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Red snapper (*Lutjanus campechanus*) Otolith Ageing Summary 1980 and 1991-2002

Robert J. Allman, Gary R. Fitzhugh, William A. Fable, Linda A. Lombardi-Carlson and Beverly K. Barnett

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National Marine Fisheries Service
Southeast Fisheries Science Center
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Panama City, FL 32408

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ABSTRACT

A total of 31,434 red snapper otoliths were aged from1980 and from 1991 through 2002. Red snapper ranged in age from 1-57 years. The commercial long-line selected the oldest individuals with fish first fully recruited to the fishery by age 5 years and a mean age of 7.8 years. The recreational fishery selected younger fish with fish entering the fishery at 3 years with 90% of individuals 2, 3 and 4 (mean= 3.2 years). The commercial hand-line fishery selected for slightly older fish with a mode of 3 years and mean age of 4.1 years. The fishery independent long-line survey had a modal age of 7 years and mean of 12.5 years. The fishery independent hand-line gear had a mode of 3 years and mean of 2.8 years. Evidence for a strong 1995 year class first emerged with a large proportion of 2 year olds (>70%) in the recreational fishery in 1997, a year later this year class appeared in the commercial hand-line fishery as 3 year olds, and the following year in the commercial long-line fishery as 4 year olds. The recreational and commercial hand-line fishery detected a strong 1989 year class starting in 1991 with a large number of 2 year olds (60%) and in 1992 in the commercial hand-line fishery as 3 year olds (60%). An examination of age frequencies from the eastern and western gulf by year and mode indicated that year class patterns were consistent geographically. Overall differences in age distributions of red snapper between the eastern and western gulf were only apparent in the commercial long-line fishery and fishery independent long-line survey. Counts of red snapper annuli made by Panama City Laboratory personnel from 1980 and 1991-1995 tended to be higher than annuli re-counts made by current Panama City laboratory personnel.

INTRODUCTION

Red snapper, *Lutjanus campechanus* are large, carnivorous reef fish which are commonly distributed along the U.S. Atlantic coast to North Carolina and throughout the Gulf of Mexico (Hoese and Moore, 1998). Adults are associated with hard bottom substrate such as coral reef, rock outcroppings, artificial reef and oil platforms (Moseley, 1966; Patterson, 1999). Red snapper support important commercial and recreational fisheries in the Gulf of Mexico. However, commercial landings in the Gulf of Mexico have declined from a high of over 14 million pounds in 1965 to a low of 2.2 million pounds in 1990. Likewise, recreational landings have declined from 6.5 million pounds in 1981 to 1.2 million pounds in 1990 (Schirripa and Legault, 1999). Despite restrictions placed on the commercial and recreational fisheries since 1991, controversy has remained over the status and management of red snapper in the Gulf of Mexico (MRAG Americas Inc., 1997). This controversy led to a congressional mandate for an independent scientific stock assessment and funding was made available for increased sampling of the recreational and commercial fishery in 1998 and 1999.

Understanding the age structure of the red snapper fishery is crucial for accurate stock assessment and for determining year class strength. Numerous studies have used otoliths to age red snapper and provide basic information on growth and annulus formation (Futch and Bruger, 1976; Bortone and Hollingsworth, 1980; Nelson and Manooch, 1982; Wilson and Nieland, 2001; Manooch and Potts, 1997; Patterson et al., 2001). The goal of this report is to update the size and age structure of red snapper collected from 1980 and during1991-2002 by fishing mode for stock assessment.

METHODS

Red snapper were sampled from Gulf of Mexico landings from Texas to the west coast of Florida. Fish were sampled from the recreational and commercial fishery as well as from fishery independent surveys. All fish were measured to total length (mm) or were converted to total length from fork length (TL(mm)= 1.061x FL(mm) + 2.601, r^2= 0.99). Sagittal otoliths were collected with corresponding fishery data from 1980 and from 1991 to 2002. Select otoliths were weighed to the nearest 0.001 g prior to sectioning. Otoliths were processed with a Hilquist high-speed thin sectioning machine utilizing the methods of Cowan et al. (1995). Two transverse cuts were made through the otolith core to a thickness of 0.5 mm. Due to recent advances in otolith preparation techniques, red snapper otoliths which were sectioned and aged in previous years by Dr. Allyn Johnson (NMFS, Panama City-retired) were ground, polished and re-aged. Otolith sections were assigned an age based on the count of annuli (opaque zones observed with reflected light at 40X) and the degree of marginal edge completion. For example, otoliths were advanced a year in age after January 1st if their edge-type was a nearly complete translucent zone. Typically, marine fish in the southeastern U.S. complete annulus formation (opaque zone formation) by late-spring to early summer. Therefore an otolith with two completed annuli and a large translucent zone would be classified as age 3 if the fish was caught during spring in expectation that a 3rd (opaque) annulus would have soon formed. After June 30, when opaque zone formation is typically complete, all fish were assigned an age equal to the annulus count by convention. By this traditional method, an annual age cohort is based on a calendar year rather than time since spawning (Jearld 1983). Biological (fractional) ages were also determined for use in fitting growth curves (remaining to be completed). Biological age accounts for the difference in time between peak spawning (defined as July 1 for red snapper) and capture date (difference in days divided by 365). This fraction is added to annual age if capture date is after July 1 and subtracted if capture date is before July 1 (Vanderkooy and Guindon-Tisdel, 2003; Wilson and Nieland, 2001).

RESULTS/DISCUSSION

A total of 31,434 red snapper otoliths received at Panama City were aged from 1980 and from 1991 through 2002. The main sampling programs represented were the trip interview program (TIP) with 70% of the otoliths, followed by the Beaufort Headboat Program with 15% and the Marine Recreational Fisheries Statistical Survey (MRFSS) with 10% (Fig. 1A). The geographic distribution of aged fish was similar to the distribution of landings with about half of the otoliths collected from the western gulf (LA and TX) and half from the eastern gulf (FL, AL and MS) (Fig. 1B). Similarly, approximately half of the fish aged were from the commercial fishery (i.e., hand-line and long-line combined) and half from the recreational fishery (i.e., charter boat, head boat and private boat combined) with the fishery independent survey accounting for 2% (Fig. 1C). For more information on sample selection see Fitzhugh et al. (2004). For characterization of the size and age distribution of each fishery, only randomly sampled fish were chosen.

Size Frequency Distributions

Size frequency distributions can provide some indication of the underlying age structure and differences were noted in the sizes of red snapper by fishing mode and collection year. The commercial long-line fishery was composed of the largest individuals with a dominant size classes in the 600-799 mm TL size range. The commercial hand-line and recreational fishery had similar size distributions with modes in 400-450 mm TL size range (Fig. 2). A similar pattern was noted for the fishery independent samples: the long-line survey consisted of the largest individuals with a mode at the 751-799 mm TL size class and the hand-line survey was made up of the smallest fish with a mode from 300-350 mm TL (Fig. 3).

An examination of the size distribution by year indicated an increase in modal size over time. In most years prior to 1998 the recreational fishery had a mode in the 351-399 mm TL size class (Fig. 4). However, after 1998 the 400-450 mm TL size class accounted for about 40% of each years totals. This could be partially due to the increase in size limits from 13 inches TL (332 mm) in the early 1990s to 16 inches TL (407 mm) by 2000. Likewise, the commercial hand-line fishery mode increased from 351-399 mm TL for most years prior to 1995 to 400-450 mm TL from 1995-2002 (Fig. 5). The mode for commercial long-line samples for most years was greater than 600 mm TL (Fig. 6). This was also reflected in the 3 years of fishery independent long-line survey (Fig. 7). The one year of fishery independent hand-line survey (2000) collected smaller fish (mode 350-350 mm TL) than the same year for the recreational and commercial fishery, probably due to the absence of a size limit (see Fig. 3).

Age Frequency Distributions

A comparison of age distributions by fishing mode indicated differences by fishing mode and by sampling year. Red snapper ranged in age from 1 to 57 years. The commercial long-line selected the oldest individuals with fish first fully recruited to the fishery by age 5, a mean age of 7.8 years and 22% of individuals 10 years or older (Fig. 8). The recreational fishery selected younger fish with fish entering the fishery at 3 years with 90% of individuals 2, 3 and 4 (mean= 3.2 years) and only 0.3% of fish 10 years or older. The commercial hand-line fishery selected for slightly older fish with a mode of 3 years, mean age of 4.1 years and 1% of fish 10 years or greater. The fishery independent survey was similar to the directed fishery age distributions. The fishery independent long-line survey had a modal age of 7 years a mean age of 12.5 years and 54% of ages 10 years or greater, while the hand-line gear had a mode of 3 years, mean age of 2.8 years and no individuals 10 years or older (Fig. 9). Size-at-age data indicated that rare and relatively old fish (ages > 20 years) were caught in all fishing sectors with the exception of fishery independent hand-line and were most common in the commercial sector and fishery independent long-line survey (Fig. 10 & 11).

Age frequency distribution by sampling year revealed changes in the age at recruitment through time, as well as the influence of strong year classes. The annual recruitment pattern of red snapper from the recreational fishery indicated recruitment occurred by age 2 or 3 prior to 1998 and age 3 after (Fig. 12). Recruitment to the commercial hand-line fishery occurred by age 3 or 4 all years (Fig.13). The age of recruitment to the commercial long-line fishery for the few years with large sample size was age 5 for most years (Fig. 14). Only one year of fishery independent hand-line ages and three years of fishery independent long-line ages were available. Like the recreational fishery, the fishery independent hand-line was dominated by 2 and 3 year old individuals (Fig. 15). The fishery independent long-line survey age distribution remained similar for the three years sampled.

Year class influence

All the directed fisheries reflected the influence of strong year classes. These strong year classes usually made a progression through the different fishing modes, first appearing in the recreational fishery, then a year later appearing in the commercial hand-line and then the commercial long-line fishery the following year. This was observed from the 1995 year class (see dashed lines on Fig. 12-14). Evidence for this year class first emerged with a large proportion of 2 year olds (>70%) in the recreational fishery in 1997, a year later this year class appeared in the commercial hand-line fishery as 3 year olds, and in 1999 in the commercial long-line fishery as 4 year olds (Fig. 16A-C). Generally the influence of these strong year classes could be followed for at least 2-3 consecutive years. In addition, the recreational and commercial hand-line fishery detected a strong 1989 year class starting in 1991 with a large number of 2 year olds (60%) and in 1992 in the commercial hand-line fishery as 3 year olds (60%) (Fig.16D-E). Weaker signals indicating potentially strong year classes were noted for 1997 in the recreational and commercial hand-line fishery and for 1991 in the recreational fishery.

Geographic age distribution

An examination of age frequencies from the eastern and western gulf by year and mode indicated that year class patterns were consistent geographically (Fig. 17-22). Overall differences in age distributions of red snapper between the Eastern and Western Gulf of Mexico were only apparent in the commercial long-line fishery and fishery independent long-line survey (Fig. 23). Recruitment to the commercial long-line fishery was by age 4 in the east and age 5 in the west with a mean age of 7.0 years for the east and 8.2 for the west. Likewise for the fishery independent long-line survey, fish were on average older from the western gulf (mean= 13.3 west and 10.6 east) and recruited later (age 7 west, age 5 east). The age distribution from the commercial hand-line fishery was similar between east and west with recruitment at age 3 for both regions and means of 4.1 and 4.2 years respectively (Fig. 24). Similarly, the recreational fishery suggested little difference between east and west with recruitment at age 3 and mean ages of 3.1 and 3.4 years respectively.

Annuli count comparison

Counts of red snapper annuli made by Panama City lab staff from 1980 and in 1991-1995 tended to be higher than annuli re-counts made by current Panama City Laboratory personnel. Annuli counts were compared instead of ages, since early methods did not advance annuli count as is done now to calculate an age. Compared to recent Panama City counts, early counts tended to over-age by one (36%) to two years (23%) (Fig. 25). Some of these differences could be attributable to recent improvements in otolith preparation techniques (Cowan et al., 1995). In addition, validations have been completed (Wilson and Nieland, 2001) and quality control efforts have been undertaken including the development of a reference collection for training and evaluating readers. Another potential factor is the recent work completed by the Panama City Laboratory on the timing and interpretation of the first annulus and edge type identification in red snapper otoliths which we feel has increased the accuracy of counts (Allman, et al., 2004).

LSU and Gulfin ages

In March 2003, Dave Nieland (Louisiana State University) and Dave Donaldson (Gulf States Marine Fisheries Commission) provided two additional fishery dependent age datasets. We briefly summarize them here. LSU age distributions were from the commercial hand-line fishery (1995-2002) and recreational fishery (1999-2001) (Fig. 26 & 27) and most years were comparable to our results (Fig. 12 & 13). Gulfin age distributions from the recreational and commercial hand-line fishery from 2002 (Fig. 28 & 29) were also similar to our results (Fig 12 & 13). We note that readers from all the various institutions (state, federal and academic) participated in an otolith exchange and quality control exercise (Allman et al. 2004)

ACKNOWLEDGEMENTS

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FIGURE LIST

1. Gulf of Mexico red snapper aged by: A. sampling program, B. state and C. mode.
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29. Gulfin recreational age distribution for 2002 by state.

Figure 1. Gulf of Mexico red snapper aged by: A. sampling program, B. state and C. mode.

