### 5.1.5. Biological Information on Key Fish Species

The figures and tables to follow illustrate size composition, sex ratio and female maturity stage of the key species as determined from data obtained at each trawl station, having standardized the number of specimens per unit area (1 $km^2$). Only data taken from actual specimens were used in the determination of body length range, mean body length, body length and weight relationship, bottom salinity and body length relationship, and feeding habits.

Data on size composition of the key species were obtained primarily using the measuring-card punching method. However, at trawl stations where too few specimens were caught, data on body length were taken instead from the multi-item biological measurement, although the latter was not necessarily carried out at all stations. Each 2 cm size class was considered for the body length composition of six of the key species, and the figures to follow show the central value of each size class. For pescadinha gó *Macrodon ancylodon*, however, each 1 cm size class was chosen instead.

**(a) Piramutaba *Brachyplatystoma vaillantii***

a-1) Body length range and mean body length

Table 33 shows fork length range and mean fork length values for piramutaba.

i) Overall body length

Throughout the surveys the maximum size found was 697 mm, and the minimum size 33 mm. Specimens as large as the one seen in Santarém, Lower Amazon, measuring over 90 cm (see Figure 121), were not found in the survey area. Mean fork length was, in survey order, 265 mm, 259 mm and 233 mm, denoting a trend toward smaller sizes.

ii) Size variation by stratum

Mean fork length was larger by many centimeters in the 5–10 m stratum than in the 10–20 m one, except in the Phase 2 Dry Season. Both maximum and minimum lengths were found in the 5–10 m stratum.

iii) Size variation by water mass region

Mean fork length was, for all seasonal surveys, larger in river than in brackish waters, the difference being more striking in the Rainy Season. With one exception, maximum and minimum sizes were found in brackish waters.

**Table 33. Range and mean body length 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.**

(A)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 40 | 74 | - | 40 | 43 | - |
| Maximum | 665 | 505 | - | 650 | 665 | - |
| Mean | 267 | 259 | - | 311 | 237 | - |
| All area : Min. 40, Max. 665, Mean 265 | | | | | | |

(B)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 45 | 59 | - | 115 | 45 | - |
| Maximum | 697 | 665 | - | 660 | 697 | - |
| Mean | 264 | 242 | - | 346 | 212 | - |
| All area : Min. 45, Max. 697, Mean 259 | | | | | | |

(C)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 33 | 62 | - | 82 | 33 | - |
| Maximum | 670 | 580 | - | 560 | 670 | - |
| Mean | 231 | 259 | - | 255 | 221 | - |
| All area : Min. 33, Max. 670, Mean 233 | | | | | | |

a-2) Relationship between bottom salinity and size

Figure 29 shows the relationship between salinity of the bottom layer and size for piramutaba. There, the fish were classified as small (under 20 cm), intermediate-size (20-40 cm) and large (over 40 cm). Piramutaba of all groups were distributed in river (less than 1 psu) and low-salinity (under 10 psu) waters; however, waters from low to intermediate salinity (around 20 psu) tended to harbor small and large fish, and highly saline waters (around 30 psu) small fish. In the rainy season, piramutaba of all groups tended to occur in regions of higher salinity than those they were around during the dry season.

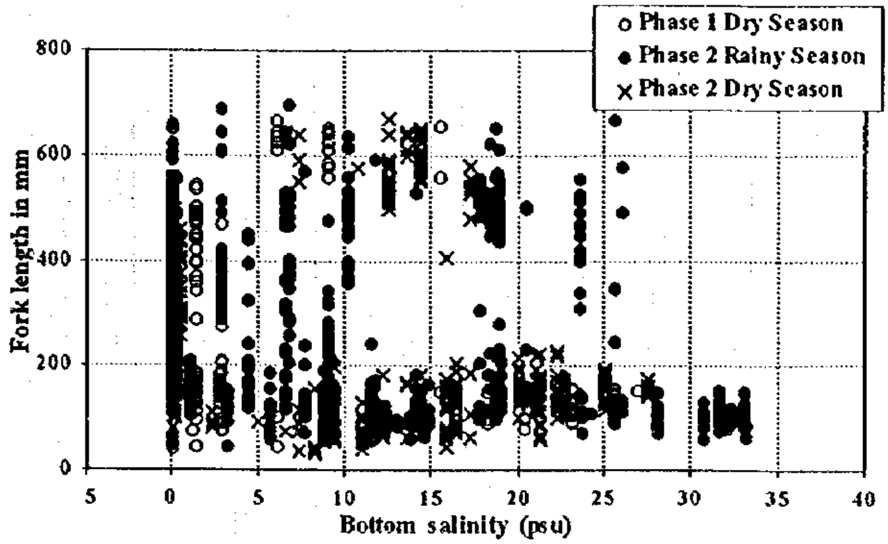



**Figure 29. Relationship between bottom salinity and size in Piramutaba *Brachyplatystoma vaillantii*.**

a-3) Size composition

Figure 30 shows the size composition for piramutaba, with body length data taken via both the measuring-card punching method and the multi-item biological measurement.

i) Overall size composition

In all survey seasons, overall size composition exhibited a poly-modal pattern of distribution. Analysis of the strong and dominant modes including a predominant mode among several modes shows piramutaba stocks were characteristically formed by mostly small (under 20 cm) and intermediate-to-large individuals, with few specimens larger than 40 cm. The dominant mode for small fishes was at 14–16 cm class in the Dry Seasons (this was the most frequent mode overall, although the 18–20 cm mode for Phase 2 close to it) and at 10–12 cm in the Rainy Season. The dominant mode for fish larger than 20 cm was at 34–36 cm and 26–28 cm classes in the Dry Season of, respectively, Phase 1 and Phase 2 and at 22–24 cm class in the Phase 2 Rainy Season, this being the most frequent mode overall. For small fish, there were other modes in the Dry Seasons of the Phase 1 (4–6 cm class) and Phase 2 (6–8 cm class), indicating recruitment of newborn fry. Temporally well correspondences between the three modes, 4-6 cm mode in the Phase 1 Dry Season, 10–12 cm mode in the Phase 2 Rainy Season, 14–16 cm and 18–20 cm modes in the Phase 2 Dry Season, and the 14-16 cm, 22–24 cm and 26–28 cm modes, in survey order reflected the natural growth of piramutaba.

ii) Size composition by stratum

In all survey seasons, size composition by stratum had a poly-modal pattern of distribution. Size composition in the 5–10 m stratum was similar to the overall size composition. In the 10–20 m stratum, size composition was characterized by comprising mainly intermediate-size fish in the Phase 1 Dry Season, the presence of all size groups with the predominance of small fish in the Phase 2 Rainy Season, and the presence of large fish but the predominance of small ones in the Phase 2 Dry Season.

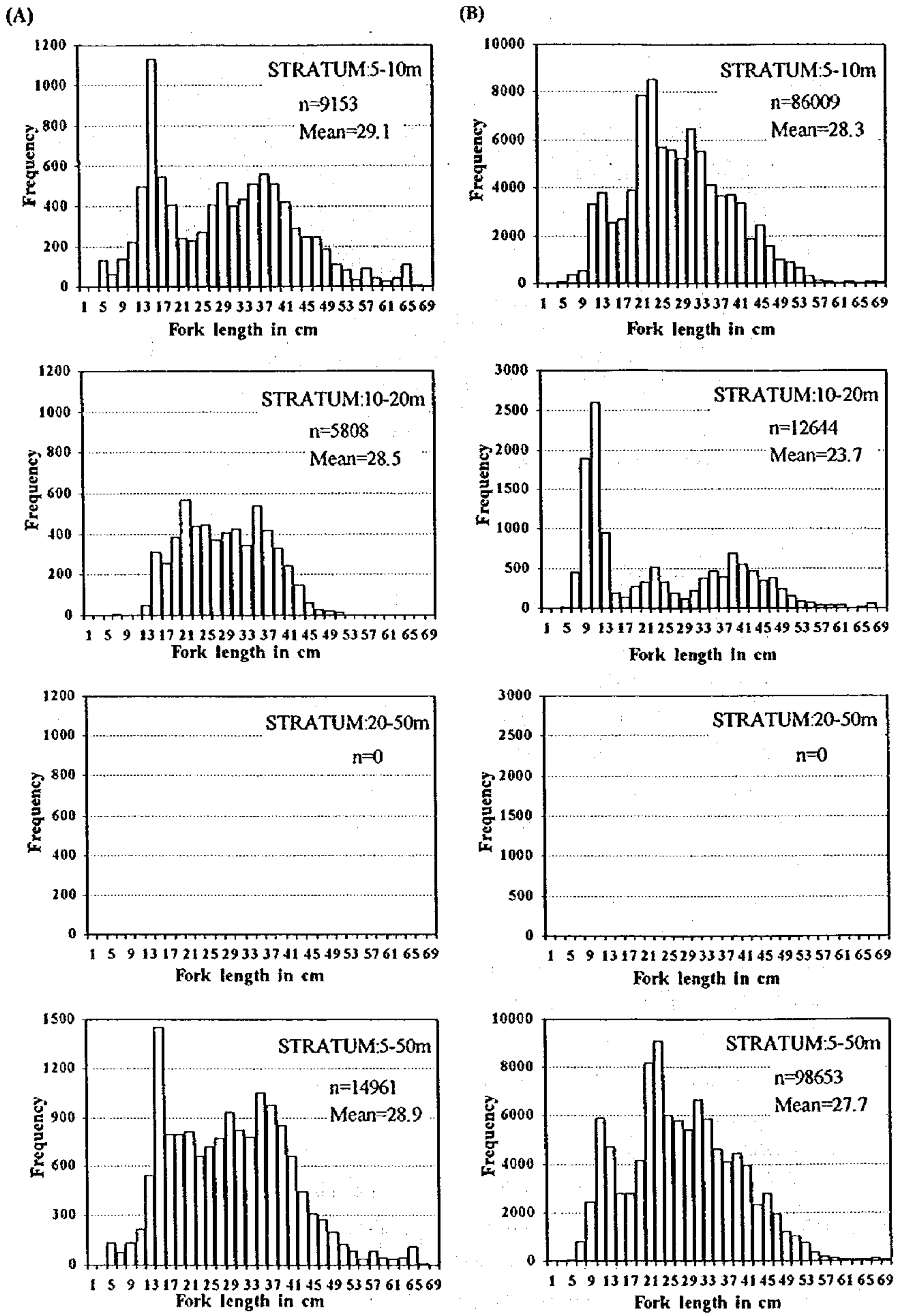
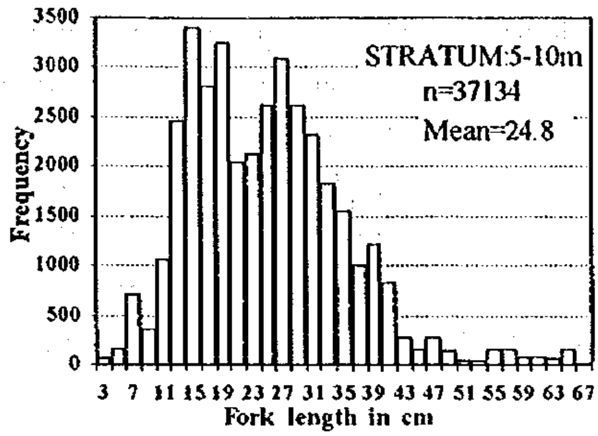
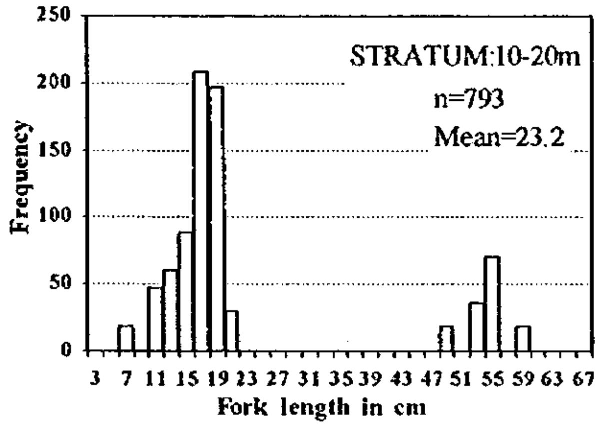


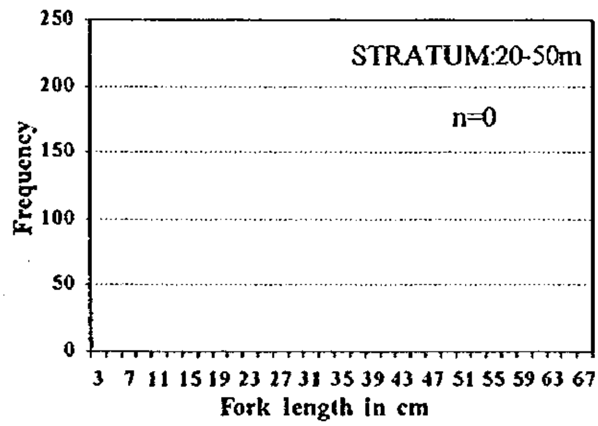

Figure 30. Size composition for piramutaba *Brachyplatystoma vaillantii.* (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

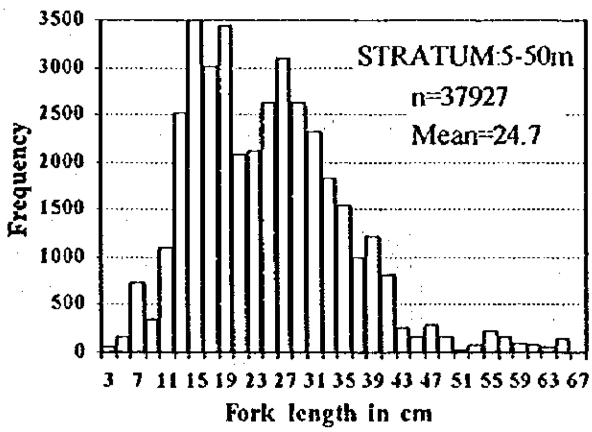
Figure 30. Continued

(C)



a-4) Body length and weight relationship

Figure 31 summarizes the relationship between fork length and body weight for piramutaba, determined from data obtained through the multi-item biological measurement. Resulting regression equations for the total number of male, female and sexually indeterminate individuals were:

Phase 1 Dry Season Survey: $BW = 5 \times FL^{3.1512} \times 10^{-6}$ (r = 0.997)

Phase 2 Rainy Season Survey: $BW = 6 \times FL^{3.1276} \times 10^{-6}$ (r = 0.997)

Phase 2 Dry Season Survey: $BW = 5 \times FL^{3.1498} \times 10^{-6}$ (r = 0.998)

These equations are very similar to each other and also close to that established by Barthem et al. (1997) as $BW = 4.6 \times FL^{3.304} \times 10^{-6}$, r = 0.960 (n = 321, FL = 0–69 cm, BW = 7–5,700 g).

a-5) Body length and weight by sex

Table 34 summarizes fork length and body weight by sex for piramutaba. In all survey seasons, mean fork length and mean weight was larger in females than in males. Differences between sexes were more accentuated in the Dry Seasons than in the Rainy Season. Males tended to grow larger in temporal sequence, but females would be larger in the Dry Seasons than in the Rainy Season. Development of reproductive organs to the point of allowing visually detectable sexual dimorphism started around 10 cm and 15 g for both sexes. But the amplitude of individual variation in the development of reproductive organs was suggested by the occurrence of sexually indeterminate individuals of 50 cm (see Figure 32) or 1 kg.

**Table 34. Body length and weight by sex for Piramutaba *Brachyplatystoma vaillantii*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 160 - 625 | 355 | 45 - 3,400 | 724 |
| Female | 169 - 665 | 444 | 50 - 4,300 | 1,396 |
| Indeterminate | 40 - 470 | 155 | 1 - 1,180 | 74 |

(B)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 113- 660 | 358 | 15 - 4,300 | 760 |
| Female | 108 - 697 | 392 | 14 - 5,100 | 1,042 |
| Indeterminate | 45 - 350 | 126 | 1 - 500 | 35 |

(C)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 151 - 645 | 394 | 20 - 4,000 | 1,018 |
| Female | 157 - 670 | 451 | 40 - 5,160 | 1,669 |
| Indeterminate | 33 - 249 | 129 | 0.3 - 158 | 30 |

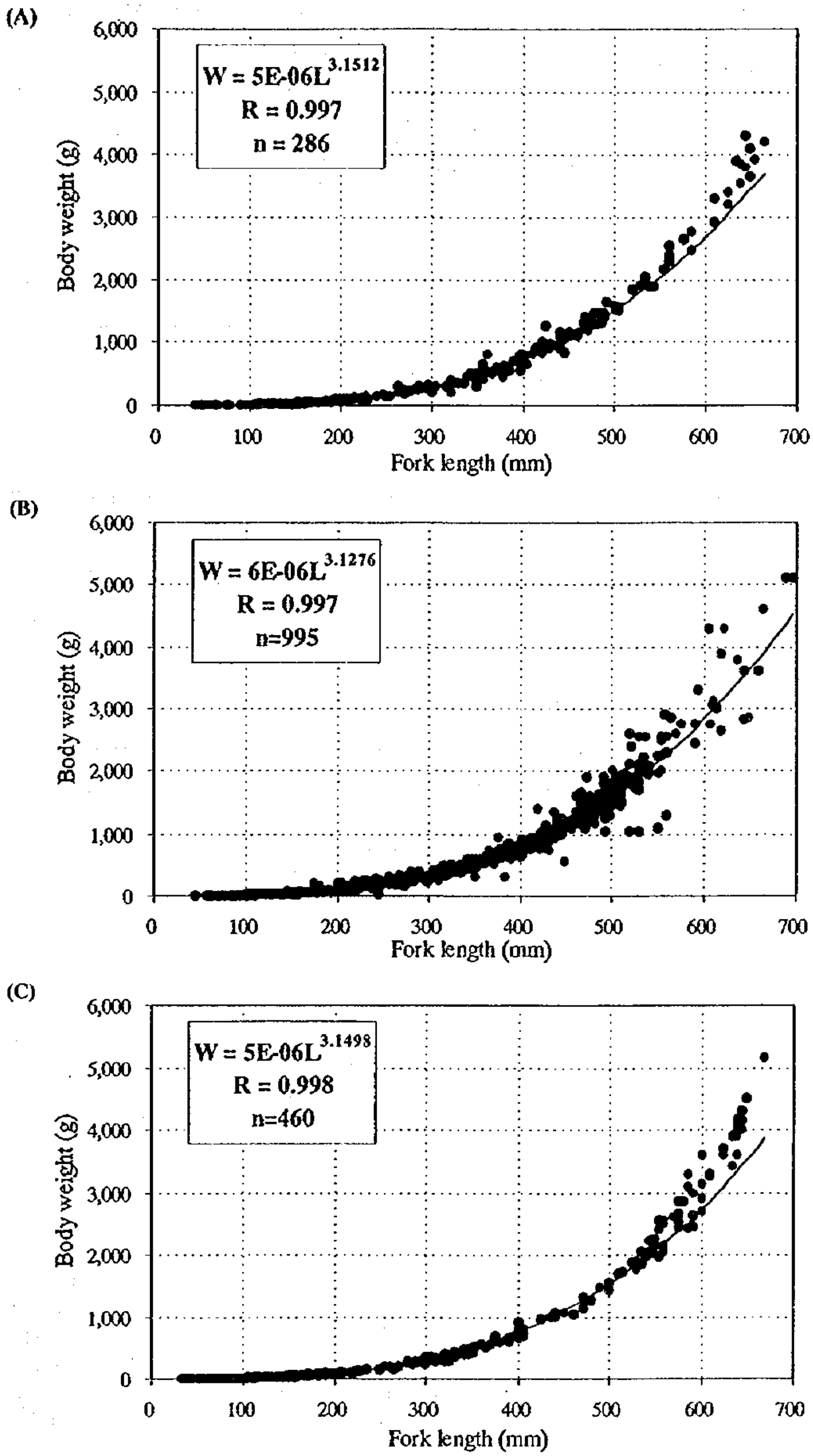



**Figure 31. Relationship between fork length and body weight for Piramutaba *Brachyplatystoma vaillantii*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

a-6) Sex ratio and female maturity stage

Table 35 summarizes sex ratio and female maturity stage for piramutaba. Sex ratio is shown as the number of females per one male.

i) Overall sex ratio

Overall sex ratio was 2.06, 0.86 and 1.04 in survey order — predominance of females, a slight majority of males and equal presence of both sexes respectively, three situations for three seasons. All females were immature.

ii) Sex ratio by stratum

Predominance of males occurred only in the 5–10 m stratum in the Phase 2 Rainy Season. Sex ratio was found to be depth-dependent, being greater in the 10–20 m stratum than in the 5–10 m stratum in all seasons: in that stratum, all individuals were female in the Phase 1 Dry Season Survey. Since minimum size for female maturity is 40 cm, according to Barthem et al. (1991), one can speculate piramutaba (it is unclear whether it is a subpopulation) does not utilize the survey area as its spawning ground, but rather as either its food searching or nursery ground.

**Table 35. Sex ratio and female maturity stage for Piramutaba *Brachyplatystoma vaillantii.* (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 217 | 0 | 0 | 217 | 140 | 1.55 |
| 10 - 20 | 330 | 0 | 0 | 330 | 0 | - |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 237 | 0 | 0 | 237 | 115 | 2.06 |

(B)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 673 | 0 | 0 | 673 | 839 | 0.80 |
| 10 - 20 | 273 | 0 | 0 | 273 | 144 | 1.90 |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 568 | 0 | 0 | 568 | 657 | 0.86 |

(C)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 439 | 0 | 0 | 439 | 424 | 1.04 |
| 10 - 20 | 45 | 0 | 0 | 45 | 27 | 1.67 |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 415 | 0 | 0 | 415 | 400 | 1.04 |

iii) Sex ratio by size class

Data obtained in all seasons through the multi-item biological measurement were grouped into each 2 cm size class. Frequency of number of individuals in these groups by sex (male, female, indeterminate) is presented in Figure 32. A size-dependent change in sex ratio was not observed in each season; however, in most of the length classes above 50 cm — or above 42 cm in the Phase 1 Dry Season — there was a predominance of females. On the other hand, sex composition in terms of the previously defined small-intermediate-large fish size categories was as follows (M, male; F, female; I, indeterminate sex), in survey order:

(1) small fish

M 9% F 6% I 86% M 6% F 14% I 80% M 7% F 11% I 82%

(2) intermediate-size fish

M 25% F 27% I 48% M 56% F 36% I 8% M 46% F 52% I 2%

(3) large fish

M 12% F 76% I 13% M 45% F 55% I 0% M 58% F 42% I 0%

a-7) Feeding habits

Table 36 presents the results of stomach contents analysis via the occurrence method. Individuals with empty stomachs were less frequent in the Rainy Season (61%) than in the Dry Seasons (71% and 77%). An overturned stomach was observed from an individual during the Phase 2 Dry Season Survey. Piramutaba fed mainly on fish, and secondarily on shrimp in both Dry and Rainy Seasons. The high rate of unidentified materials was due to the fact that the stomach contents of individuals around 10 cm were exceedingly small for proper identification. According to Barthem (1997), the young fish in the survey area feed on polychaetes and crustacean larvae.

**Table 36. Stomach contents of Piramutaba *Brachyplatystoma vaillantii*.**

| Phase | Survey season | Number of specimens | Empty stomach rate ( % ) | Evert rate (%) | Stomach contents by the occurrence method ( % ) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Fish | Crustacea | | | Unidentified |
| | | | | | | Shrimp | Crab | Other | |
| 1 | Dry | 286 | 77 | | 36 | 9 | | | 55 |
| 2 | Rainy | 995 | 61 | | 41 | 15 | 0.5 | | 43 |
| | Dry | 460 | 71 | 0.2 | 29 | 14 | 1 | 2 | 55 |

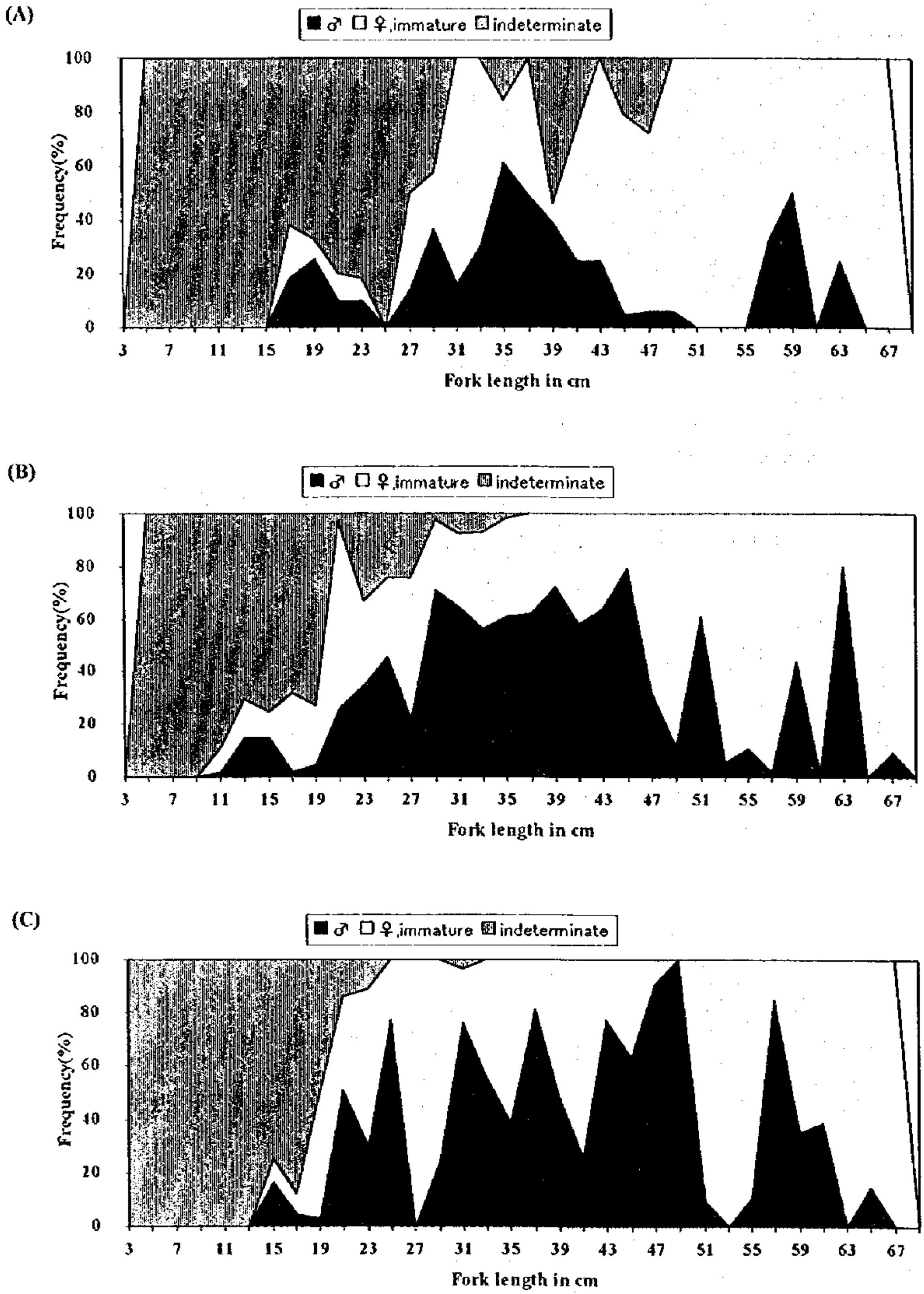



Figure 32. Frequency of male, female and indeterminate sex individuals by length class for Piramutaba *Brachyplatystoma vaillantii.* (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

### (b) Dourada *Brachyplatystoma flavicans*

b-1) Body length range and mean body length

Table 37 shows fork length range and mean fork length values for dourada.

i) Overall body length

Throughout the surveys the maximum size found was 835 mm, and the minimum size 53 mm. Specimens as large as the one measuring over 90 cm seen in Santarém, Lower Amazon (see Figure 122), were not found in the survey area. Mean fork length was larger in the Rainy Season (49 cm) than in the Dry Seasons (46 cm).

ii) Size variation by stratum

Mean fork length in the Dry Seasons was larger by 4–5 cm in the 5–10 m stratum than in the 10–20 m stratum. There was no difference between strata in the Rainy Season for mean fork length, which measured about 49 cm. Both maximum and minimum lengths were found in the 5–10 m stratum, with a single exception.

iii) Size variation by water mass region

Mean fork length was, for but one of the seasonal surveys, larger in river than in brackish waters, with a difference of some 3–5 cm. The exception happened in the Phase 2 Dry Season, when there was no much divergence in fish size between water mass regions. Minimum size was found in brackish waters and maximum size (with one exception) in river waters.

**Table 37. Range and mean body length 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.**

(A)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 66 | 110 | - | 91 | 66 | - |
| Maximum | 807 | 652 | - | 680 | 807 | - |
| Mean | 471 | 420 | - | 485 | 460 | - |
| All area : Min. 66, Max. 807, Mean 462 | | | | | | |

(B)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 61 | 76 | - | 250 | 61 | - |
| Maximum | 780 | 835 | - | 835 | 780 | - |
| Mean | 490 | 493 | - | 527 | 476 | - |
| All area : Min. 61, Max. 835, Mean 491 | | | | | | |

(C)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 53 | 64 | - | 65 | 53 | - |
| Maximum | 815 | 690 | - | 815 | 795 | - |
| Mean | 463 | 423 | - | 454 | 459 | - |
| All area : Min. 53, Max. 815, Mean 458 | | | | | | |

b-2) Relationship between bottom salinity and size

Figure 33 shows the relationship between salinity of the bottom layer and size for dourada. It can be seen there that intermediate-to-large fish (those larger than 20 cm) lived in waters from 0 psu to near 20 psu, while smaller fish were spread all over regions of higher salinity. The distribution of small fish into higher saline waters was more accentuated in the Rainy Season.

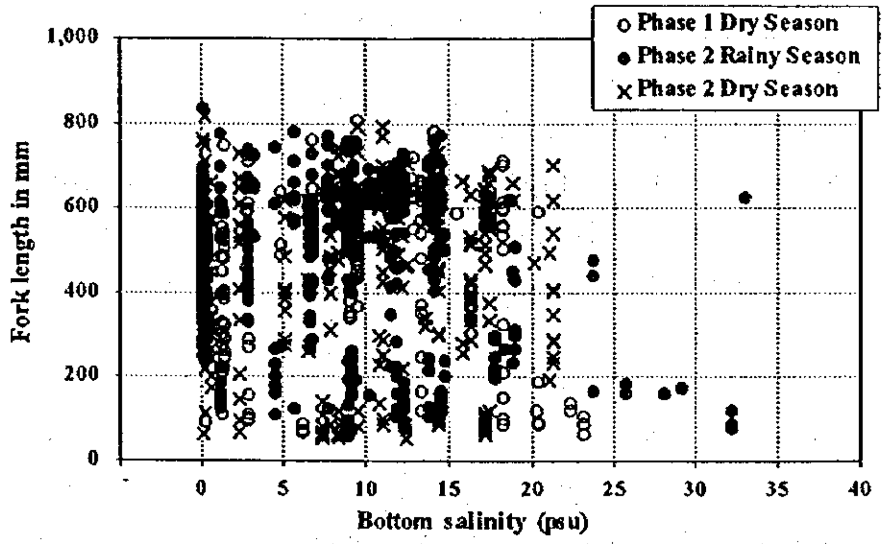



**Figure 33. Relationship between bottom salinity and size in Dourada *Brachyplatystoma flavicans.***

b-3) Size composition

Figure 34 shows the size composition for dourada, with body length data taken via both the measuring-card punching method and the multi-item biological measurement.

i) Overall size composition

In all survey seasons, overall size composition exhibited a poly-modal pattern of distribution that looks like a single mountain range. However, one could individualize two masses of mountains — formed by the highest peak and the base of many high and low mountains — separated by the valley lain the 18–20 cm class for the Dry Seasons and the 36–38 cm class for the Rainy Season. Peak for the mass of mountains corresponding to small size classes was between 8–14 cm classes, that for large size classes between 58–66 cm classes. Near the latter peak (which was also the highest peak in the entire range) there were many mountains of a close height. This allowed to understand the existence of a dourada stock with large individuals of about 60 cm and the recruitment of newborn fry of around 10 cm into it.

ii) Size composition by stratum

Size composition in the 5–10 m stratum was similar to the overall size composition. In the 10–20 m stratum, the two above-mentioned masses of mountains are clearly defined, with a widening of the valley separating them.

