5. RESULTS

5.1. Sea-Borne Survey

5.1.1. Demersal Fish Fauna

Most of the fish species living on the sea floor in the survey area choose habitats of respectively suitable levels of salinity, and are unable to survive farther away. The bottom layer of the water column in the survey area was divided into three water mass regions of different salinities: (1) river water, with salinity less than 1 psu; (2) ocean water, with salinity equal to or above 35 psu; and (3) brackish water, with a wide gradient of salinity (between 1 and 35 psu) resulting from the mixture of river and ocean waters. In this discussion, the demersal fish species were respectively allocated to one of those water mass regions based on the maximum salinity of the bottom layer they were caught in. (This bottom layer corresponds to the vertical distance between the sea floor and the head rope, as measured by the net recorder. In trawl stations where this net mouth height could not be measured, the mean value for all trawl stations was considered instead.)

(a) Composition of the demersal fish fauna

a-1) Demersal fish species composition in the entire survey area

Table 12 summarizes the composition of the demersal fish fauna caught in the entire survey area. Fishes captured in the three surveys counted 104 species in 78 genera belonging to 43 families of 13 orders. The following groups were the richest in species composition: Perciformes, 40%; Siluriformes, 20%, Rajiformes, 10% and Clupeiformes, 9%.

As for the water mass regions where trawling took place, species composition was richer in brackish waters (11 orders, 35 families, 61 genera, 81 species) than in either ocean (9 orders, 28 families, 53 genera, 69 species) or river (6 orders, 13 families, 23 genera, 30 species) waters. Demersal fish species composition in brackish and ocean waters was remarkably similar to the above-mentioned overall species composition. In river waters, however, the richest group was Siluriformes, making up for 47% of all species in that habitat.

Table 12. Demersal fish species composition in the entire survey area.

Orders	River waters			Brackish waters			Ocean waters			Total		
	Families	Genera	Species	Families	Genera	Species	Families	Genera	Species	Families	Genera	Species
1. Carcharhiniformes	0	0	0	1	3	4	1	3	5	1	3	6
2. Rajiformes	1	2	3	5	6	7	4	6	7	5	9	10
3. Elopiformes	0	0	0	2	2	2	0	0	0	2	2	2
4. Anguilliformes	0	0	0	2	2	2	0	0	0	2	2	2
5. Clupeiformes	2	3	3	2	6	7	3	6	8	3	7	9
6. Siluriformes	5	10	14	7	12	20	2	4	7	7	13	21
7. Gymnotiformes	2	2	2	0	0	0	0	0	0	2	2	2
8. Batrachoidiformes	0	0	0	1	1	1	1	2	2	1	2	2
9. Lophiiformes	0	0	0	0	0	0	1	1	1	1	1	1
10. Mugiliformes	1	1	1	1	1	1	0	0	0	1	1	1
11. Perciformes	2	5	7	11	24	33	12	27	35	14	30	42
12. Pleuronectiformes	0	0	0	2	3	3	2	2	2	2	4	4
13. Tetraodontiformes	0	0	0	1	1	1	2	2	2	2	2	2
Total	13	23	30	35	61	81	28	53	69	43	78	104

a-2) Demersal fish species composition by seasonal survey and by water mass region

Table 13 shows the composition and incidence (% = number of trawl stations where the species was caught / number of trawl stations x 100) of demersal fish species in each seasonal survey and water mass region. Composition by seasonal survey was as follows: Phase 1 Dry Season Survey, 79 species in 35 families; Phase 2 Rainy Season Survey, 83 species in 34 families; Phase 2 Dry Season Survey, 74 species in 31 families. Composition by water mass region is detailed below.

i) River waters

There was no much difference in species composition in the three seasonal surveys conducted in river waters: Phase 1 Dry Season Survey, 19 species in 10 families (8 trawl stations); Phase 2 Rainy Season Survey, 24 species in 12 families (18 trawl stations); Phase 2 Dry Season Survey, 26 species in 12 families (8 trawl stations). Most frequent families were Ariidae, Pimelodidae and Sciaenidae; these three taxa together accounted for 58% of the fish species caught in the Phase 1 Dry Season Survey, 50% of those in the Phase 2 Rainy Season Survey and 58% of those in the Phase 2 Dry Season Survey. Species with a high incidence in seasonal surveys included: canguito *Arius phrygiatus* (100%, 94% and 100% of all stations respectively in the Phase 1 Dry Season Survey, Phase 2 Rainy Season Survey and Phase 2 Dry Season Survey), family Ariidae; dourada *Brachyplatystoma flavicans* (88%, 94% and 88% respectively, as above) and piramutaba *B. vaillantii* (88%, 1000%, 100%), family Pimelodidae; pescada cascuda preta *Plagioscion auratus* (88%, 78%, 63%) and pescada branca *P. squamosissimus* (50%, 56%, 75%), family Sciaenidae; mandubé *Ageneiosus ucayalensis* (50%, 56%, 88%), family Ageneiosidae; and itui *Sternarchella* sp. (50%, 83%, 63%), family Apteronotidae. Also, in Phase 2, bacu rato *Centrodoras brachiatus*, family Doradidae, occurred in 94% and 75% of the stations in the Rainy and Dry Season Surveys respectively.

ii) Brackish waters

Species composition was less rich in the Phase 2 Dry Season Survey, with the following overall statistics: Phase 1 Dry Season Survey, 65 species in 28 families (76 trawl stations); Phase 2 Rainy Season Survey, 66 species in 28 families (82 trawl stations); Phase 2 Dry Season Survey, 51 species in 23 families (79 trawl stations). Most frequent families were Sciaenidae and Ariidae; these two taxa together accounted for 35% of the fish species caught in the Phase 1 Dry Season Survey, 32% of those in the Phase 2 Rainy Season Survey and 39% of those in the Phase 2 Dry Season Survey. The species with the highest incidence in all surveys was pescadinha gó *Macrodon ancylodon*, family Sciaenidae, which occurred in 89%, 99% and 96% of all stations respectively in the Phase 1 Dry Season Survey, Phase 2 Rainy Season Survey and Phase 2 Dry Season Survey). Other highly frequent species were the sea catfishes (family Ariidae): cambéua *Arius grandicassis* (76%, 79% and 82% respectively, as above), gurijuba *A. parkeri* (59%, 62%, 62%), cangatá *A. quadriscutis* (76%, 76%, 86%), jurupiranga *A. rugispinis* (59%, 62%, 70%), bandeirado *Bagre bagre* (76%, 79%, 80%) and uricica *Cathorops spixii* (75%, 77%, 82%). Two rays of the family Dasyatidae were also frequent: arraia morcego *Dasyatis geijkesi* (58%, 67%, 70% respectively, as above) and arraia bicuda *D. guttata* (68%, 71%, 76%).

iii) Ocean waters

Species composition did not differ much in the three seasonal surveys: Phase 1 Dry Season Survey, 52 species in 24 families (26 trawl stations); Phase 2 Rainy Season Survey, 50 species in 21 families (20 trawl stations); Phase 2 Dry Season Survey, 49 species in 22 families (33 trawl stations). Most frequent families were Sciaenidae, Ariidae, Carangidae and Carcharhinidae, which accounted together for about 50% of the fish species caught. Species with a high incidence in seasonal surveys included: espada *Trichiurus lepturus* (88%, 55% and 52% of all stations respectively in the Phase 1 Dry Season Survey, Phase 2 Rainy Season Survey and Phase 2 Dry Season Survey), family Trichiuridae; pescadinha gó *Macrodon ancylodon* (65%, 80% and 94% respectively, as above), family Sciaenidae; sardinha gato *Odontognathus mucronatus* (65%, 70%, 55%), family Pristigasteridae; manjuba savelha *Anchoa spinifer* (54%, 75%, 85%), family Engraulidae. Also seasonally frequent were: Phase 1 Dry Season Survey and Phase 2 Rainy Season Survey — gostoso *Peprilus paru* (62%, 65% respectively), family Stromateidae; Phase 2 Rainy and Dry Season Surveys — the ariids bandeirado *Bagre bagre* (75%, 76% respectively), cambéua *Arius grandicassis* (65%, 82%) and uricica *Cathorops spixii* (60%, 64%); the sciaenid pescada cambuçu *Cynoscion virescens* (70%, 67% respectively) and the dasyatid arraia bicuda *Dasyatis guttata* (60%, 82%).

Table 13. Fish species composition of catches. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters.

(A)

Water mass	Salinity (psu)	Number of trawl stations	Number of families	Number of species	Main families (Number of species)	Incidence of species in trawl stations
RW	<1	8	10	19	Ariidae (5)	100% : *Arius phrygiatus*
					Pimelodidae (4)	88% : *Brachyplatystoma flavicans**,
					Doradidae (2)	*B. vaillantii**, and
					Sciaenidae (2)	*Plagioscion auratus*
						50% : *Ageneiosus ucayalesis*,
						Sternarchella sp., and
						*Plagioscion squamosissimus**
BW	<35	76	28	65	Sciaenidae (14)	89% : *Macrodon ancylodon**
	<5	9			Ariidae (9)	76% : *Arius grandicassis*,
	<10	7			Carangidae (6)	*A. quadriscutis*,
	<15	8			Pimelodidae (4)	and *Bagre bagre*
	<20	7			Dasyatidae (3)	75% : *Cathorops spixii*
	<25	9			Pristigasteridae	68% : *Dasyatis guttata*
	<30	17			(3)	59% : *Arius parkeri**
	<35	19				and *A. rugispinis*
						58% : *Dasyatis geijkesi*
						54% : *Nebris microps*
OW	≧35	26	24	52	Sciaenidae (12)	88% : *Trichiurus lepturus*
					Ariidae (6)	65% : (Engraulidae),
					Carangidae (5)	*Odontognathus mucronatus*,
					Carcharhinidae	and *Macrodon ancylodon**
					(4)	62% : *Peprilus paru*
						54% : *Anchoa spinifer*
Total	-	110	35[a]	79[b]	-	-

[a,b] From Appendix Table 1. * Key fish species.

(B)

Water mass	Salinity (psu)	Number of trawl stations	Number of families	Number of species	Main families (Number of species)	Incidence of species in trawl stations
RW	<1	18	12	24	Pimelodidae (5)	100% : *Brachyplatystoma vaillantii**
					Ariidae (4)	94% : *Centrodoras brachiatus*,
					Sciaenidae (3)	*Arius phrygiatus*, and
					Dasyatidae (2)	*Brachyplatystoma flavicans**
					Engraulidae (2)	83% : *Sternarchella* sp.
					Doradidae (2)	78% : *Plagioscion auratus*
						56% : *Anchoa spinifer*,
						*Plagioscion squamosissimus**,
						and *Ageneiosus ucayalesis*

Table 13. (B) Continued

Water mass	Salinity (psu)	Number of trawl stations	Number of families	Number of species	Main families (Number of species)	Incidence of species in trawl stations
BW	<35	82	28	66	Sciaenidae (12)	99% : *Macrodon ancylodon**
	<5	4			Ariidae (9)	79% : *Arius grandicassis* and *Bagre bagre*
	<10	9			Carcharhinidae (4)	
	<15	11			Pimelodidae (4)	77% : *Cathorops spixii*
	<20	7			Dasyatidae (3)	76% : *Arius quadriscutis*
	<25	7			Engraulidae (3)	73% : *Anchoa spinifer*
	<30	16			Pristigasteridae (3)	71% : *Dasyatis guttata*
	<35	28			Centropomidae (3)	68% : *Lonchurus lanceolatus*
					Carangidae (3)	67% : *Dasyatis geijkesi*
						62% : *Arius parkeri** and *A. rugispinis*
						61% : *Aspredo aspredo*
						57% : *Brachyplatystoma vaillantii**
						51% : *Stellifer rastrifer*
OW	≧35	20	21	50	Sciaenidae (10)	80% : *Macrodon ancylodon**
					Ariidae (6)	75% : *Bagre bagre* and *Anchoa spinifer*
					Carangidae (6)	
					Carcharhinidae (4)	70% : *Odontognathus mucronatus* and *Cynoscion virescens*
					Engraulidae (3)	
					Pristigasteridae (3)	65% : *Peprilus paru* and *Arius grandicassis*
						60% : *Dasyatis guttata* and *Cathorops spixii*
						55% : *Trichiurus lepturus*
						50% : *Dasyatis geijkesi*, *Oligoplites palometa*, and *Stellifer rastrifer*
Total	-	120	34[a]	83[b]	-	-

[a,b] From Appendix Table 1. * Key fish species.

(C)

Water mass	Salinity (psu)	Number of trawl stations	Number of families	Number of species	Main families (Number of species)	Incidence of species in trawl stations
RW	<1	8	12	26	Sciaenidae (6)	100% : *Arius phrygiatus* and *Brachyplatystoma vaillantii**
					Ariidae (5)	
					Pimelodidae (4)	88% : *Arius couma*, *Brachyplatystoma flavicans**, and *Ageneiosus ucayalensis*
					Dasyatidae (3)	
						75% : *Centrodoras brachiatus* and *Plagioscion squamosissimus**
						63% : *Sternarchella* sp., *Pimelodus* sp., and *Plagioscion auratus*

Table 13. (C) Continued

Water mass	Salinity (psu)	Number of trawl stations	Number of families	Number of species	Main families (Number of species)	Incidence of species in trawl stations
BW	<35	79	23	51	Sciaenidae (11)	96% : *Macrodon ancylodon**
	<5	1			Ariidae (9)	86% : *Arius quadriscutis*
	<10	10			Centropomidae (3)	82% : *Cathorops spixii* and
	<15	10			Engraulidae (3)	*Arius grandicassis*
	<20	6			Pimelodidae (3)	80% : *Bagre bagre*
	<25	13				76% : *Dasyatis guttata*
	<30	17				70% : *Dasyatis geijkesi* and
	<35	22				*Arius rugispinis*
						68% : *Anchoa spinifer*
						62% : *Arius parkeri**
						58% : *Lonchurus lanceolatus*
						56% : *Stellifer rastrifer*
OW	≧35	33	22	49	Sciaenidae (11)	94% : *Macrodon ancylodon**
					Ariidae (6)	85% : *Anchoa spinifer*
					Carangidae (5)	82% : *Arius grandicassis* and
					Carcharhinidae (3)	*Dasyatis guttata*
					Dasyatidae (3)	76% : *Bagre bagre*
					Engraulidae (3)	67% : *Cynoscion virescens*
					Pristigasteridae (3)	64% : *Cathorops spixii*
						55% : *Odontognathus mucronatus*
						52% : *Trichiurus lepturus*
Total	-	120	31[a]	74[b]	-	-

[a,b] From Appendix Table 1. * Key fish species.

a-3) Relationship between bottom salinity and number of fish species

Figure 9 illustrates the relationship between salinity of the bottom layer and number of fish species . The number of species caught per haul varied from 0 to 27 and a tendency of its increase with rising levels of salinity was observed, although with a considerable dispersion of points. More than 20 species occurred in salinities above 30 psu, while less than 15 species appeared in layers with salinity levels below 5 psu.

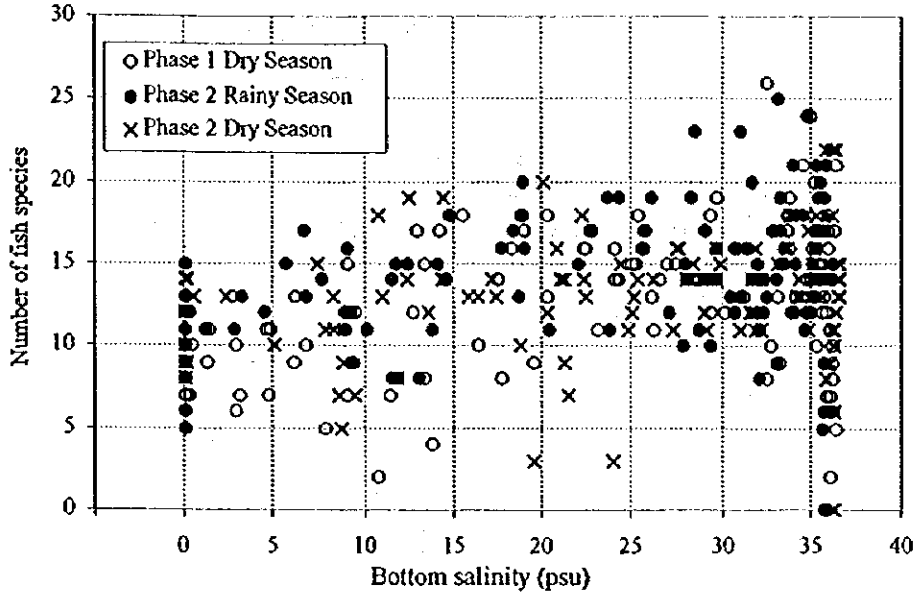


Figure 9. Relationship between bottom salinity and number of fish species.

(b) Diversity of demersal fish communities

The diversity of the demersal fish communities found in the study area was estimated by means of Shannon-Weaver (1949)'s function H' for the number of individuals per species (index of species diversity), defined as:

$$H' \cong -\sum_{i=1}^{s} pi \ln pi$$

where S : number of species in sample

pi : proportion of total number of individuals belonging to ith species

This index H' denotes the complexity of the community structure: higher values of H' show complex communities, and lower values indicate simple ones. One should bear in mind, however, that this diversity index for the number of individuals per species does not consider the particularities of the demersal fish community — which comprising large individuals such as sea catfishes and elasmobranchs and small ones such as anchovies — and the appropriate scale for data collection is not easy to determine.

b-1) Seasonal diversity of water mass regions

Table 14 shows the values of H' determined for the different water mass regions in each season. For the survey area as a whole, diversity was lower in the Rainy Season (H' = 2.658) than in the Dry Season (H' = 3.241 and 3.278 in each Phase, respectively). The diversity index was also lower for river waters ($1.262 \leq H' \leq 1.478$) than for the other two water mass regions ($2.385 \leq H' \leq 3.656$). Also, for each water mass region, diversity was lower in the Rainy Season than in the Dry Season.

Table 14. Values of H' for each water mass region and season.

Water mass	Phase		
	1	2	
	Dry Season	Rainy Season	Dry Season
River waters	1.348	1.262	1.478
Brackish waters	2.868	2.385	3.191
Ocean waters	3.656	2.649	2.760
All water	3.241	2.658	3.278

b-2) Horizontal distribution of diversity index H'

The horizontal distribution of the diversity index H' in the different trawl stations is given in Appendix Figure 4. The most of the trawl stations in the Dry Season Surveys had a diversity of H' between 2.000 and 2.999, while the majority of those in the Rainy Season Surveys had it between 1.000 and 1.999. The surveys indicated values of H' below 1 tended to be concentrated in the frontal area extending from the Northern Channel of the Amazon River to the Santa Rosa Sandbank. In the same way, values of H' above 3 were generally distributed in areas shallower than 10 m.

b-3) Relationship between bottom salinity and diversity index H'

Figure 10 shows the diversity index H', calculated at each trawl station from the abundance of the demersal fish species captured, plotted against the respective values of bottom layer salinity. It was not possible to determine a precise relationship between the bottom salinity and seasonal values of H'.

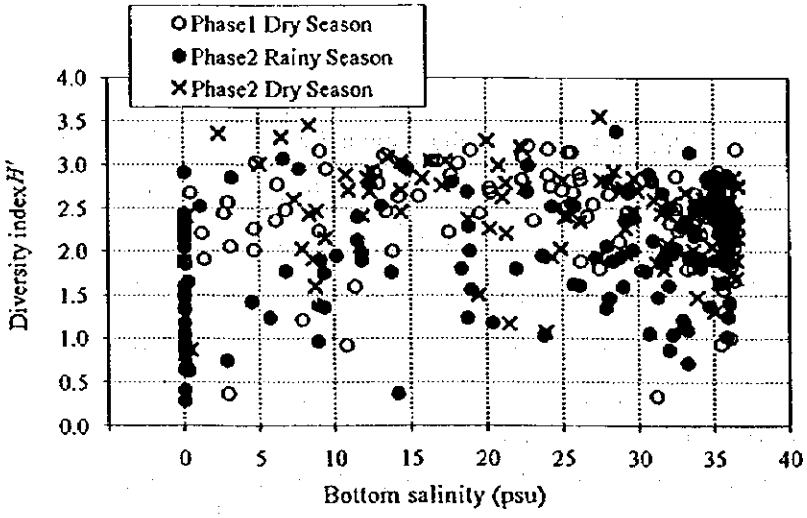


Figure 10. Relationship between bottom salinity and diversity index H'

(c) Cluster analysis of demersal fish communities by similarity index

Mountford (1962)'s method was applied for classifying many demersal fish communities of each trawl station into same groups by index of similarity between communities. In this case, Kimoto (1967)'s similarity index C_Π defined as follows, was used:

$$C_\Pi = \frac{2\sum_{i=1}^{S} n_{1i} \cdot n_{2i}}{(\sum \Pi_1^{\,2} + \sum \Pi_2^{\,2}) N_1 \cdot N_2} \qquad 0 \leqq C_\Pi \leqq 1$$

$$\sum \Pi_1^{\,2} = \frac{\sum_{i=1}^{S} n_{1i}^{\,2}}{N_1^{\,2}}, \quad \sum \Pi_2^{\,2} = \frac{\sum_{i=1}^{S} n_{2i}^{\,2}}{N_2^{\,2}}$$

where N_1, N_2 : total number of individuals respectively caught in each of two stations

n_{1i}, n_{2i} : number of individuals of species i caught in each of two stations

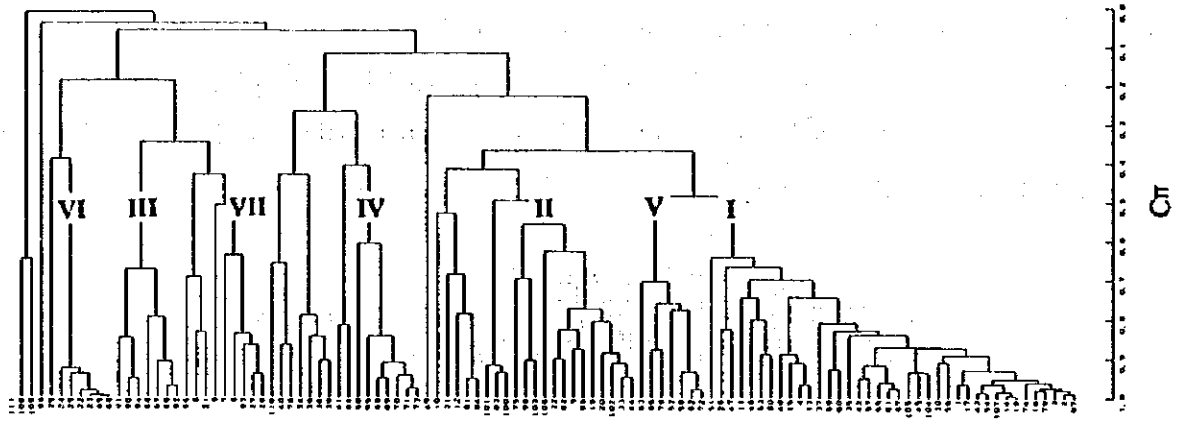
S : number of species common in the two stations considered

Results of cluster analysis following Mountford's method are shown in the dendrograms of Figure 11. A value of $C_\Pi = 0.55$ was established and only clusters with five or more trawl stations were selected (I–VIII in the figure). Table 15 shows the composition of such clusters with respect to their three highest-ranking fish species in terms of the ratio of mean number of individuals in trawl stations within the cluster to the mean number of individuals in all stations. In addition, Figure 12 illustrates the species composition of those clusters, indicating representative demersal fish communities. As defined by the above criteria, much seasonal variation was observed in the composition of those communities.

