Edge type distributions as an indication of potential aging problems for multiple reef fish species collected from the Gulf of Mexico

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Edge type distributions as an indication of potential aging problems for multiple reef fish species collected from the Gulf of Mexico

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ABSTRACT

This report documents variations in edge type distributions for six Gulf of Mexico SEDAR species (red snapper, gray snapper, gray triggerfish, greater amberjack, red grouper and vermilion snapper) based on data provided by different government agencies. Since edge type distributions are used to determine age assignment rules and reflect how samples for a given species were actually aged, any inconsistencies in edge type distributions between different labs/years can be used to identify problems in aging procedures. Results from this study show that there were consistent problems in recognizing opaque zone edges and annulus peaks in Panama City Lab samples for several species. In many cases, the opaque zone edge distributions were incomplete, fragmentary, or even absent. In addition, there were significant, sometimes drastic differences in opaque zone edge type distributions between different labs for several species. These systematic problems in opaque zone distributions may have led to aging errors and seasonal variations in age-related parameters in several SEDAR species. These results also show that a unified coding system and consistent age assignment rules are needed for all SEDAR data providers. Overall, analyses of edge type distributions for samples from different labs/years are a useful tool for assessing the accuracy of aging procedures and for ensuring that different data providers are more accountable for their aging results.

INTRODUCTION

For age-structured assessment models, age is defined by age class (i.e., fish born in a given calendar year belong to the same age class). Age class is determined based on the number of annuli and the edge type of an aging structure (e.g., otolith, dorsal spine, or other structures). Aging structures for reef fish typically show repetitive annual rings that are composed of two zones – an opaque zone (OPZ) and a translucent zone (TZ). The edge type for an aging structure could be an OPZ or TZ, depending on the birth date and the time at which a fish is sampled. The annual peak of an edge type is important because (1) it has typically been used to validate the use of a particular edge type of an aging structure to define an annulus (Campana, 2001), and (2) it determines the age assignment rules. For example, if the OPZ is used as the annulus, the monthly distribution of an OPZ edge type for a population should peak only once a year. Also, the peak should be distinct and of a high enough magnitude to verify that a majority of fish in a population form an annulus each year.

The timing of the peak annulus formation is used to adjust the age count for samples that were collected before the annulus peak in any given year. For example, if the OPZ is defined as the annulus and the annual peak of OPZ edge formation occurs in April (i.e., the majority of fish in a population form an OPZ edge by April every year) for a given species, then a fish sample collected in March with a nearly completed TZ edge type should be converted to the next age class (i.e., 1 year is added to its total number of annuli). Since the timing of the annulus peak determines the age assignment rule, correct identification of when the annulus peak occurs is important. If the annulus peak is misidentified, overestimation or underestimation of age may occur. Such overestimation or underestimation of age may create erroneous seasonal variations in age-related parameters that are not in reality present (Chih, 2018a, 2018b).

Because edge type distributions for a given year reflect how samples were actually aged for that year, analysis of edge type distributions can provide a direct indication of whether aging rules were adequate and of whether samples were aged correctly. Drastic differences in edge type distributions between years and data providers may signal serious quality control issues. Unfortunately, such differences have often been dismissed as due to regional or equipment differences. As pointed out by Campana (2001), continuous quality control monitoring is important as even a gradual deterioration in aging accuracy can lead to serious errors in stock assessments.

The current study analyzes the edge type distributions of six SEDAR species (red snapper, gray snapper, gray triggerfish, greater amberjack, red grouper, and vermilion snapper) that have aging information available to SEDAR participants. The goal of this study is to evaluate the quality of the processes used to determine ages for these species through an examination of their edge type distributions.

MATERIALS AND METHODS

All age data were from age data sets provided for recent SEDAR stock assessments (SEDAR 52- red snapper, SEDAR 51- gray snapper, SEDAR 62- gray triggerfish, SEDAR 33 Update- greater amberjack, SEDAR 61- red grouper, SEDAR 67- vermilion snapper). These data sets were compiled from age samples originating from the Panama City Laboratory (PC Lab) of the Southeast Fisheries Science Center (SEFSC) of the National Marine Fisheries Service (NMFS), the Beaufort Lab (SEFSC, NMFS), the Gulf States Marine Fisheries Commission as part of the Fisheries Information Network database (GulfFIN), and a University of Florida research lab.

For convenience of analysis, edge types were grouped into three categories for red snapper, gray snapper, greater amberjack, red grouper and vermilion snapper: opaque zone on edge (OPZ), not advanced translucent zone on edge (NTZ) and advanced translucent zone on edge (ATZ). The definition of the ATZ edge differed between different labs:

Panama City Lab (PC Lab) samples- TZ edge more than ½ completed.

GulfFIN, University of Florida, Beaufort Lab- TZ edge more than 1/3 completed.

Edge types for gray triggerfish were grouped into two categories: OPZ (opaque zone on edge) and TZ (translucent zone on edge). For red snapper, gray snapper, greater amberjack, red grouper and vermilion snapper, the opaque zone of the otolith was used as the annulus. For gray triggerfish, the translucent zone of the dorsal spine was used as the annulus. The definition of edge types can be different between different state agencies of GulfFIN. The different codes for edge types used by different GulfFIN states were collapsed into the code system used by GulfFIN.

The SEDAR age assignment rules for different edge types were the same for season 1 samples for red snapper, gray snapper, greater amberjack, red grouper and vermilion snapper: all season 1 (January to June, where 'season' is defined as 6 months in this report) samples with an ATZ edge were advanced to the next age class (age= #annuli +1). There was no adjustment in age class for season 2 (July to December) samples for red snapper, gray snapper, greater amberjack and vermilion snapper. For red grouper, OPZ samples collected in November and December were converted to the previous age class (age= #annuli -1). For gray triggerfish, the TZ edge was counted as 1 calendar age, and no age advancement was performed.

RESULTS AND DISCUSSION

I. Red snapper

(1) Inconsistencies in the timing of annulus peaks between SEDAR 52 age data and previous studies:

    There were significant differences in the timing of annulus peaks between what was observed in SEDAR 52 age samples (Fig 1(a), (b)) and what was reported in previous studies (Wilson et al., 2001; Patterson et al., 2001; also see Chih, 2018a). These differences in the timings of annulus peaks were also noted by the Panama City Lab (Allman et al., 2004). Accurate identification of the timing of an annulus peak is important since it determines the age assignment rules. As discussed below, consistent problems in recognizing an OPZ edge and OPZ peak in PC Lab samples were noted in several species, particularly in snappers (e.g., gray snapper, red snapper and gray snapper). For red snapper, atypical OPZ edge type distributions were seen in more recent years, particularly in 2015 (Fig 1(b)). Such problems in recognizing the annulus peak may lead to questionable aging rules and aging errors for individual years.

(2) Inconsistencies in edge type distributions between years for PC Lab samples:

(a) The edge type distribution for 2015 PC Lab age samples (Fig 1(b)) was drastically different from the rest of PC Lab edge type distributions in that there was a distinct OPZ peak (about 90%) occurring in Dec-Jan, which was consistent with previous academic studies (Wilson et al., 2001; Patterson et al., 2001). Whatever the cause for this drastic differences in OPZ edge distribution in 2015, applying the current age assignment rules to the 2015 samples would have created biased results. This is because most season 1 ATZ samples collected from February through June should already have formed an annulus for that year (i.e., one year had already been counted for that calendar year), so advancing season 1 ATZ samples to the next age class would have overestimated the age of season 1 ATZ samples in 2015. Also, the age of OPZ samples in late season 2 (Sept-Dec) would have been overestimated, so one year should have been deducted from the total annulus count for those OPZ samples (Wilson, et.al. 2001).

