7. UNUTILIZED AND UNEXPLOITED FISHERY RESOURCES

7.1. Unutilized Fishery Resources and Their Utilization

The existence of unutilized fishery resources is mostly known through bycatches obtained from existing fishery or resources surveys. However, the commercial worth of the exploitation of those resources should be appraised — whether their value is high enough or they can be caught in sizable numbers. From this viewpoint, unutilized fishery resources are defined as comprising those among the 104 fish species captured during the resources survey (see Appendix Table 1) that are not being commercially utilized — that is, species outside the Brazilian domestic market — and whose stock biomass is large to a certain extent — that is, species listed in Table 18, Top-ranking ten species in estimated stock size by stratum. To evaluate which species are being commercially utilized, fish names taken from the fishery statistics published by the Brazilian Institute for Geography and Statistics (IBGE) (1990 edition, as they have not been issued after 1991) and from the results of the fish price fluctuation survey regularly carried out at the Ver-o-Peso Market in Belém by the MPEG (in all 45 records from July 1994 to June 1995) were examined. It was found out that almost all fish names published by IBGE are fish group designations encompassing regional terms from all Brazil (for instance, "CAÇÃO" refers to 42 regional words for sharks, "CORVINA" and "PESCADA" account respectively for 22 and 26 local names of drums, and "BAGRE" includes 25 denominations of sea catfishes). On the other hand, those featured in MPEG lists are comparatively detailed in their classification, although one can hardly say that a given name corresponds precisely to a given species. Therefore, it was decided that those fish names just described (local or regional names, not group designations) matching one-to-one the regional names listed in Table 18 would refer to utilized fish species. All others would designate unutilized resources.

From the above, two species — buchudinho *Stellifer rastrifer* and canguito *Arius phrygiatus* — can be picked as the unutilized resources. The former is a small-size drum of about 15 cm, very common as a bycatch in industrial shrimp trawl nets in the coast of the Guianas and the Gulf of Paria. It does not have much value as a food fish but, depending on the circumstances, it could be useful in the manufacture of fisheries byproducts. By means of a trawl net with a 100 mm mesh cod-end, it would be possible to catch about 10% of the stock (Table 18, C). The latter species is a small-size sea catfish of about 20 cm without much importance for the industry, but one that could have some value for household consumption in artisanal fishermen. Also, like in the previous case, in the right circumstances it could serve for making fisheries byproducts.

7.2. Unexploited Resources and the Possibility of Their Exploitation

Unexploited resources in the Amazon River Mouth Area are defined as those distributed offshore in depths below 20 m — currently almost unexplored by either artisanal or industrial fisheries — and whose biomass is large to a certain extent. That would conveniently correspond to those species caught during the resources survey in the 20–50 m stratum and with an estimated stock size of over 200 tonnes (Table 18, A–C), hereby defined as unexploited resources and summarized in Table 86.

Table 86. Unexploited resources of the Amazon River Mouth Area in depths below 20 m. Stock size obtained from catch in cod-end.

Survey season	Species	Local name	Stock size in tonnes
Phase 1 Dry	*Arius grandicassis*	Cambéua	741
	Carcharhinus porosus	Cação	543
	Cynoscion virescens	Pescada-cambuçu	302
	Micropogonias furnieri	Pescada-curuca-grande	269
	Trichiurus lepturus	Espada	224
Phase 2 Rainy	*Arius grandicassis*	Cambéua	1,855
	A. parkeri	Gurijuba	309
	A. quadriscutis	Cangatá	366
	Carcharhinus porosus	Cação	1,158
	Cynoscion virescens	Pescada-cambuçu	1,233
	Macrodon ancylodon	Pescadinha-gó	237
	Nebris microps	Pescada-sete-buchos	222
	Sphyrna lewini	Martelo	920
Phase 2 Dry	*Arius grandicassis*	Cambéua	1,613
	A. parkeri	Gurijuba	648
	A. quadriscutis	Cangatá	879
	Carcharhinus porosus	Cação	1,188
	Cynoscion virescens	Pescada-cambuçu	591
	Micropogonias furnieri	Pescada-curuca-grande	469
	Sphyrna tudes	Cação-rodela	409

The unexploited resources comprise the following eleven species: the elasmobranchs cação *Carcharhinus porosus*, martelo *Sphyrna lewini* and cação-rodela *Sphyrna tudes;* the ariids cambéua *Arius grandicassis*, gurijuba *A. parkeri* and cangatá *A. quadriscutis;* the sciaenids pescada-cambuçu *Cynoscion virescens*, pescadinha-gó *Macrodon ancylodon*, pescada-curuca-grande *Micropogonias furnieri*, and

pescada-sete-buchos *Nebris microps;* and the trichiurid espada *Trichiurus lepturus.* Of those, gurijuba and pescadinha-gó are important species in the Amazon River Mouth Area. Pescada-cambuçu and pescada-curuca-grande are one of the most important commercial species on the continental shelf of the Venezuela and Guianas and are marketed fresh. Sharks are ordinarily salted and the other species are marketed fresh and have a certain commercial value.

One hopes the exploitation of those resources could be an alternative for the bottom-trawling industrial fisheries that today concentrate on piramutaba. Effective alternative methods of exploitation could be employed, such as longline fishing for sharks, pescada-cambuçu or gurijuba, nocturnal herding-light fishing for espada and, according to the occasion, trawl nets and gillnets for other species. In that instance, a marketing research is needed to study the profitability of these fisheries and, upon their fruition, it will be necessary to regulate the intensity of their exploitation by checking the annual function in CPUE and body length composition under continuous fishing effort.

8. GUIDELINES FOR THE MANAGEMENT OF DEMERSAL FISHERY RESOURCES IN THE AMAZONIAN ESTUARY

8.1. Characteristics of Fishery Resources

Fishery resources comprise living organisms that are utilized by human beings through fishery activities, and as such they have their own characteristic features.

Most remarkable among these features is the fact they are renewable natural resources, and therefore different from mineral resources such as petroleum, coal and the like. Also, they are free from ownership. Furthermore, any prediction of their status at a given time is difficult and loaded with uncertainty due to their own fluctuating widely.

Freedom for ownership may lead to overexploitation and stock erosion, but the ability of self-renewal can make fishery resources, with proper management, a shared property of humankind for a long time to come.

8.2. The Concept of Fishery Resources Management

Fishery resources being self-renewable, if adequate measures are taken, it would be possible to continuously explore them and later hand them over to future generations. According to the United Nations, sustainable development is defined as "a form of development that not only fulfills the needs of future generations, but also those of the contemporary generation".

This concept can be also applied to fisheries. The increment of biomass of a given species in a closed area is usually expressed by a logistic (sigmoid) curve with small differential values at the origin and at the carrying capacity level, and large differential values at the middle biomass level. Total biomass increase (increase in growth and recruitment) minus total biomass reduction (catch and natural mortality) equals surplus yield of fishery resources, which corresponds to the sustainable yield and is represented by a parabola-shaped curve against progress of exploitation of stock biomass. If fisheries utilized only the surplus yield there would not be a consequent decrease in biomass.

8.3. Trends in Fishery Resources Management

Current trends in fishery resources management had to change drastically with regards to past inclinations due to the United Nations Convention on the Law of the Sea. By this convention, it is recognized that the sovereign rights of exploitation of living resources in the Exclusive Economic Zone (EEZ) belong to the adjacent coastal nations, who would determine their capacity to harvest them and take proper action

toward their conservation and management. Those nations would determine their respective allowable catch and the surplus, if any, should be offered to other nations.

Future fishery resources management should be in accordance with this convention. Therefore, it is urgent that the Government of Brazil evaluate the present status of various fishery resources in the EEZ and then organize its own management policy.

8.4. A Summary of Fisheries and Resources

The fisheries and their resources in the Amazon and Tocantins River Mouth Area so far elucidated from the present study can be summarized as follows:

(a) In general

a-1) The basic fisheries infrastructure or socioeconomic infrastructure of the fishing communities in the Amazonian Estuary is underdepeloped, and fisheries education is not widespread. This results in people related to fisheries lacking the mentality of properly utilizing fishery resources for the long run, so as to keep them on for the common good of humankind.

a-2) As it is characteristic of tropical areas, fish species are numerous there. However, the population density of each species is low, and thus fishery resources are not abundant.

a-3) Piramutaba, the industrial fisheries prime target stock in the Estuary, is in a condition of overexploitation.

(b) Regarding artisanal fisheries

b-1) Within employing their current fishing gears and applying their current rate of effort, the impact on fishery resources by artisanal fisheries cannot be strong. It will be impossible this fleet would overfish the piramutaba stock.

b-2) The artisanal fleet explores a larger area, catches more different species, makes a better selection of profitable fish sizes as compared to the industrial fleet.

b-3) The infrastructure utilized by the artisanal fleet is underdeveloped, and so ports and places utilized for fish landing and processing facilities are hygienically precarious.

b-4) Fishermen of the artisanal fleet are not effectively organized into unions or societies. Their professional minds prohibit government officers from guiding and inquiring on their fisheries organizations.

