USE OF AGE-LENGTH KEYS TO ESTIMATE CATCH-AT-AGE OF ALBACORE (*THUNNUS ALALUNGA*) FROM THE SPANISH SURFACE FISHERY IN THE NORTH EAST ATLANTIC, YEARS 2009 TO 2011

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SUMMARY

This document presents the results of applying age-length keys obtained from direct readings of spine sections of albacore collected from commercial catches carried out by the surface fleets, bait boat and troll vessels operating in the Bay of Biscay and North eastern Atlantic fishing grounds. The period comprises the years 2009, 2010 and 2011. The catch at-size data (CAS) from these fleets and the ALKs derived were used to obtain the age composition of catches (CAA) from this fishery for the described period.

RÉSUMÉ

Ce document présente les résultats obtenus en appliquant les clés âge-taille calculées sur la base des lectures directes des sections des épines de germon recueillies sur des prises commerciales réalisées par des flottilles de surface, des canneurs et des ligneurs opérant dans les zones de pêche du golfe de Gascogne et de l'Atlantique Nord-Est. La période inclut les années 2009, 2010 et 2011. Les données de prise par taille (CAS) de ces flottilles et les clés âge-longueur dérivées ont été utilisées pour obtenir la composition par âge des captures (CAA) de cette pêcherie pour la période à l'étude.

RESUMEN

En el documento SCRS/2013/055 se presentaban los resultados de la aplicación de las claves edad-talla obtenidas de lecturas directas de secciones de espinas de atún blanco realizadas en las capturas comerciales realizadas por curricaneros y barcos de cebo vivo que operan en los caladeros del golfo de Vizcaya y del Atlántico nororiental. El periodo del estudio incluye los años 2009, 2010 y 2011. Se utilizaron los datos de captura por talla (CAS) de estas flotas y las ALK derivadas para obtener la composición por edad de las capturas (CAA) de esta pesquería para el periodo descrito.

KEYWORDS

Thunnus alalunga, *Albacore, Age-length-keys, Spine aging North Atlantic*

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1. Introduction

The length composition of albacore caught in the North Atlantic is available for all the fisheries: surface and long-line (Anon., 2010). For the assessment of the North stock it is required to estimate the catch at age distribution of the international albacore to be analysed with ADAPT-VPA model (Porch *et al.,* 2001).

The catch-at age matrix is derived from the analyses of the size composition of international catches by applying the Kimura-Chikuni algorithm (Kimura *et al*. 1987) for assessing the state of the North Atlantic albacore stock. This likelihood method has become a standard procedure to estimate the age composition of the catch-at-size for North Atlantic albacore stocks (Anon., 2010). Since 1986, the largest proportion of exploited albacore in this stock is represented by the immature albacore age-groups 1 to 5 (Anon. 2010).

Studies to estimate age composition of North Atlantic albacore based on skeleton structures, such as first dorsal spiny ray, allow for more detailed information on albacore growth rates on annual bases. Among vertebrae, otolith and the first dorsal spine, this last one skeleton piece remains as the most validated ageing structure for North Atlantic albacore and specially when ageing adult fish (Fernández, 1992; Bard, 1981).

In the last assessment of North Atlantic albacore done in 2009 (Anon., 2010), age-length keys obtained by means of direct readings of sections of first dorsal spiny ray were available for input in the stock synthesis (SS) model used in the assessment (Ortiz de Zárate *et al*., 2007a).

The aim of this paper is to present an application of the age length keys to estimate the catch-at age composition of albacore surface fishery landings as a complementary source of information on the age structure of immature albacore caught by the Spanish surface fishery

2. Materials and Methods

2.1 Data

First dorsal spiny ray from albacore were sampled at main fishing ports, starting in June until November following the sample protocol established for this species (Ortiz de Zárate *et al*., 2007b). Network sampling staff monitoring the activity of these fleets at main fishing port of northern coast of Iberian peninsula and staff from IEO (*Instituto Español de Oceanografía*) participated in the collection of samples during 2009, 2010 and 2011 albacore fishing seasons. During the landing operation, observers sampled decked albacore to collect the first dorsal spiny ray, measuring fork length to the nearest centimetre, and recording date and fishing area for each specimen. A total of 557, 681 and 584 spines were selected to estimate the age composition of the Spanish surface albacore catches in 2009, 2010 and 2011, respectively.

2.2 Ageing method and Age-length keys

Albacore spiny rays were returned to the IEO laboratory and processed following the method in previous years (Ortiz de Zárate *et al*., 2007b). The transverse cross-sections (~ 0.5μm) mounted on slides and embedded in epoxy resin were read with transmitted light on a profile projector (NIKON 6C) at x10 or x20 magnification. The criteria used to interpret the pattern of observed translucent bands (*annuli*) formed on the spine sections of albacore, was based on the hypothesis of Bard and Compeán (1980), which assumes that the formation of two translucent bands (*annuli*) per year throughout the life span of North Atlantic albacore corresponds to its migratory behaviour between feeding and spawning grounds (Bard, 1981). Occasionally, to overcome the problem of resorption of the central zone of the spine as the fish grows, back calculation was applied based on the diameter of the first visible *annuli* measured (Ortiz de Zárate *et al.,* 2005). An age was assigned to the first visible *annuli* and by counting successive *annuli*, the sample was aged.

This age estimation procedure has been tested to estimate the precision and agreement of the aging method applying the procedure described by Eltink (2000). Inter calibration among three readers was performed for the samples collected in 2004 and 2005 fishing seasons and level of mean agreement on readings was 86% and 80% respectively as well as the respective overall coefficient of variation (CV)

estimated were 9% and 7.6% (Ortiz de Zárate *et al*. 2007a). Once the agreement between readers had been accomplished, the reading of dorsal spine sections has been standardized based on the agreement on the interpretation of annual time marks between two IEO readers.