In the Rainy Season, three clusters of demersal fish communities were identified: (1) a community spreading over the shallower area in the Amazon Estuary, comprising mainly piramutaba *Brachyplatystoma vaillantii* but also canguito *Arius phrygiatus* and dourada *B. flavicans;* (2) a community covering most of the survey area, featuring pescadinha gó *Macrodon ancylodon* and seconded by cambéua *Arius grandicassis* and bandeirado *Bagre bagre;* and (3) a community limited offshore to the northern portion of the survey area, centered on sardinha gato *Odontognathus mucronatus* and also including espada *Trichiurus lepturus* and gostoso *Peprilus paru.*

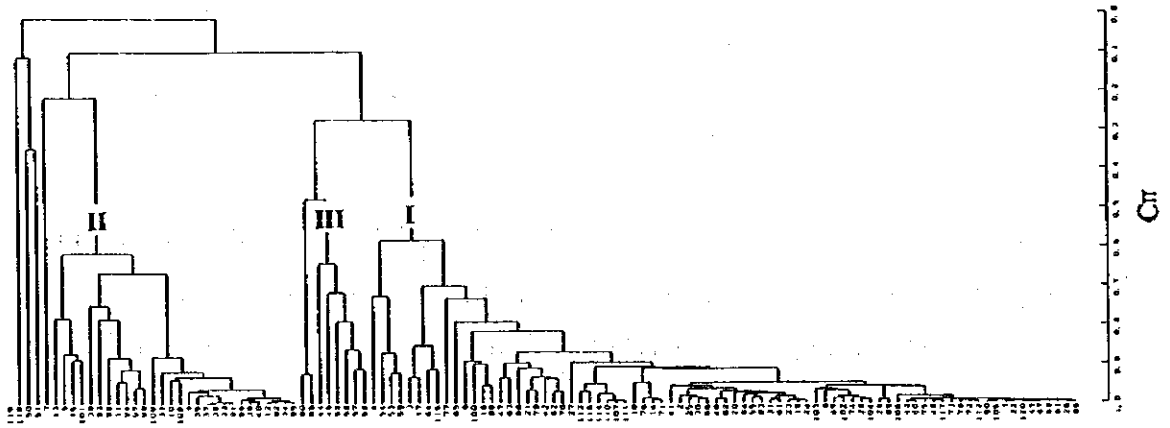
In the Dry Season, however, the communities were subdivided into 7 or 8 patchy clusters, respectively centered on the following species: pescadinha gó, cangatá *Arius quadriscutis,* canguito, sardinha gato, manjuba savelha *Anchoa spinifer,* piramutaba and rabeca *Aspredo aspredo* (Phase 1); pescadinha gó, piramutaba, cangatá, cambéua, buchudinho *Stellifer rastrifer,* canguito, manjuba savelha and jurupiranga *Arius rugispinis* (Phase 2).

(A)



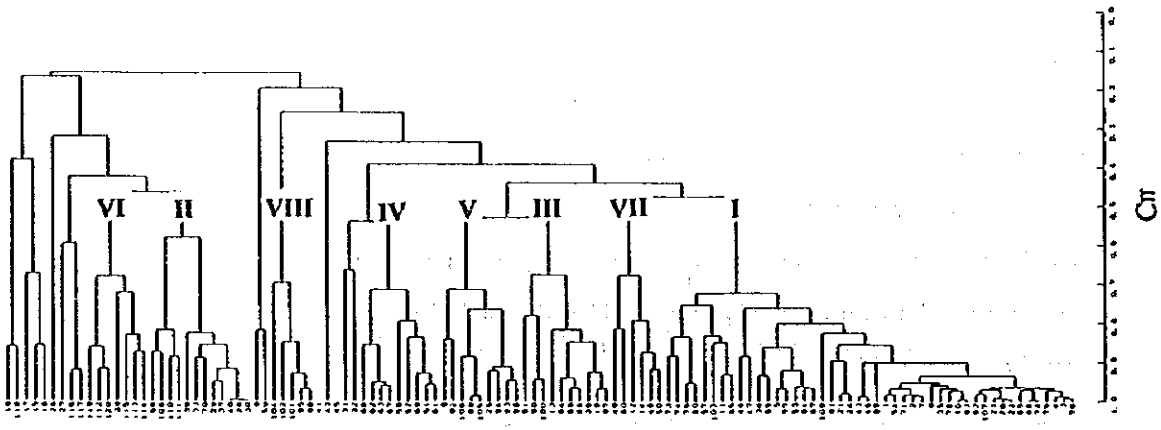
Number of trawl station

(B)



Number of trawl station

(C)



Number of trawl station

Figure 11. Results of cluster analysis following Mountford's method. (A) Phase1 Dry Season Survey ; (B) Phase 2 Rainy Season Survey ; (C) Phase 2 Dry Season Survey. For the positions of the trawl stations in each seasonal survey, refer to the Field Report on the Sea-Borne Survey, Oct. '96, May '97, and Oct. '97.

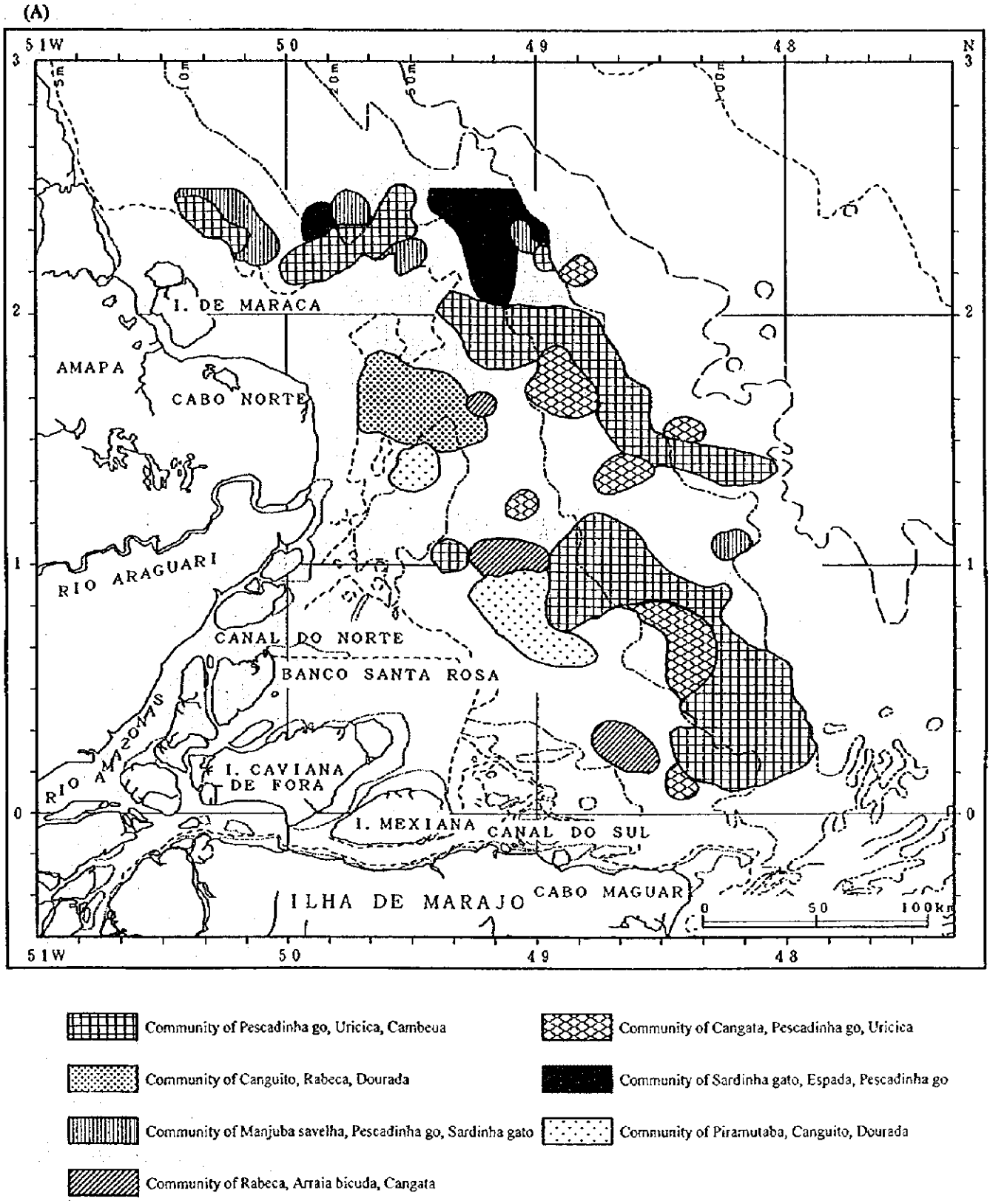
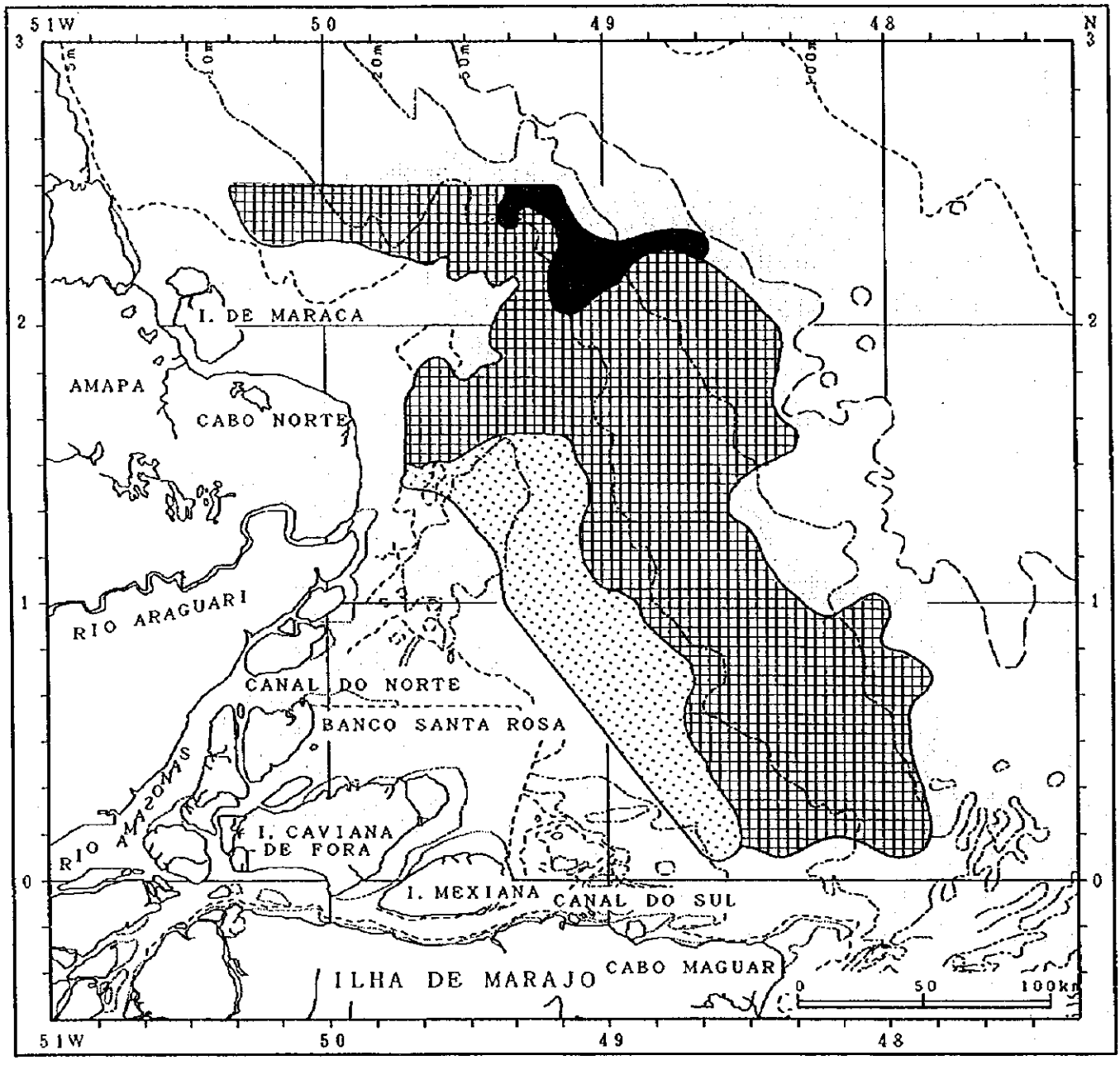


Figure 12. Representative demersal fish communities. (A) Phase1 Dry Season Survey ; (B) Phase 2 Rainy Season Survey ; (C) Phase 2 Dry Season Survey.

(B)

Figure 12. Continued



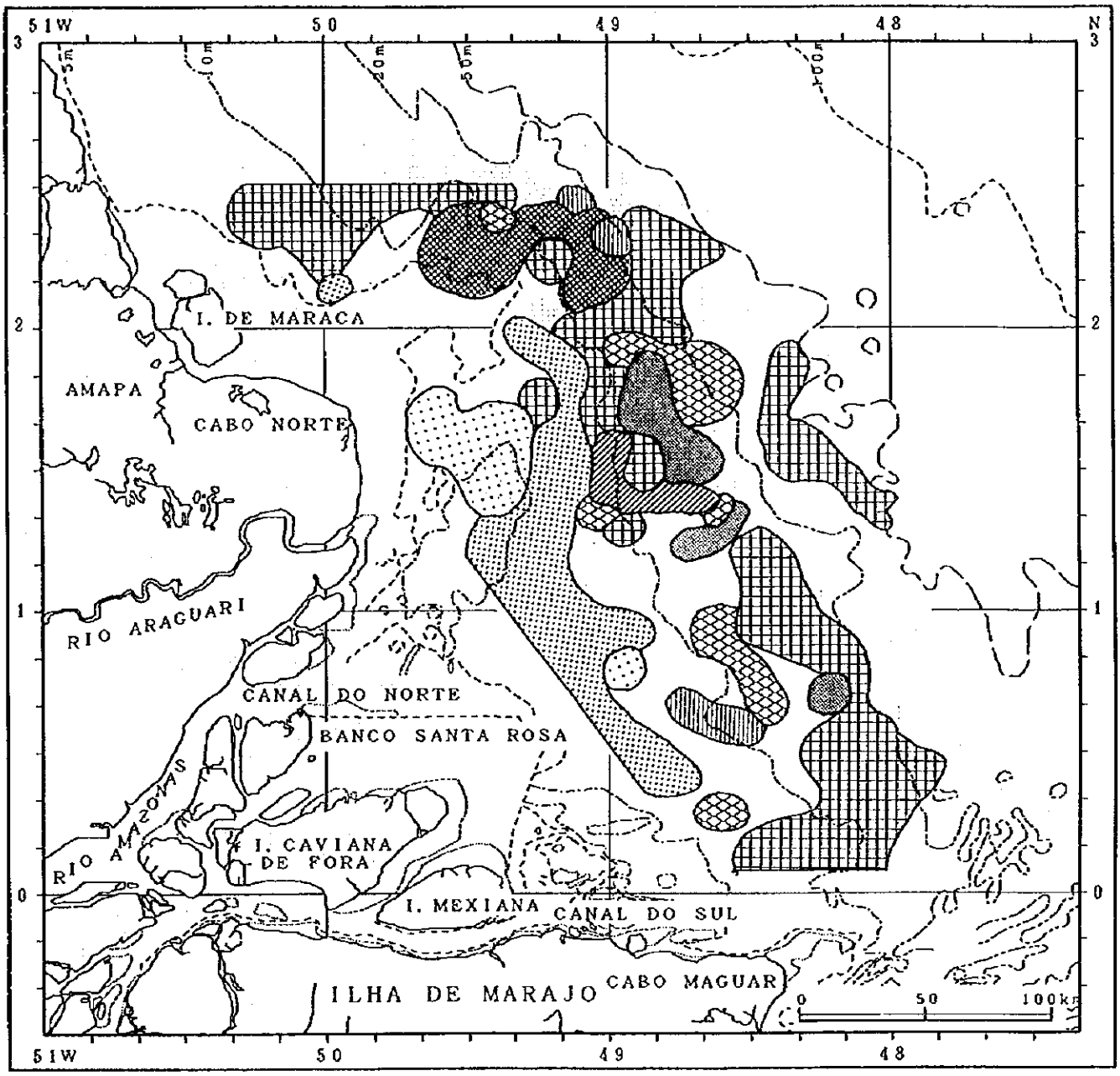
Community of Pescadinha go, Cambeua, Bandeirado

Community of Piramutaba, Canguito, Dourada

Community of Sardinha gato, Espada, Gostoso

(C)

Figure 12. Continued



Community of Pescadinha go, Uricica, Bandeirado

Community of Piramutaba, Pescadinha go, Bandeirado

Community of Cangata, Pescadinha go, Arraia bicuda

Community of Cambeua, Pescadinha go, Cangata

Community of Buchdinho, Pescadinha go, Cangata

Community of Canguito, Piramutaba, Arraia bicuda

Community of Manjuba savelha, Pescadinha go, Cambeua

Community of Jurupiranga, Cangata, Arraia bicuda

Table 15. Composition of clusters defined at C_{II} = 0.55 and containing five or more trawl stations, following Mountford's method of cluster analysis.

Survey season	Number of cluster	Consistituent trawl stations of cluster	Consistituent main fish species of cluster
Phase 1 Dry Season	I	1 2 3 4 11 13 14 15 16 17 18 26 30 35 37 42 43 45 46 47 48 51 53 54 55 56 57 59 60 61 67 74 79 80 97 104 105 107	*Macrodon ancylodon* (47%) *Cathorops spixii* (8%) *Arius grandicassis* (6%)
	II	5 19 20 32 33 44 75 82 96 98 102 103 106	*Arius quadriscutis* (28%) *Macrodon ancylodon* (15%) *Cathorops spixii* (10%)
	III	87 88 89 90 91 92 94	*Arius phrygiatus* (42%) *Aspredo aspredo* (15%) *Brachyplatystoma flavicans* (14%)
	IV	50 65 68 69 70 71 73	*Odontognathus mucronatus* (56%) *Trichiurus lepturus* (13%) *Macrodon ancylodon* (7%)
	V	52 58 62 63 66 72 78	*Anchoa spinifer* (38%) *Macrodon ancylodon* (22%) *Odontognathus mucronatus* (10%)
	VI	22 23 24 29 85 86	*Brachyplatystoma vaillantii* (80%) *Arius phrygiatus* (11%) *Brachyplatystoma flavicans* (3%)
	VII	6 7 27 28 93	*Aspredo aspredo* (48%) *Dasyatis guttata* (13%) *Arius quadriscutis* (11%)
Phase 2 Rainy Season	I	1 2 3 4 6 8 14 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 41 42 43 45 46 47 48 53 54 55 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 81 82 83 84 86 87 88 89 90 100 102 103 104 105 106 107 110 111 112 113 114 115 116 117 120	*Macrodon ancylodon* (62%) *Arius grandicassis* (5%) *Bagre bagre* (5%)
	II	5 9 10 11 12 13 15 32 33 34 35 36 37 38 39 40 91 92 93 94 95 96 97 98 99 101 108 109	*Brachyplatystoma vaillantii* (59%) *Arius phrygiatus* (13%) *Brachyplatystoma flavicans* (7%)
	III	44 49 52 56 57 58	*Odontognathus mucronatus* (34%) *Trichiurus lepturus* (14%) *Peprilus paru* (13%)

Table 15. Continued

Survey season	Number of cluster	Consistituent trawl stations of cluster	Consistituent main fish species of cluster
Phase 2 Dry Season	I	1 2 3 4 5 7 8 10 11 20 21 22 23 24 34 35 43 44 46 47 53 54 55 57 65 66 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 87 99 103 107 109	*Macrodon ancylodon* (51%) *Cathorops spixii* (9%) *Bagre bagre* (7%)
	II	28 29 30 33 37 39 40 56 70 108 110 111	*Brachyplatystoma vaillantii* (53%) *Macrodon ancylodon* (6%) *Bagre bagre* (5%)
	III	13 19 36 64 86 88 90 91 97 100	*Arius quadriscutis* (42%) *Macrodon ancylodon* (20%) *Dasyatis guttata* (7%)
	IV	51 52 58 61 62 63 67 68 69	*Arius grandicassis* (39%) *Macrodon ancylodon* (16%) *Arius quadriscutis* (15%)
	V	9 25 89 92 93 94 98 105 106	*Stellifer rastrifer* (34%) *Macrodon ancylodon* (20%) *Arius quadriscutis* (19%)
	VI	38 112 113 114 115 119 120	*Arius phrygiatus* (32%) *Brachyplatystoma vaillantii* (21%) *Dasyatis guttata* (8%)
	VII	12 14 48 49 50 60	*Anchoa spinifer* (41%) *Macrodon ancylodon* (27%) *Arius grandicassis* (7%)
	VIII	95 96 101 102 104	*Arius rugispinis* (42%) *A. quadriscutis* (15%) *Dasyatis guttata* (10%)

5.1.2. Catch per Unit Area and Dominant Fish Species

Catch per unit area — expressed in kg/km^2 and hereinafter referred to as CPUA —was calculated from the catch in weight (including both the cod-end and the covernet) and the area swept in each trawl station. The minimum weight unit for each species measured on board was 10 g, due to the specifications of the scale used. Here, CPUA values for species weighing under 10 g are indicated in figures as "<10" and in tables as zero; nevertheless, these species were in effect included in the total number of species.

In the determination of the CPUA in each water mass region, it was assumed that the salinity in the area swept at each trawl station (the maximum salinity in the bottom layer as measured at the end of a trawl) would not change within an enlarged area unit of 1 km^2 — approximately 11-13 times the mean area swept.

(a) CPUA by stratum and water mass region

Table 16 shows for each phase and season the mean CPUA, standard deviation and CPUA range by stratum and water mass region.

a-1) CPUA by stratum

In the Dry Season of both phases, the mean CPUA by stratum declined in the following order of strata: 10–20 m (Phase 1: 1,405; Phase 2: 2,808), 5–10 m (Phase 1: 718; Phase 2: 1,356) and 20–50 m (Phase 1: 411; Phase 2: 881). Thus, the mean CPUA by stratum in Phase 2 was twice that of Phase 1 in all strata. In the Rainy Season, the mean CPUA by stratum decreased in the following order of strata: 5–10 m (1,554), 20–50 m (1,247) and 10–20 m (1,172). The mean CPUA the 5–10 m and 20–50 m strata was higher in the Rainy Season than in the Dry Season of both Phases. The amplitude of mean CPUA values by stratum was narrower in the Rainy Season (about 400) than in the Dry Season (1,000 and 2,000).

The highest value of CPUA in the Dry Season was 11,258 in the 10–20 m stratum; in the Rainy Season it was 15,625 in the 5–10 m stratum. The survey showed how CPUA had a broad range of widespread values.

For each season and stratum, the percentage of mean CPUA calculated from catch in cod-end was over 70% of the mean CPUA. This proportion was higher in shallow strata: for Phase 1 Dry Season Survey, 92% (5–10 m), 87% (10–20 m) and 81% (20–50 m); for Phase 2 Rainy Season Survey, 88% (5–10 m), 78% (10–20 m) and 66% (20–50 m); for Phase 2 Dry Season Survey, 96% (5–10 m), 86% (10–20 m) and 84% (20–50 m).

a-2) CPUA by water mass region

The mean CPUA by water mass region declined in the Dry Season in the following order: brackish (Phase 1: 1,142; Phase 2: 2,015), river (Phase 1: 912; Phase 2: 1,802) and ocean (Phase 1: 611; Phase 2: 1,653) waters. Thus, the mean CPUA by water mass region in Phase 2 was twice that of Phase 1 in the respective regions. In the Rainy Season, the mean CPUA by water mass region decreased in the following order: river (1,591), brackish (1,322) and ocean (1,281) waters. Increase of mean CPUA in each water mass region did not follow the season, but happened in survey order for river (912, 1,591 and 1,802 in the respective order of surveys), brackish (1,142, 1,322 and 2,015) and ocean (611, 1,281 and 1,653) waters.

The above-mentioned highest value of CPUA in both the Dry and Rainy Seasons were obtained in brackish waters. The width and the spread of values was comparable to those observed for CPUA by stratum.

For each season and water mass region, the percentage of mean CPUA calculated from catch in cod-end was again over 70% of the mean CPUA. This proportion was lower in ocean waters. Percentages for the three water mass regions were as follows: for Phase 1 Dry Season Survey, 85% (river), 88%

(brackish) and 82% (ocean); for Phase 2 Rainy Season Survey, 91% (river), 82% (brackish) and 72% (ocean); for Phase 2 Dry Season Survey, 91% (river), 92% (brackish) and 80% (ocean).

Table 16. CPUA by stratum and water mass region. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters. CPUA obtained from catch in cod-end indicated in parentheses.