(c) Regarding industrial fisheries

c-1) Judging from their long history of ongoing exploitation, offshore fishery resources in the region have been heavily exploited both selectively and arbitrarily.

c-2) Correspondingly, non-target species and small individuals have been wastefully discarded, indicating that industrial fisheries are not properly utilizing fishery resources and are unable to avoid squandering them.

Some recommendations are proposed next, based on the findings above.

8.5. Recommendations for the Management of Fishery Resources

8.5.1. Fisheries biology

(a) Acquisition of biological information

Sound management of fishery resources requires the continuous maintenance of a program of collecting basic biological data such as size and age composition of catch, CPUE values for both artisanal and industrial fisheries in each kind of fishing ground (river/estuary), and season and place of spawning. In addition, it is necessary to publish periodic reports containing analyses of those data and current estimates of some important biological parameters such as growth rate, mortality due to natural causes and to fishing, minimum size for maturation, etc. In this study, limited information was obtained on key species other than piramutaba. For those other species, further effort at collecting them and obtaining effective information on them is highly recommended.

(b) Follow-up to the fishery resources study

Elucidation of the variation in fishery resources requires a precise picture of the changes undergone by those resources under current fishery activities and environmental conditions. It is necessary to carry out a similar study every 2 or 3 years in the future, using the same methodology on a comparable scale. The present fishery resources study must be taken as a starting point for a forthcoming similar project, in which the study area would be only shallow waters (5 to 20 m), so as to reduce the variance in stock size estimates.

(c) Collection, organization and management of fishery statistics

For the efficient and sustainable exploitation of fishery resources, it is essential that the collection, organization and management of fishery statistics is carried out by the appropriate fisheries administration agency.

For that purpose, a basic necessity would be the proper organization of all fishery statistics.

c-1) Artisanal fisheries

It is necessary to make an effort so as to obtain, at the very least, statistics for monthly catch and fishing effort by fish species.

c-2) Industrial fisheries

i) The number of fishing companies and fishing vessels is small and can be controlled. Partial fishery statistics are already being submitted by the companies to the proper government agency. It is necessary to further improve that information, especially position information on their fishing operations. There is also the need to increase the ability of quickly processing data on catch by month, by fishing ground, by fish species and size. Once those fishery statistics are fully provided, their analysis will enable the formulation of a strategy for fishery resources management.

ii) Changes in fishing effort promoted by the introduction of three- and multiple-trawler fishing instead of the customary two-trawler technique have to be evaluated with regards to the power and efficiency of those recent fishing method.

iii) The ability of many commercially important freshwater and marine species to migrate over long distances — particularly the large catfishes of the genus *Brachyplatystoma*, who travel extensively through the Amazon River in the dry season — calls for tagging experiments to study their migratory patterns.

(d) Research on the amount of fishery resources discarded by industrial fisheries

For an efficient utilization of fishery resources and an accurate estimation of current catch statistics, it is also necessary to elucidate the amount of fishery resources thrown away by the industrial fleet.

8.5.2. Socioeconomic Considerations

(a) Promotion of fisheries education

It is necessary to bring up qualified professionals through fisheries education at all levels — specialized schools, high schools and colleges — both in Brazil as a whole and in the States of Pará and Amapá in particular.

(b) Education and organization of the fisheries community

For fisheries management to become a reality, the most important point is the understanding and cooperation in the fisheries community regarding the management of fishery resources. Continuous dissemination of fisheries education and knowledge to these people is essential.

Existing cooperatives and associations involving artisanal fishermen should be stimulated back into action at the very least.

People involved in industrial fisheries are already organized in labor unions, but need to be better educated on fishery resources and on the conservation of water area environments.

(c) Organization and arrangement of fisheries administration

The management, research and study of fishery resources in the northern region of Brazil is being conducted at present mainly by CEPNOR/IBAMA. However, their current situation does not enable them to properly cope with the diversification of emerging administrative and research issues. A proper enhancement of their organization is required.

(d) Organization of the socioeconomic infrastructure

The socioeconomic infrastructure concerning production, processing, storage, distribution, sales, etc. with respect to fisheries around the Amazonian Estuary should be established properly. Also, an educational program aimed at teaching local consumers how to process and cook fish species that are usually discarded or not utilized by either the artisanal or the industrial fleet is deemed necessary.

8.5.3. Fishery Regulations

There are two kinds of fishery regulations. Qualitative restrictions can be applied to fishing gear , fishing methods, fishing grounds and fishing seasons — such as length and mesh-size limits. Quantitative restrictions refer to fishing effort — e.g., a limit on the number of vessels or the fishing gear utilized. Generally speaking, fisheries regulations are used in fact as a combination of several regulations according to the present status of fisheries.

For the enforcement of any kind of regulation, however, it goes without saying that proper understanding and cooperation of fishery-related personnel should be obtained beforehand.

(a) Restrictions on fishing gear and fishing methods

There are basically two kinds of fishing gear in fishery in the Amazonian Estuary: the bottom trawl net and the gill net. Longlines and all different kinds of traps are restricted to some areas close to the coastline and are not of much importance in total landed quantity of fish in the Estuary.

Previous studies have shown the current gill net mesh sizes cannot overexploit the target fishery resources. On the other hand, the bottom trawl net can cause the overexploitation of these resources with little effort. The restrictions here proposed should apply to bottom trawl nets of the industrial fleet.

As for the application of restrictions on cod-end mesh size, there is no basic information in the present study that could suggest either way. However, Official Directive (Portaria) No. N-9, dated 9 March 1983, establishes the minimum size for the stretched cod-end mesh as 100 mm.

(b) Restrictions on fishing grounds and fishing seasons

The objective of restricting fishing grounds and seasons is the conservation of the larval or young fish of the target fishery resources and that of their respective spawning grounds and seasons for spawning fish school. Piramutaba does not spawn in the Estuary, so these restrictions will be not effective there in

order to protect the reproductive cycle of this species. However, the small fishes are carried down to the Estuary, which becomes their nursing area. Some places are known to provide shelter for the small fishes and the current legislation indeed forbids the industrial fleet to operate in this area. The above-mentioned *Portaria* established the area south of 0° 05'N and west of 48° 00'W as being off-limits for industrial fisheries.

Furthermore, the dry season is the period when piramutaba schools migrate up the Amazon River. The total stock size of piramutaba in the survey area in the Dry Season is almost six times less than in the Rainy Season. Since the fish are confined into a restricted freshwater area in the Estuary, industrial fishing boats often operate inside the forbidden area during this period. Restrictions on the fishing season can reduce the impact of industrial fleet activities on the piramutaba stock in the Estuary.

(c) Restrictions on fishing effort

Of all restrictions proposed on fishery regulations, the limitation on fishing effort — the number of vessels — may be the most effective because it is comparatively more manageable. As a first step in restrictions on fishing effort for piramutaba trawl fishing, the number of licensed vessels should be reduced. If further restrictions are needed, it would be appropriate to relate the number of licensed vessels to the estimated stock size of piramutaba in the Dry and Rainy Seasons respectively. An even stronger measure would be controlling the number of licensed vessels in accordance with closely monitored actual piramutaba resources conditions.

Should a reduction of licensed vessels be adopted, there may be the problematic possibility that the industrial fleet request monetary compensation for their estimated losses.

(d) Limitations on catch

This limitation should be put forth in accordance with the United Nations Convention of the Law of the Sea as beforementioned in addition to other restrictions. In this case, the establishment of a catch quota by species and a system of monitoring and enforcement by both the appropriate government administrative body and a research institution is essential. The above-mentioned *Portaria* establishes the maximum catch allowed for piramutaba as 21,500 tonnes. As the total landed quantity of piramutaba in recent years have fluctuated around 10,000 tonnes, that maximum limit seems to overestimate the potential of the present stock. It is suggested that maximum catch value be reduced.

(e) Repopulation

Studies on the artificial reproduction and others of piramutaba should be conducted in order to establish a general program of its stock repopulation.

8.6. The Rational Utilization of Fishery Resources and a Strategy for Fisheries Management

Based on the results of this project, and with the goal of providing grounds for the fisheries management policy aimed at the sustainable development of fishery resources in the area, the following suggestions are proposed.

8.6.1. Special Suggestions on Piramutaba Fishing Grounds

(a) Improvement of utilization of catch by industrial fisheries

Better utilization of caught fishes (piramutaba and bycatch ones) will reduce waste of fishery resources in the piramutaba fishing ground. This could be achieved by investing in fishfood processing technology — in order to make different species more attractive for consumption —, marketing and nutritional education. This activity should involve government agencies as well as the private sector.