In this study, linear regression model was fit to estimate the relationship among the length in centimetre of the specimen and measurement of diameter in millimetre of the spine section for each given year examined. This model fit was done for the complete sample of spine section that were aged. All the measurements obtained for the three years were included in this study. The regression model is useful to estimate the expected length (age) of the fish when diameter of *annuli* correspond to first visible time mark of unknown age.

Monthly results of readings for the two gear combined were used to obtain the annual age-length keys (ALKs) for the Spanish surface fishery. According to the seasonal activity of bait boat and troll fleets each annual age-length key was split into summer and autumn seasons. The monthly aging data was aggregated into summer (June, July, August) and autumn (September, October, November) seasons. Based on this seasonal stratification the respective annual age- length keys were applied to the annual catch at size distribution by 1 cm class (CAS) of each individual fleet based on this time strata (Ortiz de Zárate and Barreiro, 2010; Ortiz de Zárate *et al.,* 2011; 2012). Hence, the summer and autumn catch at age number (CAA) of given year was added to obtain the annual catch at age composition by fleet, thereafter annual CAA by fleet were aggregated by year covered.

3. Results and Discussion

The albacore length distribution covered was from 43 cm to 107 cm fork length (FL) in 2009, 38 to 112 cm (FL) in 2010 and 41 to 120 cm FL in 2011. Accordingly, these annual sampled fish were processed and the results based on the aging method applied are shown on the age- length keys (ALKs) estimated by summer and autumn seasons on consecutive **Table 1.a** for year 2009, **Table 1.b** for year 2010 and last **Table 1.c** for 2011 year. Hence the linear model fit on the response variable, (diameter of spine section) explained by the length of the specimen aged shows a good fit on the three consecutive years estimated. The linear regression model fit for 2009 length and diameter observations explained the 92.6% of the variance (r^2 =0.9262, df= 548, (Pr(F)>0) of the relationship between length and diameter of spine. The relationship found for 2010 observations explained the 94% (r^2 =0.9392, df= 676, (Pr(F)>0) and finally the linear fit for 2011 observations explained 96% (r^2 =0.9627, df= 580, (Pr(F)>0)

The results of applying the estimated ALK´s to the CAS for every given year from 2009 to 2011, gives an estimated total number of fish by age group shown in **Table 2**. The number of readings obtained for specimen over 90 cm length was scarce across years, therefore an age plus group was fixed at 5+. As complementary information, the annual age structured separated by bait boat and troll fleets is presented in **Figure 1.** Mainly target age groups by both fleets are 1 to 3 age groups. Within same year it is found variability on the selectivity of the two fleets. This is in part due to the different fishing strategy followed by each fleet according to the spatial and temporal distribution of albacore and therefore different catchability by fleets.

The mean fork length (FL) at age and standard deviation obtained by the aging method for the three consecutive years 2009 to 2011, are summarised in **Table 3**. Only results of 1 to 4 age groups show a consistent number of samples across years. The number of samples collected for older age fish (> 5 years old) represents a testimonial presence in the catch of this fishery for the three consecutive years. In addition, it is observed the variation among the mean length at age obtained in this study. For albacore 1 to 4 age groups, the mean size is very similar among years. At the contrary, for age 5 and older age groups the differences across years were noticed, due to the scarce sample size collected.

The number at age obtained by the aging method in this study applied to the catch-at size distribution of albacore surface fishery is presented in **(Figure 2.a, b, c)** corresponding to year 2009, 2010 and 2011**.** The length frequency data set observed and the expected age composition matched reasonable well. Visual examination of histogram reveals no major differences overall the three years but the autumn fishing season of 2009 and 2010 for bait boat fishery, when clearly age 3 and 4 show different estimates.

The catch at age matrix currently used in albacore assessment (Anon, 2010) is derived from catch length composition using Kimura-Chikuni algorithm implemented by ICCAT. This is probably the most objective method from statistical point of view. Nevertheless, the age length keys obtained from readings of first dorsal spine sections show that is an alternative method that could be used to age juvenile albacore from 1 to 4 age group caught by surface fleets.

Acknowledgments

The authors would like to thank all the network sampling staff involved in the collection of data at fishing ports. The work related to this document was supported in part by the IEO project PNDB funded by EU in years 2009 to 2011. Appreciation is extended to Oscar Gutierrez (IEO) for assistance in the processing of samples.

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Table 1.a. Derived age-length keys from spine age determination from 2009 samples.

Summer 09	Age							
Length (cm)	1	2	3	4	5	6	7	Total
43	1							1
44	1							1
45	1							1
46								
47	4							4
48	8							8
49	9							9
50	14							14
51	12							12
52	9							9
53	9							9
54	8							8
55	5							5
56	6							6
57	8	1						9
58	5	2						7
59	2	3						5
60	2	4						6
61	4	5						9
62	2	10						12
63	2	7						9
64		9						9
65	2	12						14
66		7	1					8
67		11	4					15
68		11	2					13
69		5	4					9
70		4	6					10
71		6	2					8
72		4	4					8
73		1	9					10
74			6					6
75			17					17
76			14	1				15
77			16	1				17
78			14					14
79			7	3				10
80			12	2				14
81			8					8
82			6	2				8
83			6	4				10
84			1	3	1			5
85			1	1				2
86			1	2	1			4
87				3				3
88			1	2	1			4
89				1				1
90				1				1
91					1			1
92								
93								
94								
95								
96								
97							1	1
98								
99								
100							1	1
101						1	1	2
102								
103								
104								
105								
106								
107								
Total	114	102	142	26	4	1	3	392