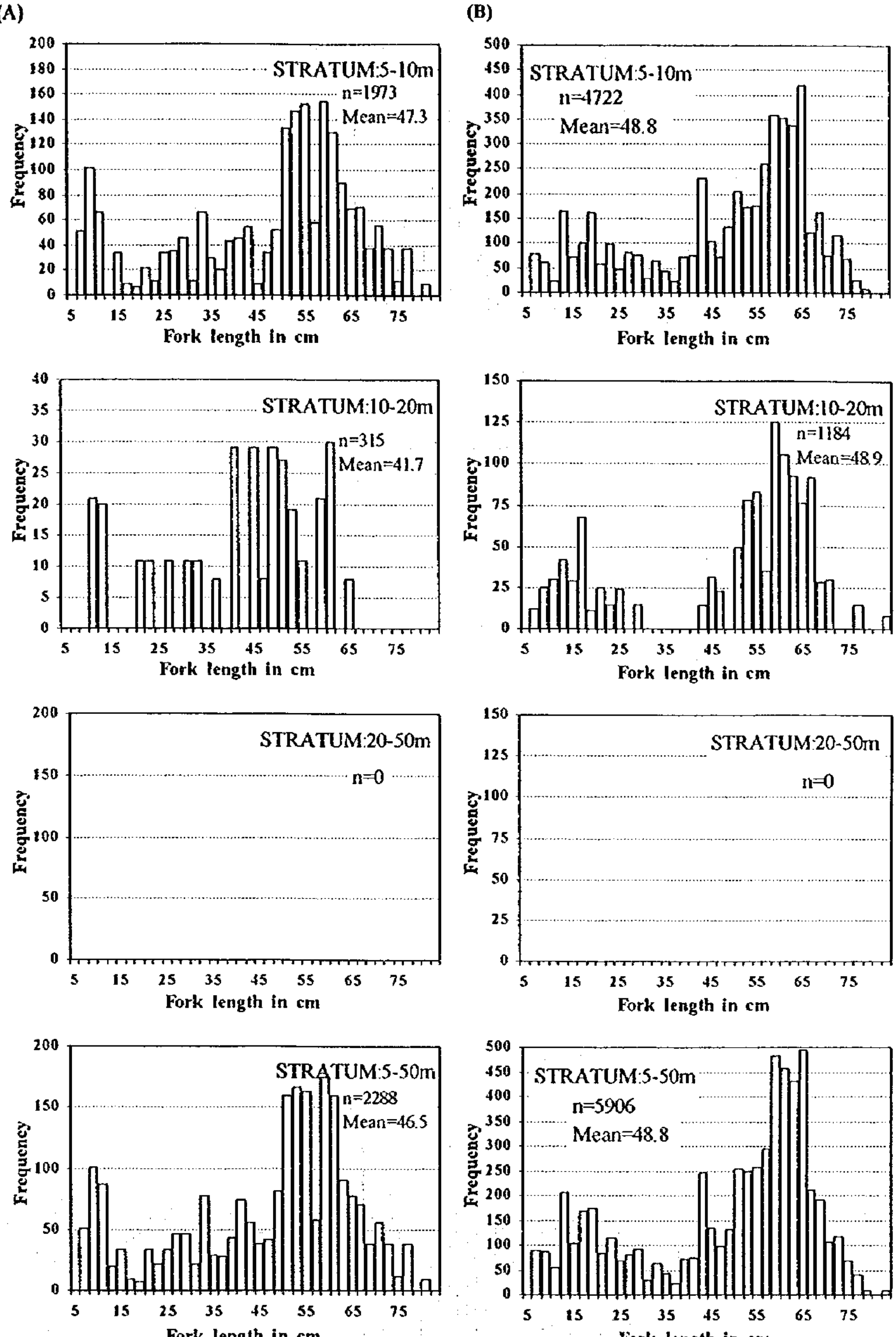
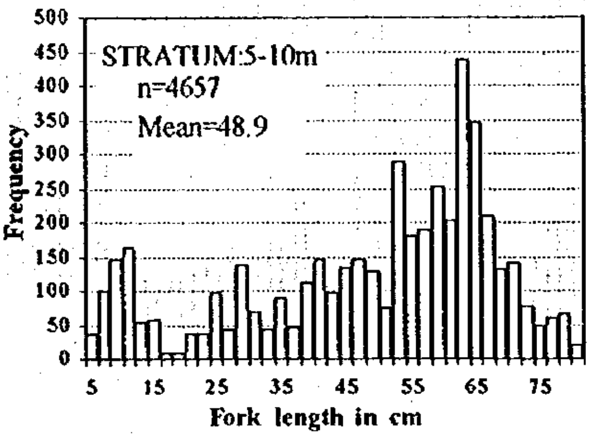
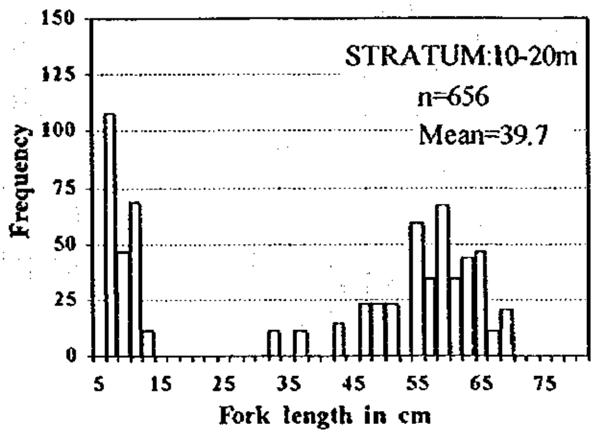


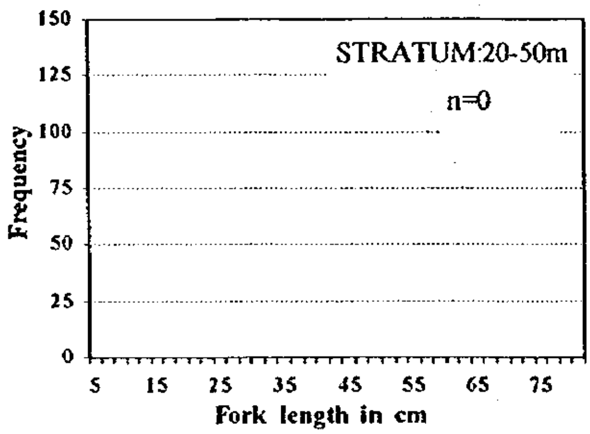

Figure 34. Size composition for Dourada *Brachyplatystoma flavicans*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

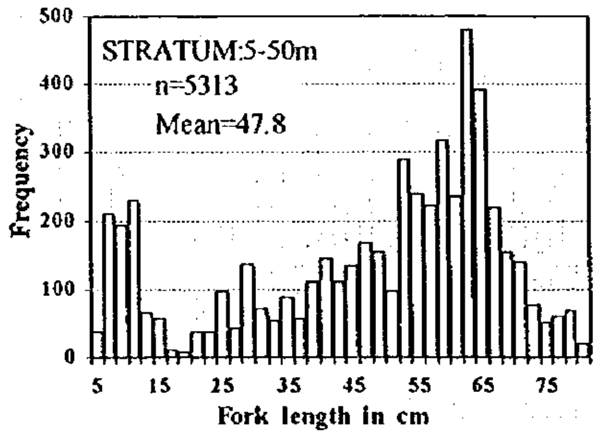
Figure 34. Continued

(C)



b-4) Body length and weight relationship

Figure 35 summarizes the relationship between fork length and body weight for dourada, determined from data obtained through the multi-item biological measurement. Resulting regression equations for the total number of male, female and sexually indeterminate individuals were:

Phase 1 Dry Season Survey: $BW = 5 \times FL^{3.1892} \times 10^{-6}$ $(r = 0.991)$

Phase 2 Rainy Season Survey: $BW = 8 \times FL^{3.0608} \times 10^{-6}$ $(r = 0.996)$

Phase 2 Dry Season Survey: $BW = 5 \times FL^{3.1161} \times 10^{-6}$ $(r = 0.998)$

These equations are very similar to each other and resemble those established by Le Guennec (1985) as $BW = 9.267 \times FL^{3.06752} \times 10^{-6}$ $(r = 0.971)$ and by Barthem et al. (1997) as $BW = 1.73 \times FL^{2.912} \times 10^{-5}$ $(r = 0.951)$.

b-5) Body length and weight by sex

Table 38 summarizes fork length and body weight by sex for dourada. In all survey seasons, mean fork length and mean weight was slightly larger in females than in males, although practically no seasonal difference in size could be detected between the sexes. Development of reproductive organs to the point of allowing sexual dimorphism detectable to the naked eye started around 12 cm and 16 g for both sexes. But the amplitude of individual variation in the development of reproductive organs was suggested by the occurrence of sexually indeterminate individuals of 50 cm (see Figure 36) or 1,400 kg. Males surpassing 78 cm were not caught.

**Table 38. Body length and weight by sex for Dourada *Brachyplatystoma flavicans*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 245 - 779 | 529 | 100 - 6,050 | 1,869 |
| Female | 210 - 807 | 530 | 50 - 7,150 | 1,909 |
| Indeterminate | 66 - 500 | 178 | 2 - 1,400 | 169 |

(B)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 130 - 770 | 540 | 19 - 5,900 | 2,084 |
| Female | 145 - 835 | 544 | 27 - 6,540 | 2,148 |
| Indeterminate | 61 - 328 | 160 | 1 - 300 | 69 |

(C)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 230 - 745 | 519 | 90 - 4,900 | 1,939 |
| Female | 121 - 815 | 540 | 16 - 7,000 | 2,055 |
| Indeterminate | 53 - 298 | 111 | 1 - 282 | 28 |

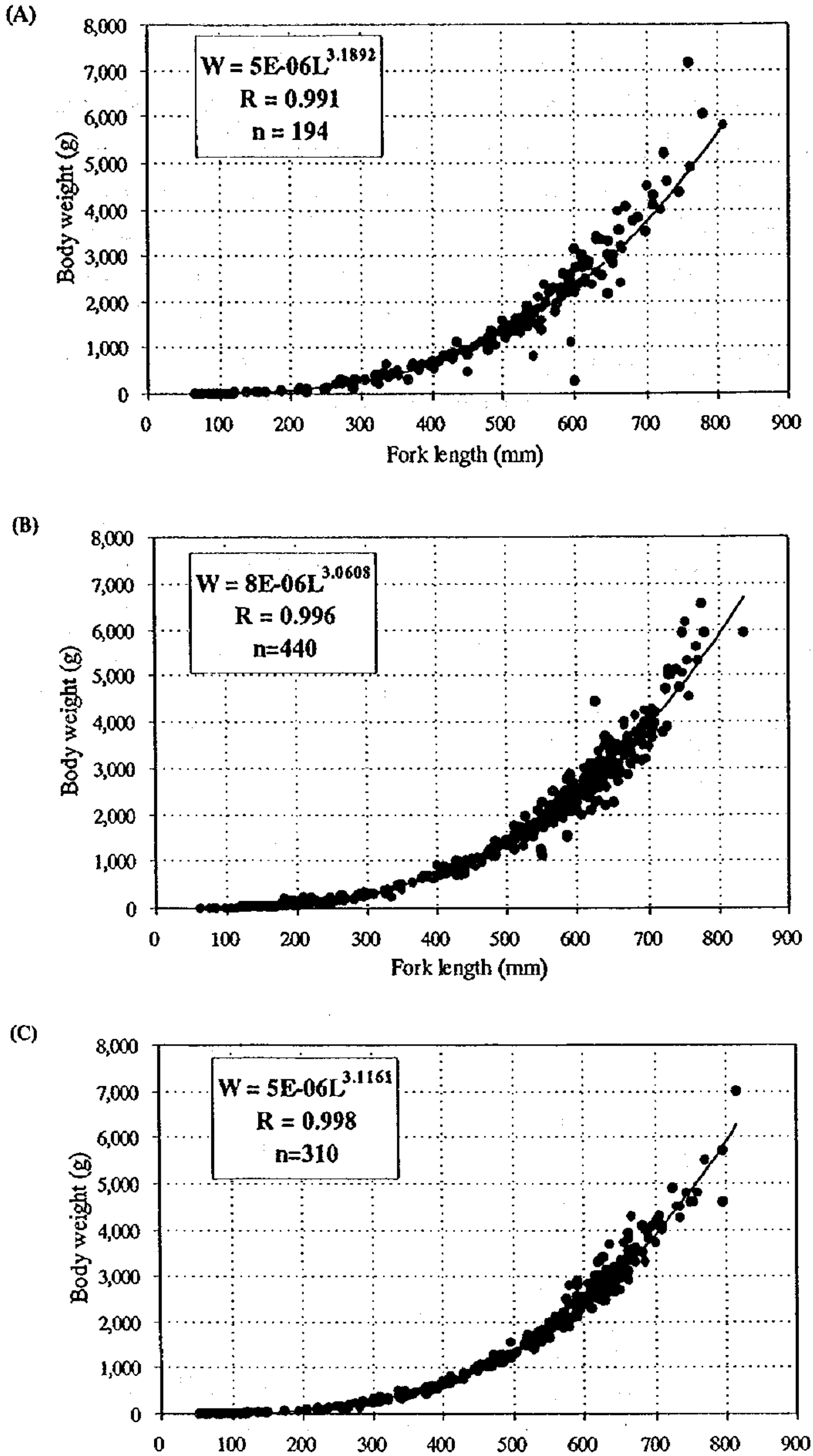



**Figure 35. Relationship between fork length and body weight for Dourada *Brachyplatystoma flavicans*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

b-6) Sex ratio and female maturity stage

Table 39 summarizes sex ratio and female maturity stage for dourada.

i) Overall sex ratio

Overall sex ratio was 1.18, 1.17 and 1.71 in survey order.

ii) Sex ratio by stratum

Predominance of males occurred only in the 10–20 m stratum in the Phase 2 Rainy Season. Depth-dependency of sex ratio could not be determined because of lack of data. All captured females were immature. According to the study by Loubens et al. (1986) in Bolivia, dourada in Río Mamoré become mature at 81 cm (males) or 97 cm (females), and spawn in December. Although there are no subpopulation studies on dourada, if one presumes the subpopulation of dourada is the same all over the Amazon Basin, the estuary should not be their spawning ground, but rather their nursery and feeding ground.

**Table 39. Sex ratio and female maturity stage for Dourada *Brachyplatystoma flavicans*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 43 | 0 | 0 | 43 | 40 | 1.08 |
| 10 - 20 | 30 | 0 | 0 | 30 | 9 | 3.33 |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 40 | 0 | 0 | 40 | 34 | 1.18 |

(B)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 63 | 0 | 0 | 63 | 47 | 1.34 |
| 10 - 20 | 31 | 0 | 0 | 31 | 43 | 0.72 |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 54 | 0 | 0 | 54 | 46 | 1.17 |

(C)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 77 | 0 | 0 | 77 | 44 | 1.75 |
| 10 - 20 | 82 | 0 | 0 | 82 | 59 | 1.39 |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 77 | 0 | 0 | 77 | 45 | 1.71 |

iii) Sex ratio by size class

Data obtained in all seasons through the multi-item biological measurement were grouped into each 2 cm size class. Frequency of number of individuals in these groups by sex (male, female, indeterminate) is presented in Figure 36. A size-dependent change in sex ratio was not observed in each season; however, in the classes except some ones above 34 cm there was a predominance of females in the Phase 2 Dry Season. On the other hand, sex composition in terms of the previously defined categories of small (under 20 cm), intermediate-size and large fish (50 cm being established as a lower boundary for the latter, for convenience) was as follows, in survey order (M, male; F, female; I, indeterminate sex):

(1) small fish

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| M 0% | F 0% | I 100% | M 15% | F 5% | I 80% | M 0% | F 1% | I 99% |

(2) intermediate-size fish

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| M 40% | F 43% | I 18% | M 37% | F 50% | I 13% | M 34% | F 59% | I 7% |

(3) large fish

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| M 44% | F 55% | I 1% | M 45% | F 55% | I 0% | M 38% | F 62% | I 0% |

b-7) Feeding habits

Table 40 presents the results of stomach contents analysis via the occurrence method. Seventy to eighty percent of the examined stomachs were empty. An overturned stomach was observed from an individual during the Phase 2 Dry Season Survey. Dourada fed mainly on fish, and sometimes on shrimp, regardless of season. Most of the unidentified stomach contents referred to small fish under 20 cm: these small dourada probably feed on microbenthos just like piramutaba.

**Table 40. Stomach contents of Dourada *Brachyplatystoma flavicans*.**

| Phase | Survey season | Number of specimens | Empty stomach rate (%) | Evert rate (%) | Stomach contents by the occurrence method (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Fish | Crustacea | | Unidentified |
| | | | | | | Shrimp | Isopoda | |
| 1 | Dry | 194 | 82 | | 69 | 3 | 3 | 25 |
| 2 | Rainy | 440 | 71 | | 72 | 11 | | 18 |
| | Dry | 310 | 78 | 0.1 | 67 | 10 | | 22 |

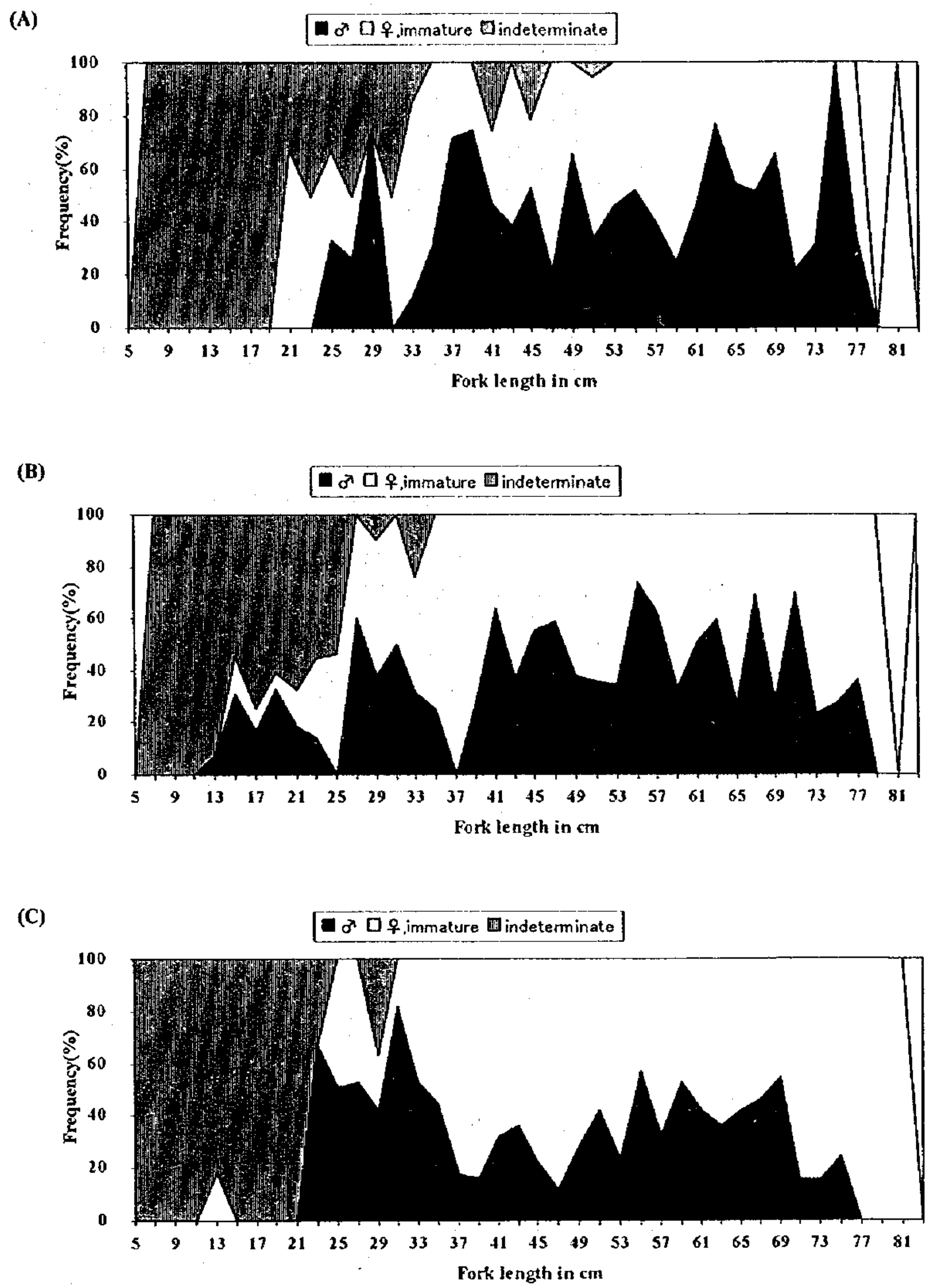



Figure 36. Frequency of male, female and indeterminate sex individuals by length class for Dourada *Brachyplatystoma flavicans*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

### (c) Filhote *Brachyplatystoma filamentosum*

c-1) Body length range and mean body length

Table 41 shows fork length range and mean fork length values for filhote. The number of captured filhote specimens was 3 in each Dry Season and 12 in the Rainy Season, making up a total of 18 — much lower than that of the previous two species. Thus, only overall body length is analyzed here, without considering its variation by stratum or water mass region. Throughout the surveys the maximum size found was 670 mm, and the minimum size 140 mm. Specimens in the 90–140 cm range like those observed at the Ver-o-Peso Market in Belém (see Figure 123) were not found in the survey area. On the other hand, the existence of young fish measuring about 15 cm could be confirmed. Mean fork length was larger in the Rainy Season (42 cm) than in the Dry Seasons (34 cm and 37 cm).

**Table 41. Range and mean body length 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.**

(A)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 610 | 140 | - | 140 | 610 | - |
| Maximum | 610 | 260 | - | 260 | 610 | - |
| Mean | 610 | 200 | - | 200 | 610 | - |
| All area : Min. 140, Max. 610, Mean 337 | | | | | | |

(B)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 159 | - | - | 159 | 250 | - |
| Maximum | 670 | - | - | 670 | 635 | - |
| Mean | 424 | - | - | 426 | 423 | - |
| All area : Min. 159, Max. 670, Mean 424 | | | | | | |

(C)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 285 | - | - | 285 | - | - |
| Maximum | 460 | - | - | 460 | - | - |
| Mean | 365 | - | - | 365 | - | - |
| All area : Min. 285, Max. 460, Mean 365 | | | | | | |

c-2) Relationship between bottom salinity and size

Figure 37 shows the relationship between salinity of the bottom layer and size for filhote. With a single exception, fish of all sizes were distributed where salinity was less than 5 psu, particularly in river waters (< 1 psu).

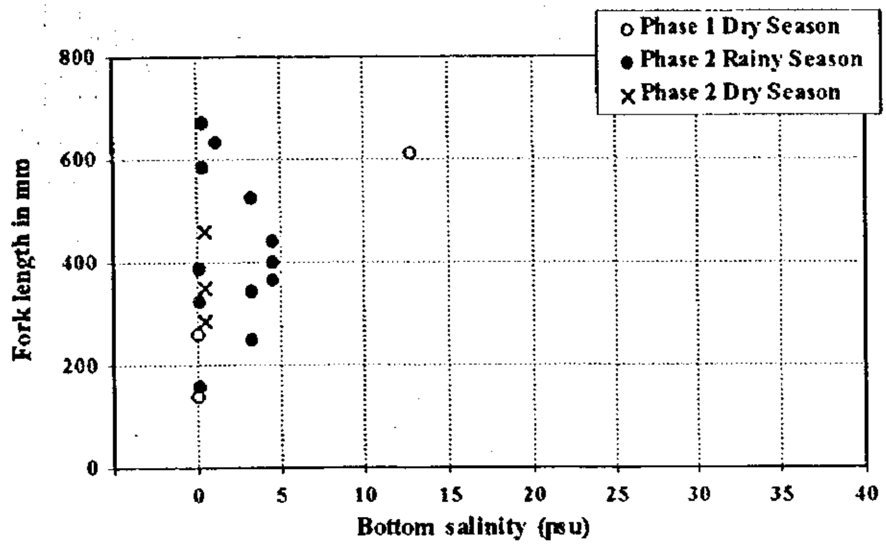



**Figure 37. Relationship between bottom salinity and size in Filhote *Brachyplatystoma filamentosum*.**

c-3) Size composition

Figure 38 shows the size composition for filhote, with data obtained from the multi-item biological measurement. Data were insufficient for an analysis of the characteristics of size composition.

c-4) Body length and weight relationship

Figure 39 summarizes the relationship between fork length and body weight for filhote, determined from data obtained through the multi-item biological measurement; insufficiency of samples made it necessary to combine data from all three seasons. The resulting regression equation for the total number of male, female and sexually indeterminate individuals was:

$$BW = 9 \times FL^{3.0467} \times 10^{-6} \quad (r = 0.995)$$

which closely resembles that established by Barthem et al. (1997) as $BW = 13.6 \times FL^{2.984} \times 10^{-5}$ ($r = 0.966$).

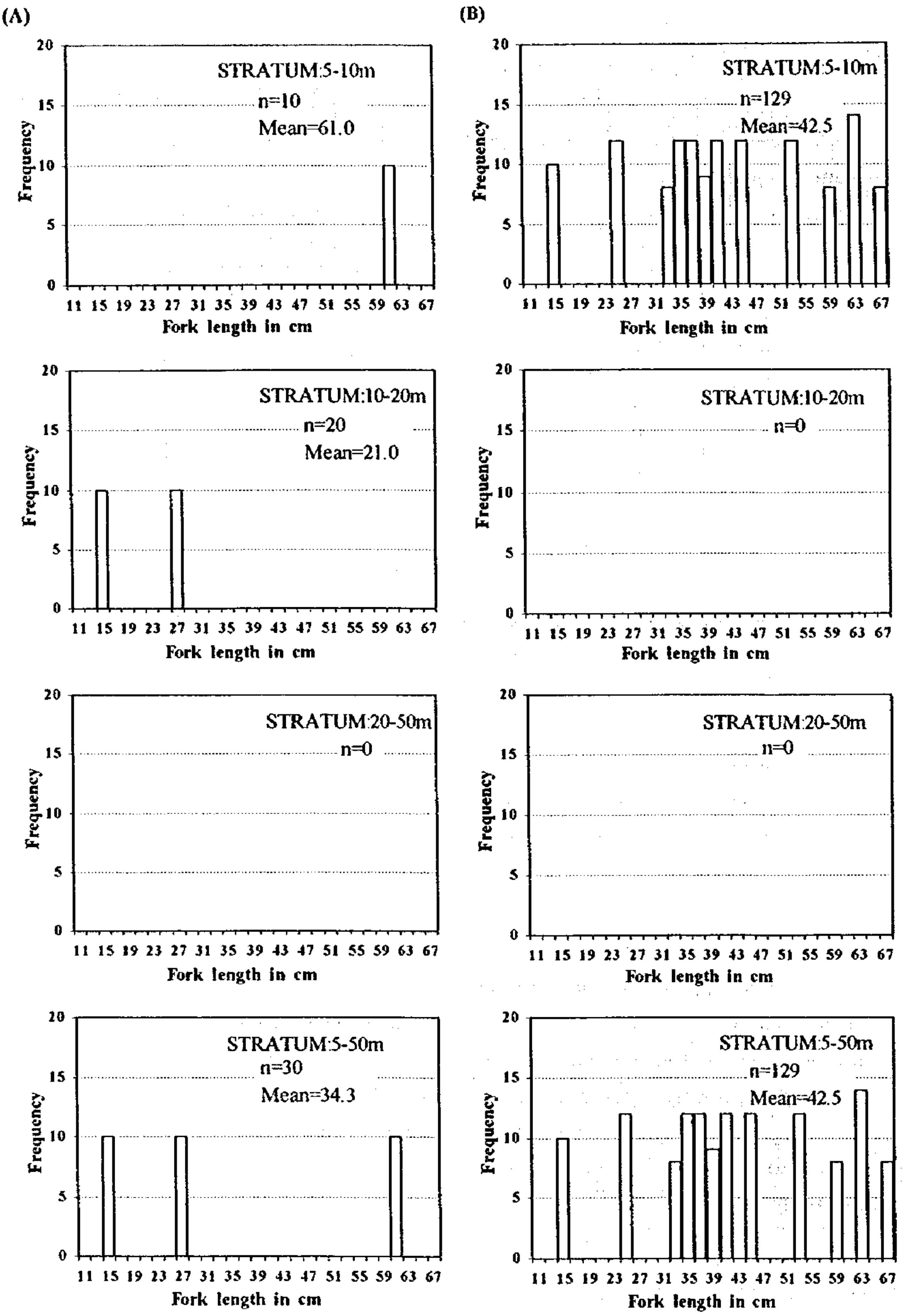
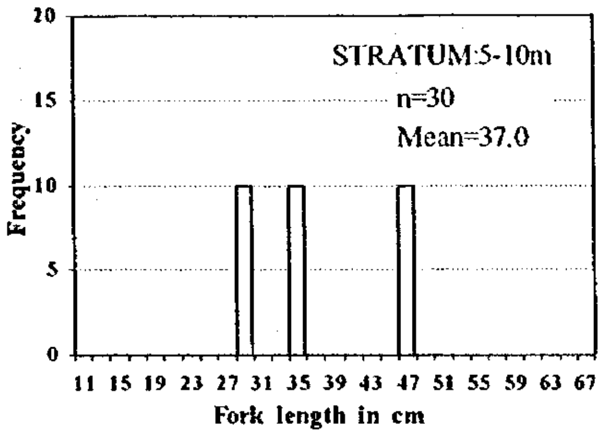
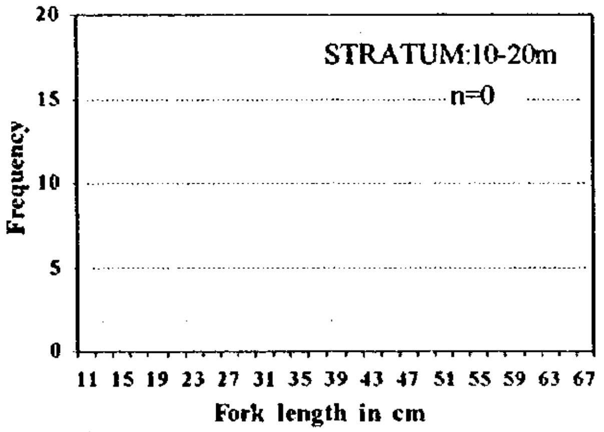


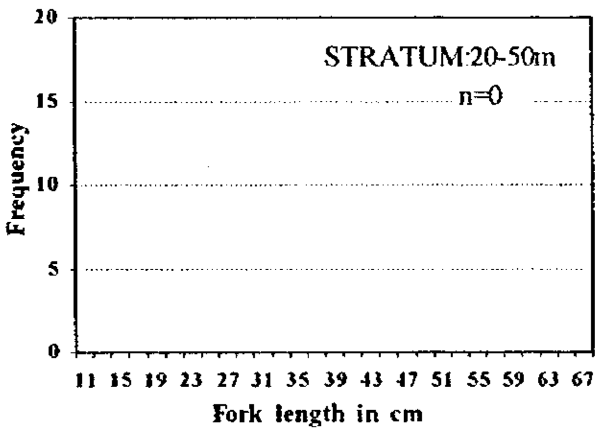

Figure 38. Size composition for Filhote *Brachyplatystoma filamentosum.* (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

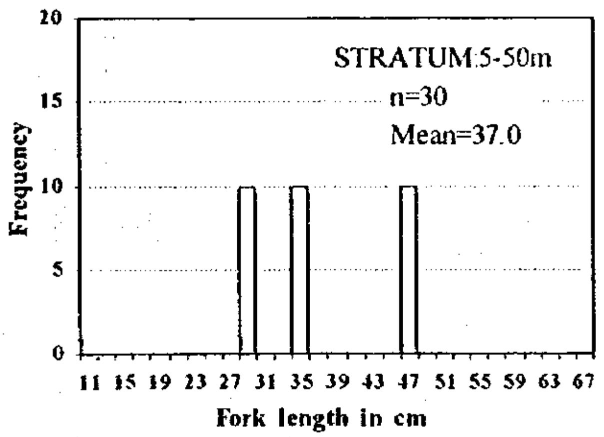
Figure 38. Continued

(C)



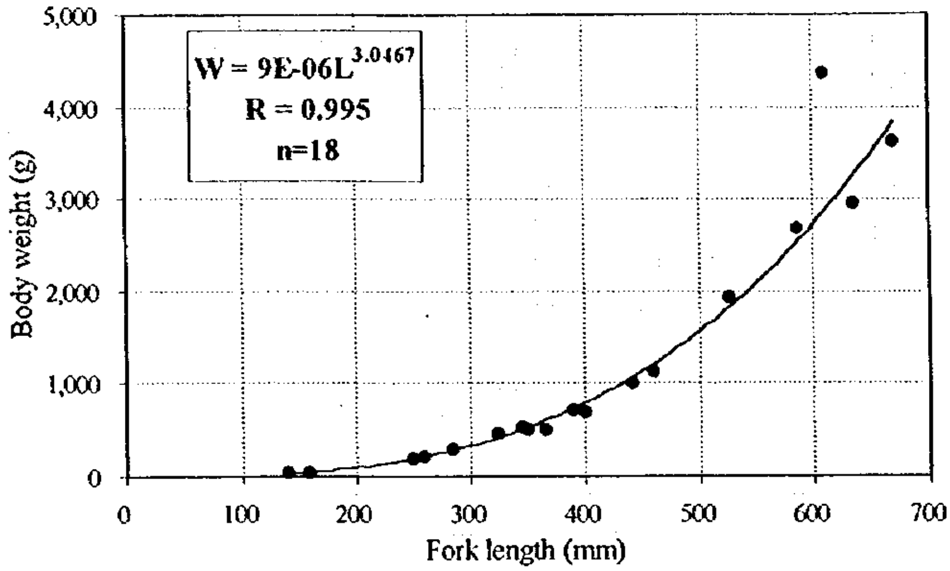



**Figure 39. Relationship between fork length and body weight for Filhote *Brachyplatystoma filamentosum*. Data combined from all three seasonal surveys.**

c-5) Body length and weight by sex

Table 42 summarizes fork length and body weight by sex for filhote. Although the sample was small, a tendency of females to grow larger than males was observed. Minimum size for visual detection of sexual dimorphism was smaller in males than in females. Data are insufficient to determine whether males mature earlier.

