5.2. Laboratory Survey

5.2.1. Selection of Age characters

In bony fishes, hard tissues have generally been used for age determination. In the present survey, hard tissues such as fin spines, vertebrae, scales, otoliths and opercles were taken from specimens and processed for age determination. Characters were selected for each fish species according to the condition of the rings — their formation, clarity and accessibility in sampling. The following paragraphs deal with the results of this process of investigation and selection of age characters. Color photographs of samples of those characters are shown in the Appendix, Plates 2–6.

(a) Piramutaba *Brachyplatystoma vaillantii*

a-1) Spines

Relatively clear rings could be observed in cross-sectioned slices of spines, but the central core of the spine was a hollow space (see Plate 2).

a-2) Vertebral centra

Relatively clear rings were observed on the facet of the centra (see Plate 3).

a-3) Otoliths (lapillus)

Rings were observed in cross-sectioned slices of otoliths; they included the nucleus but were not clear (see Plate 5). Otoliths were located in capsules so highly ossified that it was extremely difficult to extract samples.

a-4) Opercles

No ring could be observed in opercles (see Plate 6).

The above results led to the selection of vertebral centra, which exhibited relatively clear rings, as a age character.

(b) Dourada *Brachyplatystoma flavicans*

b-1) Spines

Cross-sectioned slices of spines revealed a honeycomb-like structure and no rings were effectively observed (see Plate 2).

b-2) Vertebral centra

Rings were observed on the facet of the centra, but they were not clear enough (see Plate 3).

b-3) Otoliths (lapillus)

Rings were observed in cross-sectioned slices of otoliths; they included the nucleus but were not clear (see Plate 5). Otoliths were located in capsules so highly ossified that it was extremely difficult to extract samples.

b-4) Opercles

No ring could be observed in opercles (see Plate 6).

The above results led to the selection of vertebral centra, which exhibited relatively clear rings, as a age character.

(c) Filhote *Brachyplatystoma filamentosum*

c-1) Spines

Cross-sectioned slices of spines revealed a honeycomb-like structure and no rings were effectively observed (see Plate 2).

c-2) Vertebral centra

Relatively clear rings were observed on the facet of the centra (see Plate 3).

c-3) Otoliths (lapillus)

Rings were observed in cross-sectioned slices of otoliths; they included the nucleus but were not clear (see Plate 5). Otoliths were located in capsules so highly ossified that it was extremely difficult to extract samples.

c-4) Opercles

No ring could be observed in opercles (see Plate 6).

The above results led to the selection of vertebral centra, which exhibited relatively clear rings, as a age character.

(d) Pescada branca *Plagioscion squamosissimus*

d-1) Vertebral centra

No rings were observed on the facet of the centra (see Plate 3).

d-2) Scales

This species has ctenoid scales and their ridges were indeed observed, but the disturbances on the ridge lines used as a standard in counting were not clear (see Plate 4).

d-3) Otoliths (sagitta)

Rather unclear rings were observed in cross-sectioned slices of otoliths including the nucleus (see Plate 5). Otolith capsules were not so ossified as to make difficult the extraction of otoliths, which were large in size.

d-4) Opercles

No ring could be observed in opercles (see Plate 6).

The results described above led to the selection of otoliths as a age character, even if not exhibiting very clear rings. Scales were also sampled as a complement, although their rings were not very clear either.

(e) Pescada amarela *Cynoscion acoupa*

e-1) Vertebral centra

No rings were observed on the facet of the centra (see Plate 3).

e-2) Scales

This species has ctenoid scales and their ridges were indeed observed, but the disturbances on the ridge lines used as a standard in counting were not clear (see Plate 4).

e-3) Otoliths (sagitta)

Rather unclear rings were observed in cross-sectioned slices of otoliths including the nucleus (see Plate 5). Otolith capsules were not so ossified as to make difficult the extraction of otoliths, which were large in size.

e-4) Opercles

No ring could be observed in opercles (see Plate 6).

Otoliths were selected as age characters, for reasons explained above. Scales were also sampled as a complemental age character, although their rings were not very clear either.

(f) Pescadinha gó *Macrodon ancylodon*

f-1) Vertebral centra

No rings were observed on the facet of the centra (see Plate 3).

f-2) Scales

This species has cycloid scales and their ridges were indeed observed, but the disturbances on the ridge lines used as a standard in counting were not clear (see Plate 4). Also, scales had mostly fallen from the frozen fish samples.

f-3) Otoliths (sagitta)

Rather unclear rings were observed in cross-sectioned slices of otoliths including the nucleus (see Plate 5). Otolith capsules were not so ossified as to make difficult the extraction of otoliths, which were large in size.

f-4) Opercles

No ring could be observed in opercles (see Plate 6).

Otoliths were selected as age characters, for reasons explained above. Scales were also sampled as a complement, although their rings were not very clear either.

(g) Gurijuba *Arius parkeri*

g-1) Spines

Rather clear rings could be observed in cross-sectioned slices of spines, but the central core of the spine was an empty space (see Plate 2).

g-2) Vertebral centra

Relatively clear rings were observed on the facet of the centra (see Plate 3).

g-3) Otoliths (lapillus)

Rings were observed in cross-sectioned slices of otoliths; they included the nucleus but were not clear (see Plate 5). Otoliths were located in capsules so highly ossified that it was extremely difficult to extract samples.

g-4) Opercles

No ring could be observed in opercles (see Plate 6).

The above results led to the selection of vertebral centra, which exhibited relatively clear rings, as a age character.

5.2.2. Study of Fish Body Parts to Be Sampled

This section illustrates the process and results of a investigation of what part in the body of a fish would best yield vertebral centra and scales fit for age determination.

(a) Vertebral centra

Complete skeletal specimens of the vertebral column of all seven key species were prepared, one per species, and the diameter of all vertebrae measured. To avoid errors of difference in vertebral size due to the part of the body to be sampled, a preliminary study was conducted. Color photographs of prepared vertebral column skeletons are shown in the Appendix, Plate 7. Although vertebral centra were not chosen for age determination in the three species of Sciaenidae as explained above, data for those fishes are here presented so as to put a centrum diameter – fish body length relationship to practical use in the near future.

a-1) Piramutaba *Brachyplatystoma vaillantii*

Centrum diameter measurements are shown in Figure 64. It was possible to measure diameters from the 5th visible anterior vertebra on. There was a general tendency for centrum diameters to decrease anteroposteriorly along the vertebral column. Vertebrae from the 10th to the 20th presented little variation in diameter and were chosen as samples for age determination.

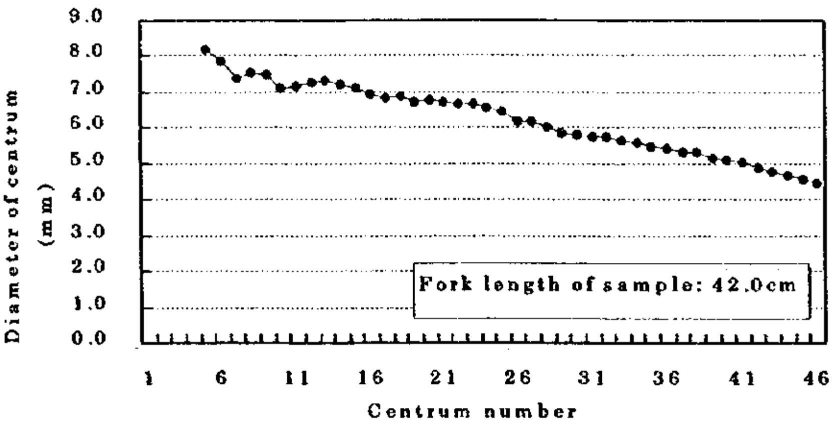


Figure 64. Centrum diameter measurements for Piramutaba *Brachyplatystoma vaillantii.*

a-2) Dourada *Brachyplatystoma flavicans*

Centrum diameter measurements are shown in Figure 65. It was possible to measure diameters from the 5th visible anterior vertebra on. Vertebrae from the 10th to the 20th presented little variation in diameter; from the 21st on it decreased gradually toward the tail. Therefore, those from the 10th to the 20th were chosen as samples for age determination.

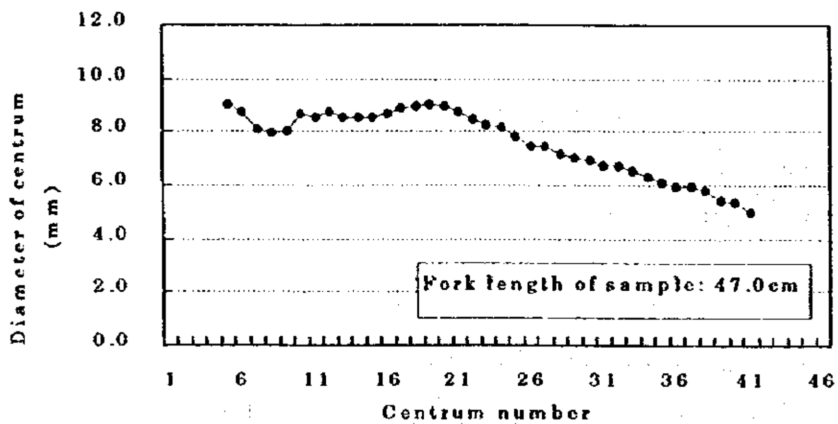


Figure 65. Centrum diameter measurements for Dourada *Brachyplatystoma flavicans.*

a-3) Filhote *Brachyplatystoma filamentosum*

Centrum diameter measurements are shown in Figure 66. It was possible to measure diameters from the 5th visible anterior vertebra on. Much like in dourada, vertebrae from the 9th to the 20th presented little variation in diameter; from the 21st on it decreased gradually toward the tail. Therefore, those from the 10th to the 20th were chosen as samples for age determination.

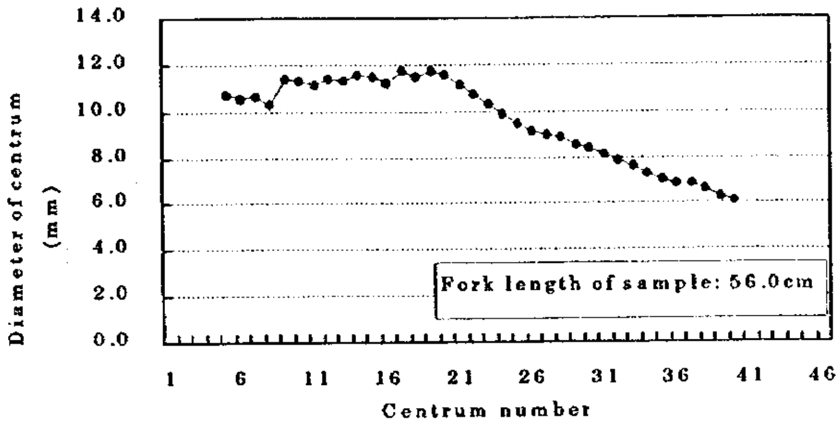


Figure 66. Centrum diameter measurements for Filhote *Brachyplatystoma filamentosum*.

a-4) Pescada branca *Plagioscion squamosissimus*

Centrum diameter measurements are shown in Figure 67. It was possible to measure diameters from the 4th anterior vertebra on. Vertebrae from the 11th to the 20th presented little variation in diameter; from the 21st on it decreased gradually toward the tail. Therefore, those around the 15th were chosen as samples.

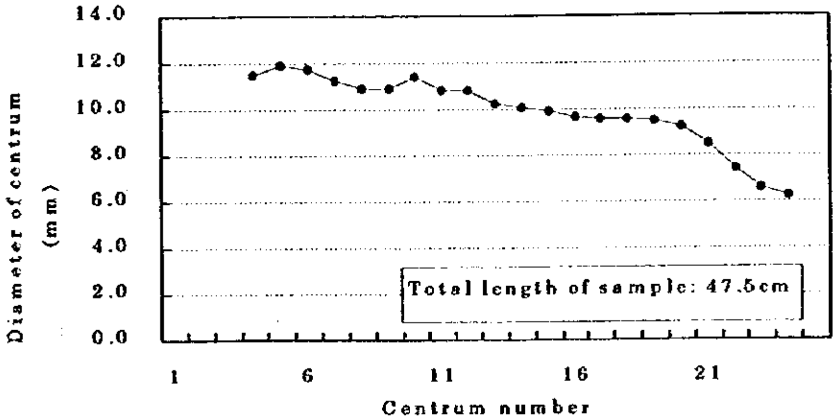


Figure 67. Centrum diameter measurements for Pescada branca *Plagioscion squamosissimus*.

a-5) Pescada amarela *Cynoscion acoupa*

Centrum diameter measurements are shown in Figure 68. It was possible to measure diameters from the 1st anterior vertebra on. Vertebrae from the 11th to the 19th presented little variation in diameter; from the 20th on it decreased gradually toward the tail. Therefore, those around the 15th were chosen as samples.

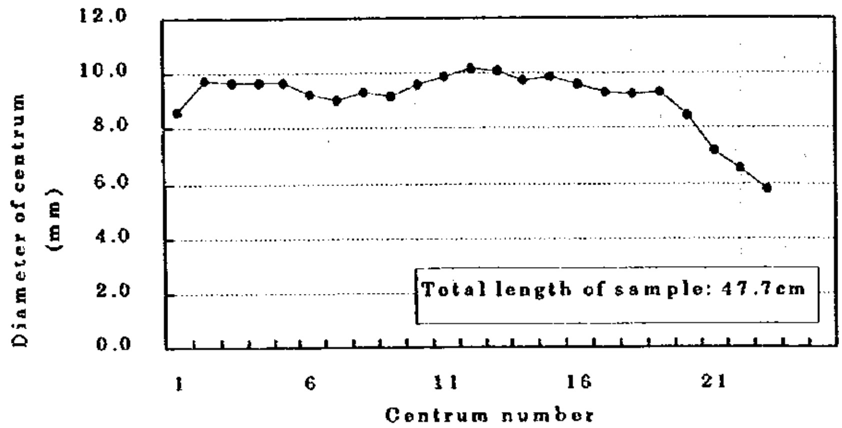


Figure 68. Centrum diameter measurements for Pescada amarela *Cynoscion acoupa*.

a-6) Pescadinha gó *Macrodon ancylodon*

Centrum diameter measurements are shown in Figure 69. It was possible to measure diameters from the 2nd anterior vertebra on. Vertebrae from the 2nd to the 14th presented little variation in diameter; from the 15th on it decreased gradually toward the tail. Therefore, those around the 10th were chosen as samples.

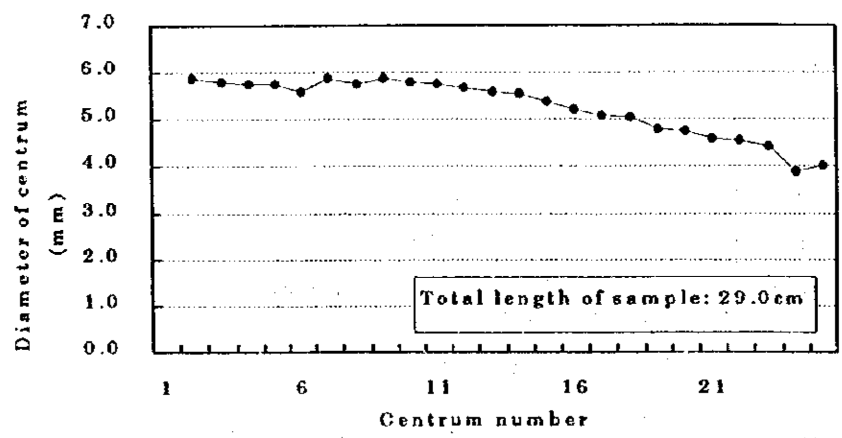


Figure 69. Centrum diameter measurements for Pescadinha gó *Macrodon ancylodon*.

a-7) Gurijuba *Arius parkeri*

Centrum diameter measurements are shown in Figure 70. It was possible to measure diameters from the 1st visible anterior vertebra on. A tendency was observed for vertebrae to gradually decrease in size toward the tail. Those from the 10th to the 20th presented little variation in diameter and were chosen as samples for age determination.

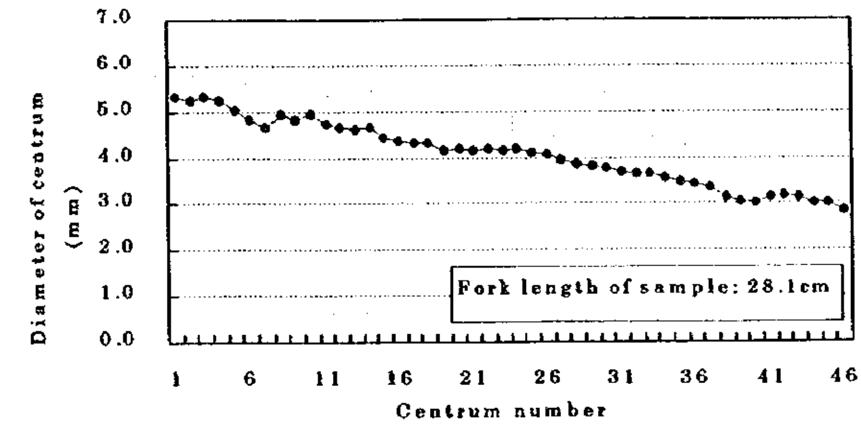


Figure 70. Centrum diameter measurements for Gurijuba *Arius parkeri*.

(b) Scales

The scaly body flank (primarily on the left side) of the three species of Sciaenidae was divided in six regions (Figures 71–73, A–F) to be compared for sampling. Nevertheless, as the specimens used in this investigation came from either fish markets or trawl catches obtained in the Sea-Borne Survey, often scales were found removed by physical contact, which resulted in that scales were not always collected from all the six established regions. Optimal sampling regions determined by this investigation are presented below. Color photographs of scale specimens from all three sciaenids are illustrated in the Appendix, Plate 4. For reasons explained previously, scales were preserved in the laboratory to complement otoliths in the investigation of age determination.

b-1) Pescada branca *Plagioscion squamosissimus*

Comparing scales from regions B and D (Figure 71), it was found out that scales rarely fell off in B and were larger than those in D. Therefore, region B was selected for sampling of scales.

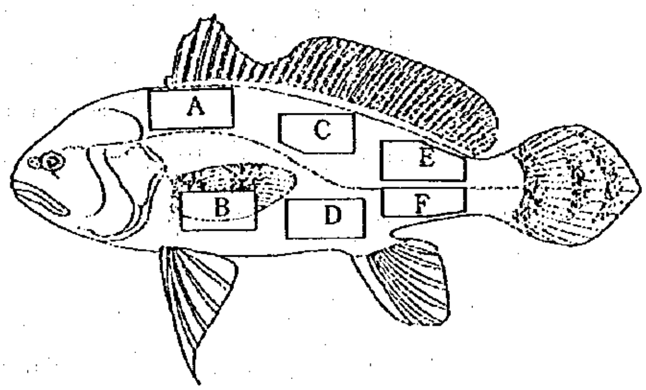


Figure 71. Scale sampling regions for Pescada branca *Plagioscion squamosissimus*.

b-2) Pescada amarela *Cynoscion acoupa*

Comparing scales from regions A, B and C (Figure 72), it was found out that scales in B were larger and remained intact in relatively large numbers. Therefore, region B was selected for sampling of scales.

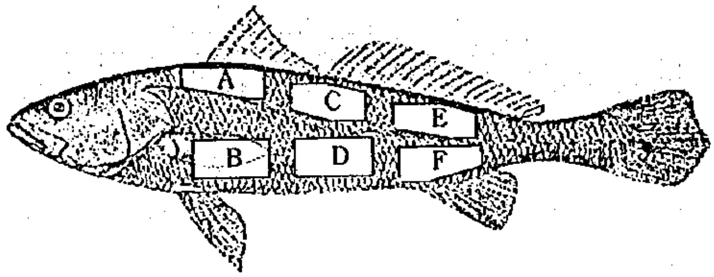


Figure 72. Scale sampling regions for Pescada amarela *Cynoscion acoupa*.

b-3) Pescadinha gó *Macrodon ancylodon*

Scales in this species were much more prone to fall off than in the other two. Regions where remaining scales could be often found were A, B, E and F (Figure 73); of these, B had larger and less deciduous scales. Therefore, region B was selected for sampling of scales.

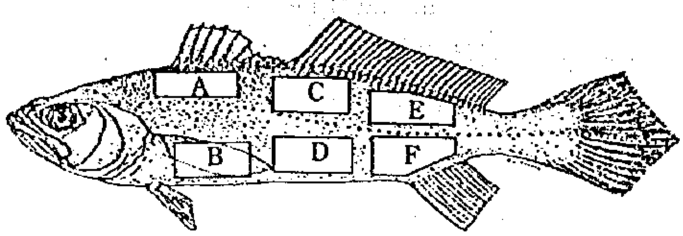


Figure 73. Scale sampling regions for Pescadinha gó *Macrodon ancylodon*.

5.2.3. Relationship Between Size of Age Characters and Body Length

The age determination by using hard anatomical structures (vertebral centra, scales, otoliths and the like) as age characters necessitates the relationship of those characters size to the body length of the fish be firmly established. Therefore, the relationship between the characters size and the body length (either fork length or total length) was examined for each fish species from samples obtained during the Sea-Borne Survey in the Phase 1 Dry Season and Phase 2 Rainy and Dry Seasons.

Analysis of such a relationship was done by calculating a linear regression equation and an exponential regression equation: of two equations, the one with both a high correlation coefficient (r) and good fitness with the distribution trend of measured values was picked.

(a) Piramutaba *Brachyplatystoma vaillantii*

Vertebral centra were chosen as age characters in piramutaba. Fork length range for 947 specimens was 76–670 mm, vertebral centrum radius range was 0.5–7.9 mm. The two equations expressing the relationship between those two values were:

FL = 85.13 R + 75.50	(r = 0.988)	linear regression equation
FL = 143.41 $R^{0.784}$	(r = 0.993)	exponential regression equation (chosen)

where FL : fork length (mm)
R : vertebral centrum radius (mm)
r : correlation coefficient

Correlation coefficient was over 0.9 for two equations, and none would yield much error if used to estimate body length from vertebral centrum radius. For this species, the exponential regression equation was chosen because of its higher correlation coefficient.

Figure 74 shows the relationship between vertebral centrum radius and body length expressed through the exponential regression equation, within a 95% confidence interval.

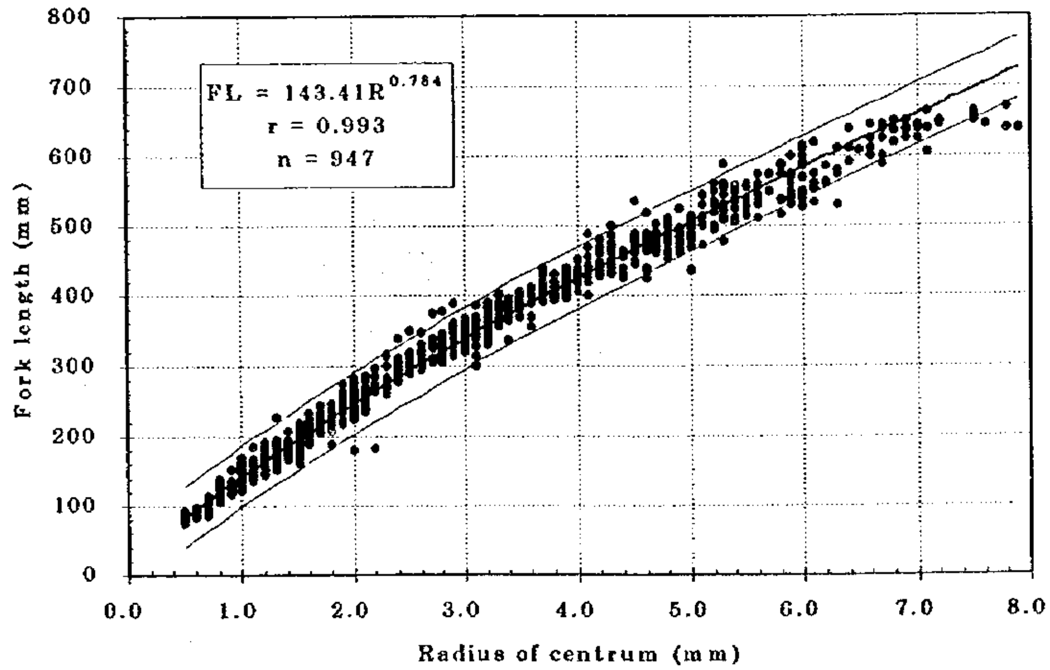


Figure 74. Relationship between vertebral centrum radius and fork length in Piramutaba *Brachyplatystoma vaillantii*.

(b) Dourada *Brachyplatystoma flavicans*

(b) Dourada *Brachyplatystoma flavicans*

Vertebral centra were chosen as age characters in dourada. Fork length range for 802 specimens was 61–835 mm, vertebral centrum radius range was 0.3–9.5 mm. The two equations expressing the relationship between those two values were:

$FL = 89.35\,R + 90.30$	$(r = 0.980)$	linear regression equation
$FL = 147.49\,R^{0.809}$	$(r = 0.990)$	exponential regression equation (chosen)

where FL : fork length (mm)

R : vertebral centrum radius (mm)

r : correlation coefficient

Correlation coefficient was over 0.9 for two equations, and none would yield much error if used to estimate body length from vertebral centrum radius. For this species, the exponential regression equation was chosen because of its higher correlation coefficient.

Figure 75 shows the relationship between vertebral centrum radius and body length expressed through the exponential regression equation, within a 95% confidence interval.

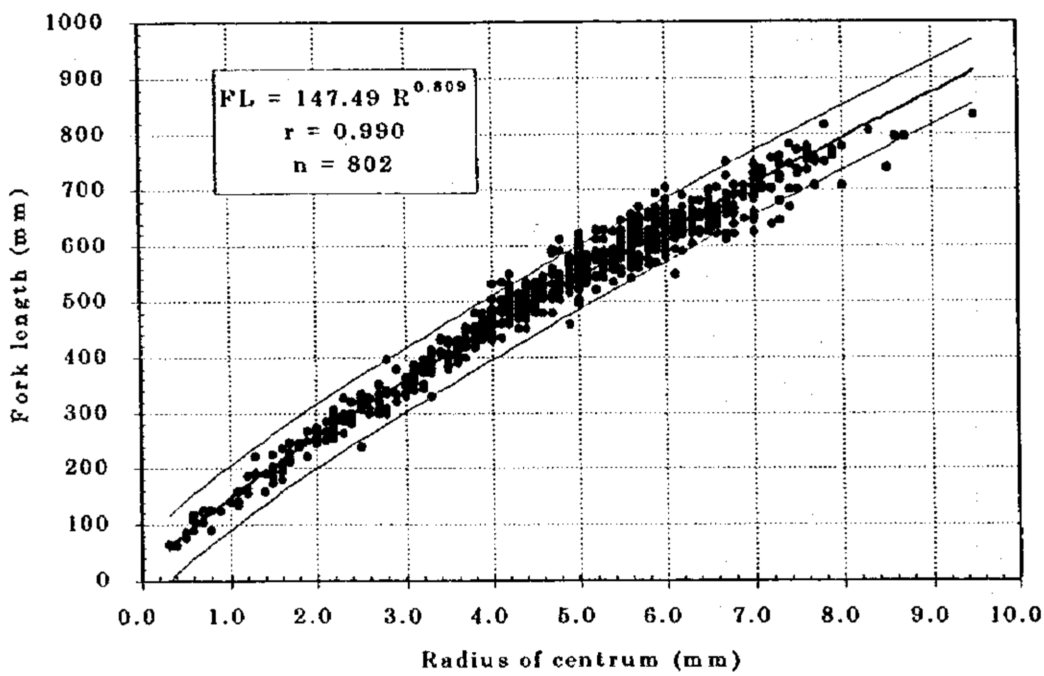


Figure 75. Relationship between vertebral centrum radius and fork length in Dourada *Brachyplatystoma flavicans.*

(c) Filhote *Brachyplatystoma filamentosum*

Vertebral centra were chosen as age characters in filhote. Fork length range for 16 specimens was 140–670 mm, vertebral centrum radius range was 1.2–6.9 mm. The two equations expressing the relationship between those two values were:

FL = 87.83 R + 65.24	(r = 0.983)	linear regression equation
FL = 129.14 $R^{0.853}$	(r = 0.987)	exponential regression equation (chosen)

where FL : fork length (mm)
R : vertebral centrum radius (mm)
r : correlation coefficient

Correlation coefficient was over 0.9 for two equations, and none would yield much error if used to estimate body length from vertebral centrum radius. For this species, the exponential regression equation was chosen because of its higher correlation coefficient.

Figure 76 shows the relationship between vertebral centrum radius and body length expressed through the exponential regression equation, within a 95% confidence interval.

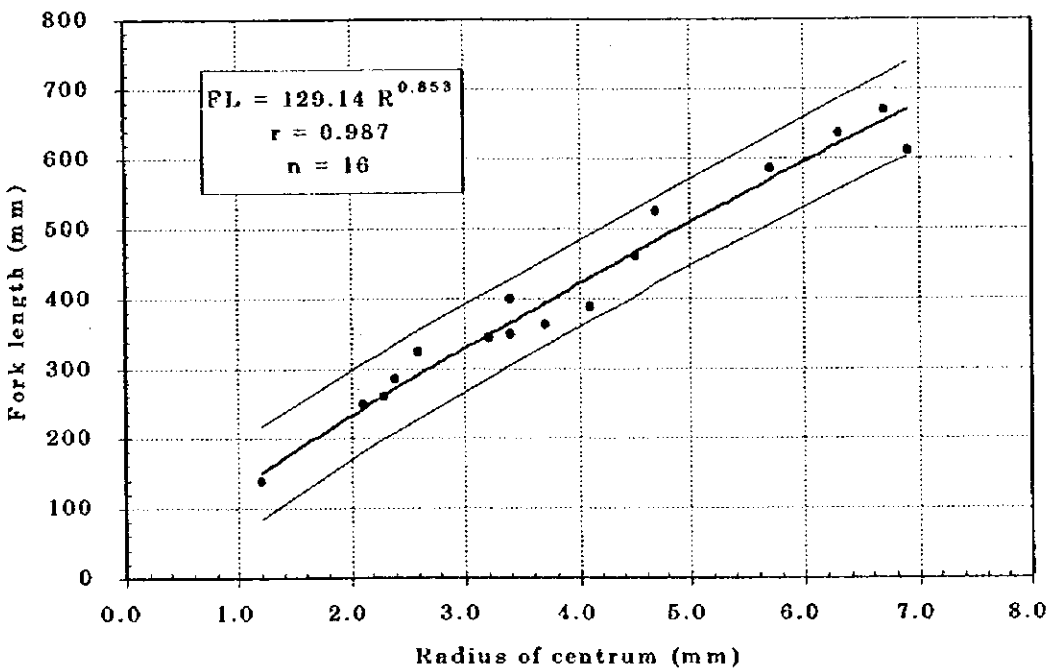


Figure 76. Relationship between vertebral centrum radius and fork length in Filhote *Brachyplatystoma filamentosum*.

(d) Pescada branca *Plagioscion squamosissimus*

Otoliths were chosen as age characters in pescada branca. Total length range for 82 specimens was 63–672 mm, otolith radii range was 0.6–9.5 mm for R_1, 0.8–10.0 mm for R_2 and 1.0–11.0 mm for R_3 (for R_1, R_2 and R_3, see Figure 6). The two equations expressing the relationship between total length and the three radii were, respectively:

For R_1:

$TL = 92.58\ R_1 + 31.29$	(r = 0.939)	linear regression equation
$TL = 104.85\ R_1^{\ 0.982}$	(r = 0.971)	exponential regression equation

For R_2:

$TL = 82.87\ R_2 - 1.30$	(r = 0.962)	linear regression equation
$TL = 74.51\ R_2^{\ 1.064}$	(r = 0.979)	exponential regression equation (chosen)

For R_3:

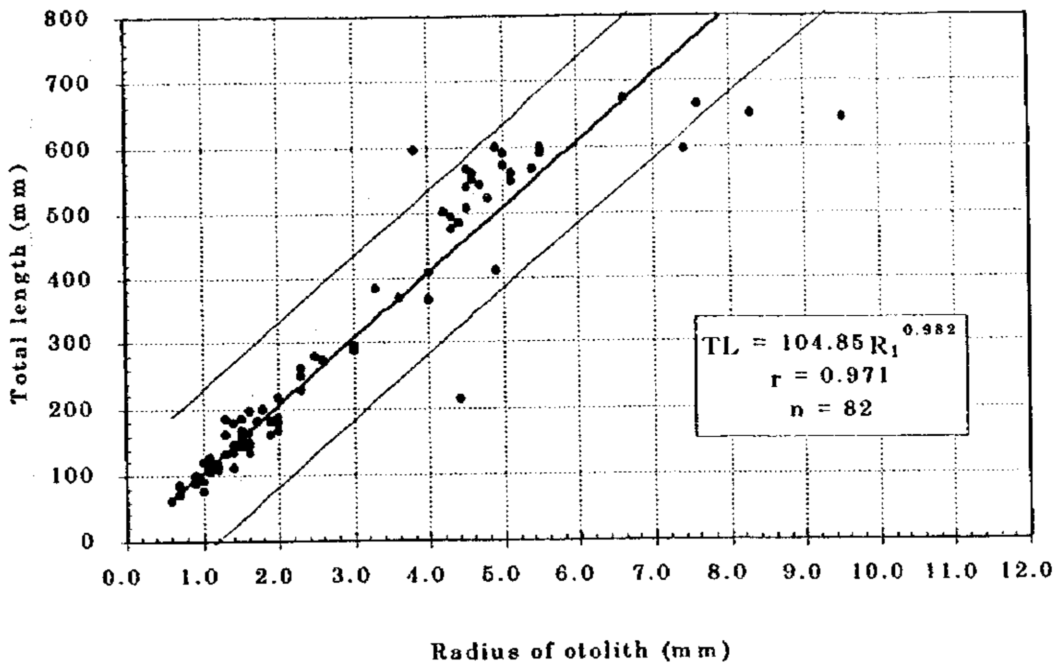
$TL = 79.02\ R_3 - 46.72$	(r = 0.967)	linear regression equation
$TL = 47.94\ R_3^{\ 1.210}$	(r = 0.977)	exponential regression equation

where TL : total length (mm)
R_{1-3} : otolith radii (mm)
r : correlation coefficient.

Correlation coefficient was over 0.9 for two equations for R_1, R_2 and R_3, and none would yield much error if used to estimate body length from otolith radii. The exponential regression equations are similar to the linear regression because the exponents are near 1. For this species, the exponential regression equation was chosen because of its higher correlation coefficient for R_1, R_2, and R_3.

Figure 77 shows the relationship between each otolith radius and body length expressed through the exponential regression equation, within a 95% confidence interval. Of those, R_2 had the highest correlation coefficient and was therefore picked (Figure 77, B).