Autumn 09	Age									
Length (cm)	1	2	3	4	5	6	7	8	9	Total
43										
44										
45										
46										
47										
48										
49	2									2
50	1									1
51	2									2
52	3									3
53	2									2
54	2									2
55	2									2
56	1									1
57										
58										
59	1	1								2
60	1	2								3
61	2	2								4
62		3								3
63		6								6
64	1	4								5
65		6								6
66		4								4
67		5								5
68		7								7
69		3	1							4
70		7								7
71		1	1							2
72			2							2
73			1							1
74		1	3							4
75		1	3							4
76			4							4
77			5	1						6
78			2	1						3
79			3	1						4
80			5	1						6
81			2	3						5
82			6	2						8
83			2	2						4
84			2	2						4
85			1	3						4
86				2	2					4
87				4						4
88			1	2						3
89				2						2
90					1					1
91					1					1
92					2					2
93				2						2
94				1	1		1			3
95					3					3
96					2					2
97						1	1			2
98				1						1
99										
100					1					1
101										
102										
103										
104										
105										
106							1			1
107									1	1
Total	20	53	44	30	13	1	3		1	165

Tabla1.b. Derived age-length keys from spine age determination from 2010 samples.

Summer 10	Age							
Length (cm)	1	2	3	4	5	6	7	Total
38								
39								
40								
41								
42								
43								
44								
45								
46								
47								
48	6							6
49	6							6
50	9							9
51	8							8
52	10							10
53	9	2						11
54	7	2						9
55	8	1						9
56	3	6						9
57	6	4						10
58	3	5						8
59	2	6						8
60		12						12
61	3	8						11
62		11						11
63		12						12
64		12						12
65		8	3					11
66		7						7
67		6	1					7
68		4	3					7
69		3	4					7
70		6	4					10
71		5	5					10
72		2	7					9
73		1	8	3				12
74			10	1				11
75			12					12
76			11	2				13
77			7	5				12
78			7	5				12
79			10	4				14
80			10	5				15
81			5	4				9
82			4	6	1			11
83			4	6	2			12
84		1	3	5	1			10
85			4	3	1			8
86			1	4				5
87				3				3
88				3				3
89								
90					1			1
91								
92					1			1
93					1	1		2
94								
95								
96								
97								
98								
99								
100								
101								
102								
103								
104						1		1
105							1	1
106								
107								
108								
109								
110								
111								
112								
Total	80	124	123	59	8	2	1	397

Autumn 10	Age										
Length (cm)	1	2	3	4	5	6	7	8	9	10	Total
38	1										1
39	2										2
40	1										1
41	1										1
42	1										1
43	3										3
44											
45	4										4
46	6										6
47	4										4
48	4										4
49	4										4
50	5										5
51	5										5
52	6										6
53	6										6
54	6										6
55	5										5
56	2										2
57	5	1									6
58	3	1									4
59	1	2									3
60	3	3									6
61	1	1									2
62	1	5									6
63		5									5
64		5									5
65		4									4
66		4									4
67		5									5
68		4									4
69		1									1
70		1	1								2
71		1	1								2
72			1								1
73		1	3								4
74		1	5								6
75		2	2								4
76			6								6
77			5								5
78			5								5
79			2	5							7
80			3	4							7
81			7	3							10
82				7							7
83			1	7							8
84			2	4							6
85				4	2						6
86				7							7
87			2	4	1						7
88				3	1						4
89					1						1
90				4	5	1					10
91				2	1		1				4
92				1	2	1					4
93				1	2						3
94					3						3
95				1	3						4
96					2	1					3
97						1					1
98					1	1	1				3
99											
100						3					3
101											
102							1				1
103							1				1
104							2				2
105					1		3		2		6
106							1	1			2
107							1		1		2
108									1		1
109						1					1
110							1			1	2
111											
112									2		2
Total	80	47	46	57	25	9	12	1	6	1	284

Tabla1.c. Derived age-length keys from spine age determination from 2011 samples.

Summer 11	Age									
Length (cm)	1	2	3	4	5	6	7	8	9	Total
41										
42										
43										
44										
45	1									1
46										
47	9									9
48	11									11
49	11									11
50	12									12
51	10									10
52	11									11
53	11									11
54	12									12
55	9									9
56	5	1								6
57	4	4								8
58	4	4								8
59	2	4								6
60	2	6								8
61	1	9								10
62	1	9								10
63		9								9
64	1	8								9
65		8	1							9
66		10								10
67		6								6
68		4	2							6
69		6	1							7
70		5	3							8
71		3	4							7
72		3	4							7
73		1	9							10
74		1	9							10
75			8							8
76			7	1						8
77			9	1						10
78			7	1						8
79			2	5						7
80			5							5
81			4	2						6
82			3							3
83				3						3
84				3						3
85			1	2						3
86				1						1
87				3						3
88				1						1
89										
90				1						1
91										
92					1					1
93										
94										
95										
96										
97										
98										
99										
100								1		1
101										
102										
103										
104										
105								1		1
106									1	1
107										
108										
109										
110									1	1
111										
112										
113										
114										
115										
116									1	1
117										
118										
119										
120										
Total	117	101	79	24	1			2	3	327