**Table 42. Body length and weight by sex for Filhote *Brachyplatystoma filamentosum*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | - | - | - | - |
| Female | 610 | 610 | 4,380 | 4,380 |
| Indeterminate | 140 and 260 | 200 | 40 and 200 | 120 |

(B)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 250 - 670 | 426 | 180 - 3,640 | 1,245 |
| Female | 325 - 635 | 475 | 470 - 2,960 | 1,568 |
| Indeterminate | 159 | 159 | 46 | 46 |

(C)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 285 | 285 | 290 | 290 |
| Female | 350 - 460 | 405 | 500 - 1,130 | 815 |
| Indeterminate | - | - | - | - |

c-6) Sex ratio and female maturity stage

Table 43 summarizes sex ratio and female maturity stage for filhote. The small sample size of 18 individuals prevented an accurate determination of sex ratio. Captured specimens were 7 males, 8 females and 3 indeterminate. All females were immature.

**Table 43. Sex ratio and female maturity stage for Filhote *Brachyplatystoma filamentosum.* (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 43 | 0 | 0 | 43 | 0 | - |
| 10 - 20 | 0 | 0 | 0 | 0 | 0 | - |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 43 | 0 | 0 | 43 | 0 | - |

(B)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 7 | 0 | 0 | 7 | 10 | 0.70 |
| 10 - 20 | 0 | 0 | 0 | 0 | 0 | - |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 7 | 0 | 0 | 7 | 10 | 0.70 |

(C)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 20 | 0 | 0 | 20 | 10 | 2.00 |
| 10 - 20 | 0 | 0 | 0 | 0 | 0 | - |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 20 | 0 | 0 | 20 | 10 | 2.00 |

c-7) Feeding habits

Table 44 shows the results of stomach contents analysis via the occurrence method. Frequency of empty stomachs was 0% in the Phase 1 Dry Season, 50% in the Phase 2 Rainy Season and 67% in the Phase 2 Dry Season. Filhote would invariably feed on fish, and sometimes shrimp.

**Table 44. Stomach contents of Filhote *Brachyplatystoma filamentosum.***

| Phase | Survey season | Number of specimens | Empty stomach rate ( % ) | Stomach contents by the occurrence method ( % ) Fish | Shrimp |
|---|---|---|---|---|---|
| 1 | Dry | 3 | 0 | 67 | 33 |
| 2 | Rainy | 12 | 50 | 83 | 17 |
| | Dry | 3 | 67 | 100 | |

### (d) Pescada branca *Plagioscion squamosissimus*

d-1) Body length range and mean body length

Table 45 shows total length range and mean total length values for pescada branca.

i) Overall body length

Throughout the surveys the maximum size found was 672 mm, and the minimum size 63 mm. The maximum size was close to that observed in Mosqueiro and Ver-o-Peso (Figure 124). Mean total length was larger in the Rainy Season (36 cm) than in the Dry Seasons (20 cm and 22 cm).

ii) Size variation by water mass region

Mean total length was, except for the Phase 1 Dry Season, larger in brackish waters than in river waters, the difference being more accentuated in the Dry Seasons. Maximum and minimum sizes, with a single exception, were found in brackish waters.

**Table 45. Range and mean body length 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.**

(A)

| Total length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 87 | - | - | 163 | 87 | - |
| Maximum | 573 | - | - | 522 | 573 | - |
| Mean | 215 | - | - | 377 | 150 | - |

All area : Min. 87, Max. 573, Mean 215

(B)

| Total length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 82 | - | - | 120 | 82 | - |
| Maximum | 672 | - | - | 580 | 672 | - |
| Mean | 358 | - | - | 336 | 407 | - |

All area : Min. 82, Max. 672, Mean 358

(C)

| Total length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 63 | - | - | 63 | 290 | - |
| Maximum | 645 | - | - | 590 | 645 | - |
| Mean | 203 | - | - | 156 | 533 | - |

All area : Min. 63, Max. 645, Mean 203

d-2) Relationship between bottom salinity and size

Figure 40 shows the relationship between salinity of the bottom layer and size for pescada branca. Individuals of all sizes were concentrated in river waters, but small fish of about 20 cm were where salinity was up to 10 psu, while large ones of about 60 cm would spread out into places where salinity would register near 15 psu.

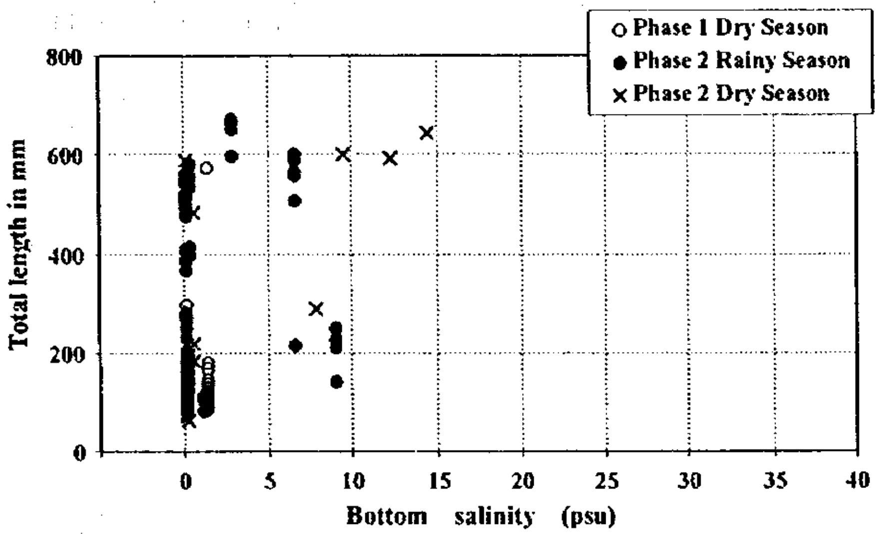



**Figure 40. Relationship between bottom salinity and size in Pescada branca *Plagioscion squamosissimus.***

d-3) Size composition

Figure 41 illustrates the size composition for pescada branca, with data taken via the multi-item biological measurement.

Size composition for this species was obtained only in the 5–10 m stratum. In all survey seasons, size composition exhibited poly-modal distribution, but there were not enough data to establish an accurate distribution pattern. Size composition of pescada branca revealed this stock was mostly formed by small fish (predominant mode at 10–12 cm class) in the Dry Seasons, and small fish (dominant mode at 12–14 cm class) and large fish (dominant mode at 50–52 cm class) in the Rainy Season.

d-4) Body length and weight relationship

Figure 42 summarizes the relationship between total length and body weight for pescada branca, determined from data obtained through the multi-item biological measurement. Resulting regression equations for the total number of male, female and sexually indeterminate individuals were:

Phase 1 Dry Season Survey: $BW = 9 \times TL^{2.9914} \times 10^{-6}$ (r = 0.996)

Phase 2 Rainy Season Survey: $BW = 8 \times TL^{3.0545} \times 10^{-6}$ (r = 0.994)

Phase 2 Dry Season Survey: $BW = 7 \times TL^{3.0455} \times 10^{-6}$ (r = 0.994)

These equations are very similar to each other and also resemble those established by Le Guennec (1985) as $BW = 1.343 \times TL^{3.09149} \times 10^{-5}$ (r = 0.997) in Bolivian Amazonia.

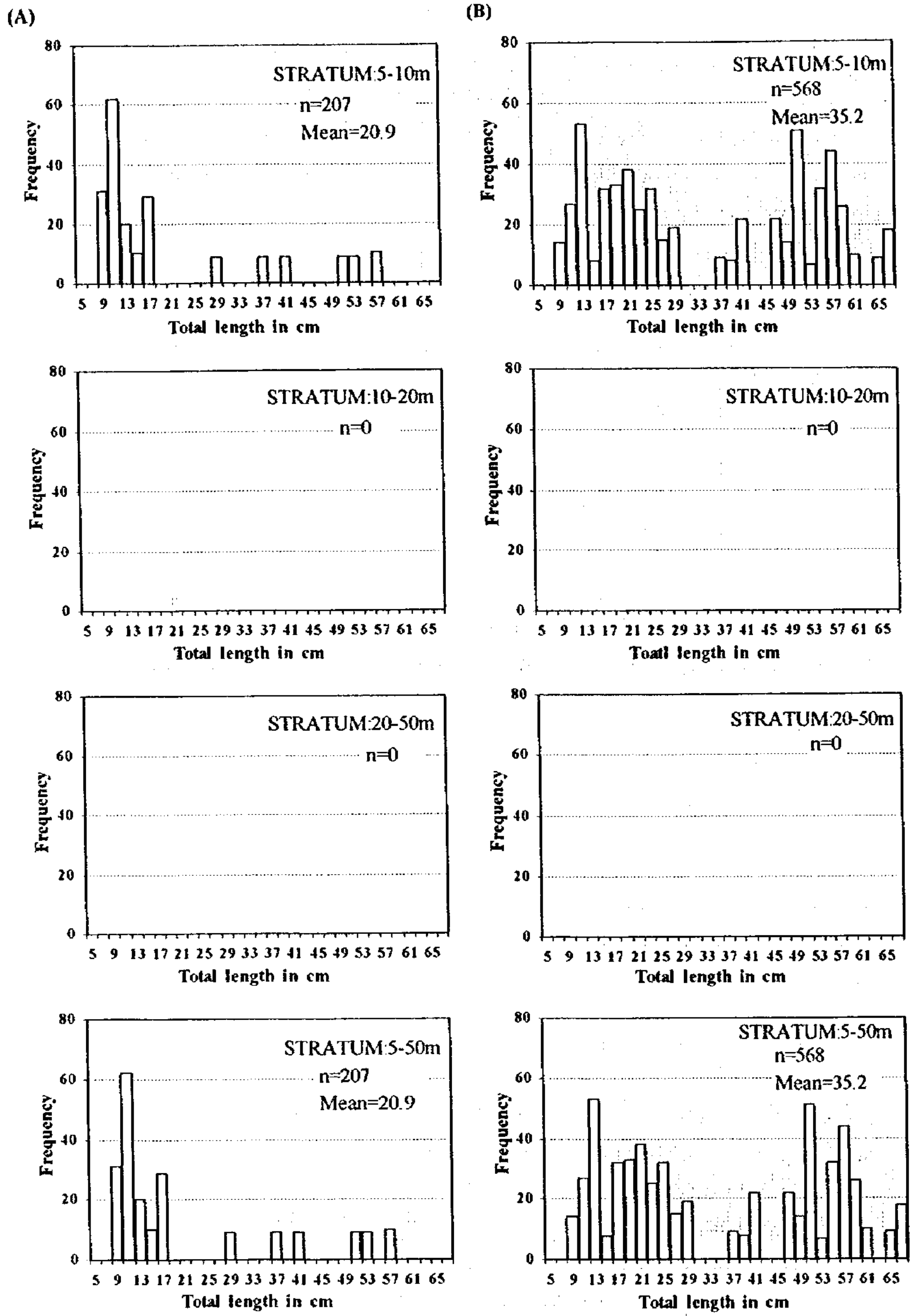
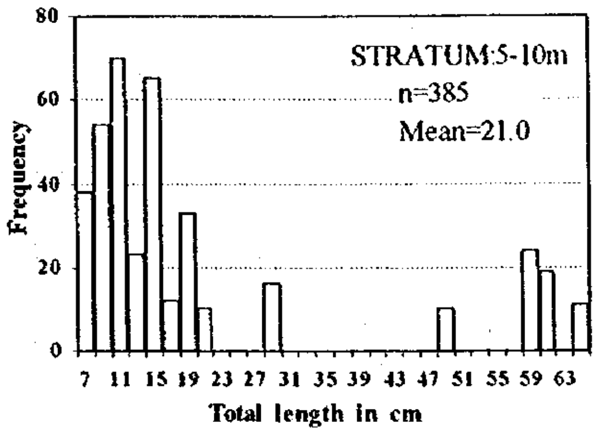
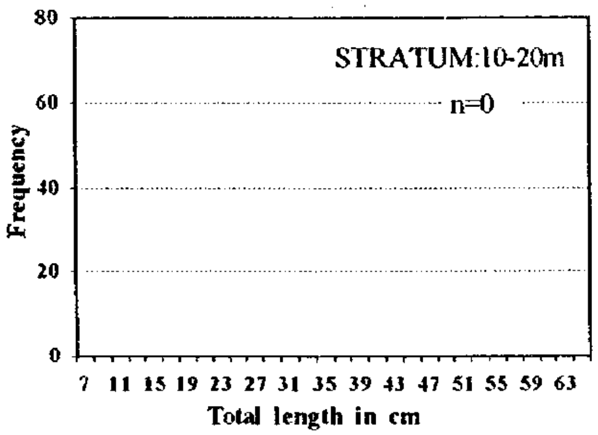


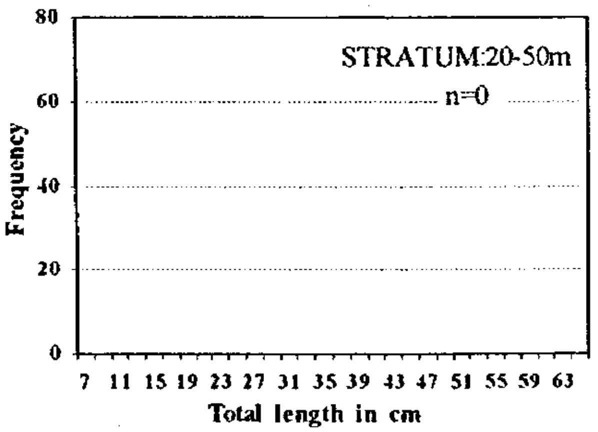

Figure 41. Size composition for Pescada branca *Plagioscion squamosissimus.* (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

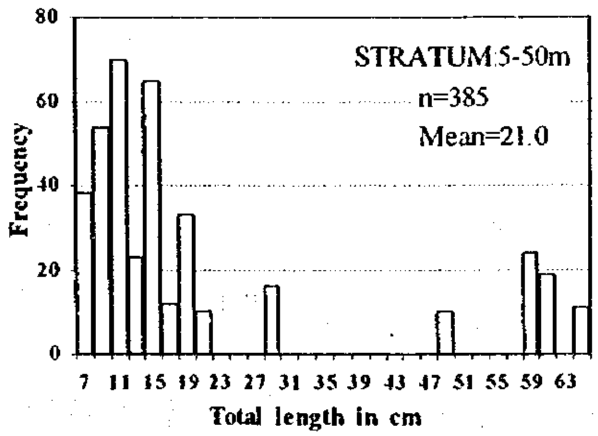
Figure 41. Continued

(C)



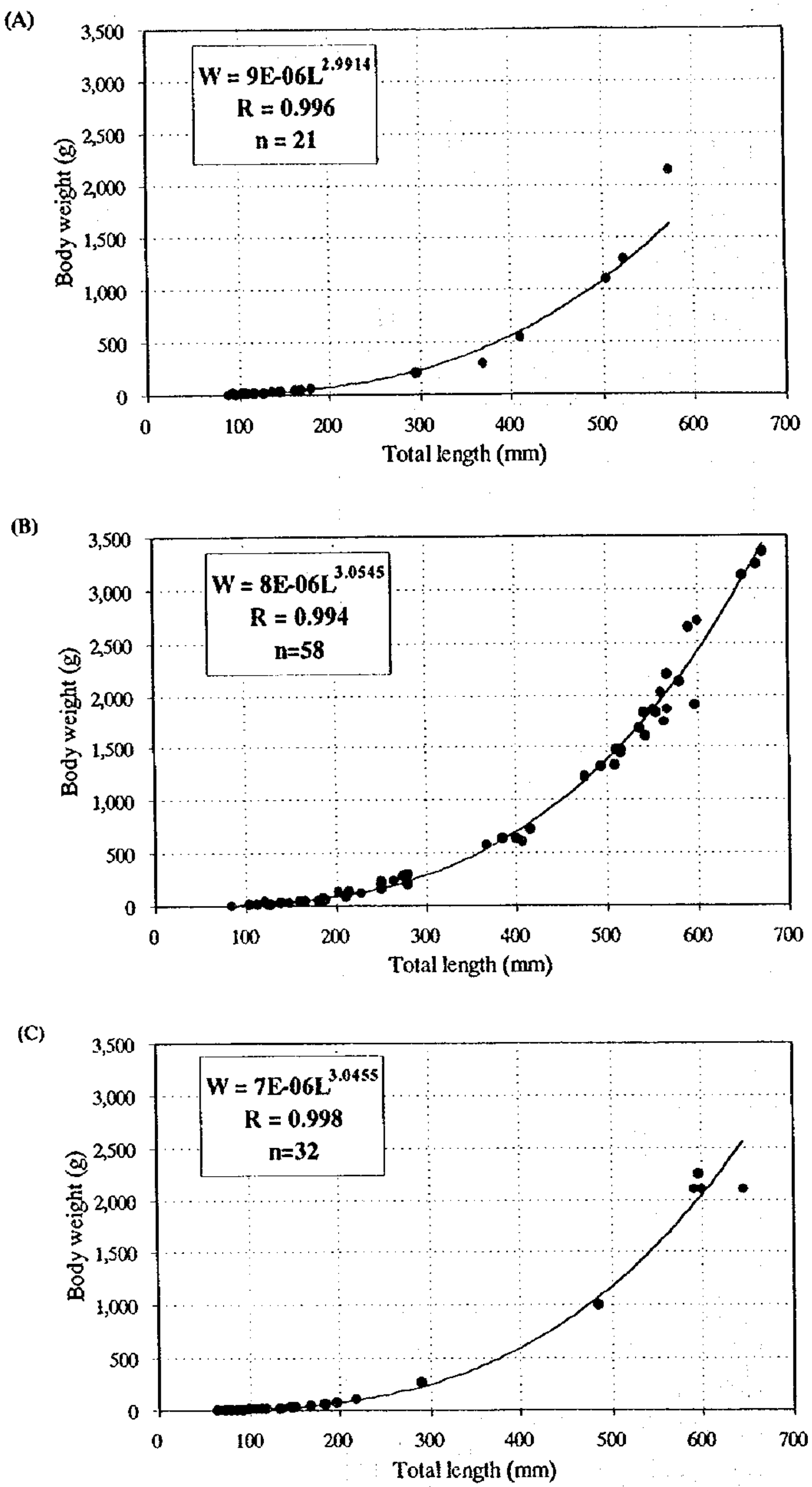



**Figure 42. Relationship between total length and body weight for Pescada branca *Plagioscion squamosissimus*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

d-5) Body length and weight by sex

Table 46 summarizes total length and body weight by sex for pescada branca. With one exception (a single male specimen) in the Phase 2 Dry Season, mean total length and mean weight was larger in females than in males. Development of reproductive organs allowing visual detection of sexual dimorphism started around 15 cm and 30 g for both sexes. The amplitude of individual variation in the development of reproductive organs was suggested by the occurrence of sexually indeterminate individuals of 40 cm (Figure 43) or 600 g.

**Table 46. Body length and weight by sex for Pescada branca *Plagioscion squamosissimus*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Sex | Total length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 145 - 522 | 334 | 32 - 1,300 | 666 |
| Female | 410 - 573 | 495 | 550 - 2,150 | 1,267 |
| Indeterminate | 87 - 368 | 147 | 5 - 300 | 48 |

(B)

| Sex | Total length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 147 - 597 | 344 | 27 - 2,020 | 707 |
| Female | 139 - 672 | 472 | 24 - 3,350 | 1,543 |
| Indeterminate | 82 - 385 | 172 | 4 - 640 | 105 |

(C)

| Sex | Total length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 645 | 645 | 2,100 | 2,100 |
| Female | 485 - 600 | 568 | 1,000 - 2,250 | 1,860 |
| Indeterminate | 63 - 290 | 133 | 2 - 260 | 33 |

d-6) Sex ratio and female maturity stage

i) Sex ratio and female maturity stage

Table 47 summarizes sex ratio and female maturity stage for pescada branca. Overall sex ratio was 1.50, 1.21 and 5.00 in survey order, but the reliability of those numbers is questionable due to insufficient data. Mature females were observed in the Phase 1 Dry Season and in the Phase 2 Rainy Season. In the Phase 1 Dry Season ovaries indicating post-spawning (spent) condition were also found. Females in the Phase 2 Dry Season were immature or semi-mature. This does not allow one to necessarily conclude that the survey area is a spawning ground for pescada branca, as the inland (freshwater) geographical distribution of the individual population inhabiting the survey area is unknown, much as the subpopulation distribution or the life history of the species.

**Table 47. Sex ratio and female maturity stage for Pescada branca *Plagioscion squamosissimus*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Stratum | Number of female ♀ by maturity stage | | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Spent | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 0 | 5 | 5 | 5 | 15 | 10 | 1.50 |
| 10 - 20 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 0 | 5 | 5 | 5 | 15 | 10 | 1.50 |

(B)

| Stratum | Number of female ♀ by maturity stage | | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Spent | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 9 | 2 | 6 | 0 | 17 | 14 | 1.21 |
| 10 - 20 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 9 | 2 | 6 | 0 | 17 | 14 | 1.21 |

(C)

| Stratum | Number of female ♀ by maturity stage | | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Spent | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 1 | 4 | 0 | 0 | 5 | 1 | 5.00 |
| 10 - 20 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| All stratum | 1 | 4 | 0 | 0 | 5 | 1 | 5.00 |

ii) Sex ratio by size class

Data obtained in all seasons through the multi-item biological measurement were grouped into each 2 cm size classes. Frequency of number of individuals in these groups by sex (male, female, indeterminate) is presented in Figure 43. Seasonal data were insufficient to verify the occurrence of size-dependent change in sex ratio. Size groups were defined as follows: small fish, under 20 cm; intermediate-size fish, in the 20–40 cm range; and large fish, over 40 cm. Sex composition of those groups (M, male; F, female; I, indeterminate sex) was as follows, in survey order, with female maturity condition indicated in parentheses in the following order: immature - semi-mature - mature - spent.

(1) small fish

| | | | | | |
|---|---|---|---|---|---|
| M | 6% | F | 0% | I | 94% |
| M | 28% | F | 15% (100% - 0% - 0% - 0%) | I | 57% |
| M | 0% | F | 0% | I | 100% |

(2) intermediate-size fish

| | | | | | |
|---|---|---|---|---|---|
| M | 0% | F | 0% | I | 100% |
| M | 46% | F | 27% (100% - 0% - 0% - 0%) | I | 27% |
| M | 0% | F | 0% | I | 100% |

(3) large fish

| | | | | | |
|---|---|---|---|---|---|
| M | 24% | F | 76% ( 0% - 32% - 32% - 36%) | I | 0% |
| M | 31% | F | 69% ( 36% - 19% - 45% - 0%) | I | 0% |
| M | 17% | F | 83% ( 19% - 81% - 0% - 0%) | I | 0% |

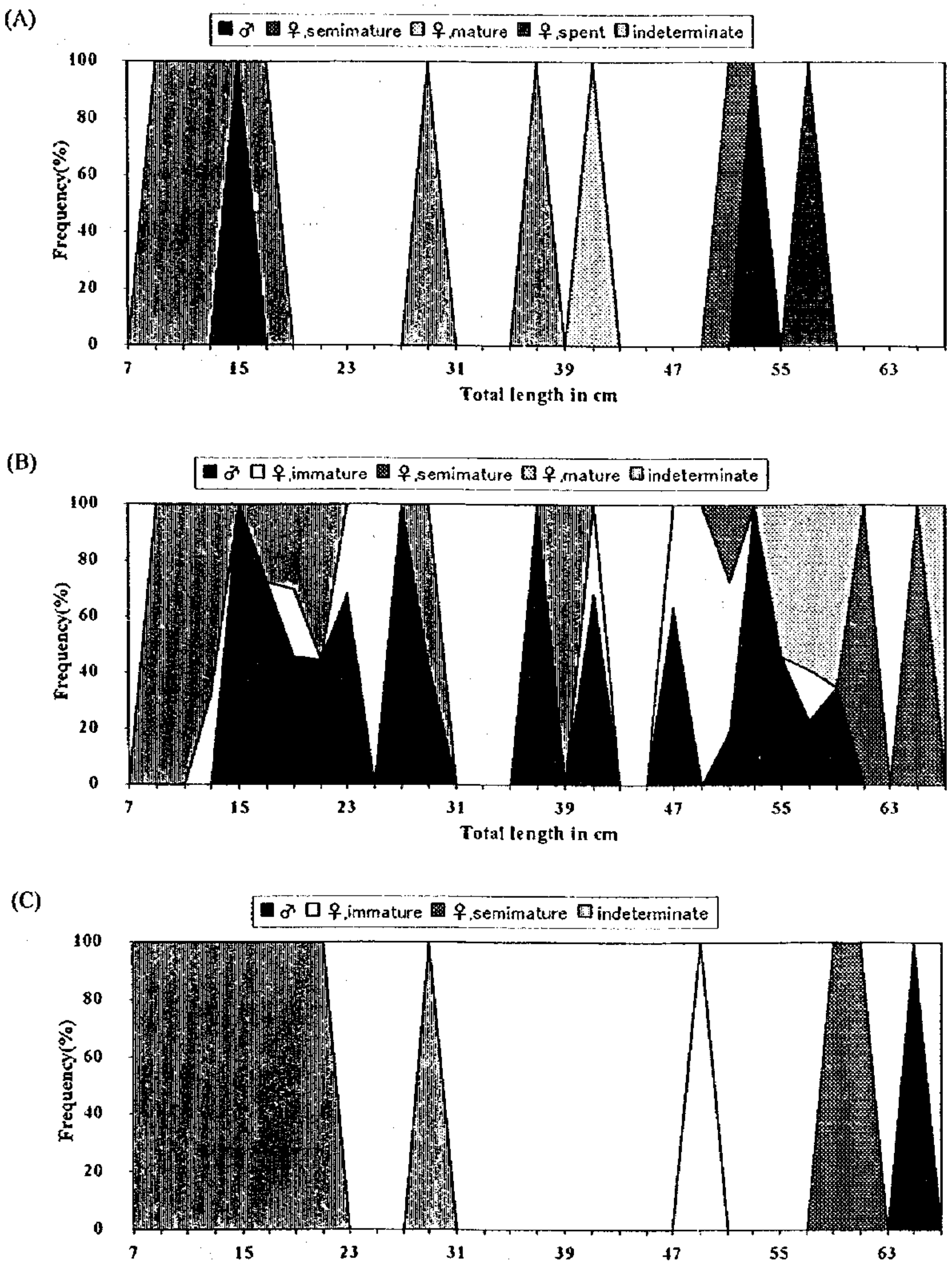



Figure 43. Frequency of male, female and indeterminate sex individuals by length class for Pescada branca *Plagioscion squamosissimus*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

d-7) Feeding habits

Table 48 presents the results of stomach contents analysis via the occurrence method. The rate of empty stomachs was, in survey order, 24%, 59% and 53%. Pescada branca fed on fish and/or shrimp, regardless of season. Most of the unidentified stomach contents referred to fish under 10 cm.

**Table 48. Stomach contents of Pescada branca *Plagioscion squamosissimus*.**

| Phase | Survey season | Number of specimens | Empty stomach rate ( % ) | Stomach contents by the occurrence method ( % ) | | |
|---|---|---|---|---|---|---|
| | | | | Fish | Shrimp | Unidentified |
| 1 | Dry | 21 | 24 | 13 | | 88 |
| 2 | Rainy | 58 | 59 | 36 | 20 | 44 |
| | Dry | 32 | 53 | 19 | 56 | 25 |

**(e) Pescada amarela *Cynoscion acoupa***

e-1) Body length range and mean body length

Table 49 shows total length range and mean fork length values for pescada amarela.

i) Overall body length

Throughout the surveys the maximum size found was 1,180 mm, and the minimum size 640 mm. Sizes smaller than 50 cm like those seen in Bragança (Figure 125) were not found in the survey area. Mean total length was in the 92–94 cm range and there was no appreciable seasonal differences.

ii) Size variation by stratum

Mean total length was found to depend on depth, the fish becoming progressively larger from shallow to deep strata.

iii) Size variation by water mass region

In all seasons, mean total length was larger in ocean waters than in brackish waters by an order of 12–17 cm.

**Table 49. Range and mean body length 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.**

(A)

| Total length in mm | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 688 | 882 | 880 | - | 688 | 880 |
| Maximum | 931 | 1,020 | 1,125 | - | 1,020 | 1,125 |
| Mean | 780 | 965 | 1,003 | - | 886 | 1,003 |
| All area : Min. 688, Max. 1,125, Mean 925 | | | | | | |

Table 49. Continued

(B)

| Total length in mm | Stratum ( isobath range in m ) 5 - 10 | 10 - 20 | 20 - 50 | Water mass RW | BW | OW |
|---|---|---|---|---|---|---|
| Minimum | 715 | 640 | 955 | - | 640 | 955 |
| Maximum | 1,010 | 1,180 | 955 | - | 1,080 | 1,180 |
| Mean | 882 | 926 | 955 | - | 900 | 1,068 |
| All area : Min. 640, Max. 1,180, Mean 920 | | | | | | |

(C)

| Total length in mm | Stratum ( isobath range in m ) 5 - 10 | 10 - 20 | 20 - 50 | Water mass RW | BW | OW |
|---|---|---|---|---|---|---|
| Minimum | 660 | 710 | 990 | - | 660 | 828 |
| Maximum | 1,100 | 1,180 | 990 | - | 1,100 | 1,180 |
| Mean | 853 | 982 | 990 | - | 887 | 1,007 |
| All area : Min. 660, Max. 1,180, Mean 935 | | | | | | |

e-2) Relationship between bottom salinity and size

Figure 44 shows the relationship between salinity of the bottom layer and size for pescada amarela. Individuals in the 60–120 cm size range were concentrated in waters with a salinity above 20 psu, particularly in highly saline places of over 30 psu.

