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THE VARIABILITY OF THE SPECIES CONTRIBUTION TO THE TOTAL CATCH OF THE POLE AND LINE TUNA FISHERIES IN SOUTHWEST ATLANTIC OCEAN

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SUMMARY

Most of tuna catches in the Southwest Atlantic Ocean are gathered by the pole and line fleet, which has the skipjack (Katsuwonus pelamis) *as main target. The sources of information about the landings are three: a) records of landings furnished by industry; b) paid observers which meet the incoming vessels and interview the fishermen; and c) logbooks. Sometimes the species contribution to the total catch reported in these sources of information is inconsistent. For instance, in the industry forms, the weights reported are precise, but the species names can be incorrect. In this work we compared the sources of information in order to improve the estimates and to investigate if spatial and temporal factors affects the variations of the species contribution to the total landings. The catch of skipjack was shown to be overestimated, and that of the other tunas, underestimated if a correction is not performed. Results from an ANOVA analysis revealed that there is significant variation in the contribution of the skipjack and yellowfin* (Thunnus albacares) *among quarters, areas and interactions between these factors. However, no significant variations were found for albacore (* T. alalunga*) data.*

RÉSUMÉ

La plupart des captures de thonidés dans l'Atlantique sud-ouest sont réalisées par les flottilles opérant à la canne et à l'hameçon et ciblant principalement le listao (Katsuwonus pelamis)*. Les sources d'information concernant les débarquements sont au nombre de trois : a) registres des débarquements fournis par l'industrie ; b) observateurs rémunérés qui interviewent les pêcheurs au débarquement ; et c) les carnets de bord. Parfois, la contribution par espèce à la capture totale déclarée dans ces sources d'information est incohérente. A titre d'exemple, dans les formulaires de l'industrie, les poids déclarés sont précis, mais les noms d'espèces peuvent être incorrects. Dans la présente étude, nous avons comparé les sources d'information afin d'améliorer les estimations et déterminer si les facteurs spatio-temporels affectent les variations de la contribution par espèce au total des débarquements. La capture du listao s'est avérée surestimée, tandis que celle d'autres thonidés sous-estimée si une correction n'est pas effectuée. Les résultats d'une analyse ANOVA ont révélé une variation considérable dans la contribution du listao et de l'albacore* (Thunnus albacares*) selon les trimestres et les zones, ainsi quet des interactions entre ces facteurs. Toutefois, aucune variation significative n'a été relevée pour les données du germon* (T. alalunga*).*

RESUMEN

La mayor parte de las capturas de atún en el océano Atlántico suroccidental provienen de la flota de caña de liña, que tiene al listado (Katsuwonus pelamis) *como principal especie objetivo. Las fuentes de información sobre los desembarques son tres: a) registros de desembarques proporcionados por la industria; b) observadores remunerados que reciben a los barcos que llegan y entrevistan a los pescadores; y c) cuadernos de pesca. Algunas veces la contribución de la especie a la captura total comunicada en estas fuentes de información no coincide. Por ejemplo, en los formularios de la industria, los pesos comunicados son precisos, pero los nombres de las especies pueden ser incorrectos. En este trabajo comparamos las fuentes de información para mejorar las estimaciones e investigar si los factores de espacio y tiempo afectan a las variaciones de las contribuciones de las especies al total de los*

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desembarques. Se ha observado que la captura de listado se sobrestima y que la de otros túnidos se infravalora si no se realiza una corrección. Los resultados de un análisis ANOVA revelaron que existía una variación significativa en la contribución del listado y rabil (Thunnus albacares*), entre trimestres y zona, e interacciones entre dichos factores. Sin embargo, no se descubrieron variaciones significativas para los datos de atún blanco* (T. alalunga).

KEYWORDS

Bait fishing, Catch composition, Catch statistics, Fishery statistics

1 INTRODUCTION

The control of multi-species gears landings is fundamental to assess the fishery impact upon the population dynamics of individual resources, and the variations in the species composition of the fished community. In southwest of the Atlantic Ocean, tuna fisheries are accomplished almost exclusively by the Brazilian pole and line fleet and have the skipjack tuna (*Katsuwonus pelamis*) as the main component. However, there is no knowledge about the spatial and temporal variations of the species composition of the catches obtained by this fleet. The knowledge of these patterns is important for the estimation of changes in vulnerability of different species to the pole and line gear, and fundamental, therefore, to the definition of tuna fish management and exploitation strategies in this region of the Atlantic Ocean.

Until 1997, the control of the fishing fleets catches in Brazil (including the pole and line fleet) was an attribution of IBAMA/MMA. The "industry production forms", which are records of landings furnished by industry after the fish is weighted at discharging piers, were the main instrument used to record catch compositions by species. Traditional logbooks, which should be delivered by the skippers to IBAMA, served as auxiliary instruments. Since 2000, the control of the landings passed to be effectively realized by MAPA (Ministério da Agricultura Pecuária e Abastecimento), throughout associations with universities related to fishery sciences. The control of the discharged quantities by species passed to be accomplished by the concatenation of the two anterior sources of information (industry production forms and logbooks), in addition with interviews made directly with the fishermen by paid observers. In the beginning, the definition of the catches by species was based on information from industry production forms, furnished by industry after the weigh of the fish. Nevertheless, the verification that small fish of genera *Thunnus* can be weighted together and reported as skipjack tuna catch in the industry production forms indicated that the utilization of this source of information by itself could result in significant errors and bias in the estimations of catch by species.