Autumn 11	Age									
Length (cm)	1	2	3	4	5	6	7	8	9	Total
41	4									4
42	2									2
43	3									3
44	4									4
45	3									3
46	3									3
47	5									5
48	9									9
49	5									5
50	5									5
51	4									4
52	7									7
53	6									6
54	7									7
55	7									7
56	7									7
57	5									5
58	6									6
59	6									6
60	7									7
61	3	3								6
62	2	2								4
63	4	3								7
64	2	1								3
65	2	2								4
66		3								3
67		3								3
68		2								2
69		4								4
70			2							2
71		1								1
72			2							2
73			2							2
74		1	2							3
75		2	1							3
76			4							4
77			4							4
78			2	1						3
79			2	1						3
80				3						3
81			1	2						3
82			1	3						4
83			2							2
84			2							2
85				2	1					3
86				2	1					3
87				1	3					4
88				5						5
89				4	1					5
90				3	1					4
91				2	2	2				6
92				2	2					4
93				2	4	1				7
94					3					3
95				1	2					3
96				1	1					2
97					2					2
98										
99				1		1		1		3
100						2	1			3
101							1			1
102							1			1
103						2	1	1		4
104										
105						1				1
106						1		1		2
107								1		1
108							1		1	2
109							2			2
110										
111										
112										
113									1	1
114							1			1
115							1			1
116										
117										
118										
119										
120							1			1
Total	118	27	27	36	23	10	10	4	2	257

Table 2. Spanish surface fishery catch-at-age (CAA) albacore obtained after applying ALKs to catch-at size (CAS) from 2009, 2010 and 2011.

	Age Groups					Nº Fish
Year	1	2	3	4	5+	Total
2009	243148	371967	481086	114953	19163	1230317
2010	340334	1022410	364608	163341	36012	1926705
2011	966274	282706	255127	35286	13291	1552685

Table 3. Mean fork length (FL) at age and standard deviation obtained by spine aging method.

2009

Age	N	Min	Max	Mean (cm)	Stdev
1	114	43	65	53.10	4.54
2	102	57	73	65.40	3.68
3	142	66	88	76.44	4.29
4	25	76	90	83.64	3.77
5	4	84	91	87.25	2.99
6	1	101	101	101.00	
7	3	97	101	99.33	2.08
Total	391	43	101	67.56	11.80

2010

Age	N	Min	Max	Mean (cm)	Stdev
1	160	38	62	51.92	4.69
2	171	53	84	63.67	4.80
3	169	65	87	76.52	4.54
4	116	73	95	82.92	4.27
5	33	82	105	90.88	4.95
6	11	90	109	98.09	5.47
7	13	91	110	103.46	4.65
8	1	106	106	106.00	
9	6	105	112	108.17	3.19
10	1	110	110	110.00	
Total	681	38	112	70.53	14.81

2011

Age	N	Min	Max	Mean (cm)	Stdev
1	235	41	65	52.60	5.13
2	128	56	75	64.75	4.23
3	106	65	85	75.80	3.86
4	60	76	99	85.43	5.18
5	24	85	97	91.79	3.45
6	10	91	106	99.10	5.61
7	10	100	120	108.10	6.71
8	6	99	107	103.33	3.27
9	5	106	116	110.60	3.97
Total	584	41	120	67.22	16.04