(b) Encouragement of the usage of selective fishing gear

Bottom trawling is an expensive fishing method that is also little selective. Therefore, its usage should be more and more restricted in piramutaba fishing grounds.

On the other hand, gear such as gillnets and longlines are very selective and would hardly lead to the overfishing of local stocks. Their usage requires many workers and would help employ a good number of the personnel eventually laid off by the industry.

8.6.2. General Suggestions on the Fisheries in the Amazon River Mouth Area

(a) Encouragement of the utilization of other fishery resources, demersal and pelagic

The vessels in the industrial fishing fleet are actually capable of exploring areas farther and deeper into the ocean than they have done hitherto. Those farther, deeper environments have not yet been commercially exploited and are currently being studied by Project REVIZEE (an acronym in Portuguese for Program for the Evaluation of the Sustainable Potential of Living Resources in the Exclusive Economical Zone), a marine resources survey project by the Brazilian Government. The results of that study will be extremely important for the future organization of fisheries in northern Brazil, and could well contribute for the further expansion of the fishing activities of the fleet now concentrated mainly on piramutaba.

(b) Preparation of the fisheries industry in order to work with a wider range of products

Tropical fishing grounds typically harbor a great number of species, each represented a few more stocks with little biomass, in contrast with temperate regions where a few different species comprise large biomasses. Tropical fisheries should avoid specialization — that is, local fleets should not concentrate on a single fishing stock. Processing of a large number of species is not easy as the market tends to be very conservative. Therefore, research on fishfood processing technology and investment in the marketing of a variety of fish species is recommended to overcome this situation.

9. SUMMARY

The Amazon River Mouth Area is a region of interaction between the voluminous riverine waters of the Amazon River and the marine water of the Atlantic Ocean. As for its fishery resources, the potential fishery production is high and the region is expected to be revealed as a superior fishing ground. Industrial fishery companies, established in the late 60s with the support of the Government of Brazil, have been developing large-scale bottom trawl fishing in a portion of the estuary fit for catching their target species piramutaba *Brachyplatystoma vaillantii*. However, this catch reached a peak in 1977 and declined thereafter, and there are indications that piramutaba stocks have been overexploited.

Surveys and research studies on important commercial fishery resources like piramutaba and others have not been hitherto conducted in the Amazon River Mouth Area. For this reason, and because of the importance of an evaluation of the present condition of fishery resources in that region so as to promote their sustainable use, in 1994 Brazil requested Japan the implementation of such a survey. Under these circumstances, a fishery resources survey of the Amazon River Mouth Area was carried out in the dry and rainy seasons of 1996 and 1997 jointly by three entities: Japan International Cooperation Agency (JICA), Museu Paraense Emílio Goeldi / Conselho Nacional de Pesquisa e Desenvolvimento Tecnológico (MPEG/CNPq — Emílio Goeldi Museum of Pará / National Council on Research and Technological Development) and Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA — Brazilian Institute for the Environment and Renewable Natural Resources). This survey had three components: (1) Sea-Borne Survey; (2) Laboratory Survey; (3) Landing Site Survey. In the Rainy Season of Phase 1 (1996), the Landing Site Survey was implemented as planned, but the other two components could not be effected because of a number of problems and circumstances concerning Brazil's internal affairs. This survey compiled data obtained for the first time in both the Rainy and Dry Seasons in the Amazon River Mouth Area concerning the demersal fish fauna, the distribution and biomass of key fish species and biological information on them, and the actual conditions of fisheries in the region. Results of the analysis of these data are summarized as follows.

1-1) The Sea-Borne Survey was jointly conducted by JICA, MPEG and IBAMA aboard two vessels employed by the former, 'Marilu' (75 GRT) and 'Crustamar V' (99 GRT). Survey periods were as follows: Phase 1 Dry Season, 43 days from 8 August to 30 September 1996; Phase 2 Rainy Season, 42 days from 7 March to 28 April 1997; Phase 2 Dry Season, 37 days from 8 August to 26 September 1997. The Sea-Borne Survey comprised resources survey, biological survey and oceanographic observation survey. Trawl operations were conducted with the two aforementioned research vessels at stations selected by a stratified random sampling method — a total of, respectively, 111, 120 and 120 stations in survey order.

1-2) Species composition and diversity of the demersal fish community was analyzed from the number of species and the number of individuals per species caught in the survey, and a clustering of that community was made based on indexes of similarity.

1-3) The distribution pattern of catch per unit area (CPUA) for all fishes was investigated, with separate analyses per stratum and water mass region identifying the respective top-ranking species.

1-4) Overall and by stratum stock size was estimated for all fishes based on the areal expansion method, and the respective top-ranking species identified.

1-5) CPUA by stratum and water mass region and distribution patterns of key fish species in the Amazon River Mouth Area — piramutaba, dourada *Brachyplatystoma flavicans*, filhote *B. filamentosum*, pescada branca *Plagioscion squamosissimus*, pescada amarela *Cynoscion acoupa*, pescadinha gó *Macrodon ancylodon* and gurijuba *Arius parkeri* — were analyzed.

1-6) Estimated stock of the seven key fish species was evaluated based on the abovementioned method.

1-7) Biological parameters — size composition, length-weight relationship, sex ratio, female maturity stage, feeding habits — were assessed for the seven key fish species.

1-8) Mesh selectivity was analyzed for piramutaba and pescadinha gó.

1-9) Four water masses were defined through T-S diagrams and their distribution analyzed: river waters, ocean waters, highly temperature surface waters, mixed waters. Also, demersal fish habitat salinity, surface layer pH, current and oceanic meteorology data were registered.

2-1) The Laboratory Survey was jointly conducted by JICA, MPEG and IBAMA in the Laboratory of Ichthyology of the Department of Zoology, MPEG, in four periods: Phase 1 Rainy Season, 62 days from 18 February to 19 April 1996; Phase 1 Dry Season, 54 days from 9 September to 1 November 1996; Phase 2 Rainy Season, 50 days from 2 April to 21 May 1997, and Phase 2 Dry Season, 63 days from 5 September to 6 November 1997. The Laboratory Survey comprised mainly treatment, preparation and analysis of age characters (including measurement of growth rings) of key fish species from material collected by the Sea-Borne Survey.

2-2) For the seven key fish species, five hard structures — spine, vertebral centrum, otolith, scale and opercle — were comparatively studied so as to determine the character best suited for age determination for each fish species. Also, the most appropriate sampling site of that character in the fish body was assessed.

2-3) For the seven key fish species, the correlation between size of age character and body length was estimated through three regressions, of which the most compatible one was chosen.

2-4) For the seven key fish species, the rings on the age characters (vertebral centra or otoliths) were investigated. Correspondence between individuals in ring formation was analyzed by examining the relationship between character radius and ring radius for each ring group.

2-5) For the seven key fish species, growth ring formation period and periodicity were estimated by calculating the marginal increment α in each ring group.

2-6) It was found out that, for the seven key fish species, the hard structures that constitute age characters were problematic. Several explanations on why their growth rings cannot be considered annual rings were discussed.

2-7) Because the age characters were found not to be reliable, four out of the seven key fish species for which there were size composition data suitable for cohort analysis were subjected to this latter procedure. For cohort analysis, the extraction of populations entering at one time into each group was assayed.

2-8) Walford plots allowed for analysis of periodicity of modal lengths of each cohort separated by the cohort analysis.

3-1) The Landing Site Survey was jointly conducted by JICA and MPEG in four periods: Phase 1 Rainy Season, 36 days from 27 February to 2 April 1996; Phase 1 Dry Season, 34 days from 5 August to 7 September 1996; Phase 2 Rainy Season, 22 days from 3 to 24 March 1997; Phase 2 Dry Season, 7 days from 4 to 12 August 1997. The Landing Site Survey comprised collection of fisheries statistics, interview survey on the actual conditions of fisheries, body length composition survey on key fish species at landing sites.

3-2) Recent fishery trends in Brazil, in Northern Brazil, and in State of Pará were analyzed from data mainly from fishery statistics, focusing in particular the production and distribution of piramutaba by industrial fishery in the State of Pará.

3-3) Actual conditions of fisheries in the region were investigated from data obtained through interviews conducted mainly in fishing ports at towns, villages and hamlets scattered over the Amazon River Mouth Area.

3-4) Size composition of key fish species obtained through the measuring-card punching method at each landing site was analyzed.

3-5) Problems inherent to fishery economics in the Amazon River Mouth Area were detected from the results of the analyses above.

4) An evaluation of exploited fishery resources in the Amazon River Mouth Area was conducted based on the results of the Sea-Borne Survey and the Landing Site Survey and so forth.

5) An evaluation of unutilized and unexploited fishery resources in the Amazon River Mouth Area was conducted based on the results of the Sea-Borne Survey and the Landing Site Survey and the like.