(A)

	Stratum (isobath range in m)			Water mass		
	5 - 10	10 - 20	20 - 50	RW	BW	OW
Mean	717.8	1,404.6	411.3	911.9	1,142.2	610.7
	(662.7)	(1,221.4)	(331.5)	(772.2)	(1,004.5)	(499.6)
Standard deviation	673.8	1,565.2	531.0	639.5	1,310.2	850.5
Range	1.6 - 2,780.1	14.2 - 8,020.2	3.0 - 1,885.6	169.7 - 1,961.6	1.6 - 8,020.2	3.0 - 3,879.6

(B)

	Stratum (isobath range in m)			Water mass		
	5 - 10	10 - 20	20 - 50	RW	BW	OW
Mean	1,554.0	1,171.5	1,246.5	1,590.6	1,321.6	1,280.6
	(1,374.1)	(909.2)	(828.2)	(1,455.2)	(1,084.7)	(926.2)
Standard deviation	2,452.5	1,231.2	835.9	1,501.6	2,068.3	1,181.8
Range	18.8 - 15,625.2	56.2 - 6,134.0	0 - 3,098.4	97.2 - 6,859.9	18.8 - 15,625.2	0 - 4,232.7

(C)

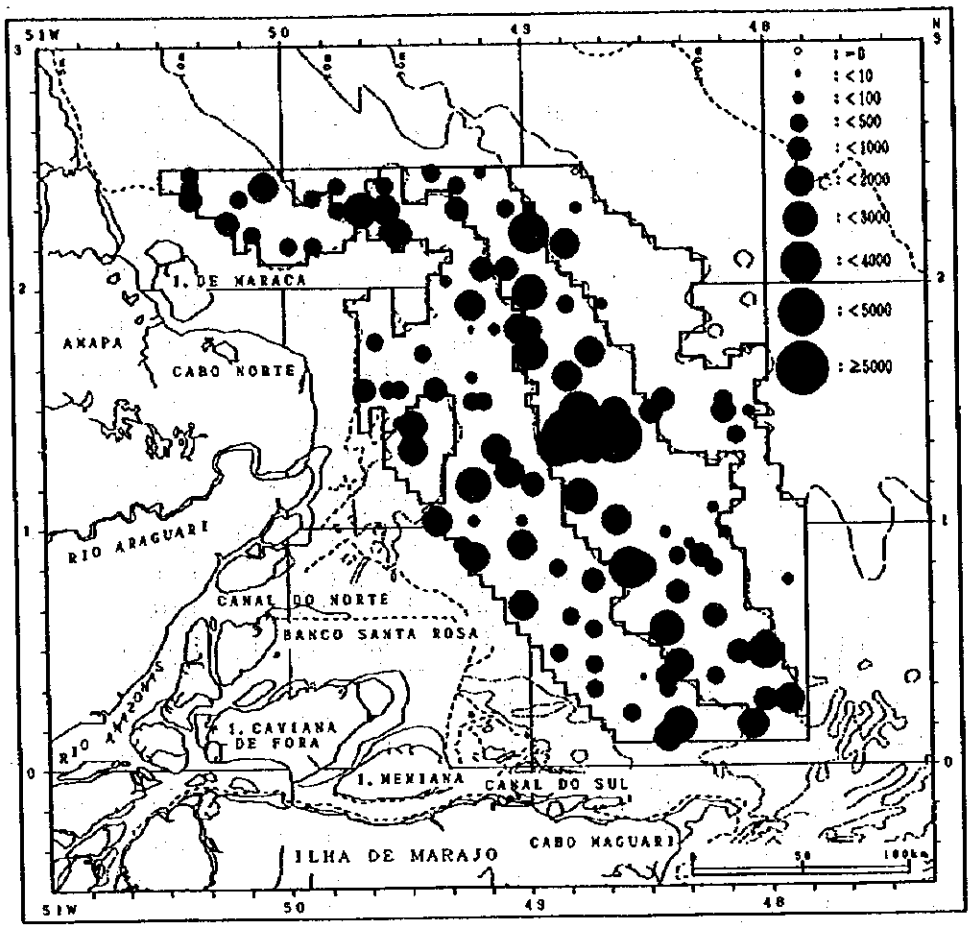
	Stratum (isobath range in m)			Water mass		
	5 - 10	10 - 20	20 - 50	RW	BW	OW
Mean	1,355.5	2,808.4	880.7	1,802.1	2,015.4	1,652.7
	(1,297.8)	(2,423.3)	(741.9)	(1,637.9)	(1,857.5)	(1,328.6)
Standard deviation	1,726.3	2,279.1	676.9	1,561.5	2,292.5	1,411.9
Range	8.7 - 8,855.8	5.5 - 11,258.1	0 - 2,185.1	150.2 - 5,379.3	5.5 - 11,258.1	0 - 6,798.7

(b) Distribution of CPUA

Figure 13 illustrates CPUA values in all trawl stations. In the Dry Season, relatively high values of CPUA tended to concentrate in water depth range of 10–20 m; in the Rainy Season, however, they were found in a wider water depth range of 5–20 m. In the Dry Season, distribution of high values of CPUA was more widespread in Phase 2 than in Phase 1. This distribution pattern reflected the mean CPUA by stratum.

This distribution pattern of CPUA and the above-discussed mean CPUA by stratum and water mass region — in particular, changes in mean CPUA by water mass region — could be attributed to either a decline in fishing pressure in the survey area by the industrial fishing fleet, or to the natural growth of the demersal fish populations there.

(A)



(B)

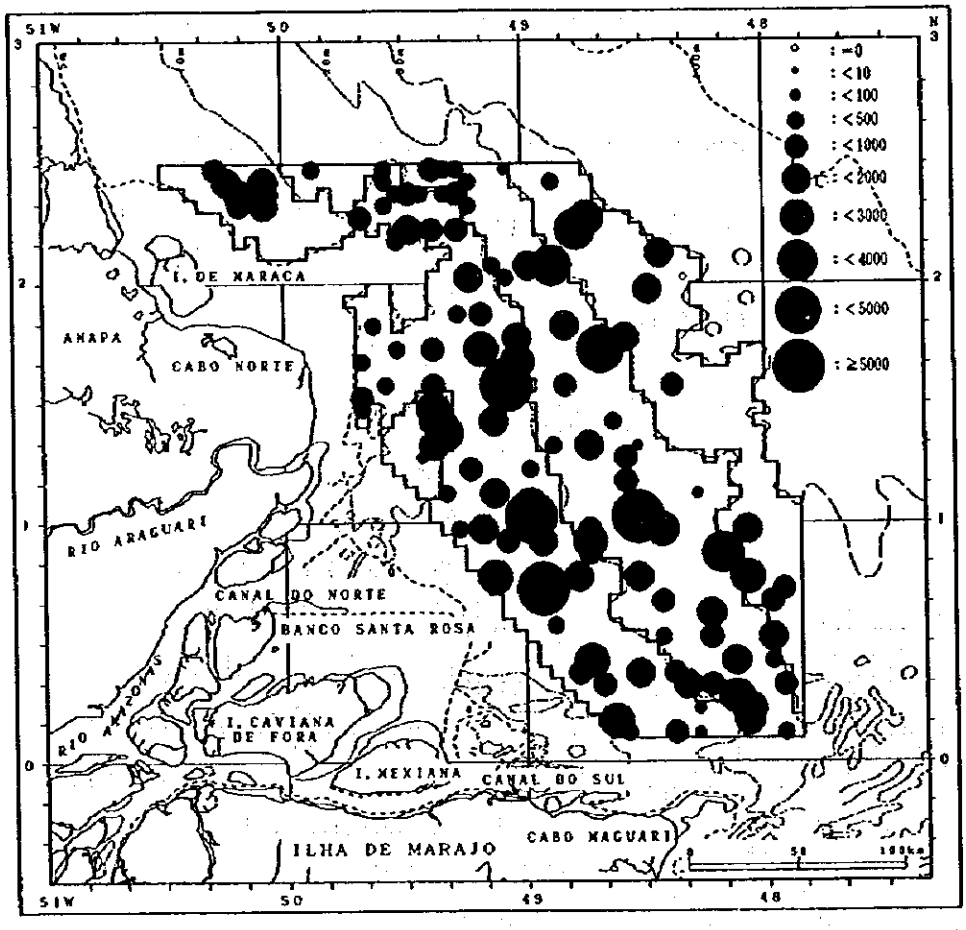
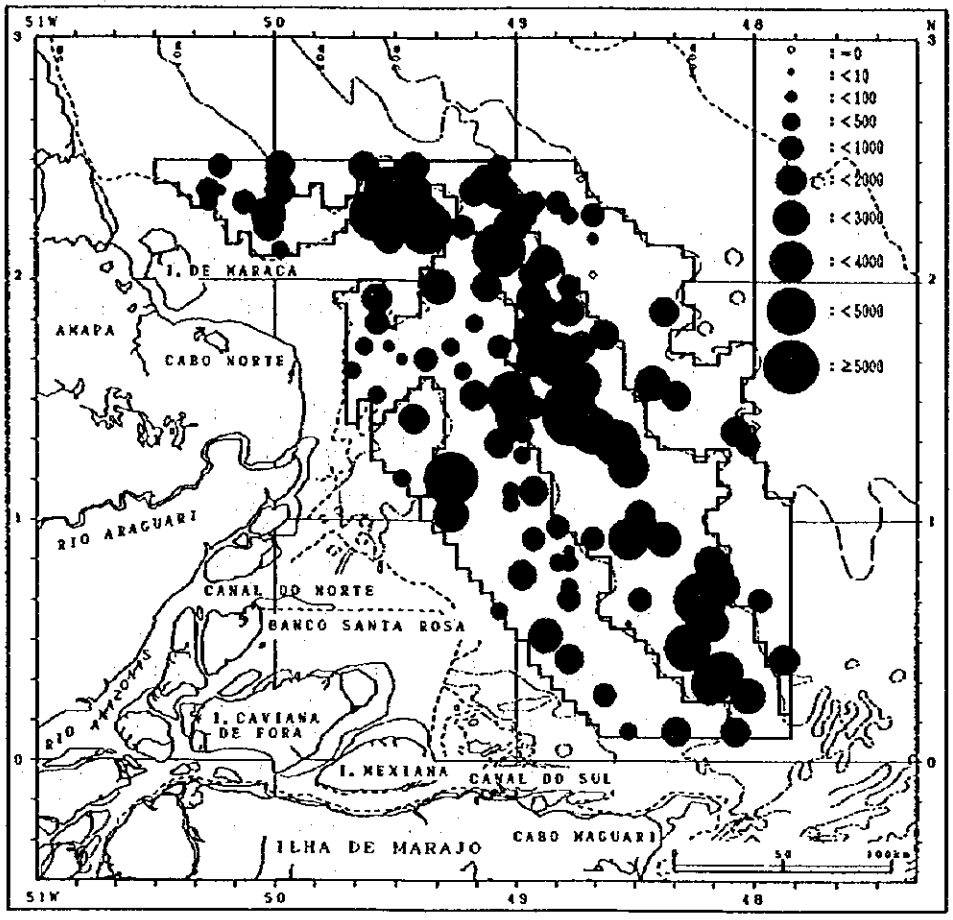


Figure 13. Distribution of CPUA. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 13. Continued

(C)



(c) Dominant fish species with respect to CPUA

Table 17 lists the five top-ranking fish species in terms of CPUA by stratum and water mass region for each seasonal survey. They made up a total of 17 species, comprising 7 sea catfishes (family Ariidae), 4 drums (Sciaenidae), 2 long-whiskered catfishes (Pimelodidae), 2 requiem sharks (Carcharhinidae), 1 sea bass (Serranidae) and 1 cutlassfish (Trichiuridae). Mean CPUA values for key species not included in the top five are also presented in that table.

c-1) Dominant species in terms of mean CPUA by stratum

In terms of mean CPUA by stratum, the five top-ranking fish species in each survey made up a total of 13: the carcharhinids cação *Carcharhinus porosus* and martelo *Sphyrna lewini;* the ariids cambéua *Arius grandicassis,* gurijuba *A. parkeri,* cangatá *A. quadriscutis,* jurupiranga *A. rugispinis* and bandeirado *Bagre bagre;* the pimelodids dourada *Brachyplatystoma flavicans* and piramutaba *B. vaillantii;* the sciaenids pescada cambuçu *Cynoscion virescens,* pescadinha gó *Macrodon ancylodon* and pescada curuca grande *Micropogonias furnieri;* and the trichiurid espada *Trichiurus lepturus.* The only species found among the top five in all strata was cambéua *Arius grandicassis.*

Different compositions of the top-ranking species (those representing more than 10% of the mean CPUA in each stratum) in, respectively, Phase 1 Dry Season Survey, Phase 2 Rainy Season Survey and Phase 2 Dry Season Survey, are presented below.

i) 5–10 m stratum

The top-ranking species in this stratum were cambéua *Arius grandicassis*, gurijuba *A. parkeri*, cangatá *A. quadriscutis*, dourada *Brachyplatystoma flavicans* and piramutaba *B. vaillantii*. Their respective values of mean CPUA and percentages of the mean CPUA in this stratum (in parentheses) in the three surveys were:

cambéua:	130 (18%)	130 (8%)	414 (31%)
gurijuba:	39 (5%)	69 (4%)	137 (10%)
cangatá:	97 (14%)	102 (7%)	173 (13%)
dourada:	68 (9%)	150 (10%)	136 (10%)
piramutaba:	88 (12%)	684 (44%)	212 (16%)

For the three species of sea catfish, mean CPUA did not vary with the season, but increased as the surveys progressed. This increase was particularly remarkable for cambéua. On the other hand, for the two species of *Brachyplatystoma* mean CPUA was higher in the Rainy Season. Also, comparing both Dry Seasons, mean CPUA was higher in Phase 2 than in Phase 1. Mean CPUA of piramutaba in the Rainy Season (684) represented 44% of the mean CPUA in this stratum.

ii) 10–20 m stratum

The top-ranking species in this stratum were cambéua *Arius grandicassis*, gurijuba *A. parkeri*, cangatá *A. quadriscutis*, jurupiranga *A. rugispinis* and pescadinha gó *Macrodon ancylodon*. Their respective values of mean CPUA and percentages of the mean CPUA in this stratum (in parentheses) in the three surveys were:

cambéua:	276 (20%)	264 (23%)	577 (21%)
gurijuba:	120 (9%)	137 (12%)	179 (6%)
cangatá:	316 (22%)	106 (13%)	863 (31%)
jurupiranga:	195 (14%)	55 (5%)	347 (12%)
pescadinha gó:	77 (6%)	199 (17%)	228 (8%)

For gurijuba and pescadinha gó, mean CPUA did not vary with the season, but increased as the surveys progressed. For the other three species, mean CPUA decreased from the Phase 1 Dry Season to the Phase 2 Rainy Season, but then increased dramatically in the Phase 2 Dry Season.

(iii) 20–50 m stratum

The top-ranking species in this stratum were cação *Carcharhinus porosus*, cambéua *Arius grandicassis*, cangatá *A. quadriscutis*, pescada cambuçu *Cynoscion virescens*, pescadinha gó *Macrodon ancylodon* and espada *Trichiurus lepturus*. Their respective values of mean CPUA and percentages of the mean CPUA in this stratum (in parentheses) in the three surveys were:

cação:	58 (14%)	125 (10%)	128 (15%)
cambéua:	90 (22%)	202 (16%)	174 (20%)
cangatá:	20 (5%)	44 (3%)	95 (11%)
pescada cambuçu:	35 (8%)	133 (11%)	64 (9%)
pescadinha gó:	20 (5%)	301 (24%)	107 (12%)
espada:	46 (11%)	66 (5%)	22 (3%)

For cação and cangatá, mean CPUA seemed not to vary with the season, but increased as the surveys progressed. For the other four species, mean CPUA was higher in the Rainy Season; and, except in the case of espada, comparing both Dry Seasons, mean CPUA was higher in Phase 2 than in Phase 1.

c-2) Dominant species in terms of mean CPUA by water mass region

In terms of mean CPUA by water mass region, the five top-ranking fish species in each survey made up a total of 13: the ariids bagre branco *Arius couma*, cambéua *A. grandicassis*, gurijuba *A. parkeri*, canguito *A. phrygiatus*, cangatá *A. quadriscutis*, jurupiranga *A. rugispinis* and bandeirado *Bagre bagre;* the pimelodids dourada *Brachyplatystoma flavicans* and piramutaba *B. vaillantii;* the sciaenids pescada cambuçu *Cynoscion virescens*, pescadinha gó *Macrodon ancylodon* and pescada cascuda preta *Plagioscion auratus;* and the serranid mero *Epinephelus itajara*.

Different compositions of the top-ranking species (those representing more than 10% of the mean CPUA in each water mass region) in, respectively, Phase 1 Dry Season Survey, Phase 2 Rainy Season Survey and Phase 2 Dry Season Survey, are presented below.

i) River waters

The top-ranking species in this water mass were bagre branco *Arius couma* and piramutaba *Brachyplatystoma vaillantii*. Their respective values of mean CPUA and percentages of the mean CPUA in river waters (in parentheses) in the three surveys were:

bagre branco:	107 (12%)	68 (4%)	233 (13%)
piramutaba:	618 (68%)	1,163 (73%)	1,181 (66%)

Mean CPUA for bagre branco was higher in the Dry Season, when Phase 2 values were twice that of Phase 1. Mean CPUA for piramutaba was higher in both Phase 2 seasons, with twice that of

Phase 1; in all cases, mean CPUA of piramutaba represented about 70% of the mean CPUA in this water mass.

ii) Brackish waters

The top-ranking species in this water mass were cambéua *Arius grandicassis*, cangatá *A. quadriscutis*, jurupiranga *A. rugispinis*, piramutaba *Brachyplatystoma vaillantii* and pescadinha gó *Macrodon ancylodon*. Their respective values of mean CPUA and percentages of the mean CPUA in brackish waters (in parentheses) in the three surveys were:

cambéua:	249 (22%)	233 (18%)	503 (25%)
cangatá:	251 (22%)	118 (9%)	580 (29%)
jurupiranga:	168 (15%)	83 (6%)	258 (13%)
piramutaba:	28 (2%)	264 (20%)	31 (2%)
pescadinha gó:	40 (4%)	172 (13%)	88 (4%)

For the three species of sea catfish, mean CPUA was higher in the Dry Season, with respective Phase 2 values about twice those of Phase 1. In contrast, mean CPUA for piramutaba and pescadinha gó were higher in the Rainy Season.

iii) Ocean waters

The top-ranking species in this water mass were cambéua *Arius grandicassis*, gurijuba *A. parkeri*, cangatá *A. quadriscutis*, pescada cambuçu *Cynoscion virescens*, pescadinha gó *Macrodon ancylodon* and mero *Epinephelus itajara*. Their respective values of mean CPUA and percentages of the mean CPUA in ocean waters (in parentheses) in the three surveys were:

cambéua:	70 (12%)	219 (17%)	438 (27%)
gurijuba:	66 (11%)	88 (7%)	117 (7%)
cangatá:	39 (6%)	95 (7%)	242 (15%)
pescada cambuçu:	86 (14%)	135 (11%)	177 (11%)
pescadinha gó:	51 (8%)	244 (19%)	202 (12%)
mero:	96 (16%)	0 (0%)	0 (0%)

For all species except pescadinha gó and mero, mean CPUA seemed not to vary with the season but increased as the surveys progressed. For pescadinha gó, mean CPUA increased dramatically from the Phase 1 Dry Season to the Phase 2 Rainy Season and declined slightly afterwards. The inclusion of mero among the top-ranking species was due to the catch of a single very large specimen (total length, 219 cm; body weight, 173 kg).

For most of the species listed in Table 17, the mean CPUA calculated from catch in cod-end was over 90% of the mean CPUA, a remarkably high percentage. The one of same exceptions was pescadinha gó, for which this ratio was lower than 20%.

Table 17. Mean CPUA by stratum and water mass region and related dominant fish species. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters. Underlined values of CPUA refer to the top five species in each category. CPUA obtained from catch in cod-end indicated in parentheses.

(A)

Top 5 ranked species of fish	Mean CPUA											
	Stratum (isobath range in m)						Water mass					
	5 - 10		10 - 20		20 - 50		RW		BW		OW	
Arius couma	34.7	(34.5)	3.5	(3.5)	0		106.5	(106.1)	14.7	(14.6)	0	
A. grandicassis	130.2	(125.4)	276.2	(264.0)	89.7	(79.7)	0		248.8	(238.4)	70.4	(65.0)
*A. parkeri**	39.4	(38.9)	120.3	(120.0)	16.7	(16.7)	0		81.3	(80.8)	65.7	(65.7)
A. phrygiatus	18.7	(16.5)	4.7	(2.8)	0		69.8	(58.9)	8.4	(6.8)	0	
A. quadriscutis	97.4	(91.8)	315.7	(299.3)	20.1	(18.6)	0.8	(0.8)	251.2	(238.1)	39.4	(36.3)
A. rugispinis	71.7	(68.2)	195.2	(187.5)	0		0		167.7	(160.6)	5.9	(5.6)
Bagre bagre	9.1	(6.9)	27.2	(20.3)	1.8	(0.5)	35.9	(35.9)	16.9	(12.7)	7.4	(2.5)
*Brachyplatystoma flavicans**	67.7	(64.2)	6.8	(6.6)	0		43.6	(40.3)	45.9	(43.8)	0	
*B. vaillantii**	87.8	(78.0)	52.9	(41.2)	0		618.0	(497.3)	27.8	(26.5)	0	
Carcharhinus porosus	0.7	(0.7)	1.5	(1.5)	58.4	(58.4)	0		0		28.9	(28.9)
Cynoscion virescens	45.8	(45.8)	94.9	(92.8)	34.6	(32.5)	0		65.7	(64.4)	85.6	(84.7)
Epinephelus itajara	0		52.8	(52.8)	0		0		0		95.5	(95.5)
*Macrodon ancylodon**	10.7	(2.0)	77.3	(13.9)	19.6	(3.7)	0		40.4	(8.9)	51.3	(4.8)
Micropogonias furnieri	4.9	(4.5)	7.2	(7.0)	30.4	(28.9)	0		6.2	(5.8)	17.4	(16.8)
Trichiurus lepturus	1.0	(0.7)	4.0	(1.5)	45.5	(24.1)	0		0.5	(0.3)	27.0	(13.3)
*Brachyplatystoma filamentosum**	1.7	(1.3)	0.1	(0.0)	0		0.3	(0.0)	1.2	(0.9)	0	
*Cynoscion acoupa**	3.7	(3.7)	18.4	(17.1)	15.4	(15.4)	0		9.5	(8.8)	19.3	(19.3)
*Plagioscion squamosissimus**	1.2	(1.1)	0		0		5.0	(4.5)	0.3	(0.3)	0	
Total	57 spp.	(49spp.)	64 spp.	(54spp.)	42 spp.	(36spp.)	19 spp.	(15spp.)	65 spp.	(55spp.)	52 spp.	(44spp.)
	717.8	(662.7)	1,404.6	(1,221.4)	411.3	(331.5)	911.9	(772.2)	1,142.2	(1,004.5)	610.7	(499.6)

* Key fish species.

(B)

Top 5 ranked species of fish	Mean CPUA											
	Stratum (isobath range in m)						Water mass					
	5 - 10		10 - 20		20 - 50		RW		BW		OW	
Arius couma	19.3	(19.2)	23.7	(23.7)	0		68.4	(68.4)	12.9	(12.9)	0	
A. grandicassis	129.9	(129.8)	264.3	(262.2)	201.8	(199.8)	0		233.4	(232.0)	218.8	(217.3)
*A. parkeri**	68.5	(68.4)	137.4	(136.5)	33.3	(33.2)	0		117.0	(116.4)	87.6	(87.5)
A. phrygiatus	36.5	(32.6)	11.2	(10.4)	0		91.4	(82.9)	11.5	(10.3)	0	
A. quadriscutis	102.0	(101.0)	105.9	(104.3)	43.6	(39.4)	6.3	(5.5)	118.0	(116.9)	94.7	(90.2)
A. rugispinis	96.9	(95.7)	54.7	(51.3)	11.8	(11.8)	0		82.7	(79.4)	81.4	(78.8)
*Brachyplatystoma flavicans**	149.8	(148.0)	44.8	(44.6)	0		136.9	(136.2)	98.9	(97.7)	0	
*B. vaillantii**	684.3	(623.7)	94.9	(90.6)	0		1,162.7	(1,045.2)	264.0	(246.3)	0	
Carcharhinus porosus	0.6	(0.6)	1.2	(1.2)	125.0	(124.5)	0		1.1	(1.1)	81.3	(80.9)
Cynoscion virescens	24.4	(24.4)	57.7	(57.7)	132.6	(132.6)	0		41.0	(41.0)	135.2	(135.2)
*Macrodon ancylodon**	86.1	(6.1)	199.2	(9.3)	300.9	(25.5)	0		172.4	(8.9)	243.7	(21.1)
Plagioscion auratus	27.0	(26.7)	17.3	(17.2)	0		76.1	(74.9)	12.4	(12.4)	0	
Sphyrna lewini	0		0		98.9	(98.9)	0		0		64.3	(64.3)
*Brachyplatystoma filamentosum**	3.1	(3.1)	0		0		3.9	(3.8)	1.2	(1.2)	0	
*Cynoscion acoupa**	3.9	(3.9)	21.6	(21.6)	7.6	(7.6)	0		12.8	(12.8)	19.4	(19.4)
*Plagioscion squamosissimus**	9.1	(8.6)	0		0		14.4	(13.7)	2.9	(2.8)	0	
Total	59 spp.	(51spp.)	63 spp.	(52spp.)	46 spp.	(38spp.)	24 spp.	(20spp.)	66 spp.	(61spp.)	50 spp.	(42spp.)
	1,554.0	(1,374.1)	1,171.5	(909.2)	1,246.5	(828.2)	1,590.6	(1,455.2)	1,321.6	(1,084.7)	1,280.6	(926.2)

* Key fish species.