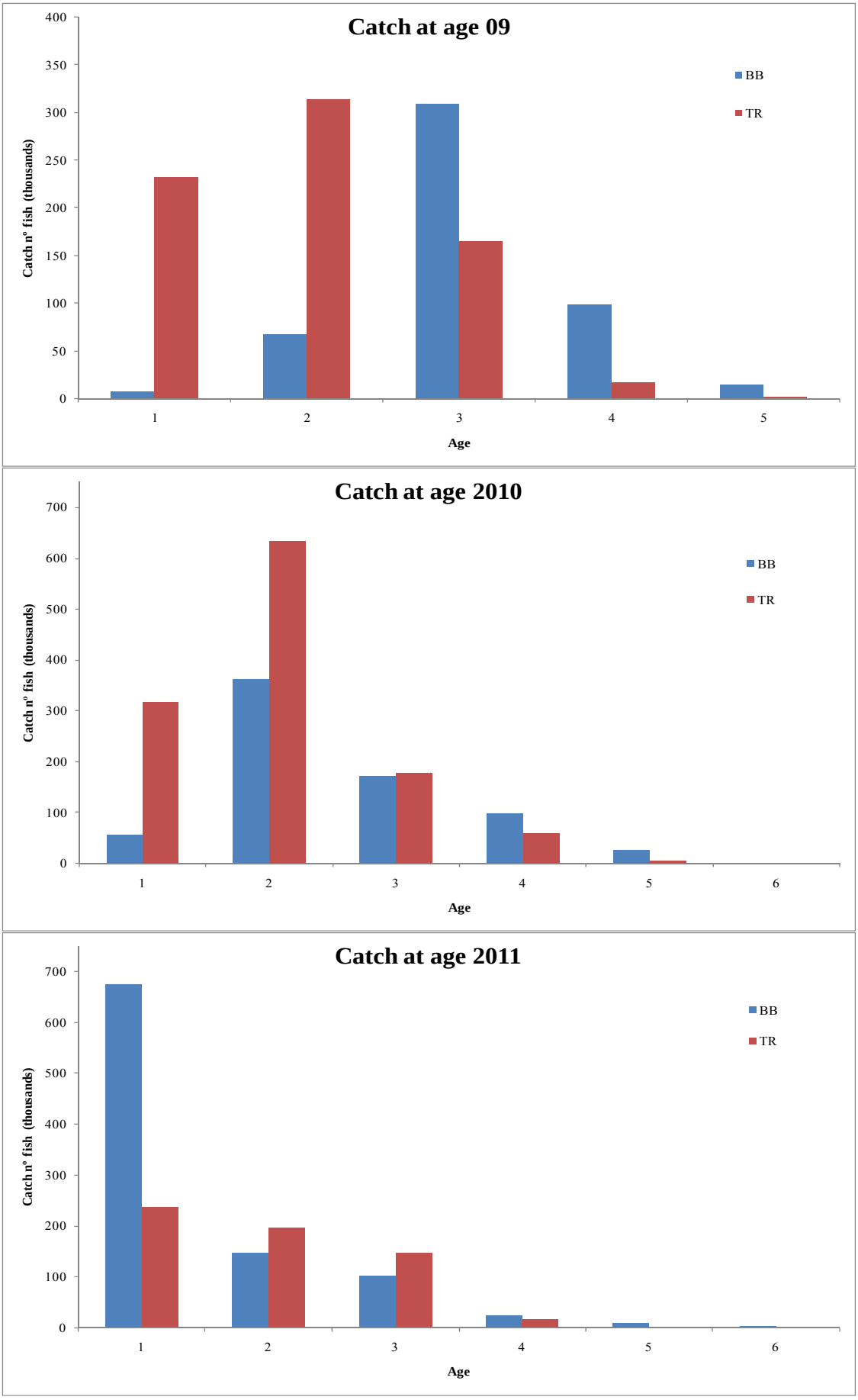
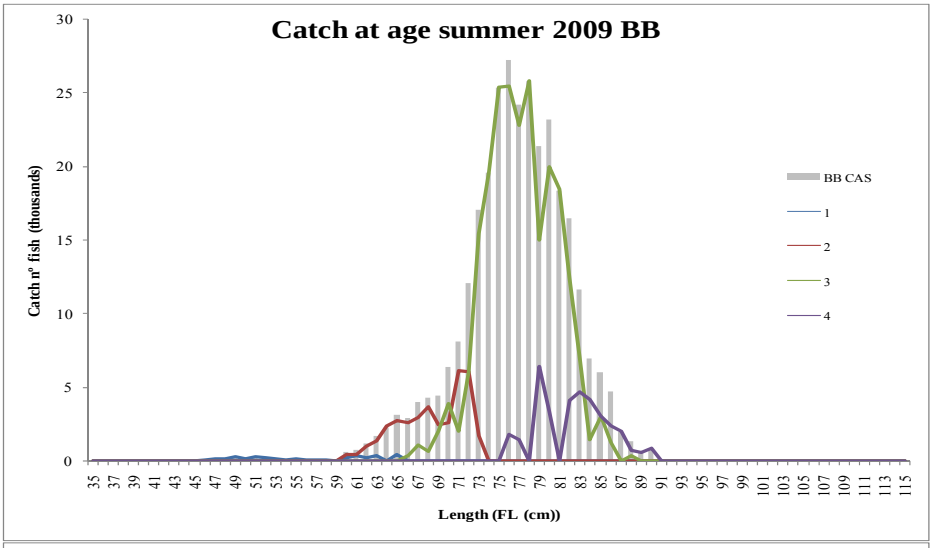
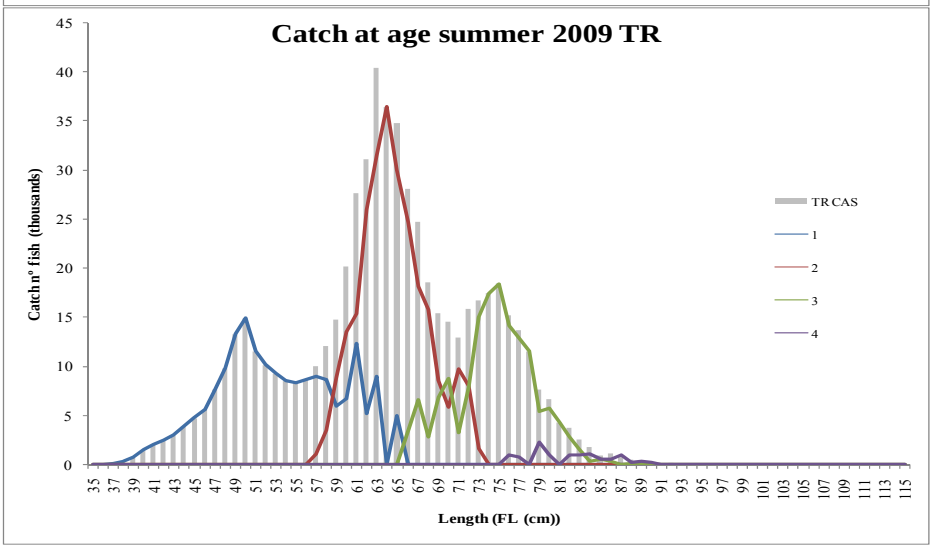


Figure 1. Albacore catch-at-age (CAA) data obtained by ALKs method by fleet and year.


Catch at age summer 2009 BB
Catch n° fish (thousands)
Length (FL (cm))
BB CAS
1
2
3
4


Catch at age summer 2009 TR
Catch n° fish (thousands)
Length (FL (cm))
TR CAS
1
2
3
4

