfFIN. The size to size conversion equations used are shown in Table 1.

The sector (recreational and commercial) and region (east, west) specific release mortality rates developed by the SEDAR7 Data Workshop (Table 6.5 in that report) were used to calculate the numbers of dead discards (open season dead discards for the commercial fishery).

data

The landings and size composition data from the finfish fisheries were aggregated into seven strata for the assessment. The Mississippi River was used as the approximate boundary between eastern and western regions; National Marine Fisheries Service (NMFS) commercial statistical areas 1-12 were assigned to the east and areas 13-21 were assigned to the west. Two commercial fishery gear groups were used as had been done in previous assessments: those were 1) longline and 2) all other gears combined which was labeled handline (or handline +) because handline generally accounted for over 90% of the total landings. Information from the handline+ gear group in the eastern Gulf of Mexico was further stratified into southeastern (statistical areas 1-7) and northeastern (statistical areas 8-12) sub-regions as recommended in the Data Workshop report because of differences in size composition of handline catches between those areas; the intention was that for assessment analyses the information from those eastern two areas would be re-aggregated, because the amount of landings from the southeast area was relatively small. The recreational fisheries statistics were assigned to eastern and western regions as well; however fishing area information is generally not recorded with the available fishery data, so state of landing was used to assign region: western Florida through Mississippi information was assigned to the eastern Gulf of Mexico, and Louisiana and Texas information was assigned to the western Gulf of Mexico. As had been done in previous assessments the age composition for the recreational fishery was developed by state and mode, and then that information was aggregated into the two regions.

Commercial landings by year, gear group and region were taken from Poffenberger and Turner (2004). Recreational harvest (A+B1 for MRFSS, landings for the SEFSC headboat survey and for the TPWD survey) and the proportion of the recreational harvest which was released (calculated from MRFSS statistics) were taken from Diaz and Phares (2004).

Size composition for the recreational fisheries was obtained from MRFSS (Marine Recreational Fisheries Statistics Survey), the NMFS SEFSC (Southeast Fisheries Science Center) headboat survey, the Alabama charter boat survey, the TPWD recreational fisheries survey, the Gulf FIN program, and the NMFS TIP (trip interview program).

Size composition for the commercial fisheries was obtained from NOAA Fisheries Trip Interview Program (TIP), the Alabama charter boat survey and Gulf FIN. Size composition data from TPWD samples from the commercial fisheries was not used because of uncertainty about the gear used to capture the fish.

closed season discards

Closed season discards from the commercial fisheries were modeled for inclusion in the catch at age. Let catch of red snapper in the open season be proportional to population abundance of legal sized fish given the amount of effort in the open season. We can model catch of red snapper during the closed season as being proportional to the population abundance (of both legal and undersized fish) and the amount of effort in the closed season. Assuming the same selectivity operates in the open and the closed season, then adding the undersized discards in the open season to the landings in the open season, we have:

$$D_{closed,y} \propto \left(\frac{W_{open,y}}{\overline{w}_y} + \frac{Wdis_{open,y}}{\overline{w}dis_y} \right) \frac{days_{closed,y}}{days_{open,y}} \qquad (1)$$

$D_{closed,y}$ is the number of discarded red snapper in the closed season in year *y*.

$W_{open,y}$ is the total weight of legally landed red snapper in the open season of year *y*.

$\overline{w}_y$ is the average weight of legally landed red snapper in year *y*.

$Wdis_{open,y}$ is the total weight of undersized red snapper that are discarded dead in the open season of year *y*.

$\overline{w}dis_y$ is the average weight of undersized red snapper that are discarded in the open season of year *y*.

$days_{i,y}$ is the number of days *i*=(*open* or *closed*) in year *y*.

For the present assessment, landings in weight are broken out into five gear-area strata, each of which has an annual estimate of average weight derived from the length samples. The number of discards in the open season is estimated by gear strata by assuming a distribution of size at age and estimating the fraction of that size distribution that is below the year-specific minimum size limit and that is vulnerable to a gear-specific selectivity. The open season length, in days, is given in Hood and Steele (2004 Table 4).

Discards in the closed season are proportional to the right-hand side of (1). A scaling factor can be estimated by comparing predicted discards from (1) with observed discards from a sample of the commercial reef fish logbook. As described in Poffenberger and McCarthy (2004 SEDAR7_DW22), a 20% sample of vessels holding a permit for snapper-grouper, king mackerel, Spanish mackerel or shark was randomly selected, and asked to report the number of fish discarded. The actual fraction reported was estimated for the 2 years by dividing the number of trips that reported discard logbooks in the closed season by the total number of trips in the closed season. These two annual fractions (0.0733, 0.0955) were used to raise reported discards to total expected number of discards. Dividing the total expected discards by the predicted discards from (1) gave two annual ratios. An average of these two ratios was used to scale predicted discards for all years when a closed season was in effect.

<u>recruitment index</u>

An age 1 relative abundance index based on SEAMAP data had previously been applied for the probabilistic ageing method described by Goodyear (1997) and applied to red snapper by Goodyear (1995) and by Schirripa and Legault (1999). For this assessment, a similar index formulation was derived by averaging age-1 index values derived from the summer and fall SEAMAP survey indices described by Nichols (2004a, 2004b) and using the proportions of fish (Table 2) sampled by age from the surveys (Nichols *et al.*, SEDAR7-AW-15).

The Summer and Fall standardized survey indices were developed using the proportion of the age-1 samples from each survey. For years where no proportions at age were available, a weighted mean proportion across all of the samples taken, by survey, was assumed appropriate. The resulting values were then rescaled with respect to their respective time-series means for the overlapping time period (1981-2002, See Table 3). The average ratio of the rescaled summer to fall series across years 1981-2002 was then used to estimate expected Summer index values (the shaded Table entries), given the observed Fall index for 1972-1980 by multiplying that average ratio (1.040, shaded light green in Table 3) times the Fall index values. Likewise, an expected fall survey value for 2003 was computed by dividing the 2003 Summer index value by that ratio and the expected. Graphically, these results are shown in Figure 1. The same process was followed for estimating separate east and west Gulf indicies.

<u>Virtual population analysis</u>

The natural mortality rates used in the previous assessment were assumed. Those were 0.5 on age 0, 0.3 on age 1 and 0.1 on ages 2 and older. Fish age 15 and older were aggregated into a plus group. Weight at age was estimated from the growth curve with the annual weight at age for the plus group computed from the disaggregated weight at age and numbers at age to age 30.