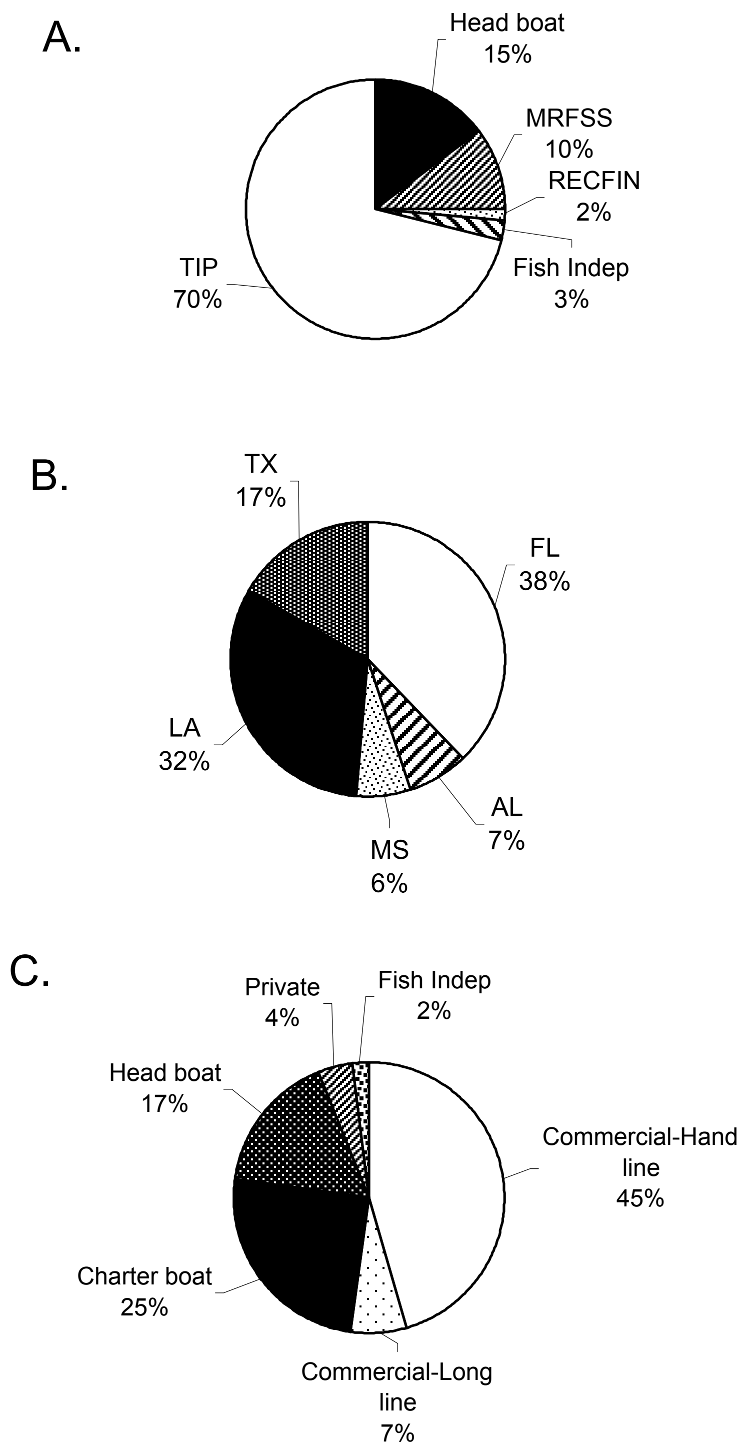


Figure 2. Gulf of Mexico red snapper size distribution by fishing mode all years combined.

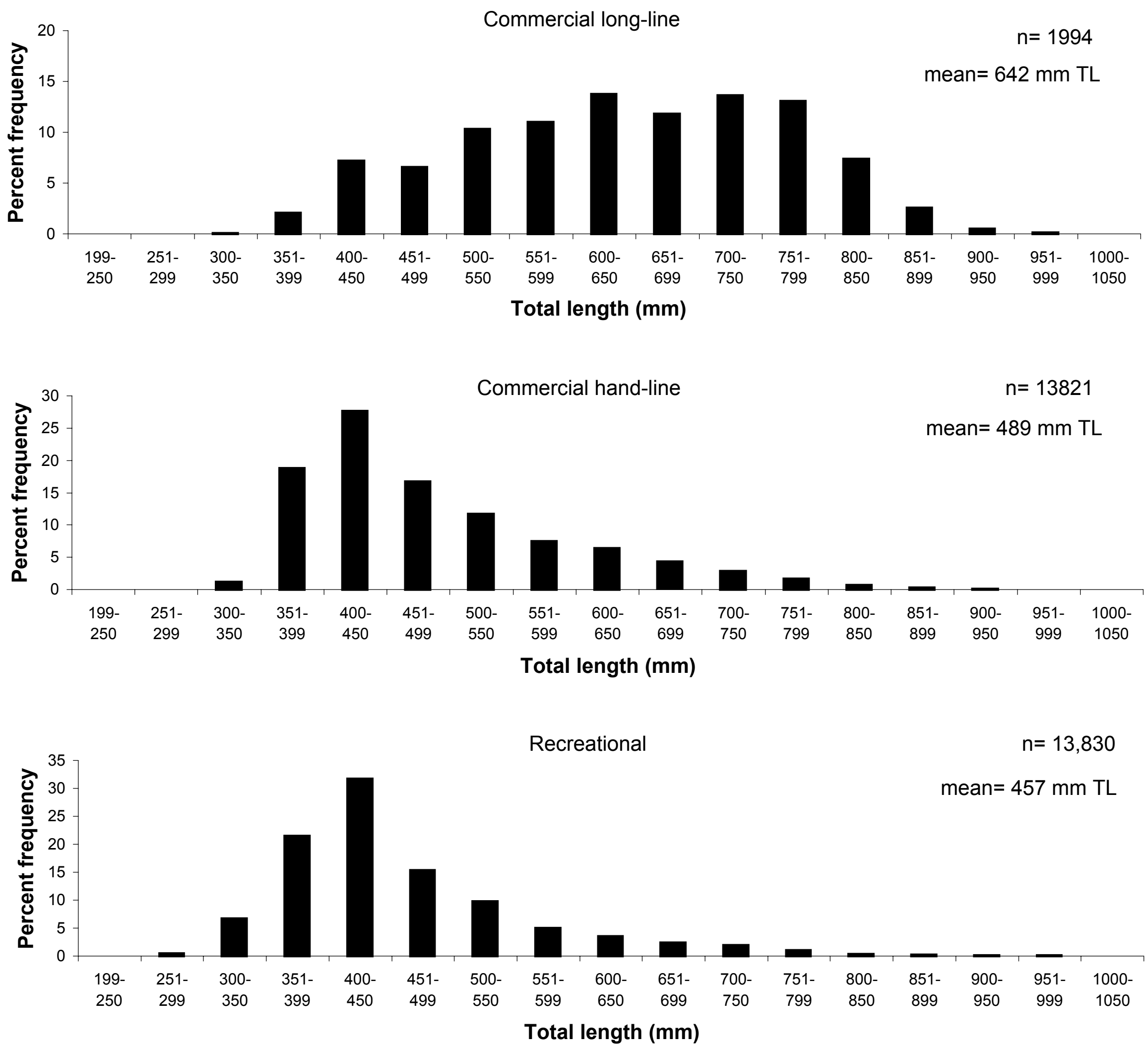
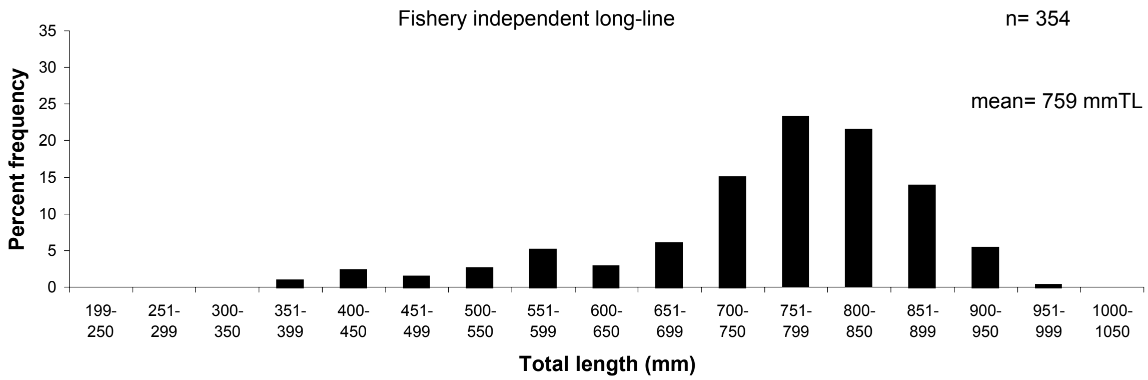


Figure. 3 Gulf of Mexico red snapper size distribution from fishery independent survey all years combined.



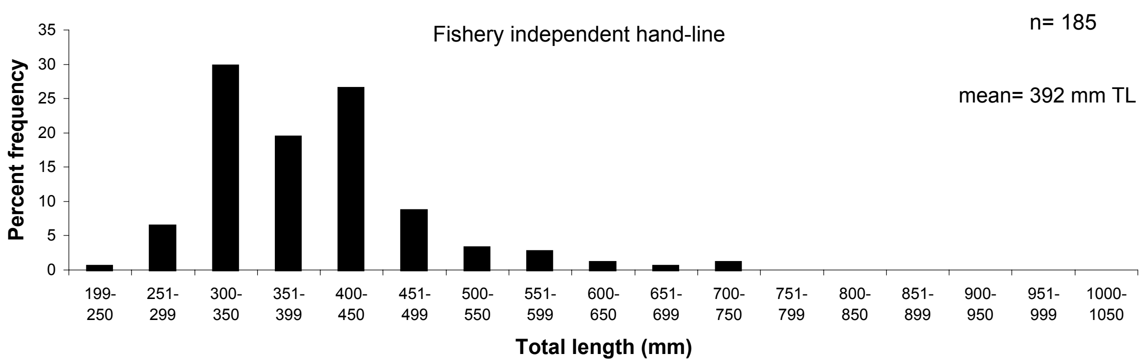
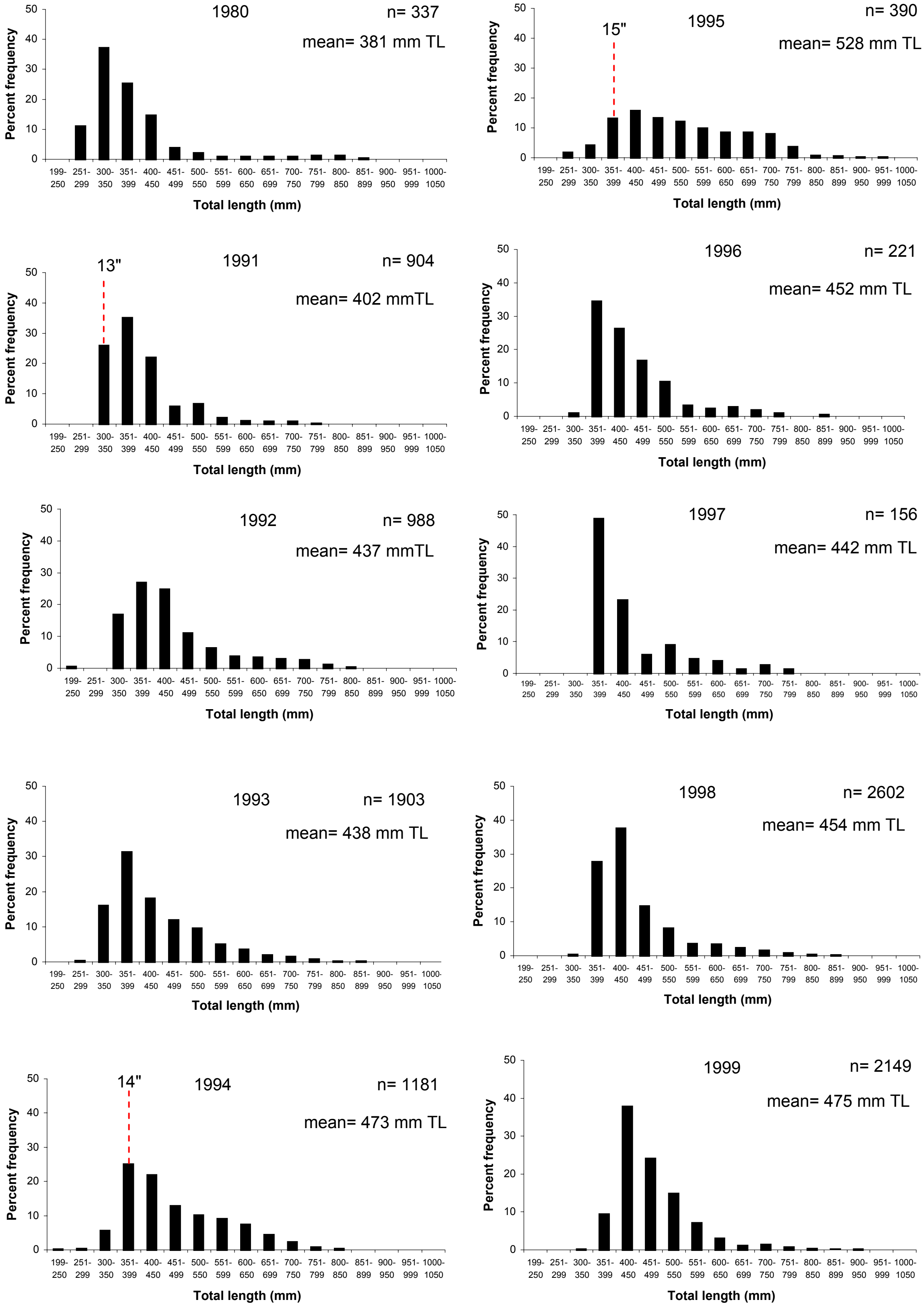


Figure 4. Size distribution of the red snapper recreational fishery by year. Size limit indicated by dashed line.



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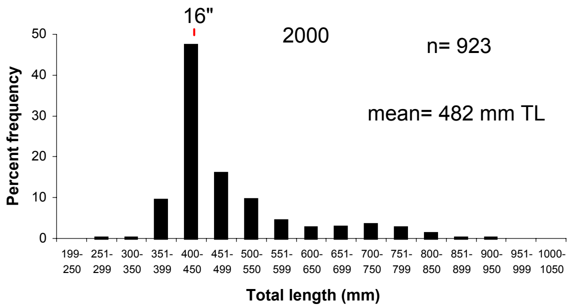
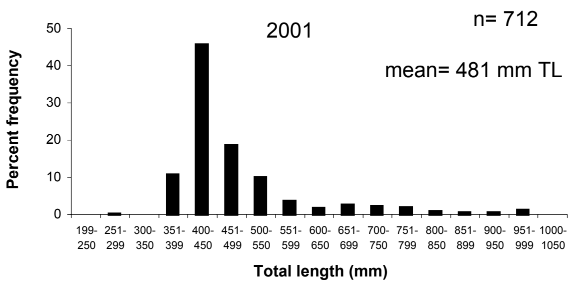




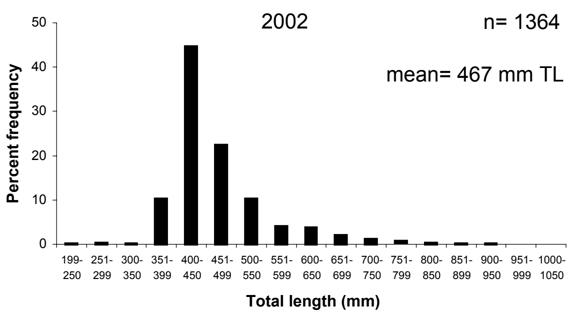


Figure 5. Size distribution of the red snapper commercial hand-line fishery by year. Size limit indicated by dashed line.