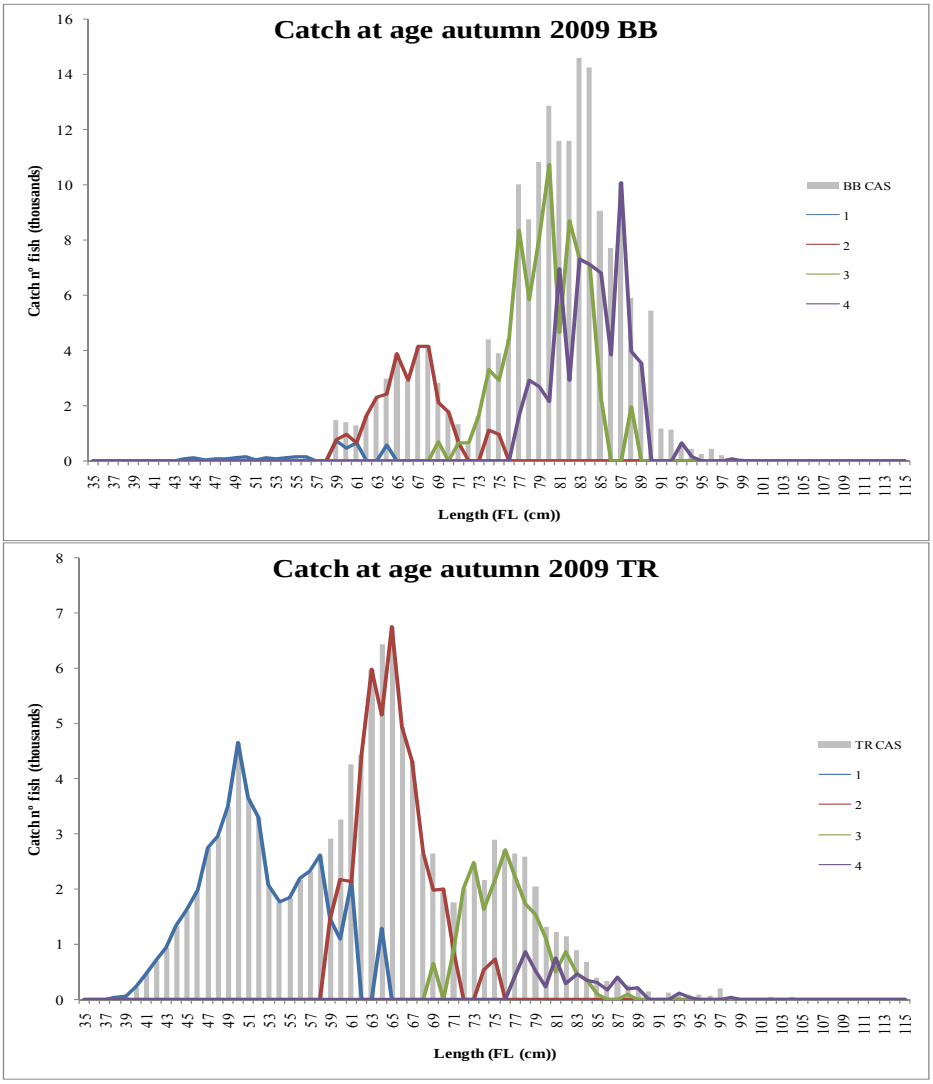
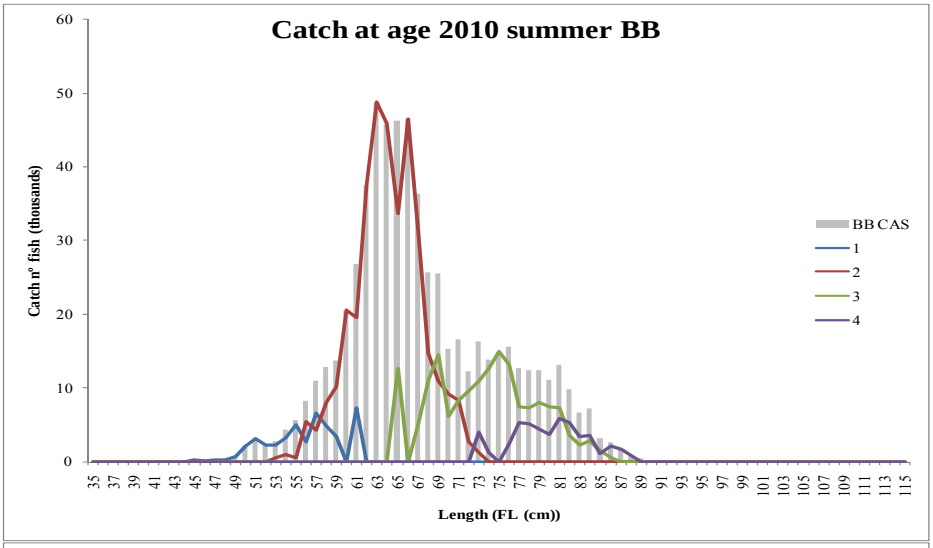
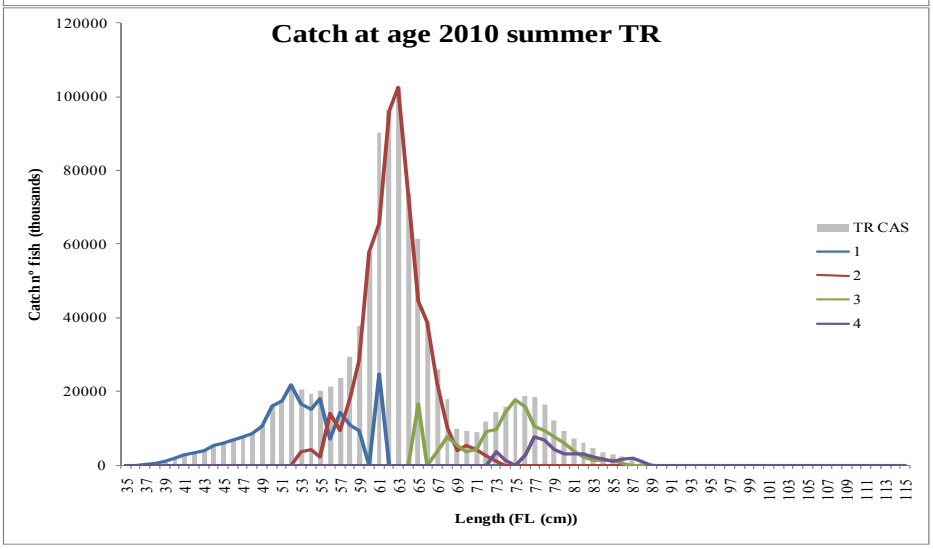