Table 17. Continued

(C)

Top 5 ranked species of fish	Mean CPUA											
	Stratum (isobath range in m)						Water mass					
	5 - 10		10 - 20		20 - 50		RW		BW		OW	
Arius couma	46.4	(46.0)	5.7	(5.7)	0		233.2	(231.5)	12.3	(12.2)	0	
A. grandicossis	414.2	(413.8)	576.8	(575.6)	173.7	(173.4)	0		503.3	(502.5)	438.4	(437.7)
*A. parkeri**	137.4	(137.2)	179.2	(179.0)	69.7	(69.7)	0		173.3	(173.2)	117.2	(117.0)
A. phrygiatus	18.6	(16.8)	7.1	(6.8)	0		93.3	(85.4)	8.0	(7.4)	0	
A. quadriscutis	172.5	(169.6)	863.2	(854.5)	95.0	(94.5)	31.8	(31.8)	580.3	(573.5)	241.7	(239.6)
A. rugispinis	66.6	(66.3)	346.8	(343.9)	4.4	(4.4)	0		258.1	(256.1)	20.6	(20.6)
*Brachyplatystoma flavicans**	135.8	(134.4)	15.7	(15.7)	0		160.0	(156.3)	88.3	(87.7)	0	
*B. vaillantii**	212.2	(189.2)	4.8	(4.6)	0		1,181.0	(1,040.2)	31.1	(29.3)	0	
Corchorhinus porosus	0		10.9	(10.9)	127.7	(127.7)	0		0		74.6	(74.6)
Cynoscion virescens	22.9	(22.9)	159.1	(159.1)	64.3	(63.5)	0		54.9	(54.9)	177.1	(176.7)
*Macrodon ancylodon**	10.6	(1.6)	228.4	(16.3)	106.5	(15.5)	0.5	(0.0)	87.6	(8.2)	202.2	(14.8)
Plagioscion auratus	11.4	(11.3)	8.6	(8.6)	0		52.1	(51.3)	8.1	(8.1)	0	
*Brachyplatystoma filamentosum**	0.4	(0.4)	0		0		2.4	(2.4)	0		0	
*Cynoscion acoupa**	20.3	(20.3)	50.3	(50.3)	15.1	(15.1)	0		23.1	(23.1)	61.7	(61.7)
*Plagioscion squamosissimus**	2.5	(2.3)	0		0		5.3	(4.4)	1.2	(1.2)	0	
Total	48spp.	(43spp.)	59spp.	(50spp.)	39spp.	(34spp.)	26spp.	(22spp.)	51spp.	(43spp.)	49spp.	(42spp.)
	1,355.5	(1,297.8)	2,808.4	(2,423.3)	880.7	(741.9)	1,802.1	(1,637.9)	2,015.4	(1,857.5)	1,652.7	(1,328.6)

* Key fish species.

(d) Relationship between bottom salinity and CPUA

Figure 14 shows the relationship between salinity of the bottom layer and CPUA for each seasonal survey. CPUA values were in the 0–16,000 range and widespread in the area. CPUAs over 4,000 were limited to waters with bottom salinities either lower than 5 psu or higher than 25 psu.

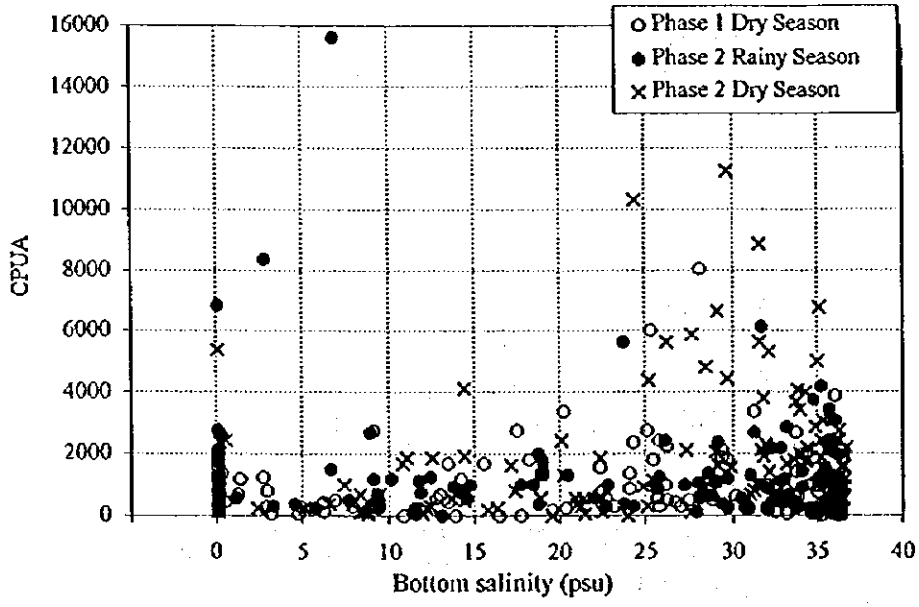


Figure14. Relationship between bottom salinity and CPUA.

Notes on four stingray species — arraia morcego *Dasyatis geijkesi*, arraia bicuda *D. guttata*, arraia redonda *Himantura schmardae* and arraia de rio *Plesiotrygon* sp.

Nearly all specimens of the four stingray species caught were large, measuring about 1 m in disc diameter. Difficulty in measuring their round weight in life and the danger of being wounded by their venomous, tooth-edged sting on the back of the tail prompted those fish to be released back into the water as soon as they were counted. Therefore, data on their weight are not available.

The following table shows the mean catch in number of individuals per unit area by water mass region for the two species of *Dasyatis*, the most numerous among the four stingrays. All four species were treated in Table 17 in the same way as species weighing less than 10 g.

Table. Mean catch in number per unit area (number/km^2) by water mass region for *Dasyatis*. That in parentheses obtained from catch in cod-end. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters.

Species	Phase											
	1						2					
	Dry Season			Rainy Season			Dry Season					
	Water mass			Water mass			Water mass					
	RW	BW		OW		RW	BW		OW		RW	BW		OW	
Dasyatis geijkesi	0	35	(35)	15	(14)	0	33	(33)	41	(41)	2 (2)	44	(44)	63	(62)
D. guttata	6 (6)	81	(81)	48	(40)	1 (1)	63	(62)	85	(85)	24 (24)	126	(125)	184	(182)

5.1.3. Estimation of Stock Size and Related Dominant Fish Species

As described in Chapter 3, the survey area was stratified into three strata of, respectively, 5–10 m, 10–20 m and 20–50 m, their respective area being 17,200 km^2, 15,700 km^2 and 9,300 km^2. However, it was difficult to divide the survey area into water mass regions — river, brackish and ocean — based on the salinity of the bottom layer as measured at each trawl station, and then determine their respective areas. This was because it was not possible to infer an isohaline extending over the entire survey area (1,330 blocks) from data on the salinity of the bottom layer taken at every one of the 111 stations in the Phase 1 Dry Season and 120 stations each in both Phase 2 Rainy and Dry Seasons. Furthermore, the salinity of the bottom layer showed spatial and temporal fluctuations that were particularly acute where river and ocean waters mix and interact with each other.

Estimation of stock size by the areal expansion method based on CPUA data is presented below for each stratum. The top-ranking ten species in estimated stock size by stratum and total estimated stock size in each seasonal survey are presented in Table 18. Some key fish species not included among the top ten are also listed.

(a) Estimated stock size by stratum and total estimated stock size

In the order Phase 1 Dry Season, Phase 2 Rainy Season and Phase 2 Dry Season, the stock size (in tonnes) for each stratum and its relative percentages of the total stock size are as follows:

5–10 m stratum:	12,346 (32%)	26,729 (47%)	23,315 (31%)
10–20 m stratum:	22,052 (58%)	18,393 (32%)	44,092 (58%)
20–50 m stratum:	3,825 (10%)	11,593 (20%)	8,190 (11%)
Total:	38,223 (100%)	56,715 (100%)	75,597 (100%)

The total stock size did not vary with the season, but increased as the surveys progressed: in the Phase 2 Dry Season the stock size was about the double of that of Phase 1. The relative percentages of the stock size in each stratum to the total stock size was, in the Dry Seasons, respectively 30%, 60% and 10%, and in the Rainy Season, respectively 50%, 30% and 20%.

Stock size estimated from catch in cod-end was about 80-90% of the total stock size for all seasons. That percentage (cod-end/total) in each stratum tended to decrease from the shallowest to the deepest strata — respectively, 92 → 87 → 81%, 88 → 78 → 66%, 96 → 86 → 84% in seasonal survey order.

(b) Dominant fish species with respect to estimated stock size

The top-ranking ten species with respect to estimated stock size by stratum were included in a list of 24 species belonging to 7 families: Ariidae (8 species); Sciaenidae (7); Carcharhinidae (4); Pimelodidae (2); Serranidae, Megalopidae and Trichiuridae (1 each).

b-1) Total stock size

Thirteen of the 24 species listed above exhibited a total stock size of over 1,000 tonnes: cação *Carcharhinus porosus* (Carcharhinidae); cambéua *Arius grandicassis*, gurijuba *A. parkeri*, cangatá *A. quadriscutis*, jurupiranga *A. rugispinis* and bandeirado *Bagre bagre* (Ariidae); dourada *Brachyplatystoma flavicans* and piramutaba *B. vaillantii* (Pimelodidae); pescada amarela *Cynoscion acoupa*, pescada cambuçu *C. virescens*, pescadinha gó *Macrodon ancylodon*, pescada sete buchos *Nebris microps* and buchudinho *Stellifer rastrifer* (Sciaenidae). Of these, the four species of *Arius*, the two species of *Brachyplatystoma*, plus pescada cambuçu and pescadinha gó, had a total stock size of over 1,000 tonnes in all seasons.

The ratio of stock size estimated from catch in cod-end to that estimated from total catch was extremely high for all species except pescadinha gó and buchudinho. For these two sciaenids, that percentage was about 20% in Phase 1 and 10% in Phase 2, as most of their catch happened at the covernet level.

Stock sizes of the five top-ranking species among the aforementioned 13 — those representing more than 10% of the overall stock size — in, respectively, Phase 1 Dry Season Survey, Phase 2 Rainy Season Survey and Phase 2 Dry Season Survey, are presented below.

cambéua:	7,409 (19%)	8,261 (15%)	17,795 (24%)
cangatá:	6,818 (18%)	3,823 (7%)	17,403 (23%)
jurupiranga:	4,298 (11%)	2,636 (5%)	6,632 (9%)
piramutaba:	2,341 (6%)	13,260 (23%)	3,723 (5%)
pescadinha gó:	1,580 (4%)	7,406 (13%)	4,758 (6%)

For cambéua, the stock size did not vary with the season but increased as the surveys progressed. The stock sizes of cangatá and jurupiranga were larger in the Dry Seasons than in the Rainy Season, while those of piramutaba and pescadinha gó were the other way around. For those species, the stock size was larger in Phase 2 than in Phase 1, a difference particularly striking in cambéua and cangatá. Those five species represented the following percentages of the overall stock size: 58%, 63% and 67% in the respective seasonal surveys.

b-2) Stock size by stratum

Ten of the 24 species listed above accounted for more than 10% of the total stock size in each stratum: cação *Carcharhinus porosus* (Carcharhinidae); cambéua *Arius grandicassis*, gurijuba *A. parkeri*, cangatá *A. quadriscutis* and jurupiranga *A. rugispinis* (Ariidae); dourada *Brachyplatystoma flavicans* and piramutaba *B. vaillantii* (Pimelodidae); pescada cambuçu *Cynoscion virescens* and pescadinha gó *Macrodon ancylodon* (Sciaenidae); and espada *Trichiurus lepturus* (Trichiuridae). The variation of their respective stock size along the three seasonal surveys is described below.

i) 5–10 m stratum

The stock size of the dominant species and their respective percentage of the total stock size in this stratum (in parentheses) are listed below in survey order.

cambéua:	2,239 (18%)	2,234 (8%)	7,124 (31%)
gurijuba:	678 (5%)	1,178 (4%)	2,363 (10%)
cangatá:	1,675 (14%)	1,754 (7%)	2,967 (13%)
dourada:	1,164 (9%)	2,577 (10%)	2,336 (10%)
piramutaba:	1,510 (12%)	11,770 (44%)	3,648 (16%)

For the three species of sea catfish, the stock size did not vary with the season but increased as the surveys progressed — remarkably so in cambéua. The two pimelodids had larger stocks in the Rainy Season than in the Dry Season, and the difference was striking in the case of piramutaba; for those two species, the Dry Season stocks were larger in Phase 2 than in Phase 1. Those five species accounted respectively for 58%, 73% (44% of which represented by piramutaba alone) and 80% of the total stock size in this stratum, in survey order.

ii) 10–20 m stratum

The stock size of the dominant species and their respective percentage of the total stock size in this stratum (in parentheses) are listed below in survey order.

cambéua:	4,336 (20%)	4,150 (23%)	9,056 (21%)
gurijuba:	1,889 (9%)	2,157 (12%)	2,813 (6%)
cangatá:	4,956 (22%)	1,663 (9%)	13,552 (31%)
jurupiranga:	3,065 (14%)	859 (5%)	5,445 (12%)
pescadinha gó:	1,214 (6%)	3,127 (17%)	3,586 (8%)

For cambéua, gurijuba and pescadinha gó, the stock size did not vary with the season but increased as the surveys progressed — although a slight reduction from the first Dry Season to the Rainy Season was observed in cambéua. Cangatá and jurupiranga had larger stocks in the Dry Seasons than in the Rainy Season; for those two species, The Dry Season stocks were larger in Phase 2 than in Phase 1. The widest amplitude in the stock size was observed for cambéua, cangatá and jurupiranga. Those five species accounted respectively for 71%, 66% and 78% of the total stock size in this stratum, in survey order.

iii) 20–50 m stratum

The stock size of the dominant species and their respective percentage of the total stock size in this stratum (in parentheses) are listed below in survey order.

cação:	543 (14%)	1,163 (10%)	1,188 (15%)
cambéua:	834 (22%)	1,877 (16%)	1,615 (20%)
cangatá:	187 (5%)	406 (4%)	884 (11%)
pescada cambuçu:	322 (8%)	1,233 (11%)	598 (7%)
pescadinha gó:	182 (5%)	2,798 (24%)	991 (12%)
espada:	423 (11%)	615 (5%)	202 (2%)

For cação and cangatá, the stock size did not vary with the season but increased as the surveys progressed. The other four species had larger stocks in the Rainy Season than in the Dry Seasons. Those six species accounted for about 70% of the total stock size in this stratum in all seasons.

Table 18. Top-ranking ten species in estimated stock size by stratum. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Underlined values of stock size refer to the top ten species in each stratum and in total. Stock sizes obtained from catch in cod-end indicated in parentheses.

(A)

Top 10 ranked species of fish	Stock size in tonnes							
	Stratum (isobath range in m)						Total	
	5 - 10		10 - 20		20 - 50			
Arius couma	597	(593)	55	(55)	0		652	(648)
A. grandicassis	2,239	(2,157)	4,336	(4,145)	834	(741)	7,409	(7,043)
*A. parkeri**	678	(669)	1,889	(1,884)	155	(155)	2,722	(2,708)
A. proops	535	(528)	144	(144)	0		679	(672)
A. quadriscutis	1,675	(1,579)	4,956	(4,699)	187	(173)	6,818	(6,451)
A. rugispinis	1,233	(1,173)	3,065	(2,944)	0		4,298	(4,117)
Bagre bagre	157	(119)	427	(319)	17	(5)	601	(443)
*Brachyplatystoma flavicans**	1,164	(1,104)	107	(104)	0		1,271	(1,208)
*B. vaillantii**	1,510	(1,342)	831	(647)	0		2,341	(1,989)
Carcharhinus porosus	12	(12)	24	(24)	543	(543)	579	(579)
*Cynoscion acoupa**	64	(64)	289	(268)	143	(143)	496	(475)
C. virescens	788	(788)	1,490	(1,457)	322	(302)	2,600	(2,547)
Ephinephelus itajara	0		829	(829)	0		829	(829)
*Macrodon ancylodon**	184	(34)	1,214	(218)	182	(34)	1,580	(286)
Micropogonias furnieri	84	(77)	113	(110)	283	(269)	480	(456)
Nebris microps	122	(72)	694	(537)	41	(17)	857	(626)
Sphyrna tiburo	0		0		164	(158)	164	(158)
Tarpon atlanticus	337	(337)	0		0		337	(337)
Trichiurus lepturus	17	(12)	63	(24)	423	(224)	503	(260)
*Brachyplatystoma filamentosum**	29	(22)	2	(0)	0		31	(22)
*Plagioscion squamosissimus**	21	(19)	0		0		21	(19)
All of other fish species	900	(695)	1,524	(768)	531	(319)	2,955	(1,782)
Total	12,346	(11,398)	22,052	(19,176)	3,825	(3,083)	38,223	(33,657)

* Key fish species.

(B)

Top 10 ranked species of fish	Stock size in tonnes							
	Stratum (isobath range in m)						Total	
	5 - 10		10 - 20		20 - 50			
Arius couma	332	(330)	372	(372)	0		704	(702)
A. grandicassis	2,234	(2,233)	4,150	(4,117)	1,877	(1,858)	8,261	(8,208)
*A. parkeri**	1,178	(1,176)	2,157	(2,143)	310	(309)	3,645	(3,628)
A. phrygiatus	628	(561)	176	(163)	0		804	(724)
A. quadriscutis	1,754	(1,737)	1,663	(1,638)	406	(366)	3,823	(3,741)
A. rugispinis	1,667	(1,646)	859	(805)	110	(110)	2,636	(2,561)
Bagre bagre	177	(117)	548	(204)	440	(195)	1,165	(516)
*Brachyplatystoma flavicans**	2,577	(2,546)	703	(700)	0		3,280	(3,246)
*B. vaillantii**	11,770	(10,728)	1,490	(1,422)	0		13,260	(12,150)
Carcharhinus porosus	10	(10)	19	(19)	1,163	(1,158)	1,192	(1,187)

Table 18. (B) Continued

Top 10 ranked species of fish	Stock size in tonnes							
	Stratum (isobath range in m)						Total	
	5 - 10		10 - 20		20 - 50			
Cynoscion virescens	420	(420)	906	(906)	1,233	(1,233)	2,559	(2,559)
*Macrodon ancylodon**	1,481	(105)	3,127	(146)	2,798	(237)	7,406	(488)
Nebris microps	337	(255)	253	(209)	316	(222)	906	(686)
Plagioscion auratus	464	(459)	272	(270)	0		736	(729)
Shyrna lewini	0		0		920	(920)	920	(920)
Trichiurus lepturus	2	(0)	13	(2)	615	(161)	630	(163)
*Brachyplatystoma filamentosum**	53	(53)	0		0		53	(53)
*Cynoscion acoupa**	67	(67)	339	(339)	71	(71)	477	(477)
*Plagioscion squamosissimus**	157	(148)	0		0		157	(148)
All of other fish species	1,421	(1,044)	1,346	(819)	1,334	(862)	4,101	(2,725)
Total	26,729	(23,635)	18,393	(14,274)	11,593	(7,702)	56,715	(45,611)

* Key fish species.

(C)

Top 10 ranked species of fish	Stock size in tonnes							
	Stratum (isobath range in m)						Total	
	5 - 10		10 - 20		20 - 50			
Arius couma	798	(791)	89	(89)	0		887	(880)
A. grandicassis	7,124	(7,117)	9,056	(9,037)	1,615	(1,613)	17,795	(17,767)
*A. parkeri**	2,363	(2,360)	2,813	(2,810)	648	(648)	5,824	(5,818)
A. proops	442	(440)	116	(115)	0		558	(555)
A. quadriscutis	2,967	(2,917)	13,552	(13,416)	884	(879)	17,403	(17,212)
A. rugispinis	1,146	(1,140)	5,445	(5,399)	41	(41)	6,632	(6,580)
Bagre bagre	347	(249)	831	(532)	164	(62)	1,342	(843)
*Brachyplatystoma flavicans**	2,336	(2,312)	246	(246)	0		2,582	(2,558)
*B. vaillantii**	3,648	(3,254)	75	(72)	0		3,723	(3,326)
Carcharhinus porosus	0		171	(171)	1,188	(1,188)	1,359	(1,359)
*Cynoscion acoupa**	349	(349)	790	(790)	140	(140)	1,279	(1,279)
C. virescens	394	(394)	2,498	(2,498)	598	(591)	3,490	(3,483)
*Macrodon ancylodon**	182	(28)	3,586	(256)	991	(144)	4,759	(428)
Micropogonias furnieri	64	(64)	240	(240)	469	(469)	773	(773)
Nebris microps	71	(58)	1,265	(1,079)	124	(97)	1,460	(1,234)
Sphyrna tudes	19	(19)	334	(334)	409	(409)	762	(762)
Stellifer rastrifer	24	(2)	1,404	(122)	50	(7)	1,478	(31)
Trichiurus lepturus	0		151	(105)	202	(168)	353	(273)
*Brachyplatystoma filamentosum**	7	(7)	0		0		7	(7)
*Plagioscion squamosissimus**	43	(40)	0		0		43	(40)
All of other fish species	1,041	(781)	1,430	(735)	667	(444)	3,138	(1,960)
Total	23,315	(22,322)	44,092	(38,046)	8,190	(6,900)	75,597	(67,268)

* Key fish species.

5.1.4. Distribution of CPUA and Stock Size of Key Fish Species

(a) Piramutaba *Brachyplatystoma vaillantii*

a-1) Distribution of CPUA

Distribution of CPUA for piramutaba in the seasons under survey is given in Figure 15. This species was found to be mainly distributed in the 5–10 m stratum in both Dry and Rainy Seasons, more widely in the Rainy Season. High values of CPUA were distributed in the offshore areas of the Northern Channel of the Amazon River (10–20 m stratum) and of the Santa Rosa Sandbank (5–10 m stratum). Piramutaba was not found in water depths below 20 m.