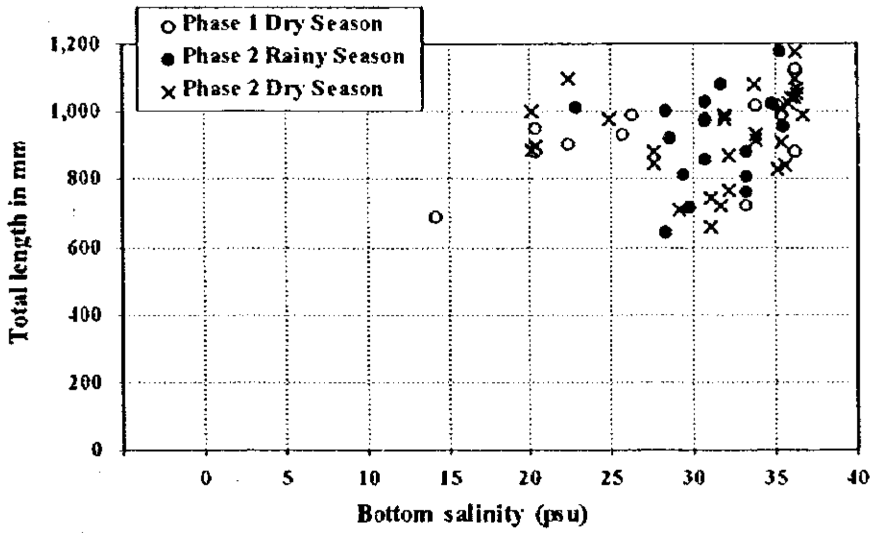



**Figure 44. Relationship between bottom salinity and size in pescada amarela *Cynoscion acoupa.***

e-3) Size composition

Figure 45 illustrates the size composition for pescada amarela, with body length data taken via the multi-item biological measurement. In all survey seasons, overall size composition exhibited poly-modal distribution, with the mode in each stratum tending to be depth-dependent. However, the limited number of samples, particularly the absence of specimens under 60 cm, precluded an accurate analysis of distribution.

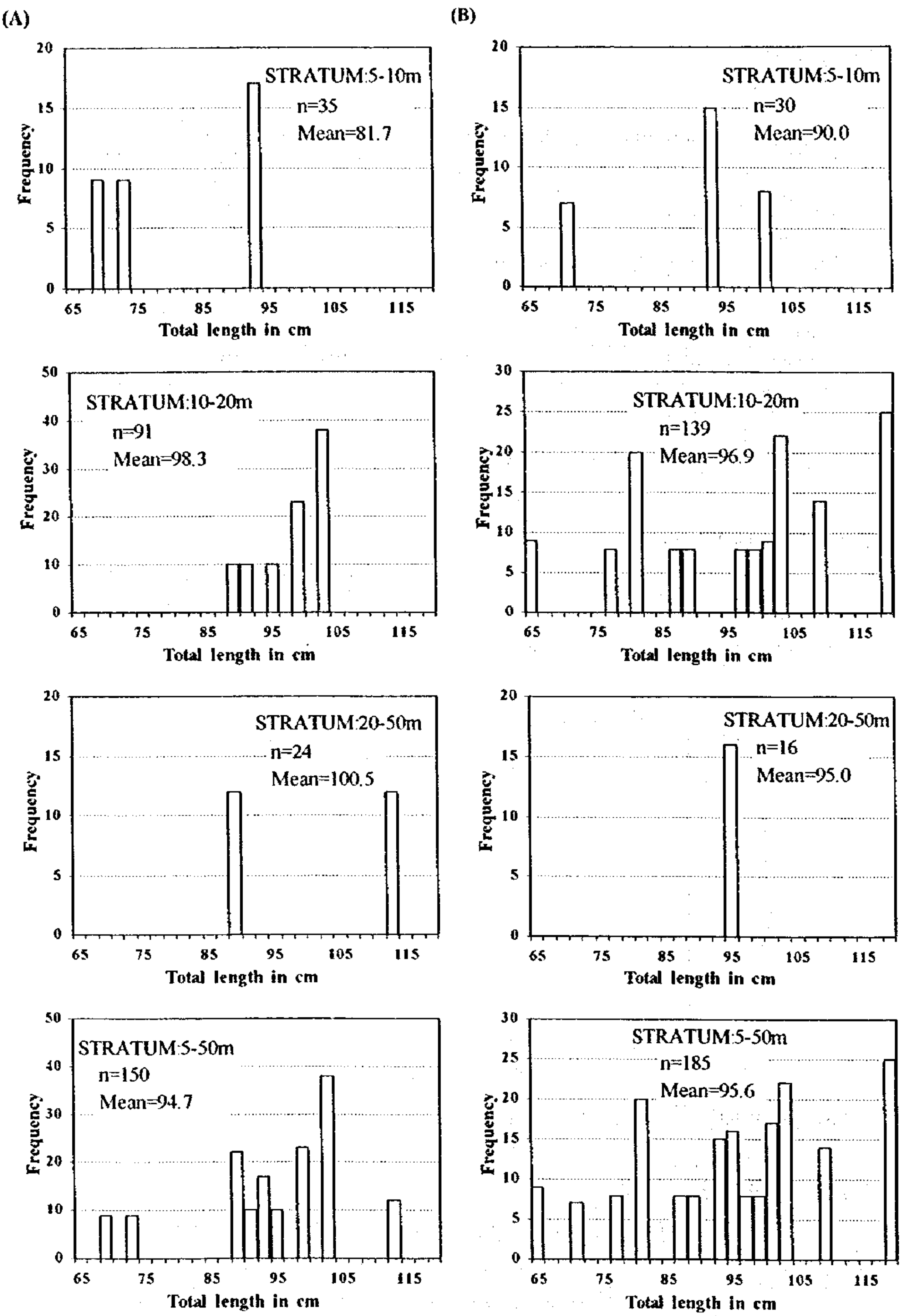
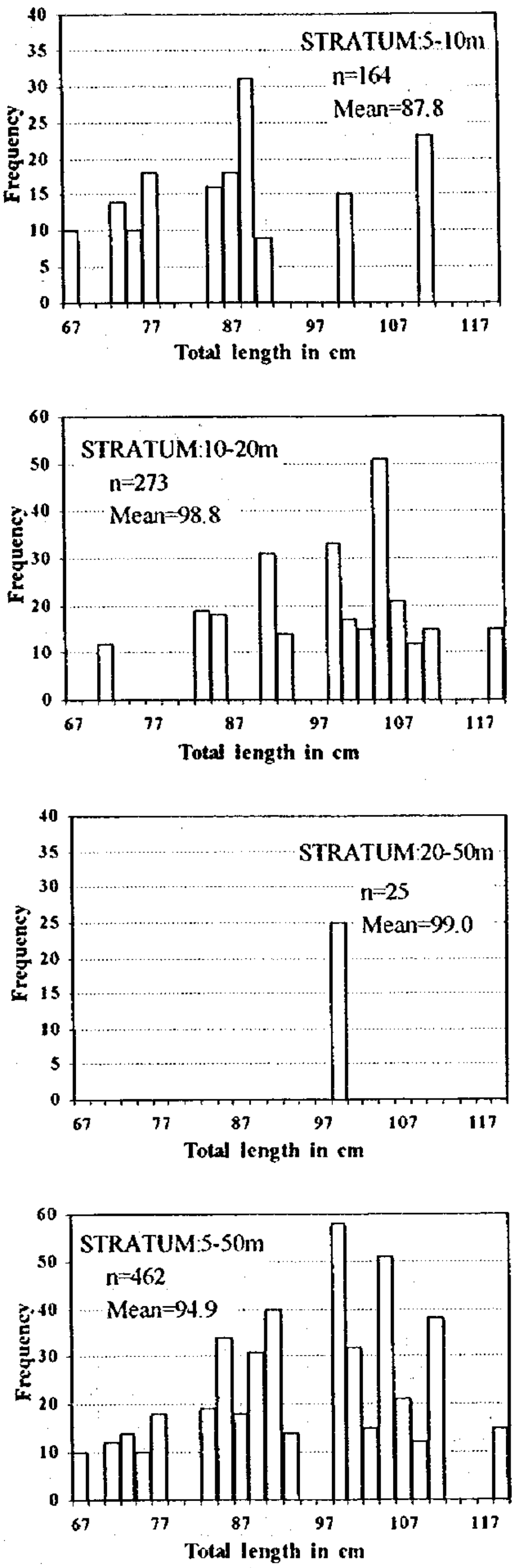



Figure 45. Size composition for Pescada amarela *Cynoscion acoupa*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 45. Continued

(C)



c-4) Body length and weight relationship

Figure 46 summarizes the relationship between total length and body weight for pescada amarela, determined from data obtained through the multi-item biological measurement; insufficiency of samples made it necessary to combine data from all three seasons. The resulting regression equation for the total number of male and female individuals was:

$$BW = 6 \times TL^{2.7380} \times 10^{-5} \quad (r = 0.957)$$

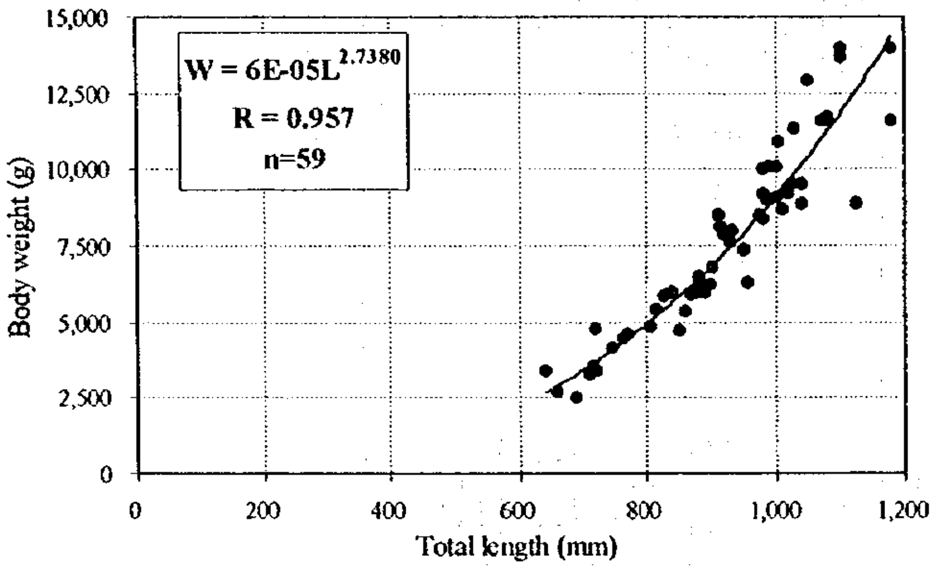



**Figure 46. Relationship between total length and body weight for Pescada amarela *Cynoscion acoupa*. Data combined from all three seasonal surveys.**

c-5) Body length and weight by sex

Table 50 summarizes total length and body weight by sex for pescada amarela. Except in the Phase 1 Dry Season, mean size for females was larger than that for males overall. Sexual difference in size was attained at around 20 cm and 4 kg in the Rainy Season. No specimens with indeterminate sex were found.

**Table 50. Body length and weight by sex for Pescada amarela *Cynoscion acoupa*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Sex | Total length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 722 - 1,125 | 946 | 3,400 - 9,400 | 7,498 |
| Female | 688 - 990 | 883 | 2,500 - 9,000 | 6,425 |

(B)

| Sex | Total length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 610 - 1,025 | 813 | 3,400 - 9,500 | 5,379 |
| Female | 920 - 1,180 | 1,014 | 6,300 - 11,700 | 9,367 |

(C)

| Sex | Total length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 660 - 1,180 | 916 | 2,720 - 14,000 | 8,041 |
| Female | 770 - 1,100 | 967 | 4,600 - 14,000 | 8,755 |

e-6) Sex ratio and female maturity stage

Table 51 summarizes sex ratio and female maturity stage for pescada amarela. Overall sex ratio was 0.36, 1.50 and 0.64 respectively in survey order, but the reliability of those numbers is questionable due to insufficient data. Mature females were observed throughout the surveys.

**Table 51. Sex ratio and female maturity stage for Pescada amarela *Cynoscion acoupa*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 3 | 0 | 0 | 3 | 9 | 0.33 |
| 10 - 20 | 2 | 2 | 2 | 6 | 10 | 0.60 |
| 20 - 50 | 0 | 0 | 0 | 0 | 23 | - |
| All stratum | 2 | 1 | 1 | 4 | 11 | 0.36 |

(B)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 0 | 0 | 8 | 8 | 2 | 4.00 |
| 10 - 20 | 0 | 7 | 2 | 9 | 8 | 1.13 |
| 20 - 50 | 0 | 16 | 0 | 16 | 0 | - |
| All stratum | 0 | 6 | 3 | 9 | 6 | 1.50 |

(C)

| Stratum | Number of female ♀ by maturity stage | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 0 | 12 | 3 | 15 | 8 | 1.88 |
| 10 - 20 | 0 | 5 | 1 | 6 | 17 | 0.35 |
| 20 - 50 | 0 | 0 | 0 | 0 | 25 | - |
| All stratum | 0 | 7 | 2 | 9 | 14 | 0.64 |

e-7) Feeding habits

Table 52 presents the results of stomach contents analysis via the occurrence method. The rate of empty stomachs was about 40% in each season. Overturned stomachs were observed for 6 individuals in the Phase 2 Dry Season Survey. Pescada amarela fed on fish and occasionally on shrimp, regardless of season.

**Table 52. Stomach contents of Pescada amarela *Cynoscion acoupa*.**

| Phase | Survey season | Number of specimens | Empty stomach rate ( % ) | Evert rate (%) | Stomach contents by the occurrence method ( % ) Fish | Shrimp |
|---|---|---|---|---|---|---|
| 1 | Dry | 12 | 42 | | 100 | 0 |
| 2 | Rainy | 17 | 35 | | 83 | 17 |
| | Dry | 30 | 40 | 20 | 79 | 21 |

**(f) Pescadinha gó *Macrodon ancylodon***

f-1) Body length range and mean body length

Table 53 shows total length range and mean total length values for pescadinha gó.

i) Overall body length

Throughout the surveys the maximum size found was 385 mm, and the minimum size 38 mm. Maximum size was similar to that found at Ver-o-Peso (see Figure 126). Mean total length was in the 16-17 cm range, with no particular regard to season.

ii) Size variation by stratum

Mean total length was depth-dependent in all seasons, generally growing from shallower (14–15 cm) to deeper (19 cm) strata.

iii) Size variation by water mass region

Mean total length was, for all seasonal surveys, larger in ocean than in brackish waters, the difference being in the order of 2–3 cm.

**Table 53. Range and mean body length 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.**

(A)

| Total length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 49 | 58 | 66 | - | 49 | 60 |
| Maximum | 326 | 375 | 345 | - | 375 | 363 |
| Mean | 135 | 174 | 185 | - | 156 | 178 |

All area : Min. 49, Max. 375, Mean 160

(B)

| Total length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 64 | 63 | 90 | - | 64 | 63 |
| Maximum | 344 | 385 | 341 | - | 385 | 365 |
| Mean | 152 | 162 | 191 | - | 156 | 186 |

All area : Min. 63, Max. 385, Mean 161

(C)

| Total length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 38 | 41 | 90 | - | 38 | 41 |
| Maximum | 337 | 374 | 320 | - | 374 | 360 |
| Mean | 143 | 176 | 191 | - | 161 | 180 |

All area : Min. 38, Max. 374, Mean 167

f-2) Relationship between bottom salinity and size

Figure 47 shows the relationship between salinity of the bottom layer and size for pescadinha gó. Specimens under 20 cm were well spread out, from estuarine sites greatly influenced by river waters (salinity around 2 psu) to ocean waters (around 36 psu). Individual distribution of fish over 20 cm in size reflected dependency on salinity — the larger the size, the more saline their habitat.

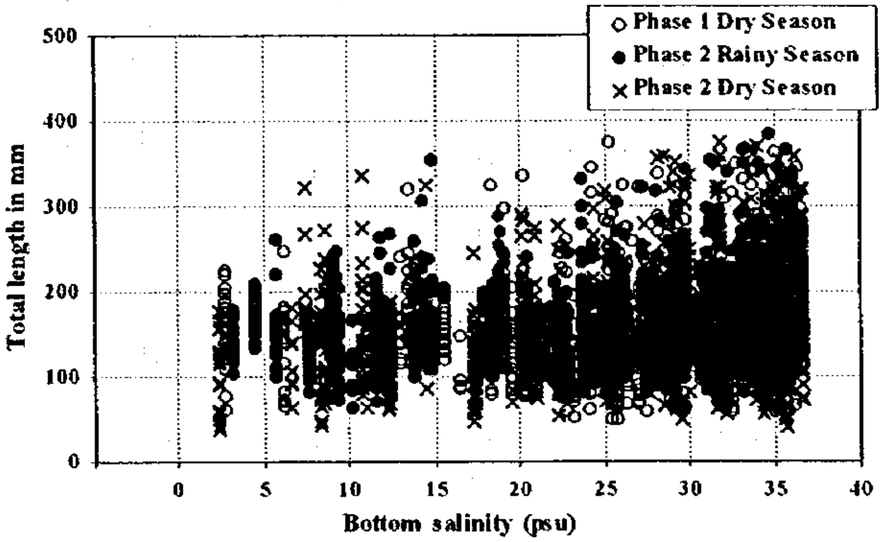



**Figure 47. Relationship between bottom salinity and size in Pescadinha gó *Macrodon ancylodon*.**

f-3) Size composition

Figure 48 shows the size composition for pescadinha gó, with body length data taken via both the measuring-card punching method and the multi-item biological measurement.

i) Overall size composition

Disregarding some low-peak, poorly defined modes, overall size composition exhibited a distribution that can be considered mono-modal, with a mode between 15–18 cm classes, in all survey seasons. Pescadinha gó stocks were mainly formed by intermediate-size fish with a above-mentioned mode.

ii) Size composition by stratum

In the same conditions as above, size composition by stratum in all survey seasons had a mono-modal distribution. For each survey season, the predominant mode class by stratum was found to be depth-dependent, its becoming larger from shallow to deep strata. Therefore, pescadinha gó stocks comprised larger individuals as depth increased.

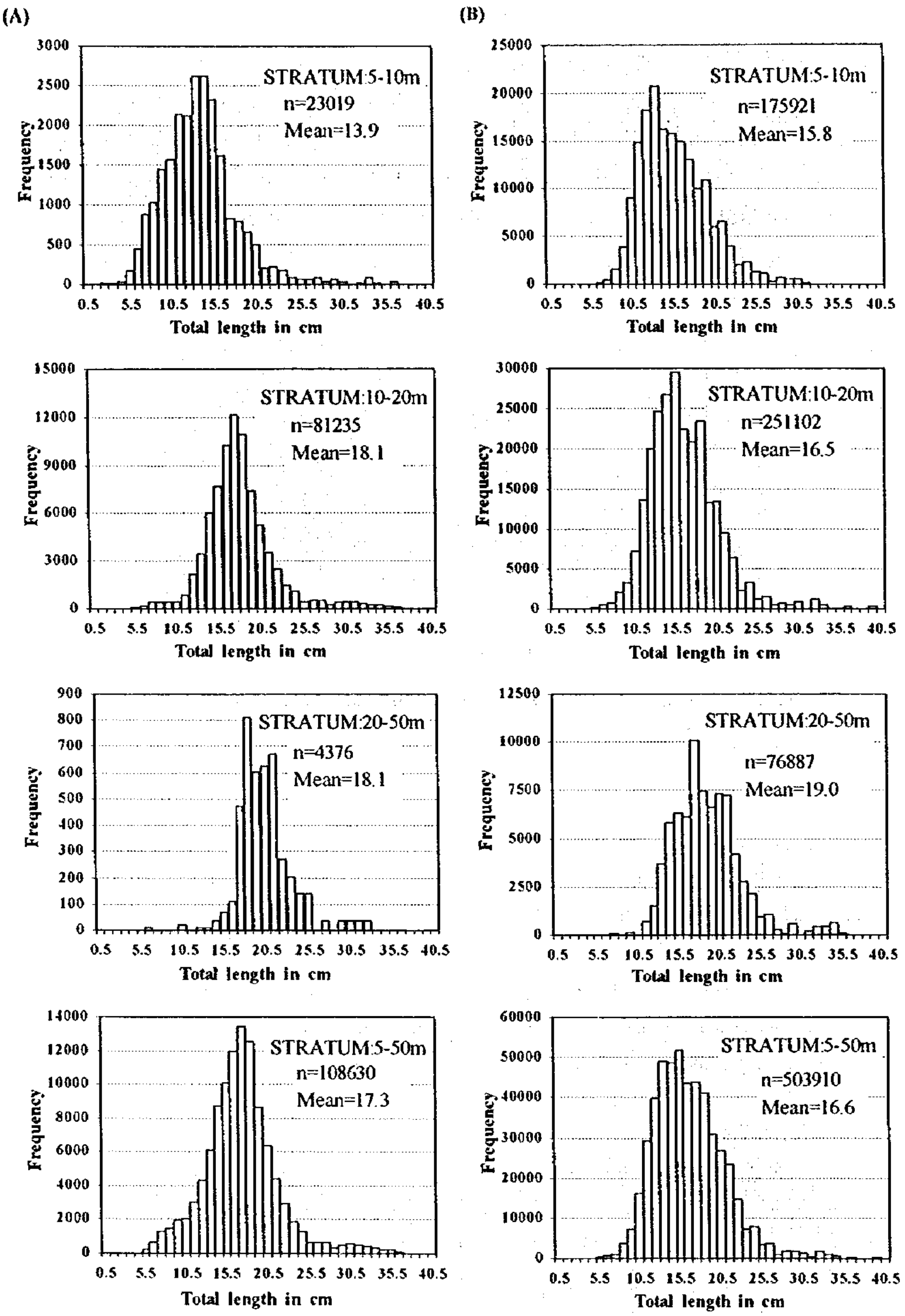
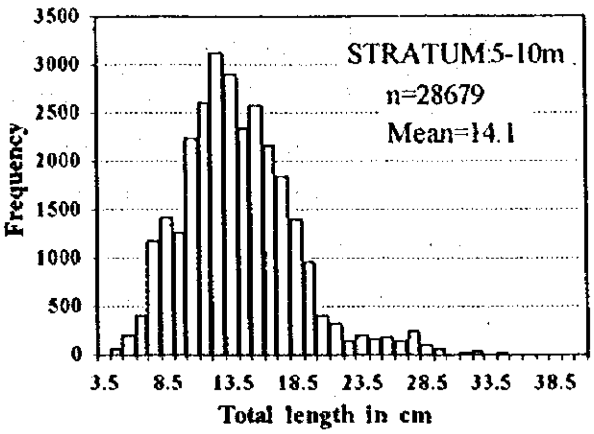
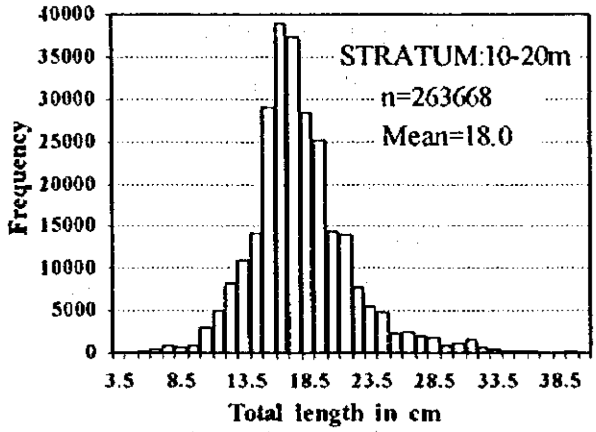


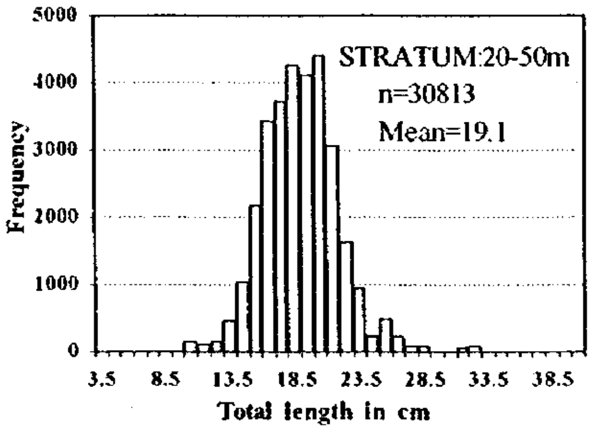

Figure 48. Size composition for Pescadinha gó *Macrodon ancylodon*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

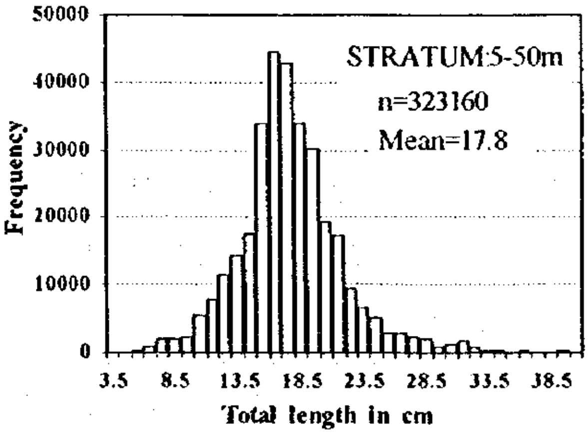
Figure 48. Continued

(C)



f-4) Body length and weight relationship

Figure 49 summarizes the relationship between total length and body weight for pescadinha gó, determined from data obtained through the multi-item biological measurement. Resulting regression equations for the total number of male, female and sexually indeterminate individuals were:

Phase 1 Dry Season Survey: $BW = 8 \times TL^{3.4155} \times 10^{-7}$ (r = 0.991)

Phase 2 Rainy Season Survey: $BW = 7 \times TL^{3.4472} \times 10^{-7}$ (r = 0.993)

Phase 2 Dry Season Survey: $BW = 1 \times TL^{3.3493} \times 10^{-6}$ (r = 0.989)

These equations are very similar to each other.

f-5) Body length and weight by sex

Table 54 summarizes total length and body weight by sex for pescadinha gó. In all survey seasons, mean total length and mean weight was larger in females than in males. Differences between sexes were around 3 cm and 30-40 g overall, except in the Phase 2 Dry Season, where it was not as pronounced as in the previous Phase at 2 mm and 13 g. Development of reproductive organs allowing visually detectable sexual dimorphism started around 8 cm and 3 g for both sexes. Amplitude of individual variation in the development of reproductive organs was suggested by the occurrence of sexually indeterminate individuals of 20 cm (see Figure 50) or 100 g.

**Table 54. Body length and weight by sex for Pescadinha gó *Macrodon ancylodon*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Sex | Total length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 93 - 295 | 160 | 4 - 205 | 29 |
| Female | 83 - 375 | 190 | 4 - 493 | 68 |
| Indeterminate | 49 - 193 | 107 | 0.4 - 48 | 8 |

(B)

| Sex | Total length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 102 - 335 | 157 | 5 - 403 | 33 |
| Female | 101 - 385 | 184 | 7 - 559 | 62 |
| Indeterminate | 63 - 216 | 117 | 1 - 82 | 11 |

(C)

| Sex | Total length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 85 - 323 | 195 | 3 - 302 | 58 |
| Female | 107 - 374 | 197 | 6 - 496 | 71 |
| Ideterminate | 38 - 231 | 119 | 0.3 - 106 | 12 |

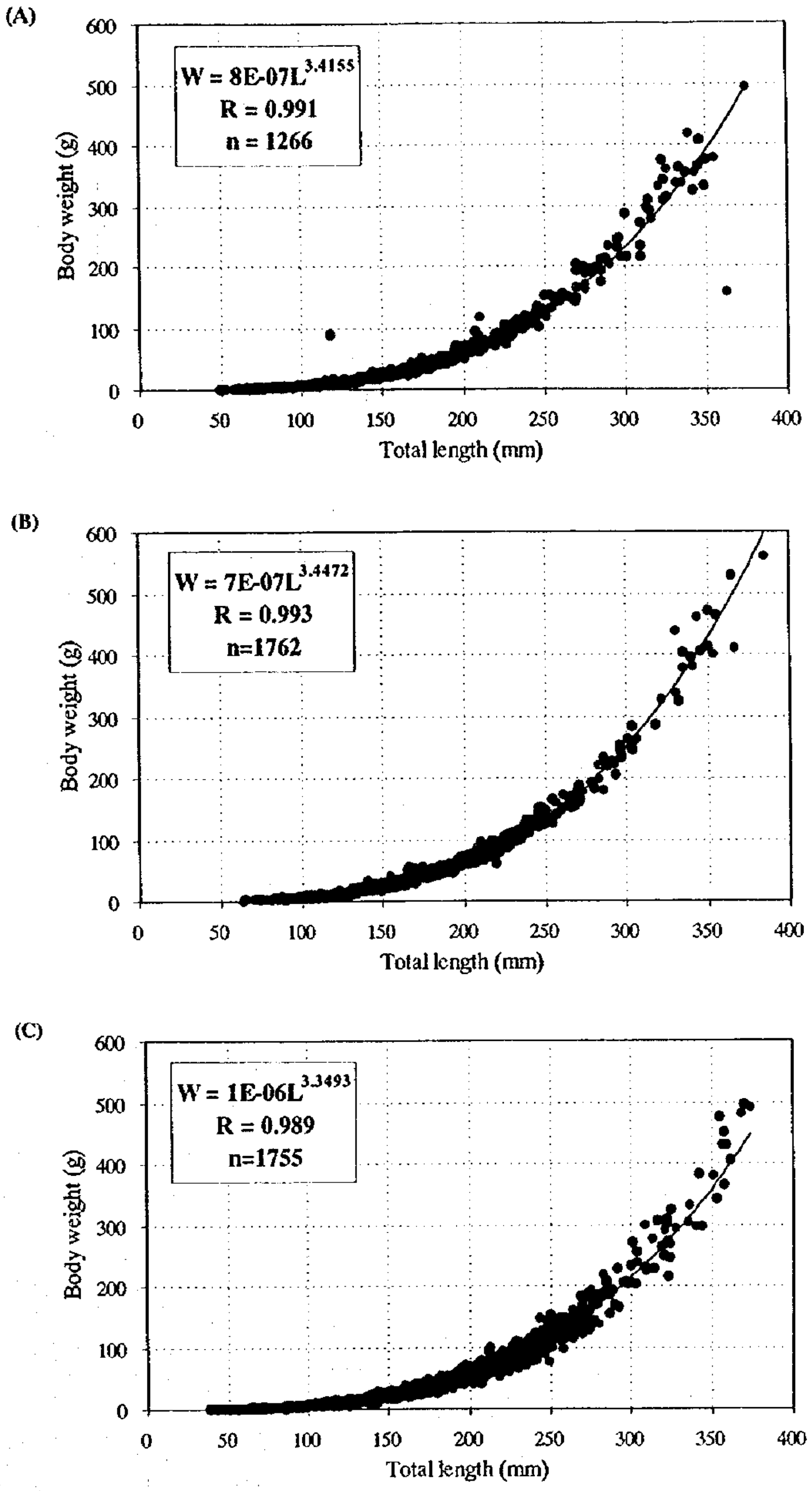



**Figure 49. Relationship between total length and body weight for Pescadinha gó *Macrodon ancylodon*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

f-6) Sex ratio and female maturity stage

Table 55 summarizes sex ratio and female maturity stage for pescadinha gó.

i) Overall sex ratio

Overall sex ratio was 1.08, 1.45 and 1.04 in survey order — equal presence of both sexes except in the rainy season. In each season, the majority of females were immature, followed by semi-mature (or in maturation) and mature. The ratio of semi-mature and mature females was higher in the Dry Seasons, particularly in Phase 2, than that in the Rainy Season.

ii) Sex ratio by stratum

Sex ratio in the Dry Seasons was found to be depth-dependent, but in opposite directions according to Phase 1 or 2. In the Phase 1 Dry Season, from the shallow to the deep strata, there was predominance of males, equal representation of both sexes and predominance of females; while in the Phase 2 the order was reversed: predominance of females, equal representation of both sexes and predominance of males. In the Rainy Season, females predominated in every stratum, and strikingly so in the 5–10 m stratum. Female maturity rate was depth-dependent ("mature" including also semi-mature individuals), growing positively along with depth; this depth-dependency was more pronounced in the Phase 2 Dry Season. Females showing ovaries in a post-spawning condition were few and could be observed in the Phase 1 Dry Season and in the Phase 2 Rainy Season. These results and the presence in the size composition of newborn fry of about 5 cm leads to hypothesize that pescadinha gó could spawn the year round in the survey area — particularly in the Dry Season, near the offshore.