Both fishery independent and fishery dependent indices of abundance were available for use in the VPAs (Figure 2). Some were measured in number of fish, others in biomass and one was considered to reflect spawning biomass. Indices of abundance considered to reflect abundance in number were the fishery independent surveys (SEAMAP trawl and reef fish video) and the recreational fishery (MRFSS). The indices from the commercial logbooks were recorded in yield per unit effort so they reflected abundance in biomass. The larval index was considered to reflect the spawning stock and therefore was compared to the population reproductive output which was derived using the reproductive potential at age estimated by Porch (2004).

Indices of abundance were calculated for the eastern and western Gulf of Mexico and in most cases for the entire Gulf of Mexico. Indices were available from three fishery independent surveys: the SEAMAP trawl surveys, the reef fish video survey and the larval survey, and indices were available from two fisheries: one from the the commercial handline fishery and the other from the recreational private and charter boat fisheries (Figure 2)

VPAs were conducted using inputs similar to those used for the 1999 assessment and with additional information available in 2004. The analyses configured in a manner similar to the 1999 assessment were used for comparison with the age composition estimated for the previous assessment.

The VPA which was part of the 1999 age modeling used two indices of abundance, an index from the recreational fishery using MRFSS data and an index to age 1 red snapper derived from the summer and fall SEAMAP surveys. The fishing mortality rate on age 3 in the terminal year was estimated and the F ratios in on the plus group fixed at 1. The catch at age in the final analyses from 1999 were derived only from the directed fisheries; the shrimp bycatch was not included. In attempting to replicate the 1999 treatment, the SEAMAP index described above and the new Gulf-wide index from the recreational fisheries (Calay 2004) were used.

For the VPAs which were part of the current age modeling, indices from all surveys and fisheries from the appropriate geographic stratum were used. Fishing mortality rates for three ages (3, 5 and 8) were estimated in the terminal year; the possibility of estimating 2003 fishing mortality rates for age 2 and ages older than 8 was investigated, but estimates at the boundaries or with very high coefficients of variation were encountered. The F ratio on the plus group was fixed at 1; attempts to estimate one F ratio for all years with and without a random walk at times resulted in estimates at the boundary conditions. Shrimp bycatch was included in these analyses.

Age composition was modeled under two assumptions with respect to stock structure. For the one stock treatment the catches at age from both regions were derived using stock wide fishing mortality rates (one VPA for all fisheries). For the separate stock treatment, separate analyses were run for each area using area specific catches and indices.

As in the previous assessment the age composition calculation and VPA process was iterated three times.

<u>total age composition</u>

After the age modeling was completed the total age composition of the was aggregated for plotting; thus the modeled age composition from the finfish fisheries derived with the above procedures was combined with the shrimp bycatch as estimated Nichols (2004c).

Results

Comparison of the modeled 1999 age composition from the finfish fisheries and the age composition derived with similar data inputs (2 indices, SEAMAP age 1 and MRFSS gulf wide) and similar methods (estimating only F on 3 year olds in the terminal year) indicates similar patterns (Figure 3). The updated age composition shows a higher proportion of age 1, probably due to the use of the new growth curve. Additionally Figure 3 shows that there is relatively greater change in age composition between the first and second iterations of the aging process and relatively less between the second and third iterations.

The aggregated catch at age (shrimp bycatch plus the modeled catch at age developed using all appropriate indices and the 2004 methods) developed under the single stock assumption is dominated by the age 0 and age 1 catches (Figure 4).

The total aggregated catches at age under the separate stock assumptions are also dominated by age 0 catches with the western stock having higher proportions of ages 0 and 1 than the eastern stock reflecting the larger shrimp bycatches in the west (Figure 5). In Figure 6 the catch at age for ages 2-15+ is shown for each iteration of the modeling process for two areas under the separate stock assumption. Higher proportions of older ages (roughly 10+) can be seen in the early-mid 1980s than in the 1990s with greater proportions of those ages in the east than the west.

The modeled catch at age by fishery is shown for the one stock treatment in Figures 7-9. The recreational fishery (including dead discards) has much higher proportions of ages 1 and 2 than the commercial fisheries (Figures 7 and 8). In general the handline fisheries from the northern Gulf of Mexico (west and northeast) show similar age composition while the southeastern area (statistical areas 1-7) generally shows higher proportions of older fish and especially the 15+ group in the older ages (Figure 8). However it should be remembered that the landings from the southeastern area are much smaller than in the northeast or west, so this difference has little impact on the assessment inputs. The relatively small longline fisheries show an older modeled age composition than the other fisheries (Figure 9).

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Table 1. Size and age conversion parameters used in developing the modeled catch at age.

von Bertalanffy growth equation

L_{inf} (inches)	34.522
k	0.22
t_0	0.366

size lenth and weight conversion equations

length to length and weight to weight ($y = a + bx$)

	a	b
fork length to total length (in.)	0.17291	1.059
standard length to total length (in.)	0.02906	1.278
maximum length to total length (in.)	0.08664	0.973
gutted weight to whole weight (lb)	0	1.11

length to weight ($y = a*x^b$)

	a	b
total length (in.) to whole weight (lb)	0.0004398	3.056
fork length (in.) to whole weight (lb)	0.0006615	2.997

Table 2 Proportion at age for Summer and Fall surveys for the period 1987-2003

Summer

	zeros	ones	two plus	n
1987	0.000	0.993	0.007	203
1988	0.000	0.980	0.020	146
1989	0.026	0.974	0.000	91
1990	0.000	0.999	0.001	696
1991	0.062	0.929	0.009	418
1992	0.033	0.940	0.027	250
1993	0.011	0.989	0.000	355
1994	0.011	0.975	0.015	546
1995	0.113	0.884	0.004	568
1996	0.001	0.992	0.007	641
1997	0.042	0.951	0.007	446
1998	0.008	0.982	0.010	378
1999	0.294	0.672	0.033	350
2000	0.354	0.633	0.013	654
2001	0.306	0.684	0.010	146
2002	0.097	0.869	0.034	487
2003	0.005	0.977	0.019	215

Fall

	zeros	ones	two plus	n
1987	0.697	0.289	0.014	159
1988	0.668	0.329	0.003	460
1989	0.925	0.068	0.007	850
1990	0.841	0.153	0.007	1160
1991	0.938	0.057	0.005	1490
1992	0.756	0.236	0.008	615
1993	0.810	0.171	0.019	1181
1994	0.894	0.100	0.006	1632
1995	0.920	0.074	0.006	1809
1996	0.774	0.206	0.020	1363
1997	0.919	0.077	0.004	1502
1998	0.904	0.093	0.003	995
1999	0.940	0.052	0.008	1776
2000	0.880	0.112	0.008	1332
2001	0.852	0.136	0.012	1196
2002	0.917	0.077	0.005	1165

Table 3. Derivation of SEAMAP age-1 index using Summer and Fall Survey information.