(A)



(B)

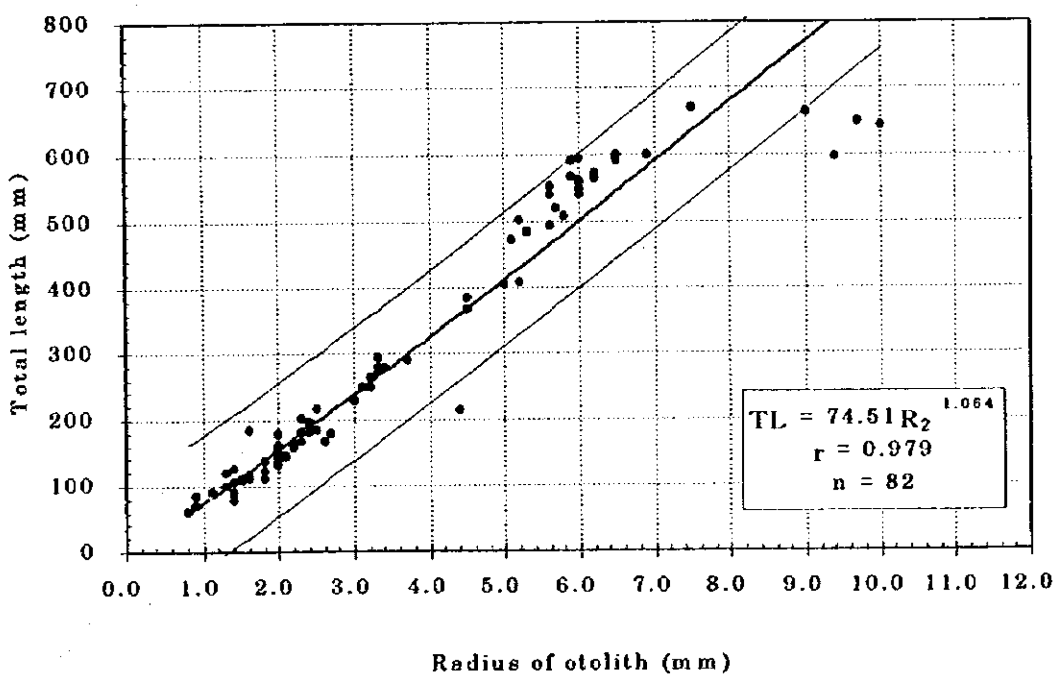
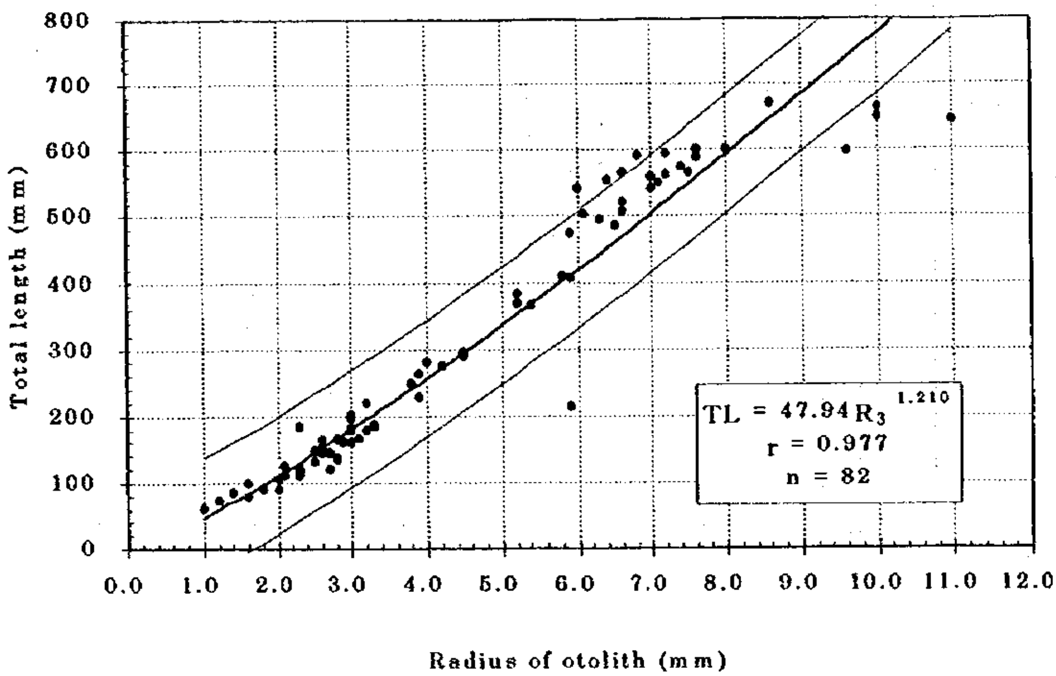


Figure 77. Relationship between otolith radii and total length in Pescada branca *Plagioscion squamosissimus*. (A) for radius R_1; (B) for radius R_2; (C) for radius R_3.

Figure 77. Continued

(C)



(e) Pescada amarela *Cynoscion acoupa*

Otoliths were chosen as age characters in pescada amarela. Total length range for 54 specimens was 640–1,180 mm, otolith radii range was 1.8–5.5 mm for R_1, 2.5–8.0 mm for R_2 and 4.0–9.0 mm for R_3 (for R_1, R_2 and R_3, see Figure 6). The two equations expressing the relationship between the three radii and total length were, respectively, as below.

For this species, no specimen under 600 mm was caught. Because the sample was biased toward relatively large individuals, the correlation coefficient was lower than in the other six species. Observations were made under such conditions.

For R_1:

$TL = 98.16\ R_1 + 614.53$	($r = 0.630$)	linear regression equation
$TL = 587.20\ R_1^{\ 0.396}$	($r = 0.687$)	exponential regression equation

For R_2:

$TL = 74.03\ R_2 + 572.04$	($r = 0.649$)	linear regression equation
$TL = 469.72\ R_2^{\ 0.435}$	($r = 0.694$)	exponential regression equation (chosen)

For R_3:

$TL = 77.52\ R_3 + 446.62$	($r = 0.659$)	linear regression equation
$TL = 317.98\ R_3^{\ 0.586}$	($r = 0.697$)	exponential regression equation

where TL : total length (mm)

R_{1-3} : otolith radii (mm)

r : correlation coefficient.

Correlation coefficient was under 0.7 for two equations for R_1, R_2, and R_3. For this species, the exponential regression equation was chosen because of its higher correlation coefficient for R_1, R_2, and R_3.

Figure 78 shows the relationship between each otolith radius and body length expressed through the exponential regression equation, within a 95% confidence interval. Of those, R_2 showed a relatively good fit between the two variables and was therefore picked (Figure 78, B).

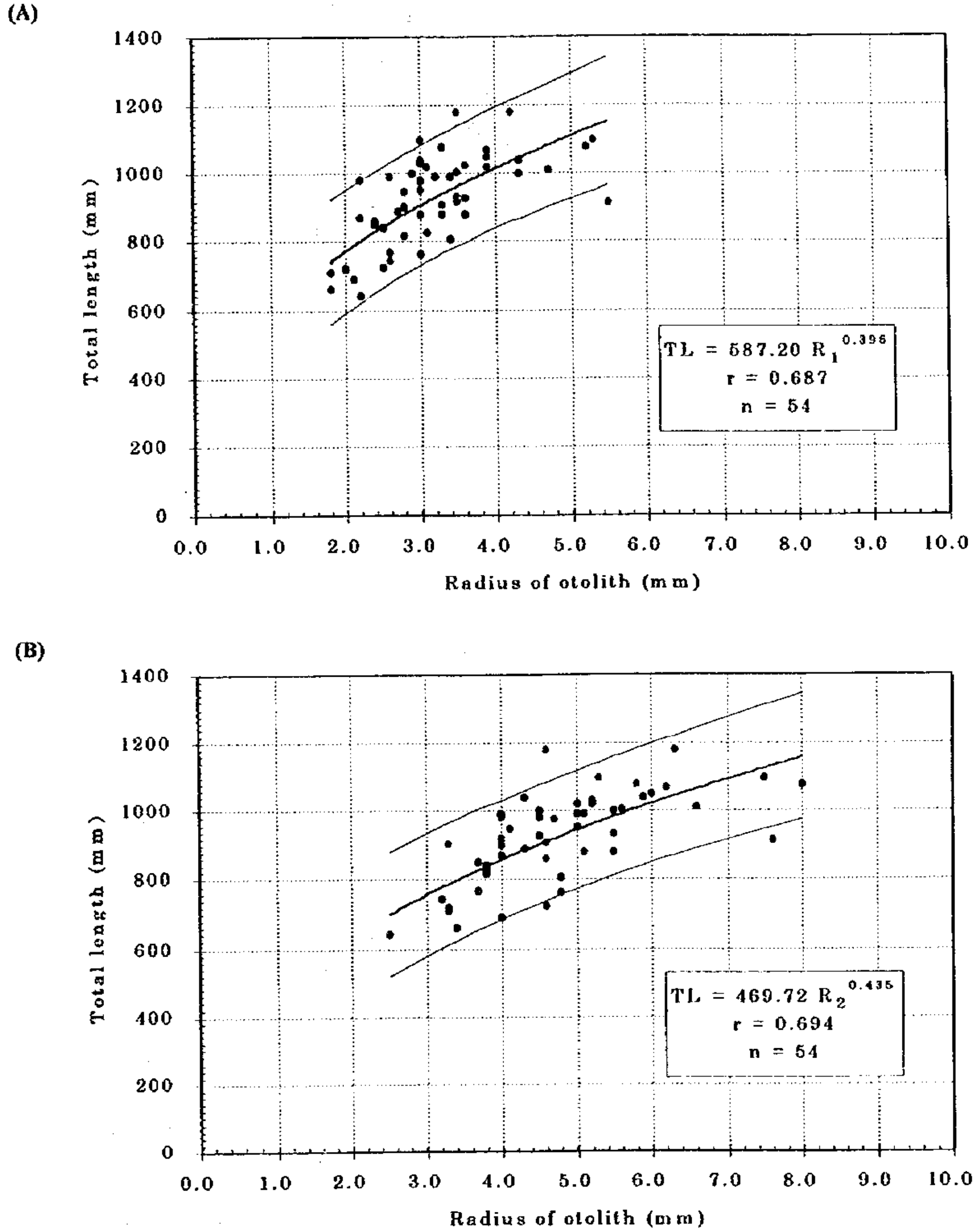
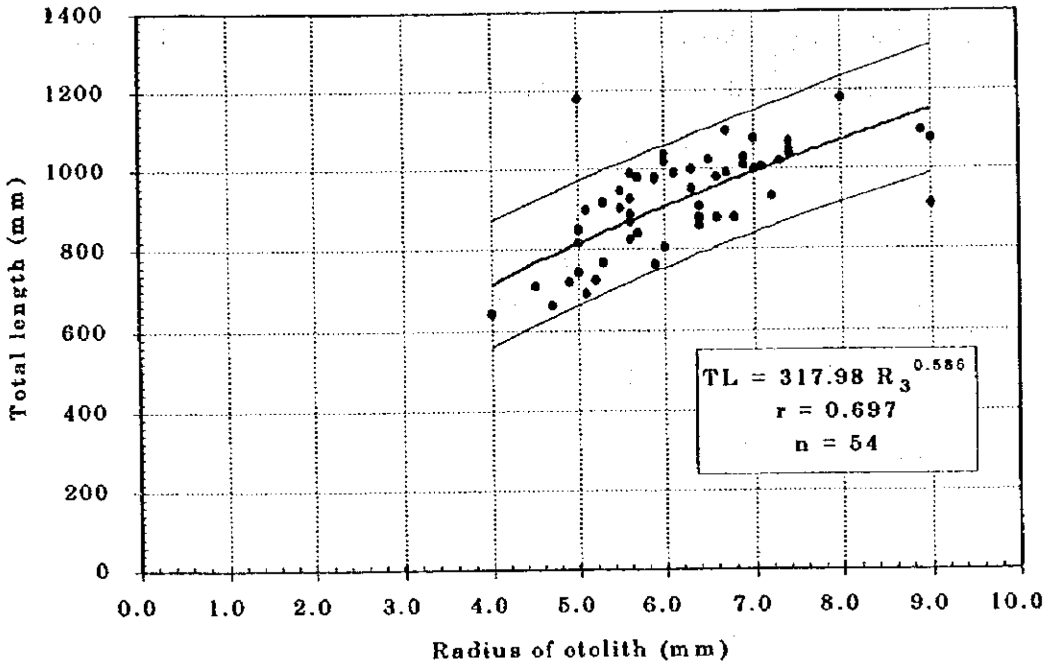


Figure 78. Relationship between otolith radii and total length in Pescada amarela *Cynoscion acoupa*. (A) for radius R_1; (B) for radius R_2; (C) for radius R_3.

Figure 78. Continued

(C)



(f) Pescadinha gó *Macrodon ancylodon*

Otoliths were chosen as age characters in pescadinha gó. Total length range for 103 specimens was 85–370 mm, otolith radii range was 0.4–1.8 mm for R_1, 0.9–3.1 mm for R_2 and 1.5–4.1 mm for R_3 (for R_1, R_2 and R_3, see Figure 6). The two equations expressing the relationship between the three radii and total length were, respectively, as follows.

This species attains a smaller size than the other two Sciaenidae described above and therefore had smaller otoliths.

For R_1:

$TL = 73.58\ R_1 + 124.55$	($r = 0.485$)	linear regression equation
$TL = 197.54\ R_1^{0.417}$	($r = 0.587$)	exponential regression equation

For R_2:

$TL = 78.65\ R_2 + 44.84$	($r = 0.691$)	linear regression equation
$TL = 118.97\ R_2^{0.743}$	($r = 0.694$)	exponential regression equation (chosen)

For R_3:

$TL = 76.05\ R_3 - 3.09$	($r = 0.743$)	linear regression equation
$TL = 74.18\ R_3^{0.992}$	($r = 0.756$)	exponential regression equation

where TL : total length (mm)
R_{1-3} : otolith radii (mm)
r : correlation coefficient.

Correlation coefficient was 0.485–0.756 for two equations for R_1, R_2, and R_3. For this species, the exponential regression equation was chosen because of its higher correlation coefficient for R_1, R_2, and R_3.

Figure 79 shows the relationship between each otolith radius and body length expressed through the exponential regression equation, within a 95% confidence interval. Of those, the relatively convenient R_2 was chosen like it happened with the two other species of sciaenids (Figure 79, B).

(A)

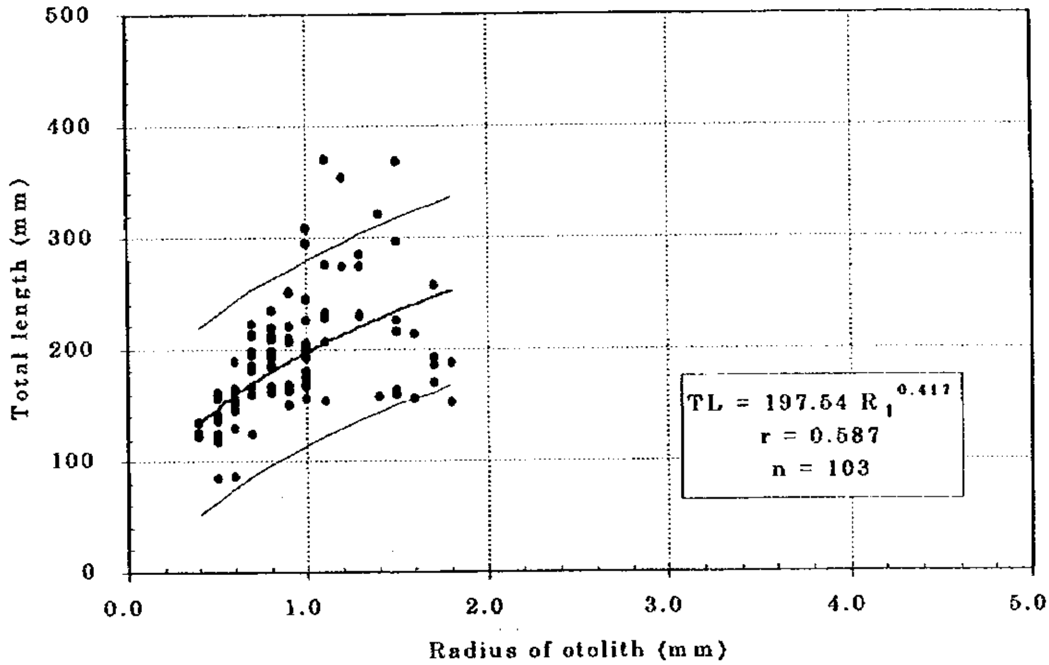
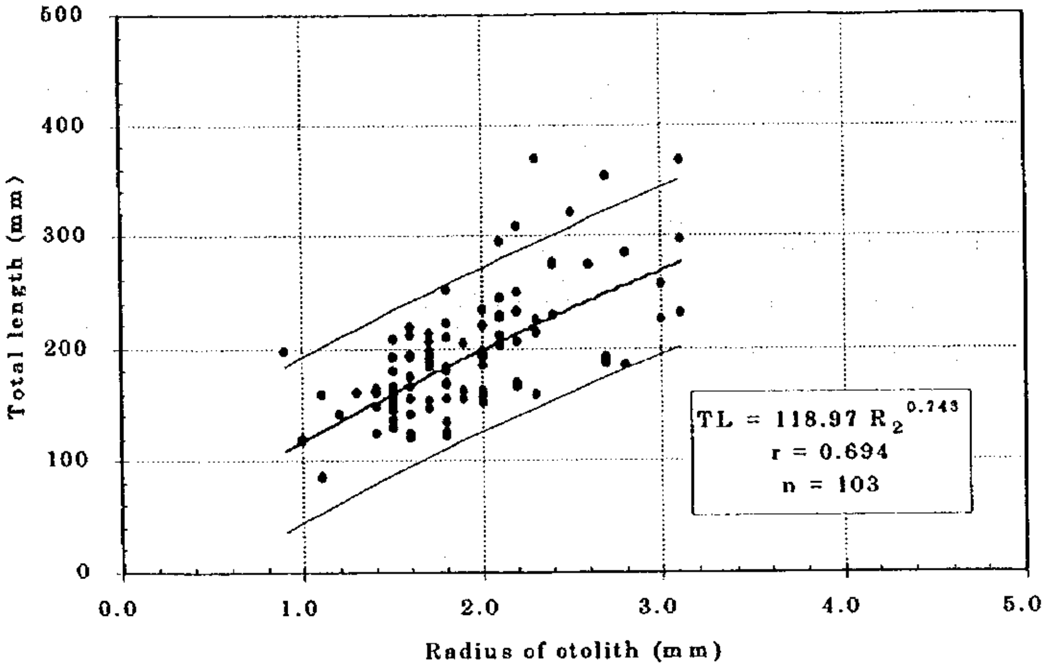


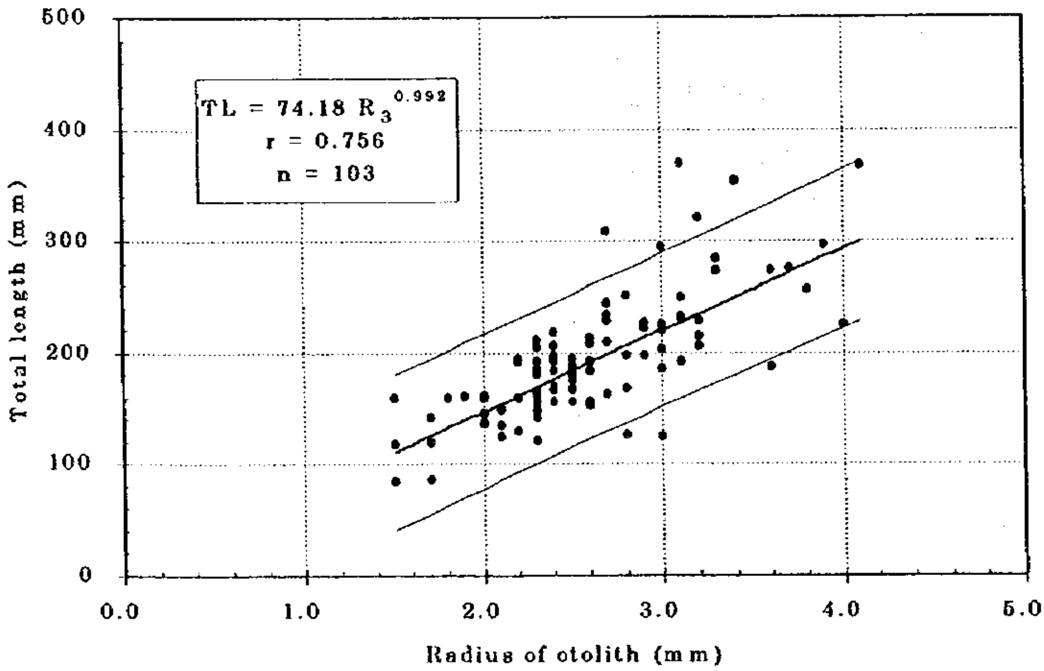
Figure 79. Relationship between otolith radii and total length in Pescadinha gó *Macrodon ancylodon*. (A) for radius R_1; (B) for radius R_2; (C) for radius R_3.

Figure 79. Continued

(B)



(C)



(g) Gurijuba *Arius parkeri*

Vertebral centra were chosen as age characters in piramutaba. Fork length range for 973 specimens was 124–1,325 mm, vertebral centrum radius range was 0.7–17.0 mm. The two equations expressing the relationship between those two values were:

$FL = 76.35\ R + 113.20$	$(r = 0.982)$	linear regression equation
$FL = 145.62\ R^{0.769}$	$(r = 0.986)$	exponential regression equation (chosen)

where FL : fork length (mm)
R : vertebral centrum radius (mm)
r : correlation coefficient

Correlation coefficient was over 0.9 for two equations, and none would yield much error if used to estimate body length from vertebral centrum radius. For this species, the exponential regression equation was chosen because of its higher correlation coefficient.

Figure 80 shows the relationship between vertebral centrum radius and body length expressed through the exponential regression equation, within a 95% confidence interval.

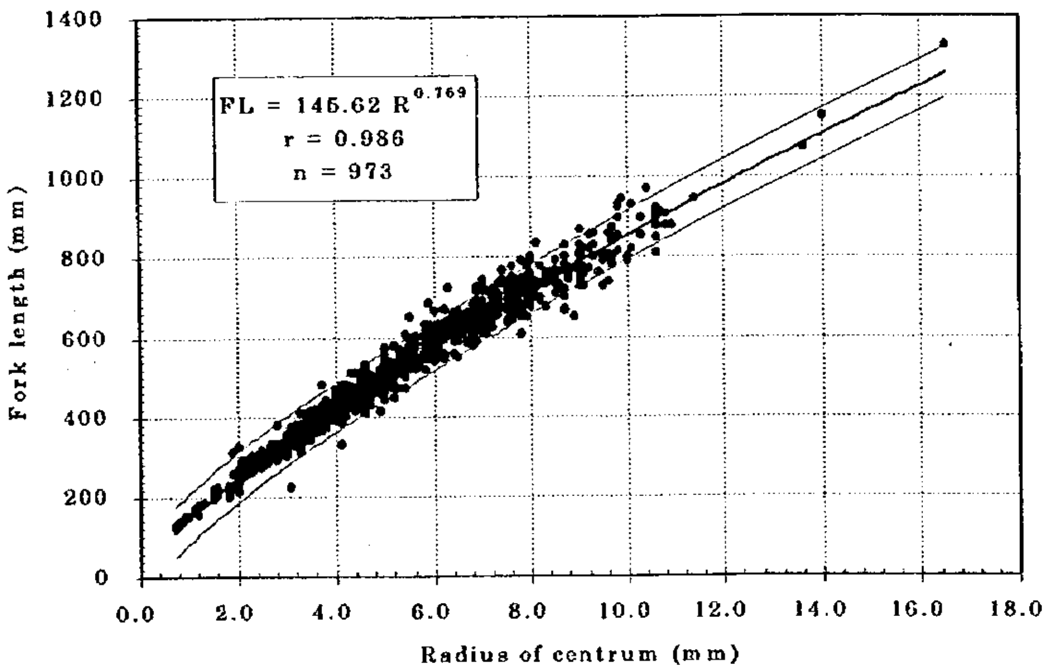


Figure 80. Relationship between vertebral centrum radius and fork length in Gurijuba *Arius parkeri*.

5.2.4. Correspondence in Ring Formation

When a given character is used for age determination, it is essential to recognize a correspondence between individuals in the features (rings) of that character. This correspondence is one of the ways of objectively judging if the reading of rings is being properly conducted. A investigation of the correspondence in ring formation was done based on measurements taken considering rings as age characters.

Of all samples collected during the Sea-Borne Survey in both the Rainy and Dry Seasons of Phase 2, some 100 individuals from each seasonal survey were picked for ring measurements, and the combined data were analyzed in search of correspondence in ring formation. For this analysis, the radius of each ring (r_1, r_2 ... r_n) was first plotted against the radius R of the character (vertebral centrum) for each ring group; then a regression line for the distribution of those values was calculated as passing through the origin of the coordinates, and its relationship to ring formation established. Mean values of ring radii and their standard deviation were respectively tabulated for each ring group.

Otoliths were used for age character in sciaenids, and as previously explained otolith radii from the nucleus to R_2 were measured. As rings could not be seen clearly in R_2, values for the latter were extrapolated from radius measurements of clearly visible R_0 rings.

Because of individual variation in the clarity of rings on vertebral centra and otoliths, it cannot be said that all rings were read following the same criterion. Therefore, depending on the person, rings were not always read in the same way. Although, there are some problems notice above, it can be deduced from the above procedures that no correspondence between individuals in ring formation and considerable individual variation in ring formation for 7 key species could be recognized.

The results for correspondence in ring formation by each species are as follows.

(a) Piramutaba *Brachyplatystoma vaillantii*

Ring readings were possible in 232 specimens of piramutaba vertebral centra. Figure 81 summarizes the relationship between radius of vertebral centrum and radius of ring for each ring group in this species. Table 66 shows mean values and their standard deviation of ring radius by ring group. Many of ring radius values

Table 66. Mean values and standard deviation of ring radius by ring group for Piramutaba *Brachyplatystoma vaillantii*.

Ring group	N*	Mean radius of ring in centrum (mm)								
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9
R1	7	0.61 ± 0.16								
R2	42	0.47 ± 0.14	0.81 ± 0.31							
R3	47	0.60 ± 0.19	1.04 ± 0.38	1.58 ± 0.58						
R4	53	0.70 ± 0.18	1.14 ± 0.29	1.69 ± 0.45	2.44 ± 0.63					
R5	34	0.79 ± 0.33	1.21 ± 0.44	1.67 ± 0.64	2.27 ± 0.87	2.93 ± 1.16				
R6	26	1.00 ± 0.28	1.45 ± 0.36	2.13 ± 0.53	2.85 ± 0.65	3.59 ± 0.76	4.30 ± 1.09			
R7	11	0.80 ± 0.33	1.16 ± 0.33	1.68 ± 0.39	2.08 ± 0.52	2.69 ± 0.59	3.47 ± 0.82	4.25 ± 1.03		
R8	10	0.98 ± 0.24	1.32 ± 0.25	1.64 ± 0.29	2.14 ± 0.39	2.62 ± 0.48	3.29 ± 0.49	4.02 ± 0.58	4.71 ± 0.69	
R9	2	0.65 ± 0.05	1.25 ± 0.05	1.65 ± 0.05	2.15 ± 0.05	2.55 ± 0.25	3.00 ± 0.30	3.55 ± 0.45	4.05 ± 0.55	4.95 ± 0.05
Mean±SD		0.70 ± 0.26	1.12 ± 0.38	1.72 ± 0.54	2.42 ± 0.71	3.06 ± 0.96	3.90 ± 0.97	4.09 ± 0.77	4.60 ± 0.67	4.95 ± 0.05
N*		232	225	183	136	83	49	23	12	2

N*: Number of specimen

had a scattered distribution along their regression lines in each ring group, and standard deviation reflected a wide variation of ring radii in the individual. These results indicated that the correlation between vertebral centrum and ring radii was low, in a word ring formation was not regular.

It can be deduced from the above that no correspondence between individuals in ring formation could be recognized, as there was considerable individual variation in ring formation.

(b) Dourada *Brachyplatystoma flavicans*

Ring readings were possible in 198 specimens of dourada vertebral centra. Figure 82 summarizes the relationship between radius of vertebral centrum and radius of ring for each ring group in this species. Table 67 shows mean values and their standard deviation of ring radius by ring group. Many of ring radius values had a scattered distribution along their regression lines in each ring group, and standard deviation reflected a wide variation of ring radii in the individual. These results indicated that the correlation between vertebral centrum and ring radii was low, in a word ring formation was not regular.

It can be deduced from the above that no correspondence between individuals in ring formation could be recognized, as there was considerable individual variation in ring formation.

Table 67. Mean values and standard deviation of ring radius by ring group for Dourada *Brachyplatystoma flavicans*.

Ring group	N*	Mean radius of ring in centrum (mm)										
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}
R1	1	0.50										
R2	8	0.84 ± 0.24	1.64 ± 0.46									
R3	40	0.74 ± 0.16	1.41 ± 0.43	2.39 ± 0.76								
R4	48	0.74 ± 0.17	1.33 ± 0.35	2.16 ± 0.61	3.29 ± 0.89							
R5	48	0.75 ± 0.16	1.27 ± 0.28	1.92 ± 0.41	2.82 ± 0.63	3.98 ± 0.86						
R6	25	0.76 ± 0.16	1.23 ± 0.33	1.72 ± 0.45	2.44 ± 0.62	3.56 ± 0.77	4.46 ± 0.85					
R7	18	0.73 ± 0.15	1.16 ± 0.24	1.59 ± 0.32	2.12 ± 0.38	2.94 ± 0.43	3.66 ± 0.48	4.70 ± 0.58				
R8	5	0.86 ± 0.19	1.24 ± 0.19	1.60 ± 0.20	2.22 ± 0.33	2.94 ± 0.54	3.82 ± 0.86	4.42 ± 0.90	5.00 ± 0.88			
R9	3	0.73 ± 0.18	0.97 ± 0.24	1.27 ± 0.31	1.57 ± 0.38	1.93 ± 0.29	2.93 ± 0.24	3.70 ± 0.33	4.37 ± 0.16	5.23 ± 0.11		
R10	1	0.50	0.70	1.00	1.50	2.40	2.80	3.20	4.70	5.40	6.00	
R11	1	0.60	1.20	2.20	2.50	2.80	3.30	3.50	4.10	4.90	5.80	6.80
Mean ± SD		0.75 ± 0.17	1.30 ± 0.33	2.00 ± 0.56	2.77 ± 0.76	3.55 ± 0.84	3.99 ± 0.79	4.45 ± 0.70	4.69 ± 0.63	5.20 ± 0.16	5.90 ± 0.10	6.80
N*		198	197	189	149	101	53	28	10	5	2	1

N*: Number of specimen

(c) Filhote *Brachyplatystoma filamentosum*

Ring readings were possible in 13 specimens of filhote vertebral centra. Figure 83 summarizes the relationship between radius of vertebral centrum and radius of ring for each ring group in this species. Table 68 shows mean values and their standard deviation of ring radius by ring group. Scarcity of samples prevented from investigating correspondence between individuals. In addition, in ring group R6 which comprises most samples, many of ring radius values had a scattered distribution along the regression line, and standard deviation revealed the dispersion of ring radii. These results indicated that the correlation between vertebral centrum and ring radii was low, in short ring formation was not regular. In any case, there was not enough data for establishing a correspondence between individuals in ring formation, and there is a current need to increase the sampling of this species.

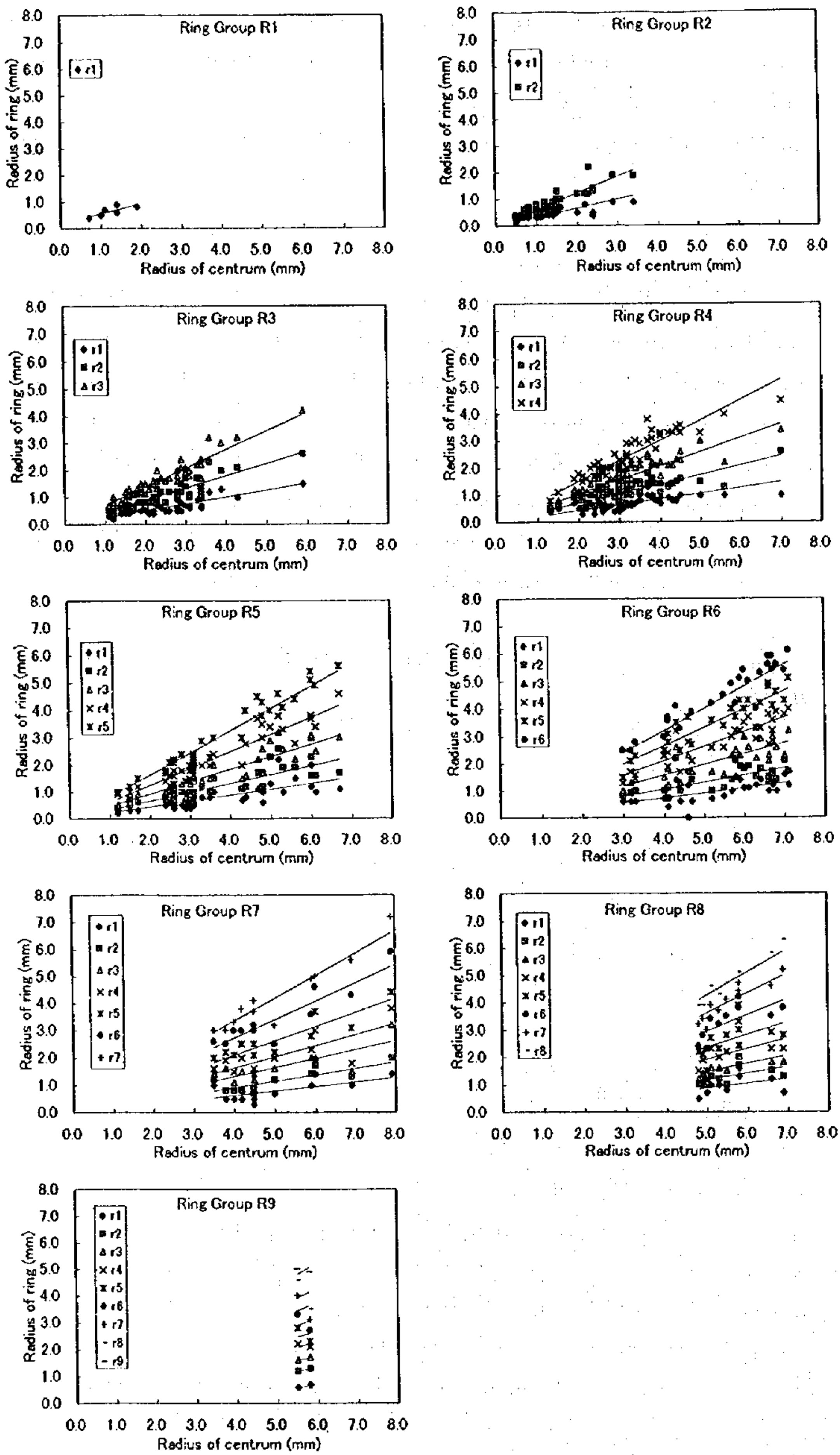


Figure 81. Relationship between vertebral centrum and ring radii by ring group in Piramutaba *Brachyplatystoma vaillantii.*

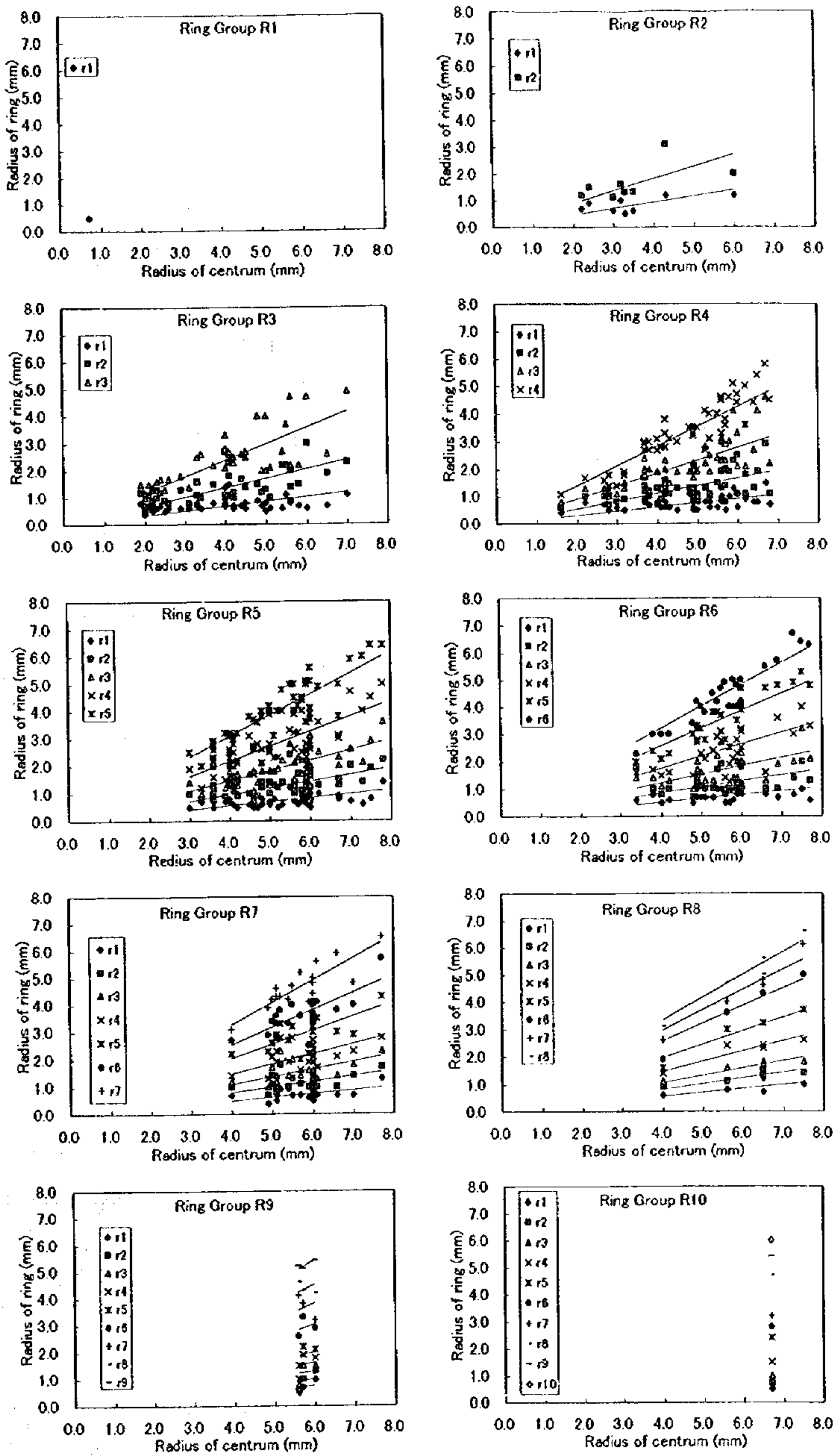


Figure 82. Relationship between vertebral centrum and ring radii by ring group in Dourada *Brachyplatystoma flavicans*.