6) Guidelines for the management of demersal fishery resources in the Amazon River Mouth Area from a biological and a socioeconomic perspective were proposed, moreover, the rational utilization of fishery resources and a strategy for fisheries management were suggested.

10. REFERECE

Anon. 1995: The Kyoto declaration and plan of action on the sustainable contribution of fisheries to food security, International Conference on the Sustainable Contribution of Fisheries to Food Security, FAO, pp. 9.

Aoyama, T. 1961: The selectivity action of trawl nets and its application to management of the Japanese trawl fisheries in the East China and the Yellow Sea, Bull. Seikai Reg. Fish. Res. Lab., 23: 1-63.(In Japanese with English summary).

Arai, S. and Sakamoto, W. 1995: Effects of seawater temperature on scale circuli deposition of reared red sea bream. Nippon Suisan Gakkaishi. 62 (3), 316-319.(In Japanese with English summary).

Asada, Y. 1981: New fisheries handbook, Chapter 10, Fishery law, Fishery economy, 601-643. Kodann-sha, Tokyo. (In Japanese).

Asada, Y., Hirasawa, Y. and Nagasaki. F. 1985: Fishery management in Japan, FAO Fish. Tech. Paper 238 pp. 26.

ASOPESCAM 1995: Estatuto de la asociacion de pescadores del Amazonas, pp. 9.

Bakkala, R. G., Wakabayashi, K., Okada, K., Traynor, J. J., Sample, T. M., Yamaguchi, H., Alton, M. S. and Nelson, M. O. 1985: Results of cooperative U.S.-Japan groundfish investigation in the Bering Sea during May-August 1979. Int. North Pac. Fish. Comm. Bull., 44: pp. 252.

Barthem, R., Ribeiro, M. C. L. B. and Petrere, M. Jr. 1991: Life strategies of some long-distance migratory catfish in relation to hydroelectric dams in the Amazon basin. Biol. Conserv., 55: 339-345.

Barthem, R. and Petrere Jr, M. 1992: Fisheries and population dynamics of the freshwater catfish *Brachyplatystoma vaillantii* in the Amazon estuary. Condition of the World's Aquatic Habitats. Proceedings of the World Fisheries Congress, Theme 1. 329-339.

Barthem, R. 1995: Avaliacao da exploracao pesqueira no estuario e baixo Amazonas 1993-1995, FINEP, pp. 23.

Barthem, R. 1996: A pesca na Amazonia problemas e perspectivas para o seu manejo, MPEG, pp. 12.

Barthem, R. 1997: Estatisticas basicas do desembarque de pescado nos frigorificos da Amazonia capitulo, MPEG, pp. 10.

Barthem, R. and Serrao, R. A. 1997: Estatisticas basicas do desembarque de pescado no porto Ver-o-Peso, MPEG, pp. 22.

Barthem, R. and Goulding, M. 1997: The catfish connection -- Ecology, Migration, and Conservation of Amazon predators -- Columbia University Press, pp. 144, New York.

Barthem, R. and Schwassmann, H. O. 1994: Amazon River influence on the seasonal displacement of the salt wedge in the Tocantins River estuary, Brazil, 1983-1985. Bol. Mus. Para. Emilio Goeldi, Ser. Zool., 10(1), 119-130.

Beverton, R. J. H. 1954: Notes on the use of theoretical models in the study of the dynamics of exploitated fish population. Beaufort, North Carolina, Misc. Contrib., 2. pp. 159.

Beverton, R. J. H. and Holt, S. J. 1959: A review of the lifespans and mortality rates of fish in nature and their relation to growth and other physiological characteristics. The lifespan of Animals, Ciba Found. Colloq. Ageing, 5: 142-180.

Centro de Pesquisa Extencao Pesqueira no Nordeste 1997: Estatistica da pesca Brasil 1995, CEPENE, Grandes Regioes e Unidades da Federacao, pp. 97.

CEPONR/IBAMA 1997: Relatorio projeto estatpesca 1977, pp. 32.

CEPONR/IBAMA 1997: Estatpesca tabela de localidade 1997, pp. 3.

Cervigon, F., Cipriani, R., Fischer, W., Garibaldi, L., Hendrickx, M., Lemus, A. J., Marquez, R., Poutiers, J.M., Robaina, G. and Rodriguez, B. 1993: Field guide to the commercial marine and brackish-water resources of the northern coast of south America. FAO Species Identification Sheets for Fishery Purposes. pp. 256.

Chen, A. and Sakurai Y. 1993: Age and growth of saffron cod (*Eleginus gracilis*). Sci. Rep. Hokkaido Fish. Exp. Stn. 42, 251-264.

Curtin, T. B. 1986: Physical observation of the plume region of the Amazon River during peak discharge, III, Currents. Cont. Shelf Res. 6, 73-86.

Doi, T. 1974: Outline of mathematical analysis on fish populations for practical use in front(Part II), Textbook for marine fisheries research course, Fisheries biology and population dynamics of marine resources, 105-210. Japan International Cooperation Agency.

Doubleday, W. G.(ed.) 1981: Manual of groundfish surveys in the Northwest Atlantic, NAFO Scientific Council Studies No.2, Ottawa.

Doubleday W. G. and Rivard, D. 1981: Bottom trawl surveys, Canadian Special Publication of Fisheries and Aquatic Science 58. pp. 273., Department of Fisheries and Oceans, Ottawa.

Federecao dos pescadores do estado do AMAPA Fecap Macapa 1997: Relatorio preliminar do censo pesqueiro do Amapa e do recadastramento socios das colonias, pp. 13.

Fishery Agency of Japan 1958: Cruise report of fishing ground survey on South and Central America by Toko Maru, Landing Site Survey. Oct., 1956 - July 1957. pp. 204.(In Japanese).

Fishery Agency of Japan 1958: Cruise report of fishing ground survey on South and Central America by Toko Maru, Sea-borne Survey. Oct., 1956 - July 1957. pp. 183.(In Japanese).

Food and Agriculture Organization of the United Nations(FAO) 1987: Yearbook of fishery statistics, catches and landings. Vol. 60, 1985. pp. 461. Rome.

Furtado, L. G. 1981: Boletim do Museu Paraense Emilio Goeldi, Antropologia No.79, Pesca Artesanal um delineamento de sua historia no Para, pp. 50.

Ghilean, T. Prance and Thomas E. Lovejoy(ed.) 1984: Key environments Amazonia. Pergamon Press Oxford, pp. 435. London.

Gulland, J. A. 1982: Fish stock assessment: A manual of basic methods. xii;pp.223, FA/Wily Series on Food and Agriculture, John Wily & Sons. New York.

Gulland, J. A.(compiled and ed.) 1970: The fish resources of the ocean. FAO Fish. Techn. Paper 97: pp. 425.

Haimovici, M. and Reis, E. G. 1984: Determinacao de idade e crescimento da castanha *Umbrina canosai*, (Pisces, Sciaenidae) do sul do Brasil. Atlantica, Rio Grande. 7: 25-46.

Haimovici, M. 1988: Growth of the king weakfish (*Macrodon ancylodon*) in the southern Brazil in the period 1984 - 1986. Publ. Com. Tec. Mix. Fr. Mar. Vol. 4, 99-105(With English abstract).

Hanyu, T. and Tabata, M.(ed.) 1988: Daily rhythmic activities in aquatic animals, Fisheries Series 69, pp. 138., Koseisha-koseikaku, Tokyo.(In Japanese).

Harding, J. P. 1949: The use of probability paper for the graphical analysis of polymodal frequency distributions. Jour. Mar. Biol. Ass. U. K., 28: 141-153.

Hasselblad, V. 1966: Estimation of parameter for a mixture of normal distributions. Technometerics, 8: 131-153.

Hatanaka, H. and Sato, T. 1983: Report on the Japan/South Africa joint trawling survey on the Agulhas Bank in November/December 1980. pp. 73. Japan Marine Fishery Resource Research Center.

IBGE 1980-1989: Estatistica da pesca 1980-1989, Brazil.

IBAMA 1983-1996: PORTARIA; N-9 9/3/1983, N-17 19/8/1988, N-1581 21/12/1989, N-110 7/10/1992, N-8 2/2/1996, pp. 5.

IBAMA 1994: Camarao norte e piramutaba, Brazil, Serie Estudos Pesca 9, 77-150.

IBAMA 1995: Relatorio de consultoria Para o projeto IARA, pp. 132.

IBAMA AMAZONAS 1996: Relatorio de armadores de pesca cadastrado no DIRHP/RGP/IBAMA AM, pp. 32.

IBAMA 1996: Colecao meio ambiente, Serie Estudos Pesca 15, Projeto IARA, pp. 100.