Year	Fall Index median	Summer Index median	Fall Index age1	Summer Index age1	Fall Index rescaled-age1	Summer Index rescaled-age1	Averaged Index
1972	90.73		10.42		4.80	4.99	**4.90**
1973	25.85		2.97		1.37	1.42	**1.40**
1974	17.26		1.98		0.91	0.95	**0.93**
1975	23.31		2.68		1.23	1.28	**1.26**
1976	19.03		2.18		1.01	1.05	**1.03**
1977	21.43		2.46		1.13	1.18	**1.16**
1978	43.26		4.97		2.29	2.38	**2.34**
1979	18.20		2.09		0.96	1.00	**0.98**
1980	52.51		6.03		2.78	2.89	**2.83**
1981	44.33	12.61	5.09	11.39	2.35	2.25	**2.30**
1982	44.29	13.17	5.08	11.89	2.34	2.35	**2.35**
1983	17.13	5.22	1.97	4.71	0.91	0.93	**0.92**
1984	8.12	2.51	0.93	2.27	0.43	0.45	**0.44**
1985	14.68	4.98	1.69	4.49	0.78	0.89	**0.83**
1986	14.62	1.49	1.68	1.34	0.77	0.27	**0.52**
1987	4.35	4.06	1.26	4.03	0.58	0.80	**0.69**
1988	7.91	2.15	2.60	2.11	1.20	0.42	**0.81**
1989	18.38	2.01	1.25	1.95	0.58	0.39	**0.48**
1990	18.96	11.09	2.90	11.08	1.34	2.19	**1.76**
1991	21.03	5.14	1.19	4.77	0.55	0.94	**0.75**
1992	6.86	4.64	1.62	4.36	0.75	0.86	**0.80**
1993	13.62	3.93	2.33	3.89	1.07	0.77	**0.92**
1994	34.07	6.76	3.42	6.59	1.58	1.30	**1.44**
1995	31.01	5.79	2.29	5.12	1.06	1.01	**1.03**
1996	14.35	8.28	2.96	8.22	1.36	1.63	**1.49**
1997	25.10	6.15	1.93	5.85	0.89	1.16	**1.02**
1998	12.51	3.76	1.16	3.69	0.53	0.73	**0.63**
1999	21.55	3.38	1.13	2.27	0.52	0.45	**0.48**
2000	17.90	7.71	2.01	4.88	0.93	0.97	**0.95**
2001	16.21	3.00	2.20	2.05	1.02	0.41	**0.71**
2002	13.39	4.95	1.03	4.30	0.48	0.85	**0.66**
2003		3.57		3.48	0.66	0.69	**0.68**
1981-2002 Mean			2.17	5.06		1.040	

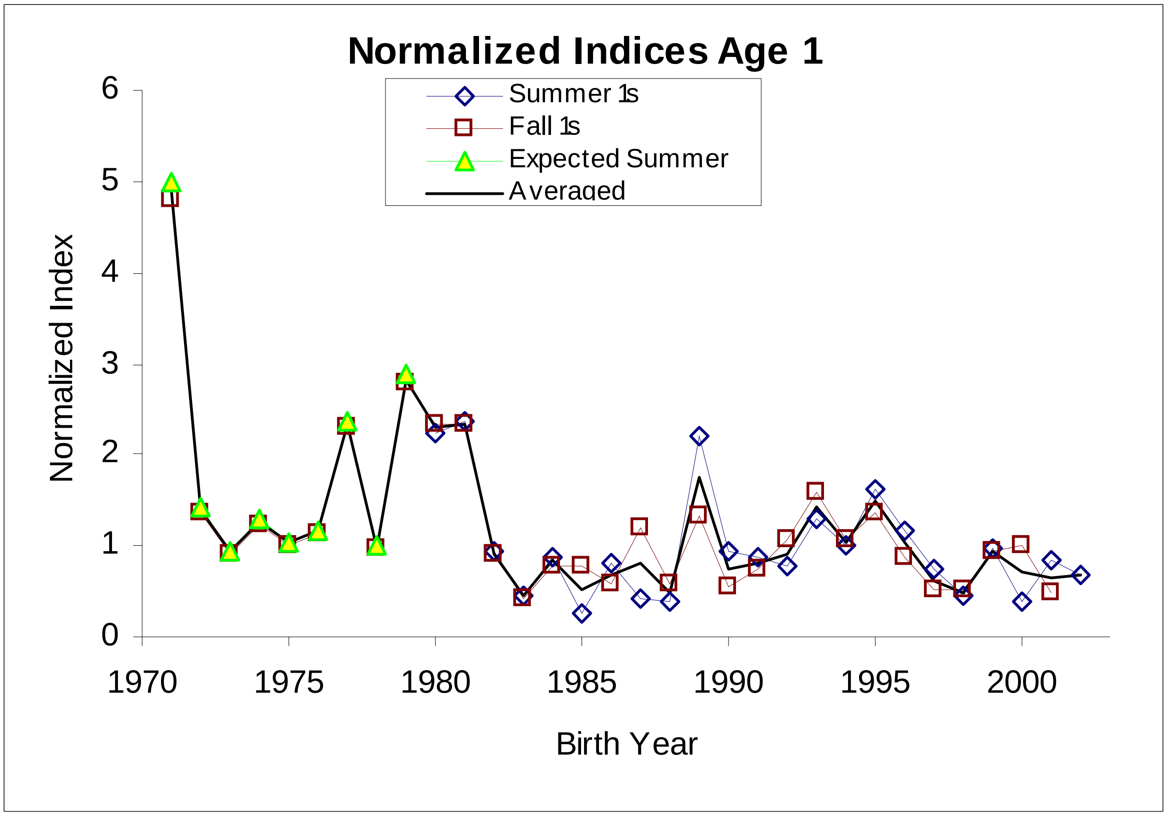


Figure 1. Index patterns for age-1 red snapper from the SEAMAP surveys plotted against hatching year.