**Table 55. Sex ratio and female maturity stage for Pescadinha gó *Macrodon ancylodon*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Stratum | Number of female ♀ by maturity stage | | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Spent | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 263 | 17 | 3 | 2 | 285 | 341 | 0.84 |
| 10 - 20 | 806 | 158 | 57 | 7 | 1,028 | 934 | 1.10 |
| 20 - 50 | 563 | 185 | 0 | 0 | 748 | 339 | 2.21 |
| All stratum | 586 | 106 | 33 | 5 | 730 | 673 | 1.08 |

(B)

| Stratum | Number of female ♀ by maturity stage | | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Spent | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 2,441 | 61 | 3 | 0 | 2,505 | 1,472 | 1.70 |
| 10 - 20 | 2,516 | 137 | 96 | 1 | 2,750 | 2,066 | 1.33 |
| 20 - 50 | 3,469 | 631 | 92 | 0 | 4,192 | 3,085 | 1.36 |
| All stratum | 2,590 | 159 | 56 | <1 | 2,805 | 1,929 | 1.45 |

(C)

| Stratum | Number of female ♀ by maturity stage | | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Spent | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 254 | 73 | 0 | 0 | 327 | 125 | 2.62 |
| 10 - 20 | 1,169 | 909 | 235 | 0 | 2,313 | 2,214 | 1.04 |
| 20 - 50 | 299 | 385 | 41 | 0 | 725 | 1,156 | 0.63 |
| All stratum | 732 | 548 | 127 | 0 | 1,407 | 1,348 | 1.04 |

iii) Sex ratio by size class

Data obtained in all seasons through the multi-item biological measurement were grouped into each 1 cm size class. Frequency of number of individuals in these groups by sex — male, female (separated by maturity stage), indeterminate — is presented in Figure 50. A size-dependent change in sex ratio was observed in each season. Percentage of females in the Phase 1 Dry Season decreased from 100% to 30% in the 7–14 cm length classes, while it grew back from 30% to 100% in the length classes over 14 cm. In the Phase 2 Rainy Season, males and females were equally represented in the 9–20 cm length classes, but from then on the proportion of females grew from 50% to 100%. Similarly, an equal distribution between the sexes for fish in the 10–25 cm classes in the Phase 2 Dry Season was followed above that limit by a female presence with up-and-down from 40% to 100%. Female maturity rate (the total number of "mature" and "semi-mature") tended to be size-dependent, being higher the larger the fish. Pescadinha gó stocks in number were composed mainly by intermediate-size fish with a single mode between the 15–18 cm length classes. Sex composition and female maturation stage for small (<10 cm), intermediate-size (10–20 cm) and large (>20 cm) fish are respectively given below, in survey order, with female maturity condition indicated in parentheses in the following order: immature - semi-mature - mature - spent.

(1) small fish

| | | | | | |
|---|---|---|---|---|---|
| M | 4% | F | 5% (100% - 0% - 0% - 0%) | I | 90% |
| M | 0% | F | 0% | I | 100% |
| M | 4% | F | 0% | I | 96% |

(2) intermediate-size fish

| | | | | | |
|---|---|---|---|---|---|
| M | 50% | F | 37%( 93% - 6% - 1% - 0%) | I | 13% |
| M | 41% | F | 40%(99.8% - 0.2% - 0% - 0%) | I | 18% |
| M | 38% | F | 34%( 78% - 22% - 0% - 0%) | I | 29% |

(3) large fish

| | | | | | |
|---|---|---|---|---|---|
| M | 18% | F | 82% (59% - 29% - 10% - 2%) | I | 0% |
| M | 21% | F | 78% (83% - 13% - 5% - -%) | I | 1% |
| M | 44% | F | 56% (26% - 56% - 18% - 0%) | I | 0.4% |

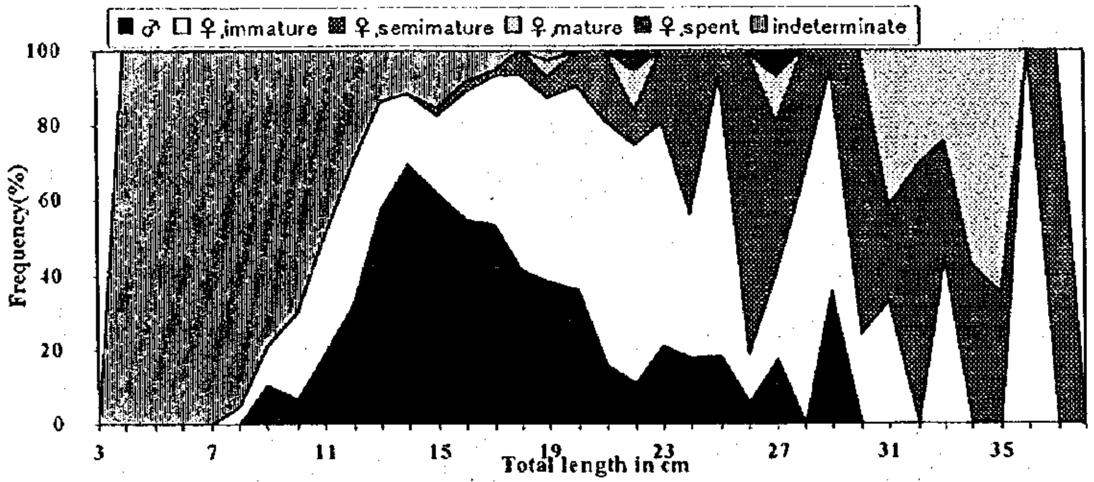
f-7) Feeding habits

Table 56 presents the results of stomach contents analysis via the occurrence method. Individuals with empty stomachs were less frequent in the Rainy Season (42%) than in the Dry Seasons (59% and 66%). Pescadinha gó fed mainly on shrimp regardless of season.

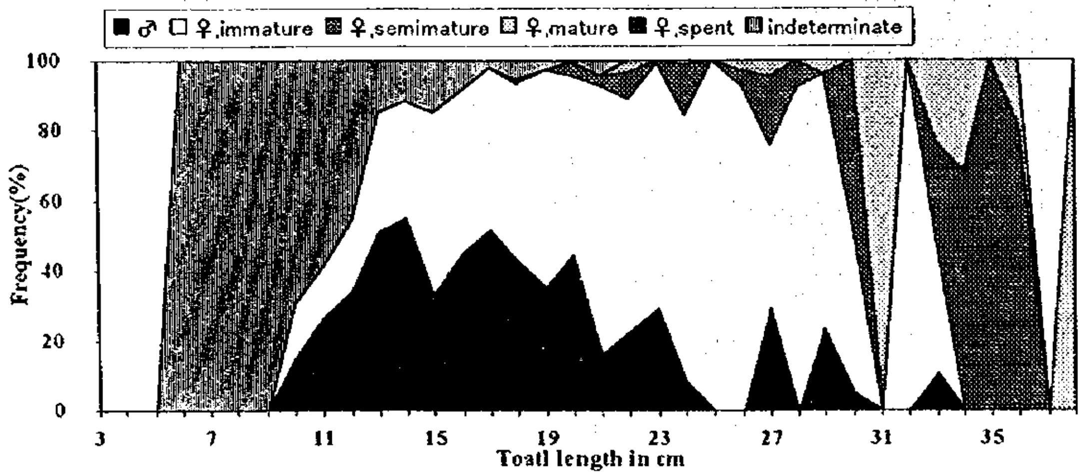
**Table 56. Stomach contents of Pescadinha gó *Macrodon ancylodon*.**

| Phase | Survey season | Number of specimens | Empty stomach rate (%) | Stomach contents by the occurrence method (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Fish | Crustacea | | | | Unidentified |
| | | | | | Shrimp | Crab | Mantis shrimp | Other | |
| 1 | Dry | 1,265 | 59 | 10 | 53 | 0.2 | | 0.8 | 36 |
| 2 | Rainy | 1,762 | 42 | 9 | 52 | 1 | 0.1 | 0.2 | 39 |
| | Dry | 1,755 | 66 | 8 | 76 | 1 | 0.5 | | 15 |

(A)




(B)




(C)

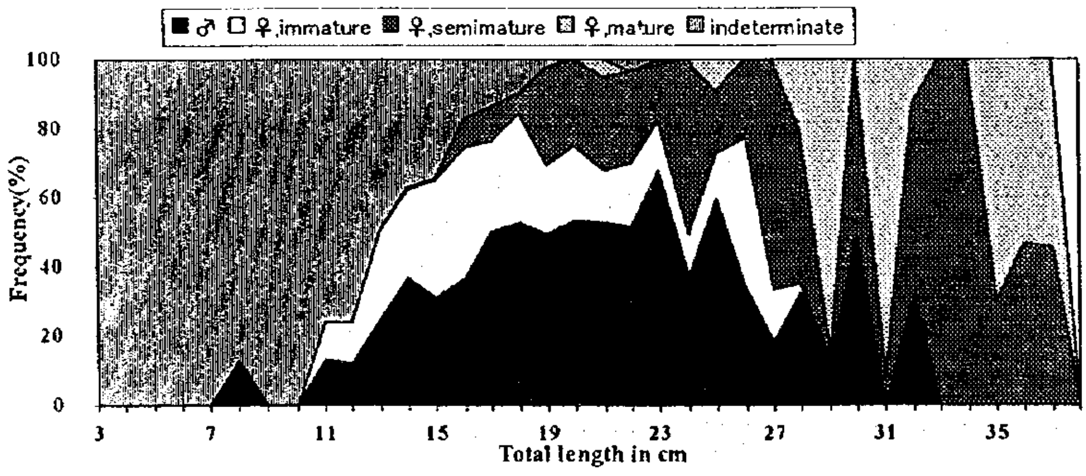



Figure 50. Frequency of male, female and indeterminate sex individuals by length class for Pescadinha gó Macrodon ancylodon. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

### (g) Gurijuba *Arius parkeri*

g-1) Body length range and mean body length

Table 57 shows fork length range and mean fork length values for gurijuba.

i) Overall body length

Throughout the surveys the maximum size found was 1,325 mm, and the minimum size 124 mm. Maximum size was much larger than those in the 84–86 cm range seen at Vigia or Ver-o-Peso (see Figure 127). Mean fork length for all seasons was between 48–53 cm, larger in the Dry Seasons.

ii) Size variation by stratum

Mean fork length was found to be depth-dependent, but in diametrically opposed directions according to the season: it increased with depth in the Dry Seasons, but decreased in the Rainy Season.

iii) Size variation by water mass region

Mean fork length was, for all seasonal surveys, larger in ocean than in brackish waters.

**Table 57. Range and mean body length 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.**

(A)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 180 | 201 | 600 | - | 180 | 430 |
| Maximum | 761 | 1,325 | 767 | - | 970 | 1,325 |
| Mean | 458 | 564 | 672 | - | 502 | 704 |
| All area : Min. 180, Max. 1,325, Mean 523 | | | | | | |

(B)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 135 | 124 | 124 | - | 128 | 124 |
| Maximum | 1,150 | 1,075 | 735 | - | 1,150 | 880 |
| Mean | 498 | 484 | 456 | - | 484 | 542 |
| All area : Min. 124, Max. 1,150, Mean 489 | | | | | | |

(C)

| Fork length | Stratum ( isobath range in m ) | | | Water mass | | |
|---|---|---|---|---|---|---|
| in mm | 5 - 10 | 10 - 20 | 20 - 50 | RW | BW | OW |
| Minimum | 176 | 176 | 390 | - | 176 | 203 |
| Maximum | 910 | 930 | 855 | - | 915 | 950 |
| Mean | 515 | 531 | 622 | - | 518 | 578 |
| All area : Min. 176, Max. 950, Mean 525 | | | | | | |

g-2) Relationship between bottom salinity and size

Figure 51 shows the relationship between salinity of the bottom layer and size for gurijuba. There, the fish were classified as small (under 40 cm), intermediate-size (40–80 cm) and large (over 80 cm). Intermediate-size gurijuba was distributed along an ample spectrum of salinity (10–36 psu), but small and large individuals tended to respectively favor highly saline, narrow spectra.

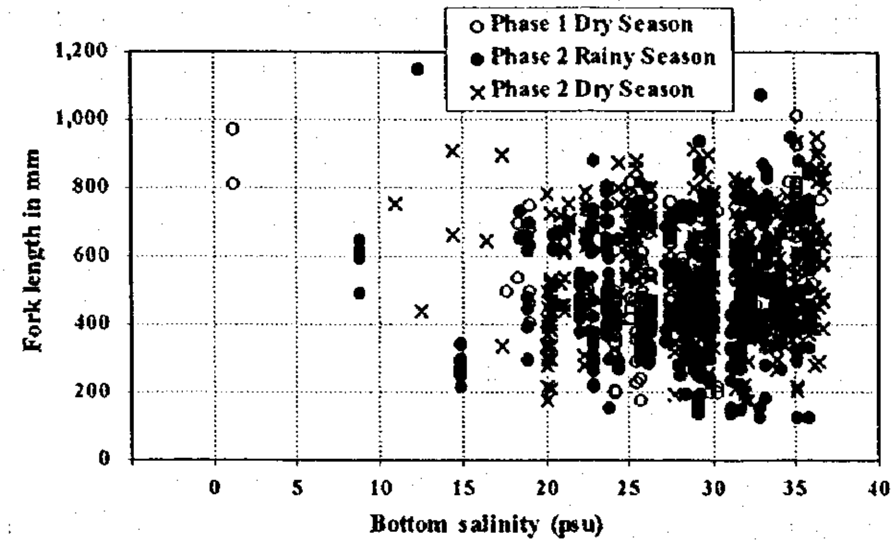



**Figure 51. Relationship between bottom salinity and size in Gurijuba *Arius parkeri*.**

g-3) Size composition

Figure 52 shows the size composition for gurijuba, with body length data taken via both the measuring-card punching method and the multi-item biological measurement.

i) Overall size composition

In all survey seasons, overall size composition exhibited a poly-modal pattern of distribution with well-defined modes. Analysis of a predominant mode or the several dominant modes would reveal the following features of gurijuba stocks. Gurijuba stocks in the Dry Seasons would comprise intermediate-size fish with a predominant mode between the 40–46 cm length classes and a dominant mode between the 62–68 cm length classes, plus some small and large individuals. The stocks in the Rainy Season would include small fish with a predominant mode at the 28–30 cm class and intermediate-size individuals with three dominant modes between the 46–76 cm classes, plus some large specimens. On the other hand, there were obvious modes for small fish at the 20–22 cm class in the Dry Seasons and at the 12–14 cm class in the Rainy Season, probably representing newly hatched fry.

ii) Size composition by stratum

In all survey seasons, not enough data was obtained in the deepest stratum. Size composition in the other two strata had a poly-modal pattern of distribution, generally similar to the overall size composition. The predominant mode in all strata in the Dry Seasons was depth-dependent, with a trend towards larger length classes from shallow to deep strata — a particularly marked tendency in Phase 1.

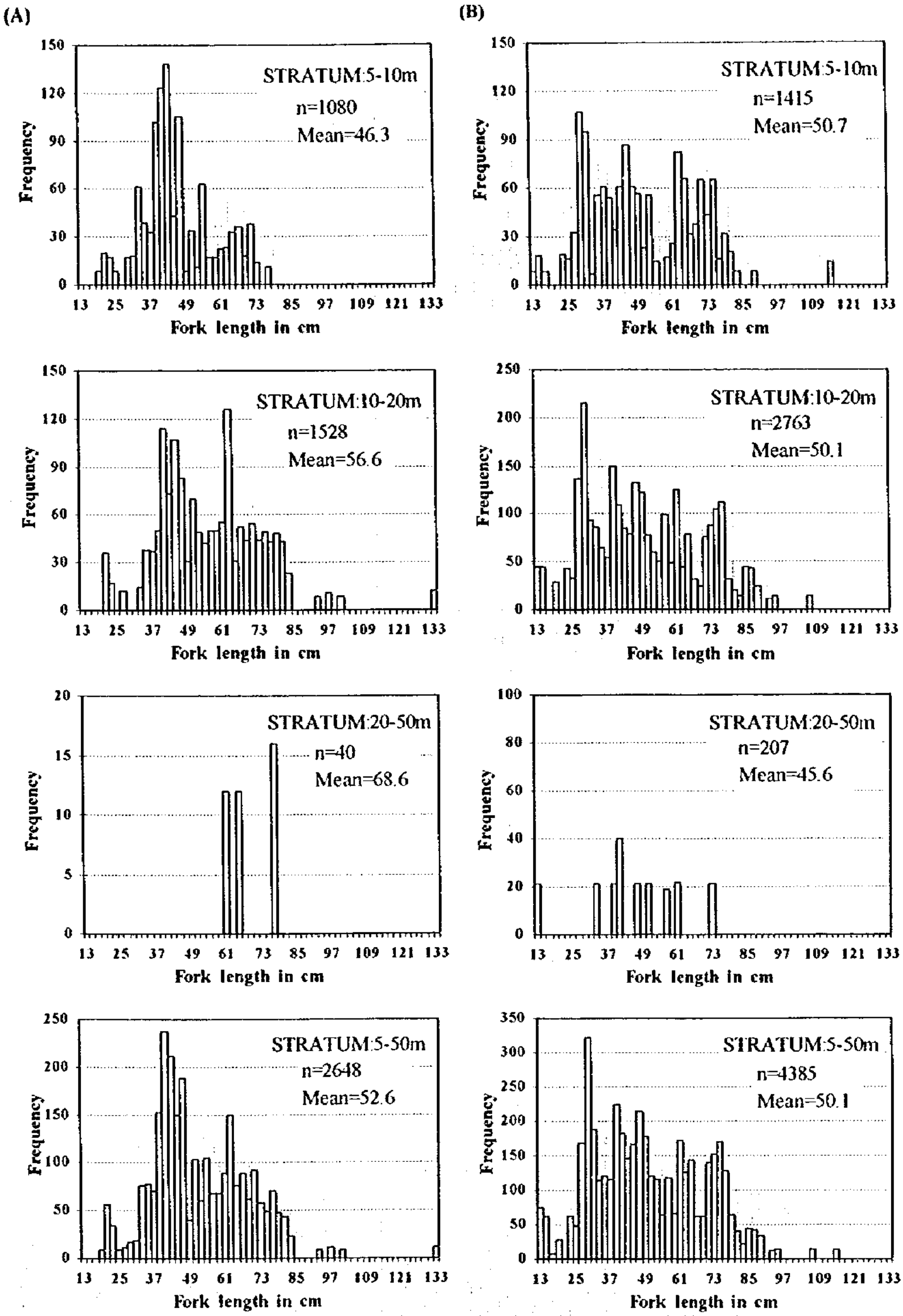
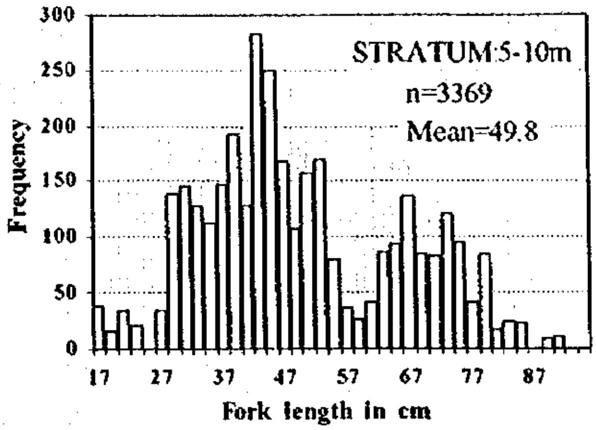
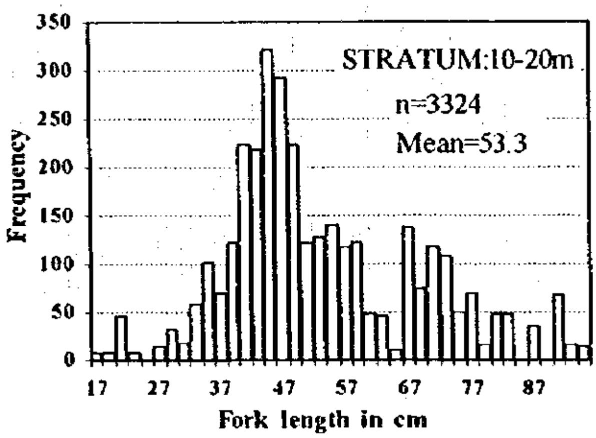


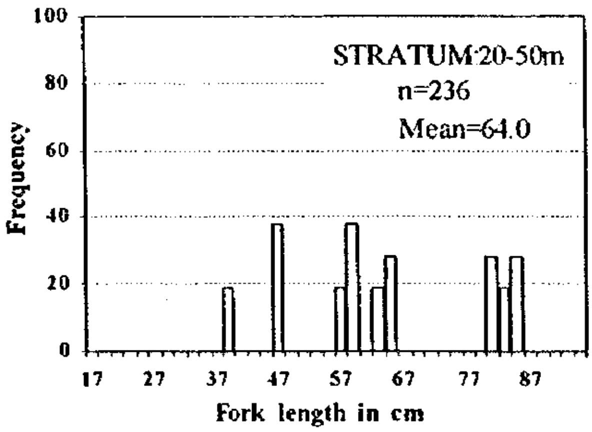

**Figure 52. Size composition for Gurijuba *Arius parkeri*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

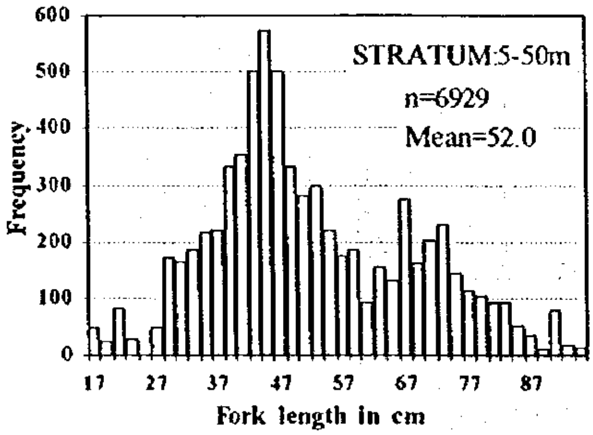
Figure 52. Continued

(C)



g-4) Body length and weight relationship

Figure 53 summarizes the relationship between fork length and body weight for gurijuba, determined from data obtained through the multi-item biological measurement. Resulting regression equations for the total number of male, female and sexually indeterminate individuals were:

Phase 1 Dry Season Survey: $BW = 2 \times FL^{3.3153} \times 10^{-6}$ (r = 0.987)

Phase 2 Rainy Season Survey: $BW = 4 \times FL^{3.1882} \times 10^{-6}$ (r = 0.990)

Phase 2 Dry Season Survey: $BW = 2 \times FL^{3.2693} \times 10^{-6}$ (r = 0.994)

These equations are very similar to each other. Males of the sea catfish family Ariidae are known for mouth breeding their fertilized egg and fry and for fasting during the breeding period (FAO, 1993); but no weight reduction in males associated with such fasting could be discerned in any of the figures.

g-5) Body length and weight by sex

Table 58 summarizes fork length and body weight by sex for gurijuba. In all survey seasons those mean values were respectively around 52–55 cm and 2,500–2,800 g for males, and 50–58 cm and 2,600–3,500 g for females, with the differences between sexes gradually getting smaller in survey order. Mean fork length and mean body weight for females in the Phase 1 Dry Season Survey were respectively larger than those for males. In both Phase 2 Seasons, mean fork length for females was smaller than for males, but mean body weight was larger for females. Visually detectable sexual dimorphism started just above 20 cm and 100 g for both sexes. Amplitude of individual variation in the development of reproductive organs was suggested by the occurrence of sexually indeterminate individuals of about 80 cm (see Figure 54) or 8 kg.

**Table 58. Body length and weight by sex for Gurijuba *Arius parkeri*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 346 - 815 | 551 | 300 - 9,100 | 2,777 |
| Female | 270 - 1,325 | 576 | 300 - 28,050 | 3,506 |
| Indeterminate | 180 - 772 | 377 | 50 - 7,550 | 975 |

(B)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 157 - 950 | 522 | 21 - 12,000 | 2,545 |
| Female | 195 - 1,150 | 502 | 110 - 28,200 | 2,633 |
| Indeterminate | 124 - 530 | 259 | 11 - 2,000 | 314 |

(C)

| Sex | Fork length in mm | | Body weight in g | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Male | 220 - 915 | 542 | 100 - 11,200 | 2,795 |
| Female | 213 - 950 | 538 | 110 - 13,400 | 2,875 |
| Indeterminate | 176 - 675 | 368 | 55 - 4,100 | 928 |

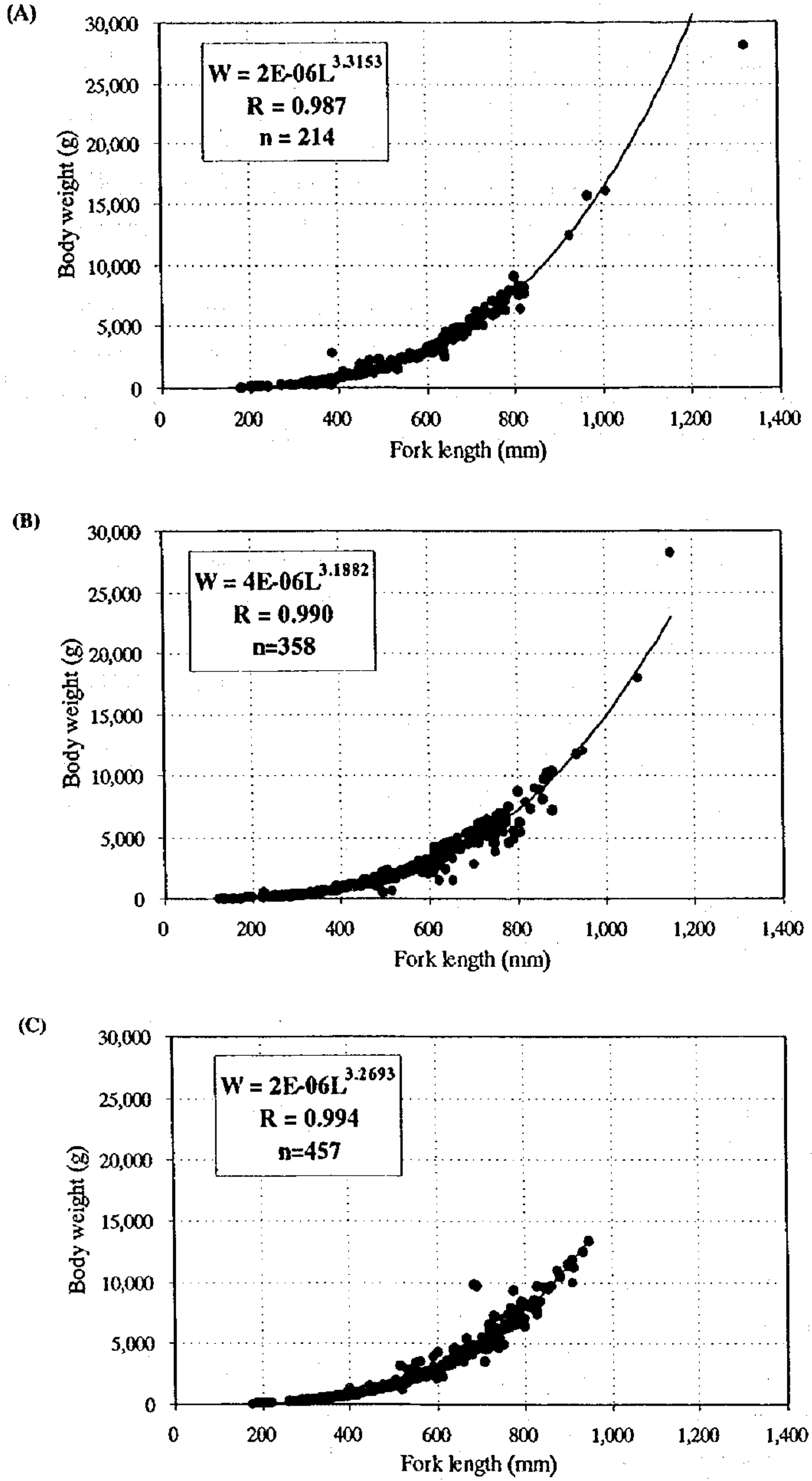



**Figure 53. Relationship between fork length and body weight for Gurijuba *Arius parkeri*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

g-6) Sex ratio and female maturity stage

Table 59 summarizes sex ratio and female maturity stage for gurijuba.

i) Overall sex ratio

Overall sex ratio was 1.65, 0.86 and 1.24 in survey order, but lack of sufficient data gives little reliability to these numbers. The ratio of semi-mature and mature females was higher in the Dry Seasons. Some females with their ovaries in post-spawning condition were found in Phase 2.

ii) Sex ratio by stratum

There was a trend for sex ratio being depth-dependent in all seasons, but in opposing directions in each Phase. In Phase 1, the relative number of females tended to decrease with increasing depth, yet in Phase 2 it had a tendency to grow along with profundity. Also, the proportion of semi-mature and mature females and that of post-spawning (spent) females both tended to be positively depth-dependent, increasing with profundity. These results and the existence of a mode reflecting the above-mentioned fry strongly suggest that gurijuba could be spawning in the survey area, particularly offshore, in the Dry Season and the beginning of the Rainy Season. While captured males were not seen carrying fertilized eggs or incubating hatchlings in their mouth cavity, an eventual confirmation of the occurrence of males in such condition would specify the spawning period of gurijuba.