(A)

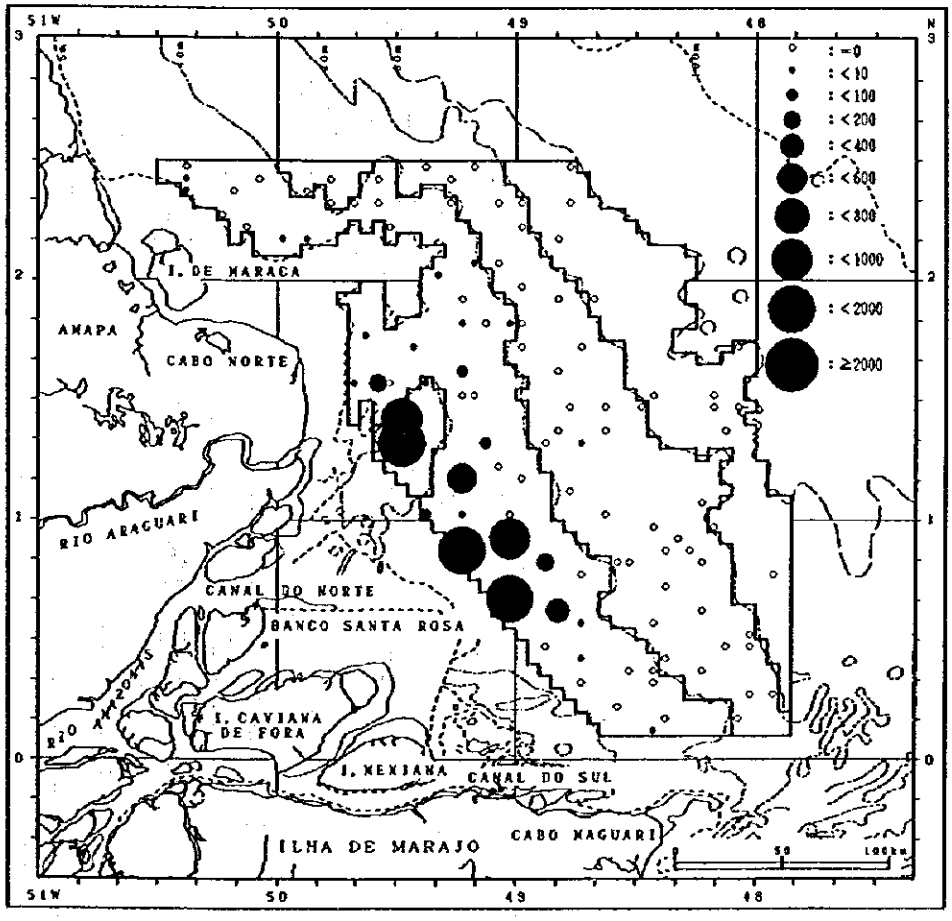
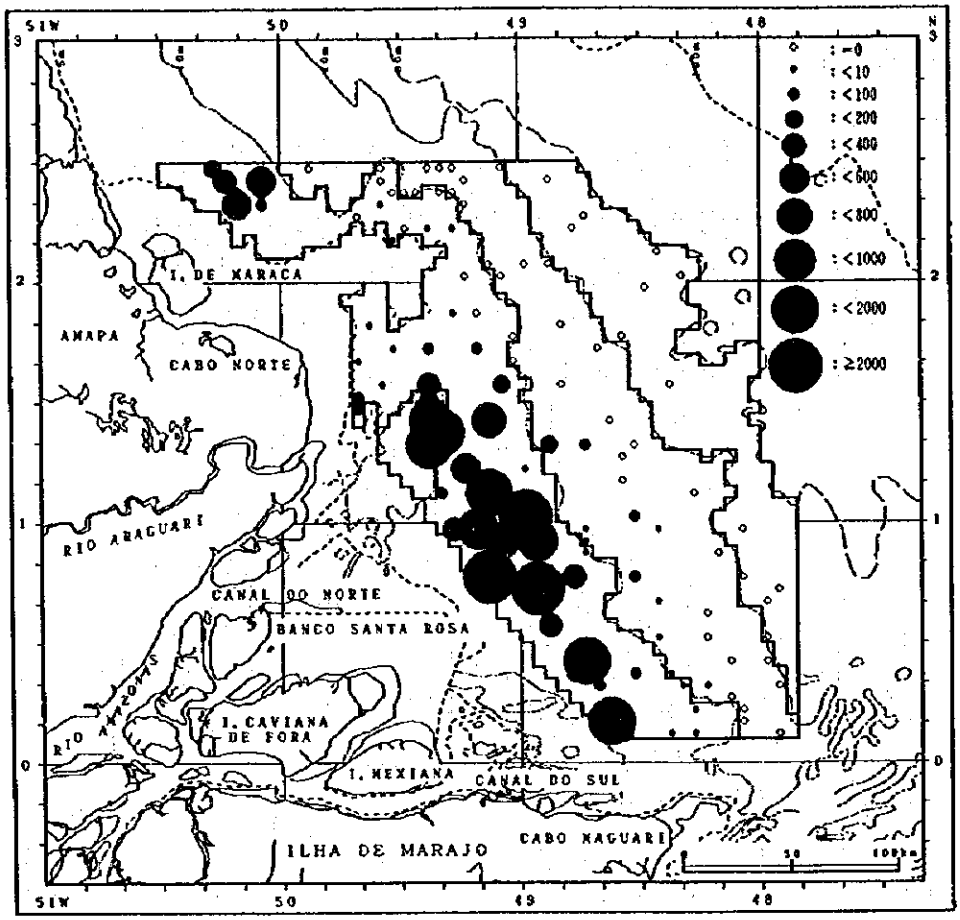


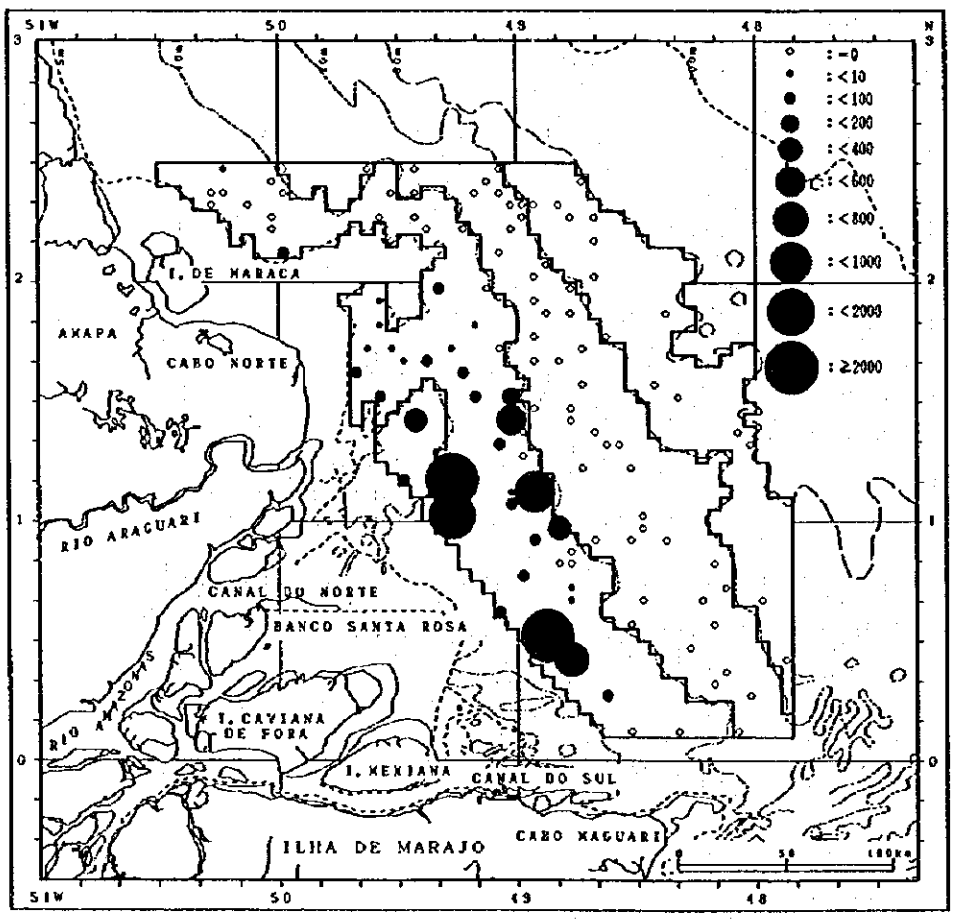
Figure 15. Distribution of CPUA for Piramutaba *Brachyplatystoma vaillantii*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 15. Continued

(B)



(C)



a-2) CPUA by stratum and water mass region

Table 19 shows CPUA values for piramutaba by stratum and water mass region.

i) CPUA by stratum

The mean CPUA by stratum was higher in the 5–10 m stratum, being extremely high except in the Phase 1 Dry Season. In that stratum, the mean CPUA was higher in the Rainy Season (684) than in both Dry Seasons (88 and 212, respectively). The highest CPUA value found in all surveys was 10,239 in the 5–10 m stratum during the Rainy Season. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was above 80% in the survey.

ii) CPUA by water mass region

As for the water mass region, the mean CPUA was considerably higher in river waters in all seasons, with the values of 618, 1,163 and 1,181 respectively in survey order. The highest CPUA value was recorded in brackish waters; piramutaba, however, was not found in ocean waters. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was above 80% in the survey.

Table 19. CPUA for Piramutaba *Brachyplatystoma vaillantii*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters. Mean CPUA in parentheses obtained from catch in cod-end.

(A)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	87.8 (78.0)	52.9 (41.2)	0	618.0 (497.3)	27.8 (26.5)	0
Standard deviation	263.6	260.4	-	637.5	128.4	-
Range	0 - 1,269.0	0 - 1,541.5	-	0 - 1,541.5	0 - 928.7	-

(B)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	684.3 (623.7)	94.9 (90.6)	0	1,162.7 (1,045.2)	264.0 (246.3)	0
Standard deviation	1,875.7	308.6	-	1,487.3	1,374.1	-
Range	0 - 10,238.5	0 - 1,493.0	-	15.8 - 6,643.9	0 - 10,238.5	-

(C)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	212.1 (189.2)	4.8 (4.6)	0	1,181.0 (1,040.2)	31.1 (29.3)	0
Standard deviation	723.6	29.5	-	1,619.9	123.2	-
Range	0 - 4,610.3	0 - 206.8	-	28.8 - 4,610.3	0 - 945.1	-

a-3) Relationship between bottom salinity and CPUA

Figure 16 illustrates the relationship between the salinity of the bottom layer and CPUA. Data on trawl stations where piramutaba was not caught are omitted. (So are heretofore those for other key fish

species in the same situation.) CPUA values were scattered within the 0–33 psu limits: high values (above 1,000) were generally found below 10 psu, and the above-mentioned highest value was registered around 25 psu.

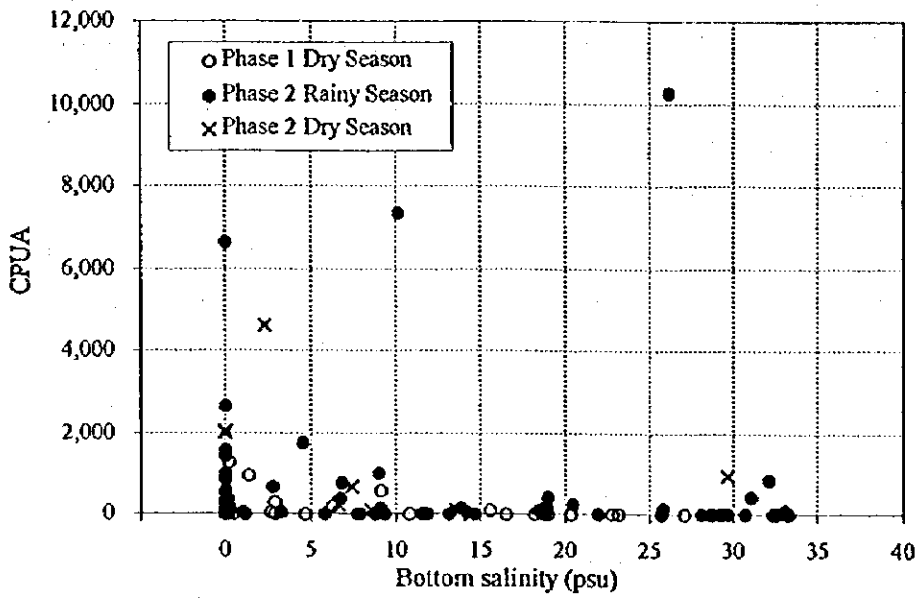


Figure 16. Relationship between bottom salinity and CPUA for Piramutaba *Brachyplatystoma vaillantii.*

a-4) Stock size

Estimates of the stock sizes of piramutaba are shown in Table 20. The estimate of the total stock size was as follows: 2,341 tonnes for Phase 1 Dry Season, with a 95% confidence interval of ± 1,962 tonnes (coefficient of variation CV = 37%); 13,260 tonnes for Phase 2 Rainy Season, with a 95% confidence interval of ± 9,980 tonnes (CV = 33%); and 3,723 tonnes for Phase 2 Dry Season, with a 95% confidence interval of ± 3,764 tonnes (CV = 45%). The stock size for each survey in the 5–10 m stratum was respectively 65%, 89% and 98% of the total stock size.

The stock size in the Phase 2 Rainy Season was about 10,000 tonnes larger than for both Dry Seasons. It is thought this is due to the fact that the river waters spread out widely into the offshore in the Rainy Season, and narrowly in the Dry Seasons. Considering the precision of the estimates (95% confidence interval and CV), the difference in the estimates is not significant. On the other hand, the stock size in the Phase 2 Dry Season was some 1,400 tonnes larger than in the Phase 1 Dry Season. However, the low precision of these estimates (95% confidence interval and CV) does not allow one to conclude there was an actual increase in a one-year period.

The ratio of the stock size obtained from catch in cod-end to the total stock size was quite high in all seasonal surveys — respectively, 85%, 92% and 89%.

Table 20. Stock size estimates of Piramutaba *Brachyplatystoma vaillantii*. Stock size in parentheses obtained from catch in cod-end.

Stratum (isobath range in m)	Area in km²	Stock size in tonnes					
		Phase					
		1		2			
		Dry Season		Rainy Season		Dry Season	
5 - 10	17,200	1,510	(1,342)	11,770	(10,728)	3,648	(3,254)
10 - 20	15,700	831	(647)	1,490	(1,422)	75	(72)
20 - 50	9,300	0		0		0	
Total	42,200	2,341	(1,989)	13,260	(12,150)	3,723	(3,326)
95% confidence interval		±1,962	(±1,659)	±9,980	(±9,584)	±3,764	(±3,422)

(b) Dourada *Brachyplatystoma flavicans*

b-1) Distribution of CPUA

Distribution of CPUA for dourada is given in Figure 17. Dourada was found to be mainly distributed in the 5–10 m stratum in both Dry and Rainy Seasons, somewhat wider in the Rainy Season. It was not recorded from water depths below 20 m.

(A)

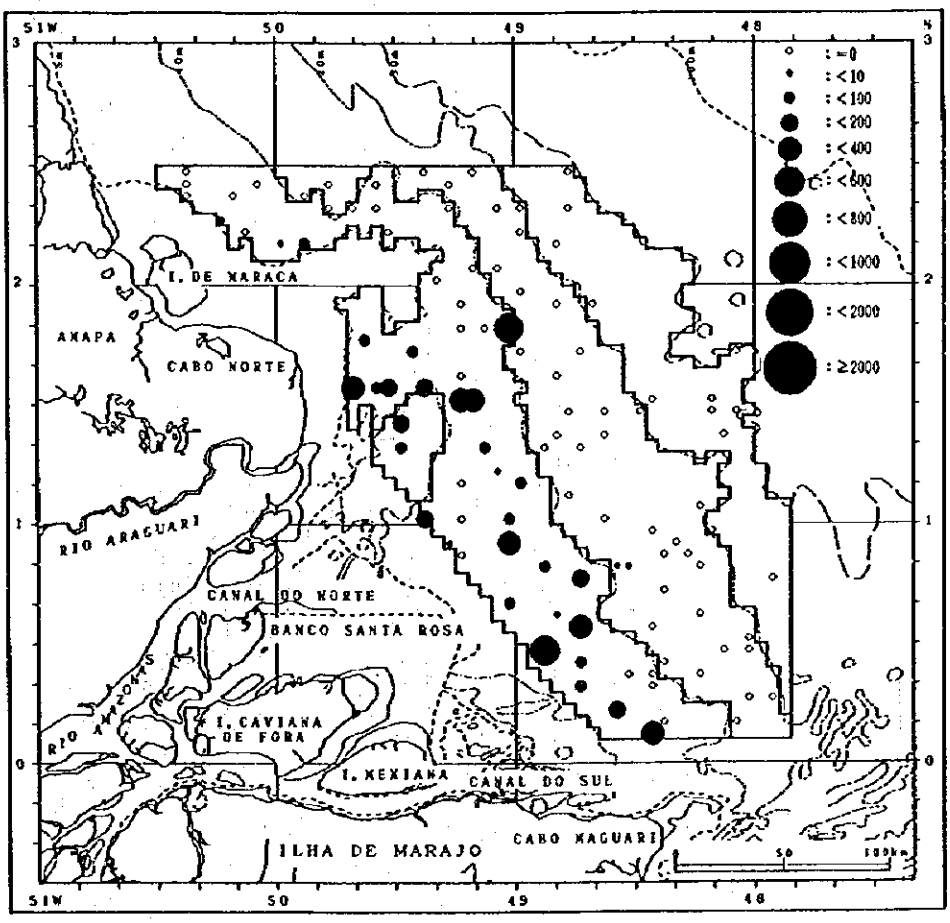
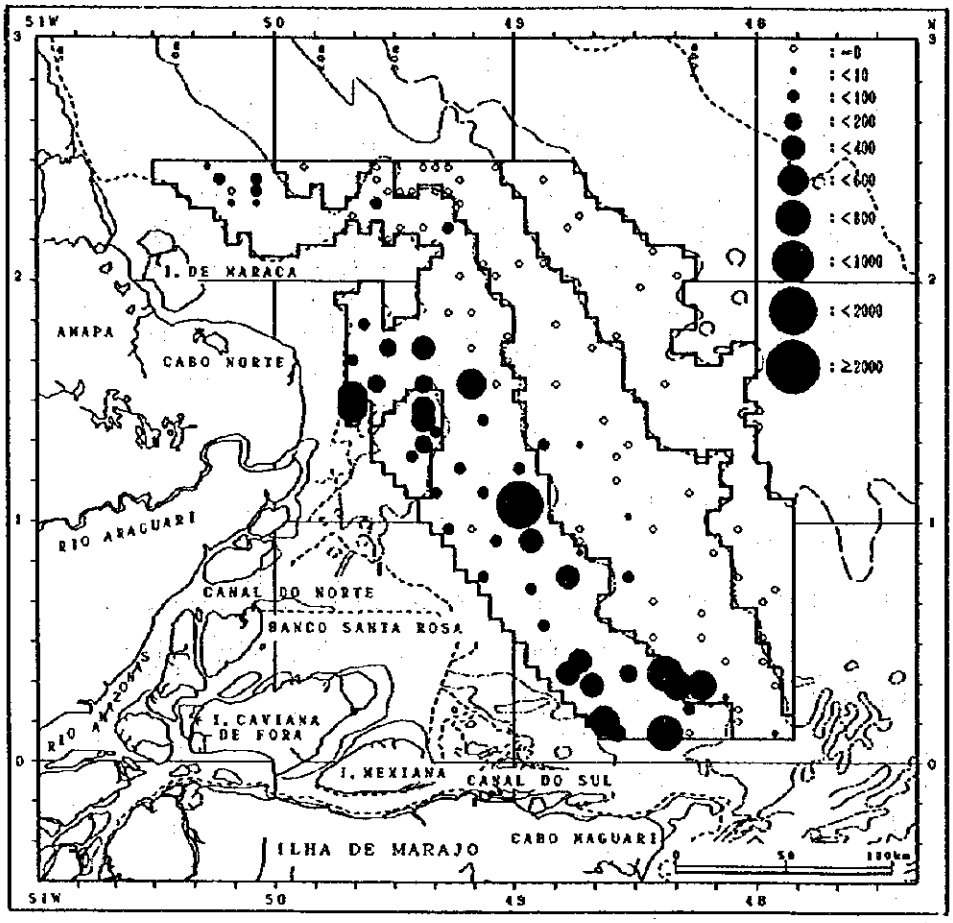


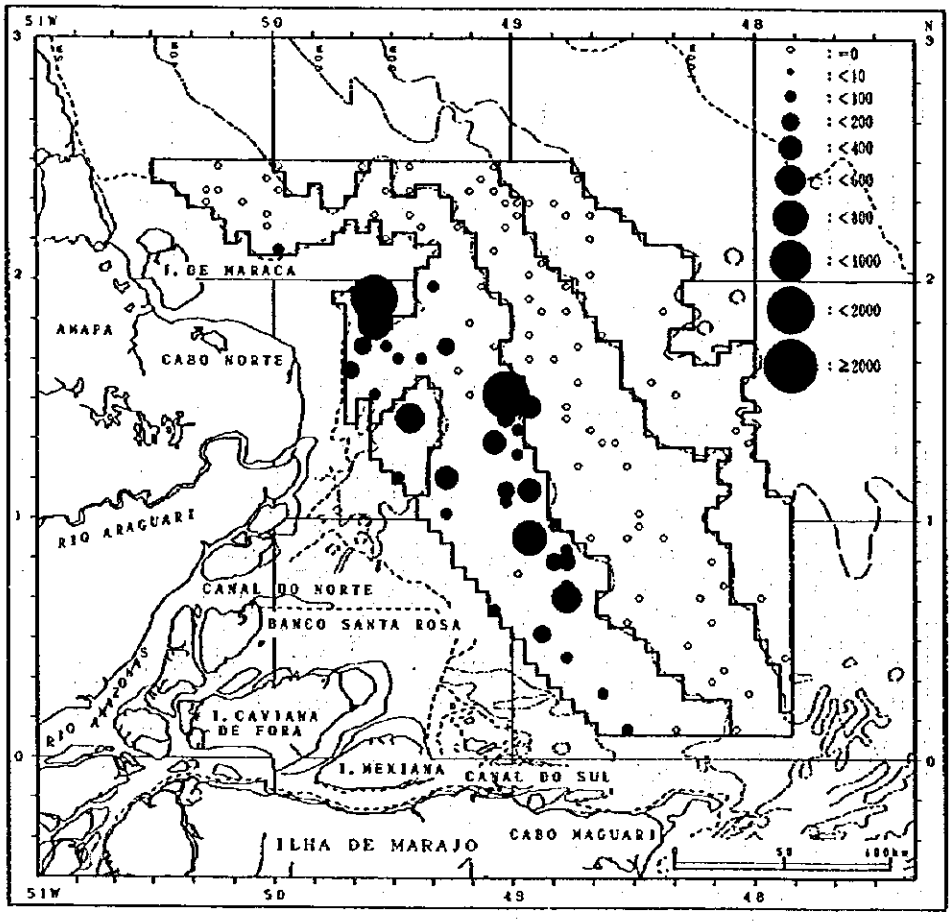
Figure 17. Distribution of CPUA for Dourada *Brachyplatystoma flavicans*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 17. Continued

(B)



(C)



b-2) CPUA by stratum and water mass region

Table 21 shows CPUA values for dourada by stratum and water mass region.

i) CPUA by stratum

The mean CPUA by stratum was quite high in the 5–10 m stratum in all seasonal surveys. In that stratum, the mean CPUA was higher in the Rainy Season (150) than in both Dry Seasons (68 and 136, respectively). The highest CPUA value found in all surveys was 1,898 in the 5–10 m stratum during the Rainy Season. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was above 95% in the survey.

ii) CPUA by water mass region

Except for the Phase 1 Dry Season, the mean CPUA by water mass region was higher in river waters: in that season, it was slightly higher in brackish waters than in river waters. The mean CPUA in river waters showed increasing values of 44, 137, 160 respectively in survey order. The highest CPUA value was recorded in brackish waters; dourada, however, was absent from ocean waters. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was above 90% in the survey.

Table 21. CPUA for Dourada *Brachyplatystoma flavicans*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters. Mean CPUA in parentheses obtained from catch in cod-end.

(A)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	67.7 (64.2)	6.8 (6.6)	0	43.6 (40.3)	45.9 (43.8)	0
Standard deviation	124.2	29.4	-	48.9	108.0	-
Range	0 - 541.9	0 - 168.4	-	0 - 128.0	0 - 541.9	-

(B)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	149.8 (148.0)	44.8 (44.6)	0	136.9 (136.2)	98.9 (97.7)	0
Standard deviation	292.9	127.3	-	144.0	256.3	-
Range	0 - 1,898.0	0 - 663.7	-	0 - 400.0	0 - 1,898.0	-

(C)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	135.8 (134.4)	15.7 (15.7)	0	160.0 (156.3)	88.3 (87.7)	0
Standard deviation	289.6	75.0	-	229.2	244.0	-
Range	0 - 1,609.6	0 - 420.7	-	0 - 689.0	0 - 1,609.6	-

b-3) Relationship between bottom salinity and CPUA

Figure 18 illustrates the relationship between the salinity of the bottom layer and CPUA. CPUA values were scattered within the 0–33 psu range: the above-mentioned highest value was registered around 10 psu.

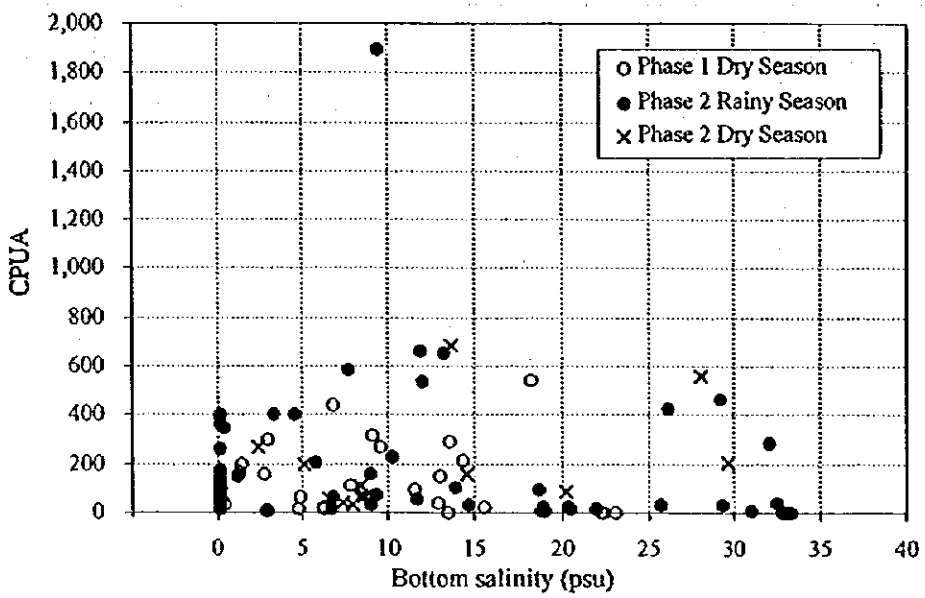


Figure 18. Relationship between bottom salinity and CPUA for Dourada *Brachyplatystoma flavicans*.

b-4) Stock size

Estimates of the stock sizes of dourada are shown in Table 22. The estimate of the total stock size was as follows: 1,271 tonnes for Phase 1 Dry Season, with a 95% confidence interval of ± 730 tonnes (CV = 24%); 3,280 tonnes for Phase 2 Rainy Season, with a 95% confidence interval of ± 1,684 tonnes (CV = 22%); and 2,582 tonnes for Phase 2 Dry Season, with a 95% confidence interval of ± 1,587 tonnes (CV = 27%). The stock size for each survey in the 5–10 m stratum was respectively 95%, 99% and 99% of the total stock size.

The stock size in the Phase 2 Rainy Season was about 2,000 tonnes larger than in the previous Dry Season and 700 tonnes greater than in the following one. This difference is thought to be due to the seasonal difference in the spreading out of river waters into the offshore in different seasons. Also, the stock size in the Phase 2 Dry Season was some 1,300 tonnes larger than in the Phase 1 Dry Season. However, the low precision of these estimates (95% confidence interval and CV) prevents one from jumping into any conclusion of increase.

The ratio of the stock size obtained from catch in cod-end to the total stock size was quite high in all seasonal surveys — respectively, 95%, 99% and 99%.