IBAMA, Ministerio do Meio Ambiente dos Recursos Hidricos e da Amazonia Legal 1997: Programa REVIZEE, pp. 33.

IBGE 1991: Censo demografico numero 7 Para 1991.

IBGE 1991/1996: Brasil em numeros, Vol. 4, pp. 212.

IBGE 1997: Anuario estatistico do Brasil 1995.

Ideguchi, R. 1991: Dictionary of comparative Fish Names on Marine and Fresh-waters in Brazilian (Portugues, Brazilian portuguese, English, Japanese, Scientific name), The Forum for Aquaculture in the Developing Countries, pp. 57.

Ishiyama, R. and Okada, K. 1956: Age determination of the ray and skate. Rakusui No.4 13-19.(In Japanese).

Japan International Cooperation Agency 1993: Report of demersal fisheries resources survey in the Republic of Turkey. i+xvi, pp. 537. Figs. 3, Plates 5.

Japan External Trade Organization(JETRO) 1995: Economics and trading information system by country, Brazil. pp. 43.(In Japanese).

Kariya, T. 1979: Statistics of medical science and biology. pp. 246. Kyoritu-Shupan. Tokyo.(In Japanese).

Kawahara, S. 1995: Manual of pre-disposal for age determination with otoliths of fishes, especially of aged ones. Gyogyou Shigen Kennkyuukaigi, Kitanihonn Sokouobu Kaihou. 28, 25-26.(In Japanese).

Kimoto, S. 1967: Some quantitative analysis on the Chrysomelid fauna of the Ryukyu Archipelago. Esakia, 5: 1-20.

Koyama, T. 1974: Study of the stem trawl. Bull. Tokai Reg. Fish. Res. Lab., 77: 171-247.(In Japanese with English summary).

Lackey, R. T. and L. A.Nielsen 1980: Fisheries management. Blackwell Scientific Publication.

Laevastu, T. and Larkins, H. A. 1981: Marine Fisheries Ecosystem, Its quantitative evaluation and management. pp. 162 Fishing News Books Ltd. England.

Le Guennec, B. 1985: Claves longitude-peso de 38 especies de pesca de la region de Trinidad, Informe Cientifico 20, Convenio ORSTOM-VUB-CORDBENI.

Loubens, G. and Aquim, J. L. 1986: Sexuallidad y reproducion de los principales peses de la Cuenca del Rio Mamore, Beni-Bolivia, Informe Cientifico 50, Convenio ORSTOM-UTB-CORDBENI.

Luis, M. L. and Issac, V. J. 1994: The fisheries of the lower Amazon: Questions of management and development. Acta Biol. Venez., 15(2): 37-46.

Mackett, D. J. 1973: Manual of methods for fisheries resources survey and appraisal Part-2 Standard methods and technique for demersal fisheries resources surveys. FAO Fish. Tech. Paper 124.

Matsuishi, T., Kishino, H. and Kanno, Y. 1996: Estimation of growth function parameters from age-length data including ring-skipping error. Nippon Suisan Gakkaishi. 62 (1), 28-31.(In Japanese with English summary).

Matsumiya, Y. 1996: An introduction to stock management. Fishery Study Series No. 46, pp. 77. Japan Fisheries Resource Conservation Association. Tokyo.(In Japanese with English summary).

Meyer, R. M., Zhang, C., Windsor, M. L., McCay, B. J., Hushak, L. J. and Muth, R. M. 1966: Fisheries resource utilization and policy, Proceedings of the world fisheries congress, Theme 2, pp. 535. Science Publishers, Inc. New Hampshire.

Mitani, F. and Sato, T. 1959: Studies on the growth and age of the Yellow-tail, *Seriola quinqueradiata* T.& S., found in Japan and the adjacent region - II . Estimation of age and growth from the opercular bone. Bull. Japan. Soc., Sci. Fish., 24(10), 803-808.(In Japanese with English summary).

Mountford, M. D. 1962: An index of similarity and its application to classificatory problem. In Murphy, P. W. (ed.), Drgress in Soil Zoology, 43-50, Butterworths, London.

Mugiya, Y., Akamine, T., Taniuchi, T. and Matsumiya, T. 1997: Growth analysis of aquatic animals, Abstract for the meeting of the Japanese Society of Fisheries Science, 283-293.(In Japanese with English summary).

Murakami, S. and Okada, K. 1967: Studies on the fishery biology of the sea bream, *Chrysophrys major* Temmick et Schlegel, in the East China and the Yellow Seas-III. Age and growth. Bull. Seikai Reg. Fish. Res. Lab., 35, 23-40.(In Japanese with English summary).

Nishimura, A. 1993: Age determination of walleye pollock based on the otoliths (Review). Sci. Rep. Hokkaido Fish. Exp. Stn. 42, 37-49.(In Japanese with English summary).

Nose, Y., Ishii, T. and Shimizi, M. 1965: Fish population dynamics, pp. 261, University of Tokyo Press, Tokyo. (In Japanese with English summary).

Ocean Association of Japan 1987: United Nation Convention on the Law of the Sea (English-Japanese translation). pp.361, Tokyo(Supervision by Ministry of Foreign Affairs).

Oversea Fishery Cooperation Foundation 1974: Jornal da pesca 1971, Jornal da pesca 1972, Anuario da pesca 1972, Anuario da pesca 1972, pp. 72.(In Japanese).

Oversea Fishery Cooperation Foundation 1997: Report of environmental investment of fishery , Republic Federative do Brasil. pp. 144.(In Japanese).

Pauly, D. 1980: On the interrelationships between natural mortality, growth parameters, and mean environmental in 175 fish species. J. Cons. Int. Explor. Mer.

Petersen, C. G. J. 1896: The yearly immigration of young plaice into the Limfjord from the German Sea, etc. Rept. Danish Biol. Sta. for 1895. 6: 1-48.(Cited from Fish population dynamics. Kubo, I. and Yoshihara, T. 1981. pp. 482. Kyoritu Shutupann K. K.).

Reis, E. G. 1986: Age and growth of the marine catfish, *Netuma barba* (Siluriformes, Ariidae), in the estuary of the Patos Lagoon (Brazil). Fishery Bulletin. 84(3), 679-686.

Reis, E. G. 1986: Reproduction and feeding habits of the marine catfish *Netuma barba* (Siluriformes, Ariidae) in the estuary of Lagoa dos Patos, Brazil. Atlantica, Rio Grande. 8: 35-55.

Ricker W. E. 1975: Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Can., Bull. 191. pp. 382.

Ronholt, L. L., Wakabayashi, K., Wilderbuer, T. K., Yamaguchi, H. and Okada, K. 1986: Groundfish resource of the Aleutian Island waters based on the U.S.-Japan trawl survey, July-November 1980. Int. North Pac. Fish. Comm. Bull., 48: pp. 251.

Samame, M. L. and Okada, K. 1973: Determinacion de la edad, crecimiento y dinamica de la poblacion de la cachema, *Cynoscion analis* Jenyns, de la costa norte del Peru. Bull. Tokai Reg. Fish. Res. Lab., 73: 23-68.(With Japanese summary).

Schaefer, M. B. 1954: Some aspect of the dynamics of populations important to the management of the commercial fisheries. Inter-American Tropical Tuna Commission, Bull. Vol. 1, No. 2: 27-56.

SECON, Prefeitura de Belem 1992: Belem indicadores socio economicos, Vol. II, No.1, pp. 85.

Secor, D. H., Dean, J. M. and Campana, S. E. 1995: Recent developments in fish otolith research. The Belle W. Baruch Library in Marine Sciencs., 19. pp. 735., Univ. South Carolina Press.

Shannon, C. E. 1949: The mathematical theory of communation. In Shannon, C. E. and Weavere, W. The mathematical theory of communinucation. 29-125., Univ. Illinois Press.

Shindo, S. 1976: Fishery and its resources in South China Sea. pp. 94, Japan Fisheries Resources Conservation Association. Tokyo(In Japanese).

SINPESCA 1997: Frota pesqueira em operacao nos estados do Para e Amapa 1997.

SINPESCA 1997: Acordo coletivo de trabalho 1997, pp. 5.

SINPESCA 1997: Relacao das empresas de pesca associadas ao SINPESCA, pp. 8.

Smale, M. J., Watson, G. and Hacht, T. 1995: Otolith atlas of southern Africa marine fishes., 1.pp. 253. J. L. B. Smith Institute of Ichthyology.

Sparre, P. E., Ursin, E. and Venea, C. 1989: Introduction to tropical fish assessment Part 1- Manual. FAO Fish. Tech. Paper 306/1. 1-337.

Sparre, P. E., Ursin, E. and Venea, C. 1989: Introduction to tropical fish assessment Part 2- Exercises. FAO Fish. Tech. Paper 306/2. 339-429.

SUDEPE 1980: IV plano nacional de desenvolvimento da pesca 1980-1985, pp.44.