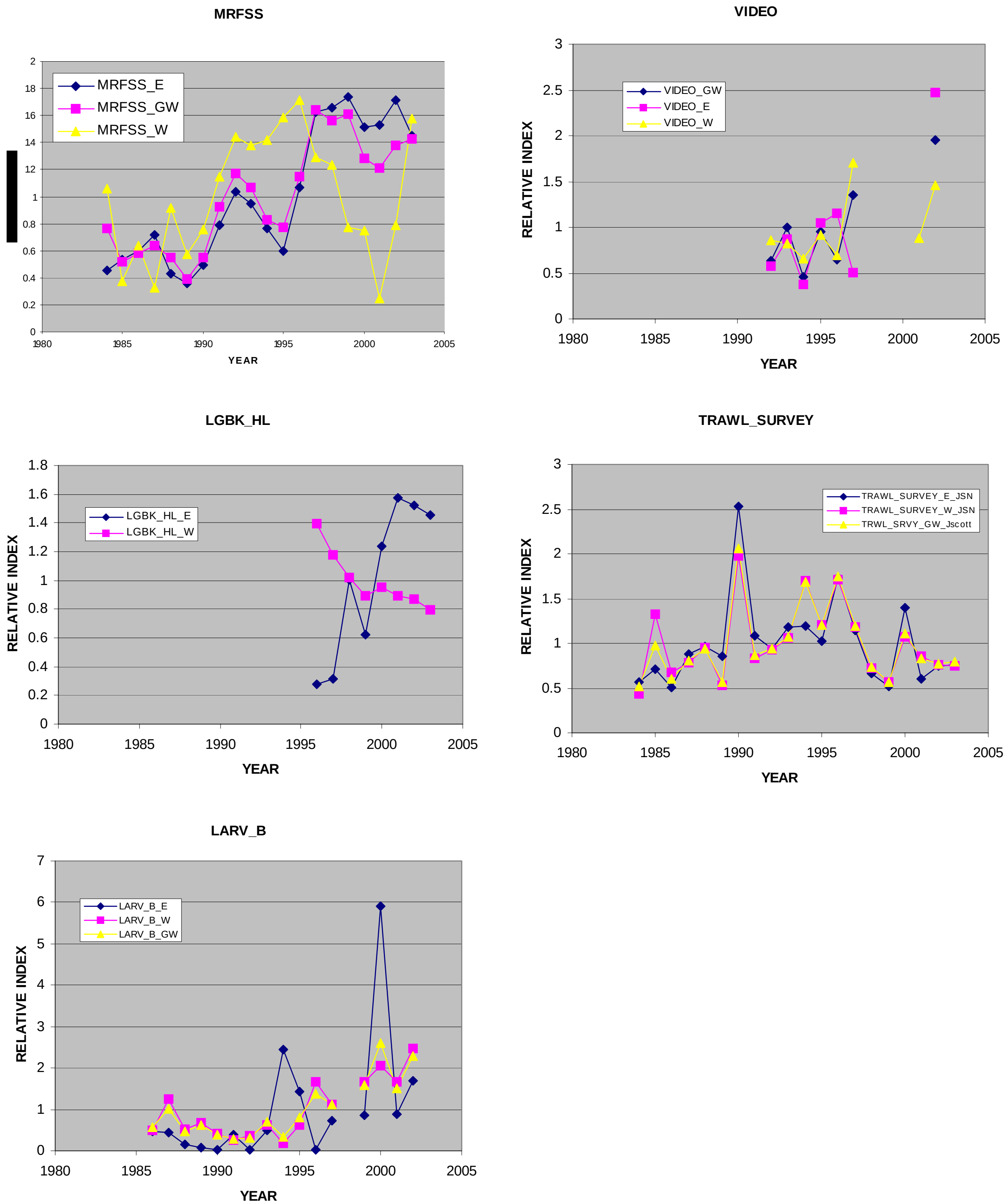


Figure 2. Available indices of abundance for assessment.

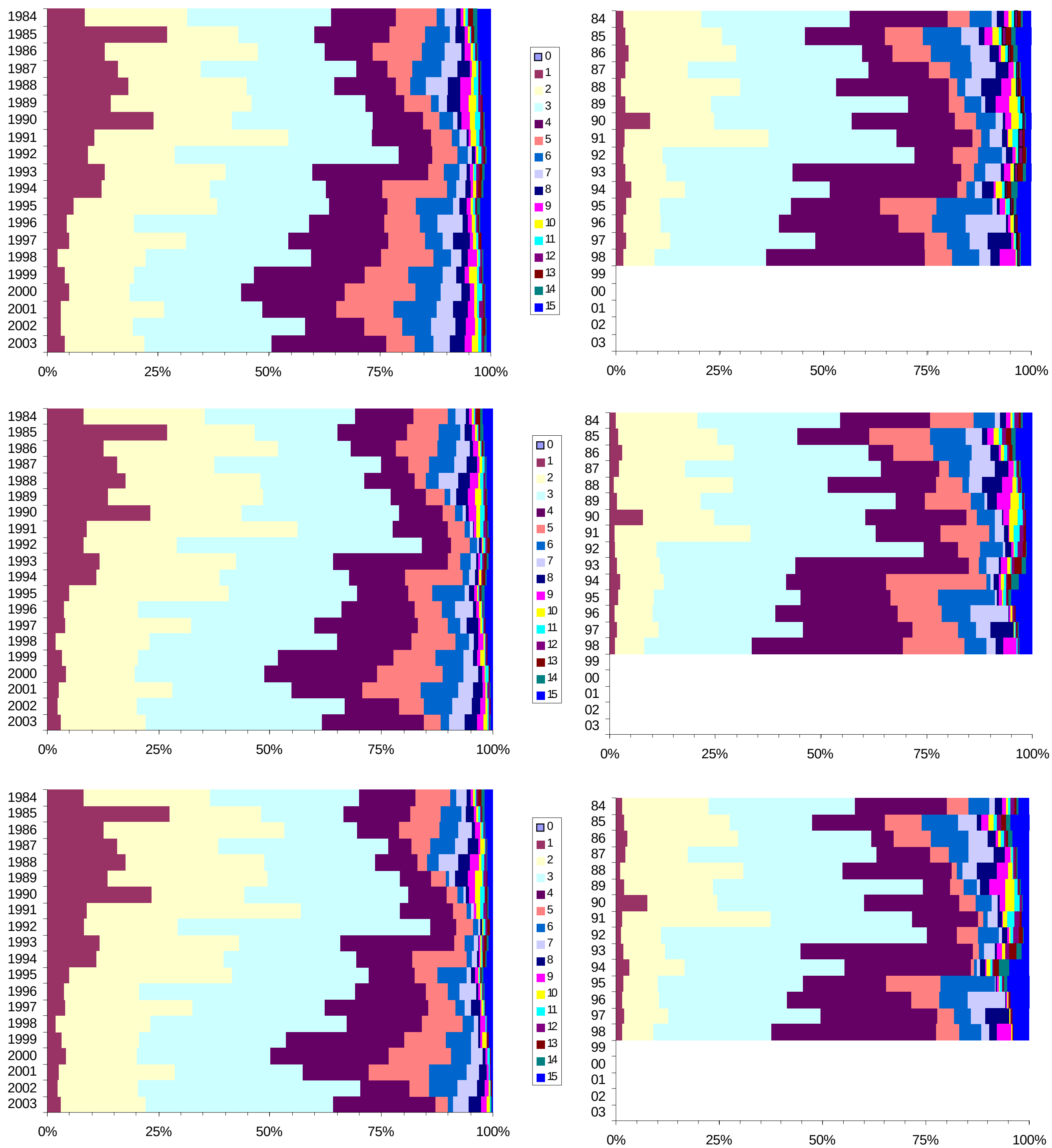


Figure 3. The modeled proportion at age by year for the Gulf of Mexico without the shrimp bycatch from the current modeling (left panels) and those estimated by Schirripa and Legault 1999; inputs to the VPA proportion of the age composition for the 2004 analyses shown here were similar to those used in 1999. Rows correspond to iterations of the modeling with the first iteration at the top and the third at the bottom.