(b) The observed low magnitudes of OPZ peaks seen in PC Lab samples processed in more recent years (2005, 2013, 2014, 2016) also signal problems in the aging process. The low magnitudes of OPZ distributions in those years cannot account for all samples that should have gone through the OPZ stage each of those years. Although advancement of season 1 ATZ samples can offset some of these problems in OPZ edge recognition, the advancement of season 1 ATZ samples itself may create a different problem. This is because the ATZ edge type can range from 1/3 (GulfFIN samples) or ½ (PC Lab samples) completion of the TZ edge to full completion of the TZ edge. As a result, a portion of fish that completed an OPZ edge during Dec.-Jan. may have reached the early stages of an ATZ (e.g., 1/3 or ½ TZ completed) by April, May or June. When these season 1 ATZ samples are advanced one year, their ages would have been overestimated by one year since the calendar age for that year would have already been counted. If a large proportion of fish form an OPZ during Dec.-Jan. (i.e., if the OPZ peak occurred in Dec-Jan, as occurred in 2015), then the percent overestimation of age may be significant.

(3) Inconsistency in edge type distributions of samples processed by different state agencies of GulfFIN

The edge type distributions of samples processed by Texas are very different from the rest of states in GulfFIN (Fig 1(c)). Part of the problem may have been the different coding systems used by different states. In any case, applying the current age assignment rules to Texas samples would have created biased aging results since there was no actual peak for the OPZ edge type in these samples. This potential bias for Texas samples could be problematic since spatial models (East and West) were used in the most recent red snapper assessment. The differences in edge type distributions between different state agencies may mean that a unified coding system is needed to ensure quality control of aging results.

II. Gray snapper

The major concern for the observed edge type distributions for gray snapper samples is the consistently low proportion of the OPZ edge type in PC Lab samples for all years between 2002-2015 (Fig 2 (b)). In particular, OPZ edge distributions were incomplete in most years and even totally absent in 2011 (Fig 2 (b)). Such problems in in recognizing the OPZ edge may also lead to misidentification of OPZ peaks and problematic age assignment rules. When currently used age assignment rules are applied to gray snapper samples, the low proportion of OPZ samples may cause errors for both season 1 and season 2 samples. For example, underestimation of age would occur for a season 2 sample that should have had a forming OPZ edge but was not recognized as an OPZ sample. Also, for season 1 samples, conversion of ATZ samples to the next age class may have led to overestimation of ages because of the loose definition of an ATZ sample and the uncertainties of the timing of the OPZ peak (also see discussion in I (2) (b)). Because of the importance of the OPZ edge distribution in age determination, the consistent inability to recognize an OPZ edge in PC Lab gray snapper samples, such as what was observed in 2011, brings into question the accuracy of aging results for gray snapper samples processed by the PC Lab.

III. Gray triggerfish

(1) Lack of an annulus peak for the combined and yearly edge type distributions:

Edge type distributions for combined PC Lab samples or GulfFIN samples (Fig 3(a)) and yearly edge type distributions for PC Lab samples (Fig 3(b)) did not show any well-defined peaks for the TZ edge of the dorsal spine, which was used to define the annulus for gray triggerfish. The lack of an annulus peak draws into question the validity of using the dorsal spine TZ edge as the annulus.

(2) Differences in edge type distributions between different labs

Edge type distributions for gray triggerfish dorsal spines differed significantly between government agencies (Fig 3(a)) and between the different states of GulfFIN (Fig 3(c)). Such drastic differences in TZ edge distributions would undoubtedly create differences in aging results. For example, 100% of State of Florida samples had TZ edges in every month of a year, and each TZ edge was counted as 1 calendar age. However, for PC Lab samples, about 50% of fish had TZ edges in every month of a year (Fig 3(a)), and each TZ edge was counted as 1 calendar age. The observed differences in edge type distributions between labs again indicate the need to have a unified coding and processing system to ensure different labs produce similar aging results.

IV. Greater amberjack

(1) Lack of a distinctive annulus peak for PC Lab and GulfFIN samples

The annulus peak for greater amberjack samples processed by the University of Florida (UF) occurred in May (Fig 4(a)). The age assignment rule that assigned season 1 ATZ samples to the next age class was consistent with the annulus peak observed in UF samples. However, there were no apparent annulus peak for either PC Lab or GulfFIN samples. This brings into question whether samples from these two labs were aged correctly. When the same age assignment rule is applied to samples with different edge type distributions, aging errors may occur.

(2) differences in edge type distributions between years

The edge type distributions for individual years varied considerably for samples processed by the PC Lab (Fig 4(b)). There was no consistent annulus peak in these yearly edge type distributions, which again raises questions regarding the accuracy of these age data.

V. Red grouper

(1) Problems with OPZ edge distributions

The yearly edge type distributions for red grouper had problems similar to the other species discussed with regard to recognizing the OPZ edge: (a) there were no distinct peaks in most years, and (b) the proportion of OPZ edges were low for most years, especially in recent years (Fig 5(b)). The consistently small proportions of OPZ edges and high proportions of ATZ edges can cause problems when the current age assignment rules are applied. For example, for all months of 2010, the OPZ edge count was low, so correct age assignments in that year relied upon advancement of ATZ samples (also see discussion in A(2b)). However, the proportion of ATZ samples remained high throughout 2010. For example, all ATZ samples collected in June (about 75% of total samples) were advanced to the next age class. However, all ATZ samples collected in July (about 65% of total samples) were not advanced to the next age class. Essentially these aging rules assumed that 75% of total samples had nearly complete translucent edges in June, and that 65% of total samples had completed the OPZ stage and formed ½ translucent edges in one month (i.e., July), which is biologically unlikely to occur. The current age assignment rules, combined with the problems of not being able to recognize OPZ edge types and of not being able to determine OPZ peaks accurately, will either overestimate age for season 1 samples, or underestimate age for season 2 samples, or both. In short, the problem of not being able to correctly recognize an OPZ edge in PC Lab samples could have created unrealistic seasonal variations that depended on how yearly edge type distributions varied.

(2) Inconsistency in age assignment rules for season 2 samples

The aging rules for red grouper samples collected in November and December were different from other SEDAR species in the Gulf of Mexico. November and December red grouper samples with completed OPZ edge types were converted to the previous age class. The conversion of OPZ samples collected in November-December to the previous age class can be used if the peak of the OPZ edge distribution occurs in winter (e.g., January). Such a rule was used by academic labs (e.g., Wilson and Nieland, 2001) for red snapper since the OPZ edge was shown to begin to form in early winter (e.g., November). However, since the aging rule used by the PC Lab assumes that the OPZ peak occurs in early summer (May), there is little reason to use different aging rules for samples collected in November-December (also see discussion in Chih, 2018a).

VI. Vermilion snapper

The yearly edge type distributions for vermilion snapper age samples processed by the PC Lab showed an inconsistent timing of annulus peaks in early years and demonstrated an inability to recognize an OPZ edge in recent years (Fig 6(b)). The peak of OPZ edges ranged from May (2006) to August (2003). The magnitudes of OPZ peaks were greater before 2011, but the proportion of OPZ edges diminished greatly in recent years. The OPZ edge distributions were mostly incomplete and fragmentary after 2011.

When the currently used age assignment rules are applied to vermilion snapper age samples, age assignment errors may occur. For example, if the actual OPZ peak is during July-Aug (>80% in some years), then the inability to recognize an OPZ edge after 2011 would lead to underestimations of age for season 2 samples. Also, for season 1 samples, conversion of ATZ samples to the next age class may lead to overestimations of age for season 1 ATZ samples because of the loose definition of ATZ samples and the uncertainties of the timing of the OPZ peak (also see discussion in I (2) (b)).