Also, a considerable portion of the catches of yellowfin tuna (*Thunnus albacares*), albacore (*Thunnus alalunga*) and bigeye tuna is often reported in logbooks and in industry production forms as a single category generically denominated "tuna", which also difficult the definition of real values of catch by species for the pole and line fleet. In 2000, for instance, the total catch of "tuna" landed in Santa Catarina State (CTTMar-UNIVALI, 2001) was around 477,000 tons, while the summation of the total catches of yellowfin tuna, albacore and bigeye tuna reach 363,000 tons. In this work we design and applied a formal framework in order to minimize errors and bias in the Brazilian baitboat statistics.

2 MATERIAL AND METHODS

2.1 Catch Data

Since 1995, paid observers realize daily visits at the main industry plants in Itajaí and Navegantes harbors (**Figure 1**), in which they interview the skippers when meet incoming vessels of the pole and line fleet. In these interviews are obtained information about catches, effort and fishing grounds.

The present paper utilized fishing data from January 2001 to June 2002. Altogether, were analyzed 356 Brazilian pole and line fleet landings accomplished in Itajaí and Navegantes harbors. The great majority of the registrations were from vessels from Santa Catarina State. However, fishing data from vessels of Rio Grande and Rio de Janeiro harbors that landed in Santa Catarina State during the same period were also used. These landings sampled represented around 2,421 days of fishing between 23°S and 33°S, and the summation of the total catches reported represents approximately 70% of the total landed in Santa Catarina State between January 2001 and July 2002.

The annual catch of the skipjack landed in the sampled harbors usually reaches more than 65% of the Brazilian total catch (Paiva, 1997; Meneses de Lima *et al.*, 2000). The fleet from these harbors fishes in the entire skipjack fishing ground, from 20°S to 34°S along the shelf margin (**Figure 1**). In the western Atlantic Ocean, other catches of skipjack only occur in the northern hemisphere, in the Caribbean Sea. Therefore, the sampling program is representative of all skipjack landings in the west margin of the Atlantic Ocean (Area n°84 – ICCAT, 2001).

To analyze the catch composition, were used only landings covered by at least two samplings approaches (e.g. interview and logbook), to assure more credibility to the estimations. In the whole, were used 276 interviews, 216 logbooks and 171 industry production forms.

2.2 Spatial and Temporal Variations of the Catch Composition

For the assessment of spatial and temporal variations of the species composition in the catches, the data were grouped by trimester and according to three areas: north (north of 27°S), central (between 27°S and 30°S) and south (south of 30°S). That division was based in preterit knowledge about peaks of fishing occurrence off Brazilian coast (Andrade, 2003). Thus, each area contains one of the main peaks of occurrence of baitboat fisheries throughout the year.

The analyses of the effects of seasonal and area factors upon the specific composition of the catches were accomplished through two-way analyses of variance with repetition (ANOVA). Was evaluate the effect of the two factor individually and the interaction between them. In that analyses were used data from the three more frequent species in the Brazilian pole and line fleet landings namely skipjack, yellowfin and albacore.

2.3 Accuracy of Estimations

To correct catches reported generic only as “tuna”, were initially calculated the percentage contribution of yellowfin, albacore and bigeye in relation to the total catch of genera *Thunnus* in each month and area. After, were estimated the mean proportions (pondered means) corresponding to each species within each trimester and each area. Thus, we constructed a “correcting key”, which was used to estimate the catch composition of baitboat landings. Comparisons between the results obtained by the old method (using only industry production forms) and by the application of this new method (correcting key) were made to show the improvement in the statistics, and how big was the inaccuracy in the past. This procedure was applied only in landings covered by one industry production form and by at least one other source of information (logbooks and/or interviews), between January 2001 and July 2002.

3 RESULTS

3.1 Data Consistency in the Sources of Information

The linear regressions between the total weights of catches registered in the three sources of information used to control the pole and line fleet landings (industry production forms, logbooks and interviews) are presented in **Figure 2**. **Table 1** contains the results of significance tests (ANOVA) applied in the linear regressions. In the three comparisons the *Ho* hypothesis was accepted, that is, there were not significative differences between total catches registered in the three sources of information.

Nevertheless, was observed homoscedasticity, indicating that the residuals are evenly distributed above and below zero (**Figure 3**).

3.2 Overall Catch Composition

The weight of industry production forms proved to be more accurate than the weight reported in other sources of information. Then, the established sequence of credibility for the weight information was: industry production forms, logbooks and interviews. However, interviews presented better registrations of the caught species and, then, served as references in most cases. When there was no interview, the logbook proved to be best to estimate catch composition.

Brazilian pole and line fleet landings in Santa Catarina State were dominated by skipjack (*Katsuwonus pelamis*), which corresponded to 90,6% of the total catch (**Table 2**). Among species of genera *Thunnus*, the yellowfin tuna (*Thunnus albacares*) was dominant and represented approximately 76,51%, while albacore (*Thunnus alalunga*) and bigeye contributed with around 21,97% and 1,51%, respectively (**Table 2**). These results are very similar to that found by Meneses de Lima *et al.* (2000) for the entire Brazilian pole and line fleet and for the fleet in the period from 1983 to 1996 (**Table 2**).