**Table 59. Sex ratio and female maturity stage for Gurijuba *Arius parkeri*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| Stratum | Number of female ♀ by maturity stage | | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Spent | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 24 | 4 | 2 | 0 | 30 | 16 | 1.88 |
| 10 - 20 | 30 | 6 | 3 | 0 | 39 | 23 | 1.70 |
| 20 - 50 | 0 | 0 | 0 | 0 | 0 | 20 | 0 |
| All stratum | 26 | 5 | 2 | 0 | 33 | 20 | 1.65 |

(B)

| Stratum | Number of female ♀ by maturity stage | | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Spent | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 28 | 1 | 0 | 2 | 31 | 40 | 0.78 |
| 10 - 20 | 36 | 3 | 0 | 2 | 41 | 50 | 0.82 |
| 20 - 50 | 34 | 0 | 0 | 7 | 41 | 21 | 1.95 |
| All stratum | 33 | 2 | 0 | 3 | 38 | 44 | 0.86 |

(C)

| Stratum | Number of female ♀ by maturity stage | | | | | Number of | Sex ratio |
|---|---|---|---|---|---|---|---|
| ( isobath range in m ) | Immature | Semi-mature | Mature | Spent | Total | male ♂ | ♀ / ♂ |
| 5 - 10 | 55 | 8 | 3 | 2 | 68 | 66 | 1.03 |
| 10 - 20 | 41 | 4 | 4 | 1 | 50 | 33 | 1.52 |
| 20 - 50 | 25 | 0 | 19 | 9 | 53 | 19 | 2.79 |
| All stratum | 45 | 5 | 4 | 2 | 56 | 45 | 1.24 |

iii) Sex ratio by size class

Data obtained in all seasons through the multi-item biological measurement were grouped into each 2 cm size class. Frequency of number of individuals in these groups by sex — male, female (maturity stage), indeterminate — is presented in Figure 54. A clear size-dependent change in sex ratio was not observed in each season, but there was a tendency for the predominance of females among large individuals: particularly in the Phase 2 Dry Season, sex ratio in the length classes above 78 cm was such as to suggest size dependency, though the data were too few to be conclusive. On the other hand, the proportion of semi-mature and mature females would tend to vary positively along size increase. Mature eggs were observed in individuals with a fork length over about 60 cm. Sex composition of those groups (M, male; F, female; I, indeterminate sex) was as follows, in survey order, with female maturity condition indicated in parentheses in the following order: immature - semi-mature - mature - spent.

(1) small fish

M 11% F 21% (100% - 0% - 0% - 0%) I 68%
M 34% F 41% (100% - 0% - 0% - 0%) I 25%
M 41% F 36% (100% - 0% - 0% - 0%) I 23%

(2) intermediate-size fish

M 34% F 53% ( 82% - 12% - 5% - 0%) I 13%
M 59% F 39% ( 87% - 10% - 0% - 3%) I 2%
M 42% F 53% ( 85% - 10% - 3% - 2%) I 5%

(3) large fish

M 21% F 79% ( 13% - 51% - 36% - 0%) I 0%
M 31% F 69% ( 37% - 7% - 0% - 56%) I 0%
M 21% F 79% ( 3% - 22% - 62% - 13%) I 0%

g-7) Feeding habits

Table 60 presents the results of stomach contents analysis via the occurrence method. Rate of empty stomachs was 40–60%, higher in the Dry Seasons. An overturned stomach was observed from an individual during the Phase 2 Dry Season Survey. In all seasons, gurijuba fed on fish, and secondarily on shrimp and many other benthic organisms.

**Table 60. Stomach contents of Gurijuba *Arius parkeri*.**

| Phase | Survey season | Number of specimens | Empty stomach rate (%) | Evert rate (%) | Stomach contents by the occurrence method (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Jerry-fish | Fish | Crustacea | | | | | | Unidentified |
| | | | | | | | Shrimp | Crab | Mantis shrimp | Cope-poda | Iso-poda | Other | |
| 1 | Dry | 214 | 58 | | | 76 | 15 | 5 | | | 1 | | 3 |
| 2 | Rainy | 358 | 40 | | | 51 | 39 | 4 | | 0.4 | | 1 | 5 |
| | Dry | 457 | 57 | 0.4 | 0.5 | 51 | 37 | 6 | 3 | | | 0.5 | 2 |

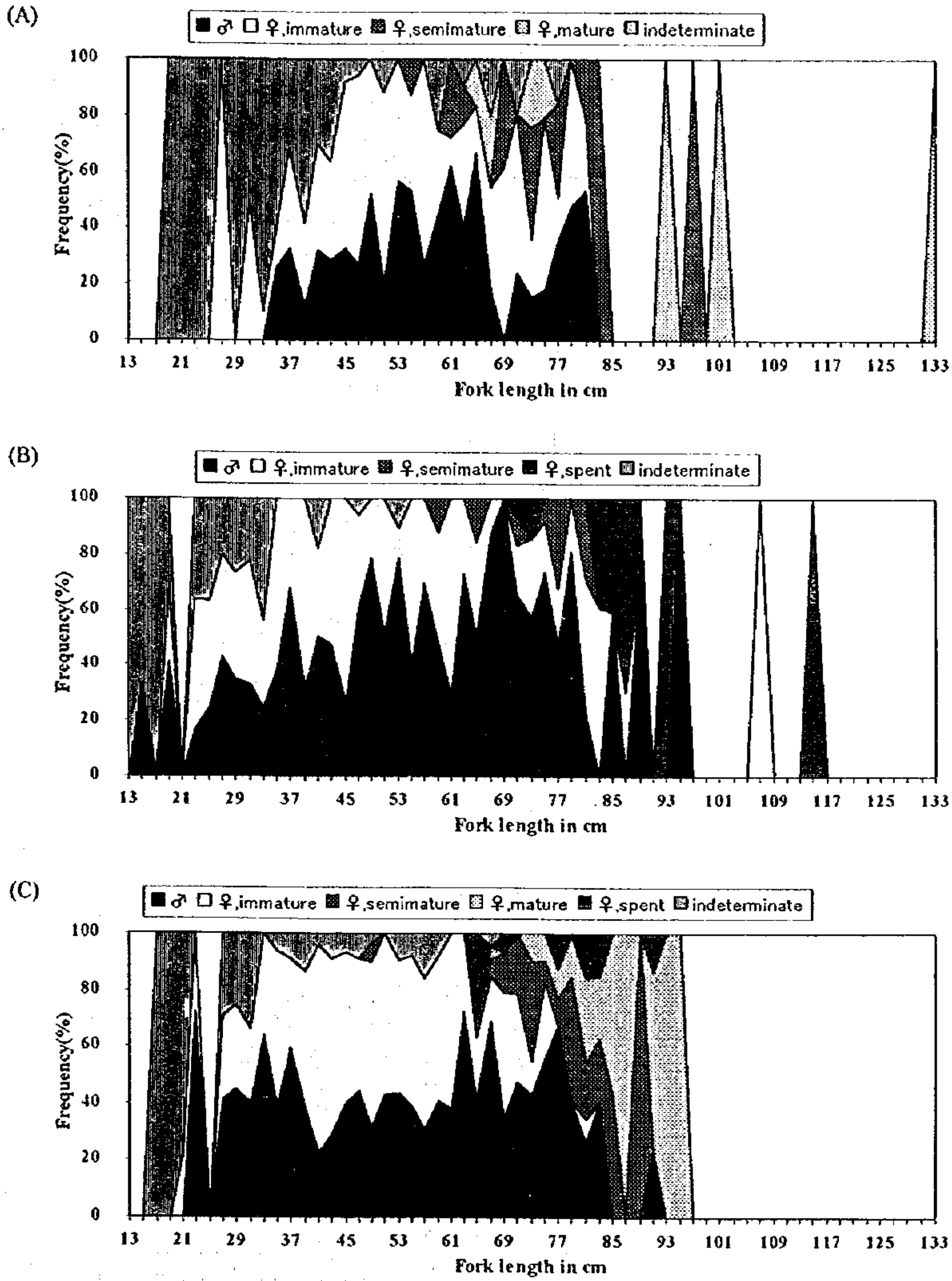



**Figure 54.** Frequency of male, female and indeterminate sex individuals by length class for Gurijuba *Arius parkeri.* (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

### 5.1.6. Mesh Selectivity

Among the key fish species, a relatively large amount of data on length composition was obtained through the measuring-card punching method for piramutaba *Brachyplatystoma vaillantii* and pescadinha gó *Macrodon ancylodon* (Table 7), caught by cod-end or covernet respectively in quite a number of trawl stations. These data also comprised information on mesh selectivity for the trawl net (cod-end mesh 100 mm between alternate knots, mesh measurements as in Appendix Table 2) currently employed in industrial fishery trawlers to piramutaba and pescadinha gó. Results of an analysis of mesh selectivity deduced from length composition data (100 individuals measured in cod-end and covernet respectively at trawl stations) are presented below.

For this analysis, retention rate was calculated for each length class as follows:

$$a_i = \frac{N_{i(cod)}}{N_{i(cod)} + N_{i(cover)}}$$

where $\alpha_i$ : retention rate at class $i$

$N_{i(cod)}$ : number of individuals in cod-end at class $i$

$N_{i(cover)}$ : number of individuals in covernet at class $i$

This retention rate was plotted in a normal probability paper, and mesh selectivity can be expressed as a straight line with a good fit of the data points. However, if the retention rate $\alpha$ is much dispersed, it would be problematic to draw a straight line along them. Therefore, in this survey, the Behrens-Karber method was used in the calculation of cumulative retention rate at each length class because it does not necessarily presuppose the retention rate as close to a normal distribution function. Results of the application of this method are in Table 61.

The procedure starts by calculating the cumulative number of the smaller individuals caught in the cod-end and the cumulative number of the larger individuals in the covernet. This is because, if for instance three individuals of 6.5 cm are retained in the cod-end, it is expected that larger individuals of 7.5 cm would necessarily be caught by the cod-end. It would mean that one individual of 7.5 cm actually caught by the cod-end would expect to represent the cumulative number of four (1+3) individuals. Likewise, if one individual of 21.5 cm manages to escape through the cod-end and gets caught by the covernet, smaller individuals of 20.5 cm are expected to also evade the cod-end. Then, one individual of 20.5 cm actually captured by the covernet would expect to represent the cumulative number of two (1+1) individuals that escaped through the cod-end. In this way, by calculating the cumulative number of individuals in the cod-end and the cumulative number of individuals in the covernet by length class, and dividing the cumulative number of individuals in the cod-end by that total at each length class, the cumulative retention rate by the class was obtained. This cumulative retention rate was plotted on a normal probability paper and a straight line fit along the points. From this line, retention rates at each length class could be obtained and a mesh selectivity curve drawn.

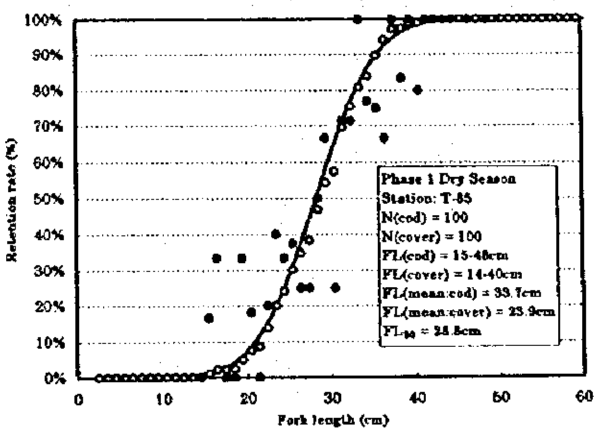
**Table 61. An example of data transformation for mesh selectivity.**

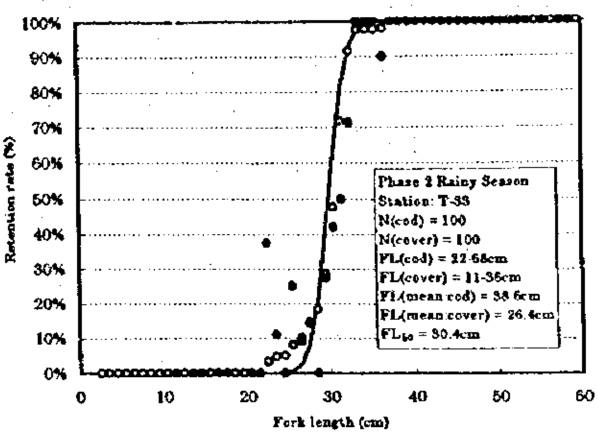
| Length (cm) | Original data | | | Cumulative data | | |
|---|---|---|---|---|---|---|
| | Cod | Cover | Cod + Cover | Cod ↓ | Cover ↑ | Cod + Cover |
| 5.5 | 0 | 0 | 0 | 0 | 100 | 100 |
| 6.5 | 3 | 0 | 3 | 3 | 100 | 103 |
| 7.5 | 1 | 2 | 3 | 4 | 100 | 104 |
| 8.5 | 4 | 0 | 4 | 8 | 98 | 106 |
| 9.5 | 2 | 3 | 5 | 10 | 98 | 108 |
| 10.5 | 10 | 6 | 16 | 20 | 95 | 115 |
| 11.5 | 17 | 10 | 27 | 37 | 89 | 126 |
| 12.5 | 21 | 12 | 33 | 58 | 79 | 137 |
| 13.5 | 11 | 22 | 33 | 69 | 67 | 136 |
| 14.5 | 13 | 17 | 30 | 82 | 45 | 127 |
| 15.5 | 12 | 12 | 24 | 94 | 28 | 122 |
| 16.5 | 4 | 7 | 11 | 98 | 16 | 114 |
| 17.5 | 0 | 4 | 4 | 98 | 9 | 107 |
| 18.5 | 0 | 3 | 3 | 98 | 5 | 103 |
| 19.5 | 0 | 0 | 0 | 98 | 2 | 100 |
| 20.5 | 0 | 1 | 1 | 98 | 2 | 100 |
| 21.5 | 0 | 1 | 1 | 98 | 1 | 99 |
| 22.5 | 0 | 0 | 0 | 98 | 0 | 98 |
| Total | 98 | 100 | 198 | 1,071 | 834 | 2,008 |

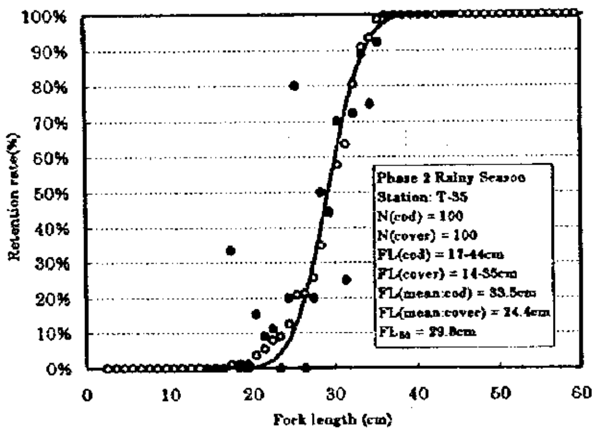
**(a) Piramutaba *Brachyplatystoma vaillantii***

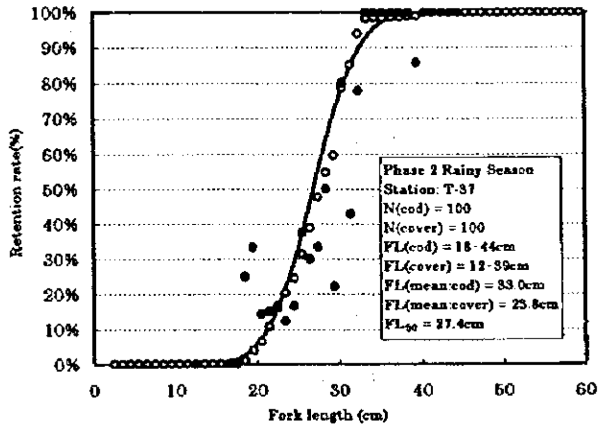
One hundred individuals were respectively measured by cod-end and covernet by the measuring-card punching method at one trawl station in the Phase 1 Dry Season Survey, four stations in the Phase 2 Rainy Season Survey (in one of which 101 specimens were measured) and two stations in the Phase 2 Dry Season Survey.

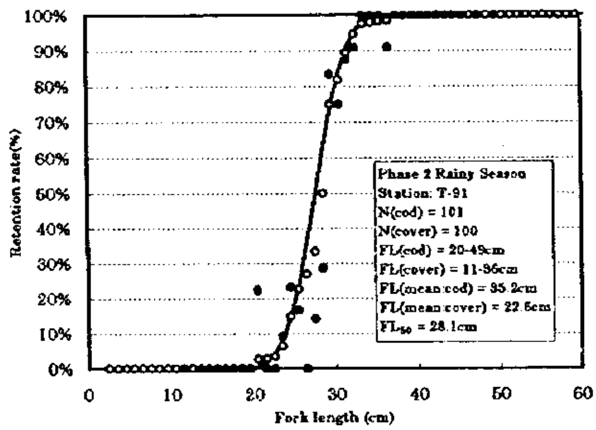
Figure 55 shows mesh selectivity curves for piramutaba at each of those stations. Results indicate that the mean fork length at 50% mesh selectivity ($FL_{50}$) was 27 cm, with a minimum value of 22 cm and a maximum value of 30 cm. Also, because the mean fork length for piramutaba caught by cod-end at each trawl station was higher than that by covernet, the 100 mm mesh cod-end was effective for the estimation of 50% mesh selectivity. Hereafter, it is desirable that experiments with cod-ends of several mesh sizes centered on the 100 mm mesh be conducted so as to estimate the cod-end mesh size to any $FL_{50}$ value.

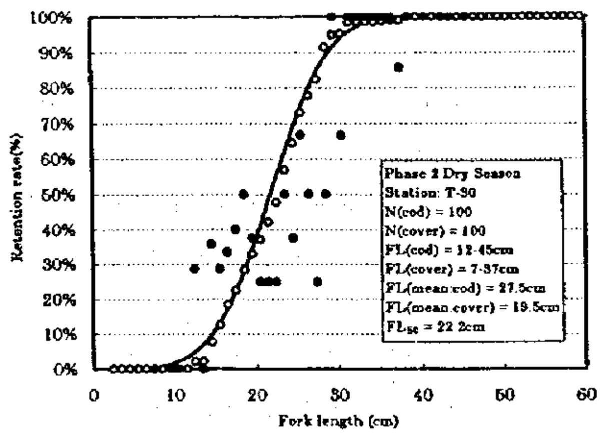


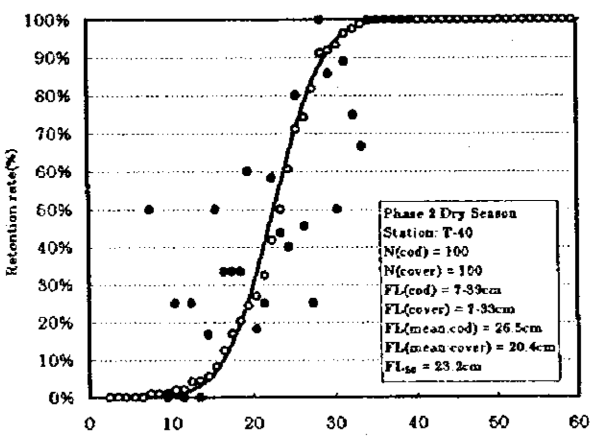




•: Retention rate calculated from original data
o: Retantion rate calculated from Behrens-Karber method
N(cod): Numbers in cod-end
N(cover): Numbers in cover net
FL(cod): Range of fork length in cod-end (cm)
FL(cover): Range of fork length in cover net (cm)
FL(mean:cod): Mean fork length in cod-end (cm)
FL(mean:cover): Mean fork length in cover net (cm)
$FL_{50}$: Fork length at 50% retention rate (cm)

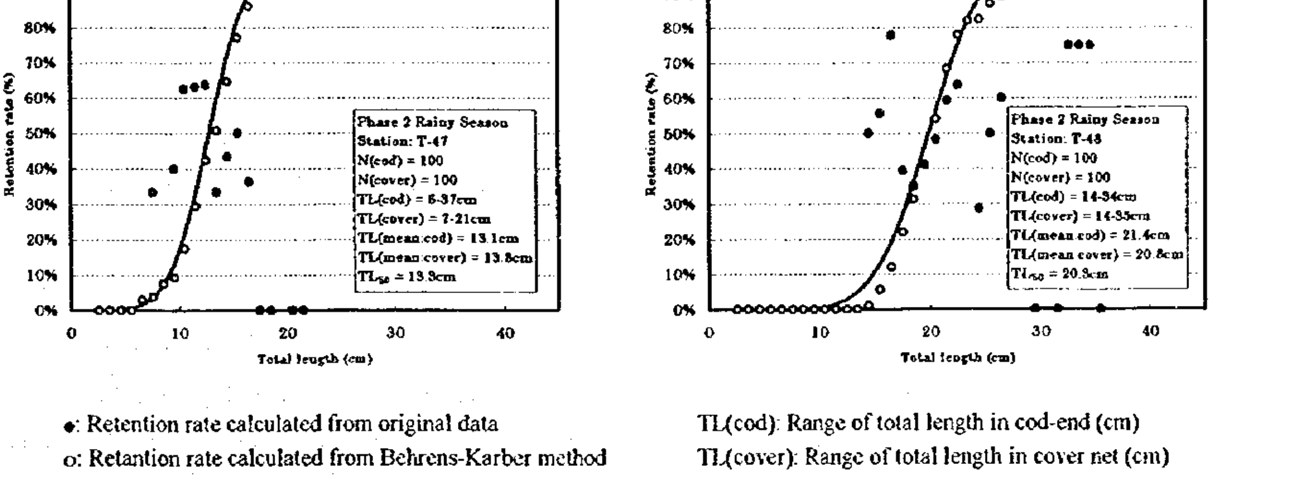
**Figure 55. Mesh selectivity curves for Piramutaba *Brachyplatystoma vaillantii*, cod-end mesh size as employed in industrial fishery trawlers.**

### (b) Pescadinha gó *Macrodon ancylodon*

One hundred individuals were respectively measured by cod-end and covernet by the measuring-card punching method at two trawl stations in the Phase 2 Rainy Season Survey.

Figure 56 shows mesh selectivity curves for pescadinha gó at each of those stations. Results indicate great disparity of total length at 50% mesh selectivity ($TL_{50}$) between stations, with 13 cm and 20 cm respectively. This can be attributed to a wide dispersion between actual retention rates — or, in other words, to the fact there was a wide difference in proportion of small and large individuals between stations.

On the other hand, at both trawl stations mean total length values by cod-end and covernet were about the same — cod-end 13.1 cm and covernet 13.8 cm at one station, respectively 21.4 cm and 20.8 cm at the other. For that reason, the retention rate of the 100 mm mesh cod-end does not increase for large individuals of this species. Therefore, this mesh size cod-end cannot be considered efficient for the estimation of $TL_{50}$. Hereafter, it is desirable that to estimate the cod-end mesh size to any $TL_{50}$ value, experiments be conducted with cod-ends of several mesh sizes smaller than 100 mm.




•: Retention rate calculated from original data
o: Retantion rate calculated from Behrens-Karber method
N(cod): Numbers in cod-end
N(cover): Numbers in cover net

TL(cod): Range of total length in cod-end (cm)
TL(cover): Range of total length in cover net (cm)
TL(mean:cod): Mean total length in cod-end (cm)
TL(mean:cover): Mean total length in cover net (cm)
$TL_{50}$: Total length at 50% retention rate (cm)

**Figure 56. Mesh selectivity curves for Pescadinha gó *Macrodon ancylodon*, cod-end mesh size as employed in industrial fishery trawlers.**

### 5.1.7. Data on the Oceanic Environment

The oceanographic observations taken seasonally at each trawl station had a two-month lag between the first and the last one and cannot be considered simultaneous. Thus, it was not possible to carry out a detailed study of the spatial distribution and temporal fluctuation of water properties and current conditions in a wide and complex marine environment like the Amazonian shelf based on such oceanographic data.

Besides the question of methodology and unachieved simultaneity, many other problems affecting those oceanographic observations resulted in clear limitations to the aforementioned goal. But the results of those observations yielded some information on the oceanic environment in the survey area.

**(a) Structure of the oceanic environment**

a-1) Distribution of water temperature and salinity

All data on water temperature and salinity at the oceanographic observation stations (in principle, the end of each haul) were taken by STD in each season. Tables 62 and 63 give statistical results of water temperature and salinity data in the surface (depth zero) and the bottom (taken at 1 m above the sea floor), plus the three strata defined for the resources survey. Also all data on water temperature and salinity are summarized in T-S diagrams and vertical profiles within specific water depth intervals in Figures 57 and 58.

i) Distribution range of T-S values over the entire area

Water temperatures observed over the entire survey area during this survey were within the 25.90–30.72 °C range. The difference between the maximum and minimum water temperature was 4.58°C and 4.31°C respectively in the Dry Seasons of each phase, and 3.70°C in the Phase 2 Rainy Season. Temperature in the surface was in the 27.03–30.72 °C range, with an amplitude of 2.73°C and 2.94°C in the Dry Seasons and 3.69°C in the Rainy Season. Temperature in the bottom was in the 25.93–29.04 °C range, with an amplitude of 3.11°C and 2.91°C in the Dry Seasons and 1.13°C in the Rainy Season. The most frequent water temperature ranges were 28–29°C in the Dry Seasons and 27–28°C in the Rainy Season (Table 62).

Salinity observed over the entire survey area during this survey was within the 0.05–36.70 psu range. Salinity in both the surface and bottom were respectively lower in the Rainy Season than in the Dry Seasons — particularly in the surface. The most frequent salinity ranges were over 35 psu in the Dry Seasons and 0–5 psu in the Rainy Season. In both Dry and Rainy Seasons, comparatively high frequencies were observed for salinity values below 10 psu and above 30 psu (Table 63).

ii) Distribution of water mass divided according to T-S distribution characteristic

The temperature-salinity diagrams reveal the presence of a number of clusters, and these clusters can be defined into four water masses (Figure 57). Namely: (1) river waters (Dry Seasons temperature, 28–29°C; Rainy Season temperature, 27–28.5°C; salinity, < 1 psu); (2) offshore ocean waters (temperature, 26–28.5°C; salinity, ≥ 35 psu); (3) high temperature surface waters (temperature, 29–

30.5°C; salinity, 0–34 psu); and (4) mixed river and ocean waters (temperature, 27–29°C; salinity, 1–35 psu). Their distribution across the continental shelf and vertically are discussed below.

River waters were observed only in shallow areas between the isobaths of 5 m and 20 m, and only between 0–15 m deep.

Offshore ocean waters were mainly observed in areas between the isobaths of 10 m and 50 m, occurring in all water column in the Dry Seasons, but only below 5 m deep in the Rainy Season. In the Dry Season they appeared also between the isobaths of 5 m and 10 m, but only below 4 m deep.

High temperature surface waters were often found in shallow areas between the isobaths of 5 m and 20 m. They occurred in 0–12 m deep in the Dry Seasons (more frequently within 0–5 m deep), and 0–2 m deep in the Rainy Season. From the isobath of 20 m to the offshore, this water mass was barely observed in the Dry Seasons and not at all in the Rainy Season.

Mixed waters were seen over the entire area, in water column from 0 to 20 m deep. The interaction between river and ocean waters resulted in the definition of two vertically distinct salinity profiles. One refers to a uniform column of vertically well-mixed waters, the other to a strongly or weakly stratified water column forming a saline front. In the former case, the water column occurs in shallow areas between the isobaths of 5 m and 20 m: in the Dry Seasons, salinity is mainly lower than 20 psu between the isobaths of 5 m and 10 m and above that value between 10 m and 20 m, while in the Rainy Season it varies between 1 and 30 psu in areas within the 5–10 m water depth and stays around 30 psu in areas between 10 m and 20 m water depth. The stratified water column in the latter case was found over the entire area. A halocline was formed from a few meters below the surface down to 10 m deep, although in the Rainy Season it was sometimes observed in water below 10m deep. The influence of river waters on the distribution of salinity in areas between the isobaths of 20 m and 50m was clearly seen as stronger in the Rainy Season than in the Dry Seasons. In this area salinity values over 20 psu were generally recorded in the Dry Seasons, that value was lower in the Rainy Season.

iii) Distribution of salinity in demersal fish habitats

Features of salinity distribution in habitats for demersal fish species are described below.

Figure 59 shows the horizontal distribution of salinity in the bottom (1 m above the sea floor). Since the observations were taken over two months, as described before, the lack of simultaneity must be taken into account.

River waters (< 1 psu) were found between the Northern Channel of the Amazon River and (1) offshore near the south side of the Santa Rosa Sandbank in the Dry Seasons or (2) offshore near the Southern Channel of the Amazon in the Rainy Season. In each survey, ocean waters (> 35psu) extended over a large area from near the isobath of 20 m to the offshore. In approximately 50–100 km wide area between the relatively stable two water mass regions, mixed waters were formed through their interactions. Based on the fact that bottom salinity values in the 10–30 psu range were found to be distributed in a complex pattern along the isobath of 10 m, it was hypothesized there could be a major, temporally mobile saline front. Particularly, the existence of a conspicuous saline front near latitude 1° N revealed the sea floor is strongly influenced by the flow of river waters from the Amazon.