ACTIONS NEEDED

(a) The systematic inability to recognize an OPZ edge in several species for age samples processed by the PC Lab needs to be investigated. There are inconsistencies in the OPZ edge definition stated in the PC Lab data keys and in PC Lab reports (Allman et al., 2012). It is unclear whether different interpretations of the OPZ definition among different otolith readers has caused the problems in recognizing OPZ edges in different years/species. If the interpretation of the OPZ edge definition is not the source of these errors, then the possibility of other technical or quality control issues should be examined.

(b) Otolith samples should be reread for those years that had particularly problematic OPZ edge distributions (e.g., 2015-2016 red snapper samples, 2010-2011 gray snapper samples, 2010 & 2015 red grouper samples, and 2014 & 2017 vermilion snapper samples) to confirm what the OPZ edge distribution should have been (e.g., the timing of the annual OPZ peak) and to see how the aging results differ when OPZ edges are correctly identified. This re-evaluation process will help determine whether changes in current age assignment rules for several SEDAR species are needed. (Note that sections of all PC Lab otolith samples are still available and can be reread.)

(c) Reevaluate different coding systems from different agencies to see if a unified edge type coding system could resolve the differences in OPZ edge distributions between different agencies (this problem is described for red snapper and gray triggerfish).

CONCLUSIONS

The major concerns regarding the edge type distributions for the six SEDAR species examined in this study include: (1) the consistent inability to correctly recognize an OPZ edge (TZ edge for gray triggerfish), which results in inconsistent and low magnitudes of annulus peaks, and sometimes incomplete or even absent annulus distributions in PC Lab samples for several species, and (2) the significant differences in edge type distributions between government agencies for some species. The problems in recognizing an OPZ edge seem to be more prevalent in more recent years, particularly for snapper species (gray snapper, vermilion snapper and red snapper). Because the OPZ edge distribution has been used to validate an annulus and to establish age assignment rules, the inability to recognize an OPZ edge represents a serious aging procedure problem that needs to be addressed. Given the fundamental importance of age data to stock assessments and to age related research, how such aging problems influence the accuracy of age data needs to be investigated.

Analysis of edge type distributions showed how samples were actually aged and is an effective tool for quality control. Continuous problems in edge type distributions signal problems in code definitions or quality control issues that should not be dismissed as due to only regional or equipment differences.

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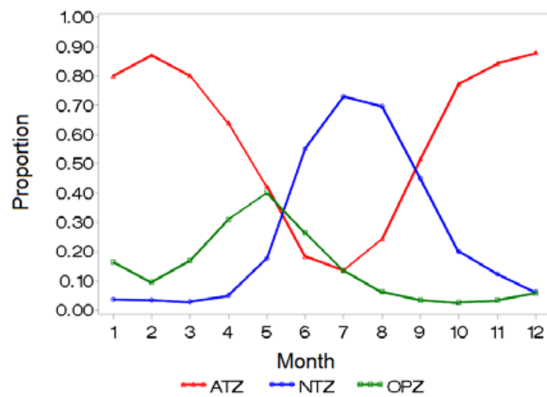
Fig 1(a). Edge type distributions for red snapper age samples processed by the Panama City Lab (PC Lab) and GulfFIN (see text for definitions of different edge types).

(1) PC lab



(2) GulfFIN

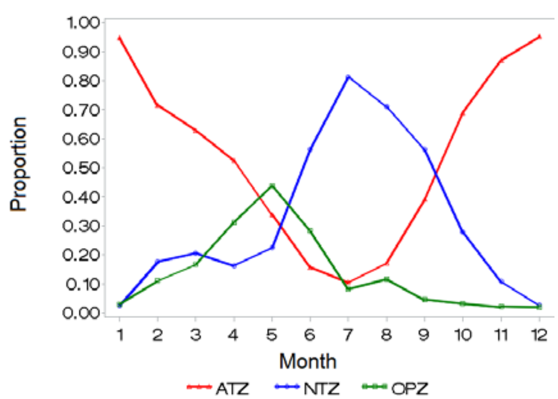


Fig 1 (b). Edge type distributions for red snapper age samples processed by the PC Lab from 2001 to 2016.

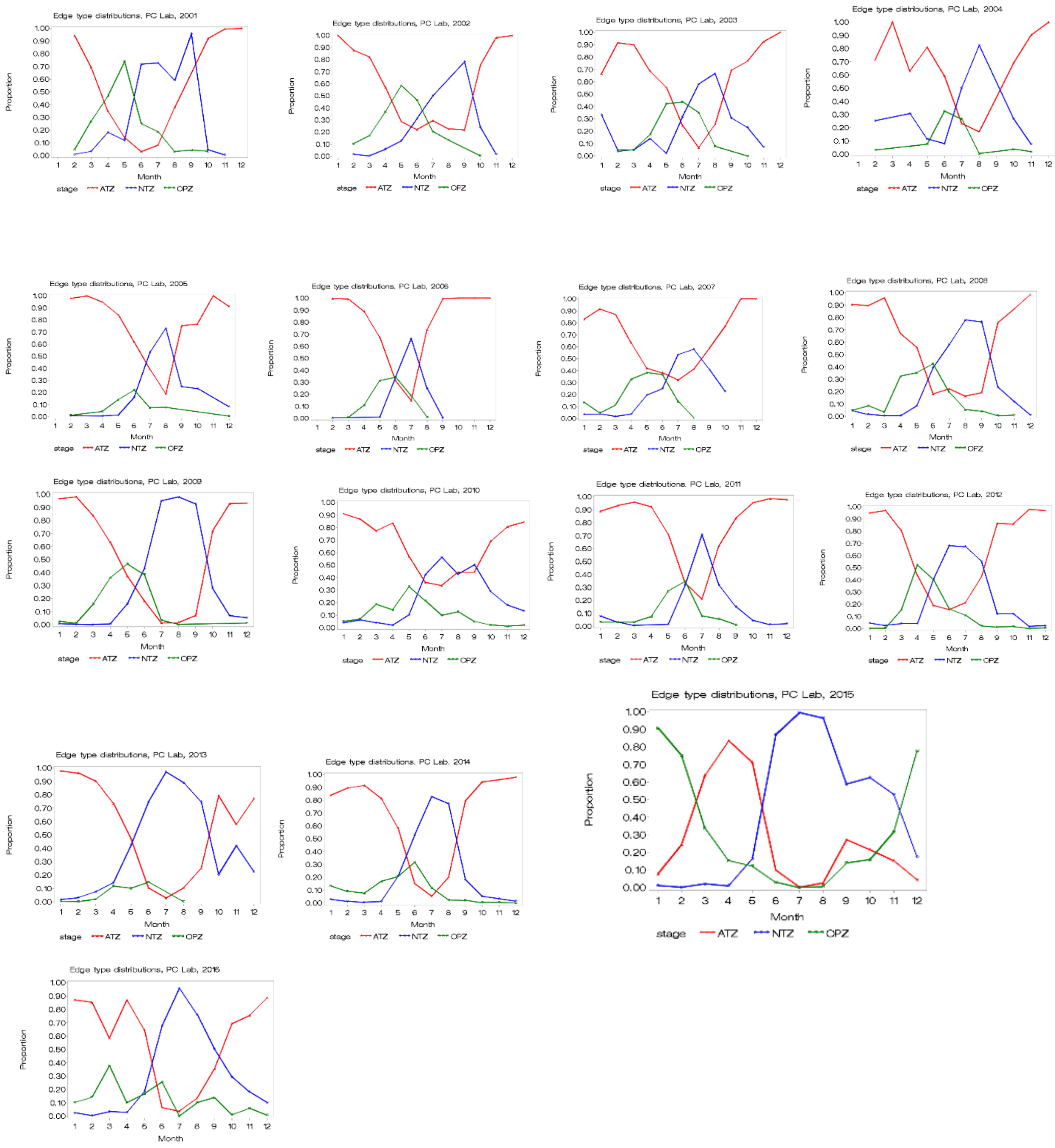
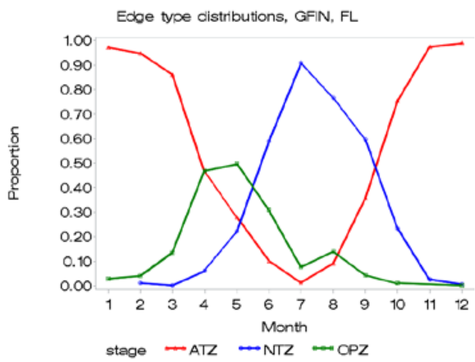
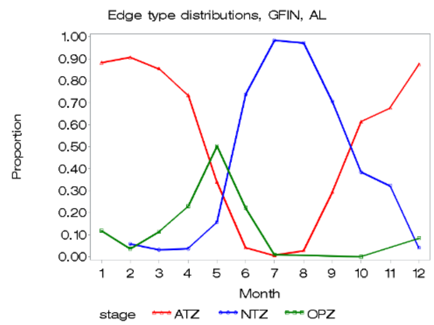