The data from 2001 and 2002 were grouped by month to facilitate the comparison between monthly catches and monthly specific composition.

Skipjack was by far the main component of the catches through the years, with mensal contributions varying between 77,4% e 97% of the total catch by month (**Figure 4**). Catches of yellowfin tuna was the second except for November, when landings of dolphinfish (*Coryphaena hippurus*) were high, representing around 4,89% of the total catch. Albacore occupied the third position from February to July, and in other months there was an alternation between the others species (**Figure 4**).

The percentage contributions of yellowfin, albacore and bigeye tuna in relation to the total catches of genera *Thunnus* by month are showed in **Figure 5**. There was an absolute dominion of yellowfin, excluding November, when bigeye reached 90% of the total landings. Nevertheless, that value should be considered with some caution, because all the bigeye tuna caught (10 tons) was from only one landing (**Table 3**).

Seasonal and spatial variations of the percentage contribution of the three main caught species (skipjack, yellowfin and albacore) within each area and each trimester were relatively large, mainly in the case of yellowfin (**Tables 4, 5 and 6**). In fact, the application of an ANOVA analyses revealed that in the case of yellowfin, the percentage of contribution presented significative variations in function of trimester and interaction between trimester and area (**Table 7**). The biggest proportion of yellowfin in the total catches was reported in the 2° trimester in the south area (south of 30°S), while the smallest occurred in the 3° trimester, in the central area (between 27°S and 30°S) (**Table 5**).

For the skipjack tuna, trimester was the main factor affecting the proportion in the landings (**Table 7**). The others factors are less significative. The biggest proportion of skipjack in the total catches occurred in the 3° trimester, in the central area (between 27°S and 30°S), while the smallest was observed in the 2° trimester, in the south area (south of 30°S) (**Table 4**).

In the case of albacore, its proportion in the total catches seems to be not significantly influenced by trimester and area factors, neither by the interaction between these factors (**Table 7**).

3.3 Catch Landing Correction Key

Table 8 contains the mean proportions (decimal values) of yellowfin, albacore and bigeye tuna within both area and trimester, that is, it represents the "correcting key" proposed in this paper. That table, throughout the multiplication of the factors correspondent to each species by the total catches of the generic category named "tuna", was used to estimate the landings of yellowfin, albacore and bigeye tuna. The end of the year (3° and 4° trimesters) and the southern area are the fishing scenarios less multi specific. Yellowfin dominates the catches of genera *Thunnus* in those cases.

The comparison of the data obtained through the application of this new method (correcting key) with the results obtained by the old method (using only industry production forms) is shown in **Table 9**. This comparison indicated that skipjack tuna was super estimated in around 1,78 % of the corrected catch, while the other species were sub estimated between 21,7% (albacore) and 100 % (bigeye tuna and lesser amberjack).

4 DISCUSSION

4.1 Data Consistency in the Sources of Information

The initial stage of this study consisted in the assessment of three sources of information used to register landings of the Brazilian baitboat fleet seated in Santa Catarina: industry production forms, logbooks and interviews accomplished with the skippers. In interviews, skippers indicate the expected weight for the fish after pass through the balance in discharging piers. In logbooks, catch values by species may be derived both from fish weigh (as foresee the legislation) and from skippers' estimations (used form in most cases). In industry production forms, the weights are registered always after the fish had passed through the balance, which guarantees a more precise value and free from subjectivity of the fishermen. The linear regressions (**Figure 2**) have showed that there are not significative differences between total weights in three sources of information (**Table 1**), which indicates the fishermen usually make a very good estimation of the catch weight, and do not hide or deliberately communicates wrong information in the interviews and logbooks. However, the regressions slopes indicate that there is a slight tendency of sub estimation in logbooks and interviews, compared with industry production forms. This indicates that fishermen seem to be rather pessimistic in relation to the total catch obtained in each fishing trip.

The choice of catch values to estimate the species composition of the Brazilian pole and line tuna fisheries follows some criteria. In all landings with registrations of industry production forms, was given a larger credit to the weights reported in them. In landings without information of industry production forms, was given preference to the weights reported in logbooks, which is slight more accurate than the interviews, as indicated by the slope nearest to 1 (**Figure 2.b**) in comparison with the slope between interview and industry production form (**Figure 2.a**).

The reported fish categories seemed in many cases different between interviews, logbooks and industry production forms. These divergences occurred because:

a) Species are not correctly separated and discriminated in the landing plants to weigh in the balance, which would result in equivocated registrations in industry production forms and in part of logbooks;
b) Wrong information about catches by species would be furnished in interviews and logbooks;
c) Species (or specimens) caught in the fishing trip was not landed in the discharging piers.

There are evidences that the occurrence of the first focused item is not rare. The tuna fish price by kilo is the same for small pieces (under 15 Kg). So, young individuals of yellowfin (*Thunnus albacares*), albacore (*Thunnus alalunga*) and bigeye tuna (*Thunnus obesus*) with small size, are often weighted together the skipjack (*Katsuwonus pelamis*), species that seldom reaches more than 80 cm and that usually dominates the pole and line catches off Brazil. Thus, a significative portion of industry production forms and logbooks might contain super estimated registers of skipjack catches and sub estimated of genera *Thunnus* species.