Table 22. Stock size estimates of Dourada *Brachyplatystoma flavicans*. Stock size in parentheses obtained from catch in cod-end.

Stratum (isobath range in m)	Area in km^2	Stock size in tonnes					
		Phase					
		1		2			
		Dry Season		Rainy Season		Dry Season	
5 - 10	17,200	1,164	(1,104)	2,577	(2,546)	2,336	(2,312)
10 - 20	15,700	107	(104)	703	(700)	246	(246)
20 - 50	9,300	0		0		0	
Total	42,200	1,271	(1,208)	3,280	(3,246)	2,582	(2,558)
95% confidence interval		±730	(±701)	±1,684	(±1,684)	±1,587	(±1,578)

(c) Filhote *Brachyplatystoma filamentosum*

c-1) Distribution of CPUA

Distribution of CPUA for filhote is given in Figure 19. In comparison with the two previously mentioned catfishes, filhote was sparsely distributed in a narrower range, and CPUA was low. It was not found to be distributed in water depths below 20 m.

(A)

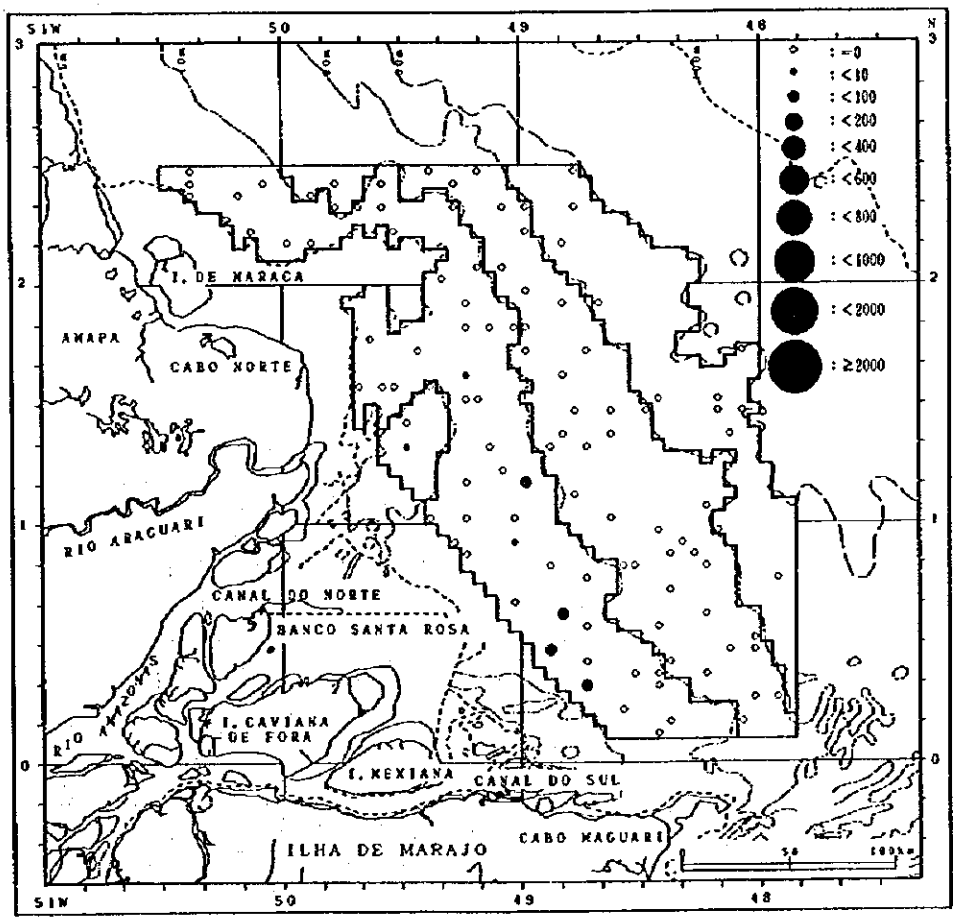
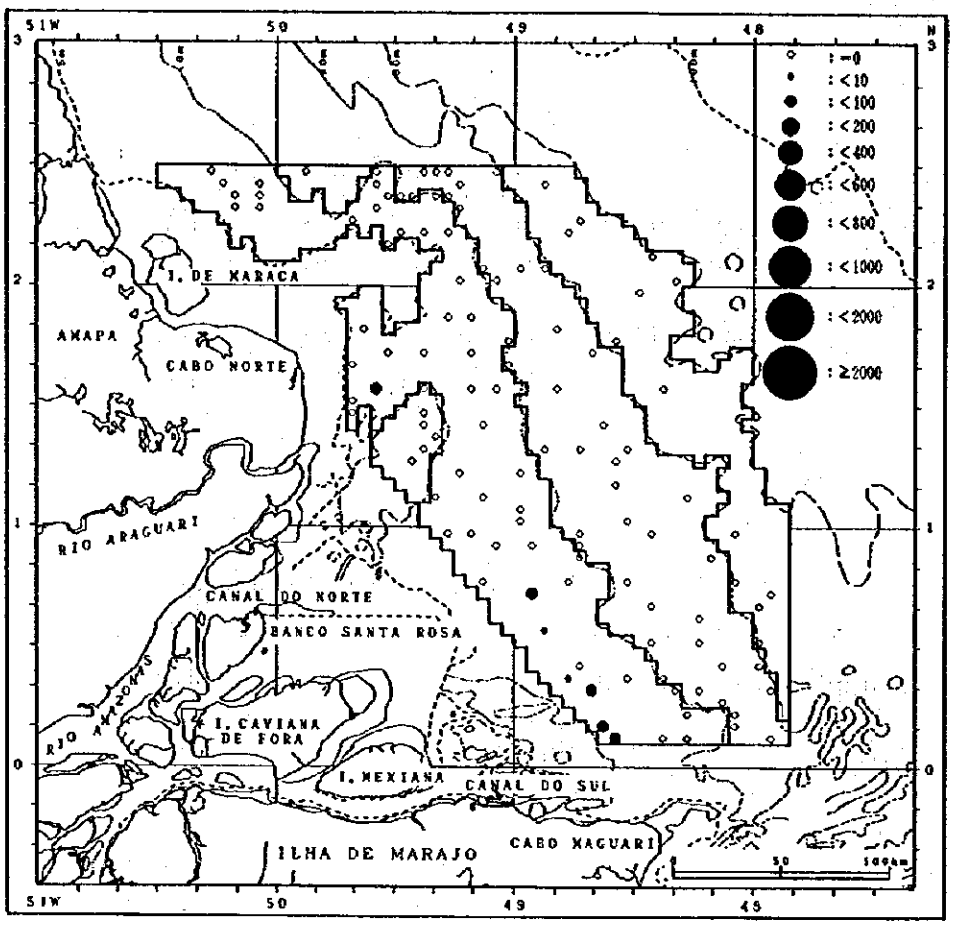


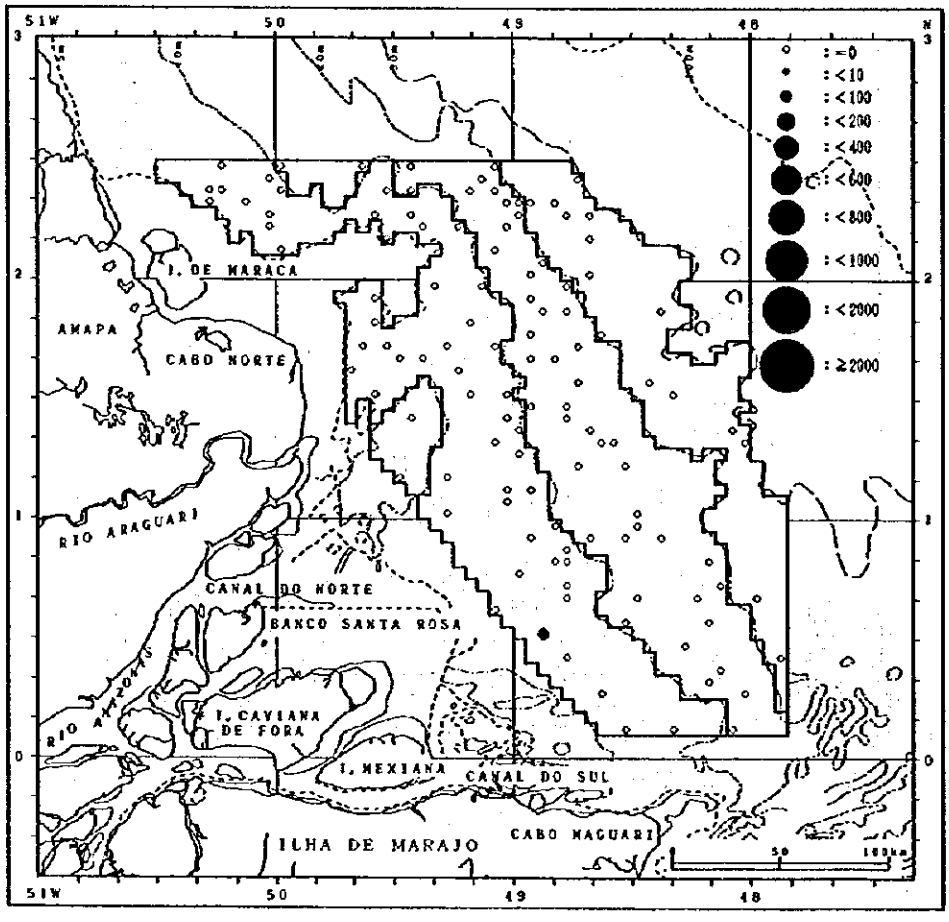
Figure 19. Distribution of CPUA for Filhote *Brachyplatystoma filamentosum*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 19. Continued

(B)



(C)



c-2) CPUA by stratum and water mass region

Table 23 shows CPUA values for dourada by stratum and water mass region.

i) CPUA by stratum

The Mean CPUA by stratum was 0.4–3 in the 5–10 m stratum, 0–0.1 in the 10–20 m stratum, both exceedingly low. The highest CPUA value overall was a low 51 recorded in the 5–10 m stratum, during the Phase 2 Rainy Season Survey.

ii) CPUA by water mass region

The mean CPUA by water mass region remained within the 0.3–4 range, and was very low. The highest value mentioned above was registered in river waters. Filhote was found not to occur in ocean waters.

Table 23. CPUA for Filhote *Brachyplatystoma filamentosum*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters. Mean CPUA in parentheses obtained from catch in cod-end.

(A)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	1.7 (1.3)	0.1 (0)	0	0.3 (0)	1.2 (0.9)	0
Standard deviation	6.9	0.4	-	0.9	5.7	-
Range	0 - 44.9	0 - 2.5	-	0 - 2.5	0 - 44.9	-

(B)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	3.1 (3.1)	0	0	3.9 (3.8)	1.2 (1.2)	0
Standard deviation	10.1	-	-	11.8	6.3	-
Range	0 - 50.9	-	-	0 - 50.9	0 - 40.3	-

(C)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	0.4 (0.4)	0	0	2.4 (2.4)	0	0
Standard deviation	2.6	-	-	6.9	-	-
Range	0 - 19.4	-	-	0 - 19.4	-	-

c-3) Relationship between bottom salinity and CPUA

Figure 20 illustrates the relationship between the salinity of the bottom layer and CPUA. In contrast to the previous two catfishes, filhote had CPUA values scattered within a narrow salinity range of 0–15 psu.

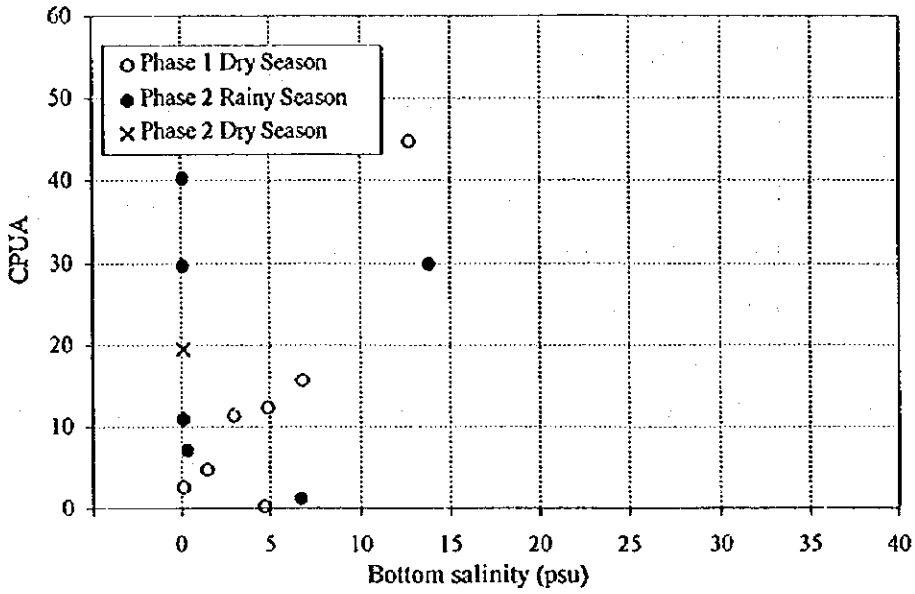


Figure 20. Relationship between bottom salinity and CPUA for Filhote *Brachyplatystoma filamentosum.*

c-4) Stock size

Estimates of the stock sizes of filhote are shown in Table 24. The estimate of the total stock size was, respectively in seasonal survey order, 31, 53 and 7 tonnes; a 95% confidence interval yielded values of, respectively, ± 38, ± 55 and ± 13 tonnes; CV values were, respectively, 53%, 44% and 87%. In the 5–10 m stratum, the seasonal stock size was respectively 76%, 100% and 100% of the total stock size.

The stock size in the Phase 2 Rainy Season was about 20 tonnes larger than in the previous Dry Season and 50 tonnes greater than in the next one. Also, the stock size in the Phase 2 Dry Season was some 20 tonnes larger than in the Phase 1 Dry Season. Considering the precision of the estimates (95% confidence interval and CV), the difference is not significant.

The ratio of the stock size obtained from catch in the cod-end to the total stock size was around 70–100%.

Table 24. Stock size estimates of Filhote *Brachyplatystoma filamentosum.* Stock size in parentheses obtained from catch in cod-end.

Stratum (isobath range in m)	Area in km^2	Stock size in tonnes					
		Phase					
		1		2			
		Dry Season		Rainy Season		Dry Season	
5 - 10	17,200	29	(22)	53	(53)	7	(7)
10 - 20	15,700	2	(0)	0		0	
20 - 50	9,300	0		0		0	
Total	42,200	31	(22)	53	(53)	7	(7)
95% confidence interval		±38	(±34)	±55	(±55)	±13	(±13)

(d) Pescada branca *Plagioscion squamosissimus*

d-1) Distribution of CPUA

Distribution of CPUA for pescada branca is given in Figure 21. This species was found to be sparsely distributed in the offshore area of the Northern Channel of the Amazon River in the Phase 1 Dry Season, but in both Phase 2 Rainy and Dry Seasons it presented a wider distribution range. Except for a single instance in the Phase 1 Dry Season, pescada branca was not found in water depths below 10 m.

(A)

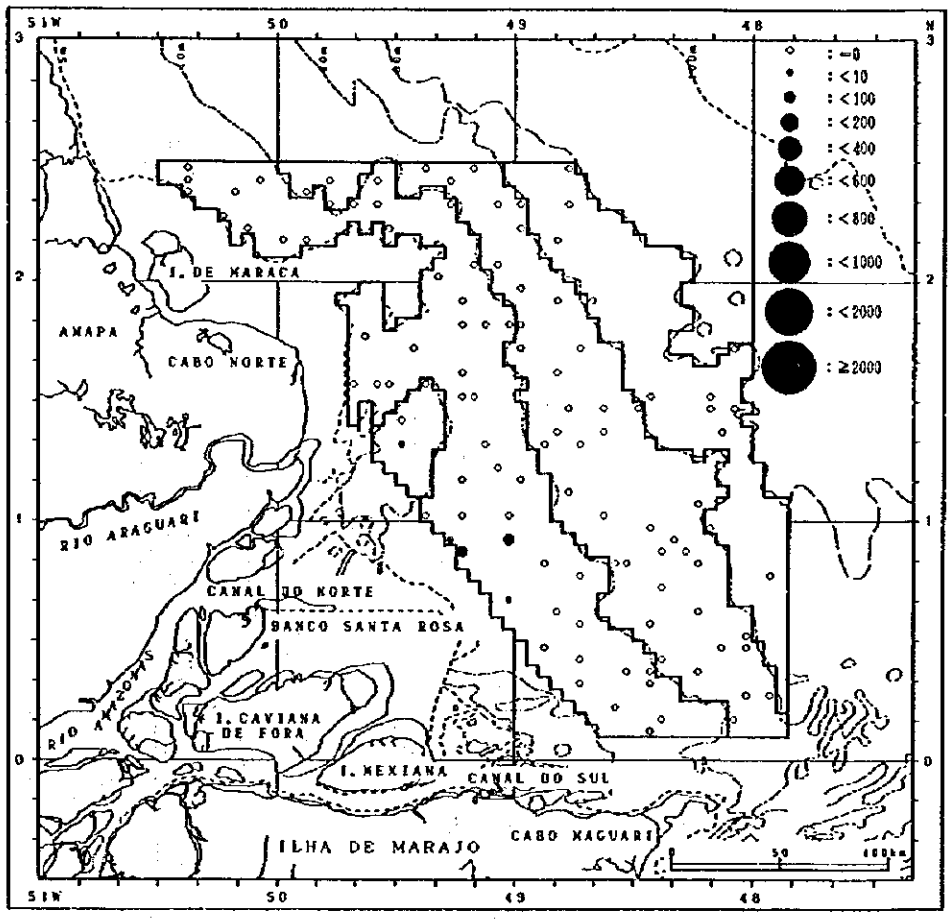
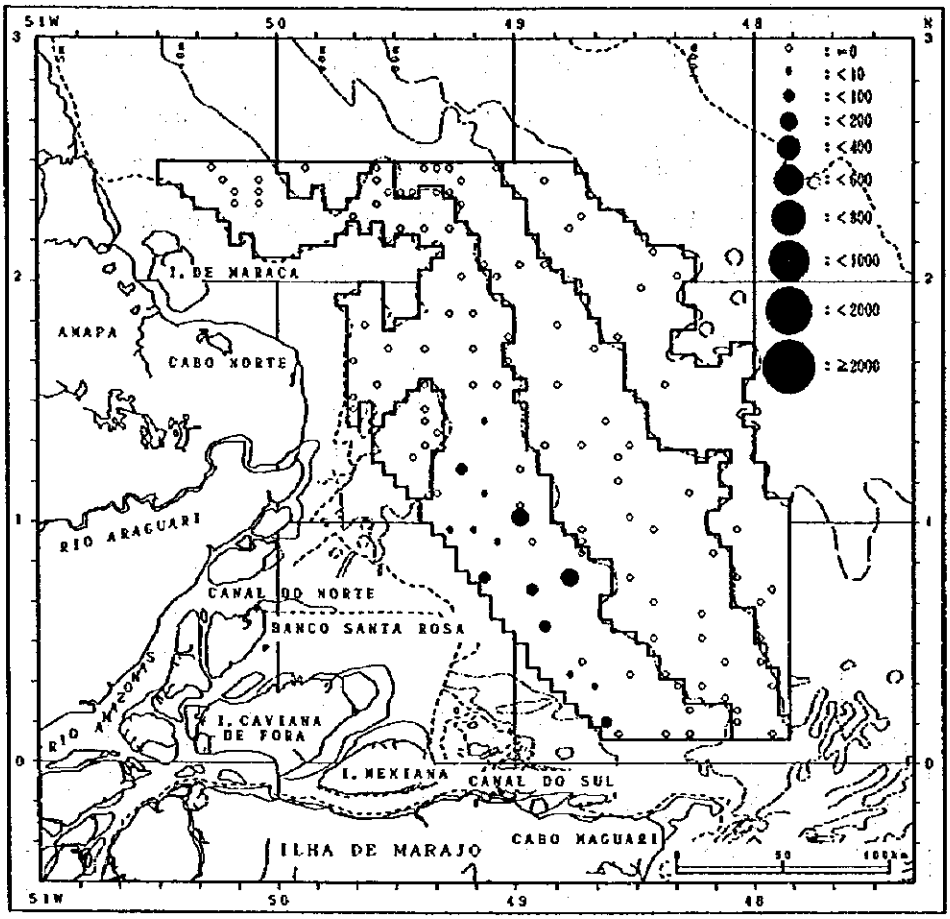


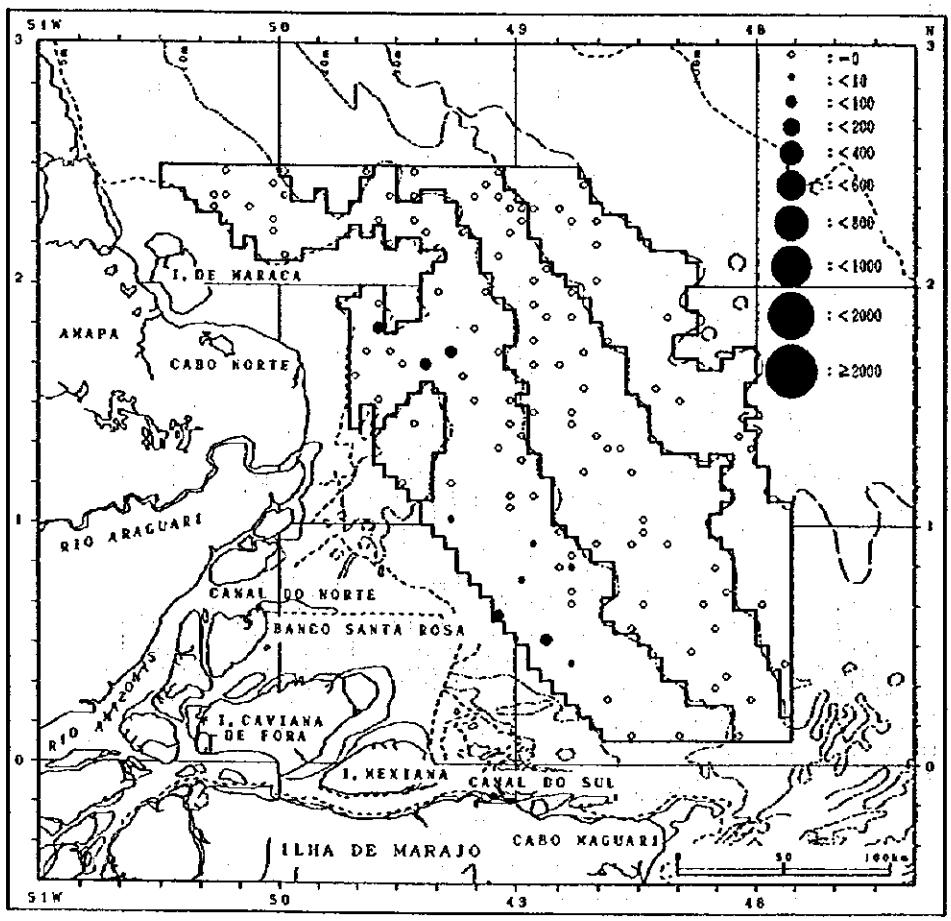
Figure 21. Distribution of CPUA for Pescada branca *Plagioscion squamosissimus*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 21. Continued

(B)



(C)



d-2) CPUA by stratum and water mass region

Table 25 shows CPUA values for pescada branca by stratum and water mass region.

i) CPUA by stratum

The mean CPUA in the 5–10 m stratum was higher in the Rainy Season (9) than in the Dry Seasons (1 and 3, respectively). In the 10–20 m stratum (Phase 1 Dry Season Survey), the mean CPUA was lower than 0.1. The highest CPUA (128) was recorded in the 5–10 m stratum during the Rainy Season. All CPUA values were quite low. In the 5–10 m stratum, the ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was above 90% in the survey.

ii) CPUA by water mass region

In all seasons, the mean CPUA by water mass region was higher in river waters than in brackish waters, and in both water mass regions that value was higher in the Rainy Season (river, 14; brackish, 3) than in the Dry Seasons (river, 5; brackish, 0.3–1). The highest CPUA value (128) was registered in brackish waters. Pescada branca was found not to occur in ocean waters. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was about about 80–100%.

Table 25. CPUA for Pescada branca *Plagioscion squamosissimus*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters. Mean CPUA in parentheses obtained from catch in cod-end.