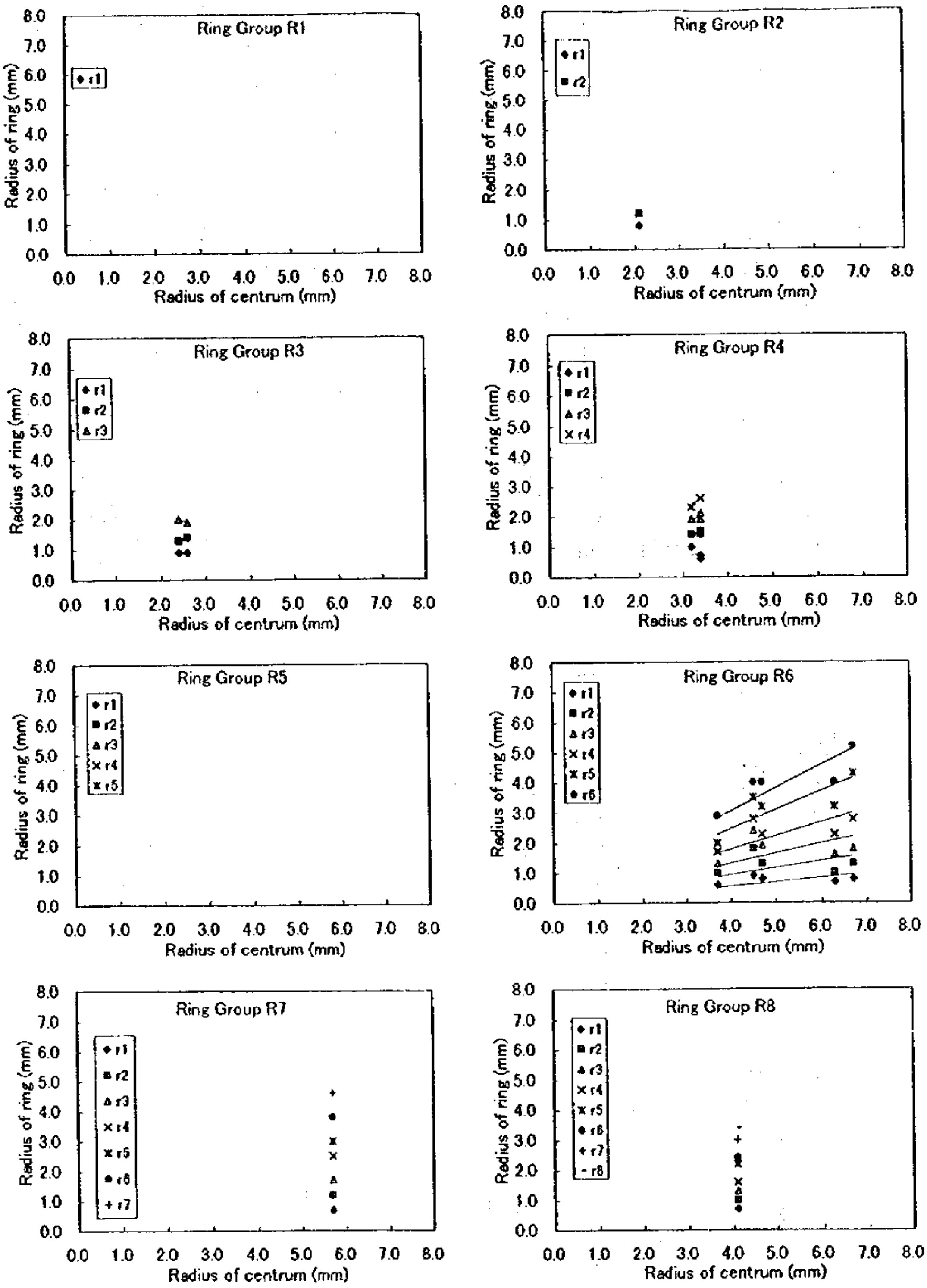


Figure 83. Relationship between vertebral centrum and ring radii by ring group in Filhote *Brachyplatystoma filamentosum*.

Table 68. Mean values and standard deviation of ring radius by ring group for Filhote *Brachyplatystoma filamentosum*.

Ring group	N*	Mean radius of ring in centrum (mm)							
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8
R1	0								
R2	1	0.80	1.20						
R3	2	0.90 ± 0.00	1.35 ± 0.05	1.95 ± 0.05					
R4	3	0.77 ± 0.16	1.43 ± 0.04	1.97 ± 0.09	2.50 ± 0.13				
R5	0								
R6	5	0.76 ± 0.09	1.28 ± 0.22	1.80 ± 0.28	2.38 ± 0.34	3.24 ± 0.53	4.02 ± 0.47		
R7	1	0.70	1.20	1.70	2.50	3.00	3.80	4.60	
R8	1	0.70	1.00	1.30	1.60	2.20	2.40	3.00	3.40
Mean ± SD		0.78 ± 0.11	1.30 ± 0.17	1.82 ± 0.23	2.35 ± 0.31	3.06 ± 0.56	3.76 ± 0.63	3.80 ± 0.80	3.40
N*		13	13	12	10	7	7	2	1

N*: Number of specimen

(d) Pescada branca *Plagioscion squamosissimus*

Ring readings were possible in 70 specimens of pescada branca otoliths. Figure 84 summarizes the relationship between radius of otolith (R_2 in figure 6) and radius of ring for each ring group in this species. Table 69 shows mean values and their standard deviation of ring radius by ring group. In ring groups R2–R10 except R7, ring radius values were generally distributed along their regression lines, and standard deviation revealed the dispersion of ring radii in each ring group.

It can be concluded from the above that, although there was a correspondence between individuals in ring formation, there was great individual variation in ring formation, and so there was no agreement in number of rings per individual for a given time period.

Table 69. Mean values and standard deviation of ring radius by ring group for Pescada branca *Plagioscion squamosissimus*.

Ring group	N*	Mean radius of ring in otolith (mm)											
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
R1	2	0.73 ± 0.04											
R2	7	0.89 ± 0.20	1.25 ± 0.25										
R3	14	0.98 ± 0.37	1.58 ± 0.42	1.93 ± 0.51									
R4	11	0.92 ± 0.28	1.52 ± 0.30	1.94 ± 0.33	2.23 ± 0.46								
R5	7	1.17 ± 0.45	1.80 ± 0.69	2.30 ± 0.81	2.89 ± 1.09	3.25 ± 1.34							
R6	10	1.13 ± 0.33	1.65 ± 0.43	2.25 ± 0.69	2.88 ± 0.97	3.34 ± 1.16	3.74 ± 1.36						
R7	3	1.36 ± 0.64	1.90 ± 0.65	2.40 ± 0.71	3.03 ± 0.87	3.62 ± 1.08	4.12 ± 1.32	4.53 ± 1.51					
R8	3	0.90 ± 0.21	1.77 ± 0.44	2.67 ± 0.82	3.65 ± 1.12	4.43 ± 1.39	5.09 ± 1.50	5.62 ± 1.69	6.19 ± 1.75				
R9	6	0.92 ± 0.24	1.68 ± 0.34	2.67 ± 0.43	3.38 ± 0.58	3.86 ± 0.68	4.69 ± 0.77	5.38 ± 0.89	5.89 ± 0.96	6.21 ± 1.05			
R10	3	1.15 ± 0.27	1.74 ± 0.34	2.34 ± 0.28	2.98 ± 0.22	3.78 ± 0.14	4.34 ± 0.18	4.70 ± 0.25	5.20 ± 0.28	5.79 ± 0.48	6.22 ± 0.56		
R11	2	0.84 ± 0.10	1.43 ± 0.08	1.82 ± 0.05	2.48 ± 0.11	2.90 ± 0.16	3.20 ± 0.09	3.62 ± 0.14	4.17 ± 0.06	4.78 ± 0.07	5.20 ± 0.10	5.56 ± 0.21	
R12	1	1.06	2.22	3.06	4.12	4.65	5.60	6.13	6.55	6.97	7.29	7.82	9.08
R13	1	2.11	2.84	3.79	4.11	4.63	5.47	6.32	6.74	7.37	8.11	8.53	8.95
Mean ± SD		1.02 ± 0.35	1.63 ± 0.46	2.22 ± 0.66	2.89 ± 0.89	3.61 ± 1.06	4.26 ± 1.11	5.08 ± 1.08	5.70 ± 1.08	6.04 ± 0.91	6.35 ± 0.97	6.86 ± 1.31	9.02 ± 0.07
N*		70	68	61	47	36	29	19	16	13	7	4	2

N*: Number of specimen

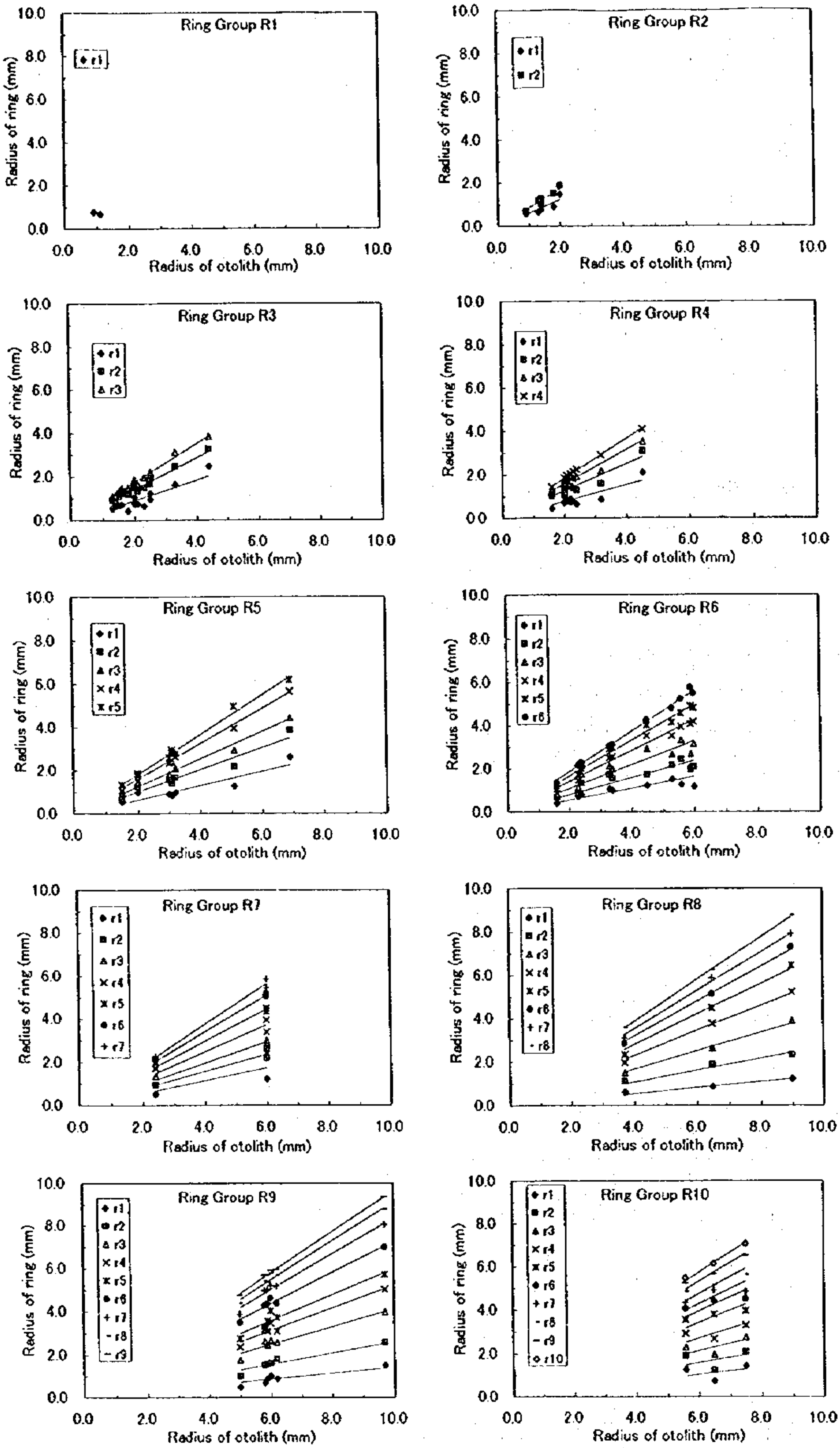


 Figure 84. Relationship between otolith and ring radii by ring group in Pescada branca *Plagioscion squamosissimus*.

(e) Pescada amarela *Cynoscion acoupa*

Ring readings were made in 45 specimens of pescada amarela otoliths. Figure 85 summarizes the relationship between radius of otolith (R_2 in figure 6) and radius of ring for each ring group in this species. Table 70 shows mean values and their standard deviation of ring radius by ring group. In ring groups R3, R4, R5, and R7, ring radius values were generally distributed along their regression lines, and standard deviation revealed the dispersion of ring radii in each ring group.

It can be concluded from the above that, although there was a correspondence between individuals in ring formation, there was great individual variation in ring formation, and there was no agreement in number of rings per individual for a given time period.

Table 70. Mean values and standard deviation of ring radius by ring group for Pescada amarela *Cynoscion acoupa*.

Ring group	N*	Mean radius of ring in otolith (mm)										
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}
R1	0											
R2	1	2.08	3.02									
R3	5	2.00 ± 0.40	2.99 ± 0.58	3.39 ± 0.61								
R4	13	1.83 ± 0.31	2.76 ± 0.43	3.43 ± 0.40	3.93 ± 0.47							
R5	16	1.71 ± 0.31	2.56 ± 0.39	3.35 ± 0.54	4.10 ± 0.59	4.62 ± 0.71						
R6	2	1.53 ± 0.01	2.14 ± 0.14	2.75 ± 0.14	3.06 ± 0.03	3.52 ± 0.17	3.75 ± 0.10					
R7	4	1.80 ± 0.48	2.55 ± 0.52	3.24 ± 0.45	3.92 ± 0.60	4.85 ± 0.75	5.36 ± 0.76	5.83 ± 0.78				
R8	2	1.93 ± 0.39	2.70 ± 0.40	3.41 ± 0.72	4.21 ± 0.79	4.89 ± 0.79	5.53 ± 0.80	6.11 ± 0.99	6.56 ± 1.18			
R9	1	1.61	2.01	2.55	3.08	3.75	4.29	4.69	5.23	5.50		
R10	0											
R11	1	1.94	2.78	3.47	4.17	4.72	5.00	5.56	6.11	6.53	6.94	7.36
Mean ± SD		1.80 ± 0.34	2.66 ± 0.46	3.33 ± 0.51	3.96 ± 0.58	4.56 ± 0.72	4.93 ± 0.77	5.72 ± 0.78	6.11 ± 0.81	6.01 ± 0.52	6.94	7.36
N*		45	45	44	39	26	10	8	4	2	1	1

N*: Number of specimen

(f) Pescadinha gó *Macrodon ancylodon*

Ring readings were made in 51 specimens of pescadinha gó otoliths. Figure 86 summarizes the relationship between radius of otolith (R_2 in figure 6) and radius of ring for each ring group in this species. Table 71 shows mean values and their standard deviation of ring radius by ring group. In each ring group, many of ring radius values appeared to be distributed rather apart from their regression lines, and standard deviation revealed the dispersion of ring radii in each ring group. These results indicated that the correlation between otolith and ring radii was low, in a word ring formation was not regular.

It can be said from the above that there was no correspondence between individuals in ring formation, and great individual variation was present in this formation.

Table 71. Mean values and standard deviation of ring radius by ring group for Pescadinha gó *Macrodon ancylodon*.

Ring group	N*	Mean radius of ring in otolith (mm)		
		r_1	r_2	r_3
R1	15	2.16 ± 0.38		
R2	23	0.92 ± 0.21	1.52 ± 0.29	
R3	13	0.69 ± 0.26	1.27 ± 0.35	1.70 ± 0.38
Mean ± SD		1.02 ± 0.36	1.43 ± 0.33	1.70 ± 0.38
N*		51	36	13

N*: Number of specimen

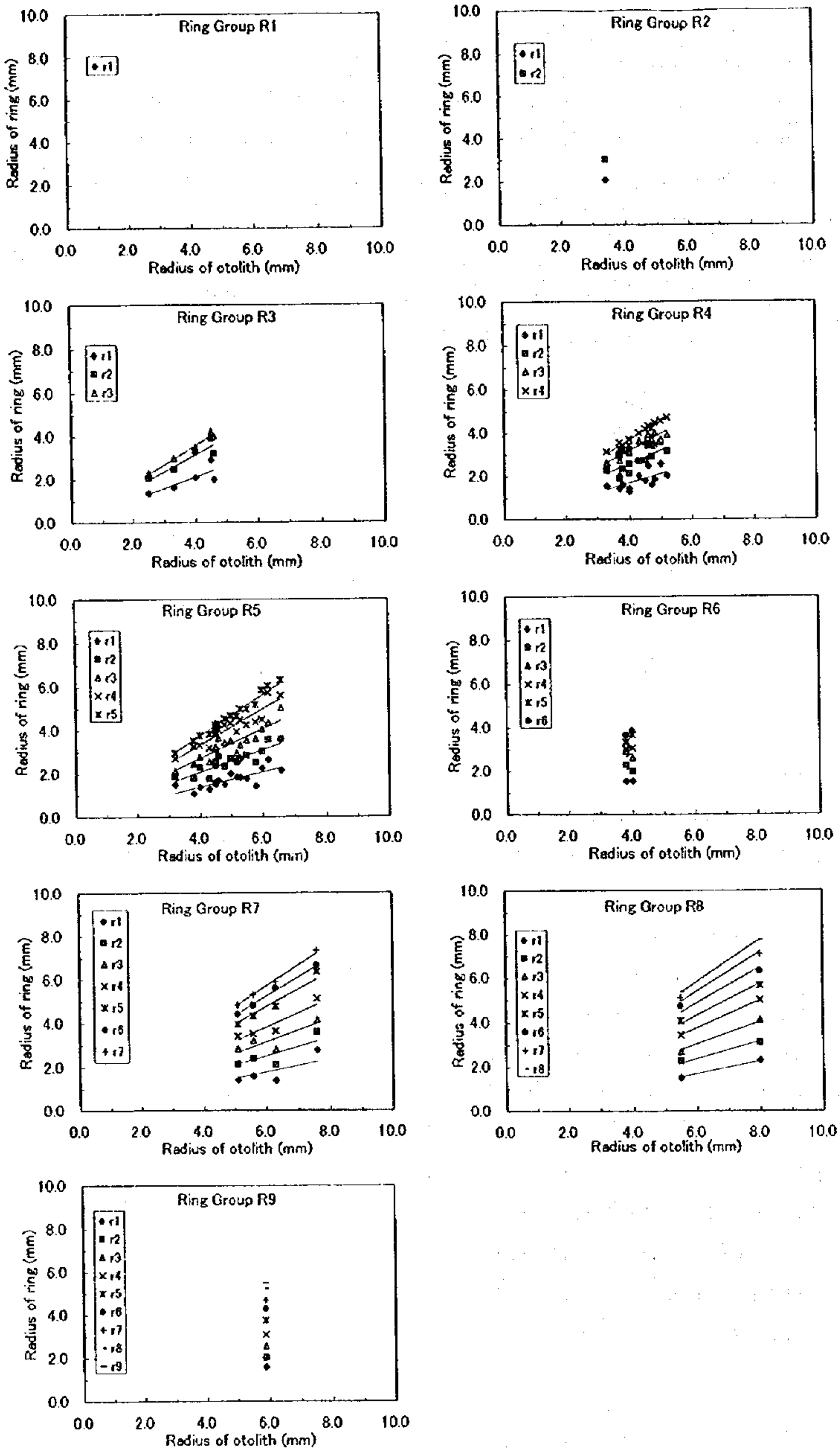


 Figure 85. Relationship between otolith and ring radii by ring group in Pescada amarela *Cynoscion acoupa*.

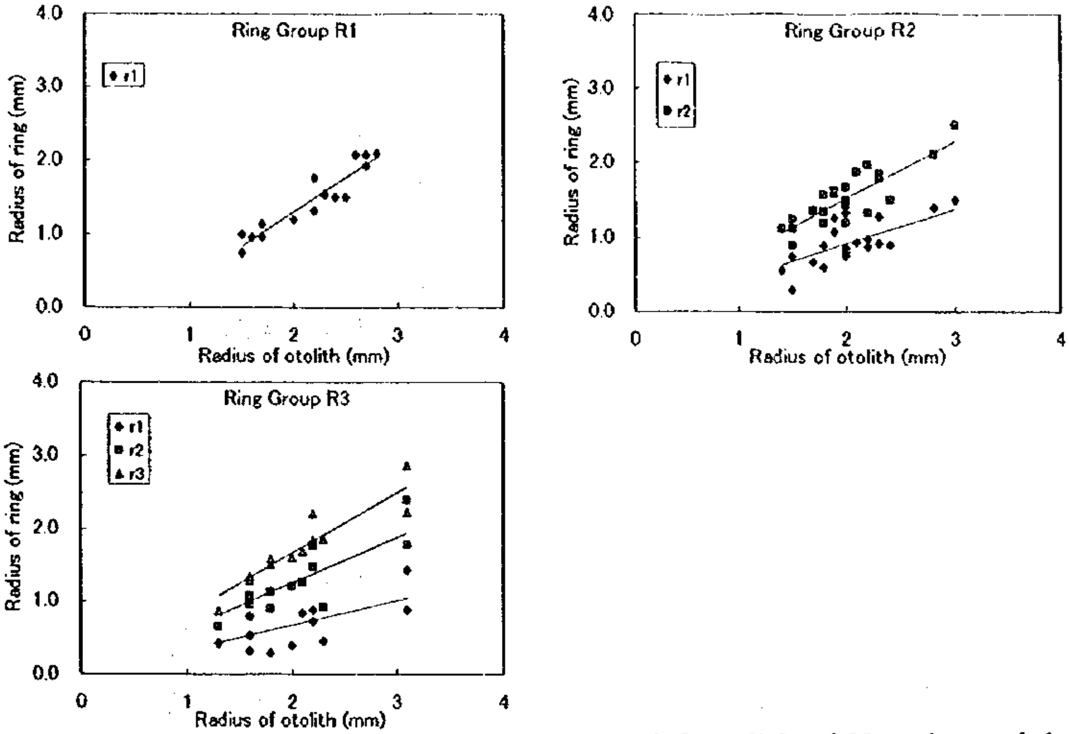


Figure 86. Relationship between otolith and ring radii by ring group in Pescadinha g6 *Macrodon ancylodon.*

(g) Gurijuba *Arius parkeri*

Ring readings were possible in 236 specimens of gurijuba vertebral centra. Figure 87 summarizes the relationship between radius of vertebral centrum and radius of ring for each ring group in this species. Table 72 shows mean values and their standard deviation of ring radius by ring group. Ring radius values were relatively distributed along their regression lines in each ring group, but not diverging as widely as in piramutaba or dourada. In ring groups like R7 or R8, however, those values deviated from their respective regression lines and overlapped with other regression lines, and standard deviation revealed the dispersion of ring radii in each ring group.

It can be concluded from the above that no correspondence between individuals in ring formation could be recognized, as there was relatively large individual variation in ring formation.

Table 72. Mean values and standard deviation of ring radius by ring group for Gurijuba *Arius parkeri.*

Ring group	N*	Mean radius of ring in centrum (mm)										
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}
R1	4	0.45 ± 0.05										
R2	14	0.82 ± 0.44	1.86 ± 0.89									
R3	41	0.78 ± 0.29	1.46 ± 0.51	2.40 ± 0.82								
R4	50	0.75 ± 0.26	1.33 ± 0.36	2.12 ± 0.55	3.05 ± 0.74							
R5	41	0.78 ± 0.28	1.34 ± 0.41	2.06 ± 0.64	2.84 ± 0.76	3.65 ± 0.87						
R6	33	0.82 ± 0.27	1.37 ± 0.42	2.17 ± 0.74	2.93 ± 0.85	3.68 ± 1.01	4.49 ± 1.16					
R7	18	1.03 ± 0.36	1.74 ± 0.64	2.38 ± 0.66	3.07 ± 0.73	3.91 ± 0.77	4.76 ± 0.84	5.67 ± 1.05				
R8	18	1.30 ± 0.40	1.93 ± 0.52	2.67 ± 0.51	3.39 ± 0.60	4.13 ± 0.67	4.92 ± 0.75	5.74 ± 0.92	6.64 ± 1.14			
R9	8	1.29 ± 0.29	1.73 ± 0.36	2.35 ± 0.39	2.96 ± 0.42	3.69 ± 0.49	4.25 ± 0.53	5.21 ± 0.71	6.19 ± 0.86	6.96 ± 0.95		
R10	5	1.08 ± 0.26	1.60 ± 0.24	2.50 ± 0.20	3.20 ± 0.36	3.80 ± 0.48	4.58 ± 0.70	5.64 ± 0.61	6.60 ± 0.72	7.30 ± 0.76	8.20 ± 0.64	
R11	4	1.20 ± 0.30	1.70 ± 0.35	2.33 ± 0.23	2.95 ± 0.28	3.83 ± 0.18	4.58 ± 0.28	5.15 ± 0.35	5.88 ± 0.58	6.70 ± 0.85	7.65 ± 1.15	8.48 ± 1.33
Mean ± SD		0.87 ± 0.33	1.50 ± 0.48	2.26 ± 0.65	3.01 ± 0.73	3.77 ± 0.82	4.62 ± 0.89	5.58 ± 0.88	6.45 ± 0.97	7.00 ± 0.88	7.96 ± 0.89	8.48 ± 1.33
N*		236	232	219	177	127	86	53	35	17	9	4

N*: Number of specimen

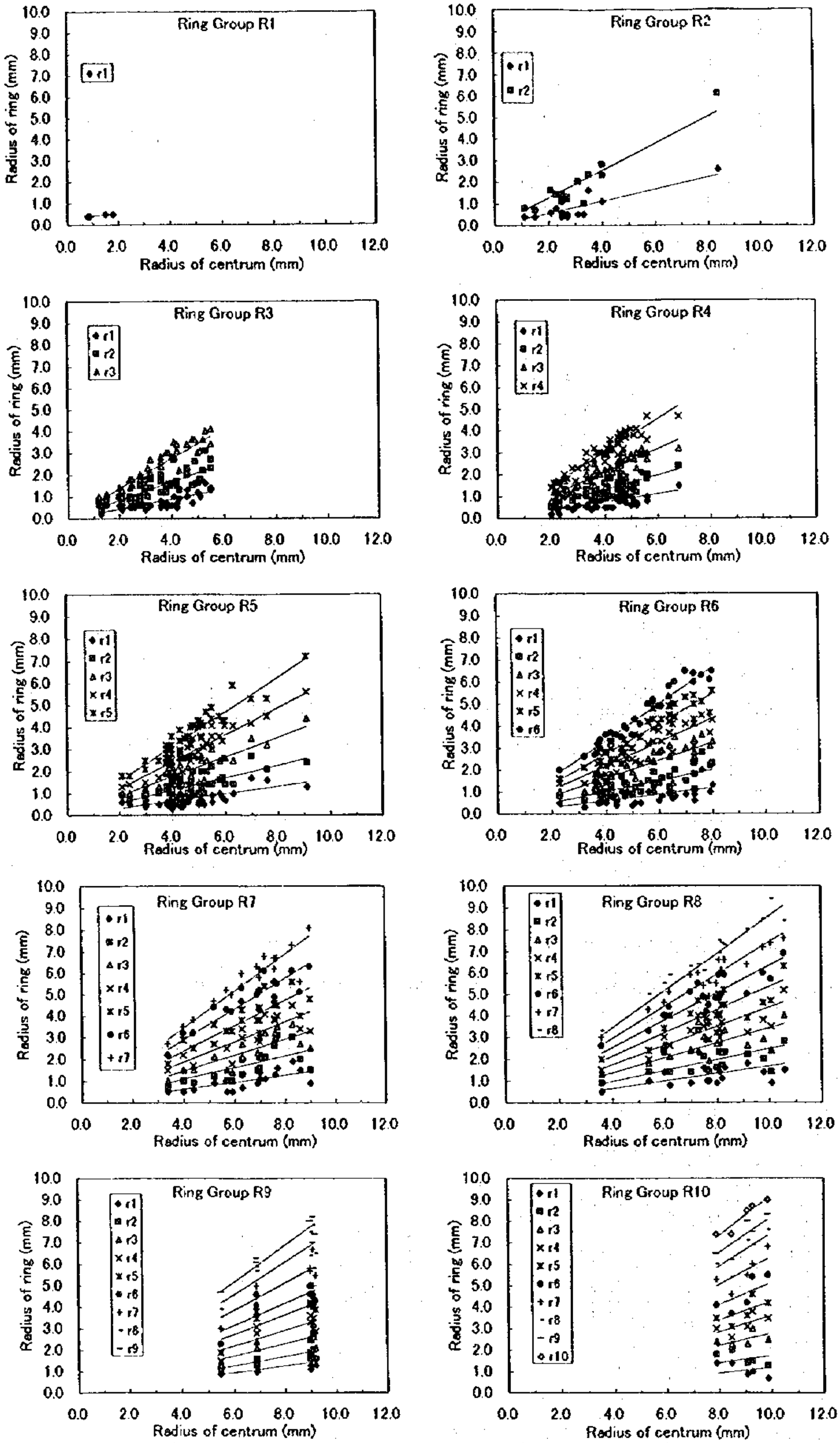


 Figure 87. Relationship between vertebral centrum and ring radii by ring group in Gurijuba *Arius parkeri*.

5.2.5. Periodicity of Ring Formation

To be identified as age rings, rings must be formed regularly over a constant time interval. In other words, the most essential feature of age rings is their periodicity. Here, in order to identify the period of ring formation, the marginal increment of vertebral centrum or otolith, expressed by (α), was defined as:

$$\alpha = \frac{R - r_n}{r_n - r_{n-1}}$$

where, R : radius of centrum or otolith (mm)

r_n : radius of the outermost ring (mm)

r_{n-1} : radius of the ring just behind the outermost one (mm)

In general, it is necessary to investigate the marginal increment over the entire year in order to know the period of ring formation. In theory, the marginal increment should change periodically from being large just before the period of ring formation to small just after the formation. In any case, if there is periodicity in ring formation, the marginal increment should always be lower than 1.0. It is possible to deduce the existence of that periodicity by comparing marginal increments in each ring group over the entire year. Thus, if the marginal increment over a fixed period is near 0.0 in each ring group, it should mean that ring formation finished in the end of that period. On the contrary, if it is near 1.0, it also should mean that the new formation started in the beginning of that period. But if ring formation occurs independently of the growth stage of the organism, in specimens collected in the same period, the marginal increment in any ring group should have about the same value. Anyway, when the marginal increment is over 1.0, or under that value but differing in individuals caught at the same time, then it can be said there is no periodicity in ring formation.

Samples for this survey were obtained in the Rainy (March–April) and Dry (August–September) Seasons and do not cover the entire year — so it cannot be said there are enough data for directly determining the period of ring formation. On the other hand, comparing the rate of marginal increment across both Seasons, it is possible to estimate the relative period of ring formation. Examination of the scattered distribution of marginal increment in individuals collected at the same time can lead to possibly estimating the periodicity of ring formation.

(a) Piramutaba *Brachyplatystoma vaillantii*

Marginal increments by ring group in piramutaba vertebral centra during both the Rainy and Dry Seasons Surveys in Phase 2 are given as in Figure 88. Marginal increments in almost all ring groups of both Seasons were widely scattered, and no clear seasonal tendency could be detected. From this it was deduced that ring formation in the vertebral centra of this species is not periodical. However, as the reading of the outermost ring is problematic, one cannot deny the possibility of having mistakenly failed to read that ring when examining the vertebral centra.

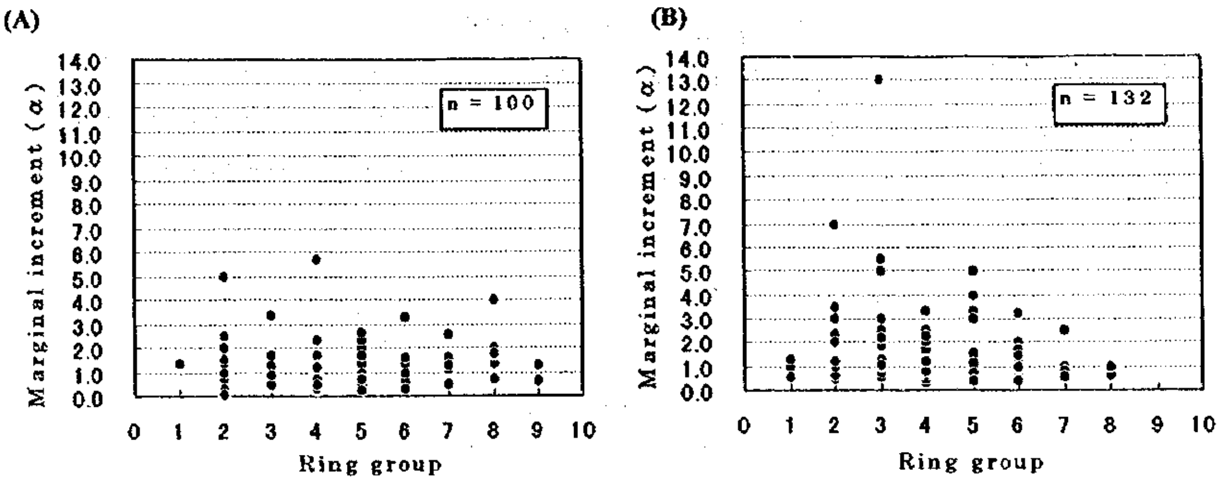


Figure 88. Marginal increment by ring group in vertebral centra for Piramutaba *Brachyplatystoma vaillantii*. (A) Phase 2 Rainy Season Survey; (B) Phase 2 Dry Season Survey.