As the comparison between the catches furnished by the skippers in interviews and the total catches obtained after the weigh of the fish (**Figure 2.a**) demonstrated that the values are very similar in most cases, there are strong indicatives that the skippers seldom give equivocated information in interviews. Therefore, the species composition reported by the fishermen has credibility and the item "b" cited above can not be considered as a cause for the discrepancies in the sources of information about the catches.

Some caught pieces are not landed and weighted, keeping with crewmembers. However, this amount is usually very small and only in rare cases occurrences like that may be considered a source of large errors in species composition. This type of situation is a potential bias source not for tuna, but for the dolphinfish (*Coryphaena hippurus*), since the catch registrations of this species are more frequent in interviews, which are accomplished before the fish weigh. Also, the problems with dolphinfish landings were reported by onboard paid observers that have been embarking on baitboat vessels during the skipjack harvest season since 1999.

The analyses of the catch registrations contained in the different sources of information indicated that a large number of species tend to be reported in the interviews, while the accuracy of the weight reported in the industry production forms is higher than in other sources of information. Therefore, seems clear that the best procedure to estimate the total catch by species in each fishing trip would be use the interviews to calculate the percentage contributions of each species in total catches, and then use this percentages to estimate what would be the amount corresponding to each species in the total weight determined by the balance reported in industry production forms.

4.2 Overall Catch Composition

The similarity between the catch composition we found (from January 2001 and July 2000) and the results presented by Meneses de Lima *et al.* (2000) (**Table 2**), indicates that there were not significative variations in the specific composition of the fished community off Brazil since 1996. Probably, the fishermen strategy and gears do not change in order to maximize the catch of one or other species. This is a consequence that almost all species and sizes landed by the baitboat fleet have the same value in the market.

There was a slight fall in the relative participation of skipjack in total catches during the second and the third trimester (**Table 4**), which was compensated by increases in the percentage contributions of yellowfin and albacore (**Tables 5 and 6**). Through the analyses of the monthly catches by species (**Table 3**), we observed that mainly in the 2nd 3rd trimesters of 2001 really happened large catches of genera *Thunnus* species and an decrease in the landings of skipjack. That variation may be related, among other factors, to the larger concentration of the fishing effort in the north area (north to 27°S) in the 2nd and 3rd trimesters around the oil extraction platforms P-XIV (26°46'S; 46°47'W) and Merluza (25°15'S; 45°25'W). Tuna are frequently associated with drifting floating objects ("logs" or drifting artificial objects set by the fishermen), or in fixed, permanent structures (anchored FADs, seamounts, islands), and one of the main characteristics of catches accomplished around them is the heterogeneity of the fishing sets, that generally involve multi-specific schools (Ariz et al., 2001). The proportions of yellowfin and albacore were usually larger in south than in other areas (**Tables 5 and 6**). In that area, although there is not oil platforms, was verified that 93% of yellowfin and 100% of albacore caught during the second trimester were from schools associated with floating objects, which reinforces the hypothesis suggested before, that free schools are more monospecific (dominated by skipjack) than others schools. However, due to the existence of some even antagonistic information in our data set, becomes evident that is necessary a more detailed assessment about the influence of floating objects on the catch composition.

4.3 Catch Landing Correction Key

The estimations of catch by species after the application of the methodology proposed in this paper indicated that usually occurs overestimations of skipjack in the traditional statistics reports (based only in industry production forms). In 2001, this error was 1,71% above the corrected catch (**Table 9**). Therefore, there are evidences that a significative number of small size individuals of genera *Thunnus* is weighted together and reported as skipjack in industry production forms and probably also in some logbooks (when filled after fish weigh). This situation occurs with certain frequency in tuna fisheries accomplished in Tropical Atlantic Ocean (Delgado de Molina *et al*., 1999), with the most significant bias and errors being those produced in the declarations of small specimens (under 10 Kg) where the distinction between juveniles of yellowfin, albacore and bigeye tuna becomes more difficult, resulting in the overestimation of skipjack. Our results also indicated that catches of yellowfin, albacore and bigeye tuna have been underestimated in industry production forms (**Table 9**), due to both the generalization of their catches only as "tuna" and by the weigh of some specimens of genera *Thunnus* together with skipjack. The same problem also happens with frigate tuna (*Auxis thazard*), which might be registered as skipjack because its sale price is the same.

The underestimation of dolphinfish (*Coryphaena hippurus*) (**Table 9**) confirms ours expectations that some specimens are left by crewmembers before the weigh of the fish.

The results obtained in this work indicate that catch statistics probably were somewhat biased in the past. Therefore, becomes fundamental the definition of "correcting keys" and the assessment of more than one source of information for all Brazilian harbors (Rio de Janeiro-RJ, Rio Grande-RS and Santos-SP), in order to improve the statistic reports in the future.

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Table 1 - Results of analyses of variance testing (ANOVA) of linear regressions lines between the total weights registered in industry production forms, logbooks and interviews.