Fig 1(c). Edge type distributions for red snapper age samples processed by the different state agencies of GulfFIN.

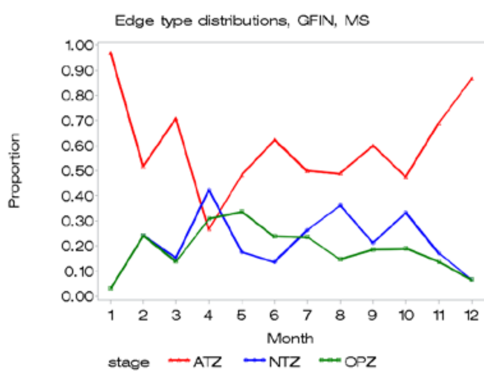
(1) Florida (n=40101)



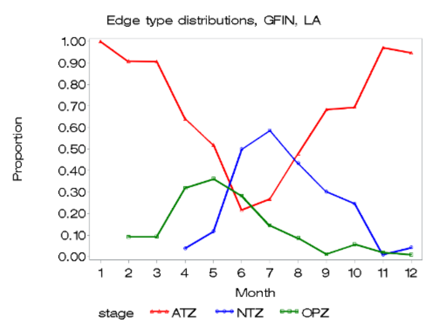
(2) Alabama (n=10740)



(3) Mississippi (n=1310)



(4) Louisiana (n=11358)



(4) Texas (n=9664)

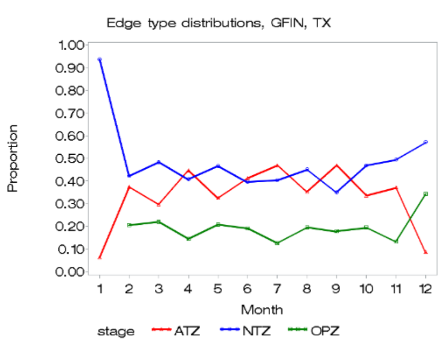


Table 1. Sample sizes for red snapper age samples processed by different labs: (a) sample sizes by month, (b) sample sizes by year.

(a) by month

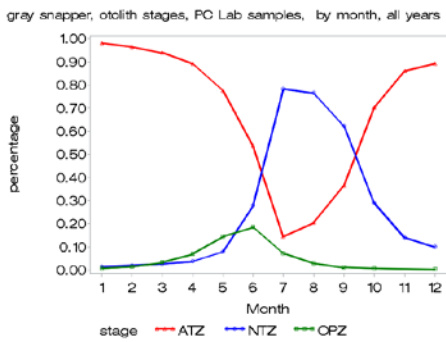
Month	GulfFIN	PC Lab
1	1236	2801
2	2775	8013
3	3670	7971
4	5691	8206
5	7295	7475
6	19028	12070
7	11434	7888
8	7046	5666
9	4954	4807
10	6873	6102
11	1689	3523
12	1482	4254

(b) by year

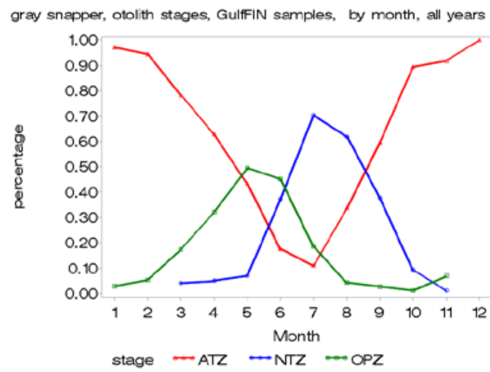
Year	GulfFIN	PC Lab
2002	2772	4968
2003	7403	3017
2004	6482	2496
2005	8289	2517
2006	7317	2687
2007	1785	3116
2008	2069	2761
2009	2420	4772
2010	3497	4053
2011	4340	3893
2012	3715	5937
2013	4669	5160
2014	5351	5405
2015	6630	5557
2016	6434	3357

Fig 2(a). Edge type distributions for gray snapper samples processed by the PC Lab, GulfFIN and the Beaufort Lab.

(1) PC Lab



(2) GulfFIN



(3) Beaufort Lab

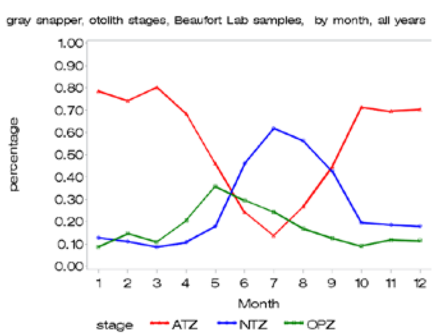


Fig 2 (b). Edge type distributions for gray snapper age samples processed by the PC Lab from 2002 to 2015. Note the absence of the OPZ edge type in 2011 and the incomplete distributions of OPZ edge types for most years.