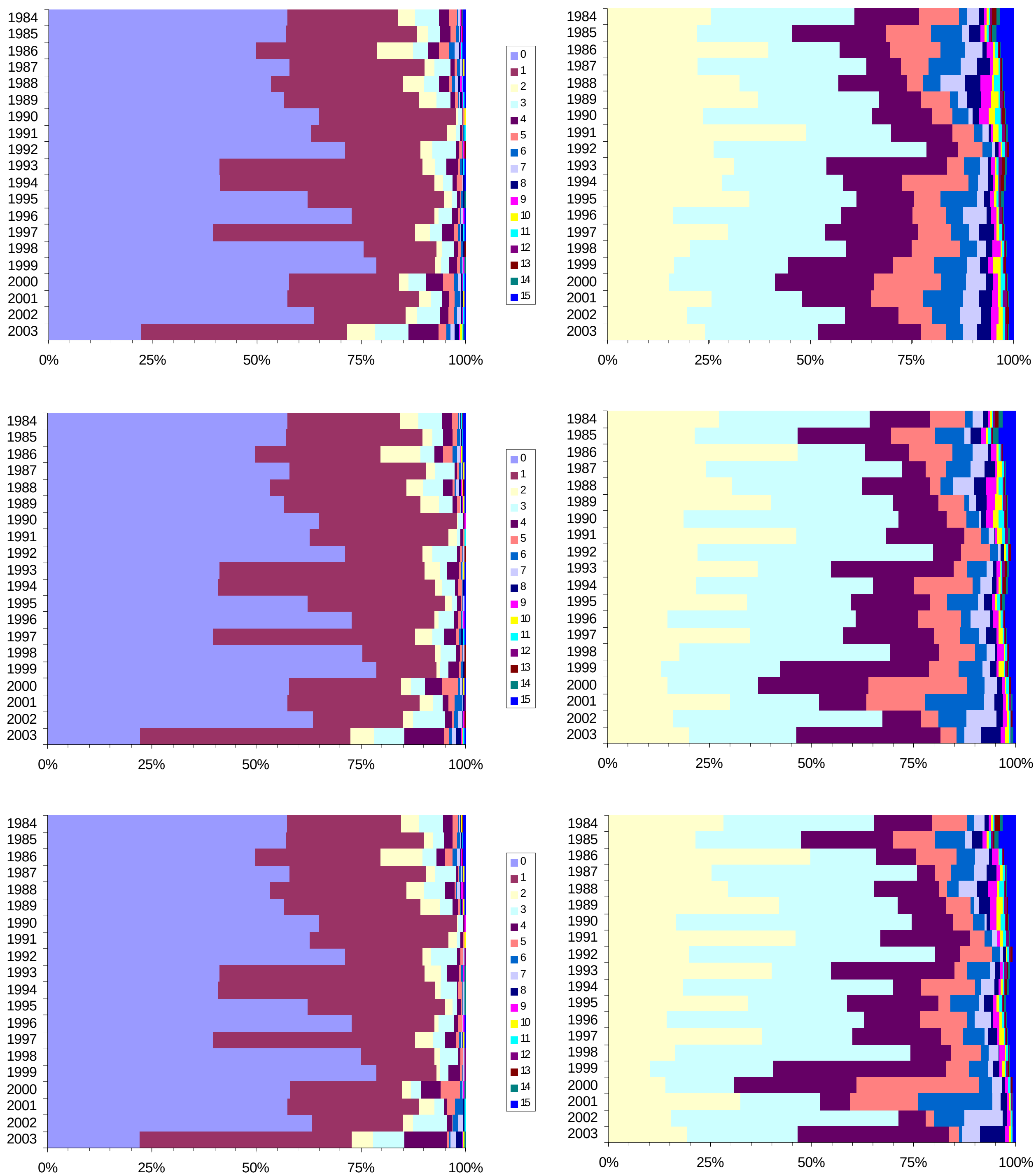
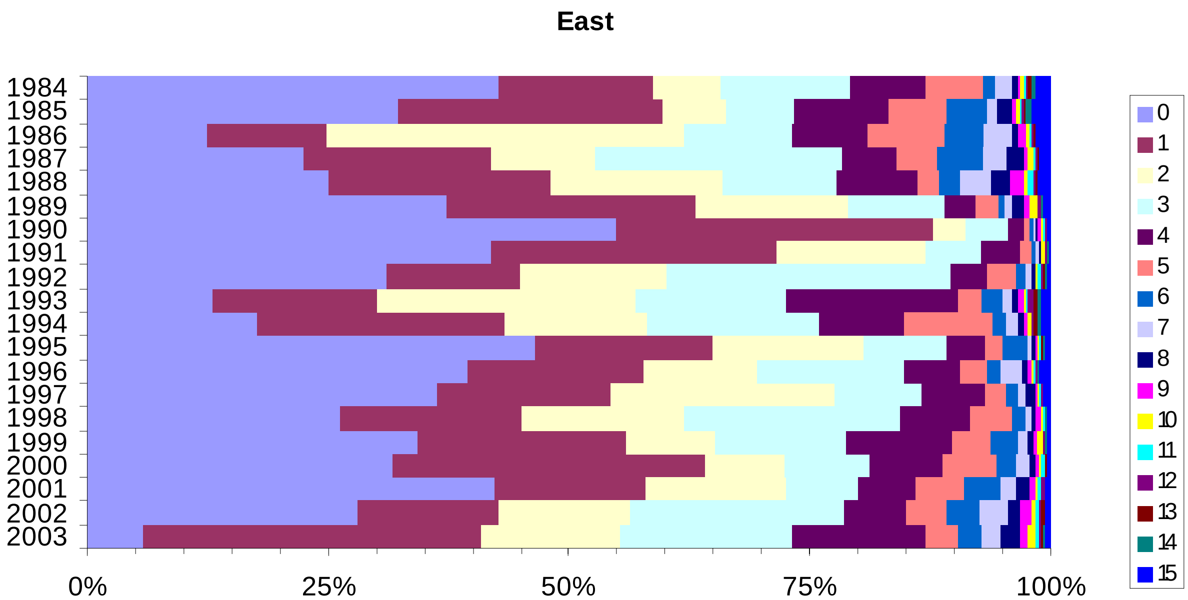


Figure 4. Proportionate catch at age for the Gulf of Mexico under the single stock assumption with all ages (0-15) on the left and with only ages ages 2-15 (right). Rows correspond to iterations of the age modeling procedure with the first at the top and the third at the bottom.