Industry production forms x interviews						
Source of variation	SQ	gl	MQ	F	P-level	F critical
Between groups	4.7099	1	4.7099	0.0052	0.9423	3.8735
Within groups	262313.6503	292	898.3344			
Total	262318.3602	293				
Industry production forms x logbooks						
Source of variation	SQ	gl	MQ	F	P-level	F critical
Between groups	51.4733	1	51.4733	0.0476	0.8276	3.8893
Within groups	212138.9760	196	1082.3417			
Total	212190.4493	197				
Logbooks x interviews						
Source of variation	SQ	gl	MQ	F	P-level	F critical
Between groups	7.9668	1	7.9668	0.0082	0.9281	3.8769
Within groups	257693.6479	264	976.1123			
Total	257701.6148	265				

Table 2 - Comparison of the average specific composition of catches of the pole and line fleet obtained in this paper with that reported by Meneses de Lima *et al.* (2000) for the entire Brazilian pole and line fleet during the period from 1983 to 1996. Values in percentage (%).

Species	Composition (1983-1996)	Composition (2001-2002)
Skipjack (*Katsuwonus pelamis*)	88.9	90.6
Yellowfin tuna (*Thunnus albacares*)	8.2	6.52
Albacore (*Thunnus alalunga*)	0.2	1.87
Frigate tuna (*Auxis thazard thazard*)	0.9	0.23
Bigeye tuna (*Thunnus obesus*)	-	0.13
Dolphinfish (*Coryphaena hippurus*)	0.92	0.61
Lesser amberjack (*Seriola fasciata*)	-	0.01

Table 3 – Total catches by month, in the 356 landings analyzed in this paper. Catches in metric tons (MT). SKJ (*Katsuwonus pelamis*), YFT (*Thunnus albacares*), BET (*Thunnus obesus*), ALB (*Thunnus alalunga*), FRI (*Auxis Thazard*), DOL (*Coryphaena hippurus*) and LA (*Seriola fasciata*).

Month/ Year	SKJ	YFT	BET	ALB	FRI	DOL	LA
January/2001	169.47	12.52	0.00	0.00	0.00	0.00	0.00
February/2001	1147.24	24.03	0.00	32.75	0.53	0.10	0.00
March/2001	1384.81	35.49	0.42	14.61	0.90	6.47	0.00
April/2001	1267.21	189.06	2.52	19.64	0.00	0.05	0.02
May/2001	846.00	145.43	0.27	65.39	0.05	6.44	0.00
June/2001	810.18	242.10	2.49	106.36	0.00	2.46	0.00
July/2001	500.35	78.61	0.00	50.28	3.73	0.20	0.00
August/2001	884.87	30.60	0.01	2.66	3.50	3.64	0.00
September/2001	187.27	41.39	5.50	0.84	1.77	3.08	2.00
October/2001	163.35	19.53	0.00	0.00	15.79	3.35	0.00
November/2001	751.63	1.10	10.00	0.00	7.0	39.64	0.00
December/2001	784.99	26.64	0.01	0.07	0.39	17.08	0.00
January/2002	310.26	0.21	0.00	0.00	0.00	2.00	0.00
February/2002	780.51	11.90	0.00	2.00	3.29	2.23	0.00
March/2002	1490.36	49.66	0.02	0.11	0.23	3.70	0.00
April/2002	1225.30	73.10	0.65	0.00	0.00	0.20	0.00
May/2002	395.98	1.60	0.00	0.00	0.00	2.20	0.00
June/2002	1318.56	18.25	0.06	0.00	0.00	0.75	0.00
July/2002	753.20	65.68	0.00	22.67	0.98	2.20	0.00

Table 4 – Percentage contributions of skipjack (*Katsuwonus pelamis*) within each area and each trimester.

	Trimester			
Area	1°	2°	3°	4°
North	95.89	88.31	86.48	86.47
Central	99.01	88.86	98.44	94.69
South	93.78	58.35	86.40	94.69

Table 5 – Percentage contributions of yellowfin tuna (*Thunnus albacares*) within each area and each trimester.

	Trimester			
Area	1°	2°	3°	4°
North	3.16	7.99	9.20	3.15
Central	0.44	8.92	0.15	1.50
South	3.60	35.96	10.69	4.56

Table 6 – Percentage contributions of albacore (*Thunnus alalunga*) within each area and each trimester.

	Trimester			
Area	1°	2°	3°	4°
North	0.39	3.51	2.69	0.01
Central	0.24	1.98	0.00	0.00
South	2.53	4.10	1.86	0.00

Table 7 – Results from ANOVA analyses with factors area and trimester for skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*) and albacore (*Thunnus alalunga*).