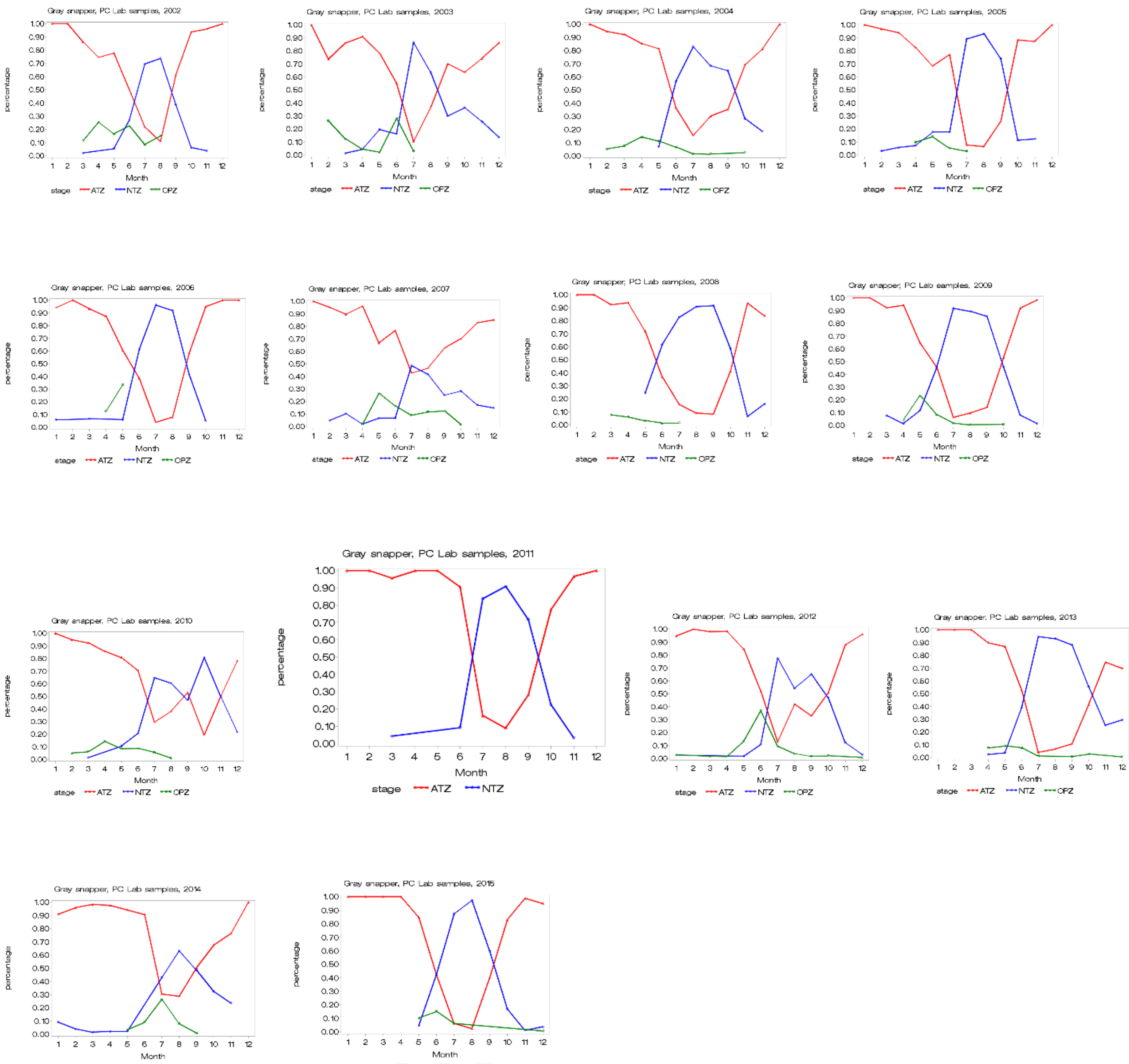


Table 2. Sample sizes for gray snapper age samples processed by different labs (a) sample sizes by month, and (b) sample sizes by year.

(a) by month

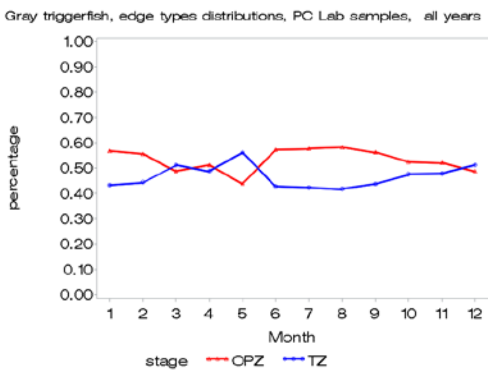
Month	Beaufort	GulfFIN	PC Lab
1	242	280	500
2	287	314	602
3	228	526	760
4	165	495	1096
5	332	849	1492
6	436	2184	1550
7	954	2388	2132
8	1018	1505	1531
9	143	1165	1266
10	241	966	1205
11	318	595	869
12	493	491	875

(b) by year

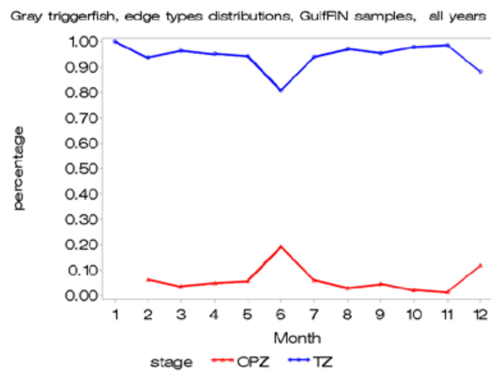
Year	Beaufort	GulfFIN	PC Lab
2004	13		604
2005	32	37	478
2006	164	249	684
2007	167	178	617
2008	115	670	585
2009	114	1403	639
2010	135	1871	1201
2011	151	1517	498
2012	245	1210	599
2013	742	1152	1504
2014	445	1164	1607
2003	994	1214	901
2015	1081	1038	778

Fig 3 (a). Edge type distributions for gray triggerfish age samples processed by the PC Lab, GulfFIN and the Beaufort Lab (TZ -translucent zone, OPZ - opaque zone).

(1) PC Lab samples (n=7834)



(2) GulfFIN samples (n=3041)



(3) Beaufort Lab (Burton et al., 2015; n=6419)

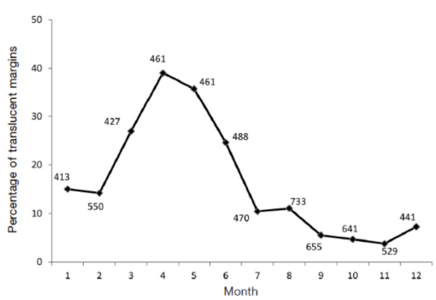


Fig 3(b). Edge type distributions for gray triggerfish age samples processed by the PC Lab from 2003 to 2016.

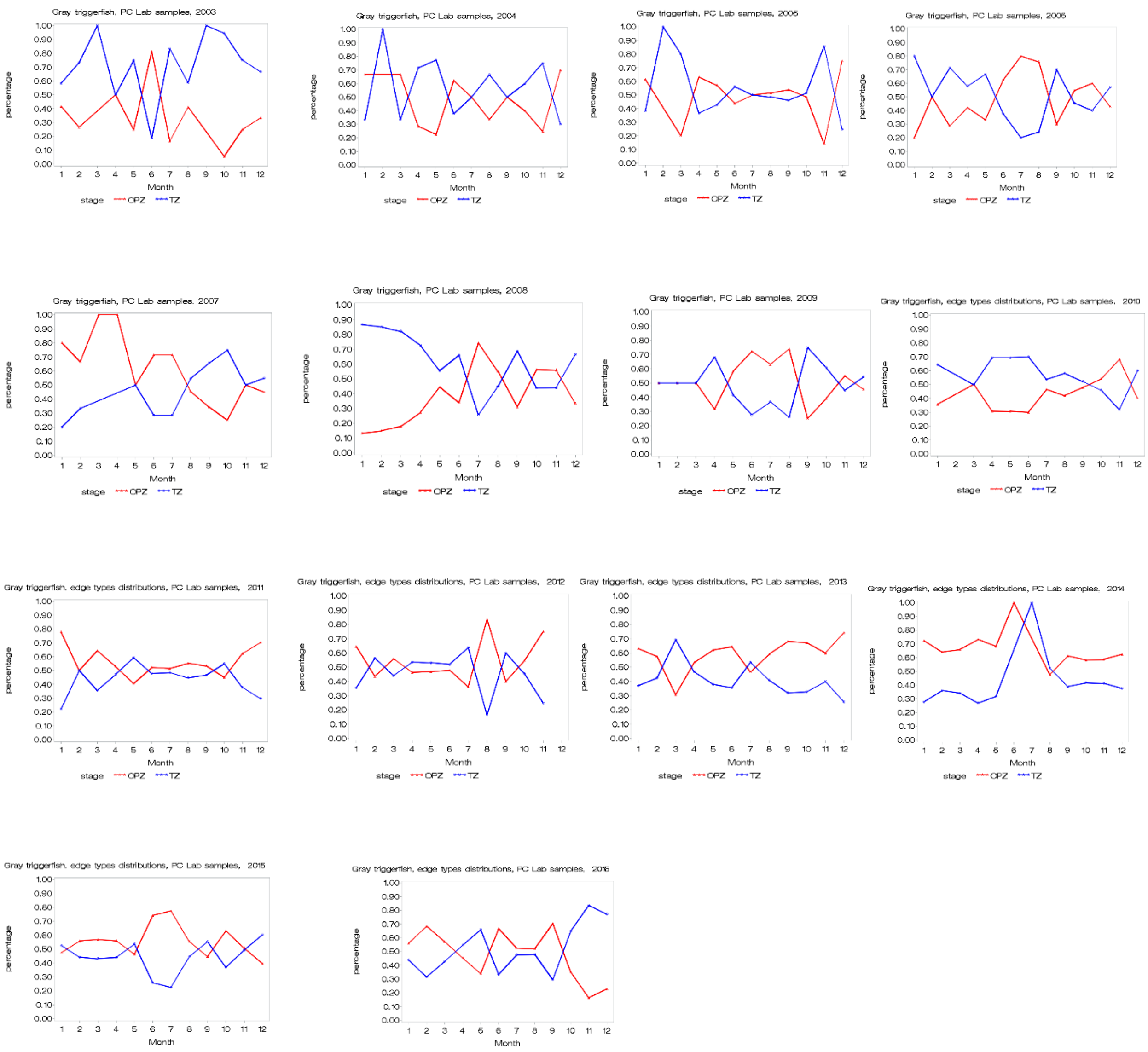
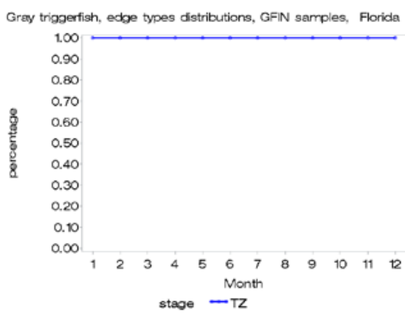
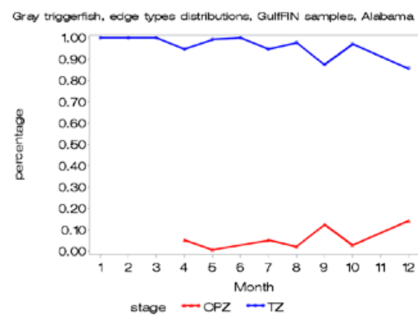