(A)

CPUA	Stratum (isobath range in m)			Water mass				
	5-10	10-20	20-50	RW		BW		OW
Mean	1.2 (1.1)	0 (0)	0	5.0	(4.5)	0.3	(0.3)	0
Standard deviation	5.6	0.03	-	11.4		2.8		-
Range	0 - 32.5	0 - 0.2	-	0 - 32.5		0 - 24.3		-

(B)

CPUA	Stratum (isobath range in m)			Water mass				
	5-10	10-20	20-50	RW		BW		OW
Mean	9.1 (8.6)	0	0	14.4	(13.7)	2.9	(2.8)	0
Standard deviation	25.5	-	-	23.4		17.8		-
Range	0 - 128.0	-	-	0 - 66.9		0 - 128.0		-

(C)

CPUA	Stratum (isobath range in m)			Water mass				
	5-10	10-20	20-50	RW		BW		OW
Mean	2.5 (2.3)	0	0	5.3	(4.4)	1.2	(1.2)	0
Standard deviation	7.9	-	-	9.2		6.0		-
Range	0 - 40.0	-	-	0 - 25.8		0 - 40.0		-

d-3) Relationship between bottom salinity and CPUA

Figure 22 illustrates the relationship between the salinity of the bottom layer and CPUA. CPUA values were scattered within the 0–15 psu range: values above 50 (all in the Rainy Season) were generally found below 5 psu, and the above-mentioned highest value (128) was recorded in brackish waters greatly influenced by river waters (i.e., freshwater) where salinity was near 0 psu.

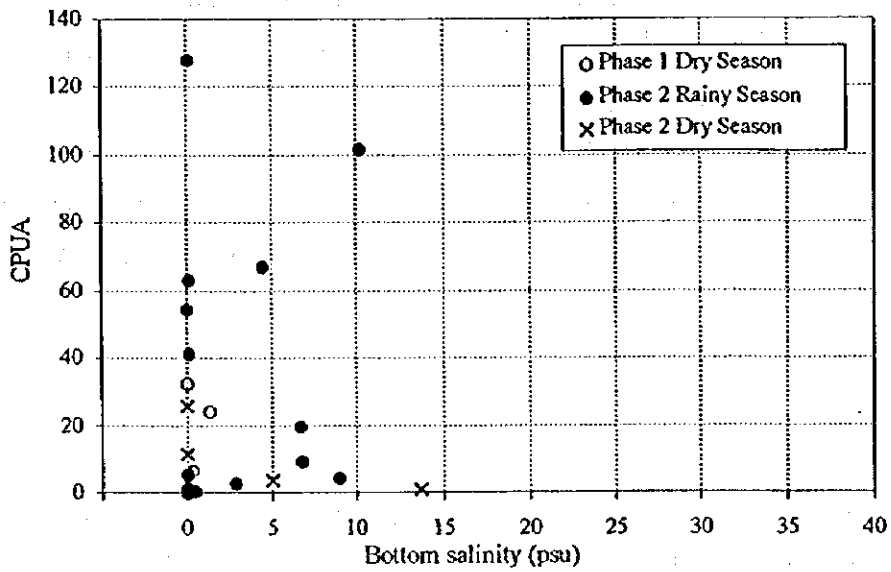


Figure 22. Relationship between bottom salinity and CPUA for Pescada branca *Plagioscion squamosissimus*.

d-4) Stock size

Estimates of the stock sizes of pescada branca are shown in Table 26. The estimate of the total stock size was as follows: 21 tonnes for Phase 1 Dry Season, with a 95% confidence interval of ± 30 tonnes (CV = 65%); 157 tonnes for Phase 2 Rainy Season, with a 95% confidence interval of ± 135 tonnes (CV = 38%); and 43 tonnes for Phase 2 Dry Season, with a 95% confidence interval of ± 42 tonnes (CV = 43%). Those stock sizes were existed in the 5–10 m stratum.

The stock size in the Phase 2 Rainy Season was about 130 tonnes larger than in the previous Dry Season and 110 tonnes greater than in the following one. This is thought to be due to the seasonal difference in the spreading out of river waters into the offshore in different seasons. Also, the stock size in both Dry Seasons differed in about 20 tonnes. Considering the precision of the estimates, the difference is not significant.

Table 26. Stock size estimates of Pescada branca *Plagioscion squamosissimus*. Stock size in parentheses obtained from catch in cod-end.

Stratum (isobath range in m)	Area in km^2	Stock size in tonnes					
		Phase					
		1		2			
		Dry Season		Rainy Season		Dry Season	
5 - 10	17,200	21	(19)	157	(148)	43	(40)
10 - 20	15,700	0		0		0	
20 - 50	9,300	0		0		0	
Total	42,200	21	(19)	157	(148)	43	(40)
95% confidence interval		±30	(±30)	±135	(±135)	±42	(±42)

(e) Pescada amarela *Cynoscion acoupa*

e-1) Distribution of CPUA

Distribution of CPUA for pescada amarela is given in Figure 23. This species was found scattered in the entire survey area. This distribution tended to be more dense as the survey continued, being particularly concentrated north of 2° N, between longitudes 49°00'W and 49°40'W, in both seasons of Phase 2.

(A)

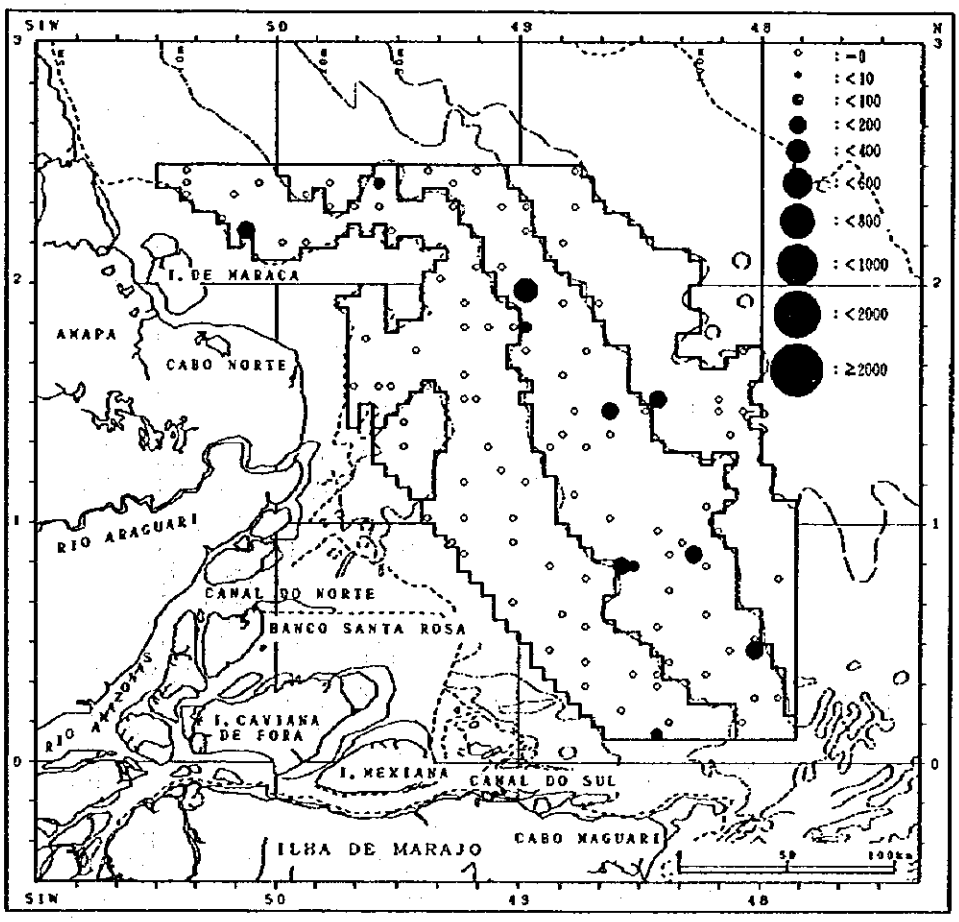
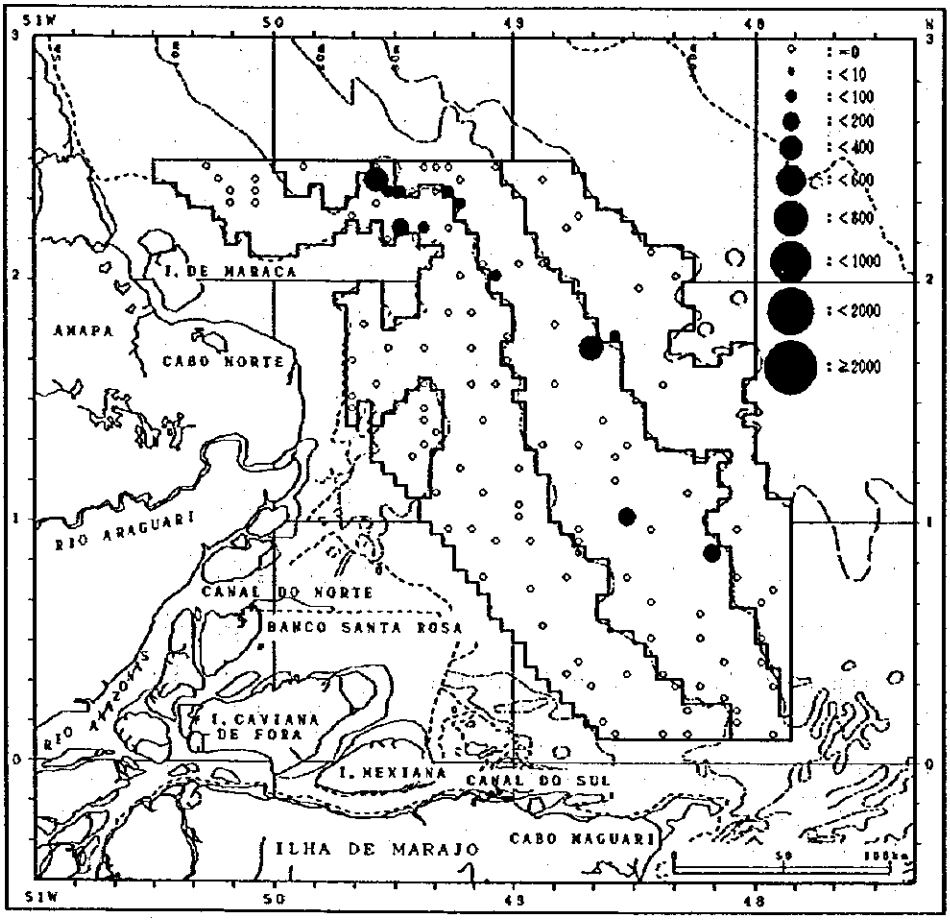


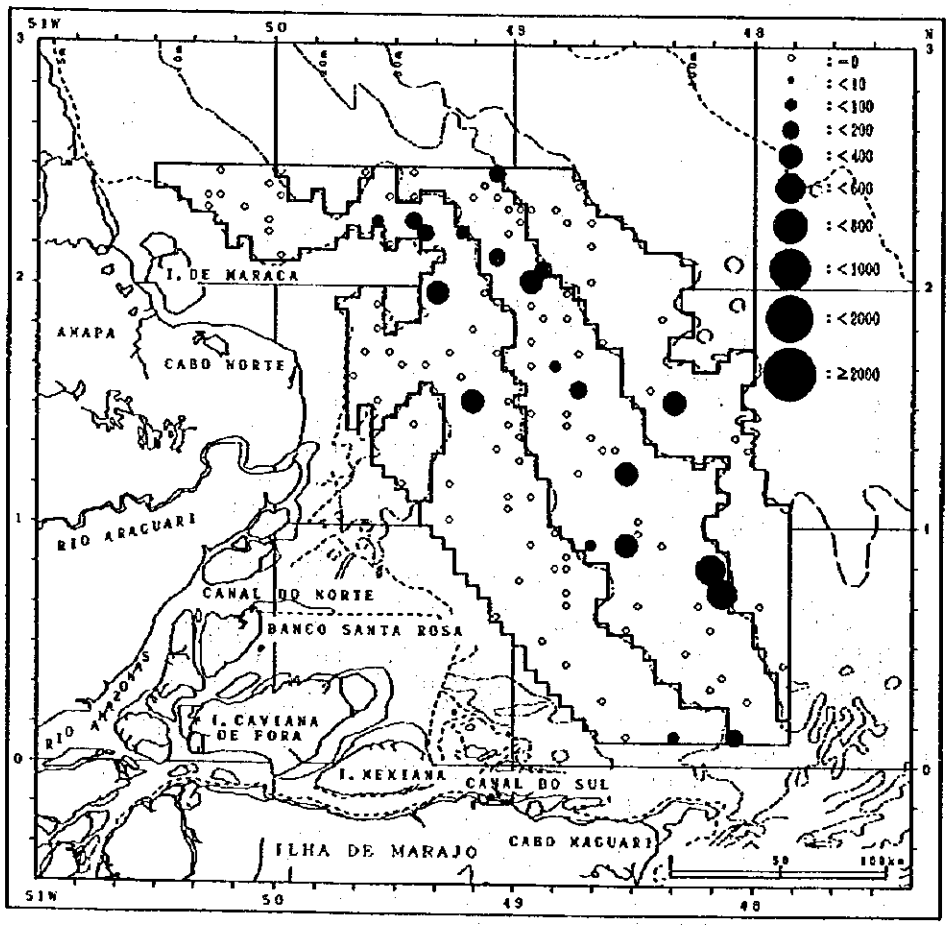
Figure 23. Distribution of CPUA for Pescada amarela *Cynoscion acoupa*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 23. Continued

(B)



(C)



e-2) CPUA by stratum and water mass region

Table 27 shows CPUA values for pescada amarela by stratum and water mass region.

i) CPUA by stratum

The mean CPUA was high in all seasons in the 10–20 m stratum. On the other hand, except for the 20–50 m stratum, the mean CPUA increased in survey order: its values were 4, 4, 20 for the 5–10 m stratum, and 18, 22, 50 for the 10–20 m stratum. For the 20–50 m stratum, however, the CPUA order was 15, 8, 15. The highest CPUA (536) was recorded in the 10–20 m stratum during the Phase 2 Dry Season Survey. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was 100%— except for one instance in 10–20 m stratum during the Phase 1 Dry Season Survey, when it was 93%.

ii) CPUA by water mass region

Pescada amarela was not found to occur in river waters. In all seasons, the mean CPUA by water mass region was higher in ocean waters (19, 19, 62 in season order) than in brackish waters (10, 13, 23), and in both water mass regions that value increased in survey order. The highest CPUA (536) was registered in ocean waters. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was 100% — except for one instance in brackish waters in the Phase 1 Dry Season Survey, when it was 93%.

Table 27. CPUA for Pescada amarela *Cynoscion acoupa*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters. Mean CPUA in parentheses obtained from catch in cod-end.

(A)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	3.7 (3.7)	18.4 (17.1)	15.4 (15.4)	0	9.5 (8.8)	19.3 (19.3)
Standard deviation	19.9	48.5	51.1	-	36.8	47.2
Range	0 - 139.8	0 - 237.7	0 - 169.6	-	0 - 237.7	0 - 169.6

(B)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	3.9 (3.9)	21.6 (21.6)	7.6 (7.6)	0	12.8 (12.8)	19.4 (19.4)
Standard deviation	18.7	61.1	26.5	-	41.5	65.5
Range	0 - 118.5	0 - 289.1	0 - 99.4	-	0 - 268.8	0 - 289.1

(C)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	20.3 (20.3)	50.3 (50.3)	15.1 (15.1)	0	23.1 (23.1)	61.7 (61.7)
Standard deviation	63.3	352.2	116.8	-	64.5	137.5
Range	0 - 324.7	0 - 535.5	0 - 226.9	-	0 - 324.7	0 - 535.5

c-3) Relationship between bottom salinity and CPUA

Figure 24 illustrates the relationship between the salinity of the bottom layer and CPUA. Pescada amarela was not found in salinities below 15 psu. CPUA values were scattered within the 15–36 psu range, and high CPUAs (over 200) were found only in waters with salinity above 25 psu.

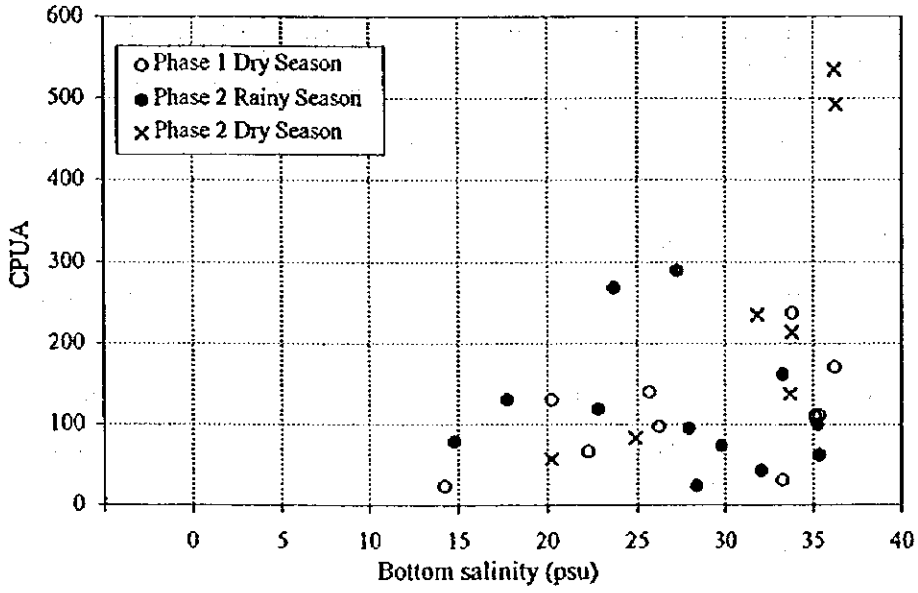


Figure 24. Relationship between bottom salinity and CPUA for Pescada amarela *Cynoscion acoupa*.

c-4) Stock size

Estimates of the stock sizes of pescada amarela are shown in Table 28. The estimate of the total stock size was as follows: 496 tonnes for Phase 1 Dry Season, with a 95% confidence interval of ± 304 tonnes (CV = 38%); 477 tonnes for Phase 2 Rainy Season, with a 95% confidence interval of ± 333 tonnes (CV = 33%); and 1,279 tonnes for Phase 2 Dry Season, with a 95% confidence interval of ± 684 tonnes (CV = 26%). In the 10–20 m stratum, the seasonal stock size was respectively 58%, 71% and 62% of the total stock size.

The stock size in the Phase 2 Dry Season was about 800 tonnes larger than in the other two seasons. This growth can be possibly due to the increasing recruitment of large-size fish into the survey area. Considering the precision of the estimates (95% confidence interval and CV), the difference should not be significant. The ratio of the stock size obtained from catch in cod-end to the stock size from overall catch was 100%, except for a 96% value in the Phase 1 Dry Season Survey.

Table 28. Stock size estimates of Pescada amarela *Cynoscion acoupa*. Stock size in parentheses obtained from catch in cod-end.

Stratum (isobath range in m)	Area in km^2	Stock size in tonnes					
		Phase					
		1		2			
		Dry Season		Rainy Season		Dry Season	
5 - 10	17,200	64	(64)	67	(67)	349	(349)
10 - 20	15,700	289	(269)	339	(339)	790	(790)
20 - 50	9,300	143	(143)	71	(71)	140	(140)
Total	42,200	496	(476)	477	(477)	1,279	(1,279)
95% confidence interval		±304	(±291)	±333	(±333)	±684	(±684)

(f) Pescadinha gó *Macrodon ancylodon*

f-1) Distribution of CPUA

Distribution of CPUA for pescadinha gó is given in Figure 25. This species was found to be widely distributed in the entire survey area except in the 5–10 m stratum near the shoreline. CPUA values were higher in both seasons of Phase 2 than in the Dry Season of Phase 1.

(A)

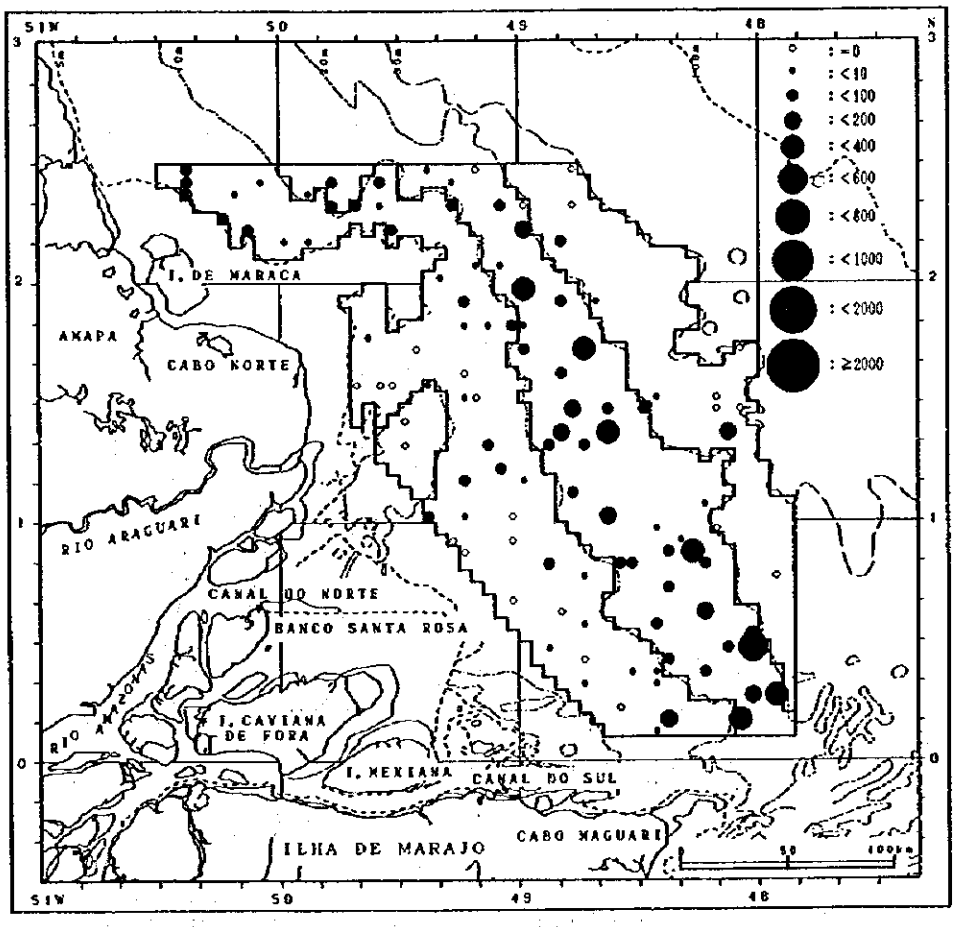
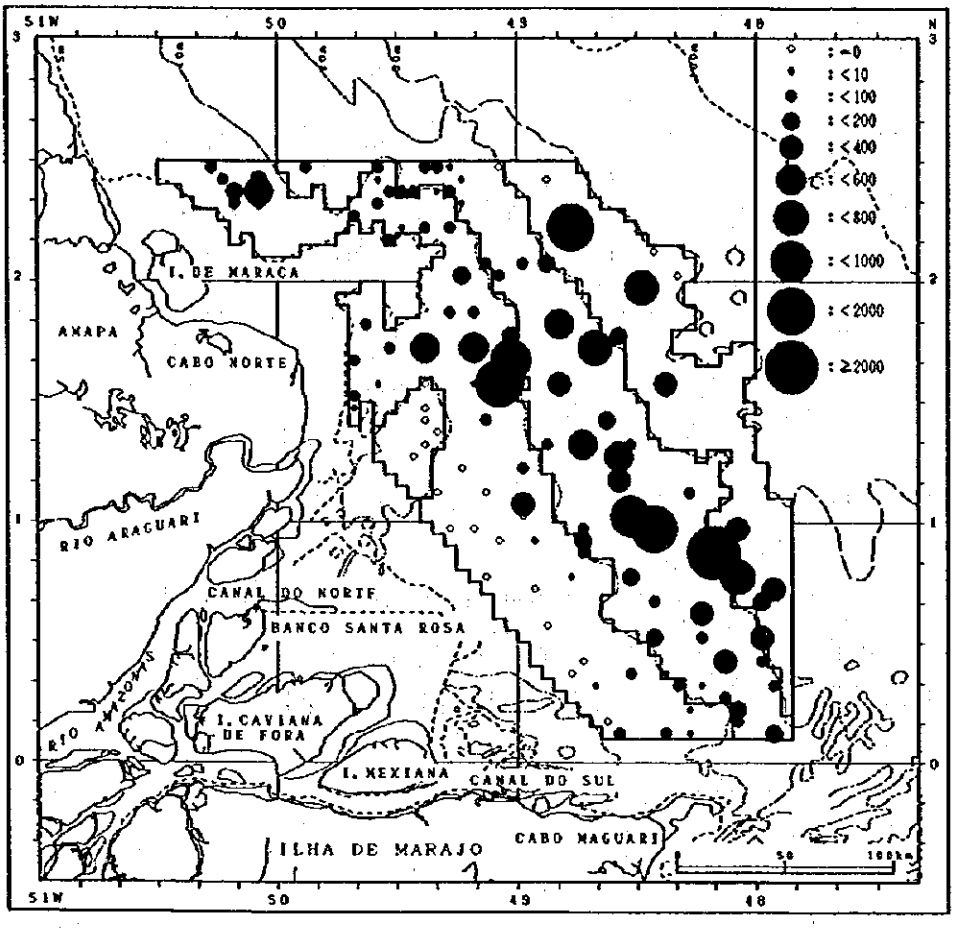