Summerfelt, R. C. and Hell, G. E. 1987: Age and growth of fish. pp. 544. Iowa State Univ. Press/Ames.

Takahashi, T., Hayakawa, Y., Kamiharako, T., Nakatani, T. and Takatsu, T. 1995: Age and growth of brown sole *Pleuronectes herzensteini* in the coastal waters of western Aomori Prefecture, Japan. Fish. Sci., 61(6), 893-897.(In Japanese with English summary).

Tanaka, S. 1956: A method of analysing the polymodal frequency distribution and its application to the length distribution of porgy, *Taius tumifrons*(T. & S.). Bull. Tokai Reg. Fish. Res. Lab., 14: 1-13.(In Japanese with English summary)

Tanaka, S. 1960: Studies on the dynamics and management of fish population. Bull. Tokai Reg. Fish. Res. Lab., 28: 1-200.(In Japanese with English summary).

Tsutumi, H. and Tanaka, M. 1994: Cohort analysis of size frequency distribution with computer programs based on a graphic method and Simplex's method. Bull. Japan Benthos Society, 46: 1-10.(In Japanese with English summary).

Uchara, S. and Shimizu, M. 1996: Age and growth of stone flounder *Kareius bicoloratus* in Tokyo Bay, Japan. Fish. Sci., 62(6), 897-901.(In Japanese with English summary).

Uozumi, Y., Hatanaka, H., Sato, T., Augustyn, J., Payne, A. and Leslie, R. 1984: Report on the Japan/South Africa joint trawling survey on the Agulhas Bank in November/December 1981. pp. 91. Japan Marine Fishery Resource Research Center.

Ursin, E. 1979: Single species and multispecies fish stock assessment. MS presented at 16th Nordic Fisheries Conference, Marrehamn, Finland.

Vieir, P. C. and Haimovici, M. 1993: Age and growth of the "pescado-olhuda" *Cynoscion striatus*(Pisces, Sciaenidae) in Southern Brazil. Atlantica, Rio Grande, 15: 73-91.(In Portugues with English summary).

Walford, L. A. 1946: A new graphic method of describing the growth of animals. Biol. Bull. Woods Hole, 90(2), 141-147.(Cited from Fish population dynamics. Kubo, I. and Yoshihara, T. 1981. pp. 482. Kyoritu Shutupann K. K.).

Appendix Table 1. List of fish species caught. Local and FAO names in round and square brackets are not available in each category.

Order name	Fmily name	Species	Local name	FAO name	Phase 1	Phase 2	
					Dry Season	Rainy Season	Dry Season
Carcharhiniformes	Carcharhinidae	*Carcharhinus limbatus*	Cação-galha-preta	Blacktip shark		○	
		Carcharhinus porosus	Cação	Smalltail shark	○	○	○
		Isogomphodon oxyrhynchus	Cação-bico-de-pato	Daggernose shark	○	○	
		Sphyrna lewini	Martelo	Scalloped hammerhead		○	
		Sphyrna tiburo	Cação-rodela	Bonnethead	○	○	○
		Sphyrna tudes	Cação-rodela, Martero	Smalleye hammerhead	○	○	○
Rajiformes	Pristidae	*Pristis microdon*	Espadarte	Largetooth sawfish	○		
	Torpedinidae	*Narcine brasiliensis*	Arraia-elétrica	Brazilian electric ray	○	○	○
	Dasyatidae	*Dasyatis geijkesi*	Arraia-morcego, Anjo	Sharpsnout stingray	○	○	○
		Dasyatis guttata	Arraia-bicuda	Longnose stingray	○	○	○
		Himantura schmardae	Arraia-redonda	Chupare stingray	○	○	
		Plesiotrygon spp.	Arraia	[Freshwater stingray]		○	○
		Urotrygon microphthalmum		-			○
	Gymnuridae	*Gymnura micrura*	Arraia	Smooth butterfly ray	○	○	○
	Myliobatidae	*Aetobatis narinari*	Jamanta-cara-de-gente	Spotted eagle ray	○	○	○
		Rhinoptera bonasus	Arraia	Cownose ray		○	
Elopiformes	Elopidae	*Elops saurus*	Ubarana	Ladyfish		○	
	Megalopidae	*Tarpon atlanticus*	Pirapema, Camurupim	Tarpon	○		
Anguilliformes	Ophichthidae	*Ahlia egmontis*	Cobra-enguia-pequena	-	○		
	Muraenesocidae	*Cynoponticus savanna*	Moréia	Guiana pike-conger		○	
Clupeiformes	Engraulidae	*Anchoa spinifer*	(Manjuba-savelha)	Spicule anchovy	○	○	○
		Anchoviella sp.		-		○	○
		Engraulidae		Anchovies	○	○	○
		Lycengraulis batesii	(Sardinha-prata)	Bates' sabretooth anchovy		○	○
	Pristigasteridae	*Chirocentrodon bleekerianus*	Sardinha	Dogtooth herring			○
		Odontognathus mucronatus	Sardinha-gato	Guiana longfin herring	○	○	○
		Pellona flavipinnis	Sarda, Apapá-branco	Yellowfin river pellona	○	○	○
		Pellona harroweri	Sardinha-chata	American coastal pellona	○	○	○
	Clupeidae	*Opisthonema oglinum*	Sardinha, (Sardinha-azul)	Atlantic thread herring		○	
Siluriformes	Ariidae	*Arius couma*	Bagre-branco	Couma sea catfish	○	○	○
		Arius grandicassis	Cambéua	Thomas sea catfish	○	○	○

Appendix Table 1. Continued

Order name	Fmily name	Species	Local name	FAO name	Phase 1	Phase 2	
					Dry Season	Rainy Season	Dry Season
Siluriformes	Ariidae	*Arius parkeri*	Gurijuba	Gillbacker sea catfish	○	○	○
		Arius phrygiatus	Canguito, Cangatá-branco, Jurupiranga-doce	Kukwari sea catfish	○	○	○
		Arius proops	Uritinga	Crucifix sea catfish	○	○	○
		Arius quadriscutis	Cangatá	Bressou sea catfish	○	○	○
		Arius rugispinis	Jurupiranga	Softhead sea catfish	○	○	○
		Bagre bagre	Bandeirado	Coco sea catfish	○	○	○
		Cathorops spixii	Uricica	Madamango sea catfish	○	○	○
	Doradidae	*Centrodoras brachiatus*	Bacu-rato	-	○	○	○
		Lithodoras dorsalis	Bacu-pedra	-	○	○	
	Ageneiosidae	*Ageneiosus ucayalensis*	Mandubé	[Bottlenose catfish]	○	○	○
	Auchenipteridae	*Pseudauchenipterus nodosus*	Caratai	Cocosoda catfish	○	○	○
	Pimelodidae	*Brachyplatystoma filamentosum*	Filhote, Piraíba	Kumakuma catfish	○	○	○
		Brachyplatystoma flavicans	Dourada	[Gilded catfish]	○	○	○
		Brachyplatystoma vaillantii	Piramutaba	Laulao catfish	○	○	○
		Goslinia platynema	Babão	[Slobberer]		○	
		Pimelodus sp.	Mandi	-	○	○	○
	Hypophthalmidae	*Hypophthalmus marginatus*	Mapará	Highwaterman catfish		○	
	Aspredinidae	*Aspredinichthys filamentosos*	Rabeca	Sevenbarbed banjo	○	○	○
		Aspredo aspredo	Rabeca	Banjo	○	○	○
Gymnotiformes	Rhamphichthyidae	*Rhamphichthys* sp.	Itui-terçada	[Knifefish]		○	
	Apteronotidae	*Sternarchella* sp.	Sarapó	[Knifefish]	○	○	○
Batrachoidiformes	Batrachoididae	*Batrachoides surinamensis*	Pacamão	Pacuma toadfish	○	○	○
		Porichthys plectrodon	Miqui	Atlantic midshipman			○
Lophiiformes	Ogcocephalidae	*Ogcocephalus* sp.	Peixe-morcego	[Batfish]			○
Mugiliformes	Mugilidae	*Mugil incilis*	Tainha	Parassi mullet			○
Perciformes	Centropomidae	*Centropomus parallelus*	Camorim, (Camorim-tapa,	Fat snook	○	○	○
		Centropomus pectinatus	Camorim, (Camorim-sovela)	Tarpon snook	○	○	○
		Centropomus undecimalis	Camorim, (Camorim-açu)	Common snook		○	○
	Serranidae	*Epinephelus itajara*	Mero	Jewfish	○	○	○