Fig 3 (c). Monthly edge type distributions for gray triggerfish samples processed by different GulfFIN state agencies (TZ -translucent zone, OPZ - opaque zone).

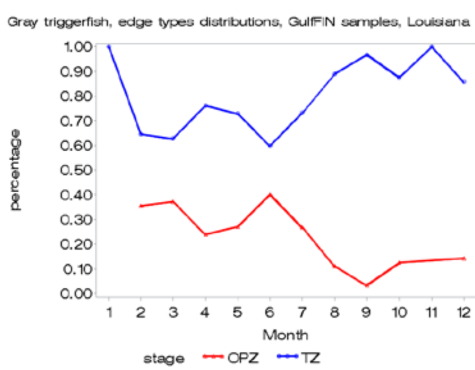
(i)   Florida (n=1702)



(ii) Alabama (n=657)



(iii)Louisiana (n= 500)



(iv) Texas (n=177)

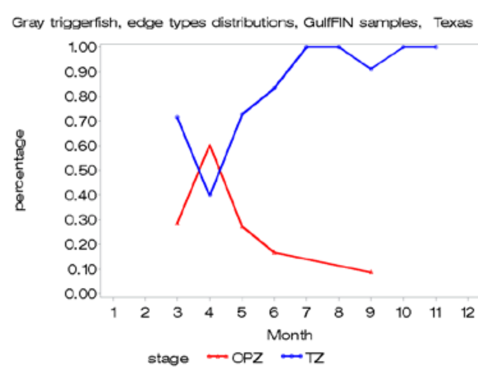


Table 3. Sample sizes for gray triggerfish samples used for edge type analysis: (a) sample sizes by month, (b) sample sizes by year.

(a) by month

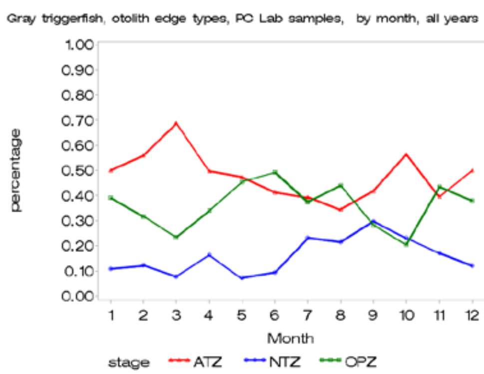
Month	GulfFIN	PC Lab
1	138	384
2	176	530
3	620	696
4	376	791
5	626	1172
6	313	621
7	222	456
8	208	786
9	152	758
10	117	758
11	76	416
12	17	466

(a) by year

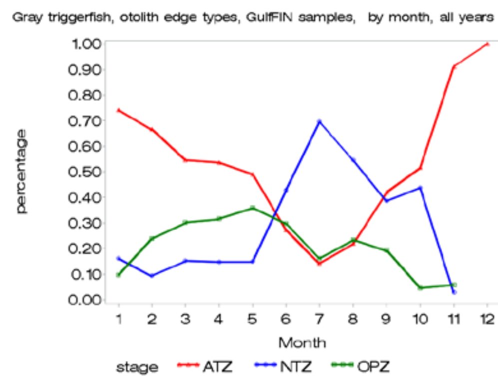
Year	GulfFIN	PC Lab
2002		2
2003		148
2004		163
2005		270
2006	11	260
2007	324	205
2008	195	425
2009	173	564
2010	92	359
2011	229	423
2012	219	706
2013	154	1004
2014	82	654
2015	120	959
2016	1442	1692

Fig 4 (a). Edge type distributions for greater amberjack age samples processed by the PC Lab, GulfFIN and a University of Florida research lab.

(1) PC Lab



(2) GulfFIN



(3) University of Florida

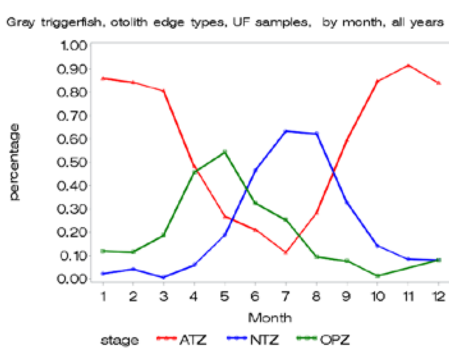


Fig 4 (b). Edge type distributions for greater amberjack age samples processed by the PC Lab from 2009 to 2014.