Figure 2a. Comparison of albacore catch-at-size (CAS) and estimated catch-at-age (CAA) by fleet and year 2009


Catch at age 2010 summer BB
Catch n° fish (thousands)
Length (FL (cm))
BB CAS
1
2
3
4


Catch at age 2010 summer TR
Catch n° fish (thousands)
Length (FL (cm))
TR CAS
1
2
3
4

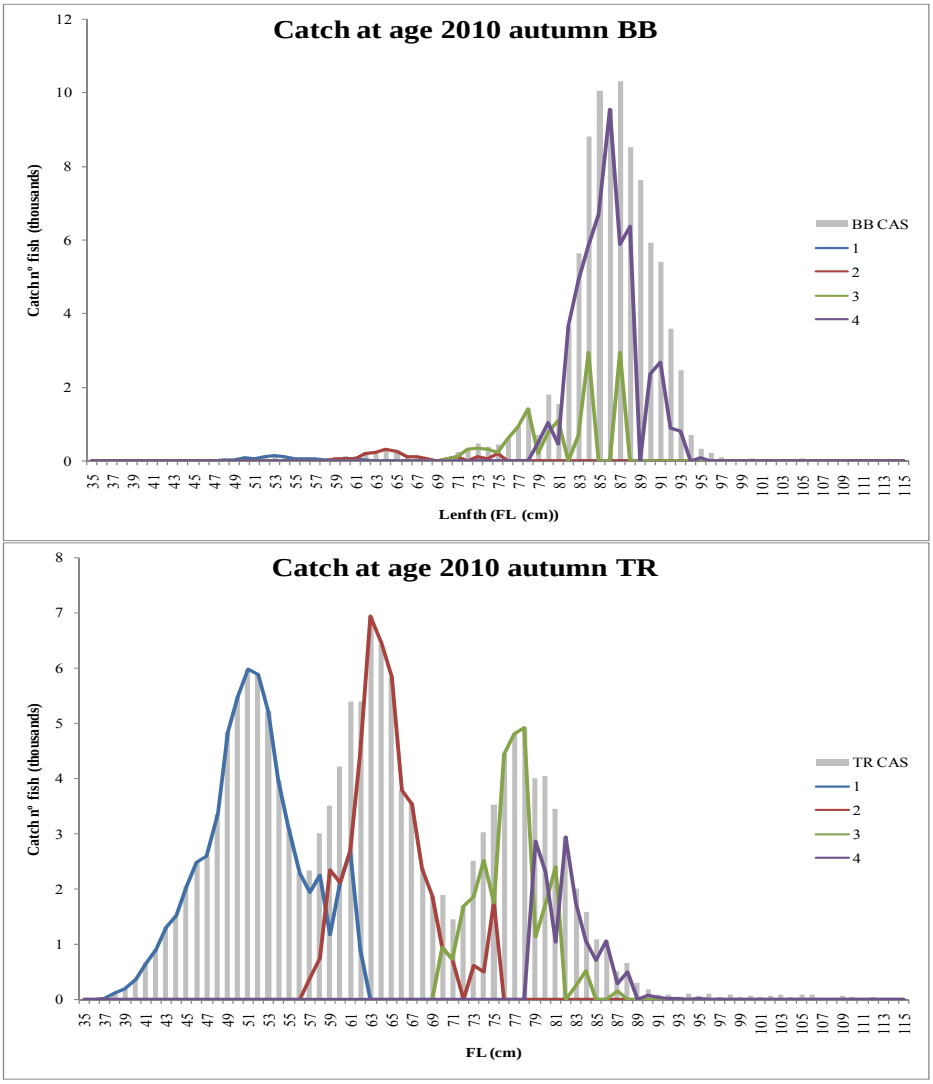
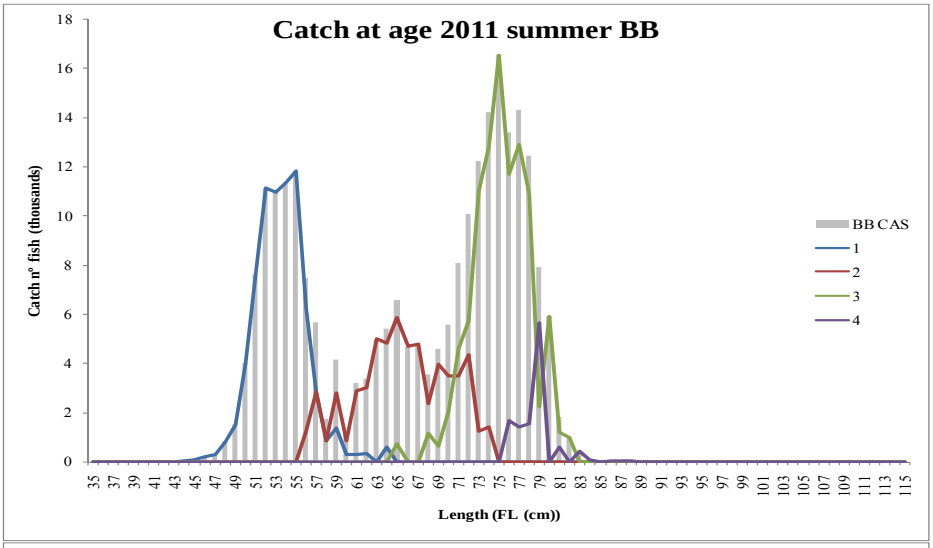
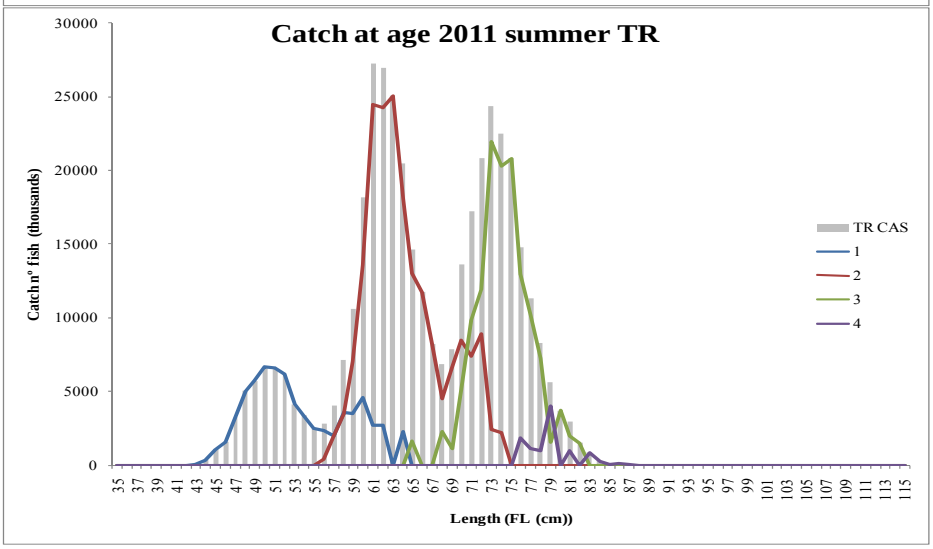