Appendix Table 1. Continued

Order name	Fmily name	Species	Local name	FAO name	Phase 1	Phase 2	
					Dry Season	Rainy Season	Dry Season
Perciformes	Serranidae	*Serranus atrobranchus*	(Mariquita)	-	○		
	Echeneidae	*Echeneis naucrates*	Piolho-de-tubarão, Rémora	Live sharksucker	○	○	
	Carangidae	*Chloroscombrus chrysurus*	Xaréu	Atlantic bumper	○	○	
		Hemicaranx amblyrhynchus	Palombeta-do-alto	Bluntnose jack	○	○	○
		Oligoplites sp.		-			○
		Oligoplites palometa	Timbira, Pratiuira	Maracaibo leatherjack	○	○	○
		Oligoplites saurus	Timbira	Atlantic leatherjack	○		○
		Selene setapinnis	Galo, (Galo-legítimo)	Atlantic moonfish	○		
		Selene vomer	Galo, (Galo-de-fita)	Atlantic look down	○	○	○
		Trachinotus carolinus	Pampo	Florida pompano		○	
		Trachinotus cayennensis	Pampo	Cayenne pompano		○	
	Lobotidae	*Lobotes surinamensis*	Cará-açu	Atlantic tripletail	○		
	Haemulidae	*Genyatremus luteus*	Coró,Peixe-pedra	Torroto grunt	○	○	○
		Orthopristis ruber	(Corcoroca-jurumirim)	Corocoro grunt	○		
	Polynemidae	*Polydactylus virginicus*	Piraquara	Barbu			○
	Sciaenidae	*Ctenosciaena gracilicirrhus*	Curucala	Barbel drum	○		
		Cynoscion sp.		-	○		
		Cynoscion steindachneri	(Pescada-jaguara)	Smalltooth weakfish	○	○	○
		Cynoscion acoupa	Pescada-amarela	Acoupa weakfish	○	○	○
		Cynoscion virescens	Pescada-cambuçu	Green weakfish	○	○	○
		Isopisthus parvipinnis	Falsa-gó, Goete	Shortfin corvina	○	○	○
		Larimus fasciatus	(Oveva)	-		○	
		Lonchurus lanceolatus	Pescada-flamengo	Longtail croaker	○	○	○
		Macrodon ancylodon	Pescadinha-gó	King weakfish	○	○	○
		Micropogonias furnieri	Pescada-curuca-grande	Whitemouth croaker	○	○	○
		Nebris microps	Pescada-sete-buchos	Smalleye croaker	○	○	○
		Paralonchurus brasiliensis	Pescada-flamengo-pequena	Banded croaker	○	○	○
		Plagioscion auratus	Pescada-cascuda-preta	-	○	○	○
		Plagioscion squamosissimus	Pescada-branca	-	○	○	○
		Stellifer microps	Pescada-curuca-pequena	Smalleye stardrum	○	○	○

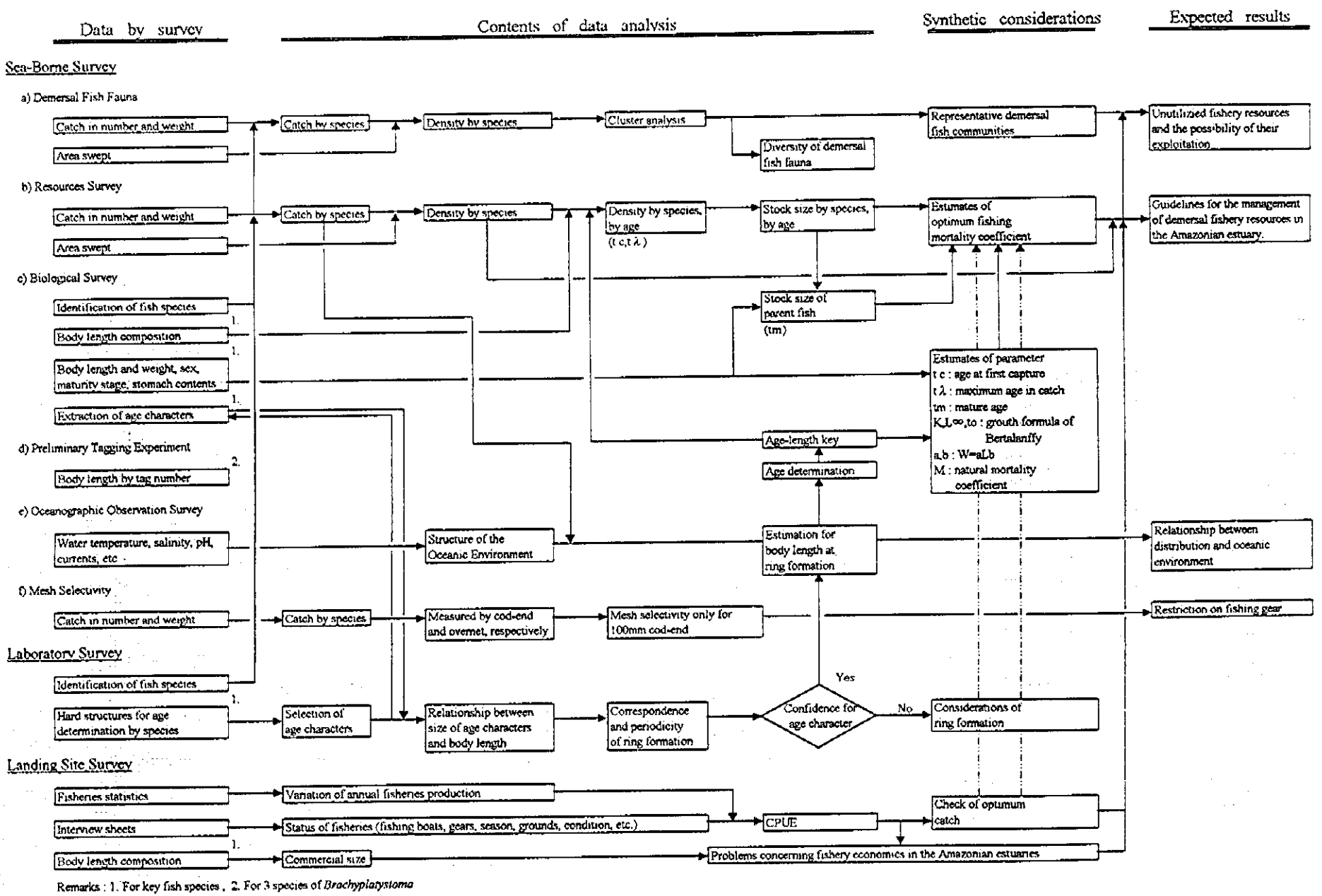
Appendix Table 1. Continued

Order name	Fmily name	Species	Local name	FAO name	Phase 1	Phase 2	
					Dry Season	Rainy Season	Dry Season
Perciformes	Sciaenidae	*Stellifer rastrifer*	Buchudinho	Rake stardrum	○	○	○
	Gobiidae	*Gobioides broussonnetii*	Amuré	-			○
		Gobioides grahamae	Amuré	-	○	○	○
	Ephippidae	*Chaetodipterus faber*	Paru	Atlantic spadefish	○	○	○
	Sphyraenidae	*Sphyraena guachancho*	Barracuda, Bicuda	Guaguanche	○		
	Trichiuridae	*Trichiurus lepturus*	Espada	Largehead hairtail	○	○	○
	Scombridae	*Scomberomorus brasiliensis*	Serra	Serra spanish mackerel	○	○	○
	Stromateidae	*Peprilus paru*	Gostoso	American harvestfish	○	○	○
Pleuronectiformes	Bothidae	*Bothus robinsi*	Xula	Twospot flounder	○		
		Citharichthys sp.	Xula	-	○		
	Soleidae	*Achirus achirus*	Xula, Solha	Drad sole	○	○	○
		Apionichthys dumerili	Xula	Longtail sole		○	
Tetraodontiformes	Tetraodontidae	*Colomesus psittacus*	Mamaiacu	Banded puffer	○	○	○
	Diodontidae	*Chilomycterus antillarum*	Baiacu-biriba	[Spiny puffer]	○	○	○

Appendix Table 2. Results of mesh measurements.