(b) Dourada *Brachyplatystoma flavicans*

Marginal increments by ring group in dourada vertebral centra during both the Rainy and Dry Seasons Surveys in Phase 2 are given as in Figure 89. In many ring groups of both Seasons, marginal increments were widely scattered, and no clear seasonal tendency could be detected. From this it was deduced that ring formation in the vertebral centra of this species is not periodical. However, as in the case of piramutaba, one cannot deny the possibility of having mistakenly failed to read the outermost ring when examining the vertebral centra.

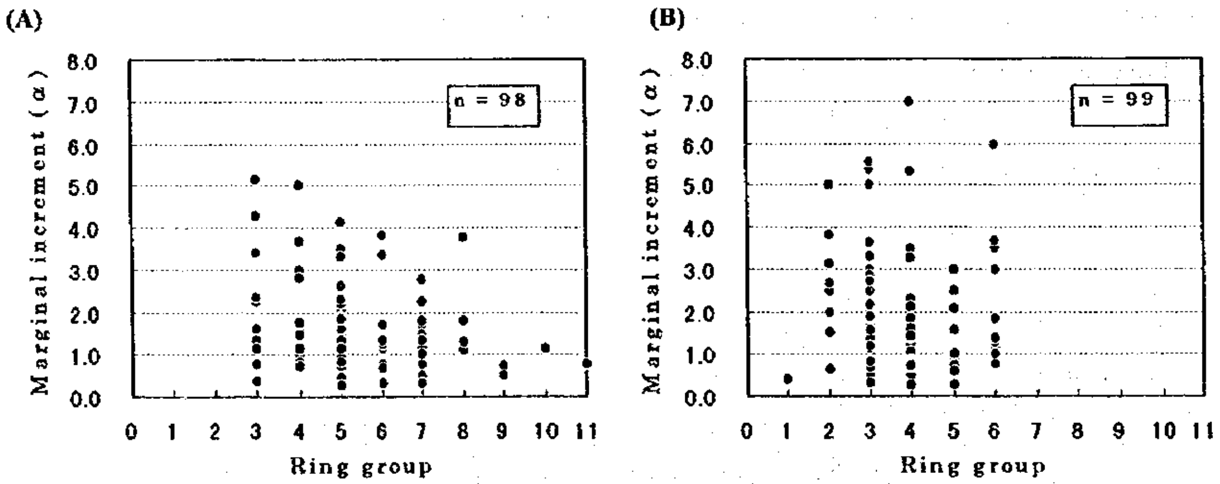


Figure 89. Marginal increment by ring group in vertebral centra for Dourada *Brachyplatystoma flavicans*. (A) Phase 2 Rainy Season Survey; (B) Phase 2 Dry Season Survey.

(c) Filhote *Brachyplatystoma filamentosum*

Marginal increments by ring group in filhote vertebral centra during both the Rainy and Dry Seasons Surveys in Phase 2 are given as in Figure 90. Scarcity of specimens in the Dry Season prevented from comparing marginal increments between Seasons. In the Rainy Season, there were relatively obtained many specimens, marginal increment range was 1–3. It can be deduced from the results in the Rainy Season that ring formation in the vertebral centra of this species is not periodical. However, as in the case of the other two species of the same genus, one cannot deny the possibility of having mistakenly failed to read the outermost ring when examining the vertebral centra.

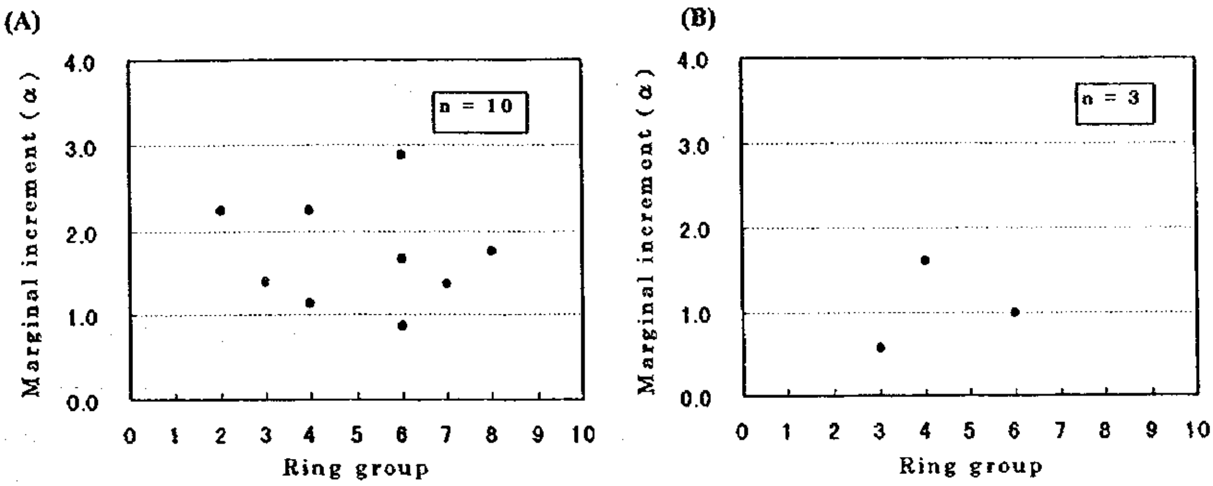


Figure 90. Marginal increment by ring group in vertebral centra for Filhote *Brachyplatystoma filamentosum*. (A) Phase 2 Rainy Season Survey; (B) Phase 2 Dry Season Survey.

(d) Pescada branca *Plagioscion squamosissimus*

Marginal increments by ring group in pescada branca otoliths during both the Rainy and Dry Seasons Surveys in Phase 2 are given as in Figure 91. In many ring groups of both Seasons, marginal increments were widely scattered, and no clear seasonal tendency could be detected. And besides, examination of otoliths is simpler than that of vertebral centra and there is no possibility of having failed to read the outermost ring. Thus it can be concluded that ring formation in the otoliths of this species is not periodical.

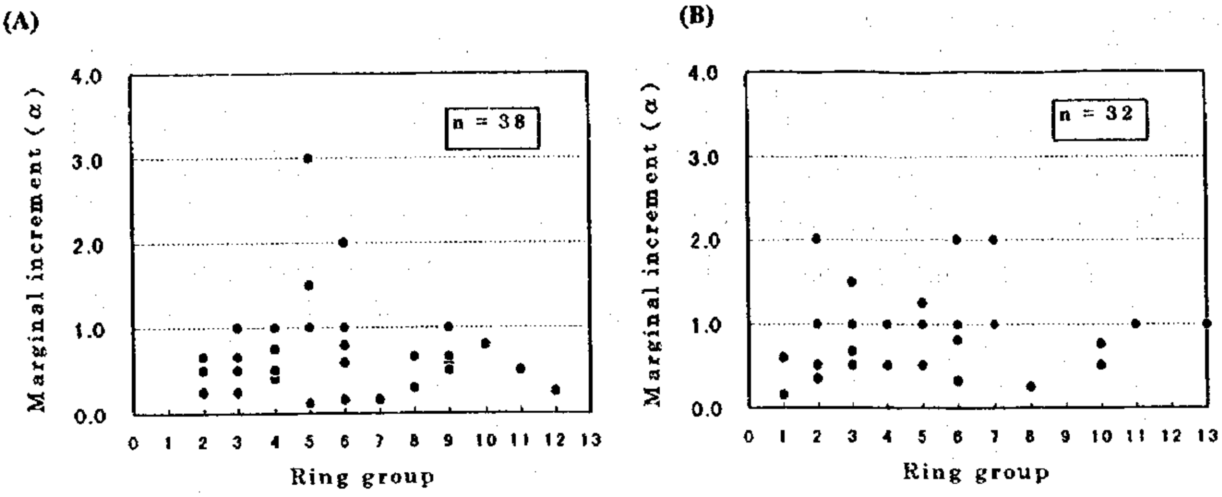


Figure 91. Marginal increment by ring group in otoliths for Pescada branca *Plagioscion squamosissimus.* (A) Phase 2 Rainy Season Survey; (B) Phase 2 Dry Season Survey.

(e) Pescada amarela *Cynoscion acoupa*

Marginal increments by ring group in pescada amarela otoliths during both the Rainy and Dry Seasons Surveys in Phase 2 are given as in Figure 92. In many ring groups of both Seasons, marginal increments were widely scattered, and no clear seasonal tendency could be detected. And besides, the situation is similar to that of pescada branca and there is no possibility of having failed to read the outermost ring. Thus it can be concluded that ring formation in the otoliths of this species is not periodical.

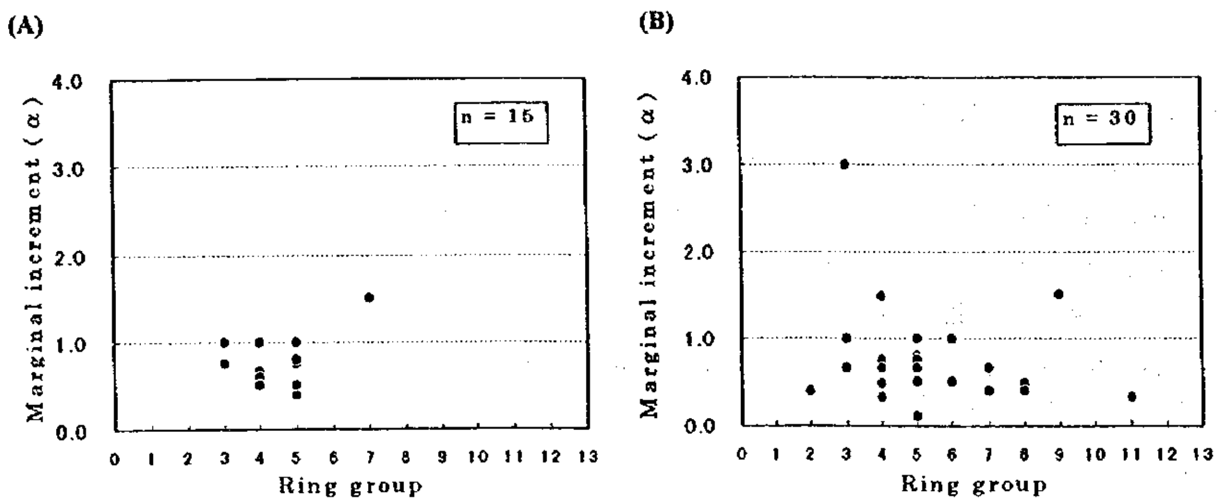


Figure 92. Marginal increment by ring group in otoliths for Pescada amarela *Cynoscion acoupa.* (A) Phase 2 Rainy Season Survey; (B) Phase 2 Dry Season Survey.

(f) Pescadinha gó *Macrodon ancylodon*

Marginal increments by ring group in pescadinha gó otoliths during the Rainy Season Survey in Phase 2 are given as in Figure 93. From the fact that marginal increments were widely scattered and, similarly to the other previously described sciaenids, there is no possibility of having failed to read the outermost ring, one concludes ring formation in the otoliths of this species is not periodical.

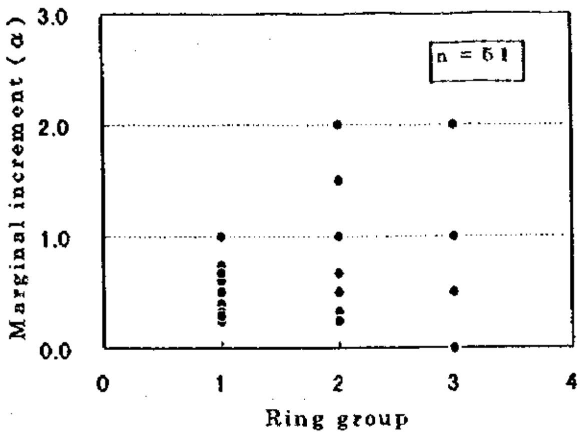


Figure 93. Marginal increment by ring group in otoliths for Pescadinha gó *Macrodon ancylodon*. Phase 2 Rainy Season Survey.

(g) Gurijuba *Arius parkeri*

Marginal increments by ring group in gurijuba vertebral centra during both the Rainy and Dry Seasons Surveys in Phase 2 are given as in Figure 94. In almost ring groups of both Seasons, marginal increments were widely scattered, and no clear seasonal tendency could be detected. From this it was deduced that ring formation in the vertebral centra of this species is not periodical. However, for the same reasons as in the three species of *Brachyplatystoma*, one cannot deny the possibility of having mistakenly failed to read the outermost ring when examining the vertebral centra.

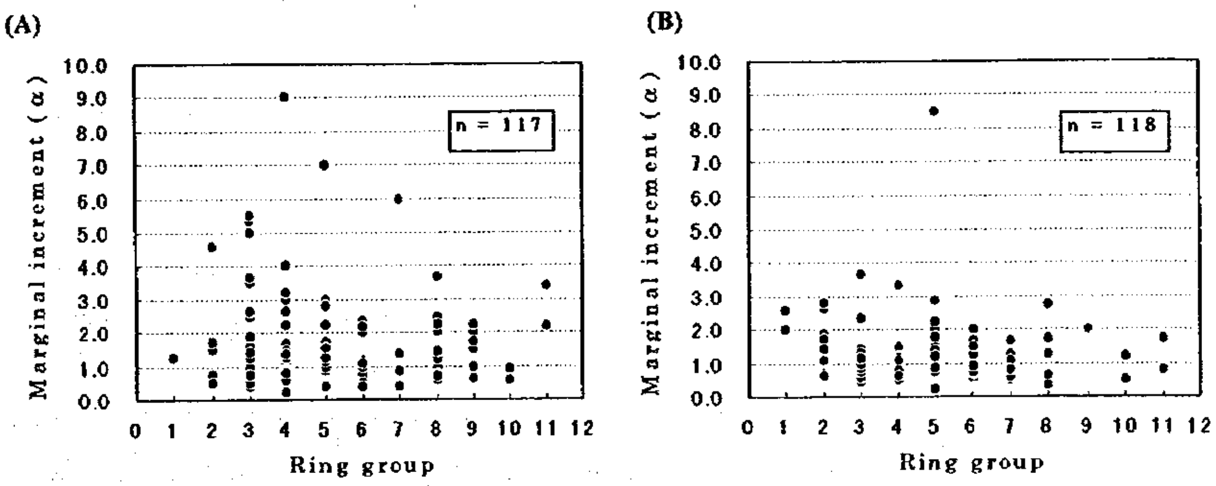


Figure 94. Marginal increment by ring group in vertebral centra for Gurijuba *Arius parkeri*. (A) Phase 2 Rainy Season Survey; (B) Phase 2 Dry Season Survey.

5.2.6. Age Determination from Hard Tissues

Results that led to an analysis of correspondence and periodicity of ring formation for each of the seven key fish species led to the conclusion that age determination was problematic because the rings formed in hard tissues cannot be considered annual rings. Listed below are some considerations on why those rings cannot be indicators for age determination.

(a) On the formation of rings

Hard tissues in teleost fishes are ectodermal tissues whose main component is calcium carbonate, and have long been utilized for age determination. It is not very clear, however, if rings are formed simply in response to external factors of change, or instead to a continuous, established internal rhythmic process. Based on experimental results hitherto obtained, it has been long known that the internal causes for ring formation are the daily periodic activities related to the circadian cycle. This daily periodicity notably applies to behavioral, physiological and biochemical processes in fishes. On the other hand, external causes include environmental factors such as light (luminosity), temperature, etc. acting on the physiology of the fish and ultimately propitiating the formation of rings.

Upon examining the influence of luminosity on ring formation, it should be borne in mind that the survey area is practically under the Equator, where sunrise and sunset times are quite the same all year round. Also, in the plume area of the Amazon River mouth, there is an immense quantity of turbidity-inducing suspended sediment — so almost no light reaches the bottom over the entire year. As for the influence of the surrounding temperature, despite the some changes that can be observed between the Dry and Rainy Seasons in the survey area, the difference in temperature from one season to another is of only 2–3°C. Therefore, as luminosity and surrounding temperature are quite stable in the survey area, it is believed they are not essential external factors inducing ring formation, as compared to their role in fishes with rings on hard tissues occurring in temperate (frigid) or subtemperate (subfrigid) zones.

On the internal factors leading to ring formation, the problem of age determination in the seven key fish species is thought to be compounded by results originating from stable external factors such as luminosity or water temperature.

Piramutaba fry live in the center of mangrove areas feeding on small polychaetes and the like, while the juveniles of that species inhabit the perimeter of the mangrove preying upon small crustaceans and insects. As they grow, piramutaba leave the mangrove and feed on shrimp and fish in the adult phase — as they increase the dependency on fish for their foods (Barthem, unpublished data). In the process of juveniles growing into adults, the distribution limits widen from the freshwater region of the river mouth to the brackish water offshore.

It is highly probable that ring formation is influenced by non-cyclical external factors such as the variety of organisms they feed on or changes in the salinity of the habitat. In order to shed a light on the formation of rings in this species, it is suggested that diet changes from fry to adult be examined, or rearing experiments performed in order to know, for instance, how does salinity affect ring formation, etc.

(b) Reading rings

As stated in the section on correspondence in ring formation, because of individual variation in the clarity of rings on vertebral centra and otoliths, it cannot be said that all rings were read following the same criterion. Therefore, depending on the person, rings were not always read in the same way. Particularly, as explained in the section on periodicity of ring formation, there is a high possibility of reading error due to the fact that reading rings near the margin of the vertebral centrum was problematic.

It is essential that further attempts at reading rings be cautions when dealing with those near the margin.

(c) Further examinations

c-1) Reexamination of the hard tissue collection

As pointed out before, because of individual variations in the clarity of rings in the hard tissue collection, it cannot be said all rings were read under the same criterion. It is important the collection is reexamined, paying particular attention to the outermost rings formed near the margins.

c-2) Tagging-and-releasing

Although tagged specimens have not been retrieved so far, it is essential to consider growth evaluation by means of tagging for species of Amazon River estuary whose age determination from hard tissues is problematic.

c-3) Rearing experiments

It is necessary to consider the experimental rearing of species to understand their growth clearly.

5.2.7. Size Composition Cohort Analysis

Results of age determination procedures for each of the seven key fish species led to the conclusion that the rings cannot be considered annual rings. Therefore, a size (length) composition cohort analysis was attempted.

Size composition of organisms includes information related to age, and distribution of length frequencies can be seen as the combination of normal distribution curves of many fish populations that differ from each other in age class. In 1896, C.G.J. Petersen measured a large number of hake samples and, through a curve of measurement dispersion, came out with a method for detecting age classes (Petersen's Method). Also known as normal probability paper method, it is still largely employed in the analysis of population dynamics for organisms without characters distinctly applicable in age determination. This method is effective in cases where there is little overlapping between age classes, and consists of detecting the inflection points of a cumulative frequency percentage curve and decomposing the latter into normal distribution curves with those points as a center. However, when there is much overlapping between adjacent age classes, individual differences should be considered when looking for inflection points.

In recent years, the popularity of personal computers led to the design of programs that aid in this analysis by simplifying the search for those inflection points. The software PROGEAN Version 4.0J (Tsutsumi and Tanaka, 1994), expressly a cohort analysis program, was tested for this decomposition study of length frequency distribution of the key fish species.

Size composition data obtained at the landings reported by the Landing Site Survey had an inherent bias because the landed catch had been previously selected by fishing ground (which was not limited to the survey area), fishing method and mesh size, and marketable size. In contrast, data on size composition obtained for the key fish species during the Sea-Borne Survey were thought to reflect natural conditions in the survey area in a generally accurate manner, and therefore were chosen for this cohort analysis.

Distribution of length frequencies of the key fish species as obtained during the Sea-Borne Survey (with 1 cm interval classes for pescadinha gó *Macrodon ancylodon* and 2 cm interval classes for the other fishes) was multi-modal for many species and the establishment of cohort compositions would be difficult in many cases. By necessity, frequency variation was adjusted so as to represent moving average per three length classes in the distribution of length frequencies. This moving average was calculated as described below, and the number or iterations it required, although left to the discretion of the analyzer, was referred in the instructions as one to four times.

$$Y_i = (y_{i-1} + y_i + y_{i+1}) / 3$$

where y_i : number of individuals in class i

Number of individuals at each length class in size composition of fishes should be properly revised according to the mesh selectivity rate by length class obtained from the mesh selectivity curve. In the present survey, however, this revision were not carried out owing to a shortage of the suitable data on mesh selectivity for the seven key fish species. Cohort analysis was performed on four of the key fish species, as explained below.

(a) Piramutaba *Brachyplatystoma vaillantii*

Results of cohort analysis made directly from piramutaba size composition data (sum total in the entire area in each seasonal survey) are given in Figure 95, and those calculated from the composition defined by the second iteration of moving average are given in Figure 96. Results of cohort analysis of size composition in moving average revealed 5-6 cohorts, and Table 73 shows mean length and standard deviation per cohort.

Table 73. Mean length and standard deviation per cohort for Piramutaba *Brachyplatystoma vaillantii* (After 2 moving average iterations).

Cohort	Mean ± Standard deviation (cm)			
	Phase 1		Phase 2	
	Rainy Season	Dry Season	Rainy Season	Dry Season
1	-	15.2 ± 3.2	12.5 ± 3.3	17.2 ± 3.9
2	-	22.7 ± 2.3	22.9 ± 3.1	28.3 ± 3.2
3	-	34.7 ± 5.6	32.2 ± 3.3	37.9 ± 3.6
4	-	49.1 ± 3.3	43.6 ± 6.1	48.1 ± 2.2
5	-	61.7 ± 3.6	66.3 ± 3.3	56.5 ± 2.9
6	-			65.2 ± 2.4

(b) Dourada *Brachyplatystoma flavicans*

Results of cohort analysis made directly from dourada size composition data (sum total in the entire area in each seasonal survey) are given in Figure 97, and those calculated from the composition defined by the fourth iteration of moving average are given in Figure 98. Results of cohort analysis of size composition in moving average revealed 4-5 cohorts, and Table 74 shows mean length and standard deviation per cohort.

Table 74. Mean length and standard deviation per cohort for Dourada *Brachyplatystoma flavicans* (After 4 moving average iterations)

Cohort	Mean ± Standard deviation (cm)			
	Phase 1		Phase 2	
	Rainy Season	Dry Season	Rainy Season	Dry Season
1	-	11.5 ± 4.0	10.4 ± 2.7	9.7 ± 2.5
2	-	28.5 ± 4.9	19.1 ± 3.8	27.6 ± 4.2
3	-	54.0 ± 8.6	30.0 ± 3.5	56.1 ± 10.1
4	-	74.1 ± 4.4	56.8 ± 8.8	77.5 ± 3.5
5	-		74.4 ± 4.3	

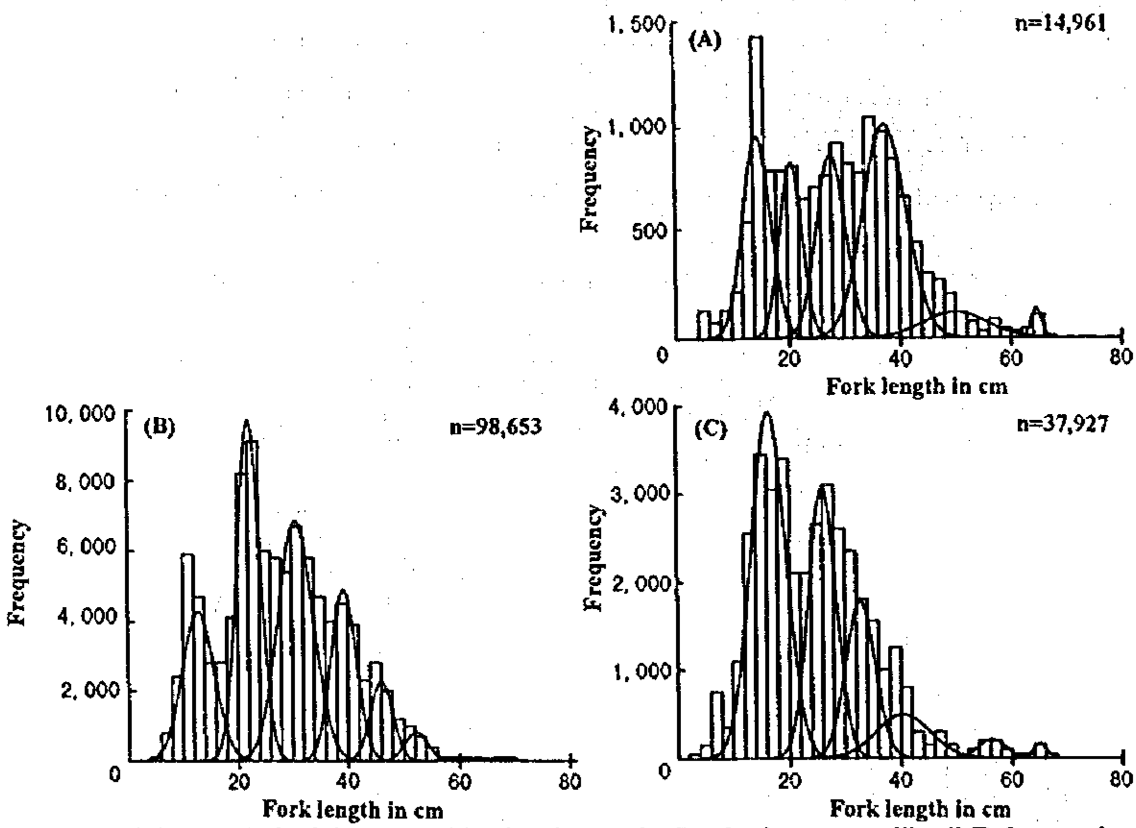


Figure 95. Cohort analysis of size composition for Piramutaba *Brachyplatystoma vaillantii* (Before moving average). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

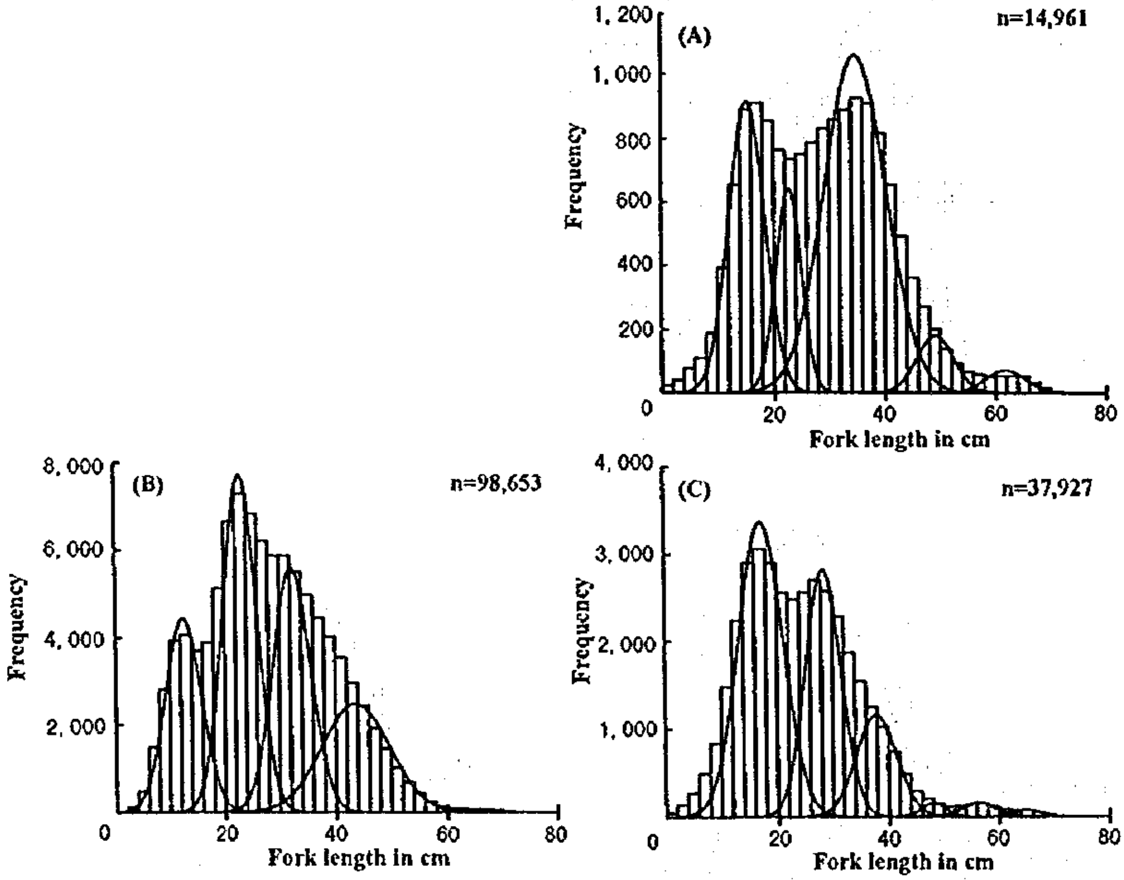


Figure 96. Cohort analysis of size composition for Piramutaba *Brachyplatystoma vaillantii* (After 2 moving average iterations). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

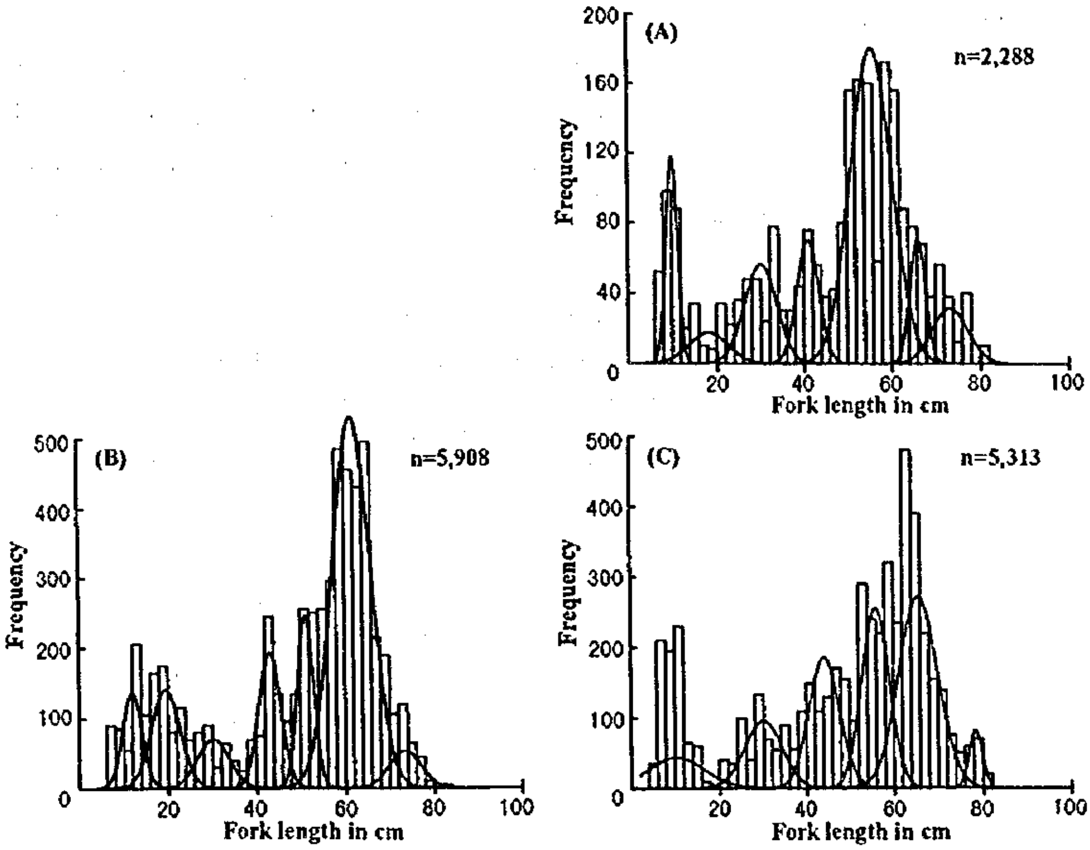


Figure 97. Cohort analysis of size composition for Dourada *Brachyplatystoma flavicans* (Before moving average). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

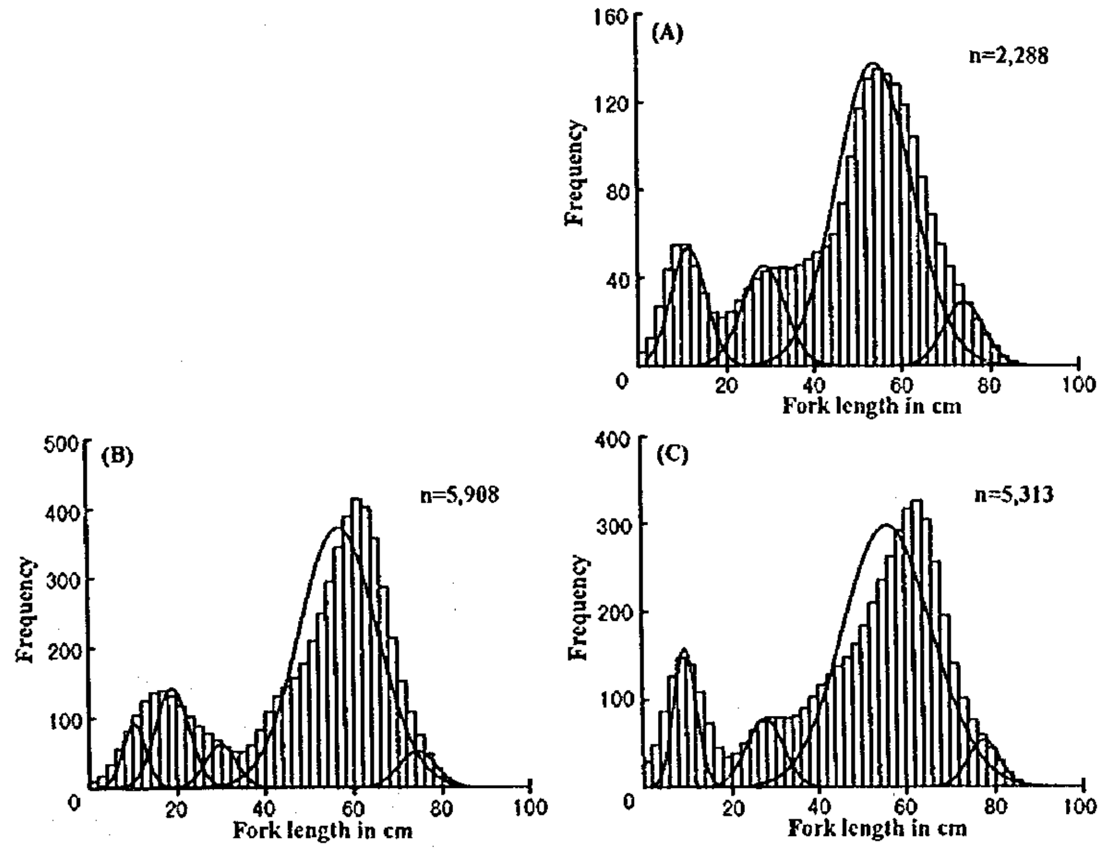


Figure 98. Cohort analysis of size composition for Dourada *Brachyplatystoma flavicans* (After 4 moving average iterations). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

(c) Pescadinha gó *Macrodon ancylodon*

Results of cohort analysis made directly from pescadinha gó size composition data (sum total in the entire area in each seasonal survey) are given in Figure 99, and those calculated from the composition defined by the first iteration of moving average are given in Figure 100. Results of cohort analysis of size composition in moving average revealed 6–7 cohorts, and Table 75 shows mean length and standard deviation per cohort.