Figure 2b. Comparison of albacore catch-at-size (CAS) and estimated catch-at-age (CAA) by fleet and year 2010


Catch at age 2011 summer BB
Catch n° fish (thousands)
Length (FL (cm))
BB CAS
1
2
3
4


Catch at age 2011 summer TR
Catch n° fish (thousands)
Length (FL (cm))
TR CAS
1
2
3
4

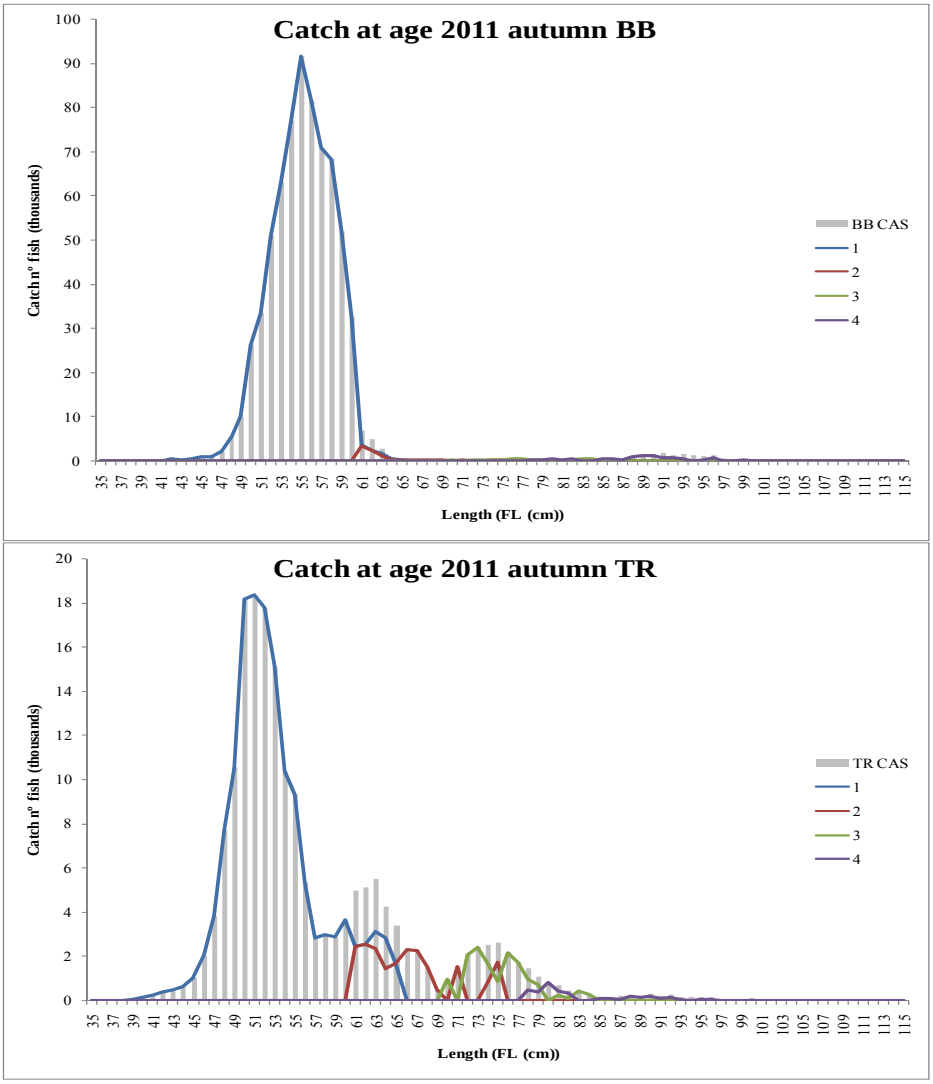


Figure 2c. Comparison of albacore catch-at-size (CAS) and estimated catch-at-age (CAA) by fleet and year 2011