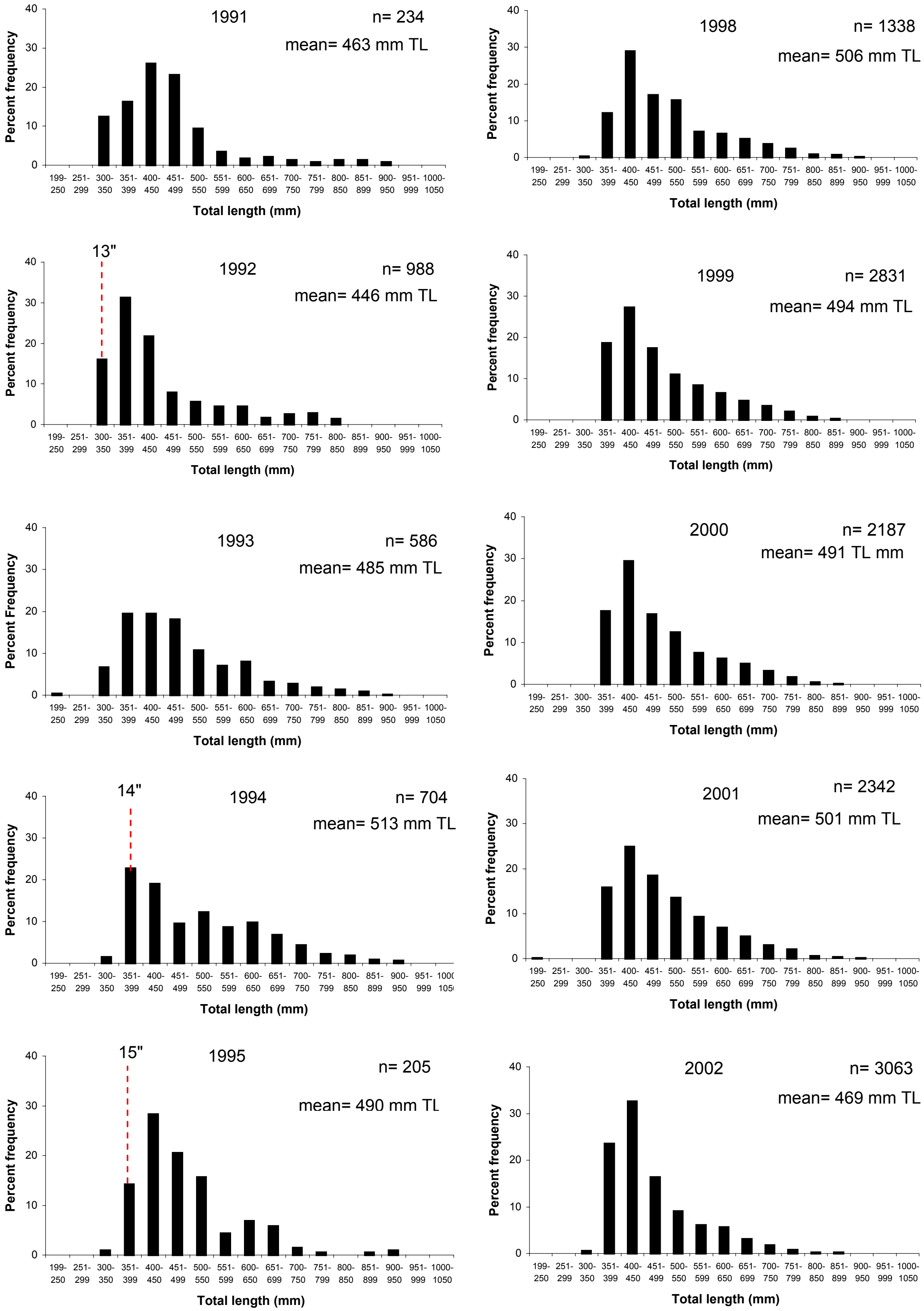


Figure 6. Size distribution of the red snapper commercial long-line fishery by year

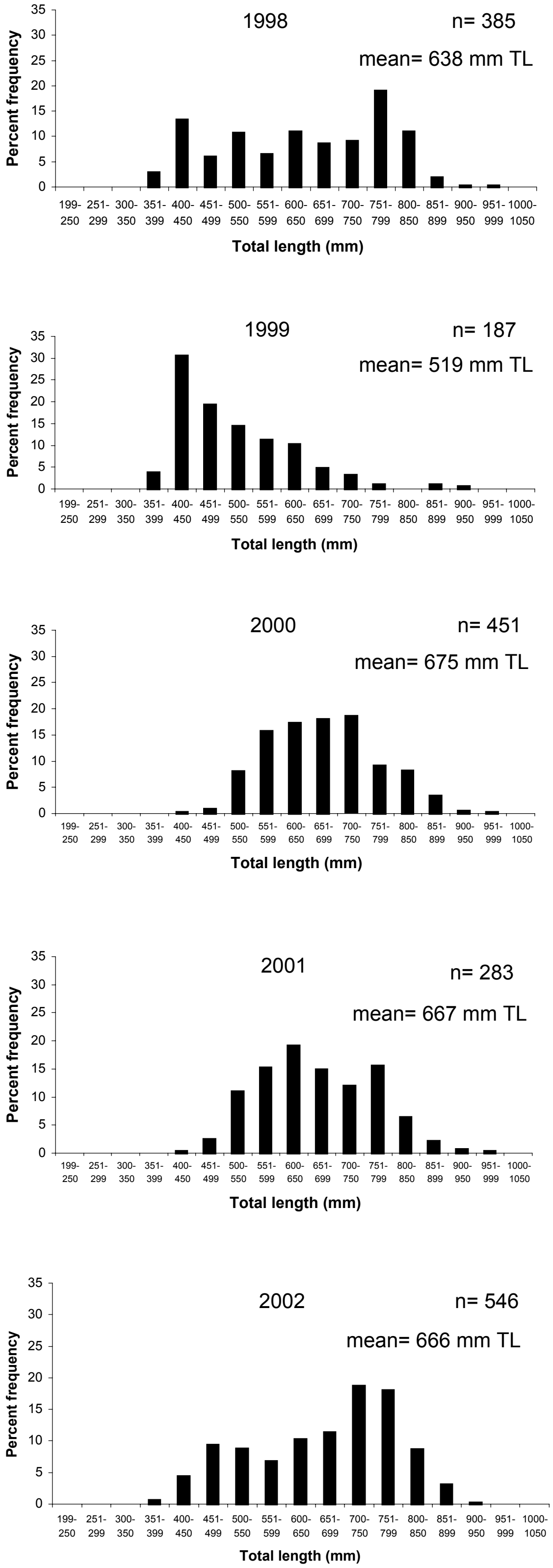


Figure 7. Size distribution for the fishery independent long-line survey all years combined.

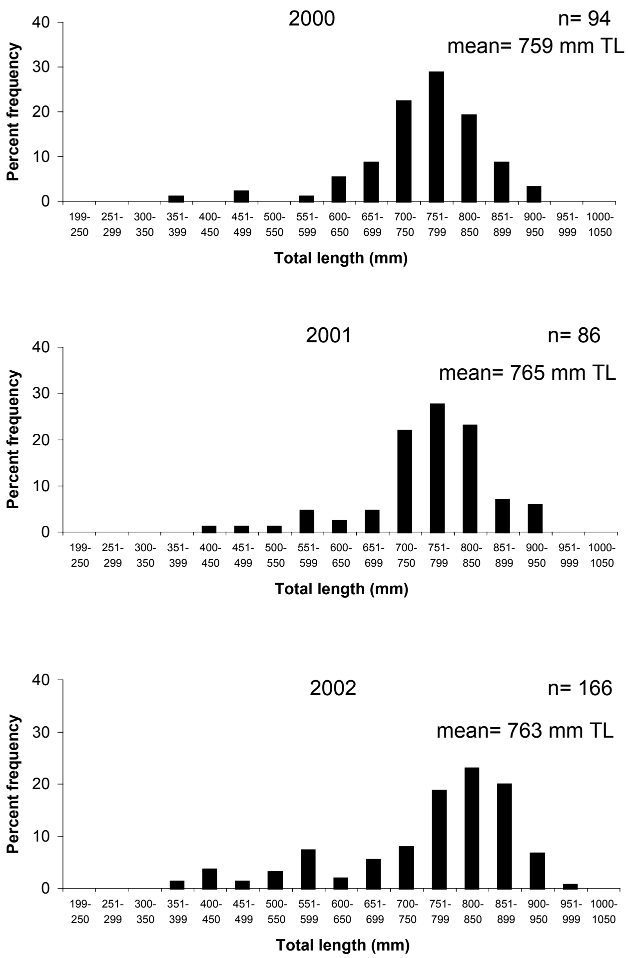
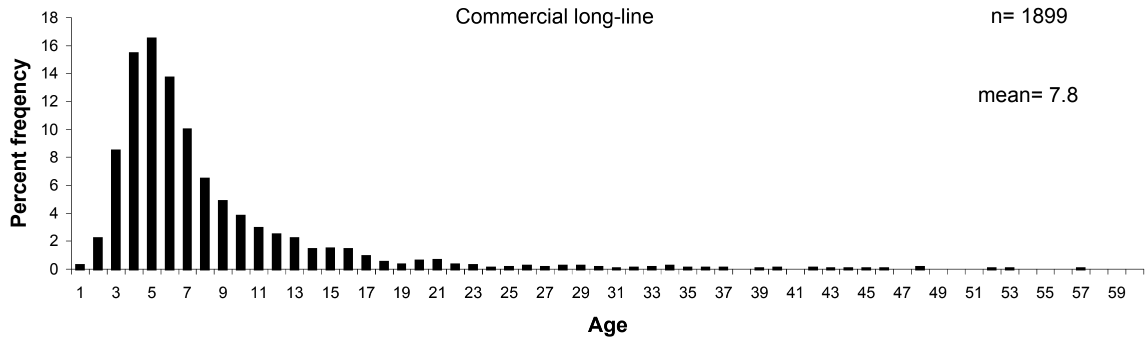


Figure 8. Gulf of Mexico red snapper age distributions by mode all years combined.



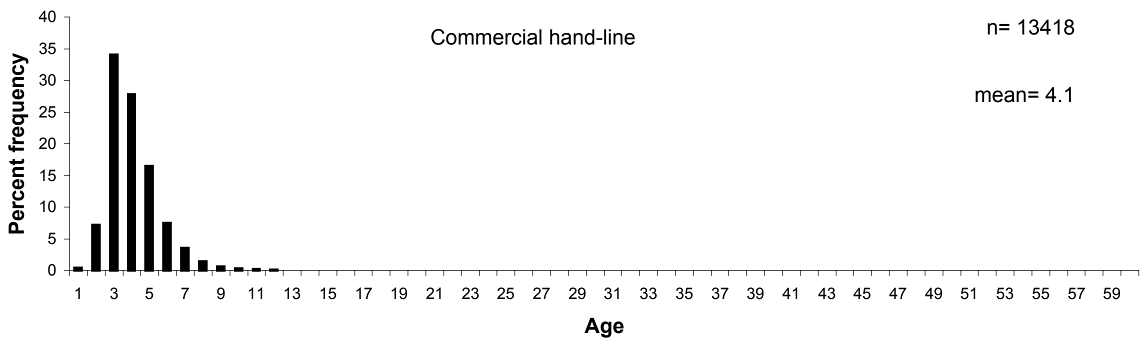


Figure 9. Gulf of Mexico red snapper age distribution from fishery independent survey all years combined.

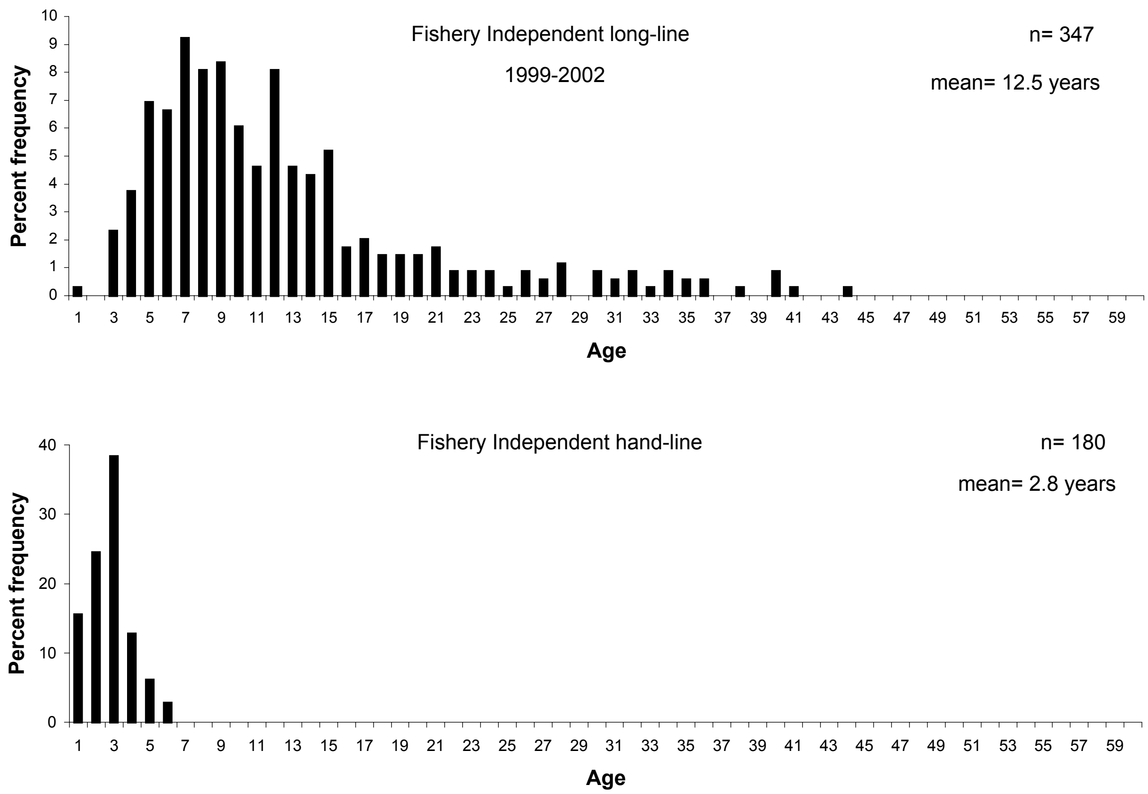
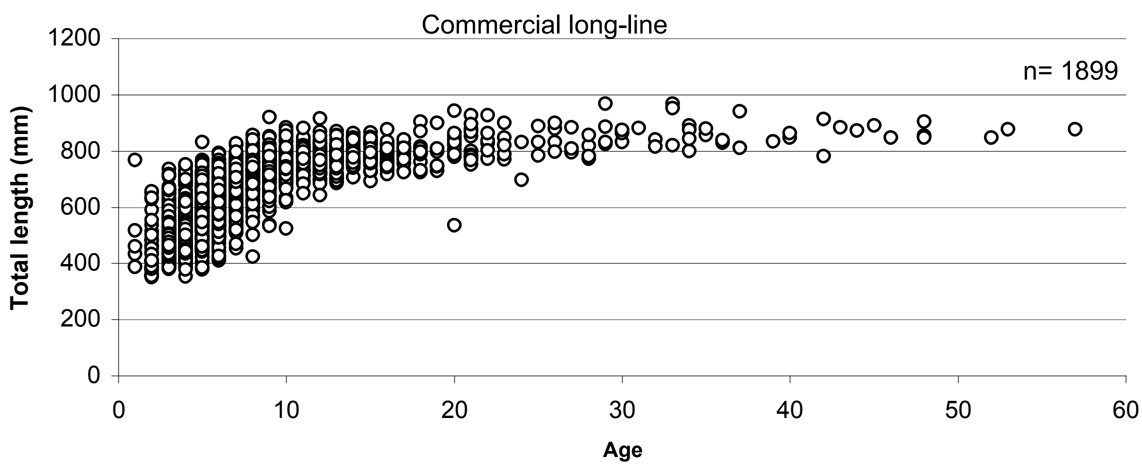