Table 75. Mean length and standard deviation per cohort for Pescadinha gó *Macrodon ancylodon* (After 1 moving average iteration).

Cohort	Mean ± Standard deviation (cm)			
	Phase 1		Phase 2	
	Rainy Season	Dry Season	Rainy Season	Dry Season
1	-	6.8 ± 1.1	12.1 ± 1.5	7.6 ± 1.0
2	-	9.5 ± 1.2	15.8 ± 1.4	12.0 ± 1.5
3	-	16.8 ± 2.6	19.9 ± 1.6	17.6 ± 2.1
4	-	23.2 ± 1.4	24.3 ± 1.3	23.0 ± 1.1
5	-	27.5 ± 1.4	28.5 ± 1.4	26.7 ± 1.6
6	-	32.6 ± 2.1	32.9 ± 1.6	31.8 ± 1.9
7	-		39.0 ± 1.5	39.0 ± 1.5

(d) Gurijuba *Arius parkeri*

Results of cohort analysis made directly from gurijuba size composition data (sum total in the entire area in each seasonal survey) are given in Figure 101, and those calculated from the composition defined by the second iteration of moving average are given in Figure 102. Results of cohort analysis of size composition in moving average revealed 5–9 cohorts, and Table 76 shows mean length and standard deviation per cohort.

Table 76. Mean length and standard deviation per cohort for Gurijuba *Arius parkeri* (After 2 moving average iterations).

Cohort	Mean ± Standard deviation (cm)			
	Phase 1		Phase 2	
	Rainy Season	Dry Season	Rainy Season	Dry Season
1	-	22.0 ± 2.9	15.2 ± 3.3	19.9 ± 2.4
2	-	42.3 ± 5.9	29.4 ± 3.5	31.1 ± 3.5
3	-	61.7 ± 4.9	44.9 ± 5.7	47.0 ± 6.7
4	-	75.9 ± 4.2	61.6 ± 3.6	70.1 ± 5.1
5	-	97.3 ± 3.8	74.5 ± 4.2	85.6 ± 5.1
6	-	133.0 ± 2.4	87.1 ± 2.5	
7	-		94.4 ± 2.5	
8	-		106.4 ± 2.1	
9	-		114.5 ± 2.8	

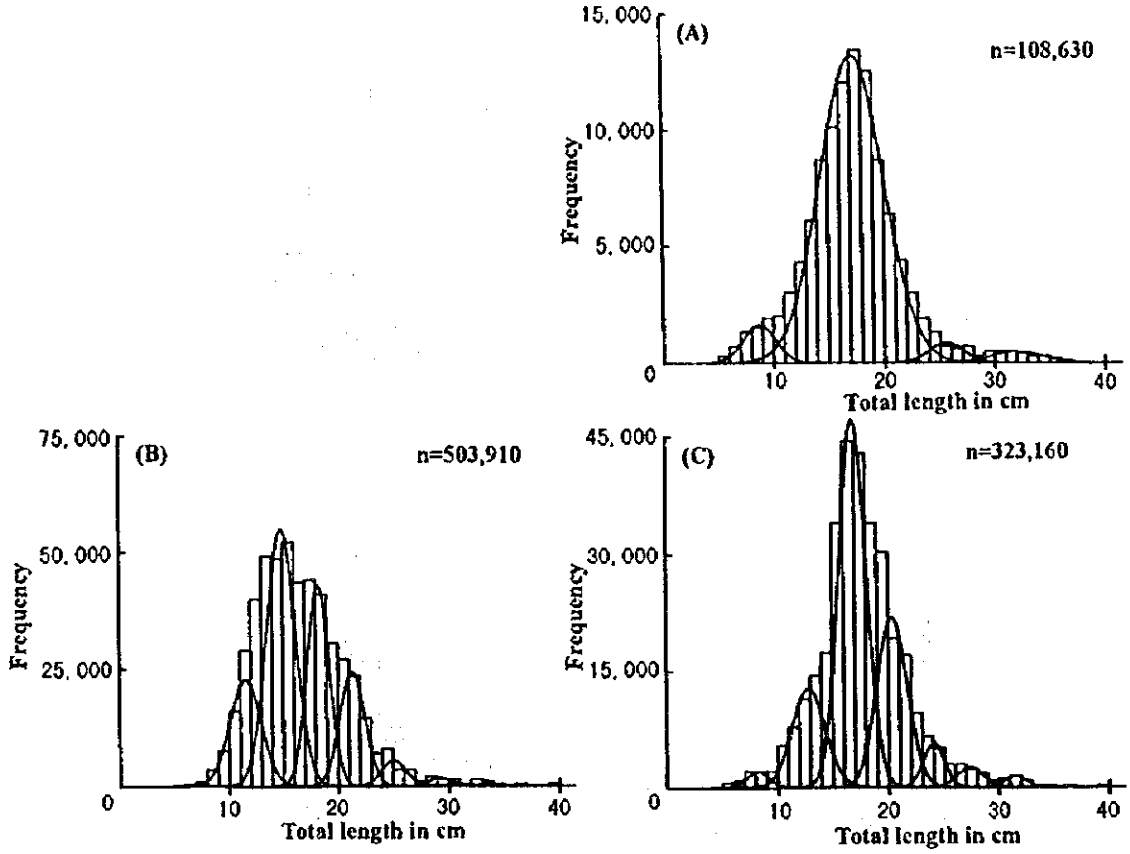


Figure 99. Cohort analysis of size composition for Pescadinha gó *Macrodon ancylodon* (Before moving average). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

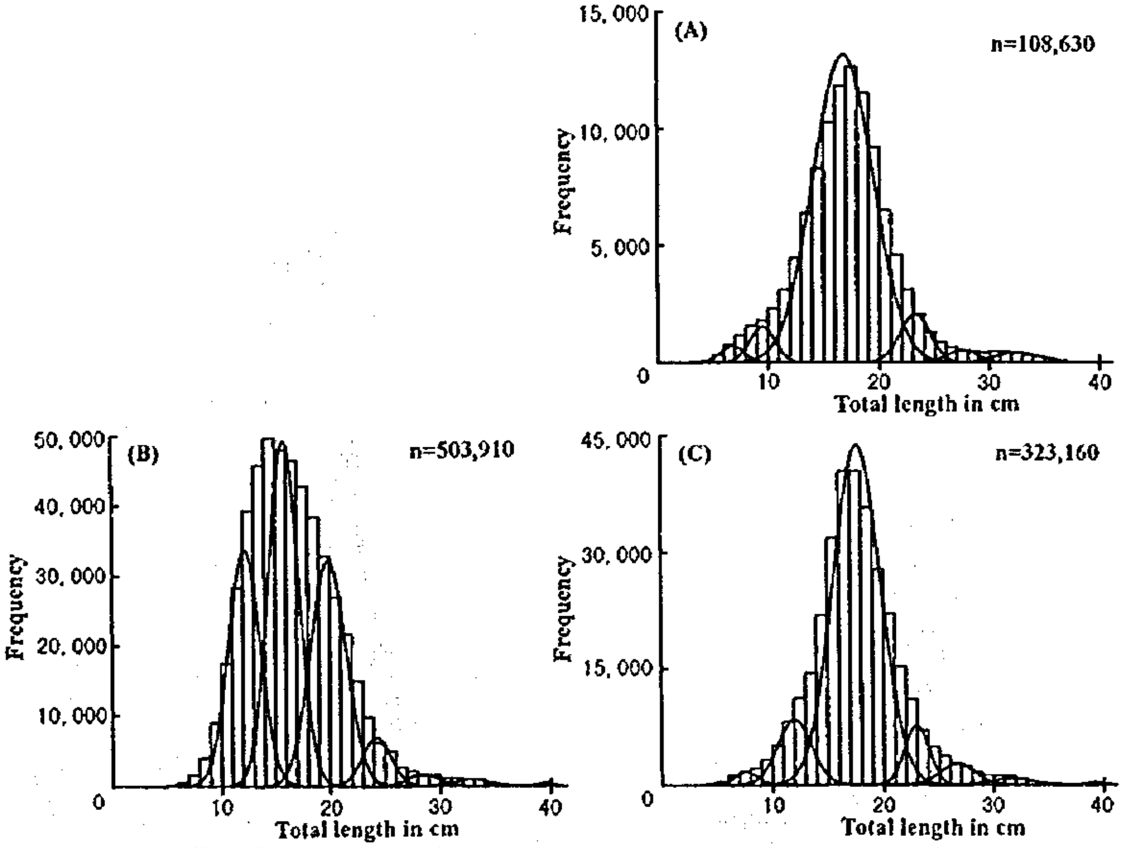


Figure 100. Cohort analysis of size composition for Pescadinha gó *Macrodon ancylodon* (After 1 moving average iteration). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

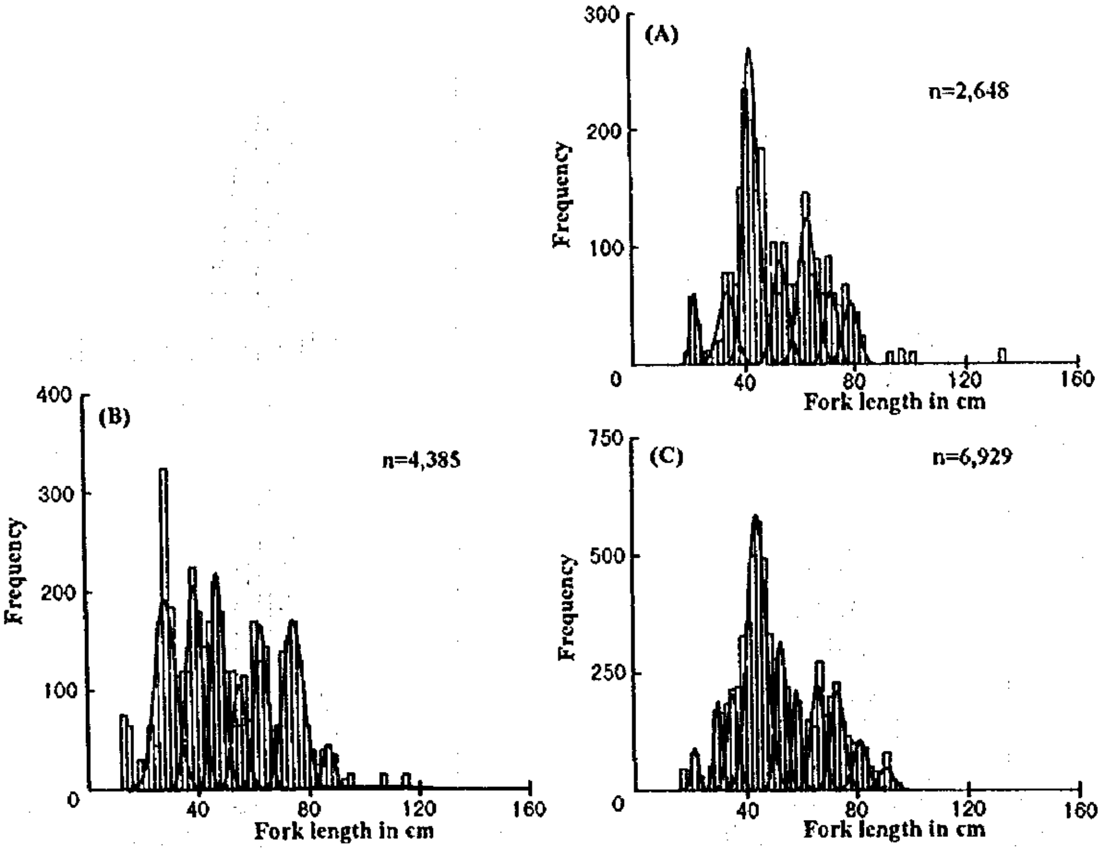


Figure 101. Cohort analysis of size composition for Gurijuba *Arius parkeri* (Before moving average). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

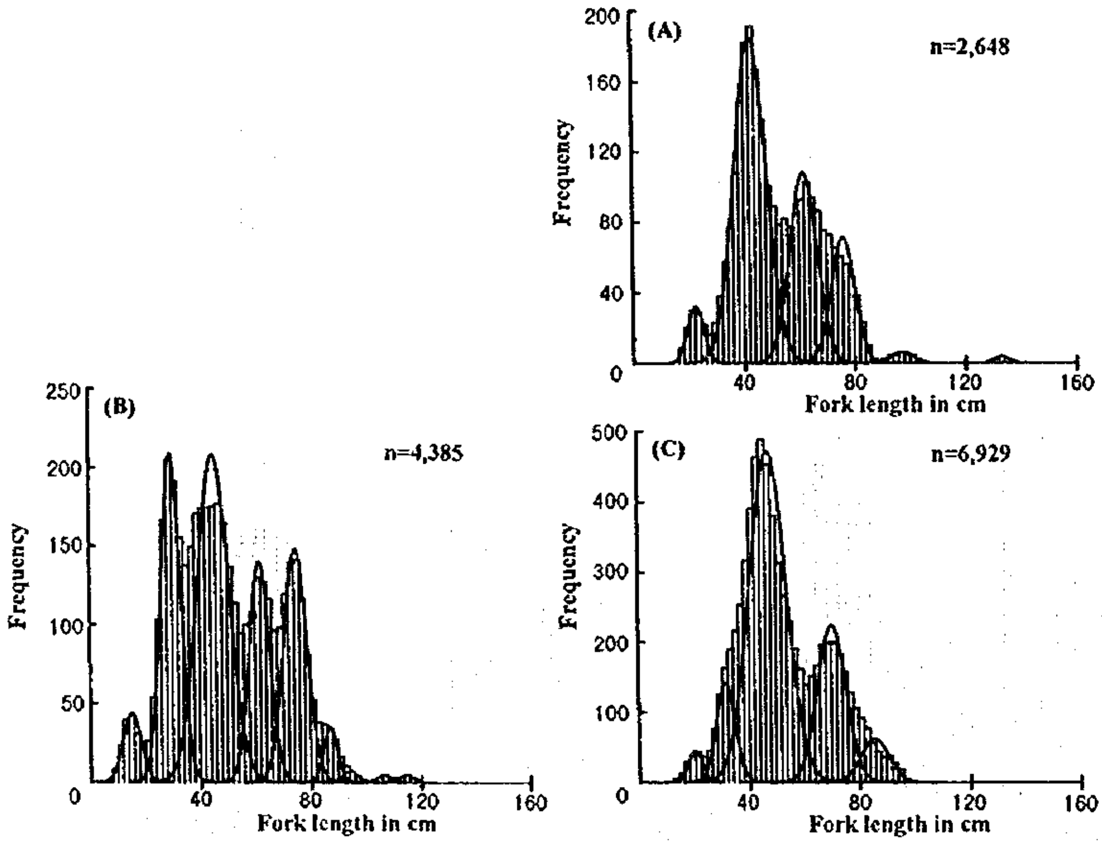


Figure 102. Cohort analysis of size composition for Gurijuba *Arius parkeri* (After 2 moving average iterations). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

5.2.8. Discussion of Growth Using the Walford's Transformation

In the previous section, results from size composition cohort analysis showed that a number of cohorts could be adjusted to a normal distribution curve. In order to elucidate growth, a Walford's growth transformation (Walford, 1946) was applied to mean length (modal length) periodicity and estimated maximum length for each cohort separated by normal distribution curves. It is possible to verify whether or not the mode of a given cohort exhibits periodicity: if a group appears in one period a year then it is a year class (age group or cohort), and if it appears many times a year it could be regarded as seasonal populations. For the key fish species in this survey, periodicity of their generations are unknown, so it cannot be presumed the cohorts represent year classes. Nevertheless, for convenience, cohorts are indeed considered year classes in the description below, which refers to the four previously analyzed species.

(a) Piramutaba *Brachyplatystoma vaillantii*

Figure 103 illustrates the Walford's growth transformation applied to mean length (see Table 73) in piramutaba size composition cohorts. As the slope of the growth transformation equation for Phase 1 Dry and Phase 2 Rainy Seasons surpasses 1.0, maximum fork length cannot be calculated. However, the equation $Y = 0.94x + 11.93$ for the Phase 2 Dry Season allowed to estimate a maximum fork length of 193 cm. The maximum fork length measured during the Sea-Borne Survey was 70 cm, and Barthem & Goulding (1997) report a value of 105 cm. The above estimated fork length value is much higher than the real reported maximum values, so the given cohorts are unlikely to express year classes correctly.

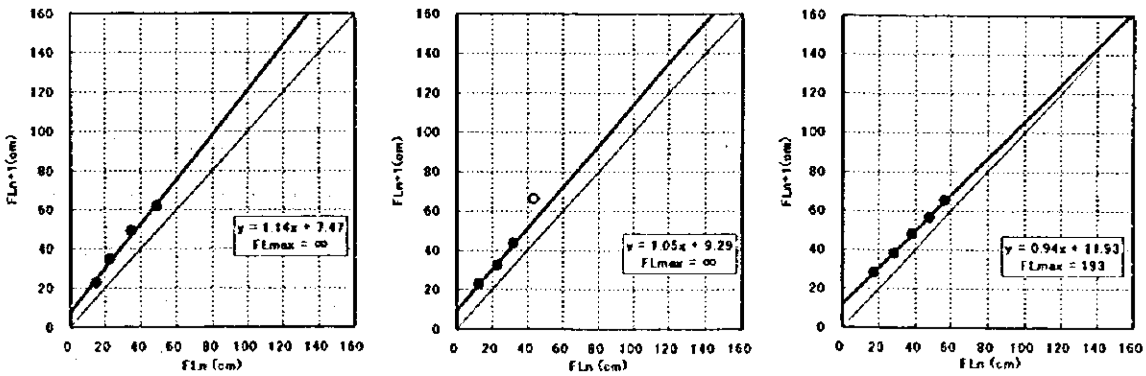


Figure 103. Walford's transformation for Piramutaba *Brachyplatystoma vaillantii* mean length values by cohort. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. (Black dots: points employed in the plotting of the regression line; white dots: points not employed in the plotting of the regression line).

(b) Dourada *Brachyplatystoma flavicans*

Figure 104 illustrates the Walford's growth transformation applied to mean length (see Table 74) in dourada size composition cohorts. For this species, differential points are widely scattered in all survey seasons. Also, a regression line was drawn from each mean length of two cohorts that appeared as large length classes. Maximum fork lengths obtained from each season's respective growth transformation equation were 149 cm for the Phase 1 Dry Season, 108 cm for the Phase 2 Rainy Season and 142 cm for the Phase 2 Dry Season. The maximum fork length measured during the Sea-Borne Survey was 84 cm, and Barthem & Goulding (1997) report a value of 192 cm. The above estimated fork length values are lower than the real reported maximum values, so the given cohorts are unlikely to express year classes correctly.

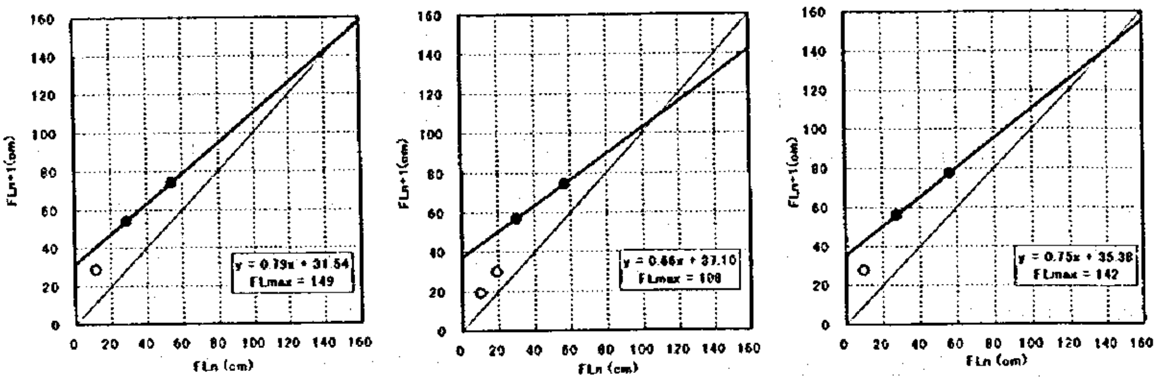


Figure 104. Walford's transformation for Dourada *Brachyplatystoma flavicans* mean length values by cohort. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. (Black dots: points employed in the plotting of the regression line; white dots: points not employed in the plotting of the regression line).

(c) Pescadinha gó *Macrodon ancylodon*

Figure 105 illustrates the Walford's growth transformation applied to mean length (see Table 75) in pescadinha gó size composition cohorts. Differential points are quite well adjusted to the regression lines of the respective growth transformation equations in all survey seasons, with a few exceptions (1 point each in the Dry Seasons of both Phases). Maximum values for total length calculated from the Dry Season equations were, respectively, 58 cm (Phase 1) and 340 cm (Phase 2). The maximum value for total length measured during the Sea-Borne Survey was 39 cm, and Haimovici (1988) gives a value of 42 cm. The above estimated total length values are much higher than the real reported maximum values. Therefore, the cohorts obtained through cohort analysis are not likely to express year classes correctly.

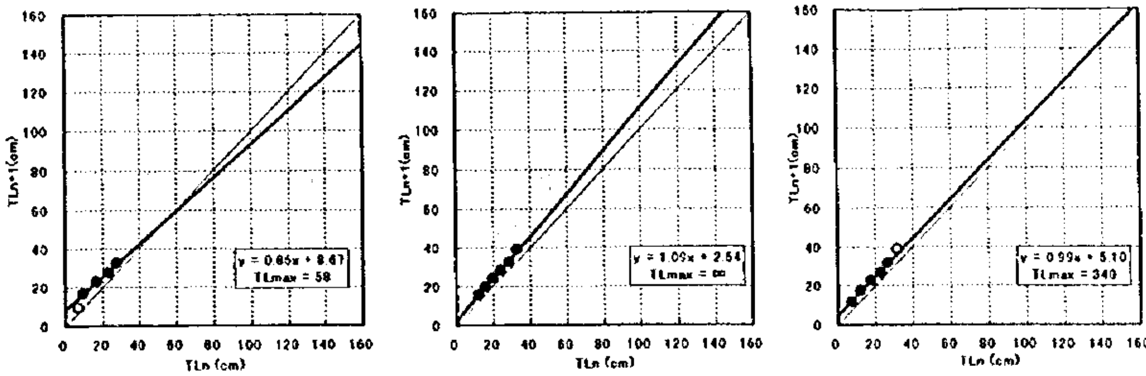


Figure 105. Walford's transformation for Pescadinha g6 *Macrodon ancylodon* mean length values by cohort. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. (Black dots: points employed in the plotting of the regression line; white dots: points not employed in the plotting of the regression line).

(d) Gurijuba *Arius parkeri*

Figure 106 illustrates the Walford's growth transformation applied to mean length (see Table 76) in gurijuba size composition cohorts. The Phase 1 Dry Season growth transformation equation Y = 0.98 x + 19.84 yielded an estimated maximum fork length value of 987 cm, and the Phase 2 Rainy Season growth transformation equation Y = 0.92 x + 17.58 produced an estimated maximum fork length of 218 cm. However, the slope of the Phase 2 Dry Season growth transformation equation Y = 1.09 x + 12.63 is above 1.0, thus maximum fork length cannot be estimated. The maximum fork length measured for gurijuba during the Sea-Borne Survey was 133 cm, and compared to that the estimated values were considerably higher. Therefore, the cohorts obtained through cohort analysis are not likely to express year classes correctly.

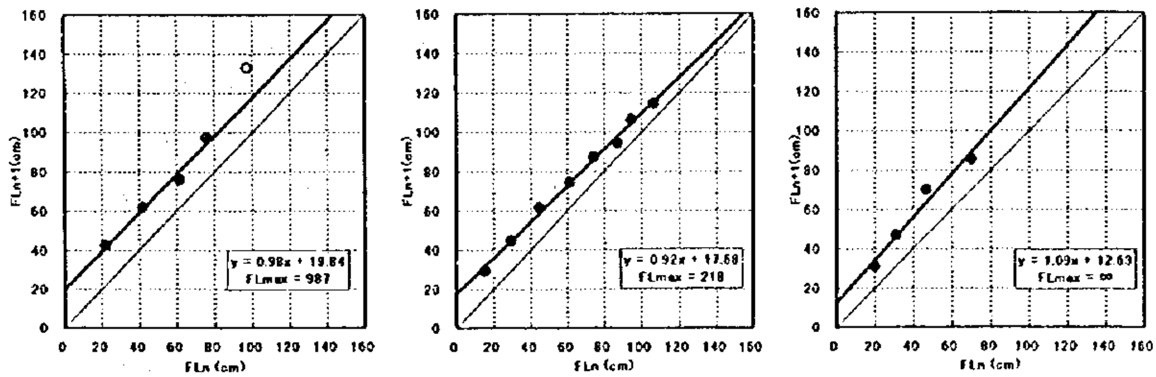


Figure 106. Walford's transformation for Gurijuba *Arius parkeri* mean length values by cohort. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. (Black dots: points employed in the plotting of the regression line; white dots: points not employed in the plotting of the regression line).

5.3. Landing Site Survey

5.3.1. An Outline of Fisheries in Northern Brazil, Particularly in the State of Pará, Based on Fishery Statistics

(a) Fisheries production in Northern Brazil

Total fisheries production in Brazil from 1978 to 1989 fluctuated around 0.8 to 1 million tonnes, with a peak registered in 1985 (approximately 0.96 million, the 19th largest catch in the world, about 1/12th of the Japanese production in that year — FAO Yearbook of Fishery Statistics, Vol. 60, 1987). The northern region of Brazil comprises seven States (Acre, Rondônia, Roraima, Amazonas, Amapá, Pará and Tocantins), of which only Amapá and Pará have coastlines, the others being land-locked. In the aforementioned period, fisheries production in Northern Brazil yielded 90–180 thousand tonnes, with a slight tendency toward increase (Figure 107, A). The ratio of fisheries production of Northern Brazil to that of all Brazil has varied around 10–20 %, with a slight increase after 1985 and a peak in 1989 (Figure 107, B). On the other hand, fisheries production in the State of Pará has declined from over 80% of the production in Northern Brazil in 1978 to some 50% of that in 1989 (Figure 107, C). The percentage of inland waters fishery production in the total fisheries production has been around 50–65 % for the State of Pará, 70–75% for Northern Brazil and 20–30% for all Brazil (Figure 107, D).

Inland waters fishery production between 1980 and 1989 (no data available for 1985) was 180–250 thousand tonnes for all Brazil, 100–150 thousand tonnes for Northern Brazil and 50–80 thousand tonnes for the State of Pará. There has been a tendency for inland waters fishery production to increase annually — except in the State of Pará, where it has stabilized around 50 thousand tonnes since 1984 (Figure 108, A). The percentage of inland waters fishery production of Northern Brazil in that of all Brazil has been about 45–60%, with a decreasing trend before 1986 and an opposite, increasing one after that year (Figure 108, B). However, the ratio of inland waters fishery production of the State of Pará to that of Northern Brazil declined, with some fluctuations, from over 60% in 1980 to about 40% in 1989 (Figure 108,C).

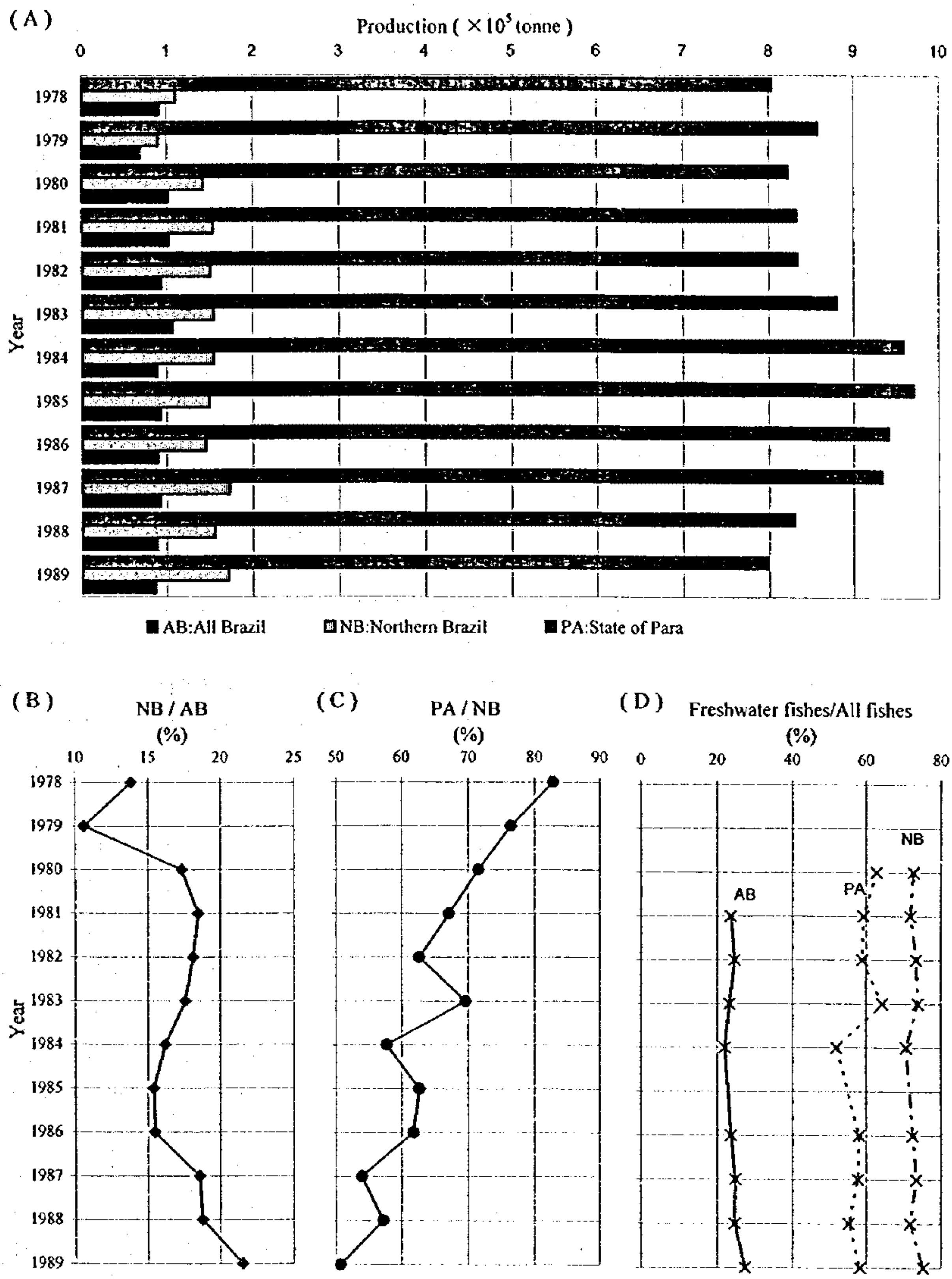


Figure 107. Variation of annual fisheries production in Brazil from 1978 to 1989. (A) Production by area; (B) Production ratio of Northern Brazil to all Brazil; (C) Production ratio of the State of Pará to Northern Brazil; (D) Production ratio of freshwater fishes to all fishes in each area. (Sources: IBGE, 1980-1990, except 1985; IBAMA, 1994).

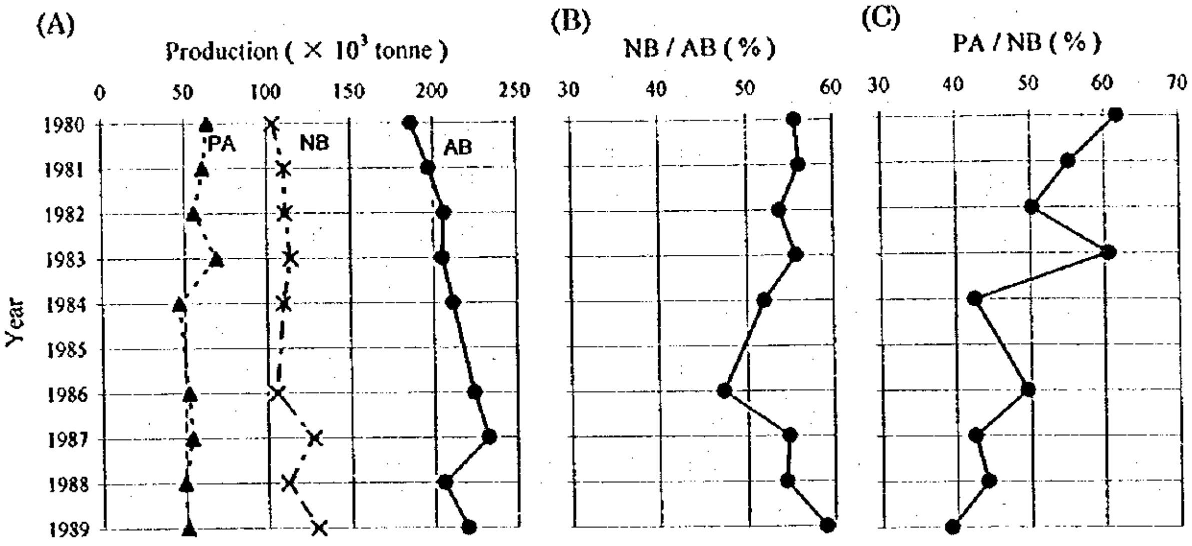


Figure 108. Variation of annual production in inland waters fishery in Brazil from 1980 to 1989. (A) Production of freshwater fishes by area; (B) Production ratio of Northern Brazil to all Brazil; (C) Production ratio of the State of Pará to Northern Brazil. (Source: IBGE, 1981–1990, except 1985).

Fish species described in fishery statistics published by IBGE (1981–1990, except 1985, for which no data were issued) under both inland waters and sea fisheries are lumped in groups such as "Characidae", "Small Clupeiformes" or "Shrimps". Figures 109 summarizes the distribution of those groups in inland waters and sea fisheries, with respect to the production ratio of Northern Brazil to all Brazil and that of the State of Pará to Northern Brazil. There, piramutaba *Brachyplatystoma vaillantii* was treated as one group with a single species.

Annual production in inland waters fishery by group in the period was as follows: Curimatidae, around 50 thousand tonnes; Characidae and Pimelodidae (except piramutaba), 20–40 thousand tonnes; Cichlidae and piramutaba, 10–30 thousand tonnes; Erythrinidae, 10–15 thousand tonnes; shrimps, Hypophthalmidae and Callichthyidae, respectively less than 10 thousand tonnes. Groups where Northern Brazil had high ratios to all Brazil included catfishes (above 90% in the case of piramutaba, Callichthyidae and Hypophthalmidae), Characidae (60–80%) and shrimps and Curimatidae (about 60%). Groups where the State of Pará had high percentages in relation to Northern Brazil were catfishes (the abovementioned three groups), shrimps and Erythrinidae (all about 80%); while Pimelodidae and Cichlidae participated with some 50% (Figure 109, A).

The predominant production in sea fishery was small Clupeiformes: 150–300 thousand tonnes. Next appear Sciaenidae, Scombridae and shrimps (50–100 thousand tonnes each), then other groups (Mugilidae, Ariidae, crabs, sharks, etc.), each with less than 50 thousand tonnes. Percentages of those groups except Pimelodidae with about 100% were low for Northern Brazil (actually, the States of Pará and Amapá alone): among them, only crabs and Ariidae had a relatively high ratio — about 40%. The State of Pará was responsible for most of the production in Northern Brazil (Figure 109, B).