			Skipjack (*Katsuwonus pelamis*)			
Factor	df Effect	MS Effect	df Error	MS	F	p-level
Area	2	0.07717	443	0.032078	2.405790	0.091372
Trimester	3	0.29017	443	0.032078	9.045718	0.000008
Interaction	6	0.06627	443	0.032078	2.066083	0.055981
			Yellowfin tuna (*Thunnus albacares*)			
Factor	df Effect	MS Effect	df Error	MS	F	p-level
Area	2	0.047625	443	0.016856	2.82549	0.060348
Trimester	3	0.230422	443	0.168560	13.67032	0.000000
Interaction	6	0.046402	443	0.168560	2.75288	0.012281
			Albacore (*Thunnus alalunga*)			
Factor	df Effect	MS Effect	df Error	MS	F	p-level
Area	2	0.000643	443	0.000442	1.454622	0.234602
Trimester	3	0.000447	443	0.000442	1.010408	0.387893
Interaction	6	0.000606	443	0.000442	1.371950	0.224312

Table 8 – "Correcting key" proposed to divide catches of genera Thunnus through information of position and date of fisheries. It contains the proportions (decimal values) of yellowfin tuna (Thunnus albacares), albacore (Thunnus alalunga) and bigeye tuna (Thunnus obesus) within each area and each trimester.

North Area			
Trimester	*Thunnus albacares*	*Thunnus alalunga*	*Thunnus obesus*
1°	0.8902	0.1095	0.0002
2°	0.6946	0.3052	0.0002
3°	0.7561	0.2212	0.0226
4°	0.6166	0.0028	0.3806

Central Area			
Trimester	*Thunnus albacares*	*Thunnus alalunga*	*Thunnus obesus*
1°	0.6507	0.3493	0.0000
2°	0.8120	0.1804	0.0076
3°	1.0000	0.0000	0.0000
4°	1.0000	0.0000	0.0000

South Area			
Trimester	*Thunnus albacares*	*Thunnus alalunga*	*Thunnus obesus*
1°	0.5846	0.4107	0.0047
2°	0.8797	0.1004	0.0199
3°	0.9599	0.0335	0.0066
4°	1.0000	0.0000	0.0000

Table 9 – Results of the comparisons between the results obtained by the old method (using only industry production forms) and by the application of this new method (correcting key). C1 total catches from industry production forms (IPF); C2 corrected catches.

Category	C1	C1 (%)	C2	C2 (%)	C2 – C1	(C2–C1)/ C2
Skipjack	7568.11	92.07	7440.26	90.52	127.84	1.72
Yellowfin tuna	360.06	4.38	545.42	6.64	-185.35	-33.98
Bigeye tuna	0.00	0.00	0.35	0.00	-0.35	-100.00
Albacore	135.67	1.65	173.30	2.11	-37.63	-21.77
Frigate tuna	15.89	0.19	20.91	0.25	-5.02	-23.99
Thunnus spp.	84.95	1.03	0.00	0.00	84.94	0.00
Dolphinfish	16.78	0.20	37.26	0.45	-20.49	-54.98
Lesser amberjack	0.00	0.00	2.02	0.02	-2.02	-100.00
Residual	38.07	0.46	0.00	0.0	38.07	0.00

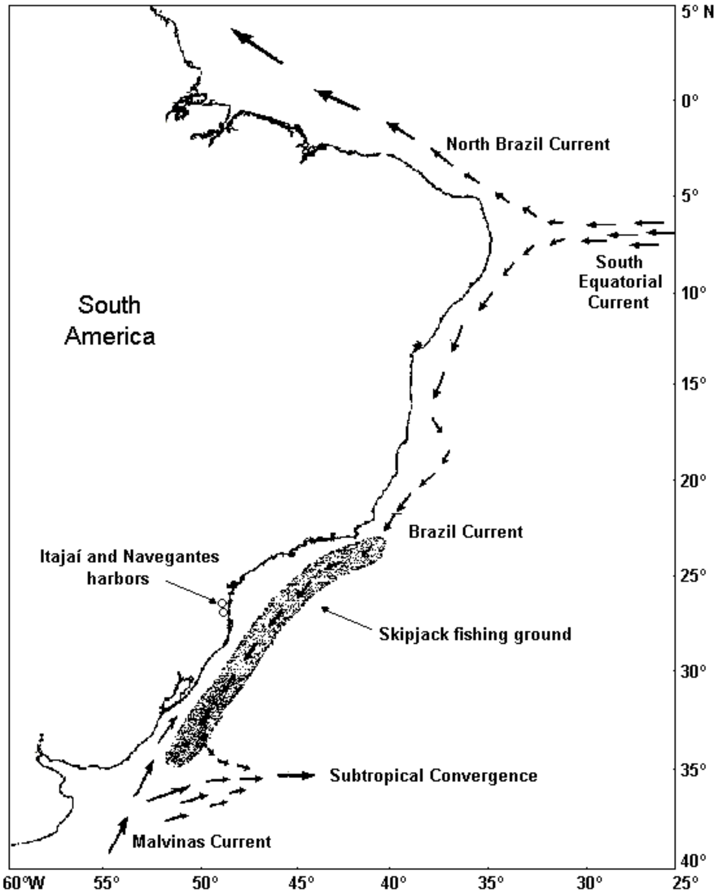

Fig. 1 – Skipjack tuna (*Katsuwonus pelamis*) fishing ground in the east coast of South America (adapted from Matsuura and Andrade, 2000)