Figure 10. Gulf of Mexico red snapper total length (mm) at age (years) by mode all years combined.



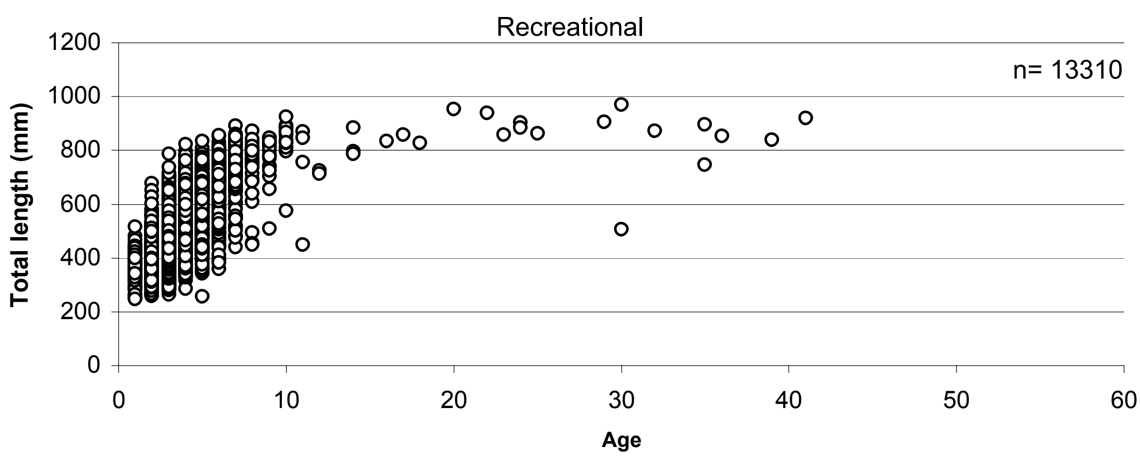


Figure 11. Gulf of Mexico red snapper total length (mm) at age (years) for fishery independent survey all years combined.

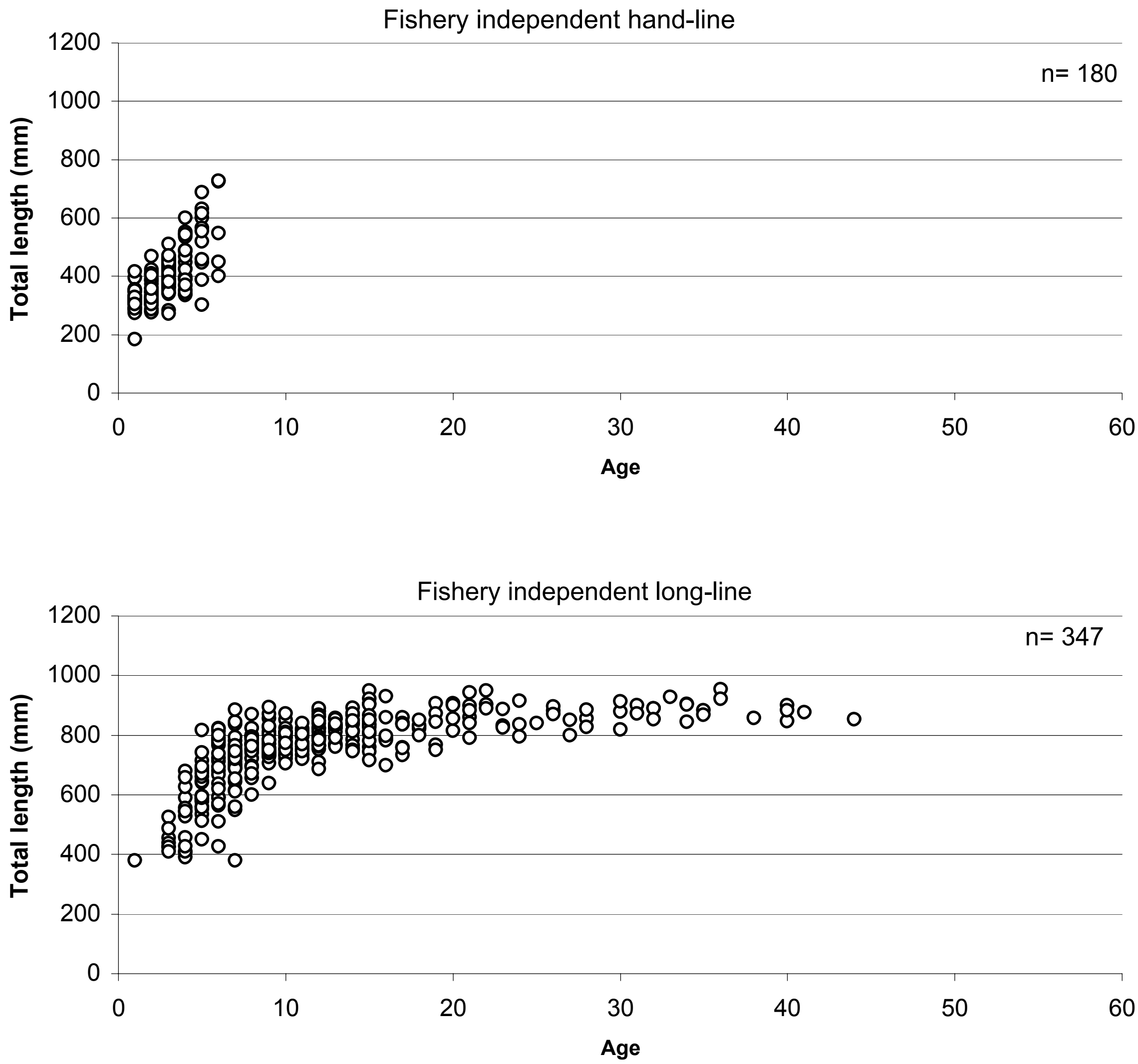
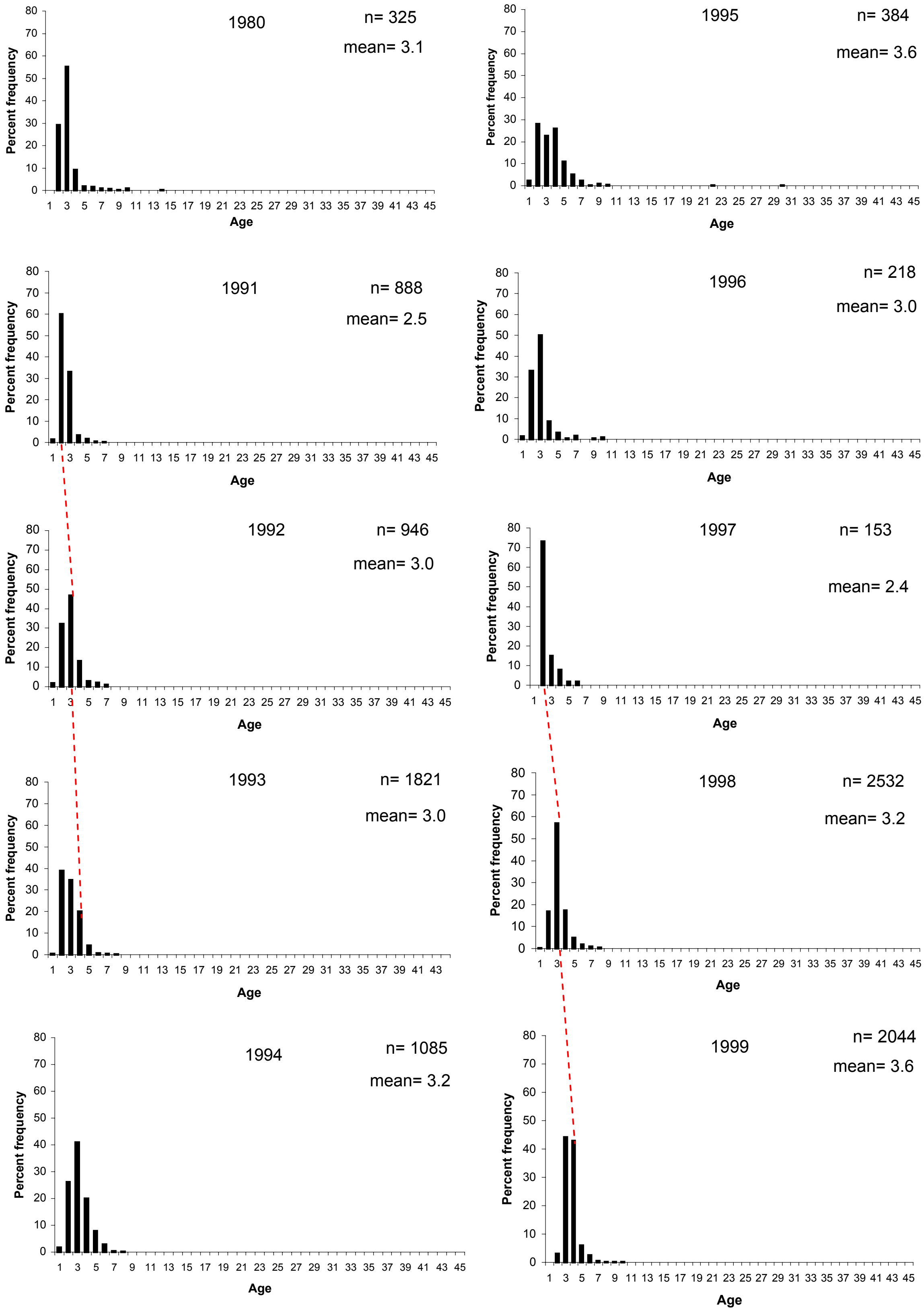


Figure 12. Age distribution of the recreational fishery by year. Dashed lines indicate year class progression.



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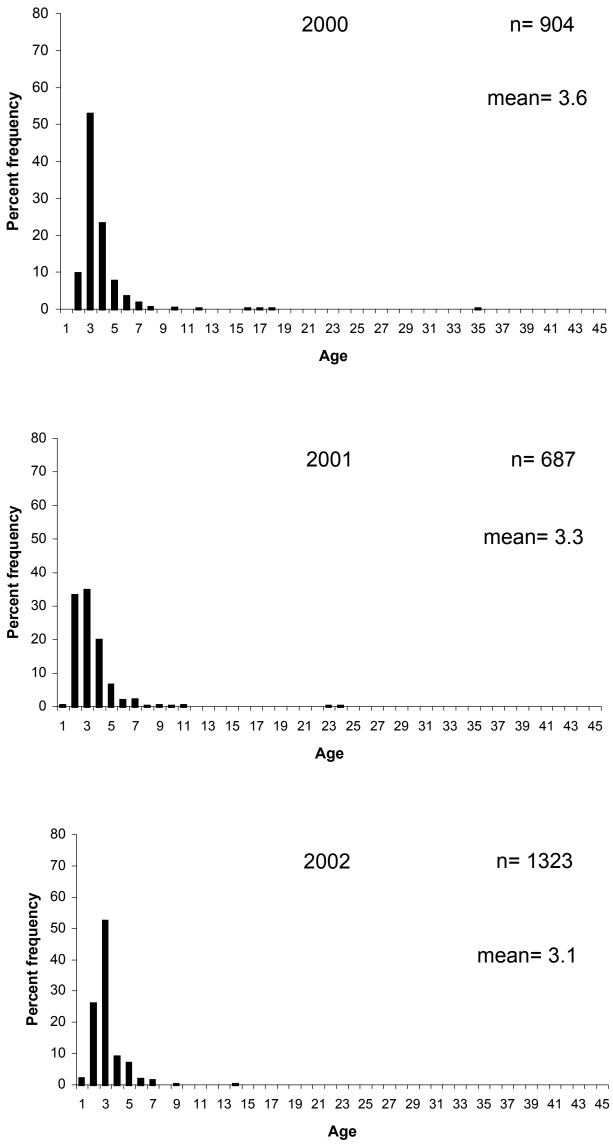


Figure 13. Age distribution of the commercial hand-line fishery by year. Dashed lines indicate year class progression.