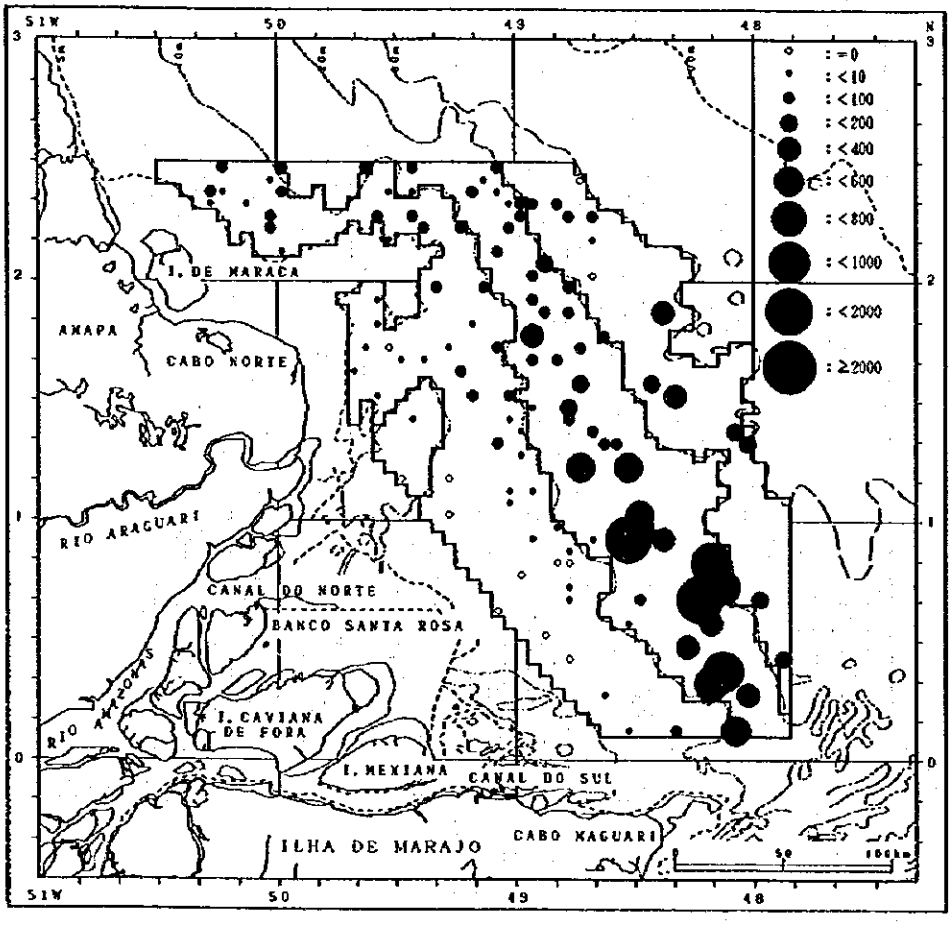
Figure 25. Distribution of CPUA for Pescadinha gó *Macrodon ancylodon*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 25. Continued

(B)



(C)



f-2) CPUA by stratum and water mass region

Table 29 shows CPUA values for pescadinha gó by stratum and water mass region.

i) CPUA by stratum

High values of CPUA were recorded in the 10–20 m stratum in the Dry Seasons, and in the 20–50 m stratum in the Rainy Season. For the 5–10 m and 20–50 m strata, the mean CPUA was higher in the Rainy Season (respectively, 86 and 301) than in the Dry Seasons (Phase 1: 11, 20; Phase 2: 11, 107). In the 10–20 stratum, the mean CPUA increased in survey order: 77, 199, 228. The highest CPUA (2,360) was recorded in the 10–20 m stratum during the Phase 2 Rainy Season Survey. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was lower than 20% in all seasons.

ii) CPUA by water mass region

Pescadinha gó was only found in river waters in the Phase 2 Dry Season Survey. In all seasons, the mean CPUA by water mass region was higher in ocean waters (51, 244, 202 in season order) than in brackish waters (40, 172, 88), and in both water mass regions that value was higher in the Rainy Season than in the Dry Seasons. The mean CPUA in river waters in the Phase 2 Dry Season was an extremely low 0.5. The highest CPUA value mentioned above was recorded in brackish waters. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was below 10% — except for a 22% value in brackish waters in the Phase 1 Dry Season Survey.

Table 29. CPUA for Pescadinha gó *Macrodon ancylodon*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters. Mean CPUA in parentheses obtained from catch in cod-end.

(A)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	10.7 (2.0)	77.3 (13.9)	19.6 (3.7)	0	40.4 (8.9)	51.3 (4.8)
Standard deviation	20.5	96.5	47.4	-	65.3	100.1
Range	0 - 116.5	0 - 414.3	0 - 157.3	-	0 - 269.6	0 - 414.3

(B)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	86.1 (6.1)	199.2 (9.3)	300.9 (25.5)	0	172.4 (8.9)	243.7 (21.1)
Standard deviation	220.7	404.7	333.1	-	360.6	316.4
Range	0 - 1,446.7	0 - 2,360.0	0 - 1,177.6	-	0 - 2,360.0	0 - 1,177.6

(C)

CPUA	Stratum (isobath range in m)			Water mass		
	5-10	10-20	20-50	RW	BW	OW
Mean	10.6 (1.6)	228.4 (16.3)	106.5 (15.5)	0.5 (0)	87.6 (8.2)	202.2 (14.8)
Standard deviation	16.6	352.2	116.8	1.3	186.5	370.8
Range	0 - 81.2	0 - 1,711.2	0 - 383.2	0 - 3.7	0 - 1,019.1	0 - 1,711.2

f-3) Relationship between bottom salinity and CPUA

Figure 26 illustrates the relationship between the salinity of the bottom layer and CPUA. Although CPUA values were scattered within the 0–36 psu range, high CPUAs (over 500, not recorded in the Phase 1 Dry Season Survey) were found only in waters with salinity in the 15–36 psu range.

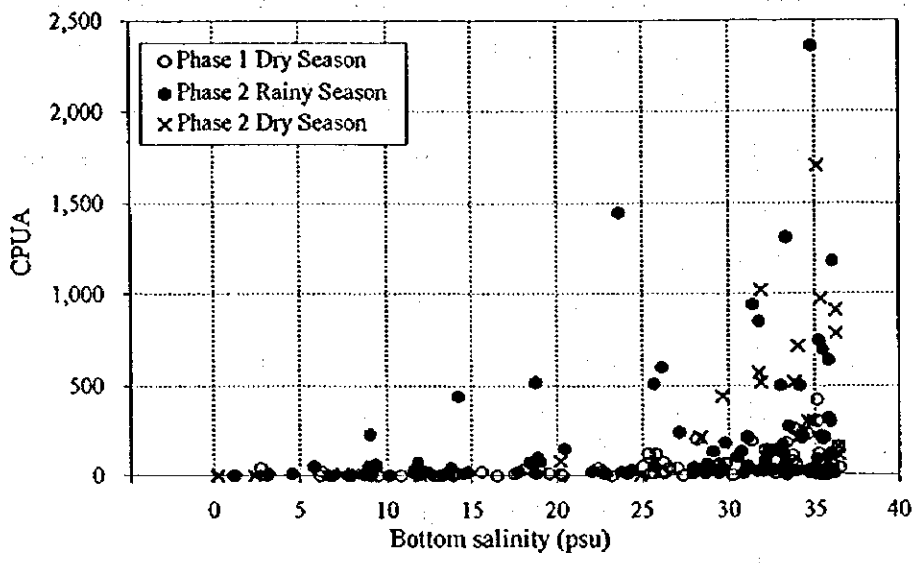


Figure 26. Relationship between bottom salinity and CPUA for Pescadinha gó *Macrodon ancylodon*.

f-4) Stock size

Estimates of the stock sizes of pescadinha gó are shown in Table 30. The estimate of the total stock size was as follows: 1,580 tonnes for Phase 1 Dry Season, with a 95% confidence interval of ± 578 tonnes (CV = 17%); 7,406 tonnes for Phase 2 Rainy Season, with a 95% confidence interval of ± 2,511 tonnes (CV = 18%); and 4,759 tonnes for Phase 2 Dry Season, with a 95% confidence interval of ± 1,899 tonnes (CV = 18%). In the 10–20 m stratum, the seasonal stock size was respectively 77%, 42% and 75% of the total stock size.

The stock size in the Phase 2 Rainy Season was about 6,000 tonnes larger than in the previous Dry Season and 3,000 tonnes greater than in the following one — a considerable difference. Also, the stock size in the Dry Seasons in both Phases showed a difference of about 3,000 tonnes in favor of Phase 2. This difference is possibly due to the natural growth of the population (recruitment plus increment minus natural mortality).

The ratio of the stock size obtained from catch in cod-end to the stock size from overall catch was, in survey order, 18%, 7% and 9%. Differently from other key fish species, pescadinha gó was mostly caught by the covernet — so its stocks probably have been relatively unaffected by the fishing gear used by the industrial fleet operating in the survey area.

Table 30. Stock size estimates of Pescadinha gó *Macrodon ancylodon*. Stock size in parentheses obtained from catch in cod-end.

Stratum (isobath range in m)	Area in km²	Stock size in tonnes					
		Phase					
		1		2			
		Dry Season		Rainy Season		Dry Season	
5 - 10	17,200	184	(34)	1,481	(105)	182	(28)
10 - 20	15,700	1,214	(218)	3,127	(146)	3,586	(256)
20 - 50	9,300	182	(34)	2,798	(237)	991	(144)
Total	42,200	1,580	(286)	7,406	(488)	4,759	(428)
95% confidence interval		±578	(±152)	±2,511	(±148)	±1,899	(±173)

(g) Gurijuba *Arius parkeri*

g-1) Distribution of CPUA

Distribution of CPUA for gurijuba is given in Figure 27. The distribution pattern for gurijuba was similar to that of pescadinha gó; however, differently from pescadinha gó, gurijuba was not found in the 5–10 m stratum offshore between the Northern and Southern Channels of the Amazon River, or in water depths below 20 m. Distribution of gurijuba did not change with the season but became more concentrated as the survey progressed.

(A)

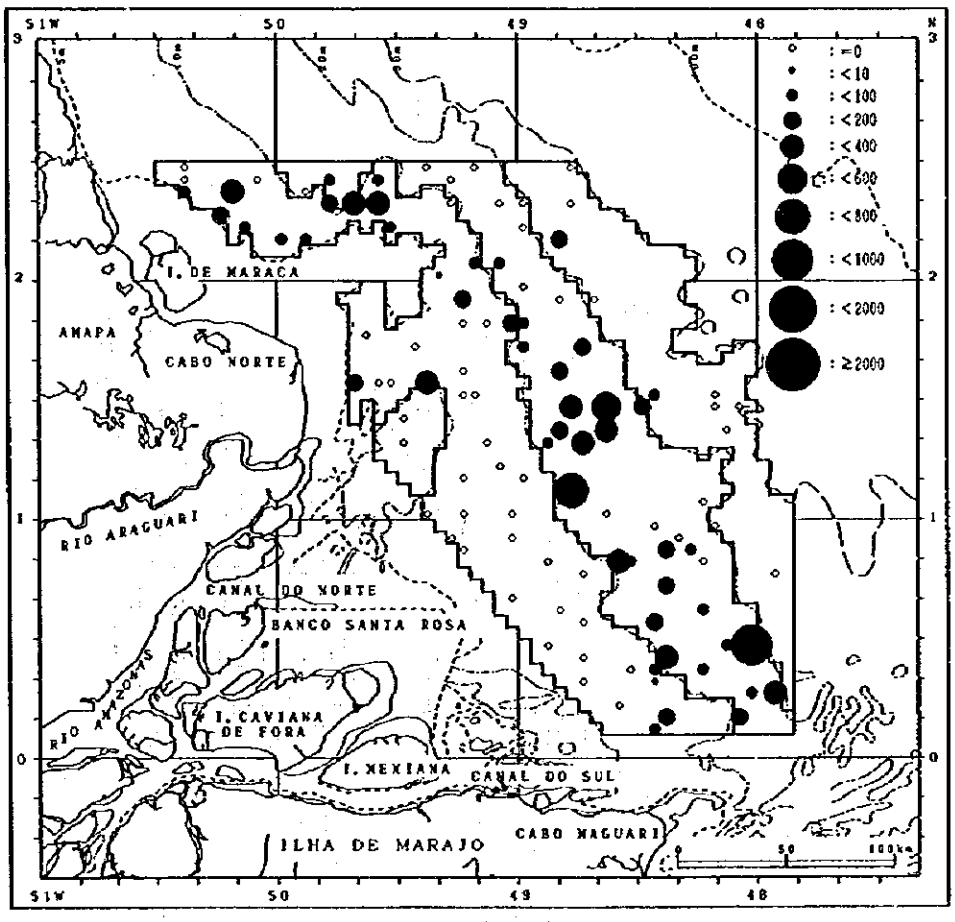
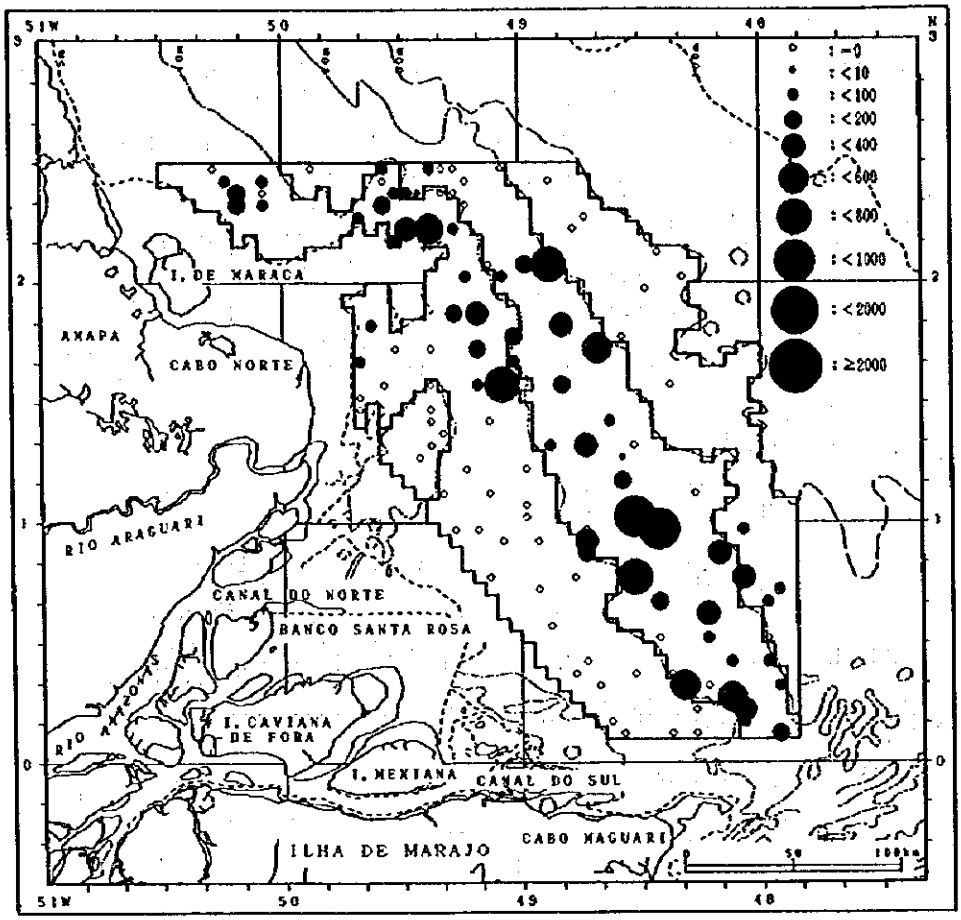


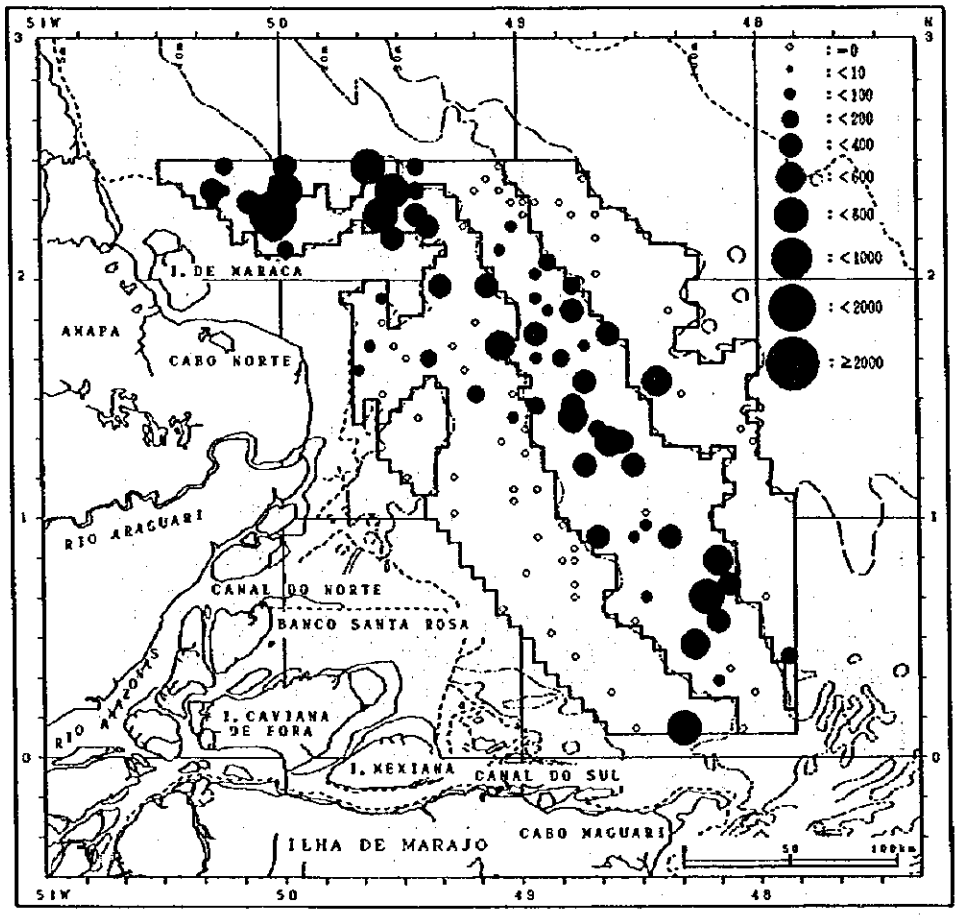
Figure 27. Distribution of CPUA for Gurijuba *Arius parkeri*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 27. Continued

(B)



(C)



g-2) CPUA by stratum and water mass region

Table 31 shows CPUA values for Gurijuba by stratum and water mass region.

i) CPUA by stratum

The mean CPUA in the 10–20 m stratum was higher than in the other strata in all seasons. Also, the mean CPUA increased in survey order in each stratum, with values of 39, 69, 137 for the 5–10 m stratum; 120, 137, 179 for the 10–20 m stratum; and 17, 33, 70 for the 20–50 m stratum. The highest CPUA value (1,031) was recorded in the 5–10 m stratum, during the Phase 2 Dry Season Survey. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was 99–100% in all seasons.

ii) CPUA by water mass region

Gurijuba did not occur in river waters in any season. The mean CPUA was higher in brackish waters than in ocean waters regardless of season. On the other hand, the mean CPUA in both water mass regions increased in survey order: values for brackish waters were 81, 117 and 173 respectively, and for ocean waters 66, 88, 117. The above-mentioned highest CPUA value was registered in brackish waters. The ratio of the mean CPUA obtained from catch in cod-end to the mean CPUA from overall catch was 99–100% in the survey.

Table 31. CPUA for Gurijuba *Arius parkeri*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey. Water mass regions: RW, river waters; BW, brackish waters; OW, ocean waters. Mean CPUA in parentheses obtained from catch in cod-end.

(A)

CPUA	Stratum (isobath range in m)						Water mass					
	5-10		10-20		20-50		RW	BW		OW		
Mean	39.4	(38.9)	120.3	(120.0)	16.7	(16.7)	0	81.3	(80.8)	65.7	(65.7)	
Standard deviation	72.6		186.8		37.6		-	117.8		199.7		
Range	0 - 290.6		0 - 941.2		0 - 104.3		-	0 - 699.4		0 - 941.2		

(B)

CPUA	Stratum (isobath range in m)						Water mass					
	5-10		10-20		20-50		RW	BW		OW		
Mean	68.5	(68.4)	137.4	(136.5)	33.3	(33.2)	0	117.0	(116.4)	87.6	(87.5)	
Standard deviation	131.0		231.1		61.5		-	193.1		185.6		
Range	0 - 700.5		0 - 939.0		0 - 217.9		-	0 - 939.0		0 - 739.5		

(C)

CPUA	Stratum (isobath range in m)						Water mass					
	5-10		10-20		20-50		RW	BW		OW		
Mean	137.4	(137.2)	179.2	(179.0)	69.7	(69.7)	0	173.3	(173.2)	117.2	(117.0)	
Standard deviation	234.8		186.1		165.6		-	220.4		190.3		
Range	0 - 1,031.2		0 - 707.3		0 - 593.4		-	0 - 1,031.2		0 - 707.3		

g-3) Relationship between bottom salinity and CPUA

Figure 28 illustrates the relationship between the salinity of the bottom layer and CPUA. Gurijuba had CPUA values scattered within the range of 0–36 psu, but high values (over 400) were mainly distributed within the interval of 25–36 psu.

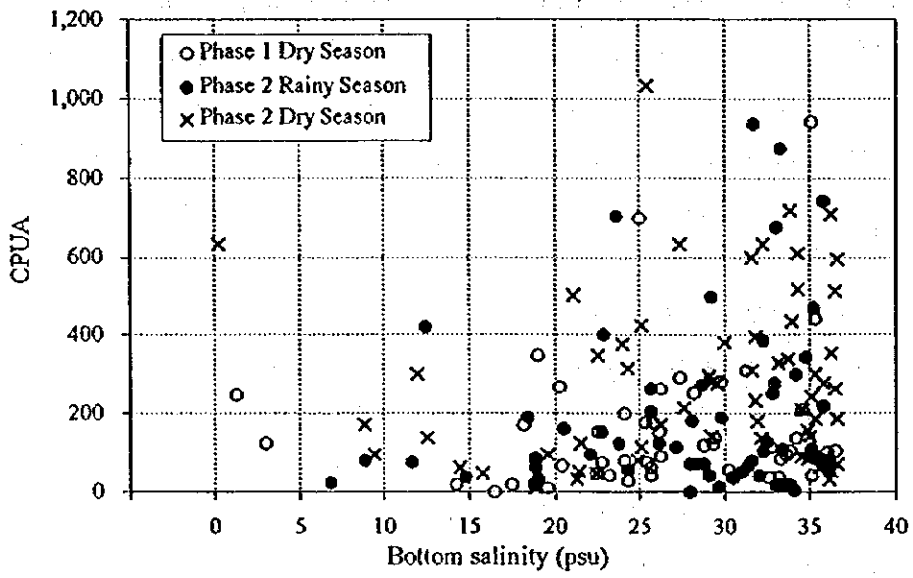


Figure 28. Relationship between bottom salinity and CPUA for Gurijuba *Arius parkeri*.

g-4) Stock size

Estimates of the stock sizes of gurijuba are shown in Table 32. The estimate of the total stock size was as follows: 2,722 tonnes for Phase 1 Dry Season, with a 95% confidence interval of ± 1,093 tonnes (CV = 17%); 3,645 tonnes for Phase 2 Rainy Season, with a 95% confidence interval of ± 1,372 tonnes (CV = 17%); and 5,824 tonnes for Phase 2 Dry Season, with a 95% confidence interval of ± 1,578 tonnes (CV = 14%).

The stock size in the Phase 2 Dry Season was about 3,000 tonnes larger than in the Phase 1 Dry Season and 2,000 tonnes greater than in the Phase 2 Rainy Season. It is not clear whether this growth in the stock size along the survey order can be attributed to a natural population growth that comes along with declining catches.

The ratio of the stock size obtained from catch in cod-end to the stock size from overall catch was quite high — near 100% in all seasons.

Table 32. Stock size estimates of Gurijuba *Arius parkeri*. Stock size in parentheses obtained from catch in cod-end.

Stratum (isobath range in m)	Area in km^2	Stock size in tonnes					
		Phase					
		1		2			
		Dry Season		Rainy Season		Dry Season	
5 - 10	17,200	678	(669)	1,178	(1,176)	2,363	(2,360)
10 - 20	15,700	1,889	(1,884)	2,157	(2,143)	2,813	(2,810)
20 - 50	9,300	155	(155)	310	(309)	648	(648)
Total	42,200	2,722	(2,708)	3,645	(3,628)	5,824	(5,818)
95% confidence interval		±1,093	(±1,089)	±1,372	(±1,376)	±1,578	(±1,578)