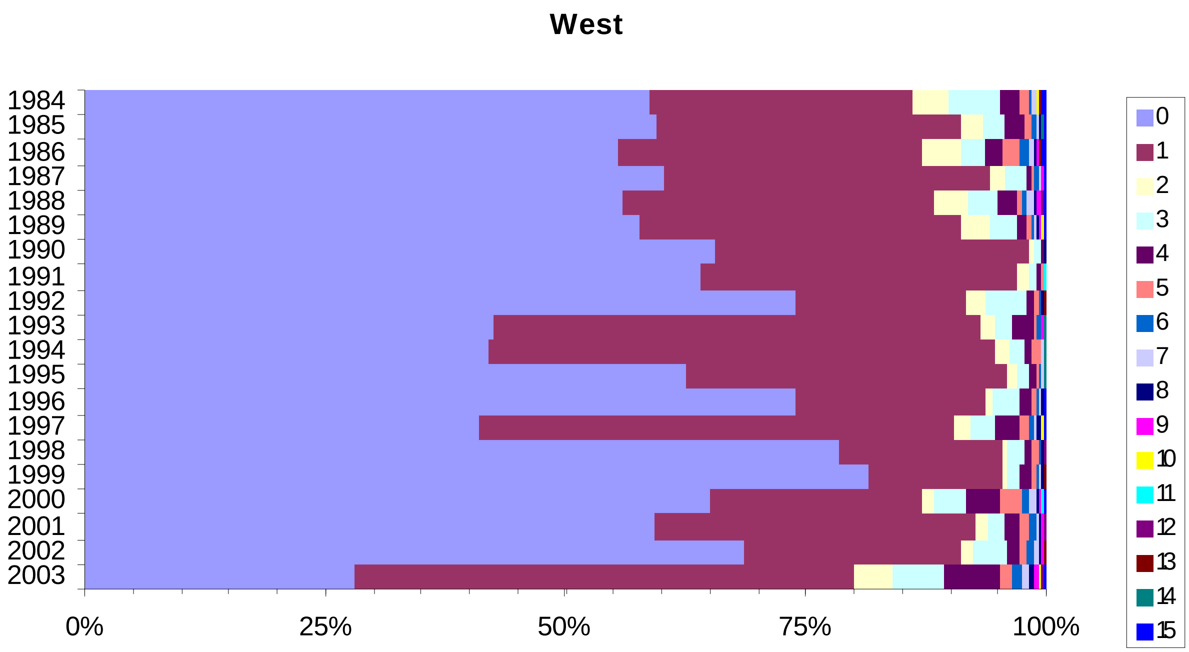


Figure 5. Total modeled proportionate catch at age from east and west Gulf of Mexico, ages 0-15 (separate stock assumption).

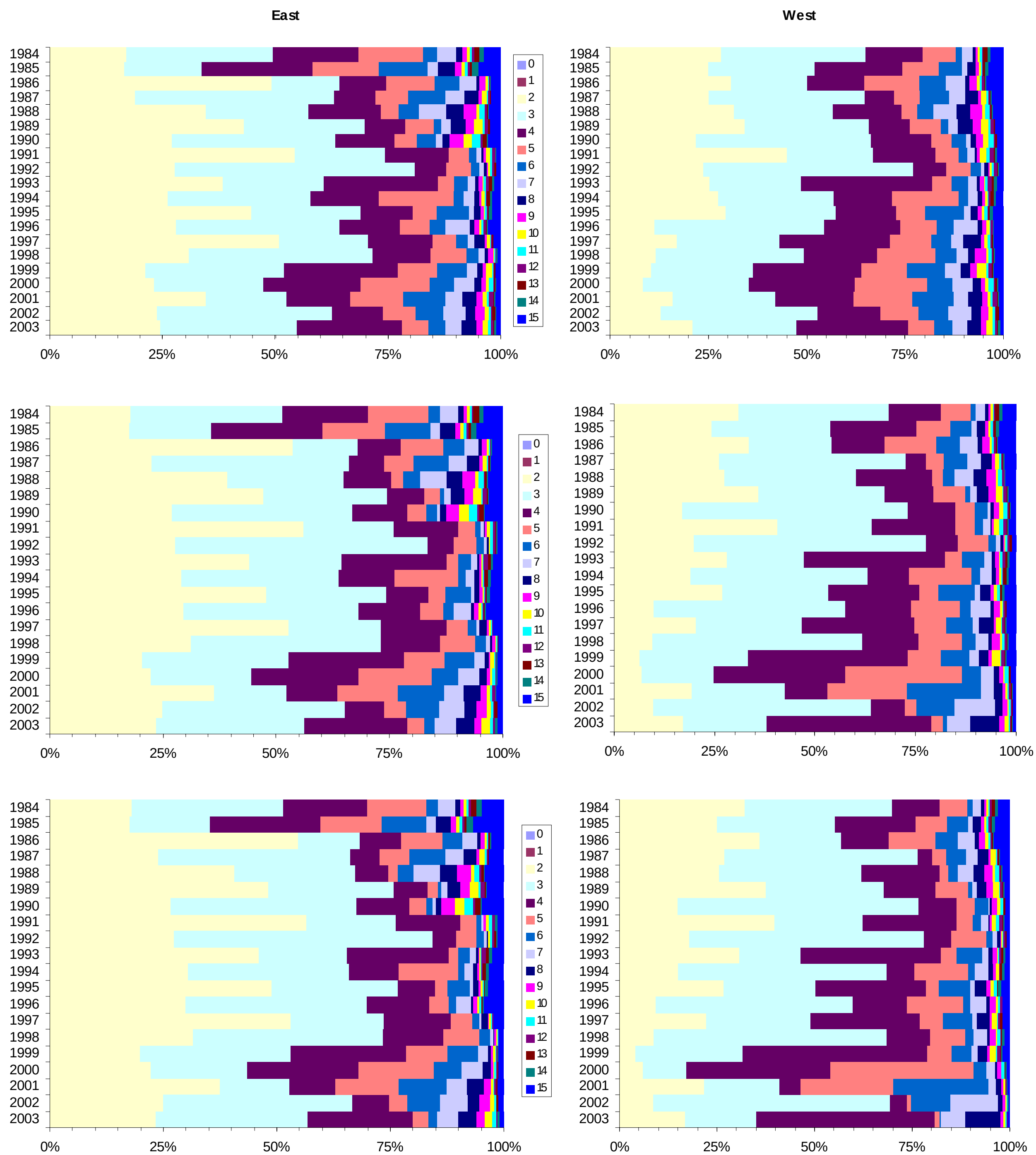
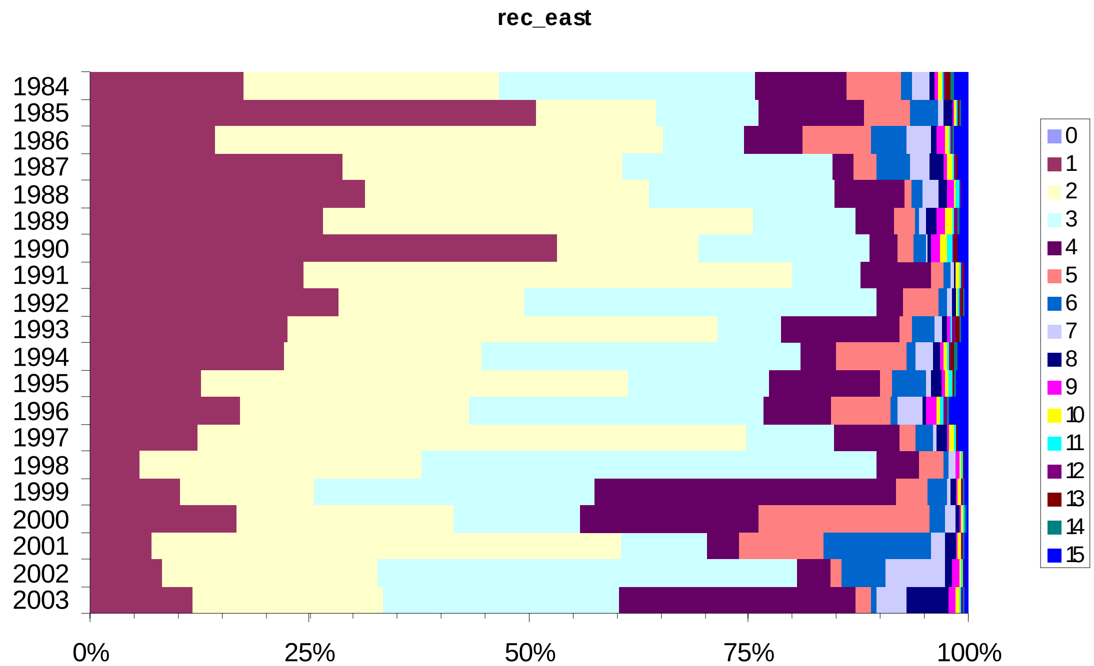