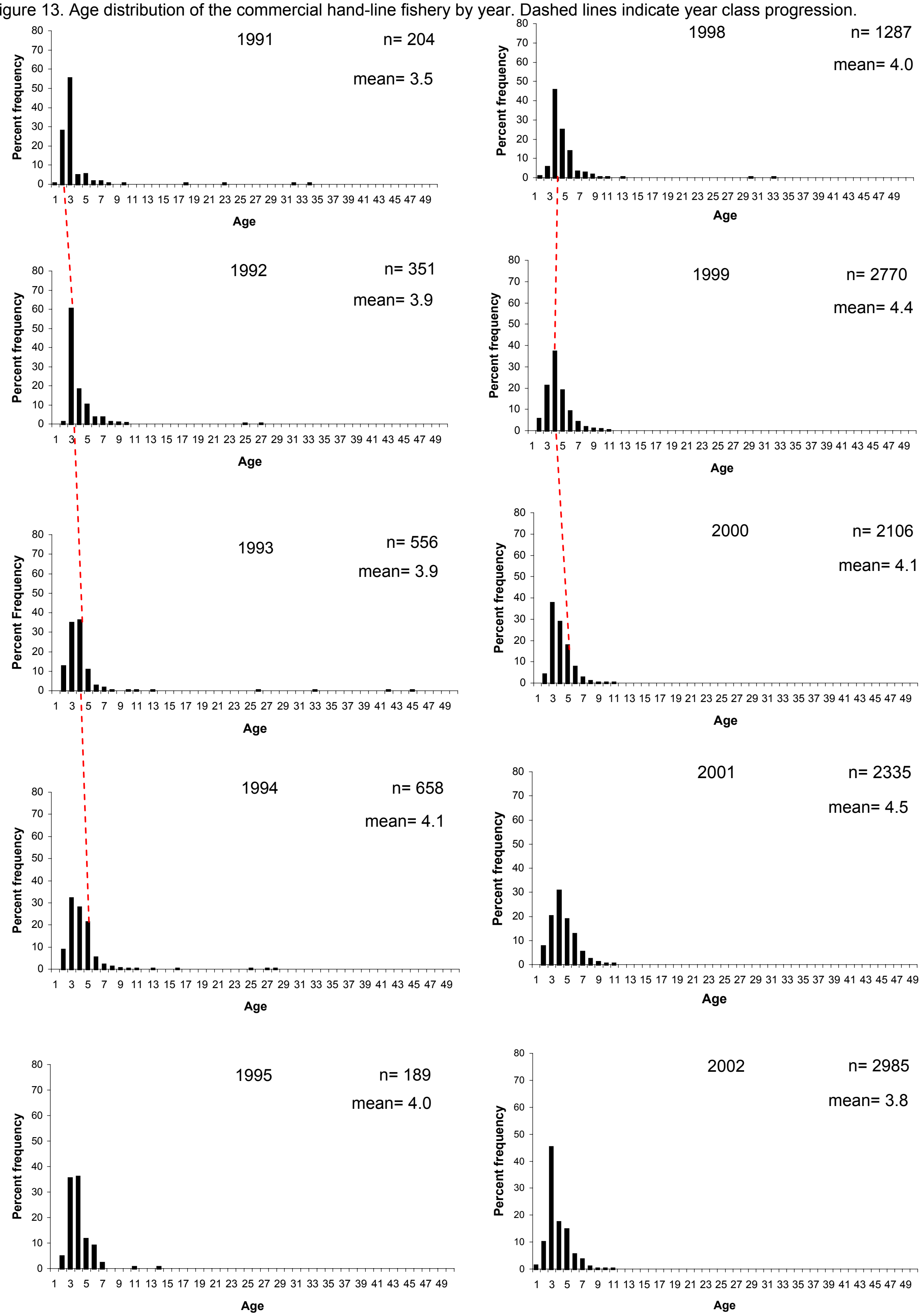


Figure 14. Age distribution for the commercial long-line fishery by year. Dashed lines indicate year class progression.

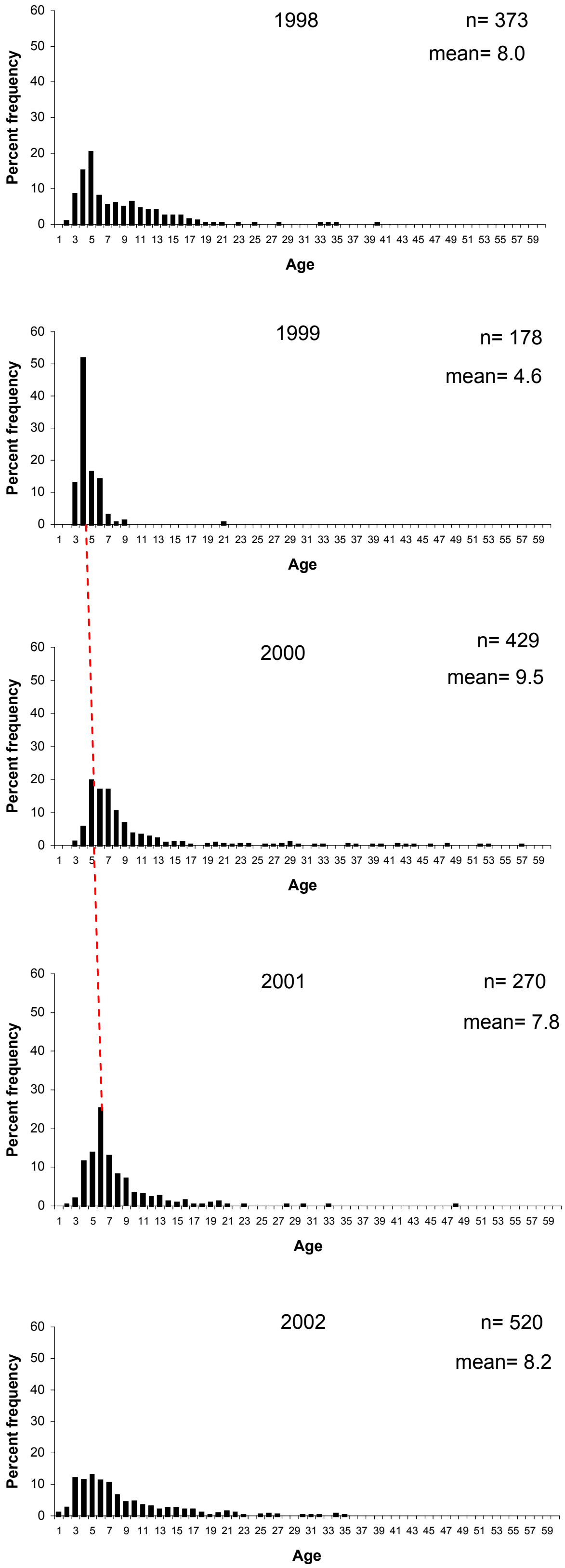


Figure 15. Age frequency for the fishery independent survey long-line and hand-line by year.

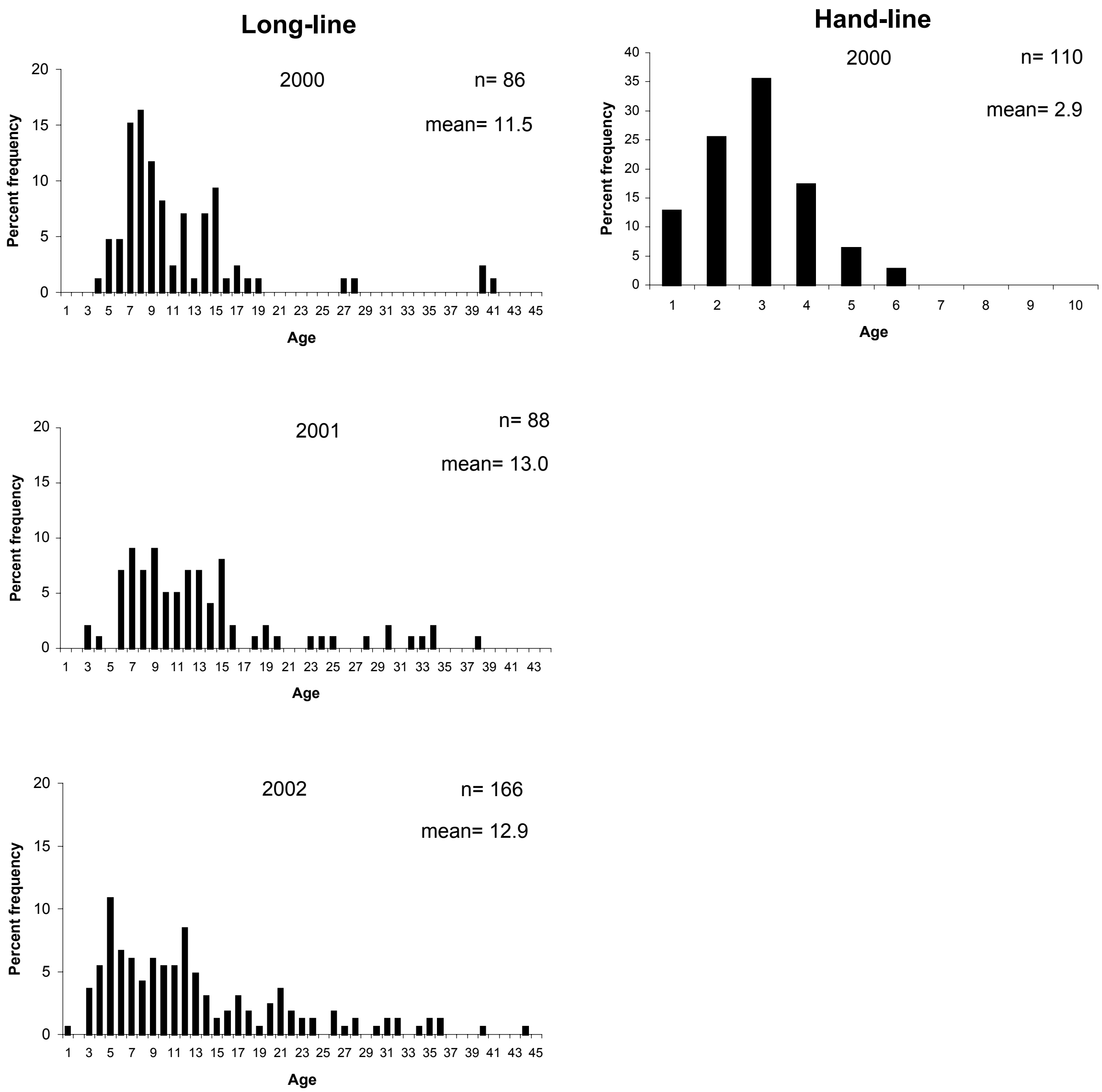


Figure 16. Progression of 1995 year class (dashed line) through rec.(A.), comm.hand-line(B.) and comm. long-line(C) and 1989 year class through the rec. (D) and comm. hand-line (E).

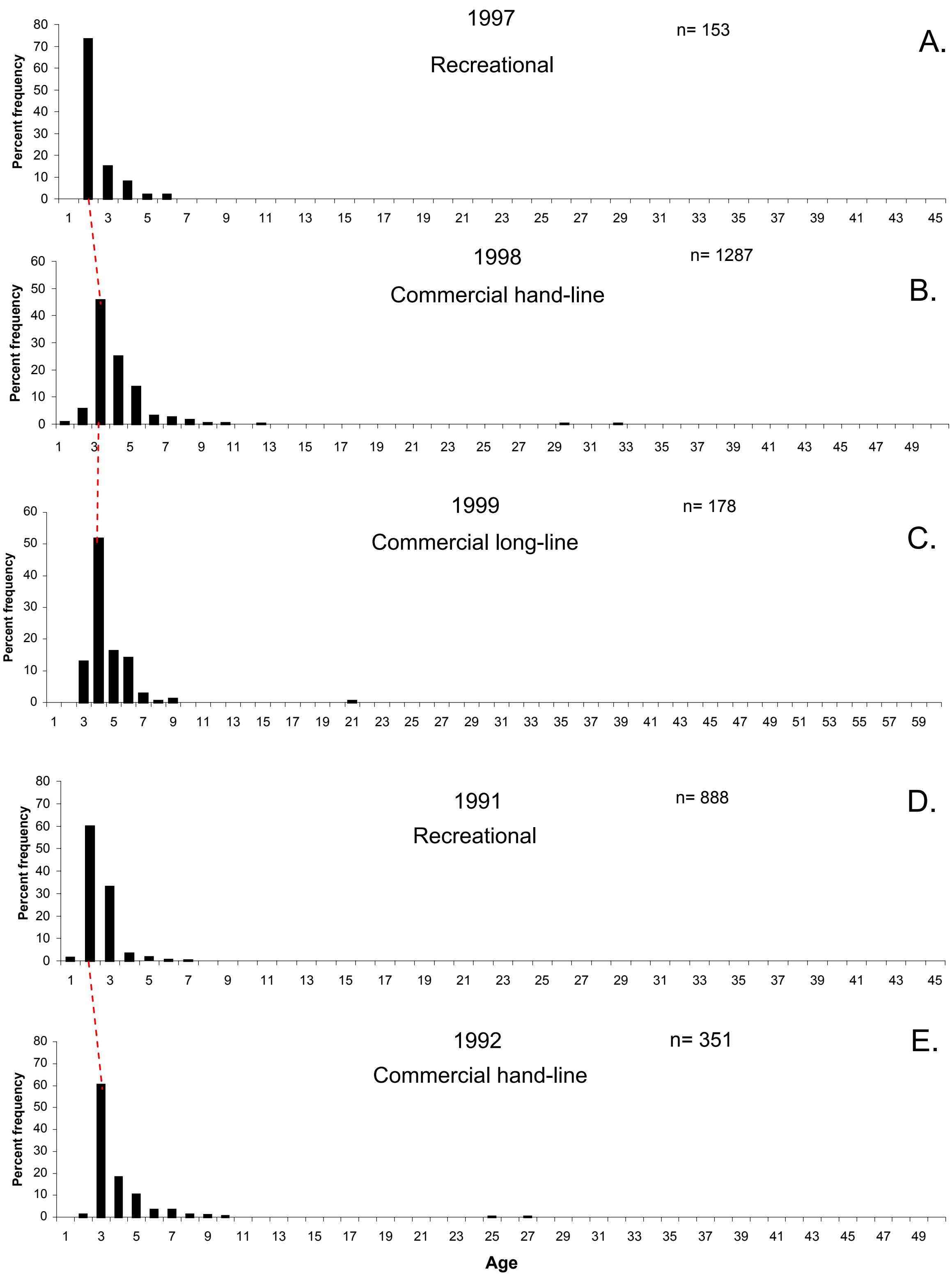


Figure 17. Recreational age distribution from the eastern gulf by year. Dashed lines indicate year class progression.