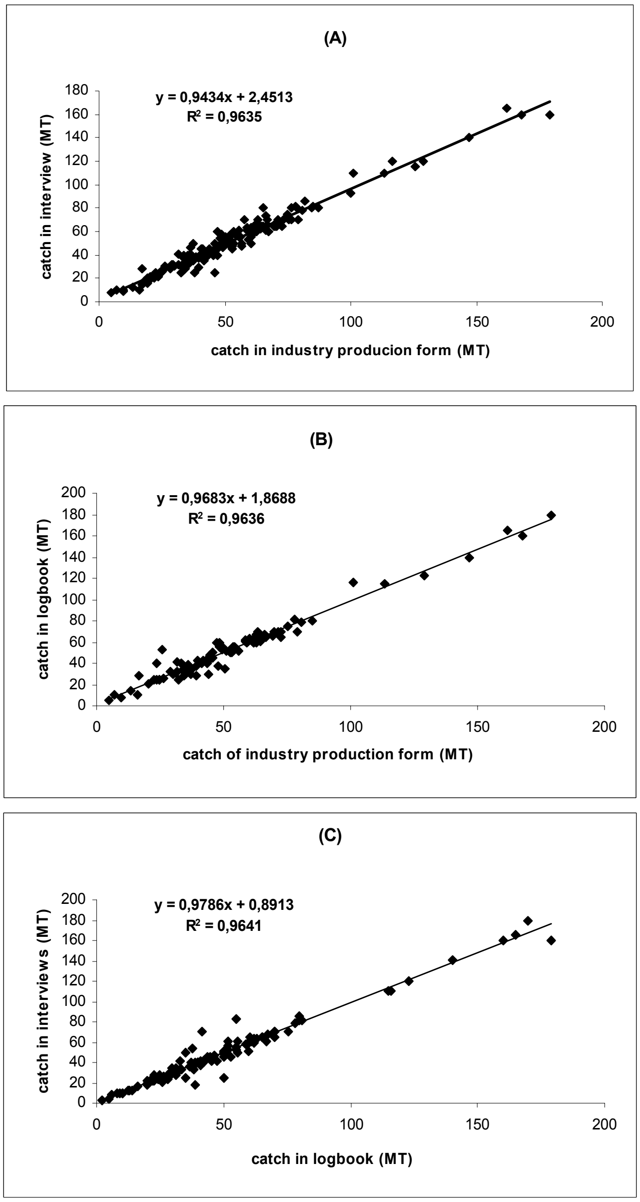

Fig. 2 - Linear regressions between the total catches reported in the three sources of information: (A) industry production forms x interviews, (B) industry production forms x logbooks, (C) logbooks x interviews. Catches in metric tons (MT).

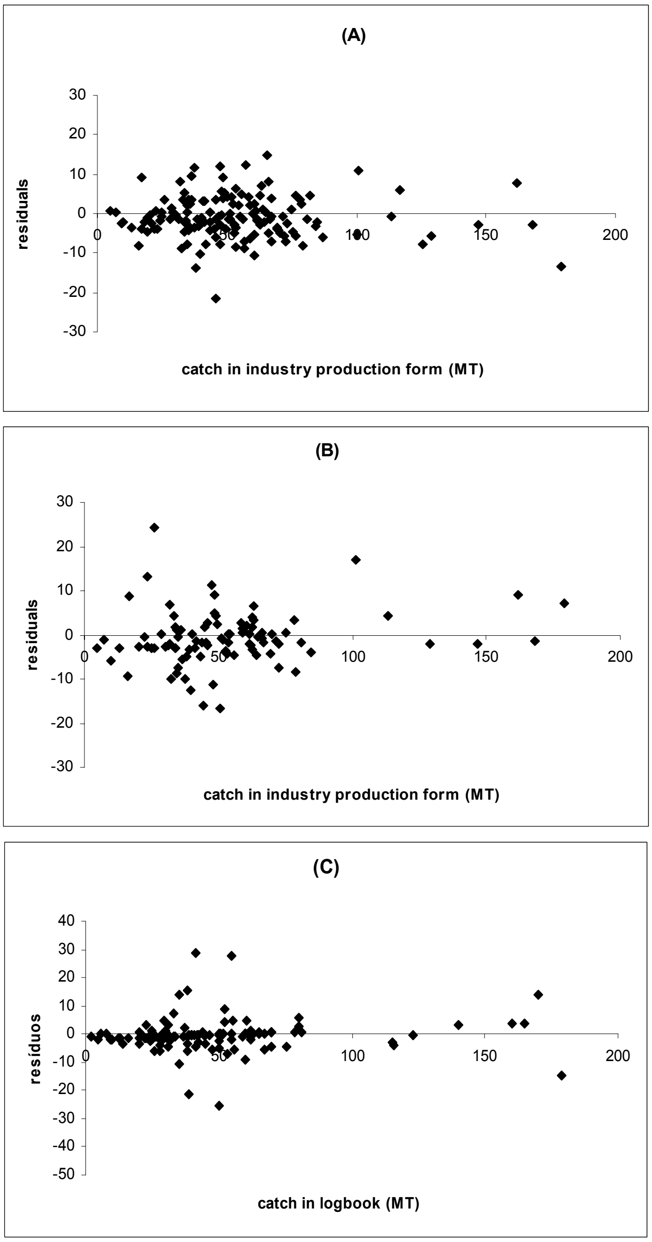

Fig. 3 – Residuals of the linear regressions between the total catches reported in the three sources of information: (A) industry production forms x interviews, (B) industry production forms x logbooks, (C) logbooks x interviews. Catches in metric tons (MT).