Figure 6. Proportionate catch at ages 2-15 from eastern (left panels) and western (right panels) Gulf of Mexico under the single stock assumptuion. Rows correspond to the first (top), second and third iterations (bottom) of the age modeling.



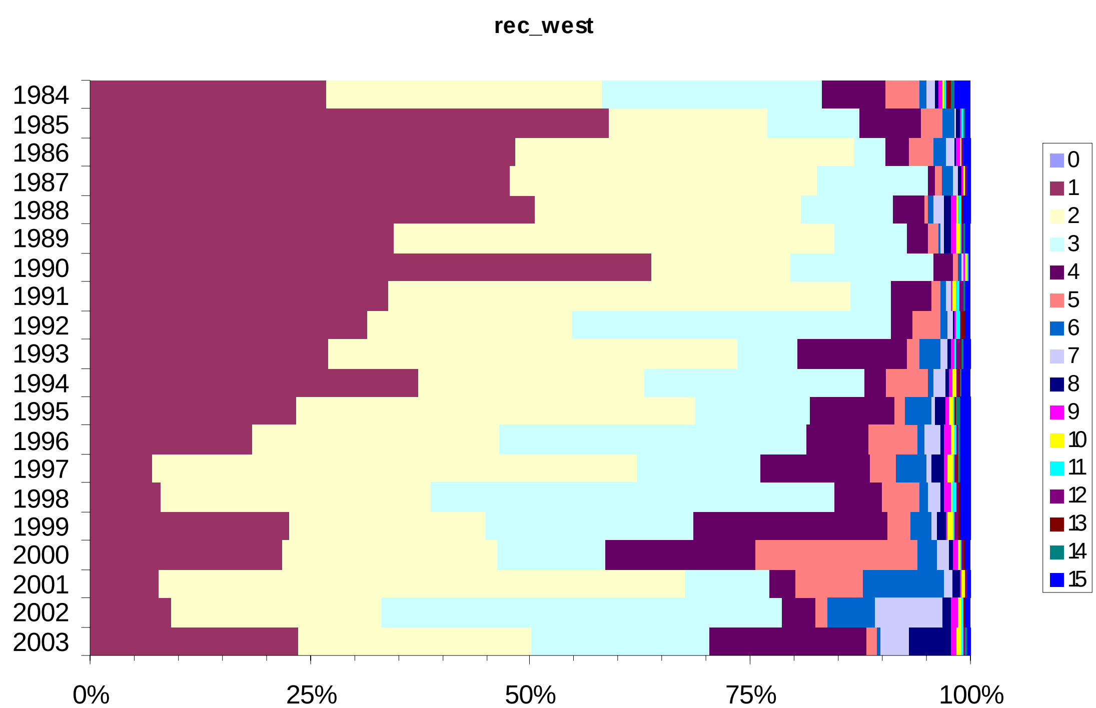


Figure 7. Catch at age of the recreational fishery in the eastern and western Gulf of Mexico (under the single stock assumption).