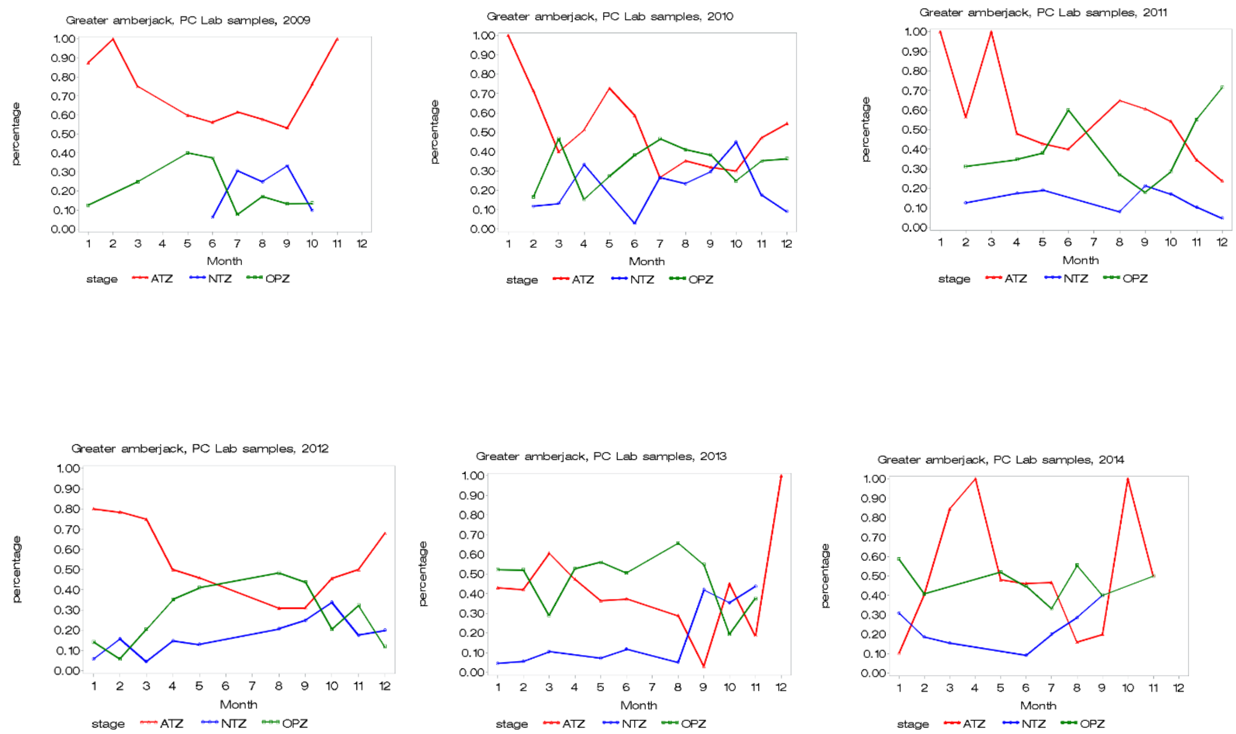


Table 4. Sample sizes for greater amberjack samples used for edge type analysis: (a) sample sizes by month, (b) sample sizes by year.

(a) by month

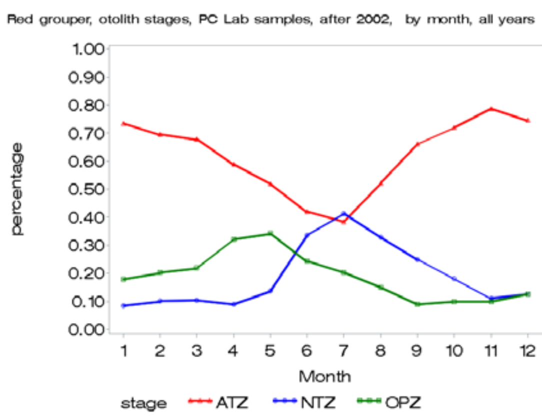
Month	GulfFIN	PC Lab	UF
1	31	156	93
2	75	252	95
3	119	128	160
4	177	153	186
5	228	224	186
6	245	396	142
7	246	104	71
8	260	336	106
9	145	222	52
10	151	273	85
11	34	129	36
12	1	58	25

(b) by year

Year	GulfFIN	PC Lab	UF
2002	81		70
2003	139		178
2004	54		96
2005	46		78
2006	35		155
2007	142		348
2008	215		29
2009	357	257	
2010	108	325	
2011	99	314	
2012	147	446	
2013	219	519	
2014	20	402	
2015	50	167	

Fig 5(a). Edge type distributions for red grouper age samples processed by the PC Lab and GulfFIN (note: only samples processed after 2002 were included).

(1) PC Lab



(2) GulfFIN

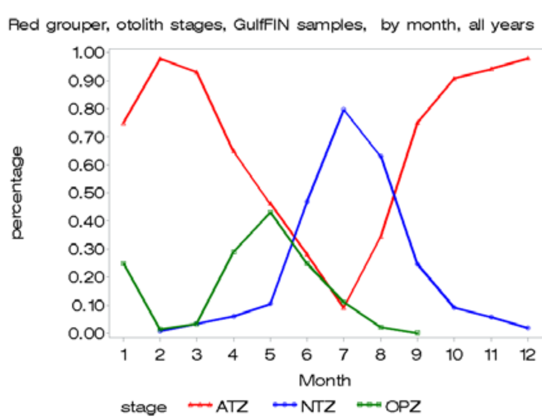


Fig 5 (b). Edge type distributions for red grouper age samples processed by the PC Lab from 2003 to 2016.

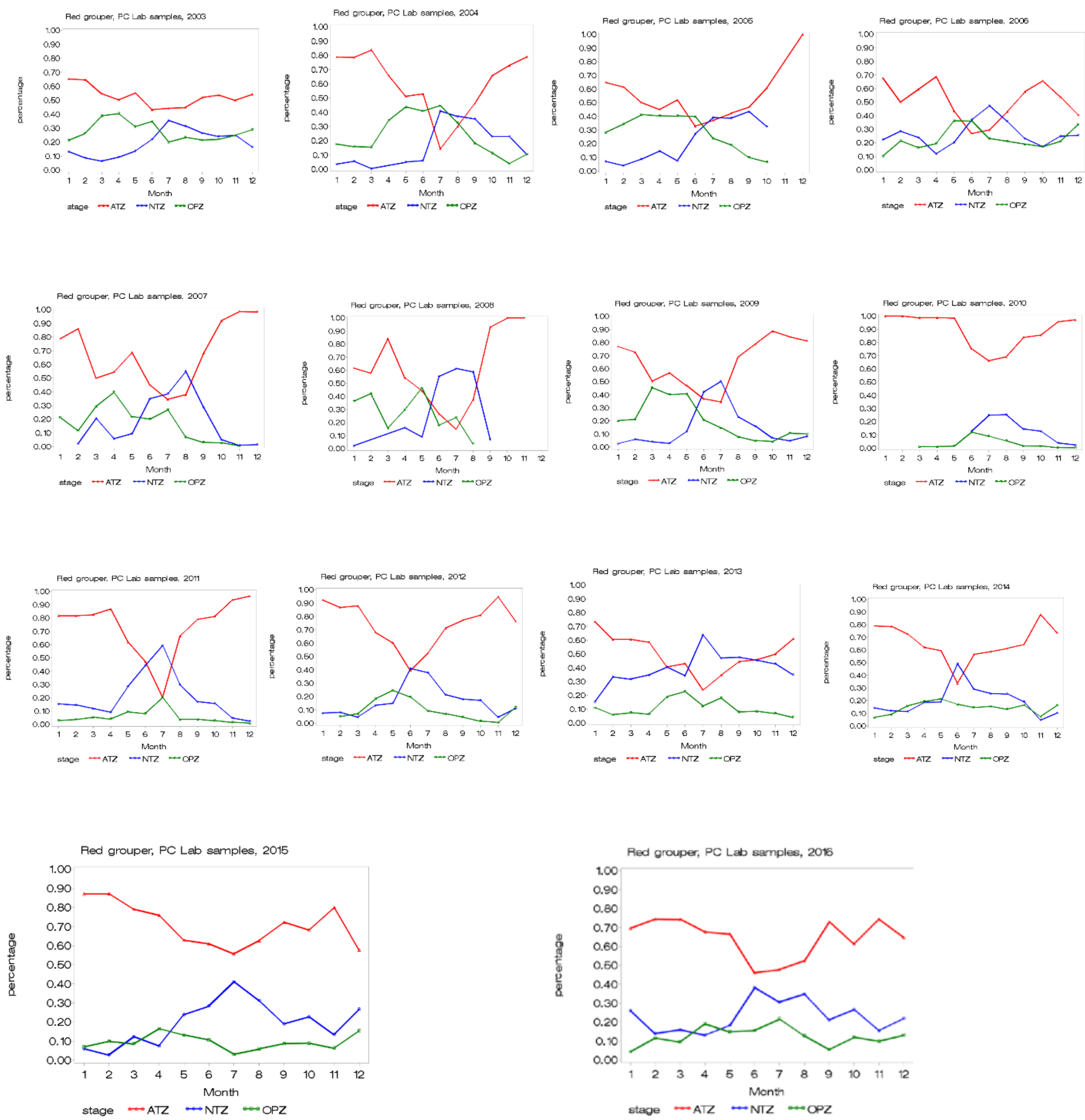


Table 5. Sample sizes for red grouper samples used for edge type analysis: (a) sample sizes by month, (b) sample sizes by year.