**Table 62. Statistical results of measured water temperature data. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| | All Layers | Surface (0m) | Bottom (B+1m) | Stratum (isobath range in m) 5-10 | 10-20 | 20-50 |
|---|---|---|---|---|---|---|
| No. of St. | 111 | 111 | 111 | 52 | 47 | 12 |
| No. of Data | 8,874 | 111 | 111 | 2,796 | 3,782 | 2,296 |
| Min. (℃) | 25.90 | 27.70 | 25.93 | 27.62 | 27.67 | 25.90 |
| Max. (℃) | 30.48 | 30.43 | 29.04 | 30.48 | 29.56 | 29.31 |
| Range (℃) | Freq. (%) | Freq. (%) | Freq. (%) | Freq. (%) | Freq. (%) | Freq. (%) |
| 25-26 | 36 ( 0.4) | 0 ( 0.0) | 1 ( 0.9) | 0 ( 0.0) | 0 ( 0.0) | 39 ( 1.6) |
| 26-27 | 24 ( 0.3) | 0 ( 0.0) | 0 ( 0.0) | 0 ( 0.0) | 0 ( 0.0) | 24 ( 1.0) |
| 27-28 | 700 ( 7.9) | 6 ( 5.4) | 8 ( 7.2) | 104 ( 3.7) | 221 ( 5.8) | 375 (16.3) |
| 28-29 | 7,672 (86.5) | 74 (66.7) | 100 (90.1) | 2,527 (90.4) | 3,318 (87.7) | 1,827 (79.6) |
| 29-30 | 432 ( 4.9) | 29 (26.1) | 2 ( 1.8) | 155 ( 5.5) | 243 ( 6.4) | 34 ( 1.5) |
| 30-31 | 10 ( 0.1) | 2 ( 1.8) | 0 ( 0.0) | 10 ( 0.4) | 0 ( 0.0) | 0 ( 0.0) |

(B)

| | All Layers | Surface (0m) | Bottom (B+1m) | Stratum (isobath range in m) 5-10 | 10-20 | 20-50 |
|---|---|---|---|---|---|---|
| No. of St. | 120 | 120 | 120 | 55 | 52 | 13 |
| No. of Data | 9,019 | 120 | 120 | 2,855 | 3,947 | 2,217 |
| Min. (℃) | 27.02 | 27.03 | 27.17 | 27.02 | 27.34 | 27.51 |
| Max. (℃) | 30.72 | 30.72 | 28.30 | 29.57 | 30.72 | 28.44 |
| Range (℃) | Freq. (%) | Freq. (%) | Freq. (%) | Freq. (%) | Freq. (%) | Freq. (%) |
| 25-26 | 0 ( 0.0) | 0 ( 0.0) | 0 ( 0.0) | 0 ( 0.0) | 0 ( 0.0) | 0 ( 0.0) |
| 26-27 | 0 ( 0.0) | 0 ( 0.0) | 0 ( 0.0) | 0 ( 0.0) | 0 ( 0.0) | 0 ( 0.0) |
| 27-28 | 6,814 (75.6) | 80 (66.7) | 97 (80.8) | 2,474 (86.7) | 2,796 (70.8) | 1,544 (69.6) |
| 28-29 | 2,175 (24.1) | 34 (28.3) | 23 (19.2) | 369 (12.9) | 1,133 (28.7) | 673 (30.4) |
| 29-30 | 25 ( 0.3) | 5 ( 4.2) | 0 ( 0.0) | 12 ( 0.4) | 13 ( 0.3) | 0 ( 0.0) |
| 30-31 | 5 ( 0.1) | 1 ( 0.8) | 0 ( 0.0) | 0 ( 0.0) | 5 ( 0.1) | 0 ( 0.0) |

(C)

| | All Layers | Surface (0m) | Bottom (B+1m) | Stratum (isobath range in m) 5-10 | 10-20 | 20-50 |
|---|---|---|---|---|---|---|
| No. of St. | 120 | 120 | 120 | 55 | 50 | 15 |
| No. of Data | 9,582 | 120 | 120 | 2,849 | 4,054 | 2,679 |
| Min. (℃) | 25.93 | 27.28 | 25.94 | 26.62 | 26.48 | 25.93 |
| Max. (℃) | 30.24 | 30.22 | 28.85 | 30.24 | 29.58 | 29.03 |
| Range (℃) | Freq. (%) | Freq. (%) | Freq. (%) | Freq. (%) | Freq. (%) | Freq. (%) |
| 25-26 | 112 ( 1.2) | 0 ( 0.0) | 1 ( 0.8) | 0 ( 0.0) | 0 ( 0.0) | 112 ( 4.2) |
| 26-27 | 149 ( 1.6) | 0 ( 0.0) | 3 ( 2.5) | 57 ( 2.0) | 65 ( 1.6) | 27 ( 1.0) |
| 27-28 | 4,216 (44.0) | 34 (28.3) | 44 (36.7) | 938 (32.9) | 1,429 (35.2) | 1,849 (69.0) |
| 28-29 | 4,996 (52.1) | 74 (61.7) | 72 (60.0) | 1,795 (63.0) | 2,520 (62.2) | 681 (25.4) |
| 29-30 | 105 ( 1.1) | 11 ( 9.2) | 0 ( 0.0) | 55 ( 1.9) | 40 ( 1.0) | 10 ( 0.4) |
| 30-31 | 4 ( 0.0) | 1 ( 0.8) | 0 ( 0.0) | 4 ( 0.1) | 0 ( 0.0) | 0 ( 0.0) |

**Table 63. Statistical results of measured salinity data. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

(A)

| | All Layers | | Surface | | Bottom | | Stratum ( isobath range in m ) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ( 0m ) | | ( B+1m ) | | 5-10 | | 10-20 | | 20-50 | |
| No. of St. | 111 | | 111 | | 111 | | 52 | | 47 | | 12 | |
| No. of Data | 8,874 | | 111 | | 111 | | 2,796 | | 3,782 | | 2,296 | |
| Min. (psu) | 0.05 | | 0.05 | | 0.05 | | 0.05 | | 0.05 | | 18.86 | |
| Max. (psu) | 36.52 | | 36.50 | | 36.45 | | 35.06 | | 36.12 | | 36.52 | |
| Range (psu) | Freq. | (%) | Freq. | (%) | Freq. | (%) | Freq. | (%) | Freq. | (%) | Freq. | (%) |
| 0-5 | 992 | (11.2) | 26 | (23.4) | 17 | (15.3) | 814 | (29.1) | 178 | ( 4.7) | 0 | ( 0.0) |
| 5-10 | 638 | ( 7.2) | 23 | (20.7) | 8 | ( 7.2) | 565 | (20.2) | 73 | ( 1.9) | 0 | ( 0.0) |
| 10-15 | 559 | ( 6.3) | 12 | (10.8) | 8 | ( 7.2) | 424 | (15.2) | 135 | ( 3.6) | 0 | ( 0.0) |
| 15-20 | 576 | ( 6.5) | 10 | ( 9.0) | 8 | ( 7.2) | 308 | (11.0) | 253 | ( 6.7) | 15 | ( 0.7) |
| 20-25 | 579 | ( 6.5) | 10 | ( 9.0) | 8 | ( 7.2) | 304 | (10.9) | 251 | ( 6.6) | 24 | ( 1.0) |
| 25-30 | 851 | ( 9.6) | 10 | ( 9.0) | 16 | (14.4) | 232 | ( 8.3) | 580 | (15.3) | 39 | ( 1.7) |
| 30-35 | 1,733 | (19.5) | 14 | (12.6) | 19 | (17.1) | 124 | ( 4.4) | 1,444 | (38.2) | 165 | ( 7.2) |
| 35- | 2,946 | (33.2) | 6 | ( 5.4) | 27 | (24.3) | 25 | ( 0.9) | 868 | (23.0) | 2,053 | (89.4) |

(B)

| | All Layers | | Surface | | Bottom | | Stratum ( isobath range in m ) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ( 0m ) | | ( B+1m ) | | 5-10 | | 10-20 | | 20-50 | |
| No. of St. | 120 | | 120 | | 120 | | 55 | | 52 | | 13 | |
| No. of Data | 9,019 | | 120 | | 120 | | 2,855 | | 3,947 | | 2,217 | |
| Min. (psu) | 0.06 | | 0.06 | | 0.06 | | 0.06 | | 0.06 | | 6.96 | |
| Max. (psu) | 36.09 | | 32.81 | | 36.08 | | 33.46 | | 35.83 | | 36.09 | |
| Range (psu) | Freq. | (%) | Freq. | (%) | Freq. | (%) | Freq. | (%) | Freq. | (%) | Freq. | (%) |
| 0-5 | 1,929 | (21.4) | 54 | (45.0) | 23 | (19.2) | 1,196 | (41.9) | 733 | (18.6) | 0 | ( 0.0) |
| 5-10 | 1,042 | (11.6) | 32 | (26.7) | 9 | ( 7.5) | 362 | (12.7) | 578 | (14.6) | 102 | ( 4.6) |
| 10-15 | 780 | ( 8.6) | 10 | ( 8.3) | 10 | ( 8.3) | 320 | (11.2) | 371 | ( 9.4) | 89 | ( 4.0) |
| 15-20 | 768 | ( 8.5) | 14 | (11.7) | 7 | ( 5.8) | 398 | (13.9) | 226 | ( 5.7) | 144 | ( 6.5) |
| 20-25 | 513 | ( 5.7) | 2 | ( 1.7) | 9 | ( 7.5) | 303 | (10.6) | 177 | ( 4.5) | 33 | ( 1.5) |
| 25-30 | 662 | ( 7.3) | 2 | ( 1.7) | 15 | (12.5) | 244 | ( 8.5) | 380 | ( 9.6) | 37 | ( 1.7) |
| 30-35 | 1,570 | (17.4) | 6 | ( 5.0) | 27 | (22.5) | 32 | ( 1.1) | 1,123 | (28.5) | 415 | (18.7) |
| 35- | 1,756 | (19.5) | 0 | ( 0.0) | 20 | (16.7) | 0 | ( 0.0) | 359 | ( 9.1) | 1,397 | (63.0) |

(C)

| | All Layers | | Surface | | Bottom | | Stratum ( isobath range in m ) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ( 0m ) | | ( B+1m ) | | 5-10 | | 10-20 | | 20-50 | |
| No. of St. | 120 | | 120 | | 120 | | 55 | | 50 | | 15 | |
| No. of Data | 9,582 | | 120 | | 120 | | 2,849 | | 4,054 | | 2,679 | |
| Min. (psu) | 0.06 | | 0.06 | | 0.06 | | 0.06 | | 0.06 | | 15.75 | |
| Max. (psu) | 36.70 | | 36.68 | | 36.65 | | 33.86 | | 36.65 | | 36.70 | |
| Range (psu) | Freq. | (%) | Freq. | (%) | Freq. | (%) | Freq. | (%) | Freq. | (%) | Freq. | (%) |
| 0-5 | 883 | ( 9.2) | 25 | (20.8) | 10 | ( 8.3) | 711 | (25.0) | 172 | ( 4.2) | 0 | ( 0.0) |
| 5-10 | 547 | ( 5.7) | 18 | (15.0) | 9 | ( 7.5) | 427 | (15.0) | 120 | ( 3.0) | 0 | ( 0.0) |
| 10-15 | 581 | ( 6.1) | 16 | (13.3) | 10 | ( 8.3) | 422 | (14.8) | 159 | ( 3.9) | 0 | ( 0.0) |
| 15-20 | 378 | ( 3.9) | 10 | ( 8.3) | 6 | ( 5.0) | 201 | ( 7.1) | 159 | ( 3.9) | 18 | ( 0.7) |
| 20-25 | 859 | ( 9.0) | 18 | (15.0) | 13 | (10.8) | 512 | (18.0) | 305 | ( 7.5) | 42 | ( 1.6) |
| 25-30 | 1,078 | (11.3) | 16 | (13.3) | 17 | (14.2) | 374 | (13.1) | 670 | (16.5) | 34 | ( 1.3) |
| 30-35 | 1,534 | (16.0) | 7 | ( 5.8) | 22 | (18.3) | 202 | ( 7.1) | 1,253 | (30.9) | 79 | ( 2.9) |
| 35- | 3,722 | (38.8) | 10 | ( 8.3) | 33 | (27.5) | 0 | ( 0.0) | 1,216 | (30.0) | 2,506 | (93.5) |

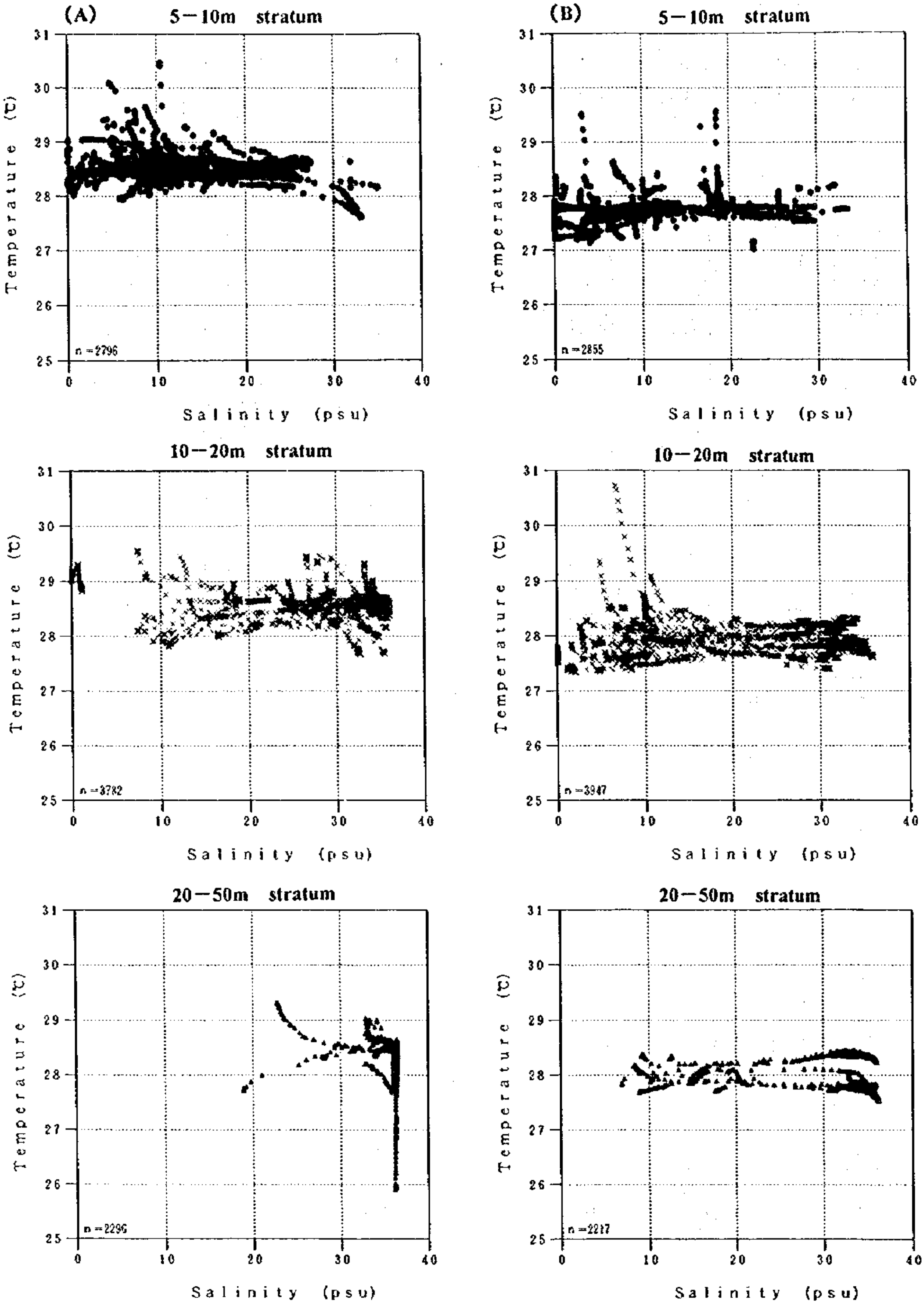
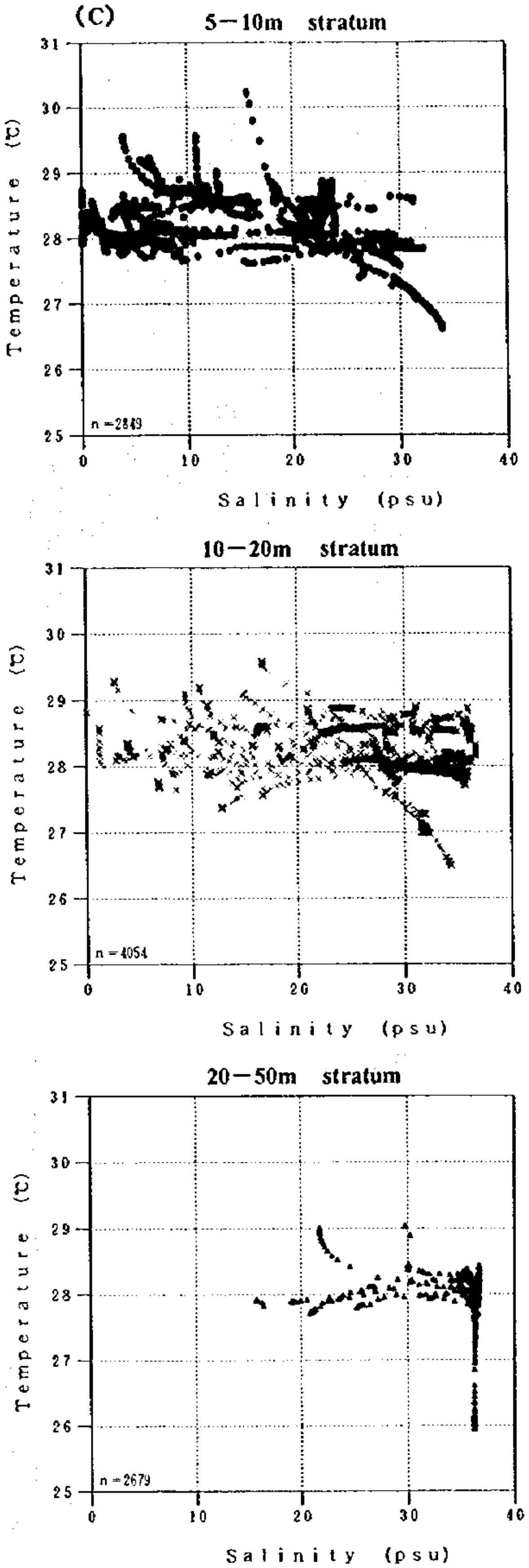



Figure 57. T-S diagram within specific water depth intervals. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 57. Continued

(C)



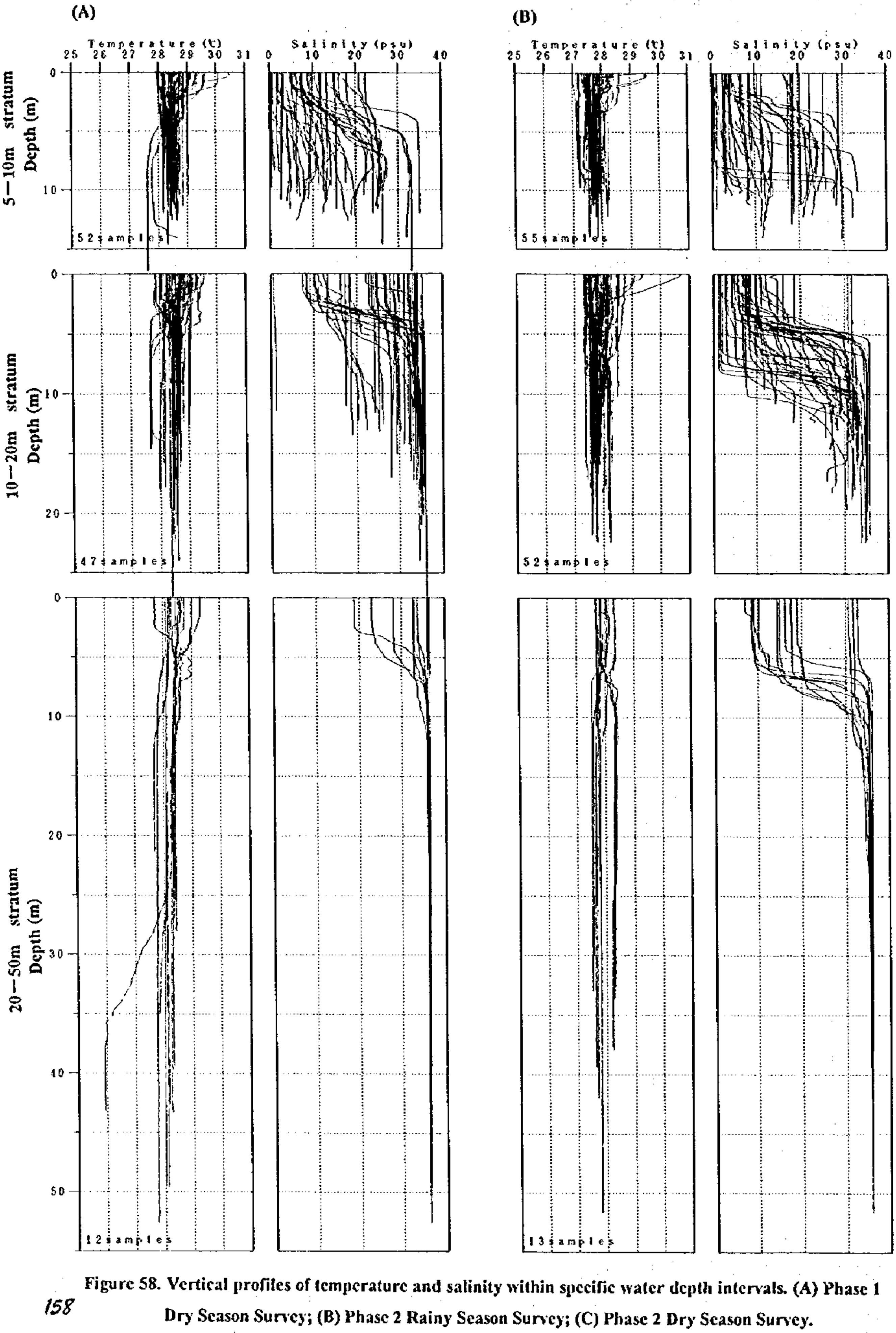
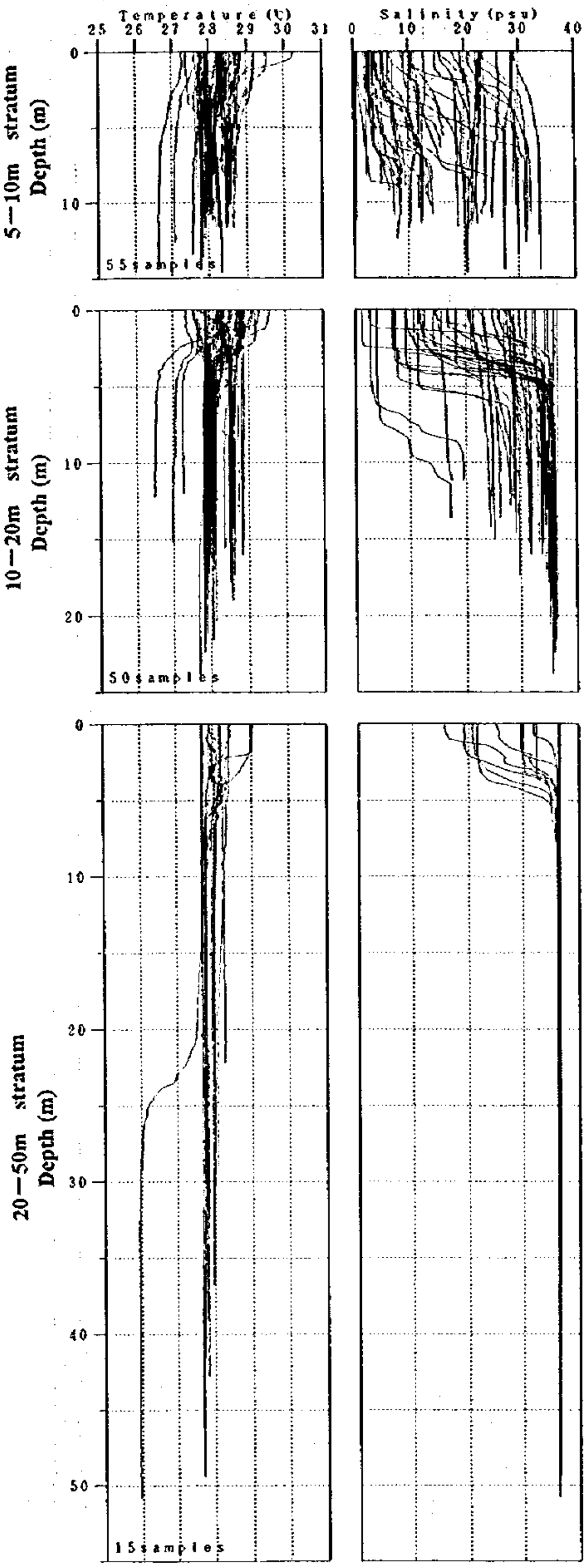



Figure 58. Vertical profiles of temperature and salinity within specific water depth intervals. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 58. Continued

(C)



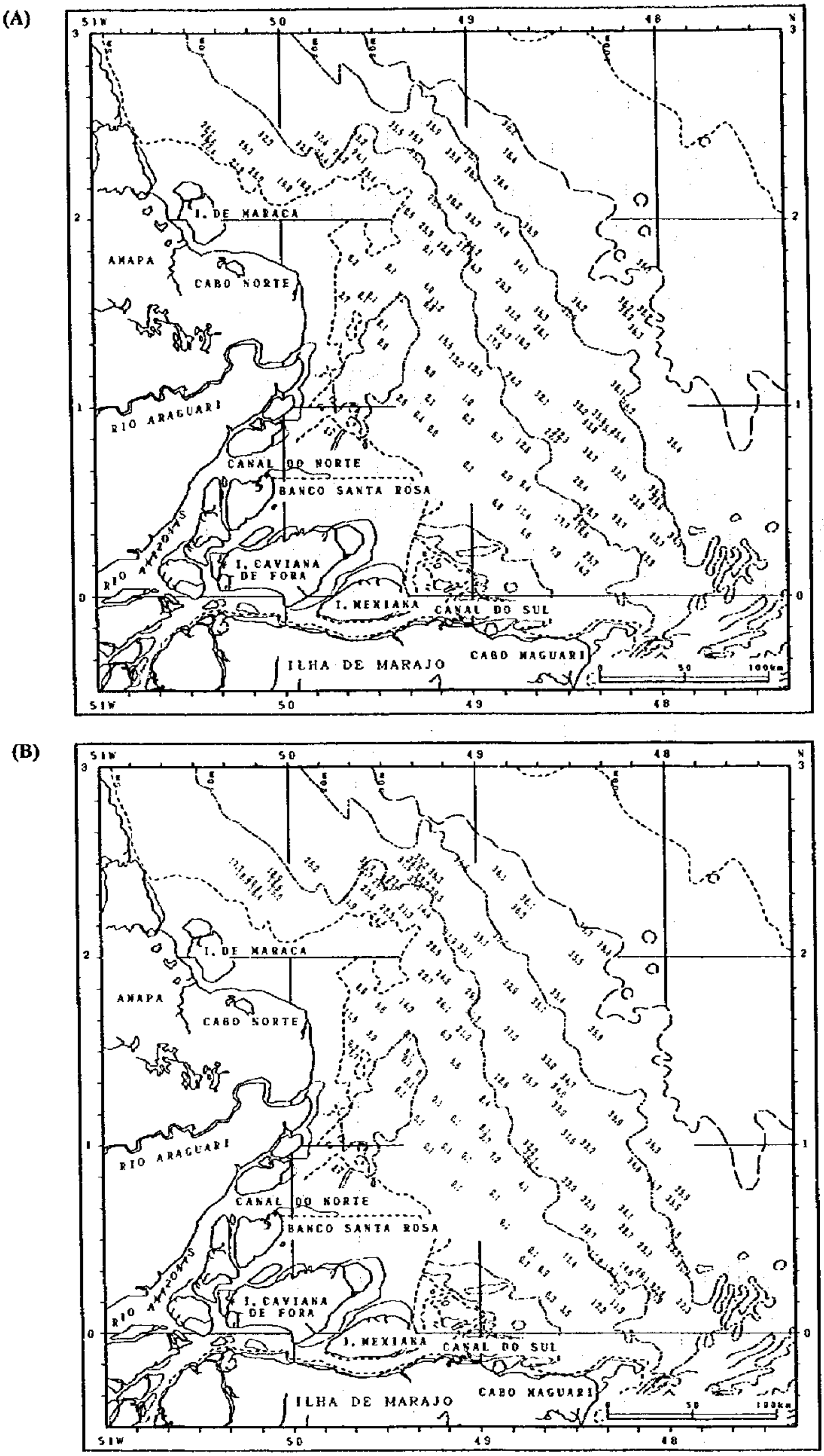
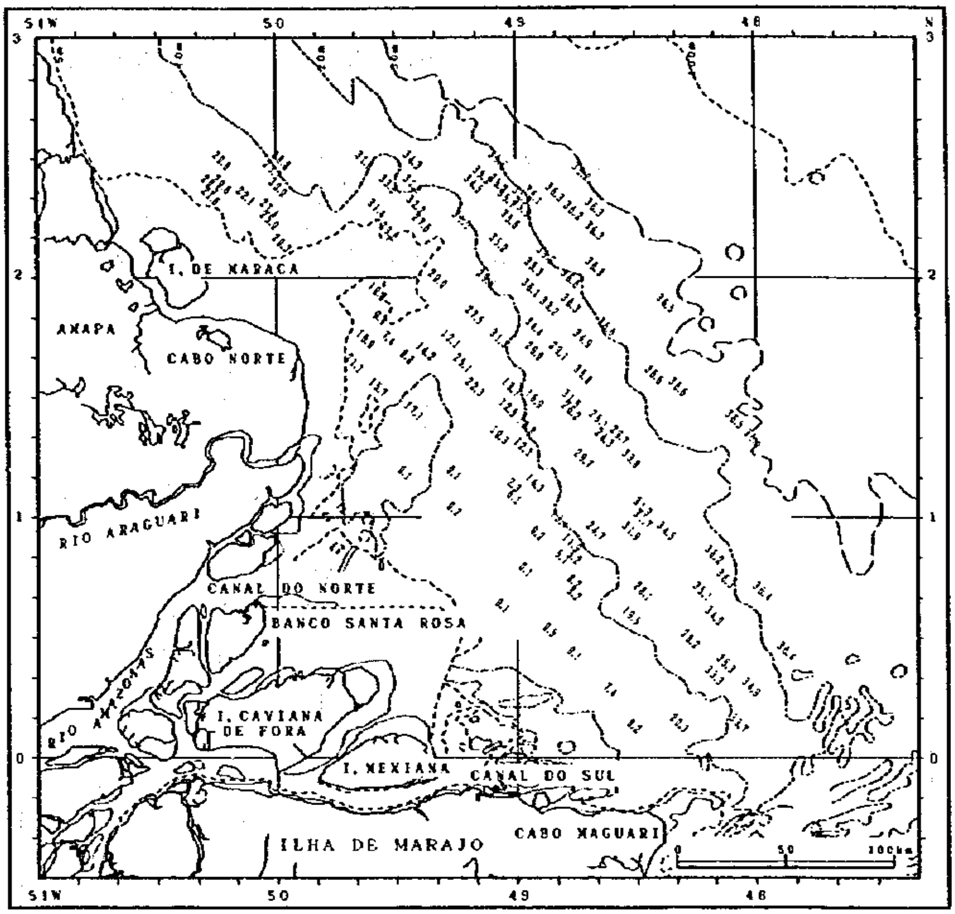



**Figure 59. Horizontal distribution of salinity in the bottom (1m above the sea bed). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.**

**Figure 59. Continued**

(C)




a-2) Horizontal distribution of pH in the surface

Table 64 shows all data on pH measured in the surface (i.e., near the water surface) sample in each oceanographic observation station, tabulated according to the three strata defined in the resources survey. Their horizontal distribution is illustrated for each seasonal survey in Figure 60.

Values of pH observed over the entire survey were in the 7.05–8.64 range. In each seasonal survey, mean pH by stratum depended on depth, increasing from shallow stratum (between isobaths of 5 m and 10 m) to deep stratum (between isobaths of 20 m and 50 m). In offshore, beyond the isobath of 20 m, pH values below 8.0 were not reported (Table 64). In general, pH values tended to rise with depth: considering a value of 8.0 as a reference in the shoreward area from around the isobath of 10 m, pH was lower than that value and in the offshore area from that was higher. On the other hand, pH values in the area between isobaths of 5 m and 10 m north of latitude 2° N and west of longitude 50° W were relatively higher than those in other areas of the same isobaths (Figure 60).