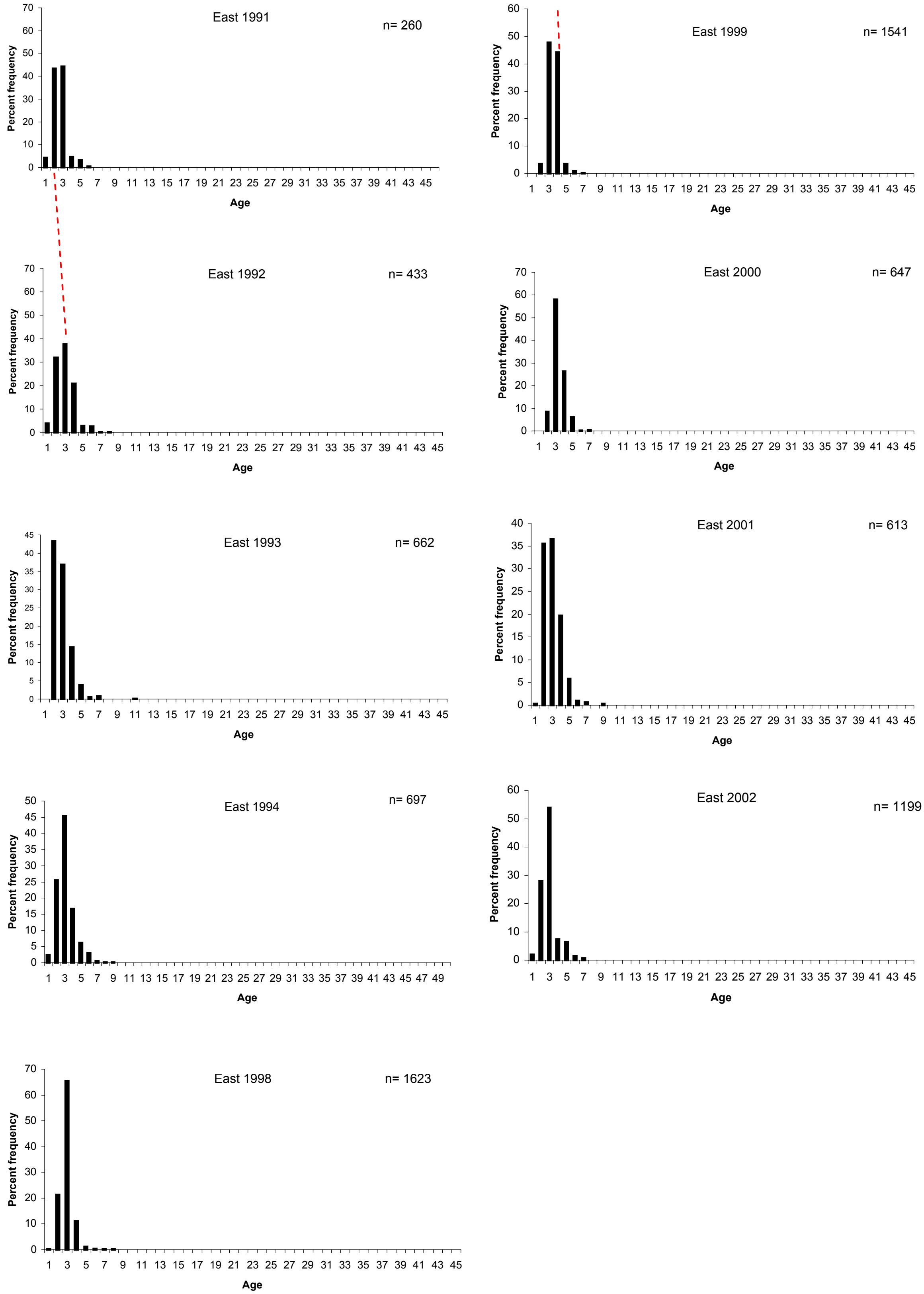


Figure 18. Recreational age distribution from the western gulf by year. Dashed lines indicate year class progression.

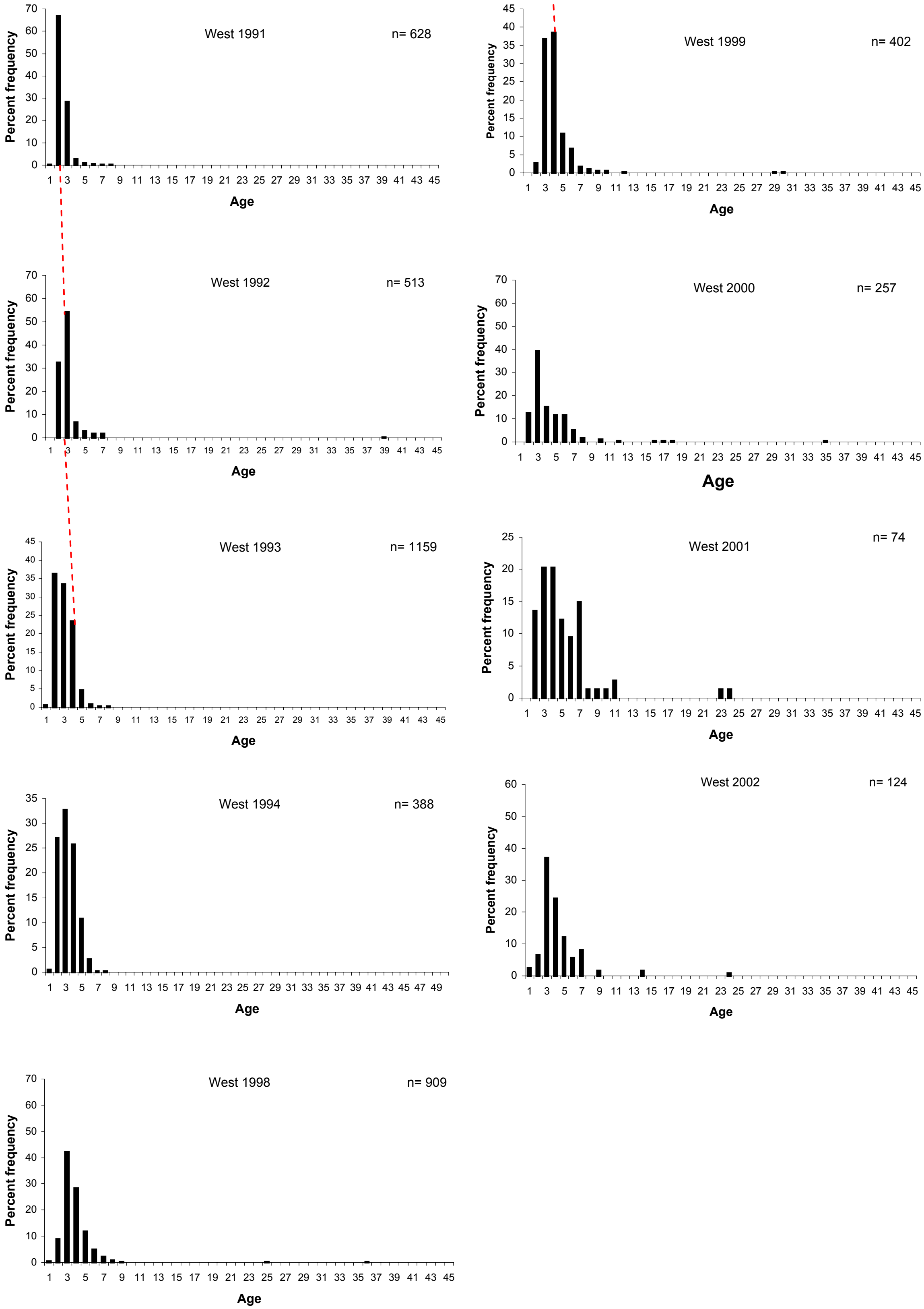


Figure 19. Commercial hand-line fishery age distribution from the eastern gulf by year. Dashed lines indicate year class progression

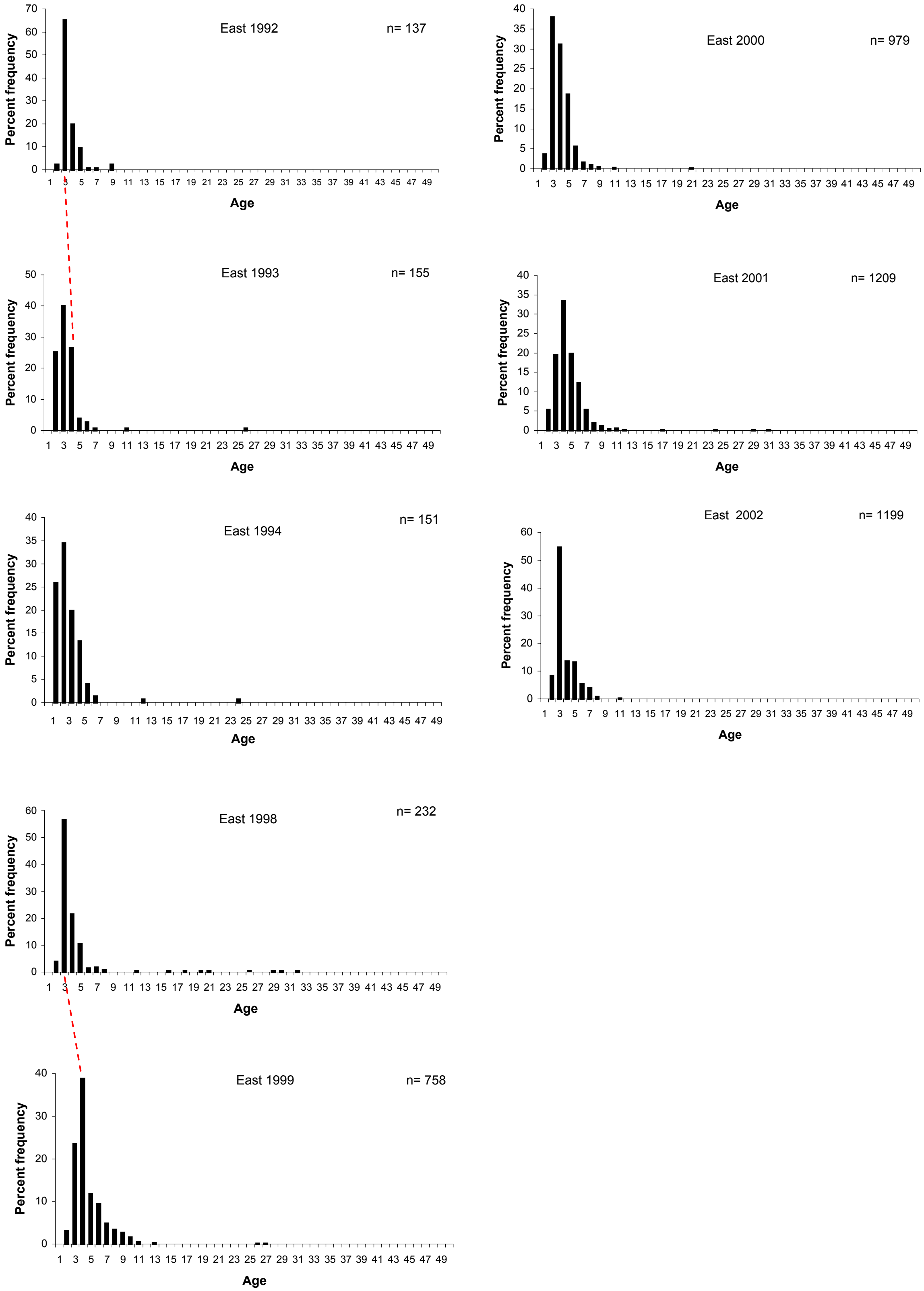


Figure 20. Commercial hand-line age distribution from the western gulf by year. Dashed lines indicate year class progression

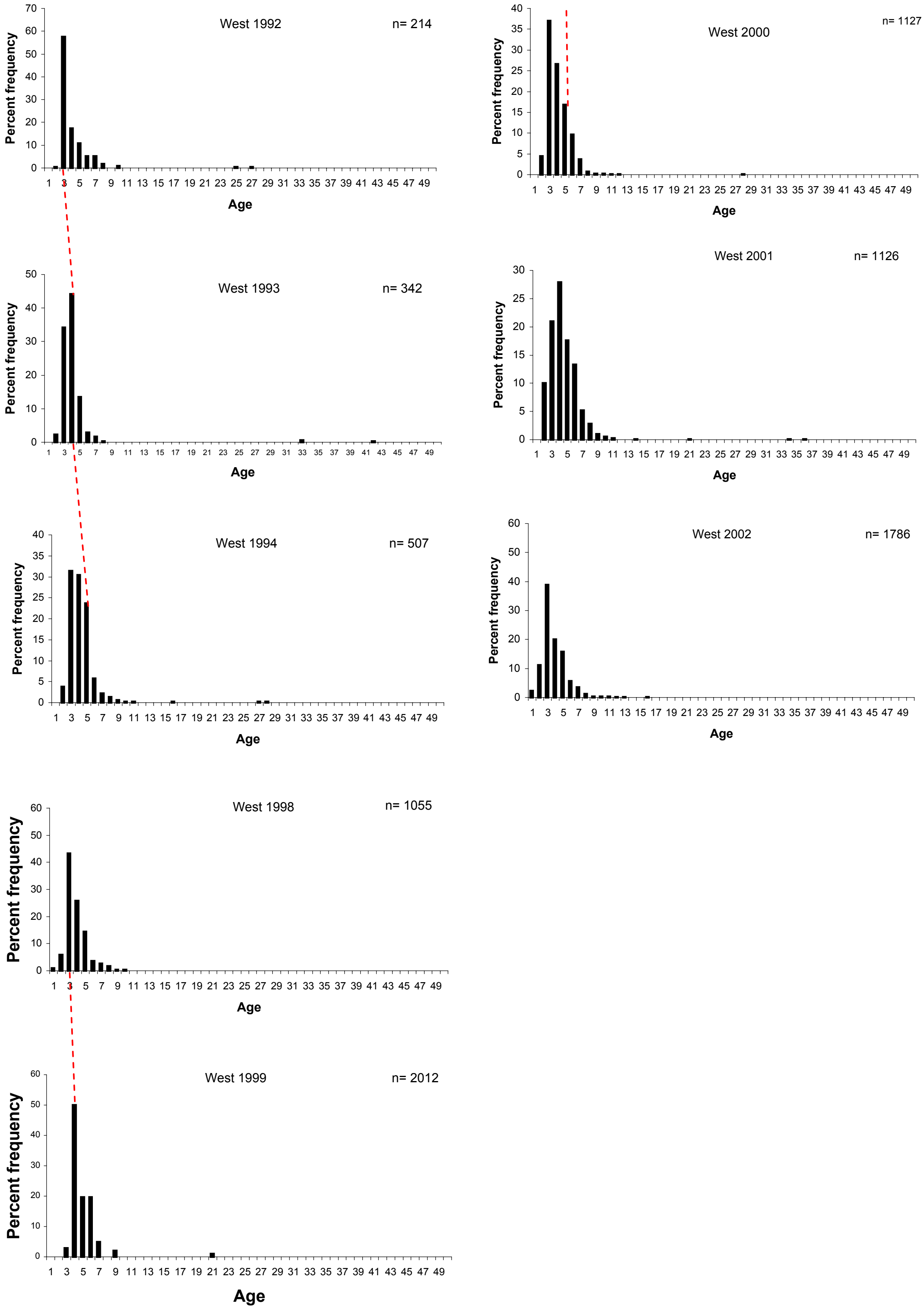


Figure 21. Commercial long-line fishery age distribution from the eastern gulf by year. Dashed lines indicate year class progression