(a) by month

Month	GulfFIN	PC Lab
1	24	2228
2	136	2178
3	145	2709
4	214	4760
5	432	4768
6	869	4162
7	1109	3962
8	971	4763
9	734	3190
10	717	3160
11	239	2502
12	50	2419

(b) by year

Year	GulfFIN	PC Lab
2003	6	2008
2004	14	2862
2005	3	2403
2006	87	1520
2007	195	1353
2008	80	1412
2009	321	4536
2010	953	2449
2011	510	3795
2012	553	2498
2013	807	2157
2014	536	1942
2015	742	1506
2016	704	1311

Fig 6(a). Edge type distributions for vermilion snapper age samples processed by the Panama City Lab.

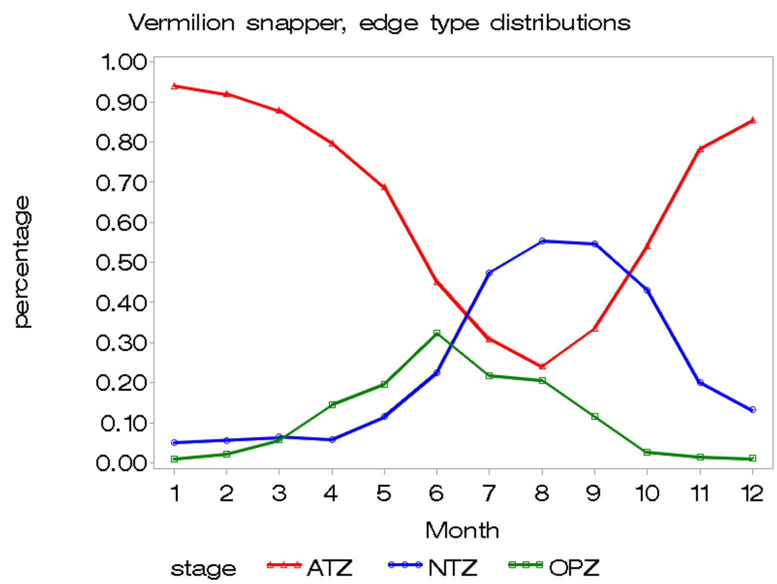


Fig 6(b). Edge type distributions for vermilion snapper age samples processed by the Panama City Lab from 2000 to 2017.

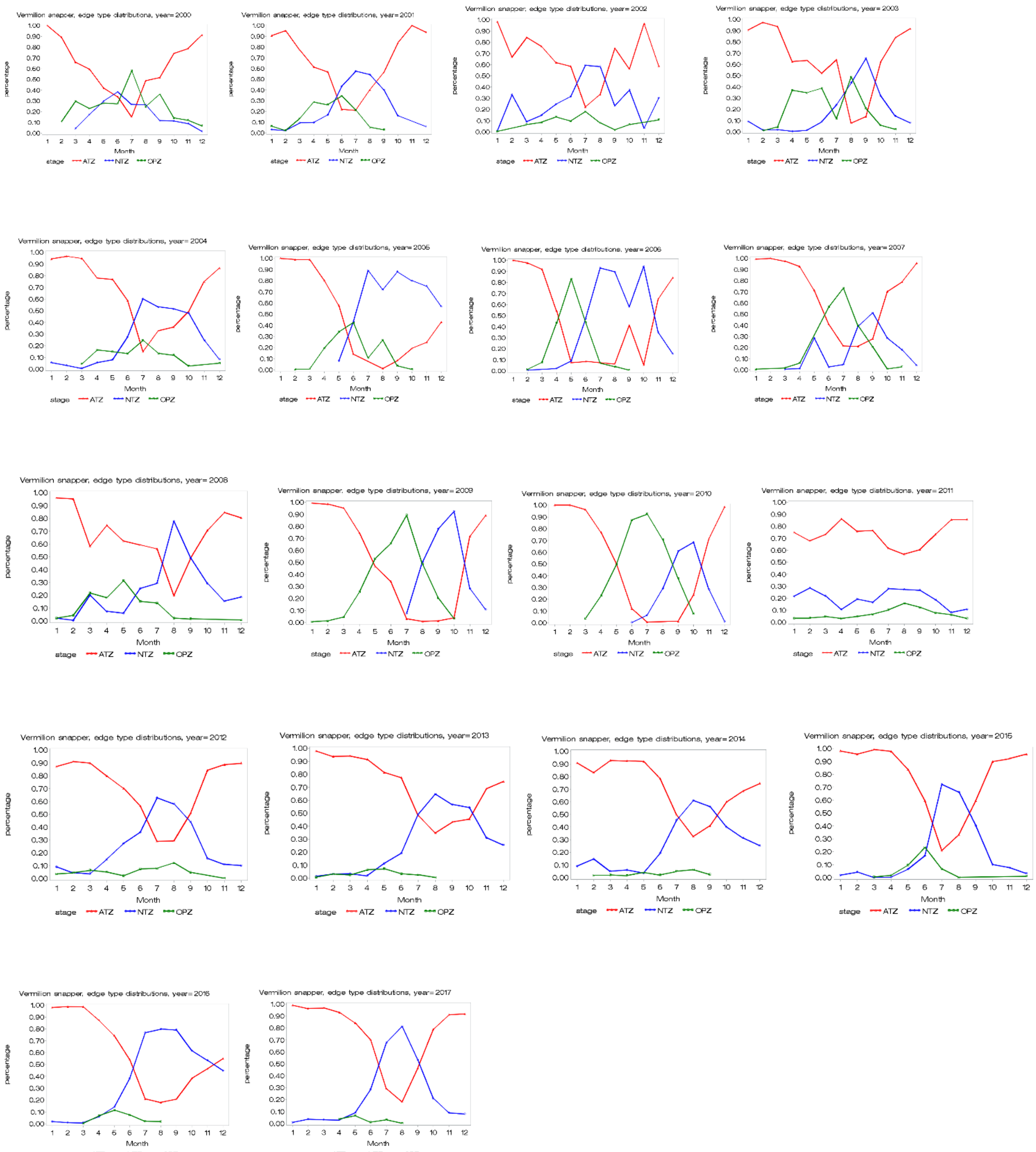


Table 6. Sample sizes for PC Lab vermilion samples used for edge type analysis: (a) sample sizes by month, (b) sample sizes by year.

(a) by month (for year >1999)

Month	Sample size
1	2212
2	2747
3	3953
4	4448
5	4452
6	5003
7	4174
8	5706
9	4554
10	3676
11	2852
12	2079

(b) by year

Year	Sample size
2000	944
2001	2134
2002	1792
2003	2854
2004	1329
2005	2305
2006	2332
2007	2157
2008	2791
2009	3322
2010	2863
2011	5201
2012	3040
2013	2493
2014	2419
2015	2560
2016	2649
2017	2671