Table 64. Statistical results of measured pH data in the surface. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

| Survey season | Phase 1 Dry Season | | | Phase 2 Rainy Season | | | Phase 2 Dry Season | | |
|---|---|---|---|---|---|---|---|---|---|
| Stratum (isobath range in m) | 5 - 10 | 10 - 20 | 20 - 50 | 5 - 10 | 10 - 20 | 20 - 50 | 5 - 10 | 10 - 20 | 20 - 50 |
| No. of data | 52 | 47 | 12 | 55 | 52 | 13 | 56 | 49 | 15 |
| Minimum | 7.07 | 7.24 | 8.11 | 7.05 | 7.14 | 8.06 | 7.06 | 7.17 | 8.07 |
| Maximum | 8.22 | 8.64 | 8.33 | 8.08 | 8.45 | 8.56 | 8.05 | 8.28 | 8.34 |
| Mean | 7.66 | 8.06 | 8.20 | 7.53 | 7.82 | 8.25 | 7.58 | 7.98 | 8.17 |
| Standard deviation | 0.291 | 0.228 | 0.060 | 0.254 | 0.391 | 0.163 | 0.255 | 0.231 | 0.075 |
| Frequency (%) by pH range | | | | | | | | | |
| 7.0 - 7.2 | 3.8 | 0.0 | 0.0 | 5.5 | 3.8 | 0.0 | 9.1 | 2.0 | 0.0 |
| 7.2 - 7.4 | 21.2 | 2.1 | 0.0 | 30.9 | 15.4 | 0.0 | 18.2 | 2.0 | 0.0 |
| 7.4 - 7.6 | 15.4 | 4.3 | 0.0 | 25.5 | 15.4 | 0.0 | 27.3 | 0.0 | 0.0 |
| 7.6 - 7.8 | 21.2 | 4.3 | 0.0 | 20.0 | 13.5 | 0.0 | 27.3 | 14.0 | 0.0 |
| 7.8 - 8.0 | 25.0 | 14.9 | 0.0 | 12.7 | 9.6 | 0.0 | 9.1 | 24.0 | 0.0 |
| 8.0 - 8.2 | 11.5 | 42.6 | 50.0 | 5.5 | 17.3 | 38.5 | 9.1 | 48.0 | 60.0 |
| 8.2 - 8.4 | 1.9 | 29.8 | 50.0 | 0.0 | 19.2 | 30.8 | 0.0 | 10.0 | 40.0 |
| 8.4 - 8.6 | 0.0 | 0.0 | 0.0 | 0.0 | 5.8 | 30.8 | 0.0 | 0.0 | 0.0 |
| 8.6 - 8.8 | 0.0 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

(A)

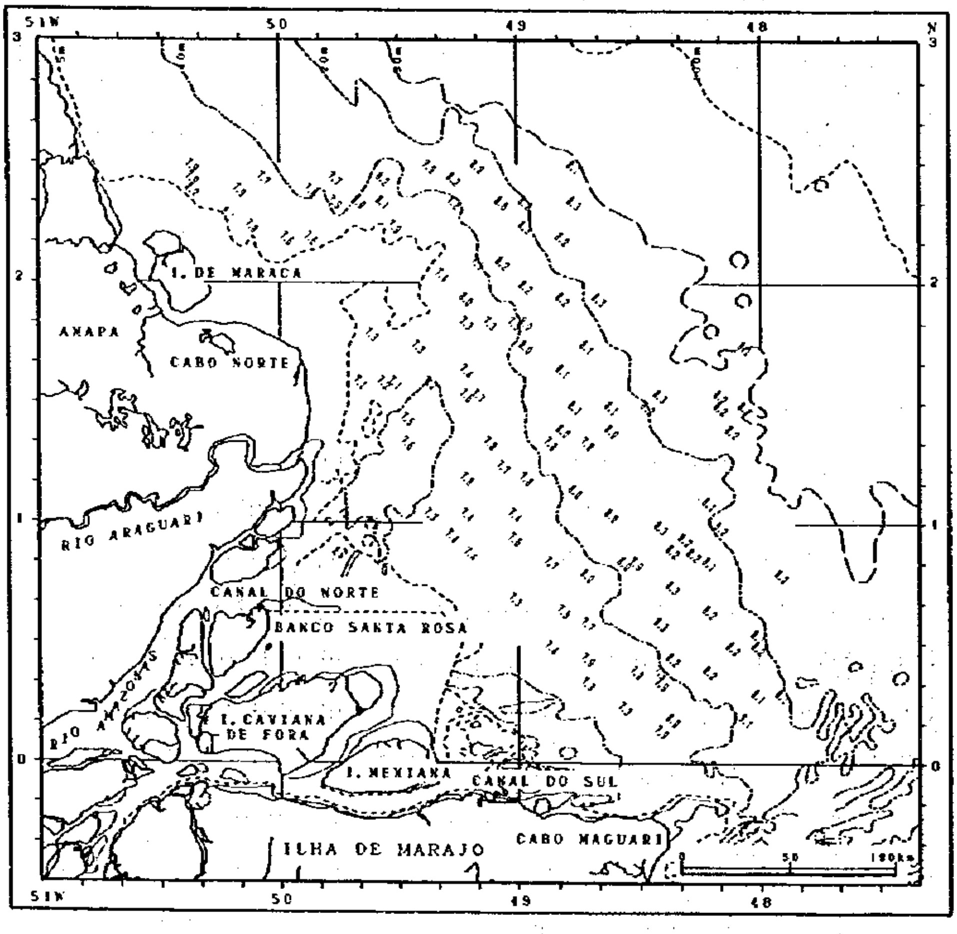
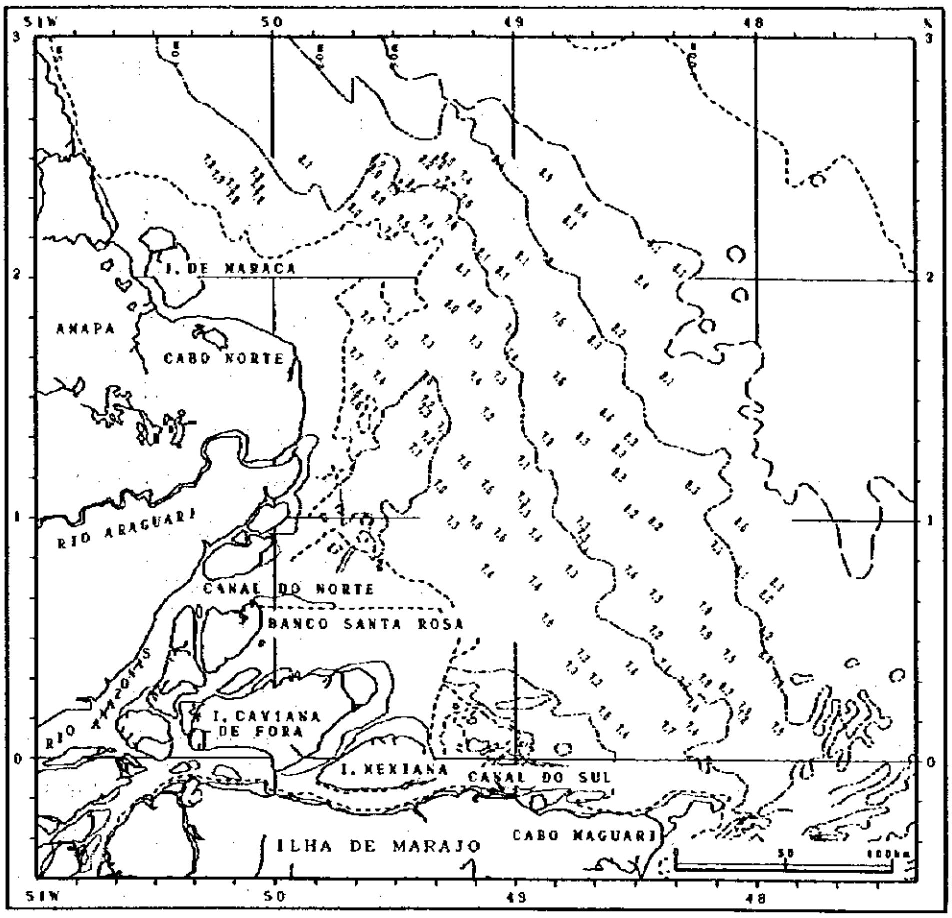


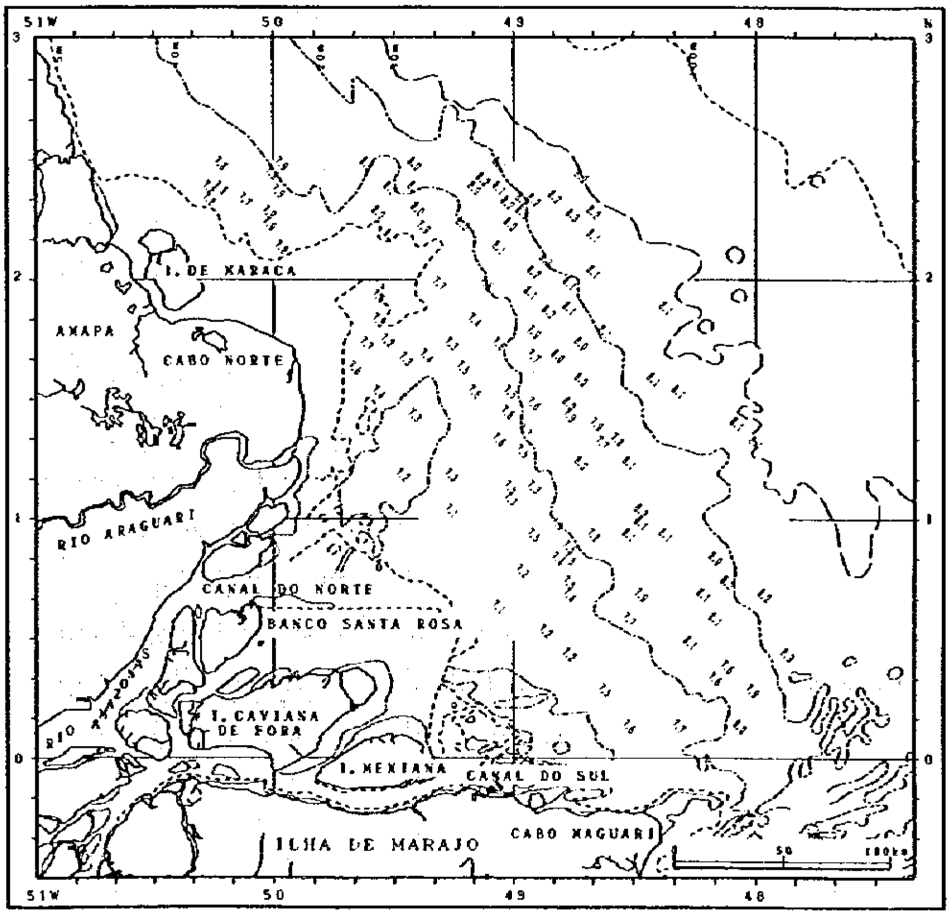

Figure 60. Horizontal distribution of pH in the surface (near the water surface). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

**Figure 60. Continued**

(B)




(C)



a-3) Current conditions

Figures 61 and 62 show, respectively, the horizontal distribution of water current in the surface (measured in 4 m below the water surface) and bottom (taken in 2 m above the sea floor) layers, from data on direction and speed of water current obtained at each oceanographic observation station, and Figure 63 show current direction frequency distribution in the surface layer in each stratum. Due to problems concerning the performance of the equipment (Acoustic Doppler Current Profiler) and its measurement of layer thickness, data on current conditions (direction and speed) were limited; also, in stations where depth was shallow, many problematic data were obtained. It should also be considered that data on current condition should indicate only instantaneous readings taken at a given time and place. Especially in this area with great tidal range, the distribution of currents over a two-month period indicates extremely stable ones over time, which can be visualized, for instance, in river water current axes in the surface.

In all seasonal surveys, currents in surface in the area from the isobath of 10 m toward offshore were predominantly directed across the isobath (either towards the shore and off), suggesting they are regulated by the tides. The illustrated currents appear to be weak from the isobath of 10 m to the shore and strong toward the offshore, but their seeming weak even in the river mouth where river waters are thought to flow fast may be attributed to the unsuitability of the measuring equipment for the area in question. Currents in the bottom presented a complex distribution, being directed across the isobath and also along it; however, much like those in the surface, they seem stronger in areas toward the offshore. On the other hand, there seems to be stable and relatively strong northward and northwestward currents in the northern offshore portion of the survey area.

The highest current velocity recorded was about 150 cm/s, in the northern portion of the survey area (around 2° 25'N 50° 30' W), between the isobaths of 5 m and 10 m, during the Phase 2 Rainy Season Survey. In most stations, currents were stronger in the surface layer than in the bottom layer and it appears that a vertical shear has been formed (For the reason that current velocities could not be measured in area shallower than 10 m water depth, it was impossible to find that characteristics in the area.)

With respect to current direction frequency in the surface layer by water depth range in the area between the isobaths of 5 and 10 m high frequent directions were northeasterly (NNE, NE, ENE), suggesting the outflow of the Amazon River would be the most important cause for determining the direction of currents in this area. In the area between the isobaths of 10 m and 20 m, high frequent current directions were eastward across the continental shelf (from NE to ESE around the compass) or, conversely, westward (from SSW to WNW around the compass); it is thought that would actually indicate changes in direction along with tidal currents. In the area between the isobaths of 20 m and 50 m, except in the Phase 2 Dry Season, there were more currents directed easterly (ENE and E).

(A)

(B)

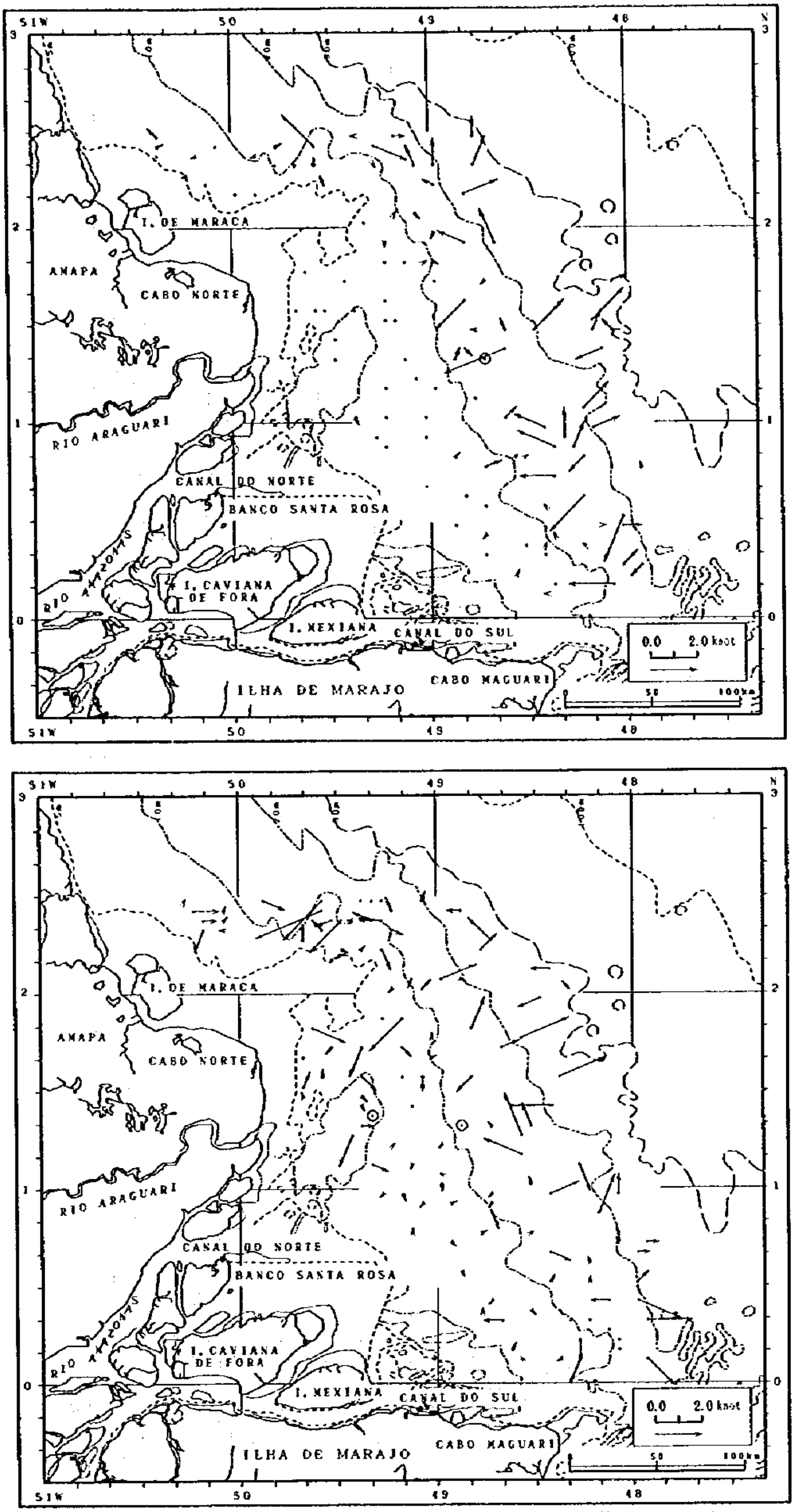
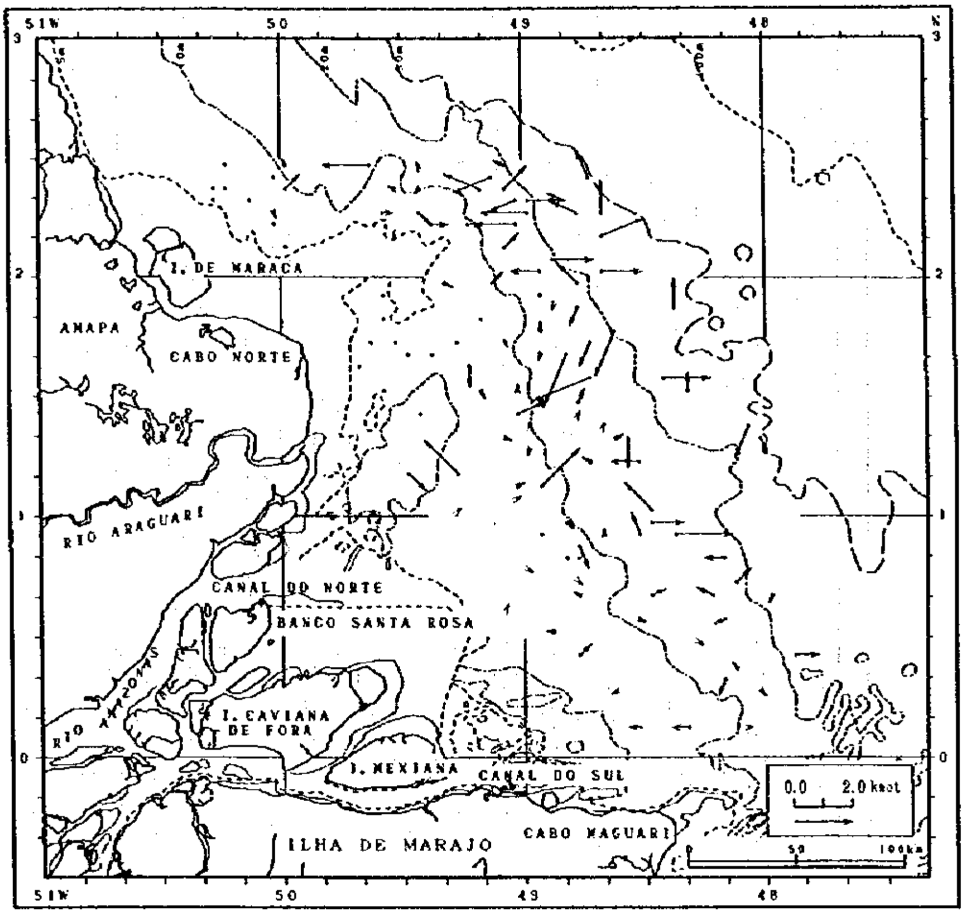



Figure 61. Horizontal distribution of current in the surface layer (4m below the water surface). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 61. Continued

(C)




(A)

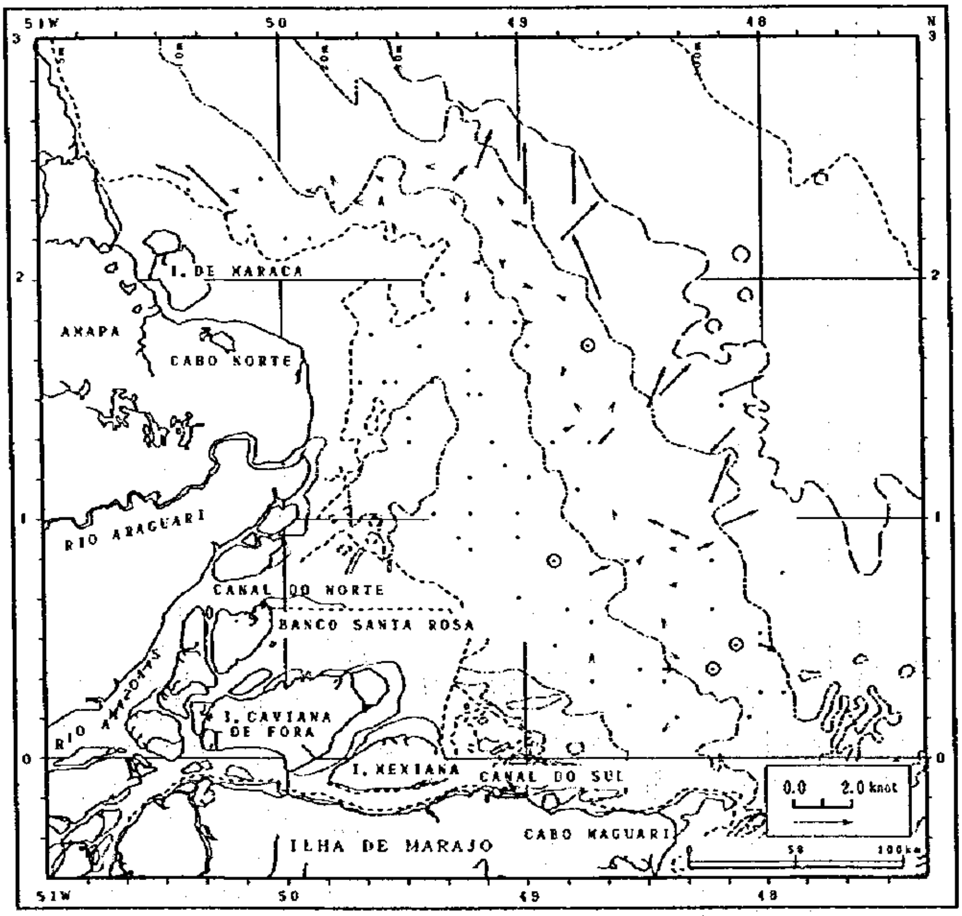
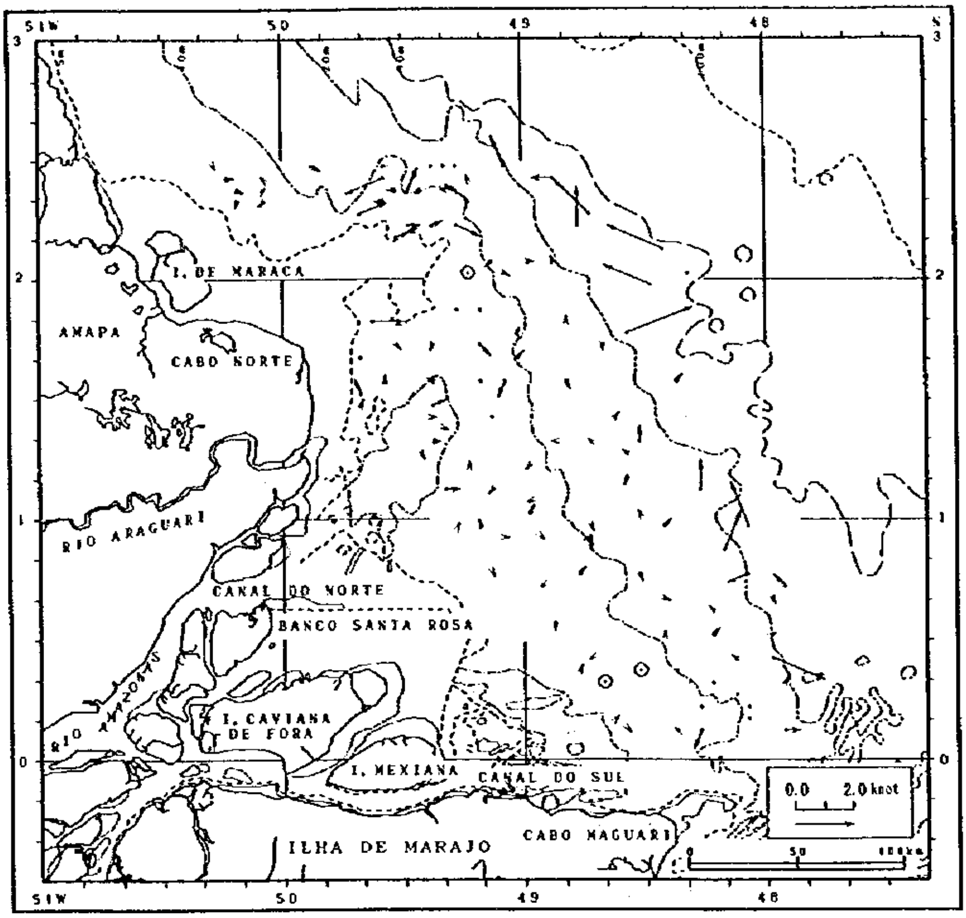


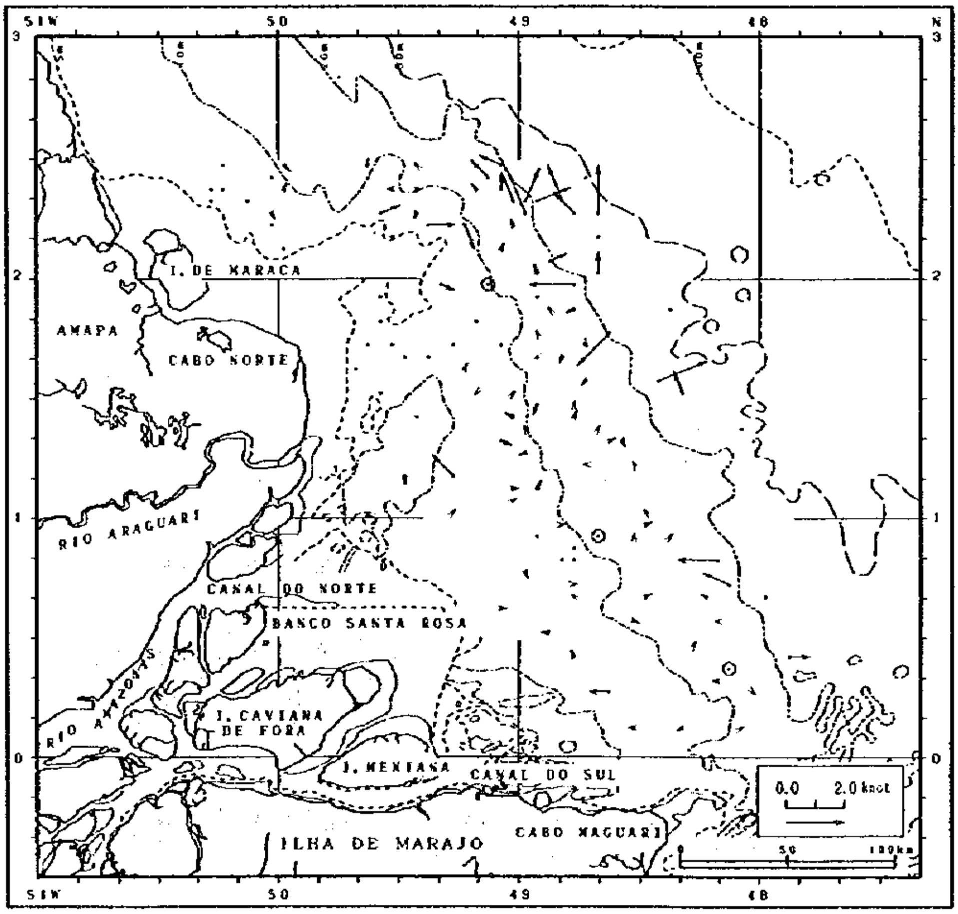

Figure 62. Horizontal distribution of current in the bottom layer (2m above the sea bed). (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

Figure 62. Continued

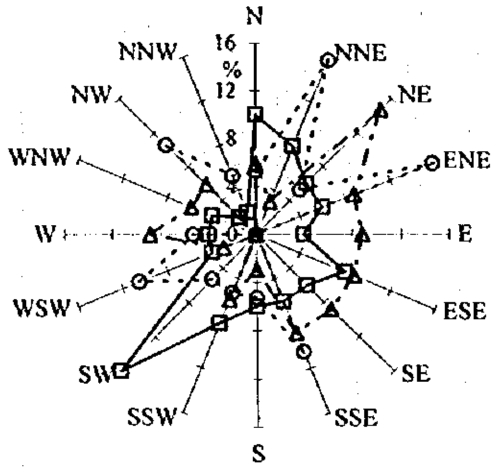
(B)



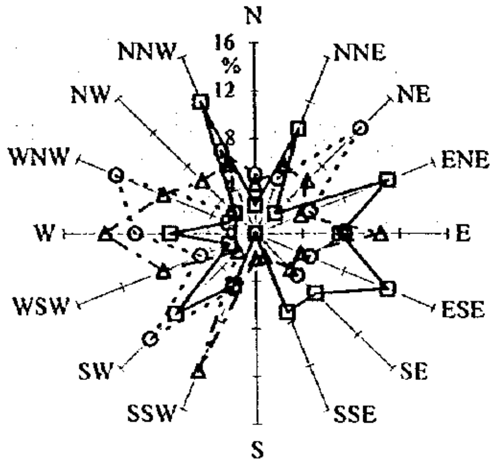

(C)



Stratum : 5-10m




Stratum : 10-20m




Stratum : 20-50m

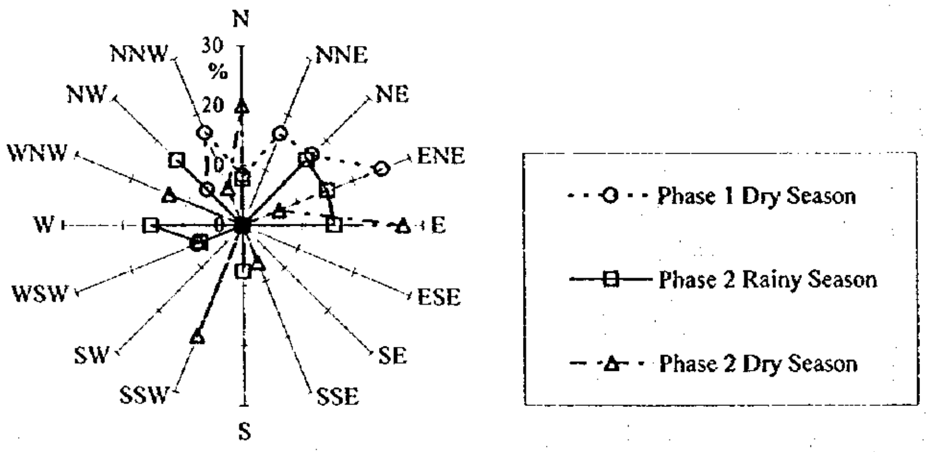



**Figure 63. Frequency distribution of current direction in the surface layer (4m below the water surface).**

### (b) Meteorology

At each trawl station, meteorological conditions were recorded during the haul; these data are summarized in Table 65.

Fair weather (bc: blue sky with detached clouds) was overwhelmingly more frequent in the Dry Seasons. On the other hand, there were about equal frequencies of fair (bc), overcast weather [c: cloudy, o: overcast sky and r: rain]. Prevailing winds in terms of distribution frequency of directions were ESE in the Dry Seasons and E and ENE in the Rainy Season. The predominant wind force in the Beaufort scale was gentle breeze (scale 3: winds of 3.4–5.4 m/s at altitude 10 m in the open flat ground) for all seasonal surveys. The prevailing wave size in the wind wave scale were smooth wavelet (scale 2: wave height 0.1–0.5 m) and slight (scale 3: wave height 0.5–1.25 m) in the Dry Seasons, and smooth wavelet (scale 2) in the Rainy Season.

**Table 65. Statistical results of meteorological data.**

| Survey season | | | Phase 1 Dry Season | Phase 2 Rainy Season | Phase 2 Dry Season |
|---|---|---|---|---|---|
| No. of data | | | 110 | 120 | 120 |
| Frequency (%) | Weather[a] | b | 1.8 | | 1.7 |
| | | bc | 93.7 | 52.5 | 95.0 |
| | | c | 3.6 | 21.7 | 1.7 |
| | | o | 0.9 | 20.0 | 1.7 |
| | | r | | 5.8 | |
| | Wind direction | NE | | 6.7 | |
| | | ENE | 9.9 | 36.7 | 1.7 |
| | | E | 19.8 | 48.3 | 25.0 |
| | | ESE | 39.6 | 4.2 | 45.0 |
| | | SE | 24.3 | 3.3 | 27.5 |
| | | SSE | 6.3 | 0.8 | 0.8 |
| | Beaufort scale[b] | 1 | | | 0.8 |
| | | 2 | 14.4 | 33.3 | 47.5 |
| | | 3 | 57.7 | 60.8 | 50.0 |
| | | 4 | 27.9 | 5.8 | 1.7 |
| | Wind wave scale[c] | 1 | | 2.5 | 5.0 |
| | | 2 | 36.9 | 77.5 | 58.3 |
| | | 3 | 49.5 | 20.0 | 35.8 |
| | | 4 | 12.6 | | 0.8 |
| | | 5 | 0.9 | | |

a. b: blue sky, bc: blue sky with detached clouds, c: cloudy, o: overcast sky, r: rain

b. 0: calm (0-0.2m/s), 1: light air (0.3-1.5m/s), 2: light breeze (1.6-3.3m/s), 3: gentle breeze (3.4-5.4m/s), 4: moderate breeze (5.5-7.9m/s). Wind speed in parentheses corresponds to it at a height of 10m above the flat ground in the open area. Besides the name of each wind force scale is one after WMO, World Meteorological Organization.

c. 0: calm glassy (0), 1: calm rippled (0<Hw≦0.1), 2: smooth wavelet (0.1<Hw≦0.5), 3: slight (0.5<Hw≦1.25), 4: moderate (1.25<Hw≦2.5), 5: rough (2.5<Hw≦4). Range of value in parentheses show a height of wave in m.