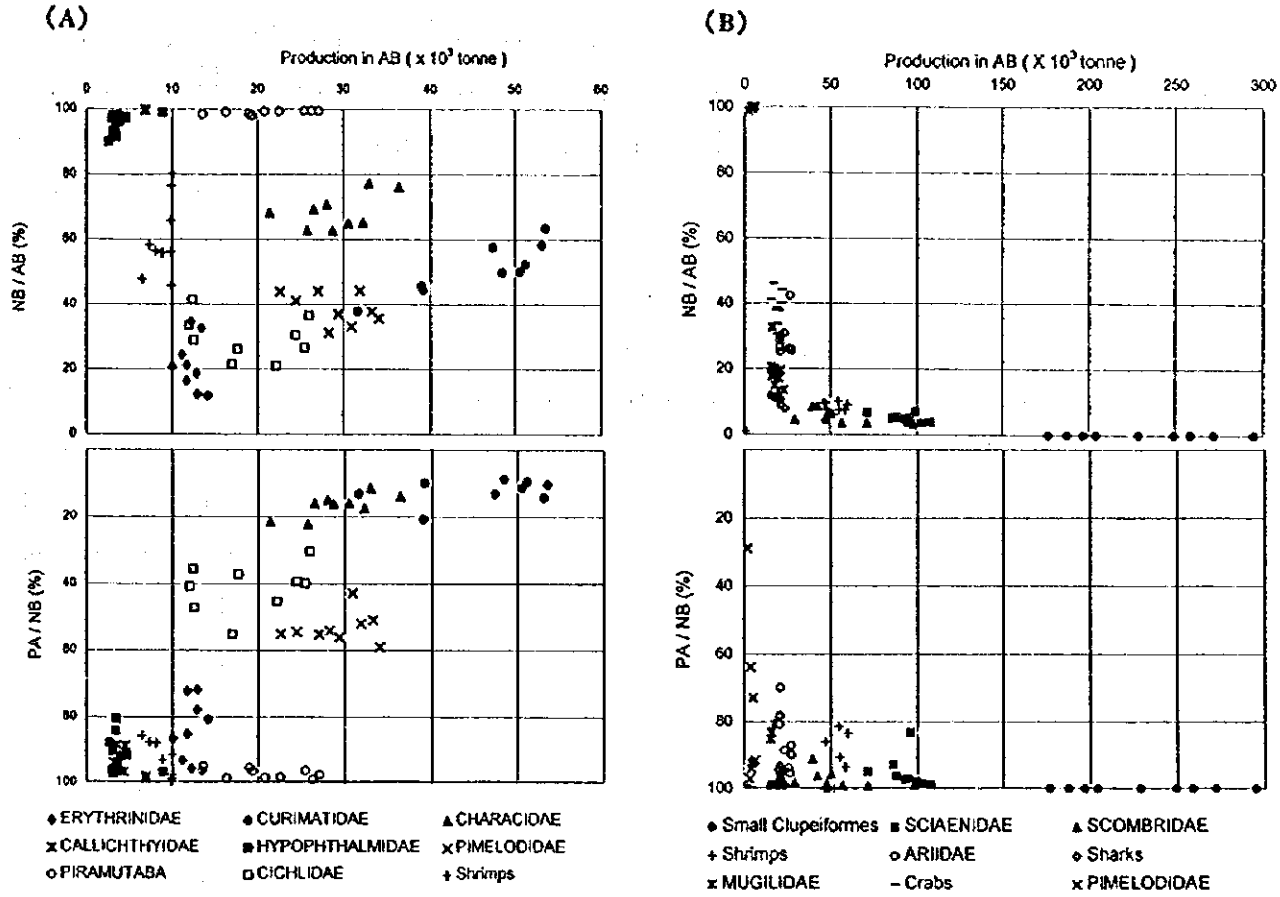


Figure 109. Annual production distribution of main fish groups in Brazil. (A) Inland waters fishery; (B) Sea fishery. AB, all Brazil; NB, Northern Brazil; PA, State of Pará. (Source: IBGE, 1981–1990, except 1985).

From the results above, one can characterize recent fisheries in Brazil, Northern Brazil and the State of Pará as follows:

Total fisheries production in all Brazil is about 0.8 million tonnes, of which some 80% correspond to sea fishery. The main production of sea fishery are small Clupeiformes, followed by Sciaenidae, Scombridae, shrimps and Ariidae. On the other hand, the main production in inland waters fishery are Curimatidae, Characidae, catfishes (the abovementioned three groups), Cichlidae and so on.

Fisheries production in Northern Brazil represents about 20% of that of all Brazil, and approximately 80% of that percentage is composed by inland waters fishery production. The main production of sea fishery in Northern Brazil (actually, the States of Pará and Amapá alone) are Pimelodidae, Ariidae and crabs, with no other relevant species. On the other hand, the inland waters fishery production of this region — Curimatidae, shrimps, Characidae, catfishes (the abovementioned three groups) — represented over 50% of the respective production in all Brazil, and catfishes stand out as over 90% of the national production for this group.

Fisheries production in the State of Pará represents some 50% of that in Northern Brazil, and 60% of it comprises inland waters fishery production. The predominant inland waters groups are catfishes (the aforementioned three taxa), shrimps and Erythrinidae, and correspond to over 80% of the production in Northern Brazil.

Therefore, if one estimates the total fisheries production in all Brazil in 1997 to be about 0.8 million tonnes, the total biomass of demersal fishes in the survey area during Phase 2 Dry Season Survey should account for some 10% of that.

(b) Landed quantity of piramutaba in Northern Brazil

Landed quantity of piramutaba in Northern Brazil (including the State of Pará) between 1980 and 1989 varied from 10 to 30 thousand tonnes (Figure 110, A, detailed in Figure 111, A). The ratio of landed quantity of piramutaba to inland waters fishery production in Northern Brazil varied from 10% to 20%, tending to a yearly decrease (Figure 110, C). In the State of Pará, that ratio was in the 20–40% range, with much fluctuation (Figure 110, D). The ratio of inland waters fishery production in the State of Pará to that of Northern Brazil was 40–60%, tending to a yearly decrease (Figure 110, B). However, the percentage of landed quantity of piramutaba in the State of Pará to that of Northern Brazil is overwhelmingly high — over 90% (Figure 110, E).

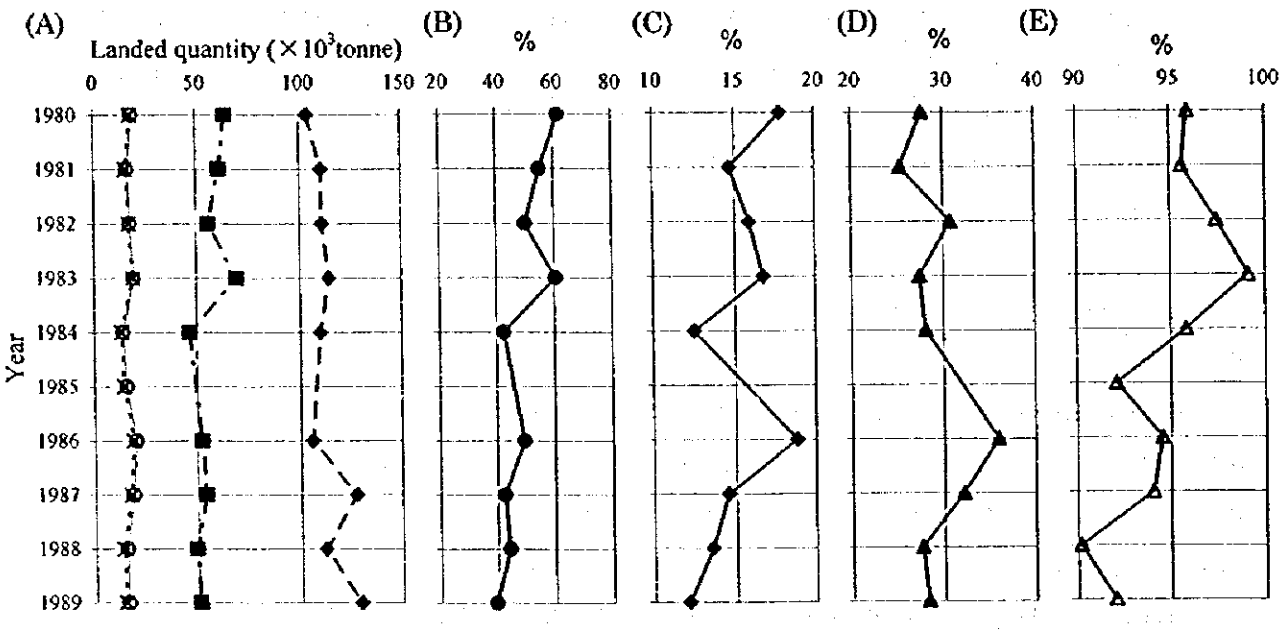


Figure 110. Variation of landed quantity of freshwater fishes, including Piramutaba, in Northern Brazil from 1980 to 1989. (A) Landed quantity of freshwater fishes and Piramutaba in Northern Brazil and the State of Pará (◆ freshwater fishes in Northern Brazil; ■ freshwater fishes in the State of Pará; ○ Piramutaba in Northern Brazil; × Piramutaba in the State of Pará); (B) Landed quantity ratio of freshwater fishes in the State of Pará to Northern Brazil; (C) Landed quantity ratio of Piramutaba to freshwater fishes in Northern Brazil; (D) Landed quantity ratio of Piramutaba to freshwater fishes in the State of Pará; (E) Landed quantity ratio of Piramutaba in the State of Pará to Northern Brazil. (Sources: IBGE, 1981–1990, except 1985; IBAMA, 1994).

Of the seven States comprising Northern Brazil, only those of Amazonas and Pará have published data on landed quantity of piramutaba. In the 1972–1990 period, landed quantity of piramutaba in Pará was overwhelmingly larger than that in Amazonas. Through that period, the landed quantity tended to slightly increase every year in Amazonas, while in Pará it peaked in 1977 (about 30 thousand tonnes) and has decreased ever since (Figure 111, A). As for landed quantity of piramutaba by fisheries system, industrial fishery made up for over 60% of the quantity in the State of Pará and has stabilized since 1981 at 90%. In contrast, artisanal fishery are totally responsible for the quantity in the State of Amazonas (Figure 111, B).

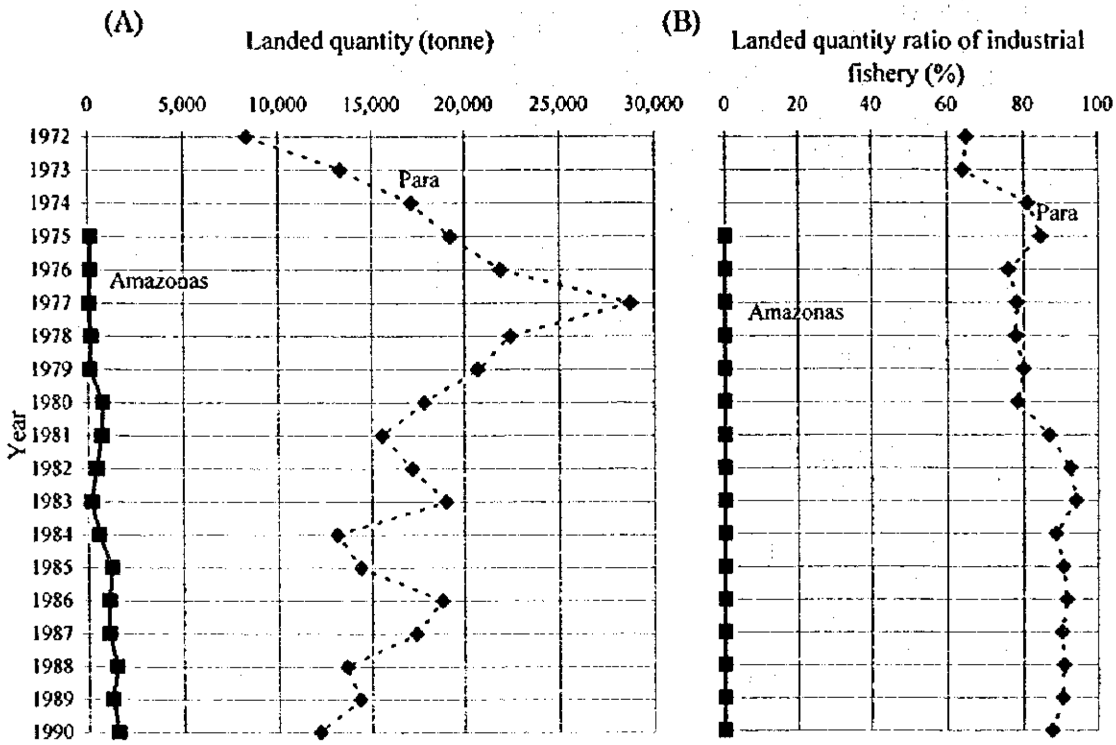


Figure 111. Landed quantity of Piramutaba in the States of Amazonas and Pará by fisheries system from 1972 to 1990. (A) Landed quantity by State; (B) Landed quantity ratio of industrial fishery. (Source: IBAMA, 1994).

(c) Catch effort for piramutaba by industrial fishery

Piramutaba catches (total of landed and discarded quantity) by industrial fishery trawlers increased fourfold from about 8 thousand tonnes in 1972 to around 32 thousand tonnes in 1977; after that, however, and despite some fluctuations, there has been a clear tendency toward decline. Piramutaba catches corresponded to some 80% and more of the total catch caught by industrial fishery, a very large proportion (Figure 112).

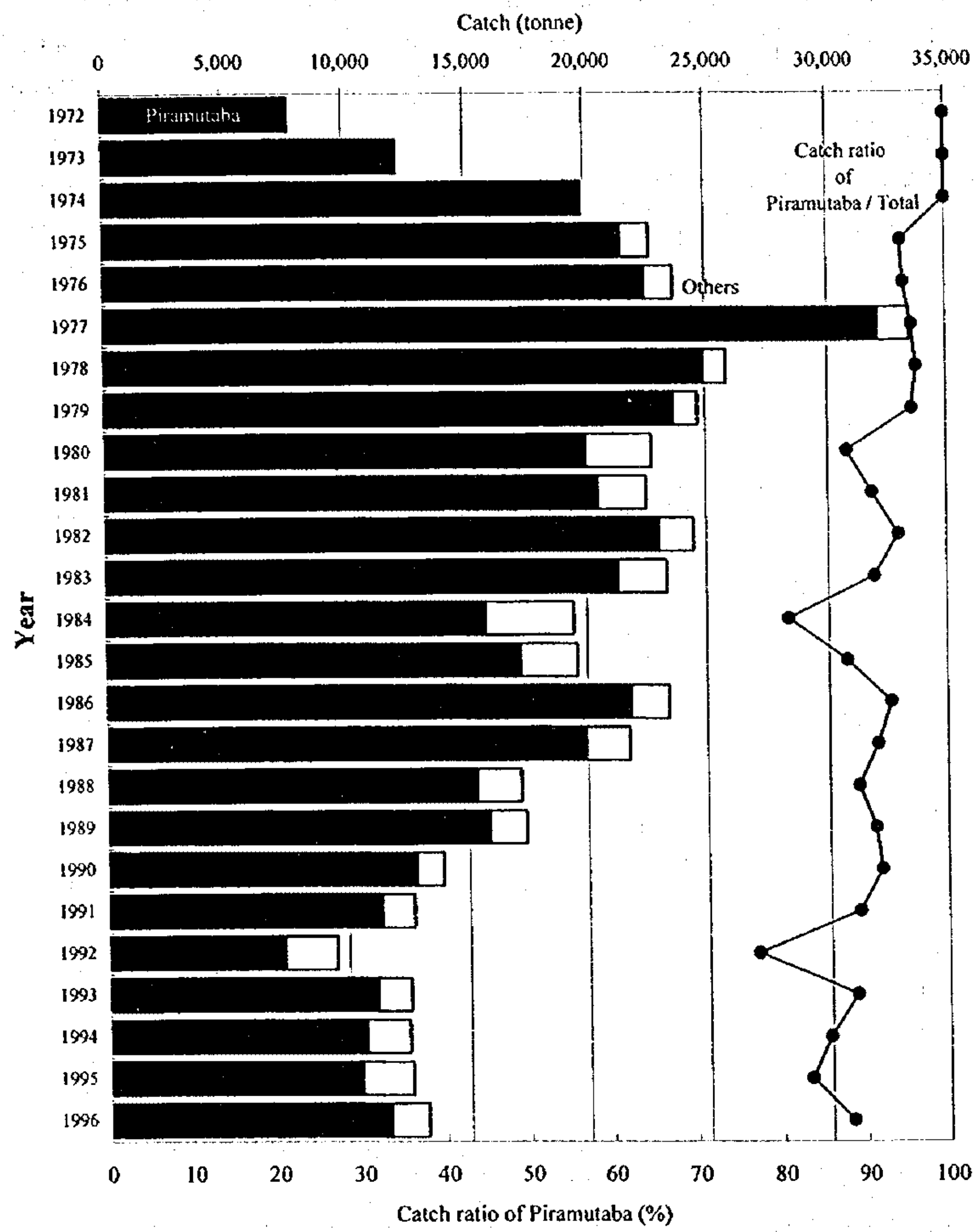


Figure 112. Variation of annual catch by industrial fishery trawlers in Northern Brazil from 1972 to 1996. Piramutaba (closed symbols); Others (open symbols); Catch ratio of Piramutaba to total catch (closed circles). (Source: IBAMA, 1997).

Catch effort was determined by three parameters — number of fishing vessels, number of fishing trips and number of days at sea. Maximum catch effort was obtained in 1980, with 69 fishing vessels, about 700 fishing trips (slightly less than in 1977) and a total of some 9 thousand days at sea. In average, therefore, a single vessel would have spent 13 days at sea making 10 fishing trips. On the other hand, the least number of vessels and trips happened in 1985, and that of days at sea in 1996. In 1985 there were 36 vessels and less than 500 trips, and the total number of days at sea in 1996 was about 4.5 thousand (Figure 113, A).

Catch per unit effort (hereinafter referred to as CPUE) reached its peak in 1977, with about 650 tonnes per vessel, 45 tonnes per trip and 4.8 tonnes per day at sea. It decreased to 1980 (when catch effort was maximum) and reached a nadir in 1992 with the following values: about 100 tonnes per vessel, 15 tonnes per trip and 1 tonne per day at sea. After 1993, CPUE tended to increase. A decline in catch leads to a reduction of number of trips per vessel and an increase in the number of days at sea per vessel (Figure 113, B).

(d) Economic aspects of piramutaba

Summarized below are the number of hired hands (although not necessarily engaged only in piramutaba fishing) employed by fisheries in Northern Brazil, as well as data on distribution of landed piramutaba for domestic consumption and export.

d-1) Employment

In 1990, the number of people working in fisheries in Pará, Amapá and Amazonas — among the seven States of Northern Brazil — was estimated as 100 thousand in Pará, 12 thousand in Amazonas and 6 thousands in Amapá. Of these, artisanal fishery employed 100% of the Amazonas and Amapá fishermen, and 97% of those in Pará (Figure 114, A).

In artisanal fishery, all personnel are engaged in fishing proper, while in the industrial fishery of the State of Pará many are involved in fish processing (Figure 114, B).

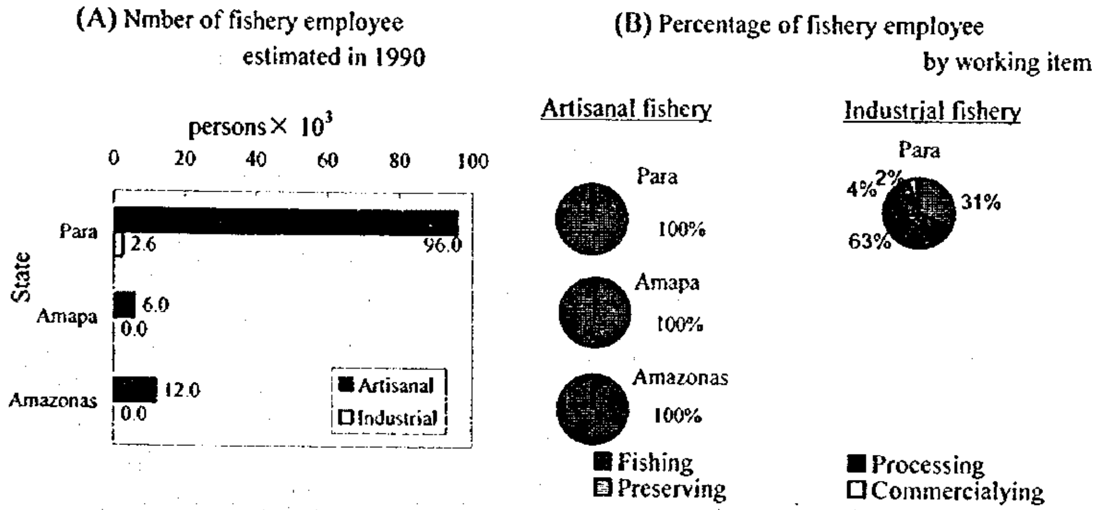


Figure 114. Estimated population of fishermen in Northern Brazil in 1990. (Source: IBAMA, 1994).

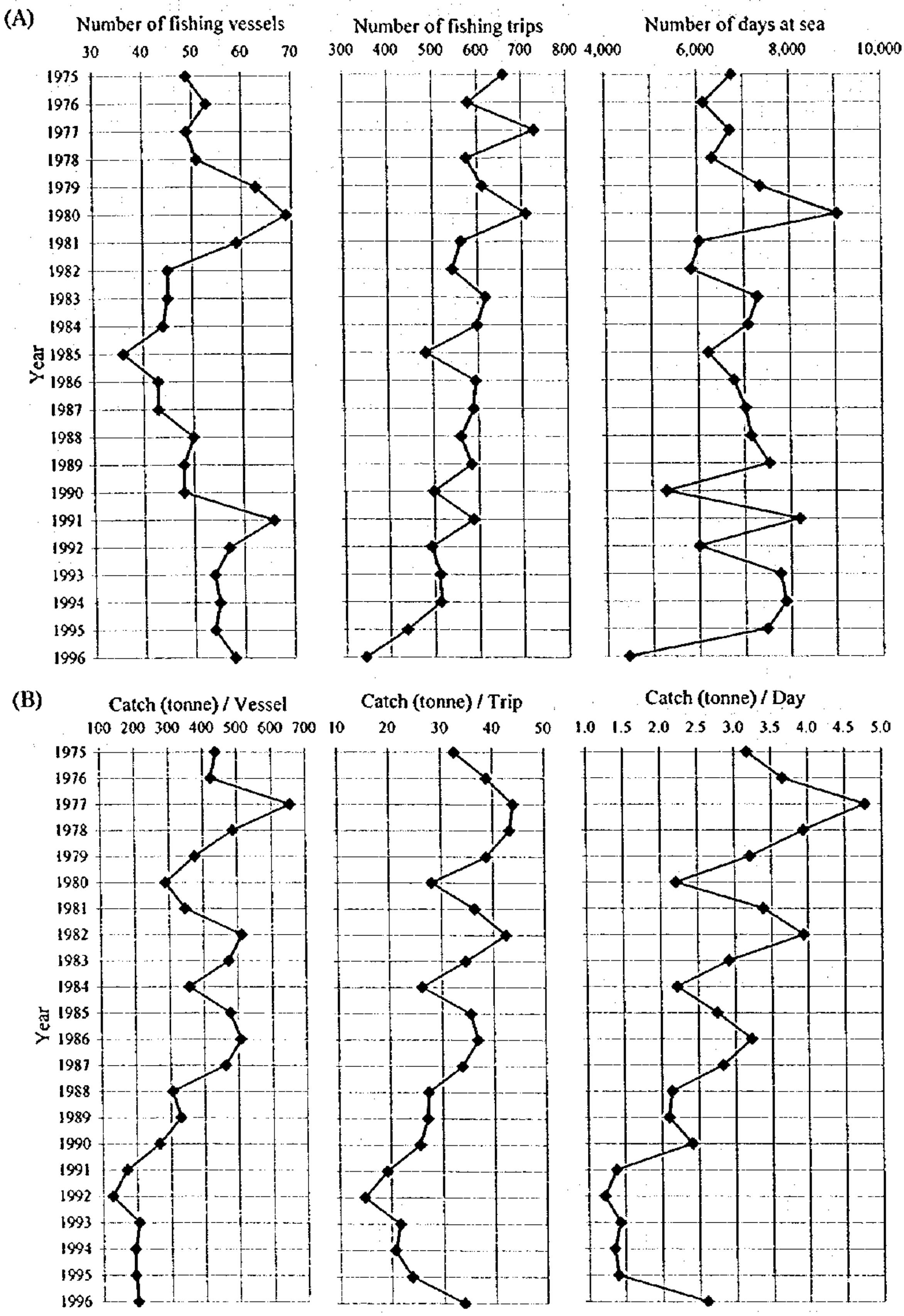


Figure 113. Catch effort and CPUE by industrial fishery trawlers in Northern Brazil from 1975 to 1996. (A) Catch effort; (B) CPUE, Catch per unit effort. (Source: IBAMA, 1997).

d-2) Domestic consumption

Figure 115 illustrates the results of a study conducted in 1987 and 1988 on the processing, product manufacturing and distribution (sales) of piramutaba.

Some 80–90% of the landed piramutaba were utilized as raw material for products, of which about 80–85% were processed into fish products. Sixty to eighty percent of the latter were sold in the domestic market (Figure 115, A). Processed piramutaba products were distributed (sold) mainly to the State of Ceará, and also to other States such as Pará, São Paulo, Pernambuco, Mato Grosso, etc. Commercialization took place then in more than ten Brazilian States, a number that increased to 12 in 1987 and 17 in 1988 (Figure 115, B). The raw material for products were mainly in the form of chilled round fish (Figure 115, C). The processed fish products were mainly comprised frozen fish head, frozen headless fish and frozen fish meat cuts with bone: those three kinds made up for over ¾ of the total of fish products (Figure 115, D). Mean prices for those material and products (in Cr$/kg) were higher for frozen fish fillet, followed by frozen fish meat cuts with bone and frozen headless fish (Figure 115, E, F).

d-3) Export

Production and export of piramutaba in the 1982–1990 period peaked in 1983, with values of 18 thousand tonnes for the former and 13 thousand tonnes for the latter: in that year, the ratio export / production attained its highest value (about 70%). In the following year, however, both production and export were reduced to 12 thousand and 3 thousand tonnes respectively. Later, production rose to its second peak in 1986 and then declined. In that period, export was rather stable, despite some fluctuations in production, around 4 thousand tonnes, except in 1990. The ratio export / production after 1984 varied between 20% to 30% (Figure 116, A, B).

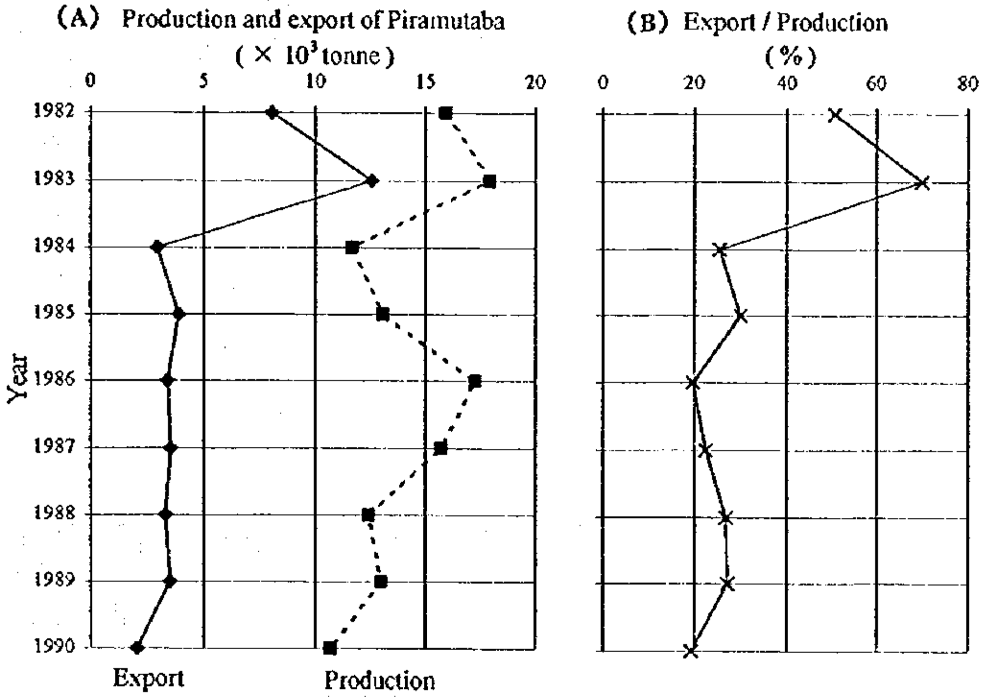


Figure 116. Production and export of Piramutaba from 1982 to 1990. (Source: IBAMA, 1994).

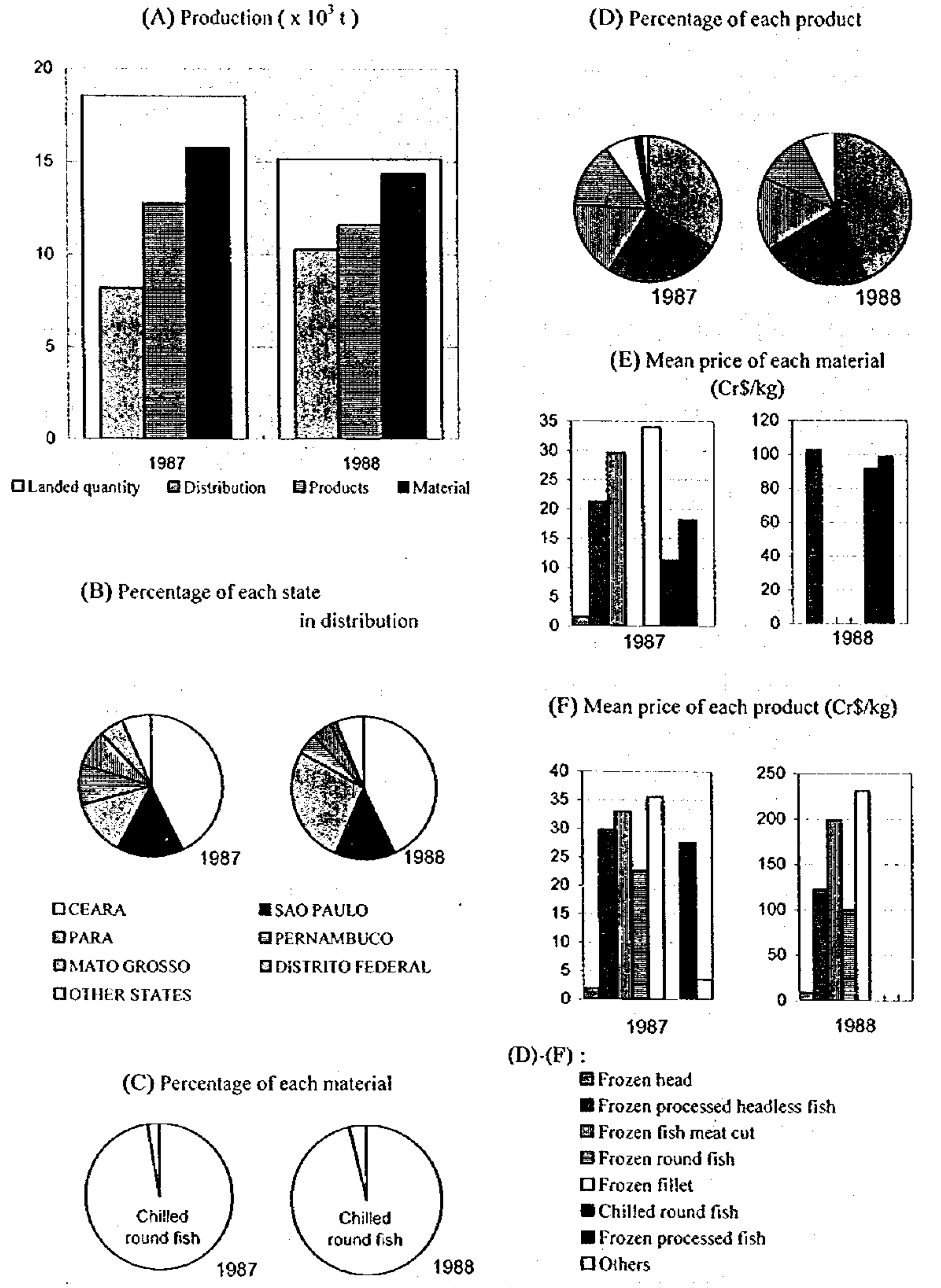


Figure 115. Production and distribution of Piramutaba for domestic consumption in the State of Pará during 1987–1988. (Source: IBAMA, 1994).

Between 1982 and 1990, the quantity of fish exported by Brazil varied in the 40-60 thousand tonnes range; of that, the percentage for piramutaba peaked in 1983 (slightly over 20%) and has dropped to levels below 10% ever since. Export ratio by piramutaba products also reversed after 1983. In 1982 and 1983, the most important export products were frozen processed headless fish (75-90%), followed by frozen fillet and frozen fish meat cuts (both making up 10-25%). In 1984, those percentages declined and rose, respectively, to 30% and 70%. From 1985 to 1987, each export of headless fish and fillet and cuts was 50-50. However, from 1988 export of fillet and cuts was on the rise and the gap between the two kinds of product started to widen (Figure 117, A).

The value of fish exports by Brazil in the 1982-1990 period fluctuated between US$ 100 million and 200 million (in 1966, exceptionally, it reached US$ 60 thousand). At the time, piramutaba exports varied from US$ 2 million to US$ 9 million, with a tendency toward a yearly decline. In most years, the ratio of value of piramutaba / value of fish exported was lower than 5%. The mean export price for fish varied in the US$1-4 /kg range (maximum price in 1987, minimum in 1986). The mean export price by piramutaba products and the mean export price for them were both lower than the mean export price for whole fish in general, and varied around US$ 0.5-2 /kg. Among piramutaba products, frozen fillet and frozen meat cuts commanded mean export prices higher than frozen processed headless fish — and their respective prices in relation to the value of piramutaba exports presented a pattern of fluctuations similar to that for quantity of piramutaba exported (Figure 117, B).

(e) Fisheries biology of piramutaba

Figure 118 shows the variation of monthly mean body length of piramutaba caught by industrial fishery trawlers from 1979 to 1988 (complete data only for all months of 1979). Figure 119 illustrates the variation by sex of mean body length of piramutaba caught by industrial fishery trawlers, measured every three months. Monthly mean body length of piramutaba tended to have high values in the rainy season (October-April), particularly in February, and low values in the dry season (May-August). Maximum and minimum values among monthly mean body lengths in a year were noticeably different, respectively in the 35-55 cm and 25-35 cm range. Three-monthly mean body length had slightly higher values for females than for males. Maximum value of that measurement occurred mostly in the period January-March.

Figure 120 summarizes the size composition of piramutaba landed by industrial fishery trawlers from 1981 to 1986, considering both sexes together. In all years, size composition of piramutaba exhibited a mono-modal distribution with a mode at 25-30 cm class in 1982, 30-35 cm class in 1981 and 1985, and 35-40 cm class in the other three years. The relationship between catch and modal class for size has not been recognized (Figure 111, cf. 1981-1986).