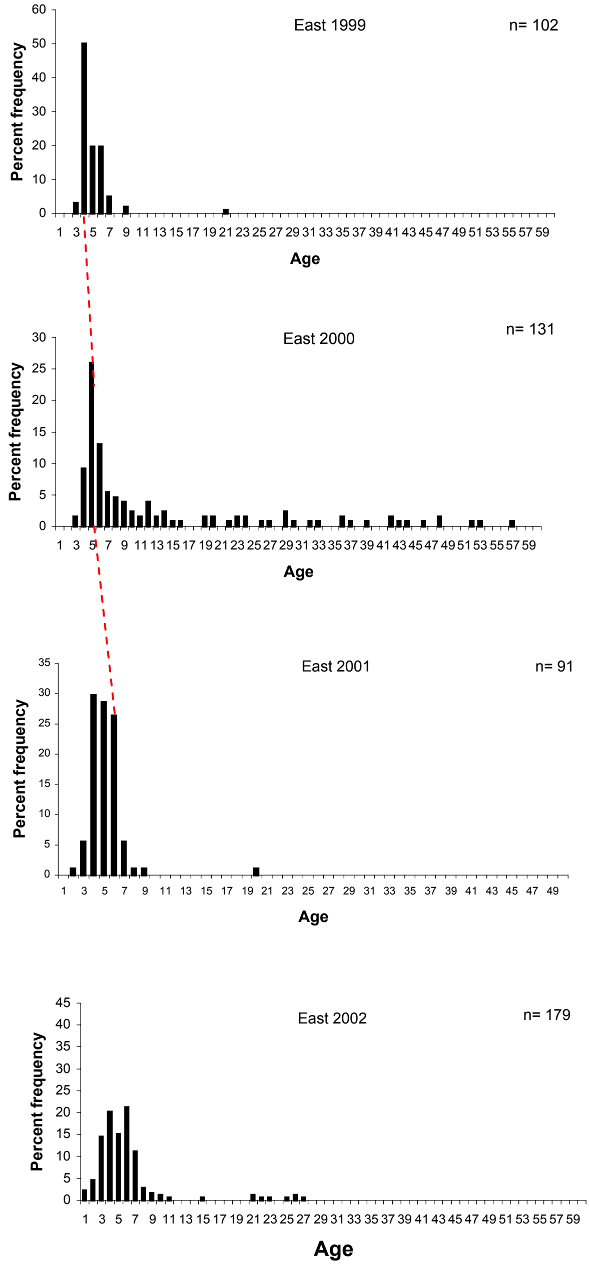


Figure 22. Commercial long-line age distribution from the western gulf by year. Dashed lines indicate year class progression.

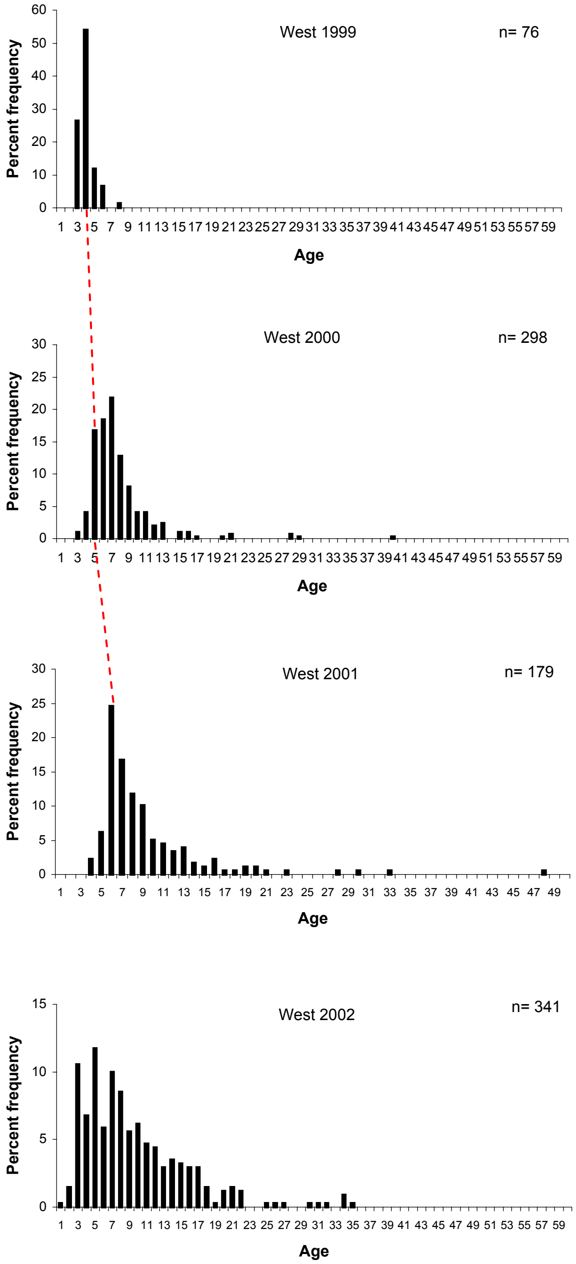


Figure 23. Age frequency distribution for commercial long-line and fishery independent long-line by region all years combined

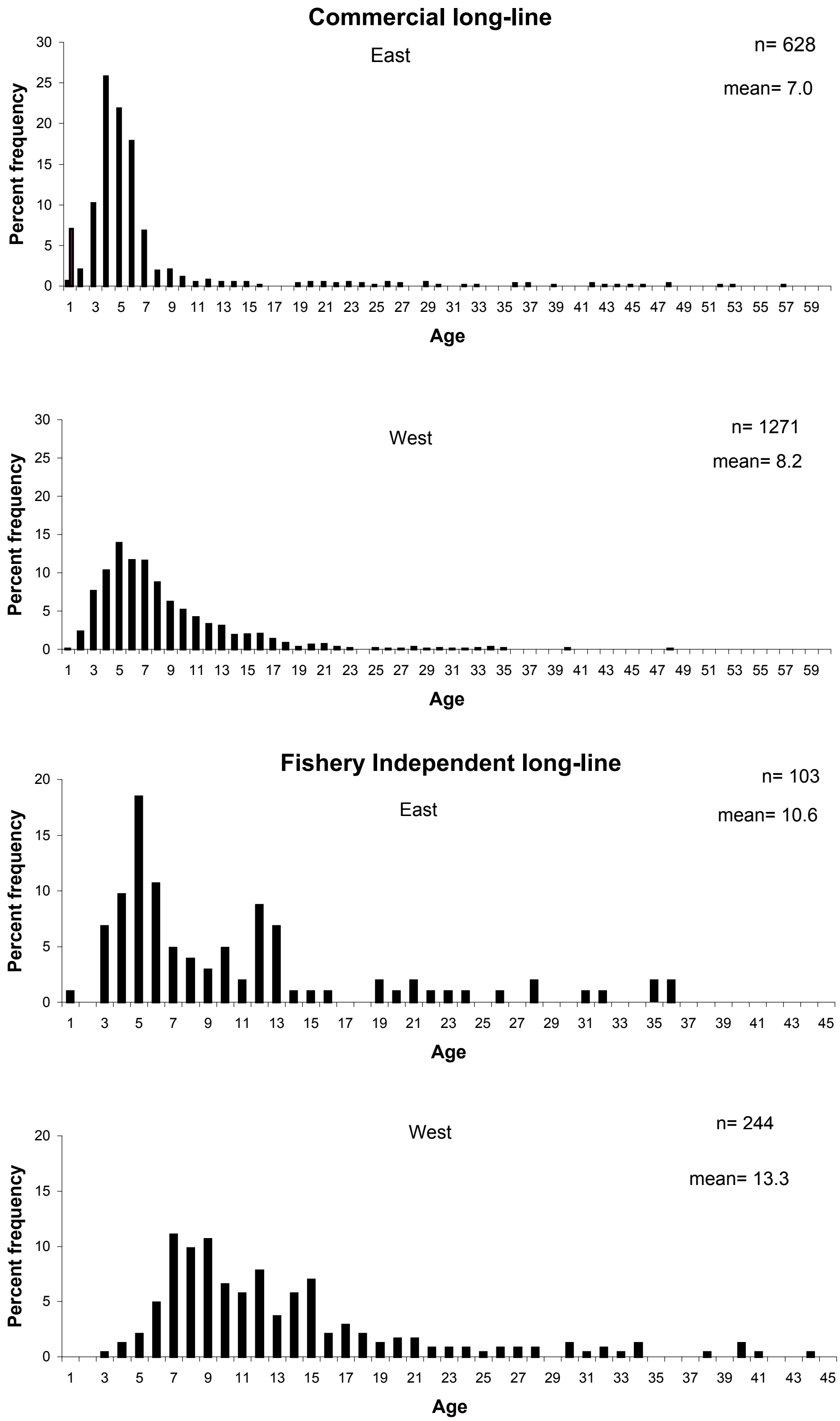


Figure 24. Age frequency distribution for the commercial hand-line and recreational fishery by region all years combined.

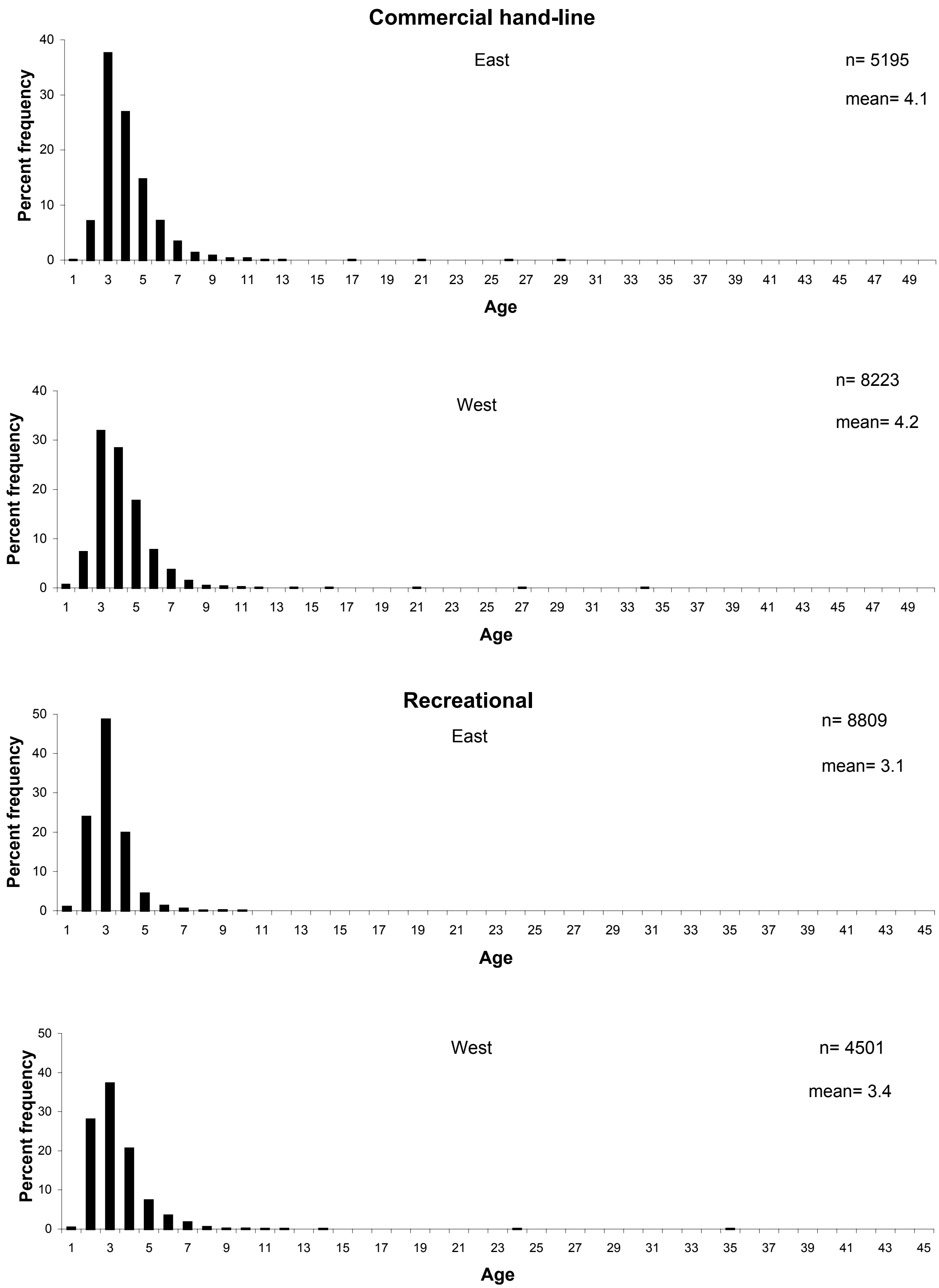


Figure 25. Age bias plot of mean annuli count (± standard error)of prior laboartory staff for each category of annuli counts from current labaortory staff. Solid line represents a 1:1 equivalence.