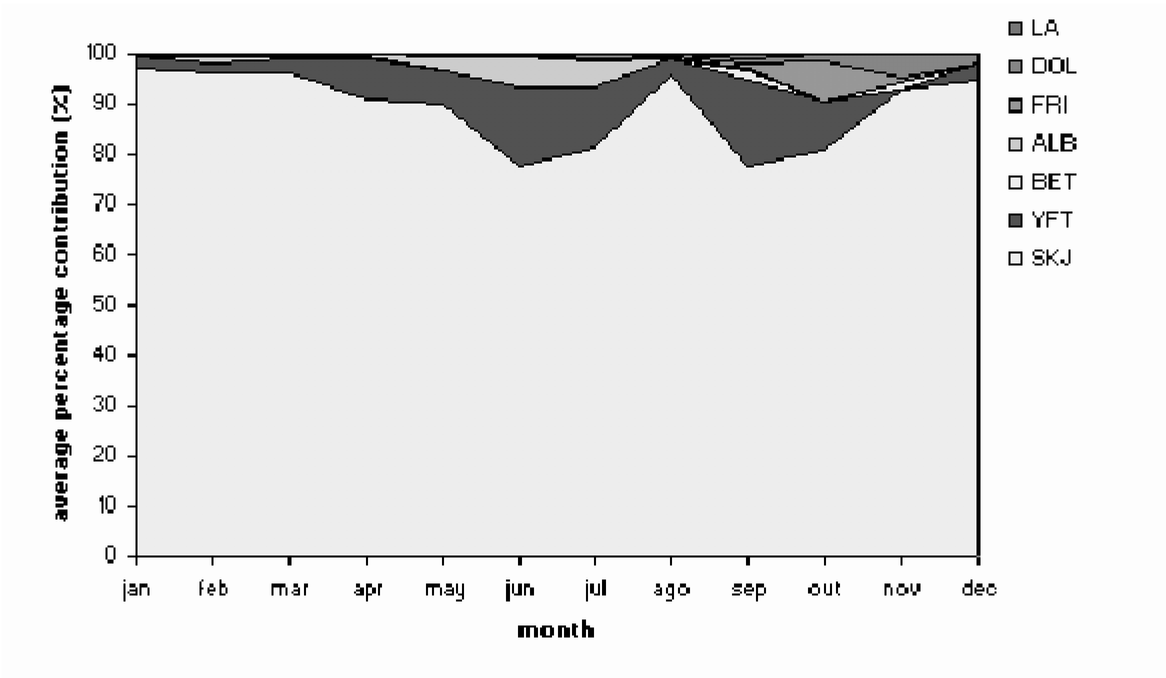

Fig. 4 – Monthly variations in the specific composition pole and line catches landed in Santa Catarina State between January 2001 and July 2002. SKJ (*Katsuwonus pelamis*), YFT (*Thunnus albacares*), BET (*Thunnus obesus*), ALB (*Thunnus alalunga*), FRI (*Auxis Thazard*), DOL (*Coryphaena hippurus*) and LA (*Seriola fasciata*).

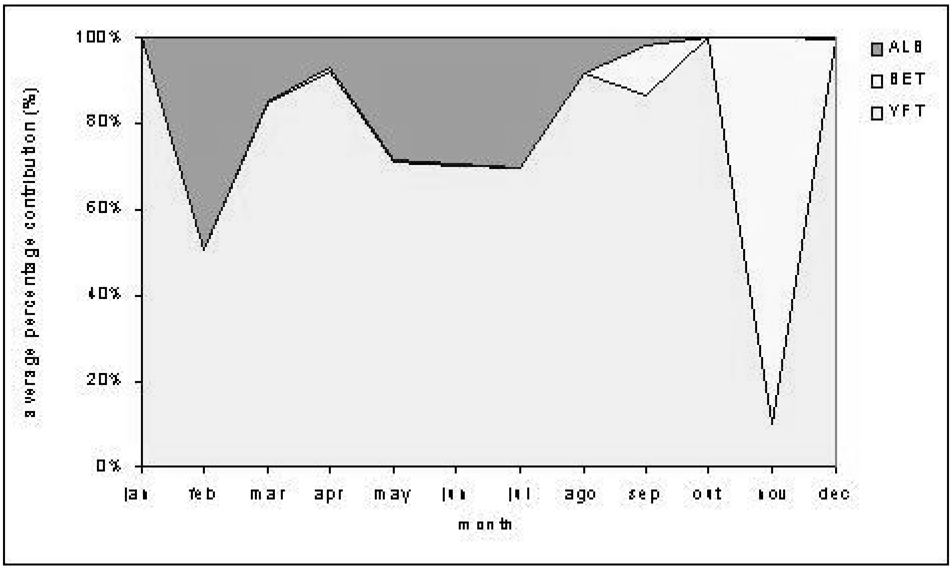

Fig. 5 – Monthly variations in the specific composition catches of genera *Thunnus* landed in Santa Catarina State between January 2001 and July 2002. YFT (*Thunnus albacares*), BET (*Thunnus obesus*), ALB (*Thunnus alalunga*).