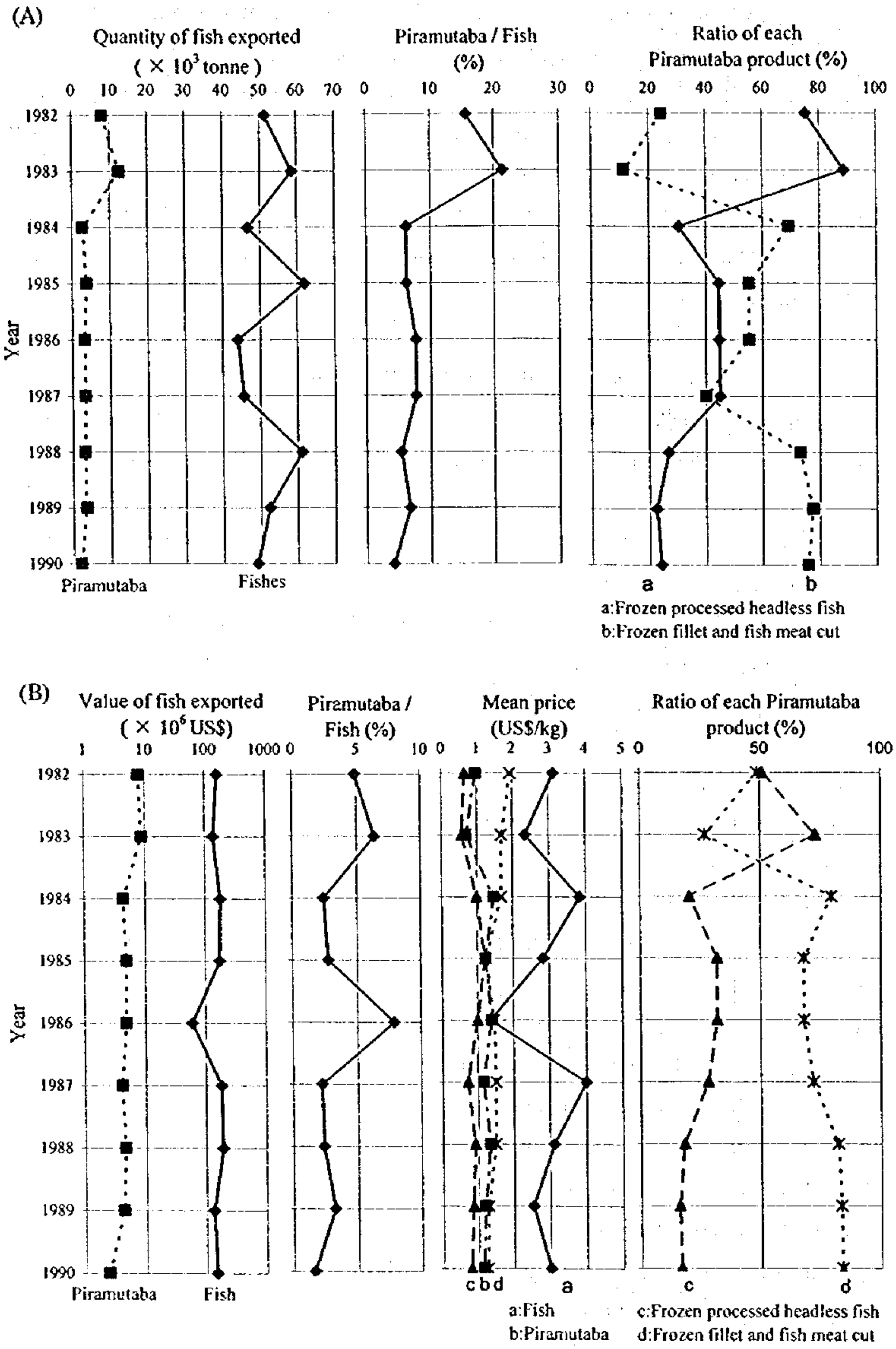


Figure 117. Piramutaba exports and their value during 1982–1990. (A) Exported quantities; (B) Value of exports. (Source: IBAMA, 1994).

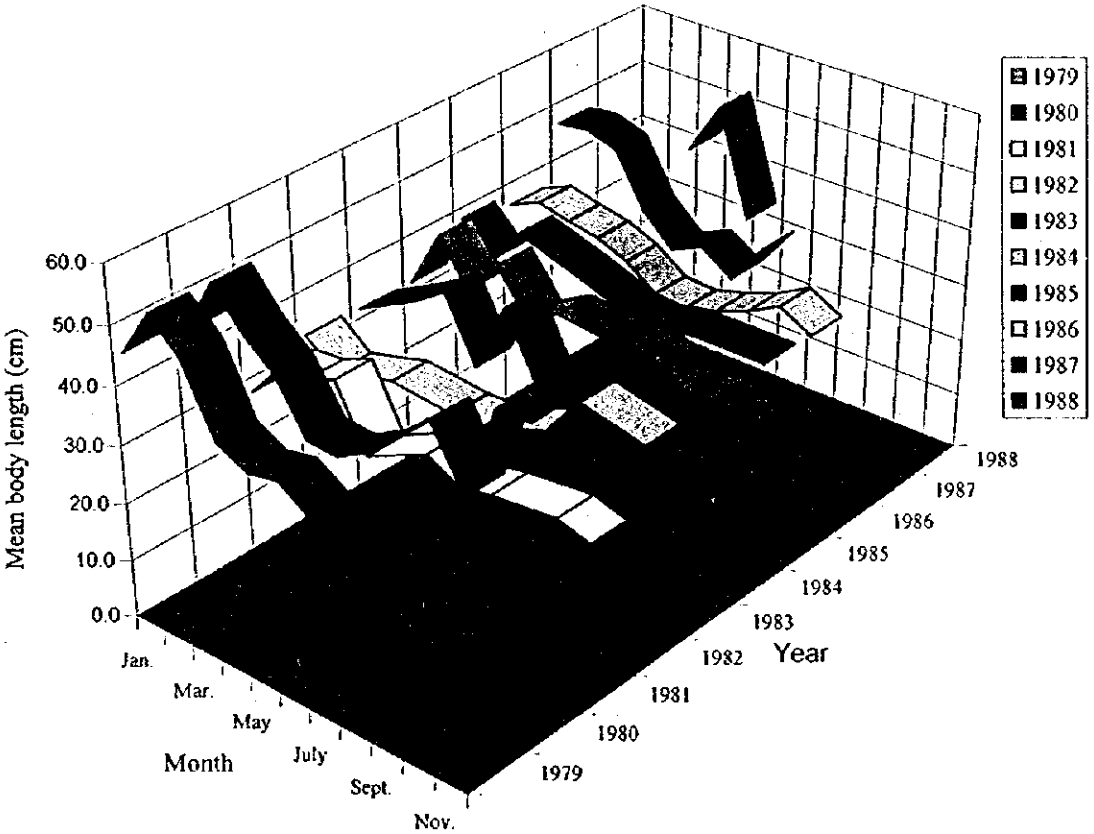


Figure 118. Variation of monthly mean body length of Piramutaba landed by industrial fishery trawlers from 1979 to 1988 (Source: IBAMA, 1994).

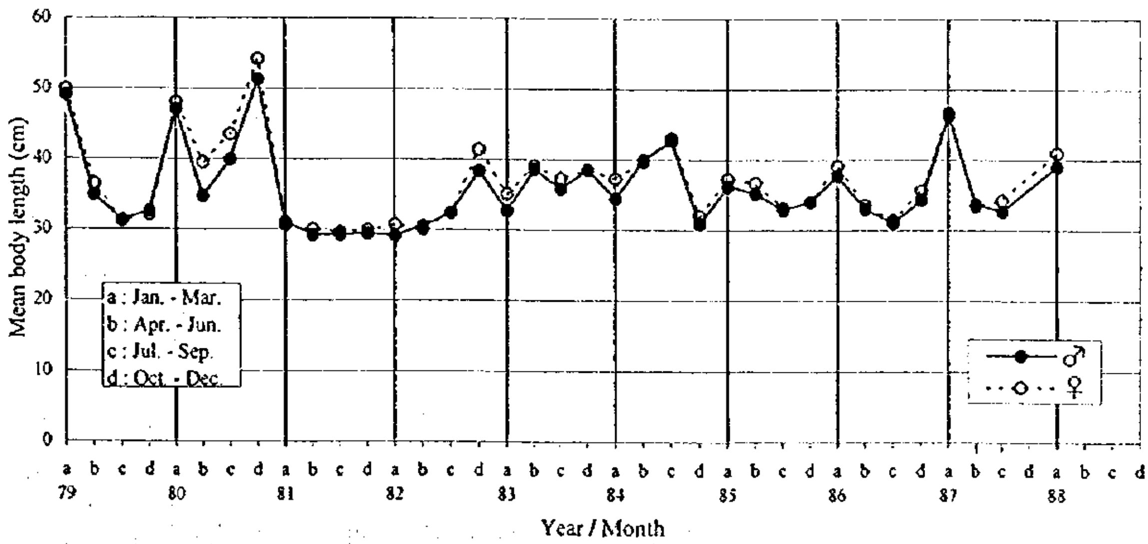
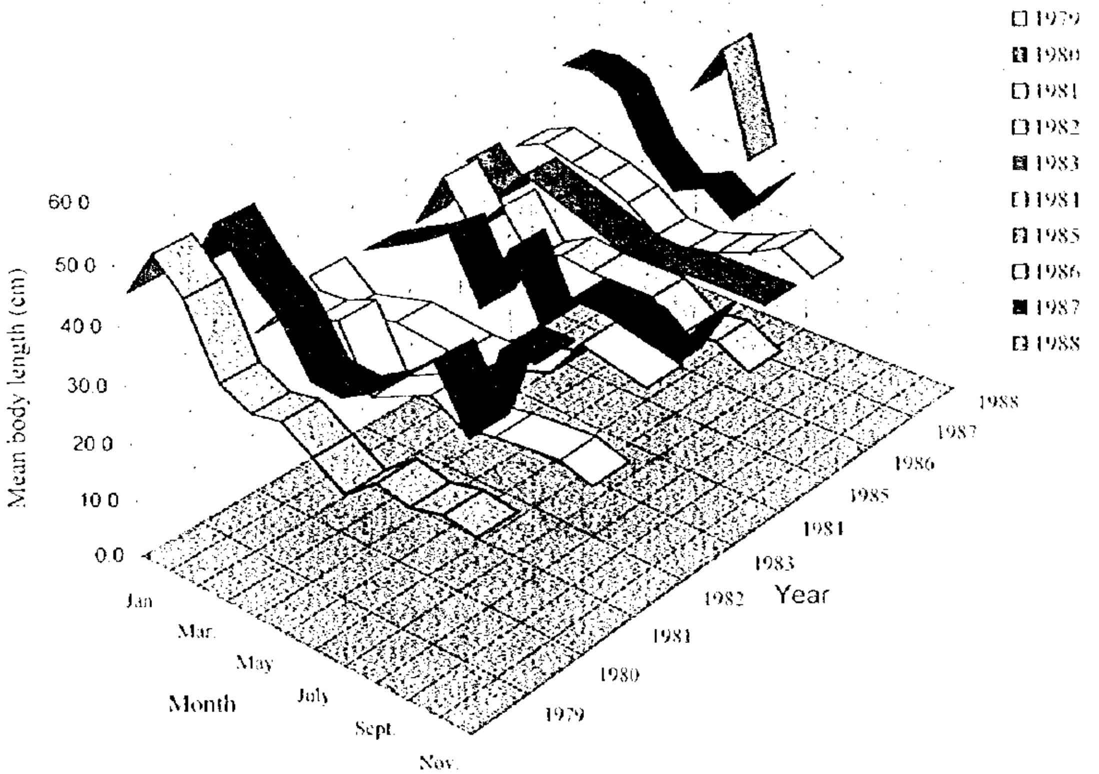


Figure 119. Variation by sex of mean body length of Piramutaba landed by industrial fishery trawlers from 1979 to 1988, measured every three months. (Source: IBAMA, 1994).



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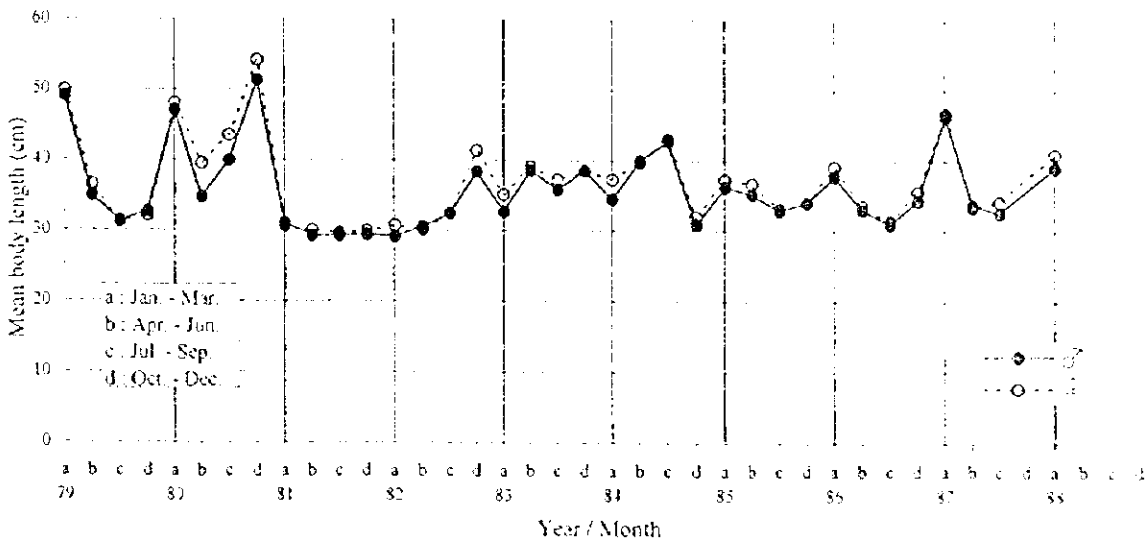

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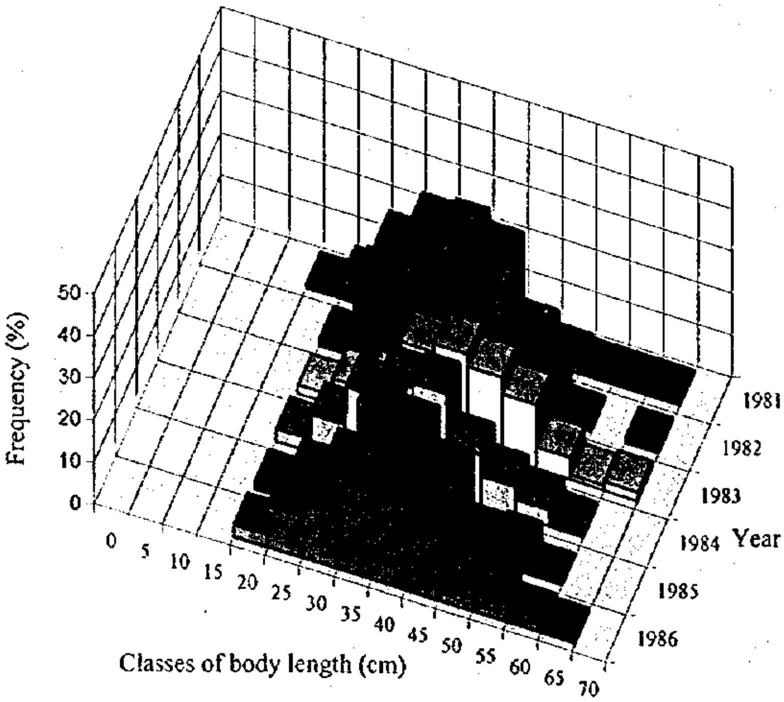


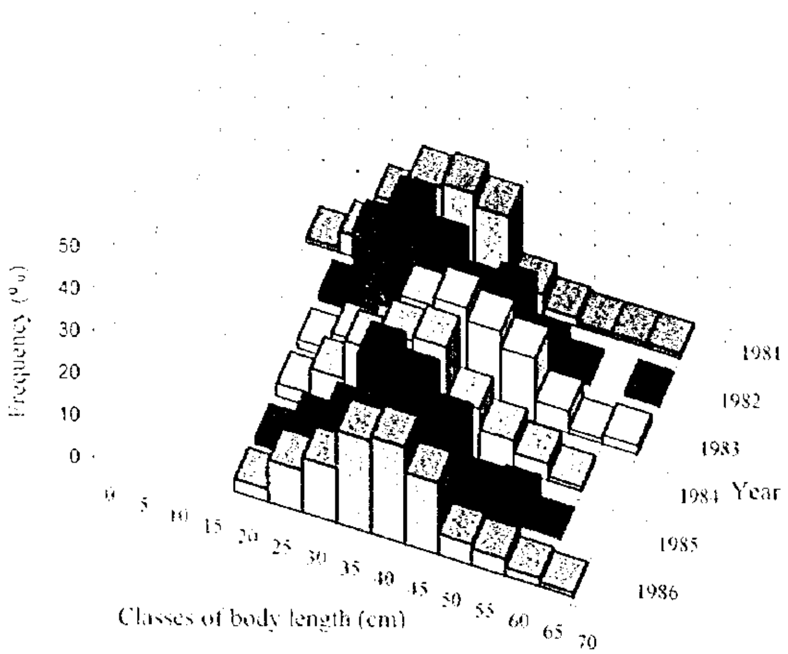
Figure 120. Size composition of Piramutaba landed by industrial fishery trawlers from 1981 to 1986. (Source: IBAMA, 1994).

5.3.2. Status of Fisheries in Northern Brazil, Particularly in the State of Pará, Based on the Interview Survey

(a) Summary of fisheries

Table 77 presents a general summary of data on fisheries compiled from a total of 32 interviews conducted in the Phase 1 Dry and Rainy Seasons and in the Phase 2 Rainy Season. Those interviews involved artisanal fishermen, representatives of artisanal fisherman colonies, industrial fisheries supervisors, union representatives at industrial fisheries, market-related personnel, fish processors, fishery brokers and public organizations established or residing in a total of 20 fishing communities in the Amazonian Estuary and upstream portions of the Amazon River.

Some kinds of information were not possible to obtain from interviews, such as that pertaining to annual catch, annual income, fishing grounds environment or allocation of fish caught in each community. However, interviews conducted in the Phase 2 Rainy Season indicated catch size depended on community size: thus, Icoaraçi (community size : town) would have an annual catch of approximately 20 thousand tonnes; Abaetetuba (village), about 10 thousand tonnes; and 3 communities (hamlet), some 1.5 thousand tonnes.



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a-1) Artisanal fishery

The number of fishermen and fishing boats involved in artisanal fishery around the Amazonian Estuary depended largely on the size of fishing communities. These numbers differ considerably, ranging from 16 to 15 thousand people (20–60 years of age, primarily men aged 30–40 years) and from 15 to 2,400 fishing boats. Besides, communities located near major consumption markets tended to be larger, and those in more remote areas smaller. Those consumption markets within the survey area were, going downstream along the Amazon: Manaus (population: 1,100,000), Santarém (220,000), Macapá (250,000) and Belém (1,500,000). The number of fishermen and boats in fishing communities also depended on those consumption markets (with an obvious trend toward underpopulation in remote areas) and, as a result, their geographical distribution was not determined by proximity to fishing grounds -- a major feature of this river basin. In many cases, the basic fisheries infrastructure in the fishing communities was underdeveloped and this degree of development was not significantly affected by community size. Fishing boats, one of the means of production in fisheries, were wooden boats that varied in length from 5m to 25 m (mainly about 10 m in most communities), in tonnage from <1 to 30 (mostly under 10 tonn.) and from non-powered to powered by 100 HP motors (mostly powered by motors under 20 HP, nearly all of Japanese make). Another mean of production in fisheries, fishing gear, consisted of gill nets and longlines, the former type accounting for more than 90% of the gear in all communities surveyed.

Nearly all fishermen belonged to fisherman colonies *(colonias de pescadores),* located in their respective communities. Although these colonies were established for the purpose of increasing income and improving the way of life for fishermen by means of providing retirement pensions, joint purchase of fishing gear and supplies and joint distribution of fresh fish, in fact their activities have recently laid stagnant in many communities.

The most conspicuous difference between artisanal fishery in the two communities located upstream of the Amazonian Estuary and that in the aforementioned communities of the Estuary proper is the size of the fishing boats employed. The communities upstream had smaller boats equipped with less powerful motors than those in the Estuary — most of the boats, in fact, with a tonnage of less than 5 and being non-powered.

a-2) Industrial fishery

Interviews conducted at industrial fishery companies in Belém revealed they use much larger and more powerful vessels than those employed in artisanal fishery. These vessels had a length of 20–25 m, a tonnage of 40–100 and motors of 180–300 HP. Also, with a single exception, they were all made of steel. In all cases, the gear chosen was the bottom trawl.

Table 77. Outline of fisheries in Northern Brazil, especially in the State of Pará, from Interview Survey. (A) Phase 1 Rainy Season Survey; (B) Phase 1 Dry Season Survey; (C) Phase 2 Rainy Season Survey.

(A)

Contents of interview	Artisanal fishery			Industrial
(Unit : community)	Town	Village[a]	Hamlet[b]	fishery company[c]
No. of interviews	—	3	11	1
Interviewees	—	Cooperative, IBAMA, and city office	Fisherman, marketing, and representative of fishery colony	Cooperative
No. of fishermen	—	1,280 - 3,000 (Soure) (mainly men of 30 - 40 years old)	16 - 3,600 (men of 20 - 60 years old)	— (mainly men of 30 - 40 years old)
Fishery brokers	—	3 (Soure)	Not fixed (Joanes)	—
No. of fishing boats	—	20 - 250	—	—
Fishing boat by size and material	—	1 - 20 ton 0 - 20 HP < 10m Wood-made	< 1 - 30 ton (mainly < 10 t) 0 - 100 HP (mainly <20 HP) < 15 m (mainly 10 m) Wood-made	40 - 100 ton 300 HP 20 - 25 m Steel-made
Fishing gears	—	Gill net	Gill net and longline	Bottom trawl
Annual catch (tonne:t)	—	—	(20 - 50 kg/day/boat)	—
Fishing season	—	—	—	—
Fishery infrastructure	—	Jetty and ice-making factory	Nothing (5 hamlets) Jetty (5 hamlets) Ice-making factory (1hamlet) Processing and refrigerating factory (1 hamlet)	—
Fishermen's organization	—	Colony	Colony except Monsaras, Cooperative (Cachoeira)	—
Fishing ground environment	—	—	—	—
Consumption of fish	—	—	—	—

[a] Abaetetuba, Macapa, and Soure ; [b] Baia do sol, Cachoeira, Colares, Condeixes, Joanes, Jubim, Marapanim, Monsaras, Salvaterra, Santana, and Sao Caetano ; [c] Icoaraci in Belem

Table 77. Continued

(B)

Contents of interview (Unit : community)	Artisanal fishery Town[a]	Village[b]	Hamlet[c]	Industrial fishery company
No. of interviews	4	3	2	—
Interviewees	IBAMA, broker, fishery processing company, and representative of colony	Representative of colony, fishery processing company, and marketing	Fisherman	—
No. of fishermen	20,000	15,000 (Vigia) 2,000 (Obidos)	—	—
Fishery brokers	1 ≤	2 (Vigia)	≦ 5	—
No. of fishing boats	—	2,400 (Vigia)	15 - 21	—
Fishing boat by size and material	< 5 ton 0 - 18 HP (mainly 0 HP) 5 - 10 m Wood-made	Vigia : 20 - 30 ton 10 - 100 HP (mainly 10 - 20 HP) 10 - 25 m (mainly 5 - 15 m) — Obidos : < 5 ton 0 HP	< 5 ton 0 - 10 HP < 5 m —	—
Fishing gears	Gill net and longline	Gill net	Gill net	—
Annual catch (tonne:t)	5,000 - 8,000 t	1,200 - 1,500 t (processing company) (70 - 80 t / day)	—	—
Fishing season	Piramutaba : especially in Jun. - Sep. Others : through the year	Fresh water fish : winter (rainy season), Sea water fish : summer (dry season) in Vigia	—	—
Fishery infrastructure	Jetty	Jetty (Vigia and Obidos), Processing, refrigerating, and ice-making factory (Vigia)	Jetty	—
Fishermen's organization	4,800 colonies	Colony	Colony	—
Fishing ground environment	—	No pollution (Vigia)	—	—
Consumption of fish	(Selling fillet to Belem, Sao Paulo, and Rio de Janeiro)	—	—	—

[a] Santarem ; [b] Obidos and Vigia ; c Braganca

Table 77. Continued

(C)

Contents of interview	Artisanal fishery			Industrial
(Unit : community)	Town[a]	Village[b]	Hamlet[c]	fishery company[d]
No. of interviews	2	2	3	1
Interviewees	Representative of fishery colony	Representative of fishery colony	Representative of colony, and fisherman	Director of company
No. of fishermen	4,000 (men of 20 - 45 years old)	2,500 (men of 30 - 45 years old)	80 (Baia do Sol) 140 (Cajueiro)	12 men / 2 boats
Fishery brokers	4	38 (number of broaker's boats)	2	—
No. of fishing boats	150 - 180	180 - 200	40 - 65	—
Fishing boat by size and material	0.3 - 35 ton 9 - 100 HP Wood-made	15 - 22 ton 25 HP Wood-made	0.3 - 6 ton 15 HP Wood-made	54 ton 180 HP Wood-made
Fishing gears	Gill net and Longline	Gill net	Gill net and Longline	Bottom trawl
Annual catch (tonne:t)	18,000 - 20,000 t in landing	7,000 - 9,000 t in selling	1,200 - 1,500 t in catching	18,000t
Fishing season	Full season (mainly in rainy season)	Full season (mainly in rainy season)	Full season (mainly in rainy season)	—
Fishery infrastructure	Jetty Processing and refrigerating factory	Jetty	—	—
Fishermen's organization	Colony, syndicate, and cooperative	Colony and cooperative	Colony	—
Fishing ground environment	—	—	—	—
Consumption of fish	—	—	—	—

[a] Icoaraci in Belem ; [b] Abaetetuba ; [c] Baia do Sol and Cajueiro in Mosqueiro Is. ; [d] Small fishery company in Icoaraci / Belem

(b) Trends in fisheries

Table 78 shows trends in local fisheries, as identified through interviews conducted in the Phase 1 Rainy and Dry Seasons and the Phase 2 Rainy Season. These interviews involved 146 people —fishermen, representatives of fisherman colonies, market-related personnel, industrial fishery supervisors, union representatives at industrial fishery, etc.— established in 25 fishing communities in the Amazonian Estuary and upstream.

b-1) Means of production in fisheries

Size and equipment of fishing boats operated by artisanal fishery in the Amazonian Estuary tended to depend upon the size of the community they belonged to. The larger the community, the larger, more powerful and better equipped its boats. Nevertheless, the number of fishing boats fully fitted with navigational instruments, fishing apparatuses, radio and safety equipment was extremely low even in large communities. With one exception, all fishing boats were made of wood, regardless of community size.

In the regions upstream from the Estuary, there were no differences in the size of fishing boats resulting from differences in community size, and tonnage and horsepower of those boats varied considerably. However, as mentioned in subsection (a), fishing boats belonging to communities in Santarém and Óbidos were mostly non-powered, with a tonnage of less than 5. These boats were also not fitted with major instruments, apparatuses and equipments; also, they were all made of wood.

Fishing gear utilized in artisanal fishery consisted of gill nets, except for three cases in which longlines were used. Around the Amazonian Estuary, gill nets measured 1,000–4,500 m in length; upstream they were 70–440 m long, except in Santarém and Óbidos, where they had a length of 2,000–3,000 m. Mesh size of these gill nets was 6–15 cm (mostly 14–15 cm) around the Estuary, 10–15 cm in Santarém and 18 cm in Óbidos and Parintins — although in the latter village it could reach 30 cm. In most cases, gill nets were 5–6 m in net depth. Gill net fisheries in Manaus were characterized by the presence of several (up to ten) small, non-powered canoes accompanying the main boats. Though not shown in Table 78, the interviews also revealed that gill nets were made of nylon monofilament or multifilament, and styrofoam blocks were used as buoys. Longlines ranged from 1,800 m to 3,000 m in length, and 700–1,500 fish hooks were attached to the main lines. Fishing boats using longlines got mainly relatively high-priced fishes such as large sharks, gurijuba *Arius parkeri*, pescada amarela *Cynoscion acoupa* and the like. Since this method required that bait be obtained prior to fishing, small bait-catching gill nets were also loaded onto the boat, so the full operation had the inconvenience of having to deploy two types of fishing gear.

Bottom trawlers operated by industrial fishery around the Amazonian Estuary were overwhelmingly larger, more powerful and better equipped than those employed in artisanal fishery as described above. The trawlers aimed for demersal fish were made of steel, measuring 22–23 m in length, with a tonnage of 85–100 and powered by 300–350 HP motors (An exception was a single, 12 m long, 120 HP motor-powered fishing boat operating from Belém.). Shrimp trawler in Macapá was steel-made, 22 m long, 110 tonnage vessels powered by 425 HP motors— although in the Phase 2 Rainy Season Survey a wooden 54 tonnage, 180 HP motor-powered vessel was observed in Icoaraçi. On the other hand, size and equipment of gill net fishing vessels operated by industrial fishery companies (two outfits in Vigia and one in Macapá) did not differ much from those of larger boats employed in artisanal fishery.

b-2) Landed quantity and landed monetary amount

Annual landed quantity of fish per boat (vessel) tended to depend upon the boat's size and equipment, as already described. Industrial fishery has superior vessels compared to artisanal fishery, and his annual landed quantity of fish per vessel was 300–3,000 tonnes for trawlers (in 1996, 58 vessels landed about 12 thousand tonnes, or about 200 tonnes per vessel — see Figure 112,113) and 120–1,500 tonnes for gill net vessels. In contrast, annual landed quantity of fish per boat in artisanal fishery was 9–250 tonnes in towns (13 tonnes in Manaus), 3–200 tonnes in villages (35 tonnes in Parintins) and 0.2–150 tonnes in hamlets (the landed quantity of 500–2,700 tonnes recorded in Iranduba does not refer to one boat, but rather to the amount purchased by processing companies). Estimated annual landed quantity of fish per boat in artisanal fishery operating longlines was around 10–150 tonnes, calculating catch size per trip and number of operational days in a year (Table 78, B).

In addition, annual landed quantity of one shrimp trawler in industrial fishery (in Macapá) was 40 tonnes, not discriminating whole or headless shrimp.

Annual landed monetary amount per boat in artisanal fishery was obtained in the Phase 2 Rainy Season Survey. That amount also depended upon community size: US$ 150,000–200,000 in towns, US$ 80,000–150,000 in villages and US$ 20,000–50,000 in hamlets. Information on annual landed monetary amount per vessel in industrial fishery could be obtained only from two companies, one in the Phase 1 Rainy Season Survey, the other in the Phase 1 Dry Season Survey. However, since one of the reported amounts was exceedingly high (R$ 5 million), that amount was interpreted as the total income of that company. The other company reported an annual landed monetary amount per vessel of R$ 300,000.

b-3) Fishing circumstances

For both artisanal and industrial fisheries, the annual number of fishing days was between 100 and 300 days (220 on the average) — with the exception of Bragança, where it was 360 days. The number of fishing days per trip in artisanal fishery can be counted as 1 for villages and hamlets and 46 for towns — in most cases, it ranged from a few days up to dozens of days, at most 20 days. In contrast, the number of fishing days per trip in industrial fishery was 10–25 days (the mean values obtained from fishery statistics was 13 days in 1966, see Figure 113).

In artisanal fishery, duration of fishing time per haul was generally 10–12 hours with gill nets. According to one testimony, in Óbidos it was of 4 hours. Duration of fishing time per haul in industrial fishery could not be determined.

The number of crew members on board in artisanal fishery was under 10, generally 5. Upstream from the Amazonian Estuary, the use of canoes around the main fishing boat increases that number to more than 10, sometimes up to 30. In industrial fishery, the crew numbered 5–9.

b-4) Fish species landed

No differences could be observed in landed species composition between artisanal and industrial fisheries operating in the Amazonian Estuary. Landed fishes comprised both freshwater and marine species, the latter including those found in brackish and oceanic waters. They are:

Freshwater fishes:

dourada	*Brachyplatystoma flavicans*
filhote	*Brachyplatystoma filamentosum*
pescada branca	*Plagioscion squamosissimus*
piramutaba	*Brachyplatystoma vaillantii*

Marine fishes:

bagre	*Arius* spp.
cação	*Carcharhinus* spp.
gurijuba	*Arius parkeri*
pescada amarela	*Cynoscion acoupa*
pescadinha gó	*Macrodon ancylodon*
sarda	*Pellona* spp.
serra	*Scomberomorus brasiliensis*
xaréu	*Caranx* spp.

Species landed by shrimp trawler operated by industrial fishery in Macapá included pescada amarela *Cynoscion acoupa* and pescadinha gó *Macrodon ancylodon*, mixed with pink shrimp.

All species landed by artisanal fishery upstream from the Amazonian Estuary were freshwater fishes. They are (underlined species also found in the Estuary) the following:

apapá	*Pristigaster* spp. and *Pellona* spp.
aracu	Anostomidae (several genera)
curimatá	*Prochilodus* spp.
<u>dourada</u>	<u>*Brachyplatystoma flavicans*</u>
<u>filhote</u>	<u>*Brachyplatystoma filamentosum*</u>
jaraqui	*Semaprochilodus* spp.
jaú	*Paulicea luetkeni* (= *Zungaro zungaro*?)
mapará	*Hypophthalmus* spp.
pacu	*Myleus* spp.

pescada branca	*Plagioscion squamosissimus*
piramutaba	*Brachyplatystoma vaillantii*
pirapitinga	*Colossoma bidens*
pirarucu	*Arapaima gigas*
sardinha	*Triportheus* spp.
surubim	*Pseudoplatystoma fasciatum*
tambaqui	*Colossoma macropomum*
tucunaré	*Cichla* spp.

b-5) Other aspects: commercially important species and fishing grounds

Data on commercially important species, discarded fishes and fishing grounds were obtained through interviews with artisanal fishermen of the Amazonian Estuary during the Phase 2 Rainy Season Survey. Commercially important species were filhote, dourada, pescada branca, piramutaba and bagre. No species were discarded by artisanal fishery. Fishing grounds exploited by artisanal fishery in the Amazonian Estuary comprised the shallow (up to 12 m water depth) coastal area of Marajó Bay and the Amazon River. In the Rainy Season, the major fishing grounds switched to the Northern Channel of the Amazon River, near the northern portion of Marajó Island, due to the upstream migration of piramutaba and other species. Fishing villages by the sea (Vigia and Cachoeira) had their major fishing grounds located in the Atlantic coast.

b-6) Recent changes in fisheries

Summarized below are trends affecting the current status in fisheries from the past two or three years, as indicated by frequent answers to interviews.

The number of fishing boats (vessels) and fishermen engaged by artisanal and industrial fisheries in the Amazonian Estuary has tended to increase, but their respective catch sizes have been declining. The composition of fish species has not changed, and the size of captured fish has either remained unchanged or tended to decrease.

The number of fishing vessels and fishermen engaged by artisanal fishery upstream from the Amazonian Estuary has tended to increase and the catch size remained the same. Composition of fishes there was characterized as rich, average or poor depending on the specific region. Size of captured fish has either grown larger or remained unchanged. With one exception, all people interviewed were full-time fishermen.

b-7) Necessity for fishermen

The respondents' main concern was trying to get low-interest government loans to secure capital for fishing.

Table78. Trend of fisheries in Northern Brazil, especially in the State of Pará, from Interview Survey. (A) Phase 1 Rainy Season Survey; (B) Phase 1 Dry Season Survey; (C) Phase 2 Rainy Season Survey.