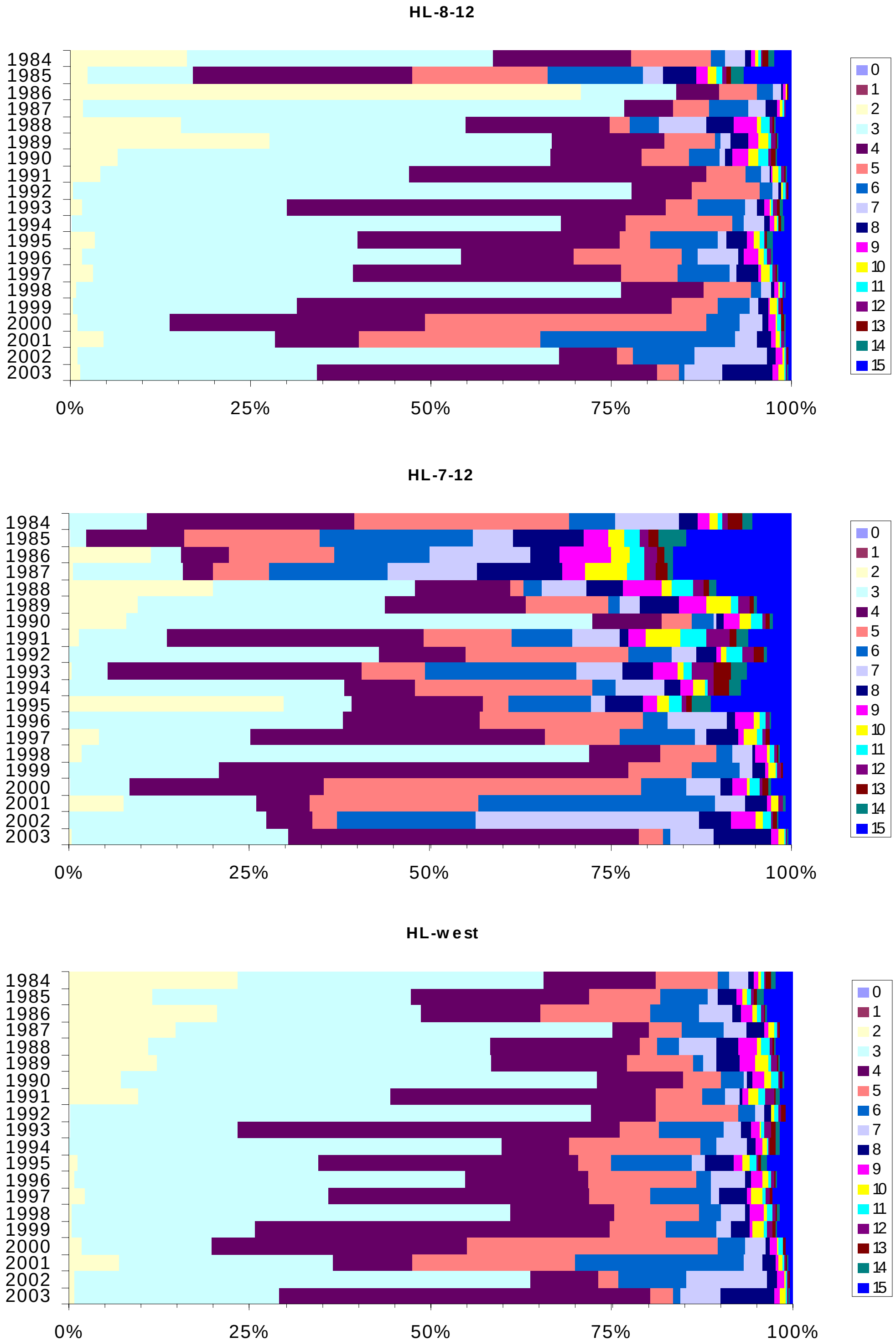
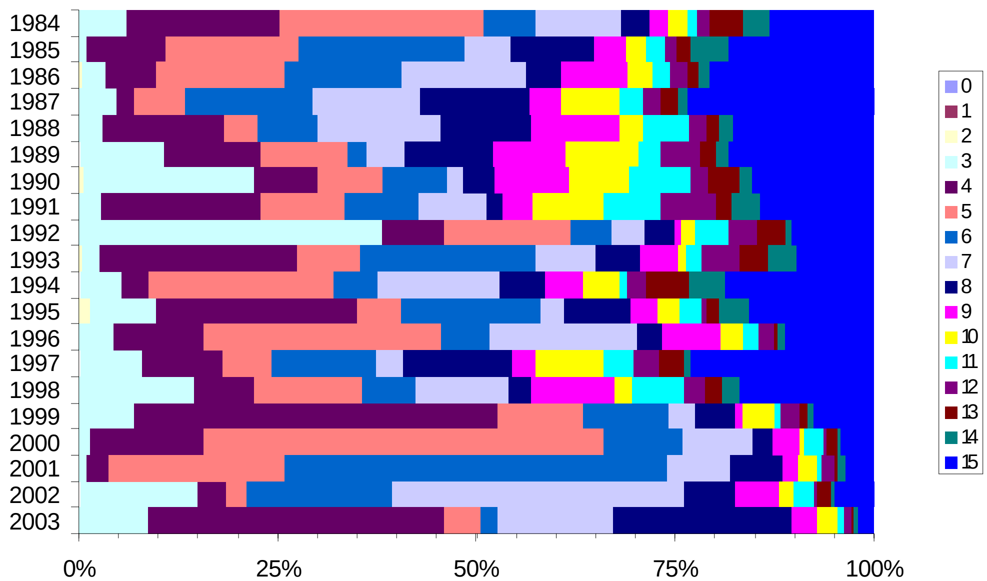


Figure 8. Proportionate catch at age from the handline fisheries in the eastern (upper 2 panels, statistical areas 8-12 are northeast and 1-7 are southeast) and the western Gulf of Mexico under the single stock assumption.

LL_east



LL-west

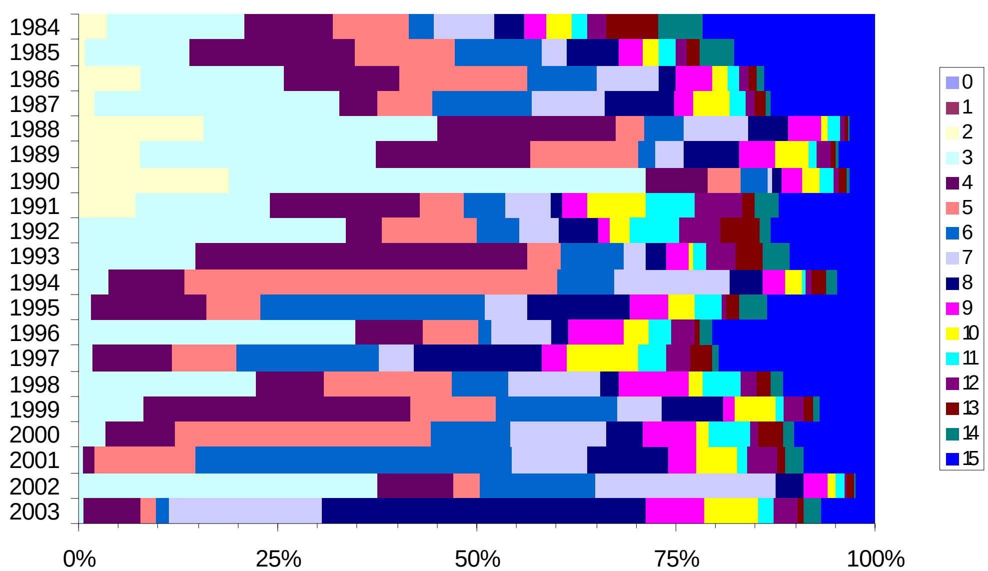


Figure 9. Proportionate catch at age from the longline fisheries from the eastern and western Gulf of Mexico under the single stock assumption.