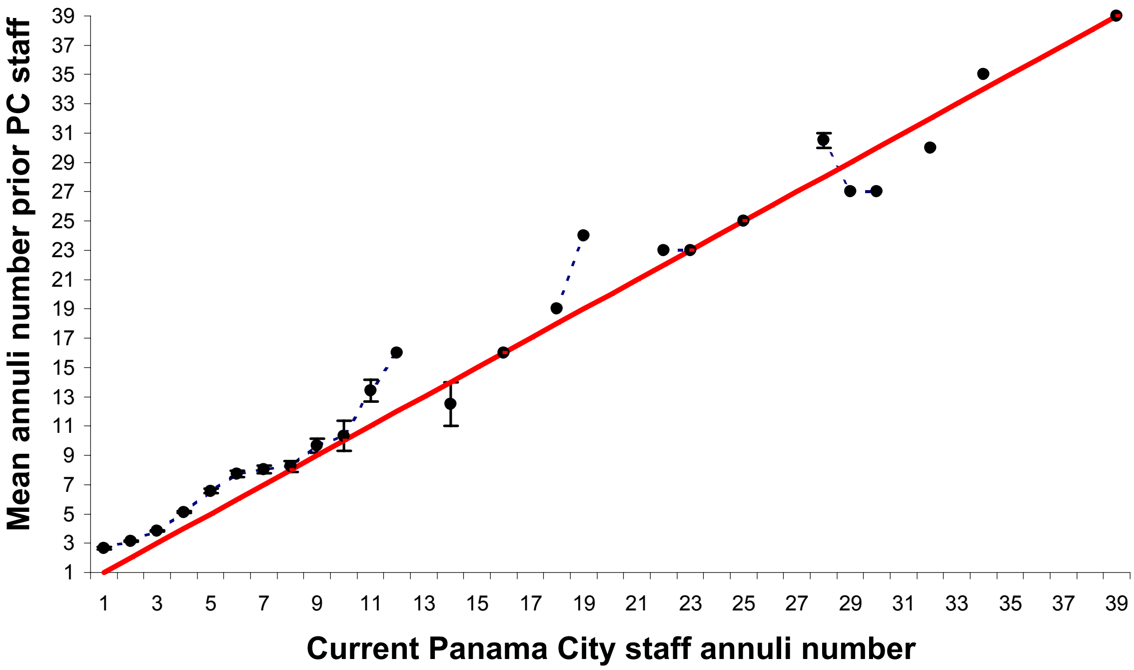


Figure 26. LSU commercial hand-line age distribution by year.

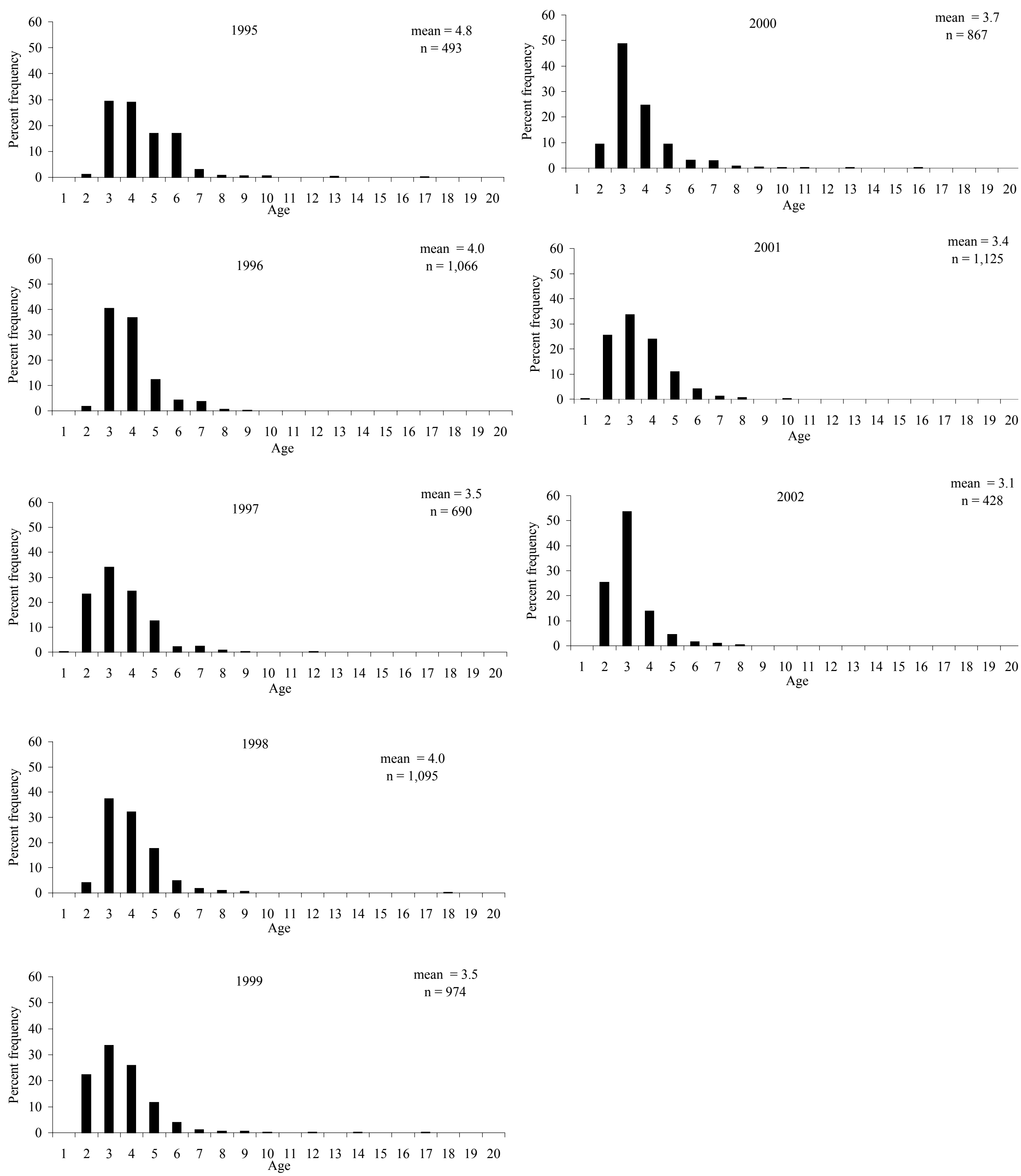
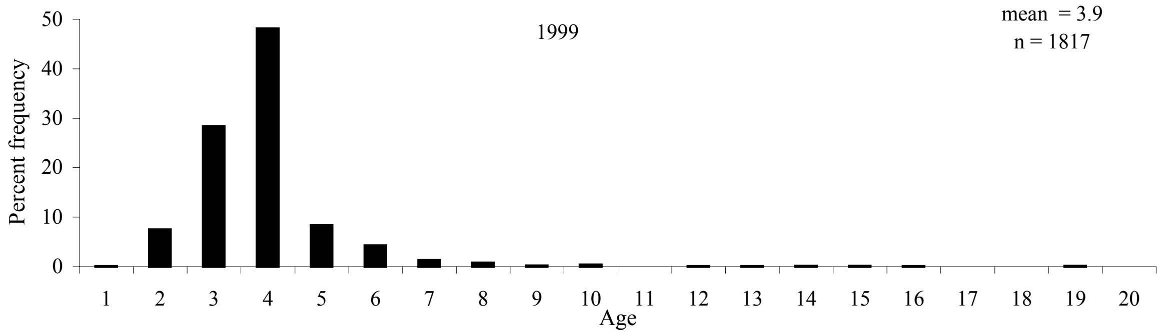
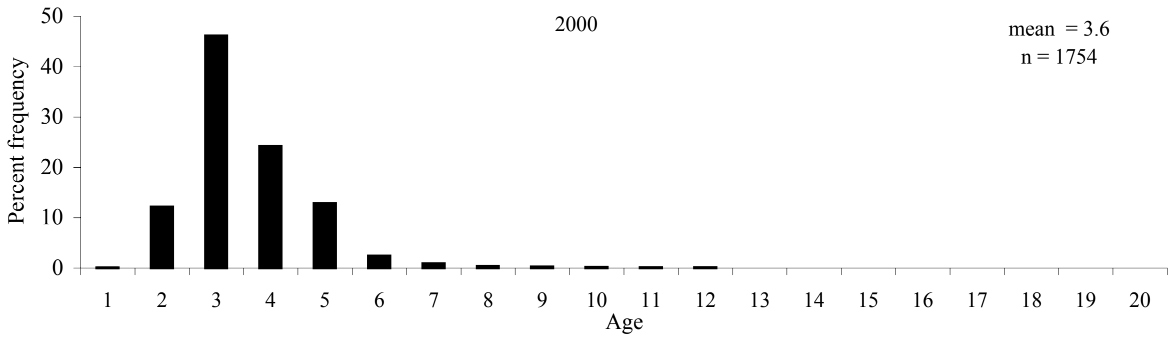


Figure 27. LSU recreational age distribution by year.





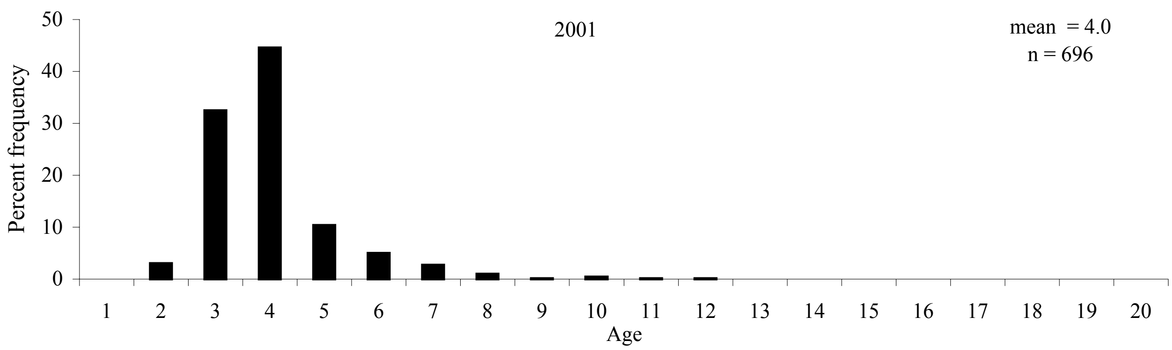


Figure 28. Gulfin commercial hand-line age distribution for 2002 by state.

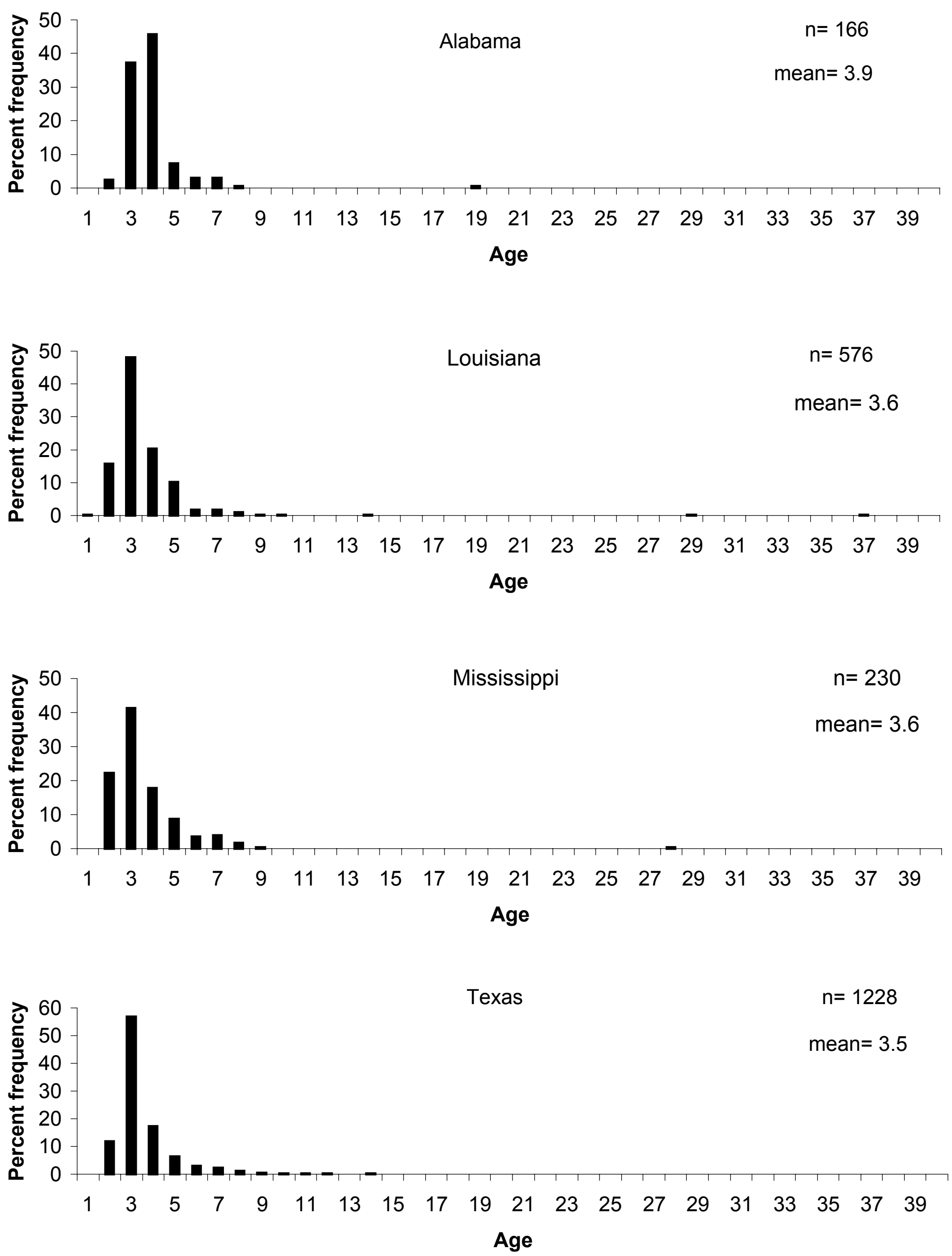


Figure 29. Gulfin recreational age distribution for 2002 by state.