(A)

Contents of interview (Unit: boat or person)	Artisanal fishery			Industrial fishery company		
					Village	
	Town[a]	Village[b]	Hamlet[c]	Town[d]	Gill net[e]	Shrimp trawl[f]
No. of interviews	6	7	10	2	3	1
Interviewees	Fisherman	Fisherman and representative of colony	Fisherman	Manager and captain	Manager and captain	Manager
Size of fishing boat	1 - 25 ton 18 - 270 HP 8 - 20 m Wood-made	2 - 15 ton 0 - 69 HP 5 - 13m Wood-made and steel-made (one)	0.8 - 8 ton 0 - 36 HP 5 - 14 m Wood-made	98 - 100 ton 300 - 350 HP 22 - 23 m Steel-made	5 - 20 ton 23 - 170 HP 11 - 16 m Wood-made	110 ton 425 HP 22 m Steel-made
Equipments on fishing boat	Windlass, net hauler, compass, generator, and fire extinguisher	Life boat, generator, and fire extinguisher	Compass (one boat)	Fire extinguisher, fish finder, GPS, compass, winch, deck crane, net hauler, life boat, windlass, generator, and wireless telegraph	Winch, life boat, and fire extinguisher	Net hauler, winch, fish finder, rader, windlass, life boat, deck crane, GPS, fire distinguisher, refrigerator, generator, and wireless telegraph
Annual catch (tonne:t)	9 - 80t	3 - 80t	0.2 - 12t (5 - 70 kg/day)	700 - 3,000 t	120 - 1,500 t	40 t
Annual income	-	-	-	(0.5 - 0.8 R$/kg)	5,000,000 R$	-
Annual fishing days	118 - 300	120 - 300 (depend upon the weather)	100 - 300	300	120 - 270	230 - 270
Fishing days per voyage	7 - 20	1 - 8 (24 : one steel boat)	1 - 11 (mainly 1 day)	10 - 20	12 - 25	-
Time per haul	12 h	6 - 12 h	12 h	-	-	-
No. of crews	2 - 7	3 - 6	3 - 5	7 - 9	5 - 8	5
Fishing gears	Longline (1,800m, 700 angles), Gill net (1,000-1,500m, 15cm in mesh size)	Gill net (1,500-2,000m, 14 - 15cm in mesh size ; 4,400m, one steel boat)	Gill net (1,000-3,000m, 14 - 15cm in mesh size)	Bottom trawl for fish	Gill net	Trawl net for shrimp
Top rank fish in quantity	Dourada, Filhote, Pescada amarela, P. branca, and Piramutaba	Bagre, Dourada, Filhote, Gurijuba (especially in summer) Pescada amarela, P. branca, and Piramutaba	Bagre, Dourada, Filhote, Gurijuba, Pescada amarela, P. branca, and Piramutaba	Bagre, Dourada, Filhote, Gurijuba, Pescada branca, and Piramutaba	Dourada, Filhote, Gurijuba, Pescada amarela, P. branca, and Piramutaba	Pescada amarela, Pescadinha go, and Pink shrimp
Top rank fish in value	-	-	-	-	-	-

a Icoaraci and Ver o Peso in Belem ; b Macapa, Soure, and Vigia ; c Cachoeira, Cajueiro, Colares, Condeixas, Joanes, Monsaras, Salvaterra, Sao Caetano, and Abade (Vila) ; d Icoaraci in Belem ; e Macapa and Vigia ; f Macapa

Table 78. (A) Continued

Contents of interview (Unit : boat or person)	Artisanal fishery			Industrial fishery company		
					Village	
	Town[a]	Village[b]	Hamlet[c]	Town[d]	Gill net[e]	Shrimp trawl[f]
Fish discarded	-	-	-	-	-	-
Fishing ground	-	-	5 - 20m water depth	-	-	-
Recent fishery condition compared with 2 - 3 years ago						
No. of fishermen and fishing boats	Increase No change (1 answer)	Increase No change (1 answer)	Increase Decrease (1 answer)	Increase Decrease	Increase	No change
Catch size	Decrease	Decrease No change	Increase Decrease No change	Decrease	Decrease	Decrease
Fish species composition	No change	No change	No change Change	No change	No change	No change
Fish size	Smaller No change (1 answer)	Smaller No change	Smaller No change	Smaller	Smaller No change	No change
Side job	Nothing	Nothing	Nothing Other job (1 answer)	Nothing	Nothing	Nothing
Necessary things	Good equipments, low-priced oil, finance, and prohibition of trawl	Finance, new boat, new net, and fishing tecnique	Finance, low-priced oil, rise in the fish price, new net, new big boat, cooperative, fishing tecnique, prohibition of trawl net by law, lighting, warehouse, and wharf	Low - priced oil	-	Finance

a Icoaraci and Ver o Peso in Belem ; b Macapa, Soure, and Vigia ; c Cachoeira, Cajueiro, Colares, Condeixas, Joanes, Monsaras, Salvaterra, Sao Caetano, and Abade (Vila) ; d Icoaraci in Belem ; e Macapa and Vigia ; f Macapa

Table 78. Continued

(B)

Contents of interview (Unit : boat or person)	Artisanal fishery: Town[a]	Artisanal fishery: Village[b]	Artisanal fishery: Hamlet[c]	Industrial fishery company[d] except for processing company
No. of interviews	20	10	7	1
Interviewees	Captain ; Manager of processing company (Manaus)	Captain ; Representative of processing company and cooperative (Parintins)	Captain ; Fishery processing company (Iranduba)	Captain
Size of fishing boat	0.5 - 22 tonn., 4 - 26 HP, 7 - 16 m, and wood-made	**Vigia** 3 - 12 tonn., 18 - 46 HP, 10 - 12 m, and wood-made **Obidos** < 1 tonn., 0 - 11 HP, 5 - 11 m, and wood-made **Parintins** 3 - 36 tonn., 4 - 66 HP, 11 - 22 m, and wood-made	**Braganca and Cachoeira** 2 - 3 tonn., 7 - 16 HP, 4 - 9 m, and wood-made **Iranduba** $<$1.40tonn., 0 - 100 HP, 12 - 20 m, and wood-made	85 tonn., 120 HP, 12 m, and steel-made
Equipments on fishing boat	Generator and fire extinguisher (one boat in Icoaraci)	Generator (one boat in Vigia)	Nothing	Winch, net hauler, GPS, fish finder, windlass, rader, life boat, deck crane, fire extinguisher, generator, wireless telegraph, and switchboard
Annual landed quantity (tonne:t)	**Belem** 120 t, (3.5 - 8 t/one day in Aug.) **Manaus** 13 t, (0.3 - 0.7 t/day) **Santarem** (50 - 500 kg/day)	**Vigia** (40 - 1,000 kg/day) **Obidos** - **Parintins** 35 t, (40 - 200 kg/day)	0.5 t (one boat in Cachoeira); 2,200 - 2,700 t (one processing company), 500 t (the other processing company) in Iranduba	300 - 500 t
Annual income	-	-	-	300,000 R$
Annual fishing days	-	-	360 (one boat in Braganca)	120
Fishing days per trip	7 - 22	Vigia : 8 - 23 Obidos : 1 Parintins : 10 - 20	1 - 5	20
Time per haul	8 - 12 h (Belem)	4 h (one boat in Obidos)	-	-
No. of crews	Belem : 3 - 6 Santarem : - Manaus : 5 - 12	Vigia : 5 - 7 Obidos : 2 Parintins : 4 - 10	Cachoeira : 4 Iranduba : 30	7
Fishing gears	**Gill net** Belem : 2,500 - 3,000 m Santarem : 3,300 m, 10 - 15 cm in mesh size Manaus : 100 - 200 m, with 2 - 10 canoes	**Gill net** Vigia : 3,000 m Obidos : 2,200 m, 18 cm in mesh size Parintins : 70 - 180 m, 18 - 30 cm in mesh size	**Gill net** Cachoeira : 2,000 m Iranduba : 440 m	Bottom trawl

a Icoaraci and Ver o Peso in Belem, Manaus, and Santarem ; b Obidos, Parintins, and Vigia ; c Braganca, Cachoeira, and Iranduba ; d Icoaraci in Belem

Table 78. (B) Continued

Contents of interview (Unit : boat or person)	Artisanal fishery: Town[a]	Artisanal fishery: Village[b]	Artisanal fishery: Hamlet[c]	Industrial fishery company[d] except for processing company
Top rank fish in quantity	**Belem** Dourada, Filhote, Gurijuba, Pescada amarela, P. branca, Pescadinha go, and Piramutaba **Santarem** Curimata, Dourada, Mapara, Pescada branca, Piramutaba, Surubim, and Tambaqui **Manaus** Aracu, Curimata, Dourada, Jaraqui, Pescada branca, Pacu, Pirarucu, Sardinha, Surubim, Tambaqui, and Tucunare	**Vigia** Cacao, Dourada, Gurijuba, Pescada amarela, P. branca, Pescadinha go, Piramutaba, and Sarda **Obidos** Summer Dourada, Filhote, Piramutaba, Pirarucu, and Surubim Winter Curimata, Pacu, Pescada branca, Tambaqui, and Tucunare Through the year Mapara **Parintins** Apapa, Curimata*, Dourada, Filhote, Jaraqui*, Pacu, Pescada branca, Piramutaba*, Pirapitinga, Pirarucu, Surubim, and Tambaqui *especially in summer	**Braganca and Cachoeira** Espadarte, Pescada amarela, Pescadinha go, Sarda, Serra, and Xarew **Iranduba** Dourada, Filhote, Jau, Mapara, Piramutaba, Pirarucu, and Surubim	Dourada,Filhote, Pescada amarela, P. branca, and Piramutaba
Top rank fish in value	Dourada and Pescada (one boat in Belem)	-	-	-
Fish discarded	-	-	-	-
Fishing ground	-	-	-	-
Recent fishery condition compared with 2 - 3 years ago				
No. of fishermen and fishing boats	Belem : decrease > no change, increase Santarem : increase Manaus : increase > no change	Vigia : increase, decrease Obidos : increase Parintins : decrease > no change, increase	Braganca and Cachoeira : decrease> nochange,increase Iranduba: decrease, increase, no change	Increase
Catch size	Belem : decrease > increase Santarem : no change Manaus : no change > increase > decrease	Vigia : decrease Obidos : increase, no change Parintins : no change > increase, decrease	Braganca and Cachoeira : decrease Iranduba : decrease, no change,increase	Decrease
Fish species composition	Belem: poorer > no change Santarem and Manaus : no change	no change, richer (one boat in Parintins)	Braganca and Cachoeira : no change Iranduba : poorer	Poorer
Fish size	Belem : no change > smaller Santarem and Manaus : no change	Vigia : smaller Obidos : bigger Parintins : no change	Braganca and Cachoeira : no change Iranduba : bigger	No change
Side job	Nothing	Nothing	Nothing	Nothing
Necessary things	Capital, finance, and new net	Money, finance, organization, and encouragement	Money and finance	Control of unlawful fishing

a Icoaraci and Ver o Peso in Belem, Manaus, and Santarem ; b Obidos, Parintins, and Vigia ; c Braganca, Cachoeira, and Iranduba ; d Icoaraci in Belem

Table 78. Continued

(C)

Contents of interview (Unit: boat or person)	Artisanal fishery Town[a]	Village[b]	Hamlet[c]	Industrial fishery company[d] except for processing company
No. of interviews	15	47	16	1
Interviewees	Fisherman	Fisherman	Fisherman	Director of company
Size of fishing boat	2 - 25 ton (Mean 10 ton) 9 - 90 HP	0.5 - 25 ton (Mean 5 ton) 9 - 36 HP	2 - 5 ton (Mean 4 ton) 12 - 40 HP	54 ton 180 HP
Equipments on fishing boat	Life jackets and fire extinguisher	Nothing	Fire extinguisher	-
Annual catch (tonne:t)	200 - 250 t per boat	Gill net: 100 - 200 t Longline per boat	100 - 150 t per boat	300 t / 2 boats 18,000 t / company
Annual income	US$150,000 - 200,000	US$80,000 - 150,000	US$20,000 - 50,000	-
Annual fishing days	230 - 260 (mainly in rainy)	200 (mainly in rainy)	200 (mainly in rainy)	280
Fishing days per voyage	8 - 46	1 - 30	1 - 20	-
Time per haul	10 - 12 h	10 - 12 h	10 - 12 h	-
No. of crews	3 - 12	2 - 7	2 - 6	6 / boat
Fishing gears	Gill net (1,500 - 4,500 m in length; 6 - 12 cm in mesh size)	Gill net (2,000 m in length; 6 - 12 cm in mesh size) Longline (3,000 m, 1,500 angles)	Gill net (1,500 - 3,000 m in length; 6 - 15 cm in mesh size)	Bottom trawl
Top rank fish in quantity	Dourada, Pescada branca, Filhote, Piramutaba, Bagre	Dourada, Pescada branca, Filhote, Piramutaba, Bagre	Dourada, Piramutaba, Pescada branca, Filhote, Bagre	-
Top rank fish in value	Filhote, Dourada, Pescada branca, Piramutaba, Bagre	Filhote, Dourada, Pescada branca, Piramutaba, Bagre	Filhote, Dourada, Pescada branca, Piramutaba, Bagre	-
Fish discarded	No discard	No discard	No discard	-
Fishing ground	Baia Marajo (depth 12 m) Amazon river (especially in rainy season)	Baia Marajo Amazon river Ocean	Baia Marajo Ocean (especially in dry season)	-
Recent fishery condition compared with 2 - 3 years ago				
No. of fishermen	Increase	Increase	Increase	-
and fishing boats	Increase	Increase	Increase, No change	
Catch	Decrease	Decrease	Decrease	-
Fish species composition	No change	No change	No change	-
Fish size	Smaller	Smaller	Smaller	-
Side job	Nothing	Nothing	Nothing	-
Necessary things	Finance, govermental backup, prohibition of trawl, and new technique	Finance	Finance, new boat, good equipments, and prohibition of trawl	-

a Icoaraci and Ver o Peso in Belem; b Abaetetuba, Soure, and Vigia; c Baia do Sol, Barcarena, Cachoeira, Igarape Miri, and Mosqueiro (Villa); d Icoaraci in Belem

(c) Catch per unit effort

From the 146 data sets (Phase 1 Rainy Season: 29; Phase 1 Dry Season: 38; Phase 2 Rainy season: 79) on trends in fisheries described above, 96 data sets (Phase 1 Rainy and Dry Seasons: 23; Phase 2 Rainy Season: 73) were selected for their having complete information on fishing gears, landed quantity, number of fishing days in specific periods, and fishing boat (vessel) tonnage and horsepower. These data were organized into landed quantity and fishing effort (calculated from the three parameters, the number of fishing days, boat (vessel) tonnage and motor horsepower) by fishing gear, fishery category and size of fishing community. Assuming all fish or shrimp caught was landed, the catch by the three parameters was then determined. Table 79 summarizes the results by fishing gear and Phase.

c-1) Catch per day

Of the three fishing methods, industrial bottom trawl fishing exhibited by far the highest value of catch per day at 2,333–4,167 kg/day, with the single exception of a catch of 175 kg/day of a small, wooden trawler during the Phase 2 Rainy Season Survey. A low CPUE value in that range was similar to the CPUE (2,600 kg/day) in 1996 obtained from fishery statistics (see Figure 113). Catch per day for artisanal longline fishing at Icoaraçi and Vigia, in the Amazonian Estuary, was about 100 kg/day (except for one instance of 15 kg/day), tending to be lower than that of artisanal gill net fishing in the same area. Catch per day for artisanal gill net fishing in the Amazonian Estuary was as follows: towns (Belém [Icoaraçi and Ver-o-Peso]), 50–678 kg/day; villages (Abaetetuba, Soure, Vigia), 44–586 kg/day; hamlets (three communities each in Mosqueiro and Marajó Islands), 5–240 kg/day — the CPUE tending to depend upon community size. Upstream of the Estuary, catch per day for artisanal gill net fishing was as follows: towns (Manaus), 300–677 kg/day; villages (Parintins), 40–1,750 kg/day, with no significant differences from the CPUEs in similar-size communities in the Estuary (except for Parintins itself, which yielded 1,750 kg/day). Catch per day for industrial gill net fishing in village (Vigia) was 40–741 kg/day, with no remarkable differences from the CPUE for artisanal gill net fishing in Belém.

c-2) Catch per day per tonnage

Catch per day per tonnage for artisanal longline fishing in Phase 1 had the high value of approximately 100 kg/day/tonnage. There were no significant differences in catch per day per tonnage between industrial bottom trawl fishing and gill net fishing by artisanal and industrial fisheries. In nearly all cases, the CPUE was around 50 kg/day/tonnage, with a few exceptions (Manaus in Phase 1; Soure, Vigia and Baía do Sol in Phase 2).

c-3) Catch per day per horsepower

Catch per day per horsepower for artisanal gill net fishing had high values in Manaus (upstream town, 15–94 kg/day/HP), Parintins (upstream village, 10–50 kg/day/HP), Abaetetuba and Soure (both estuary villages, 16-42 kg/day/HP). Next was the CPUE for industrial bottom trawl fishing, 8-35 kg/day/HP (with one exception of 1 kg/day/HP in Phase 2). No significant differences were found between CPUEs for artisanal longline fishing and gill net fishing by artisanal and industrial fisheries in the Estuary, all around less than 10 kg/day/HP. CPUEs for non-powered fishing boats used in artisanal gill net fishing (Soure and Joanes), however, could not be determined and are not shown in the tables.

CPUEs of industrial bottom trawl fishing for shrimp in Macapá (estuary village) were respectively 148-178 kg/day, 1.35-1.58 kg/day/tonnage and 0.35-0.41 kg/day/HP.

(d) Market price of fishery products

Table 80 summarizes market sale prices of fishery products and purchase prices from fishermen, based on surveys conducted in both Phase 1 Rainy and Dry Seasons and in the Phase 2 rainy season.

d-1) Sale price

Retail prices in the Amazonian Estuary could vary widely for some species depending on the size of the community they are sold at. For instance, retail price per kilogram for pescadinha gó *Macrodon ancylodon*, as obtained in the Phase 1 Dry Season Survey, was as follows: Belém (town), R$ 2.00; Vigia (village), R$ 1.50; Bragança (hamlet), R$ 1.00. However, for most species retail prices were the same regardless of community size. Overall, for the same species, retail prices tended to be higher in the Rainy Season than in the Dry Season — markedly so in March, when the demand for fishery products increases dramatically due to the Catholic Holy Week. Retail prices during the Phase 2 Rainy Season of tended to be higher than those of the Phase 1 Rainy Season, allowing for some variation in fish species. Listed below are fishes whose retail price was relatively high — R$ 3.00 /kg and over in the Rainy Seasons and R$ 2.00 /kg in the Dry Season (underlines refer to freshwater species, asterisks indicate retail prices in the Dry Season not available)

Rainy Season:

* camorim	*Centropomus* spp.
* corvina	*Cynoscion* sp.
<u>dourada</u>	<u>*Brachyplatystoma flavicans*</u>
<u>filhote</u>	<u>*Brachyplatystoma filamentosum*</u>
gurijuba	*Arius parkeri*
pargo	*Lutjanus* spp.
pescada amarela	*Cynoscion acoupa*
<u>pescada branca</u>	<u>*Plagioscion squamosissimus*</u>
pescadinha gó	*Macrodon ancylodon*
tainha	*Mugil incilis*
<u>tucunaré</u>	<u>*Cichla* spp.</u>

Dry Season:

dourada	*Brachyplatystoma flavicans*
filhote	*Brachyplatystoma filamentosum*
gurijuba	*Arius parkeri*
pargo	*Lutjanus* spp.
pescada amarela	*Cynoscion acoupa*
pescada branca	*Plagioscion squamosissimus*
pescadinha gó	*Macrodon ancylodon*
tainha	*Mugil incilis*
tamuatá	*Hoplosternum littorale* group

In addition, the export price for piramutaba fillets sold to the United States by the industrial fishery companies was R$ 2.20 /kg. The mean price for piramutaba *Brachyplatystoma vaillantii* fillets in 1990 obtained from fishery statistics was US$ 1.30 /kg (see Figure 117). Due to the close rate proximity between the Brazilian Real (R$) and the U.S. Dollar (US$) in 1996, there has been an actual doubling of price in six years. Distribution price of piramutaba rounds to Brasilia was R$ 1.30 /kg. The export price of piramutaba fillets was 2 to 3 times higher than the retail price for piramutaba sold in Belém.

Among fishery products other than fish, shrimp — particularly pink shrimp — was sold at very high prices. Headless pink shrimp commanded R$ 20 /kg.

Upstream from the Amazonian Estuary, retail prices for freshwater fishes were higher for a given species in Manaus than in Parintins or Santarém. For instance, retail price per kilogram of pescada branca *Plagioscion squamosissimus* was R$ 2.50–3.00 in Manaus, R$ 1.00–1.20 in Parintins and R$ 0.5 in Santarém. Listed below are fishes whose retail price was relatively high — R$ 3.00 /kg and over in Manaus, R$ 1.00 /kg and over in Parintins and Santarém:

Manaus:

aruanã	*Osteoglossum bicirrhosum*
pescada branca	*Plagioscion squamosissimus*
pirarucu	*Arapaima gigas*
tambaqui	*Colossoma macropomum*

Parintins:

curimatá	*Prochilodus* spp.
jaraqui	*Semaprochilodus* spp.
matrinchã	*Brycon* spp. and *Bryconamericus* spp.
pacu	*Myleus* spp.
pescada branca	*Plagioscion squamosissimus*
pirapitinga	*Colossoma bidens*

	pirarucu	*Arapaima gigas*
	surubim	*Pseudoplatystoma fasciatum*
	tambaqui	*Colossoma macropomum*
	tucunaré	*Cichla* spp.
Santarém:		
	tambaqui	*Colossoma macropomum*
	tucunaré	*Cichla* spp.

d-2) Purchase price

In the Phase 1 Rainy Season, purchase prices paid by fishery brokers to artisanal fishermen in Soure (estuary village) varied according to fish species; for example, that of piramutaba was R$ 0.30 /kg, and filhote *Brachyplatystoma filamentosum* cost R$ 1.50 /kg. At Ver-o-Peso, purchase price for a given fish was in most cases 2–3 times higher than in Soure. This also applied to the relationship between purchase price and retail price at Ver-o-Peso in the Phase 2 rainy season, though in the latter case prices were roughly twice those of the previous year. Purchase prices for a given species in the Phase 2 Rainy Season also depended on community size, and were higher in town (Ver-o-Peso) than in a village (Vigia) or a hamlet (Cachoeira). In the hamlet of Santana, purchase price of cação, pargo, pescadinha gó, etc. by fish processing factories from artisanal fishermen in the Phase 1 Rainy Season was R$ 0.50 /kg, regardless of species.

In the Phase 1 Dry Season, purchase price by fish processing factories from artisanal fishermen in Santarém (upstream town) varied for different species and even for different sizes of the same species. For instance, the purchase price per kilogram of surubim *Pseudoplatystoma fasciatum* was R$ 0.70–1.10 for large individuals, R$ 0.65–0.90 for medium-size individuals and R$ 0.50–0.70 for small ones. Although there were cases in Santarém of retail prices being many times higher than purchase prices, there were not wide differences like those observed in the Estuary.

(e) The role of fishery brokers

Table 81 summarizes the information on the role of brokers in the distribution of fishery products, as obtained through interviews with 18 brokers (two of whom were fish product processors in Vigia) in seven fishing communities, conducted in both Phase 1 Rainy and Dry Seasons and in the Phase 2 Rainy Season.

e-1) Purchase and sale

Nearly all brokers purchased mostly fish caught by fixed fishermen and vessels that could command high market prices without establishing large price differences according to size or freshness. Then they sold their purchase wholesale to local markets or larger markets such as Ver-o-Peso. Some brokers sold fish at their own stores, and one broker purchased only sea fish to resell to a supermarket.

Table 79. Landed quantity and catch effort in Northern Brazil, especially in the State of Para, from Interview Survey. (A) Bottom trawl; (B) Longline; (C) Gill net.
(Data compiled from interview on fishery trends in the Phase 1 Rainy and Dry Seasons Survey except Manaus and Parintins surveyed only in the Dry Season) .

	(A)		(B)	(C)					
	Industrial fishery		Artisanal fishery	Artisanal fishery					Idustrial fishery in Vigia
	Town			Town		Village		Hamlet[a]	
	Icoaraci	Macapa	Icoaraci	Belem	Manaus	Soure	Parintins		
No. of data	2	1	1	3	5	2	2	5	2
Landed quantity (tonne:t)	300 - 700 t/year	40 t/year	8.6 - 13.7 t/year	15 - 80 t/year	5 t/15days; 10 t/15days; 3 t/8days; 8 t/21days; 3 t/10days;	10 t/year and 80 t/year	400 kg/2-10days; 35 t/20days	5 - 10 kg/day; 50 - 70 kg/day; 12 t/year; 50 kg/day; 400 kg/6days;	480 kg/12days and 120 - 200 t/year
Fishing days	120 - 300 days/year	230 - 270 days/year	120 days/year	118 - 240 days/year	8 - 21 days/year	225 and 300 days/year	2 - 20 days/trip	1 day and 6 days/trip 240 - 300 days/year	120 - 270 days/year
Tonnage	85 - 98	110	1	5 - 18	3 - 22	7 and 10	3 and 36	0.8 - 4	5 and 18
HP	120 - 300	425	18	19 - 200	4 - 45	0 and 16	4 and 66	0 - 11	23 and 170
Catch per unit effort									
Catch / day	2,333 - 4,167 kg	148 - 174 kg	72 - 114 kg	100 - 678 kg	300 - 667 kg	44 and 233 kg	40 - 1,750 kg	5 - 70 kg	40 - 741 kg
Catch / day / tonn.	24 - 49 kg	1.35 - 1.58 kg	72 - 114 kg	17 - 38 kg	17 - 222 kg	4 and 33 kg	13 - 67 kg	6 - 35 kg	8 - 41 kg
Catch / day / HP	8 - 35 kg	0.35 - 0.41 kg	4 - 6 kg	4 - 6 kg	15 - 94 kg	3 kg	10 - 50 kg	5 - 7 kg	2 - 4 kg
Main species	Bagre, Dourada, Filhote, Gurijuba, Pescada amarela, P. branca, and Piramutaba	Pink shrimp (Pescada amarela and Pescadinha go)	Dourada, Filhote, Pescada spp., and Piramutaba	Dourada, Filhote, Gurijuba, Pescada amarela, P. branca, Pescadinha go, and Piramutaba	Aracu, Curimata, Dourada, Jaraqui, Pacu, Pescada branca, Saldinha, Surubim, Tambaqui, and Tucunare	Bagre, Dourada, Pescada amarela, P. branca, and Piramutaba	Apapa, Curimata, Dourda, Filhote, Jaraqui, Pacu, Pirapiranga, Surubim, and Tambaqui	Bagre, Dourada, Filhote, Pescada amarela, P. branca, and Piramutaba	Dourada, Filhote, Gurijuba, Pescada amarela, P. branca, and Piramutaba

a Cajueiro, Condeixas, Joanes and Salvaterra

Tabla 79. Continued (Shown the results of the Phase 2 Rainy Season on this table.)

	(A)	(B)	(C)							
	Industrial fishery	Artisanal fishery	Artisanal fishery							
			Town		Village			Hamlet		
	Icoaraci	Vigia	Icoaraci	Ver o Peso	Abaetetuba	Soure	Vigia	Baia do Sol	Igarape Miri	Mosqueiro
No. of data	1	3	3	12	2	8	34	2	1	7
Landed quantity (tonne:t)	2.1 t/12days	0.3, 2, 1.48 t/20days	0.4 t/8days 2 t/16days 2.5 t/46days	0.57 t/7days | 8 t/20days	0.5 t/8days 2.3 t/15days	0.53 t/1day | 4.1 t/7days	0.15 t/4days | 9.8 t/30days	0.2 t/3days 1.2 t/5days	0.28 t/4days	0.02 t/1day | 3 t/15days
Fishing days	12 days/trip	20 days/trip	8 days/trip 16 days/trip 46 days/trip	7 - 20 days/trip	8, 15 days/trip	1 - 7 days/trip	4 - 30 days/trip	3, 5 days/trip	4 days/trip	1 - 15 days/trip
Tonnage	54	3, 2.5, 15	2.5, 10, 10	2 - 25	2.5, 5.5	2.6 - 8	0.3 - 25	3, 2	2	3.5 - 6
HP	180	18, 36, 10.3	16, 66, 61	16 - 69	1.5, 36	16 - 36	10 - 135	18	18	9 - 46
Catch per unit effort										
Catch / day	175 kg	15, 100, 74 kg	50, 125, 54 kg	82 - 400 kg	63, 153 kg	400 - 586 kg	38 - 327 kg	67, 240 kg	70 kg	20 - 200 kg
Catch / day / tonn.	3.2 kg	5, 40, 5 kg	20, 13, 5 kg	5 - 6 kg	25, 28 kg	73 - 154 kg	13 - 127 kg	22, 120 kg	35 kg	5 - 43 kg
Catch / day / HP	1 kg	1, 3, 7 kg	3, 2, 1, kg	0.1 - 0.3 kg	42, 4 kg	16 - 33 kg	2 - 6 kg	4, 13kg	4 kg	2 - 8 kg
Main species	Dourada and Piramutaba	Bacu, Dourada, Pescada amarela, P. branca and Piramutaba	Dourada, Filhote, Pescada branca, and Piramutaba	Dourada, Filhote, Pescada branca, and Piramutaba	Dourada, Filhote, Pescada amarela, P. branca, and Piramutaba	Dourada, Pescada branca, and Piramutaba	Bacu, Dourada, Pescada amarela, P. branca, and Piramutaba	Dourada, Filhote, Pescada amarela, P. branca, and Piramutaba	Dourada, Filhote, Pescada amarela, P. branca, and Piramutaba	Dourada, Pescada amarela, P. branca, and Piramutaba

Table 80. Market price of fishery products in Northern Brazil,especially in the State of Para, from Interview Survey. (A) Phase 1 Rainy Season Survey; (B) Phase 1 Dry Season Survey; ; (C) Phase 2 Rainy Season Survey, Retail price at Ver o Peso on 25 July 1997 appeared in the Liberal, published on 30 July 1997, indicated in parentheses.

(A)

Species	Sale price (R$/kg) in fish shop				Purchase price (R$/kg) from fisherman	
	Town		Hamlet			
	Ver o Peso	Icoaraci	Mosqueiro	Salvaterra	Broker in Soure	Processing company in Santana
Fish						
Arraia		1.50				
Bagre	1.20		1.50			
Bandeirado	1.80					
Cacao		2.00				0.50
Camorim	3.50			2.50		
Corvina		4.00				
Dourada	2.30 - 2.50	2.00 - 3.50	2.00 - 3.50		1.00	
Filhote	3.00 - 5.00	4.00	2.50 - 4.00		1.50	
Gurijuba	2.50					
Mandi		2.50				
Mapara	1.00					
Mero	2.00					
Pargo		3.00				0.50
Peixa pedra						0.50
Pescada amarela	3.00 - 3.50			2.00	1.50	
P. branca	1.80 - 2.50	2.50 - 3.00	2.50		1.00	
Pescadinha go	2.20 - 2.50	2.50				0.50 - 0.90
Piramutaba	1.00 - 1.20	1.20 - 2.00	1.00	1.20	0.30	
Salda		2.00				
Tainha	3.50	2.00		2.00		
Tucunare	2.00					
Xareu		2.50				
Crustacea						
Pink shrimp	headless 20.00					5.00 - 30.00
White shrimp	2.00 - 4.00	1.00 - 5.00				
Seabob (Sete B.)						6.00
Caranguejo	0.50 /1crab					
Mollusk						
Mexilhao	4.00					

Table 80. Continued

(B)

Fishery product	Sale price (R$/kg)								Purchase price (R$/kg)
	Fish shop								
	Industrial fishery company[a]	Town			Village		Hamlet		Processing company in Santarem
		Belem	Manaus	Santarem	Vigia	Parintins	Mosqueiro	Braganca	
Fish									
Aracu						0.65			
Arraia								0.75	
Aruana			2.50 - 3.50	0.60 - 0.70		0.65			
Bacu									M. 0.20
Bagre							1.00		
Barbado									M. 0.30 - 0.50
Cacao								1.10 - 1.50	
Curimata				0.60		1.00			
Dourada		1.50 - 2.00		0.80	1.50 - 2.00	0.65	2.50	1.50	M.0.60 - 0.90 ; S. 0.30 - 0.35
Filhote		1.50 - 2.50					3.00		M. 0.60 - 0.90 ; S. 0.30 - 0.35
Gurijuba		1.50 - 2.00			1.50 - 2.00			2.00	
Irapema								1.00	
Jaraqui						1.00			
Jau									M. 0.30
Mapara						0.65			M. 0.30 ; S. 0.05
Matrincha						1.00			
Pargo		3.50						1.50	
Pacu						1.00			
Paru								0.20	
Pescada amarela		1.00 - 3.20			2.00		3.00	3.00	
P. branca		1.00 - 2.00	2.50 - 3.00	0.50		1.00 - 1.20	1.50		
P. sp.									M. 0.50
Pescadinha go		2.00			1.50			1.00	
Piraiba (Filhote)									20kg< 0.70 - 1.00
Piramutaba		0.70 - 1.20		0.35	1.00	0.65		1.00	M. 0.30 - 0.50
Piranha						0.65			
Pirapitinga[b]			2.00			1.00			
Pirarucu			3.50 - 4.00 ; 2.50 - 5.00[e]			1.80 -2.00			M. 1.50
Sarda		1.50		0.30			1.00	0.70	
Sete gurude								1.00	
Surubim			2.00 - 2.50	0.50 - 0.60		1.00			L. 0.70 - 1.10 ; M. 0.65 - 0.90 ; S. 0.50 - 0.70
Tainha		1.50 - 2.50							
Tambaqui			2.00 - 5.00 ; M. 2.5	0.90 - 1.00		1.00			5-10kg 2.00 ; 10kg< 2.50
Tamuata						0.70	2.50		
Tucunare			1.00 - 2.50	2.00 - 2.50		1.20			M. 0.60
Xareu								1.30	
Processed									
Piramutaba									
Fillet	2.20[c]								
Round	1.30[d]								

[a] Icoaraci in Belem ; [b] Red Tambaqui ; [c] To USA ; [d] To Brasilia ; [e] salt. S small size ; M medium size ; L large size

Table 80. Continued

(C)

Species	Sale price (R$/kg) in fish shop				Purchase price (R$/kg) of broker from fisherman		
	Town	Village			Town	Village	Hamlet
	Ver o Peso	Vigia	Abaetetuba	Barcarena	Ver o Peso	Vigia	Cachoeira
Fish							
Aracu	(1.88)						
Bacu		0.40 - 2.00					
Bagre	(1.13)				1.00	0.70	
Cacao	(1.37)						
Camorim	(3.00)						2.50 - 3.00
Corvina	(2.50)						2.00
Curimata	(1.93)						
Dourada	2.50 - 4.00 (2.00)	1.20 - 2.50	1.50 - 3.00	2.50 - 3.00	2.20	1.30 - 1.50	
Filhote	3.00 - 5.00 (3.05)		2.00		2.80 - 3.00	2.00	
Gurijuba	2.00 - 3.50 (2.18)	2.00 - 2.50			2.00	1.50	1.80
Mandi			0.50				
Mapara			0.70 - 1.50	1.00			
Mero	(2.50)						
Pescada amarela	3.00 - 5.00 (2.33)	3.50			3.50	2.00 - 2.50	3.00
P. branca	2.00 - 3.00 (1.86)	1.80 - 2.50	2.00	2.50 - 2.80	1.20-1.80	1.20 - 1.50	2.50
Pescadinha go	2.00 - 3.00 (1.57)		2.00				1.80
Piramutaba	1.50 - 2.00 (1.17)	1.30 - 1.70	0.80 - 1.50	1.50	1.20	0.50 - 0.70	
Pirapema	(2.00)						
Pratiqueira	(1.89)						
Sarda	2.00 - 2.50 (1.47)		0.20 - 1.00				
Serra	(2.25)						
Tainha	3.00 - 3.50 (1.96)						
Tamuata	(2.04)						
Tucunare	2.00 - 4.00			3.00			
Xareu	(1.79)						