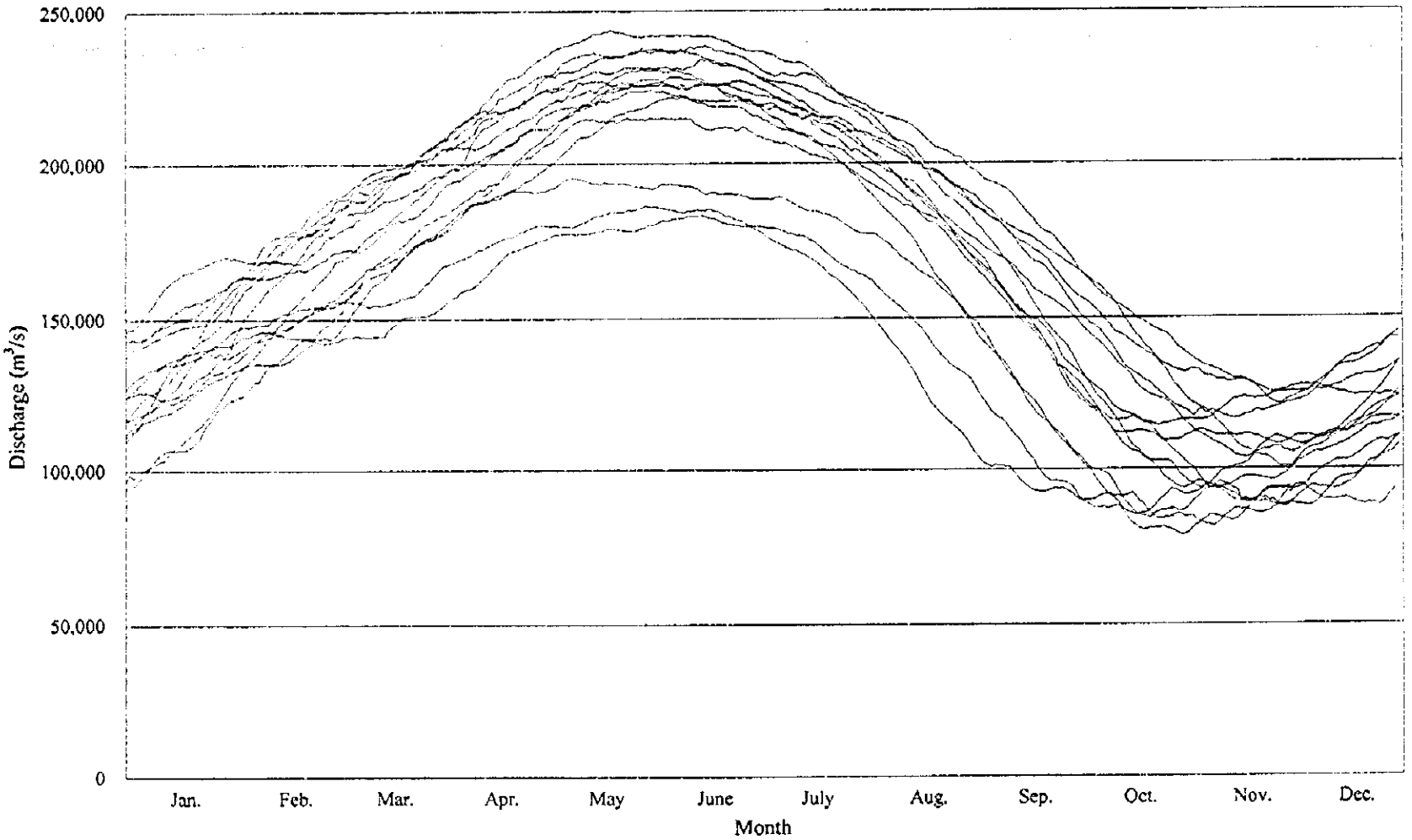
Date	7 Sep.1996				8 Apr.1997				26 Apr.1997				5 Aug.1997				25 Aug.1997			
Place	at sea				at sea				at sea				at sea				at sea			
Status of net	wet				wet				wet				wet				wet			
Measured part	upper				upper				upper				upper				upper			
Material of net	nylon				nylon				nylon				nylon				nylon			
Type of gauge	slide caliper				slide caliper				slide caliper				slide caliper				slide caliper			
Net type	covernet		cod-end		covernet		cod-end		covernet		cod-end		covernet		cod-end		covernet		cod-end	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	35	35	93	107	36	38	100	98	34	40	87	78	35	37	87	93	36	36	81	94
2	33	37	102	103	33	35	95	95	35	34	94	97	37	35	86	99	35	39	85	92
3	33	33	105	99	36	37	92	93	34	35	92	91	34	36	87	89	35	38	80	87
4	35	35	113	100	37	38	93	95	35	36	83	91	36	35	85	94	35	36	86	95
5	35	33	88	96	37	36	92	87	35	34	83	92	35	38	95	94	35	35	86	88
6	34	35	92	97	35	41	93	91	36	34	84	91	35	36	95	94	31	37	89	98
7	33	35	99	99	36	37	96	98	36	33	91	91	34	35	81	83	35	35	83	88
8	35	39	101	98	33	37	95	89	38	32	90	91	32	38	82	89	35	34	82	93
9	37	35	82	85	34	38	90	95	36	36	90	93	35	35	91	93	35	39	92	85
10	35	35	99	94	37	38	95	92	36	35	94	87	35	36	82	90	34	36	81	89
Mean size* in mm	35	35	97	98	35	38	94	93	36	35	89	90	35	36	87	92	35	37	85	91
Standard deviation	1.00	1.12	6.92	3.84	1.58	1.58	2.77	3.62	1.18	2.18	4.29	4.94	1.32	1.20	5.11	4.94	1.35	1.72	3.87	4.12

* 2 legs and 1 knot

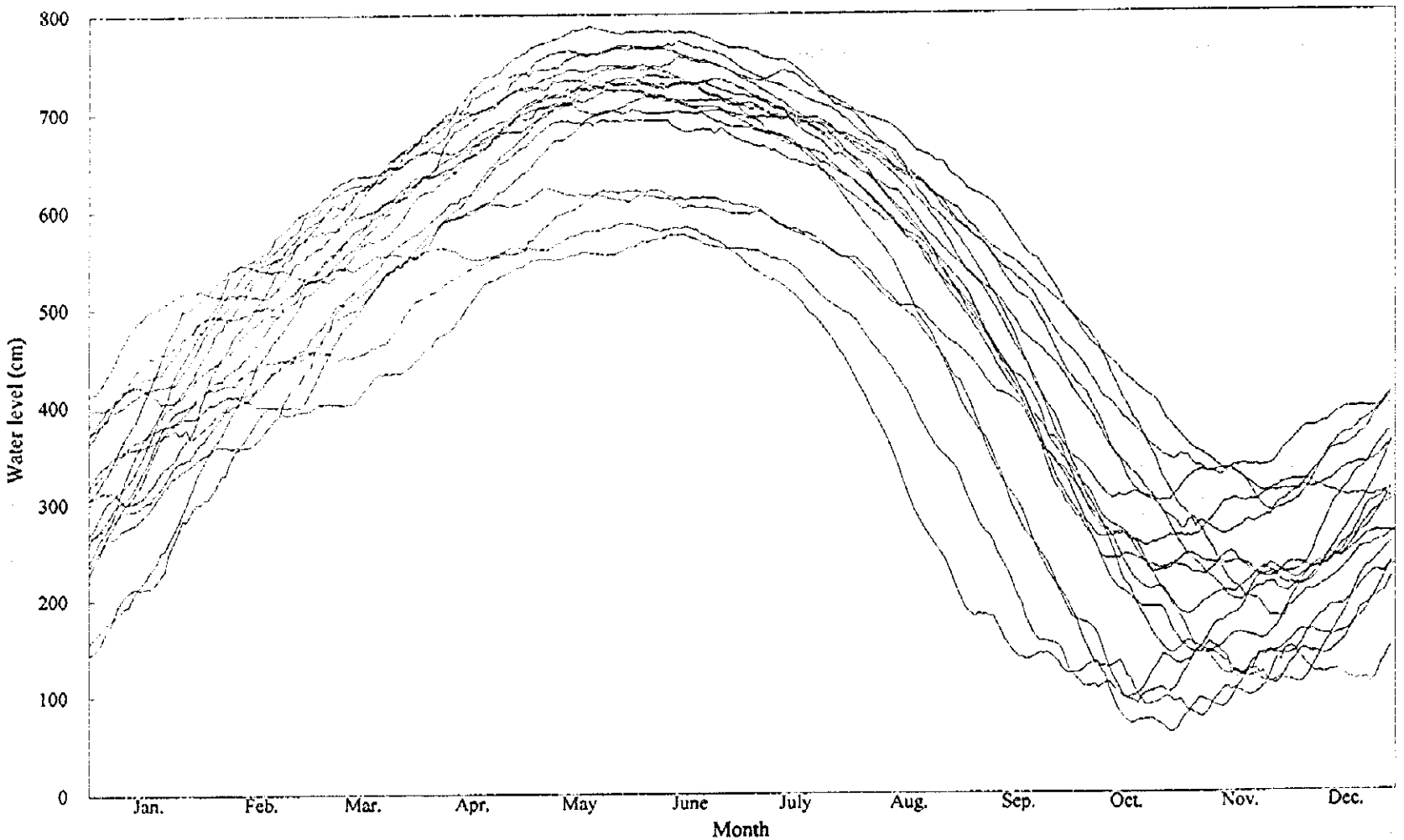


Remarks : 1. For key fish species , 2. For 3 species of *Brachyplatystoma*

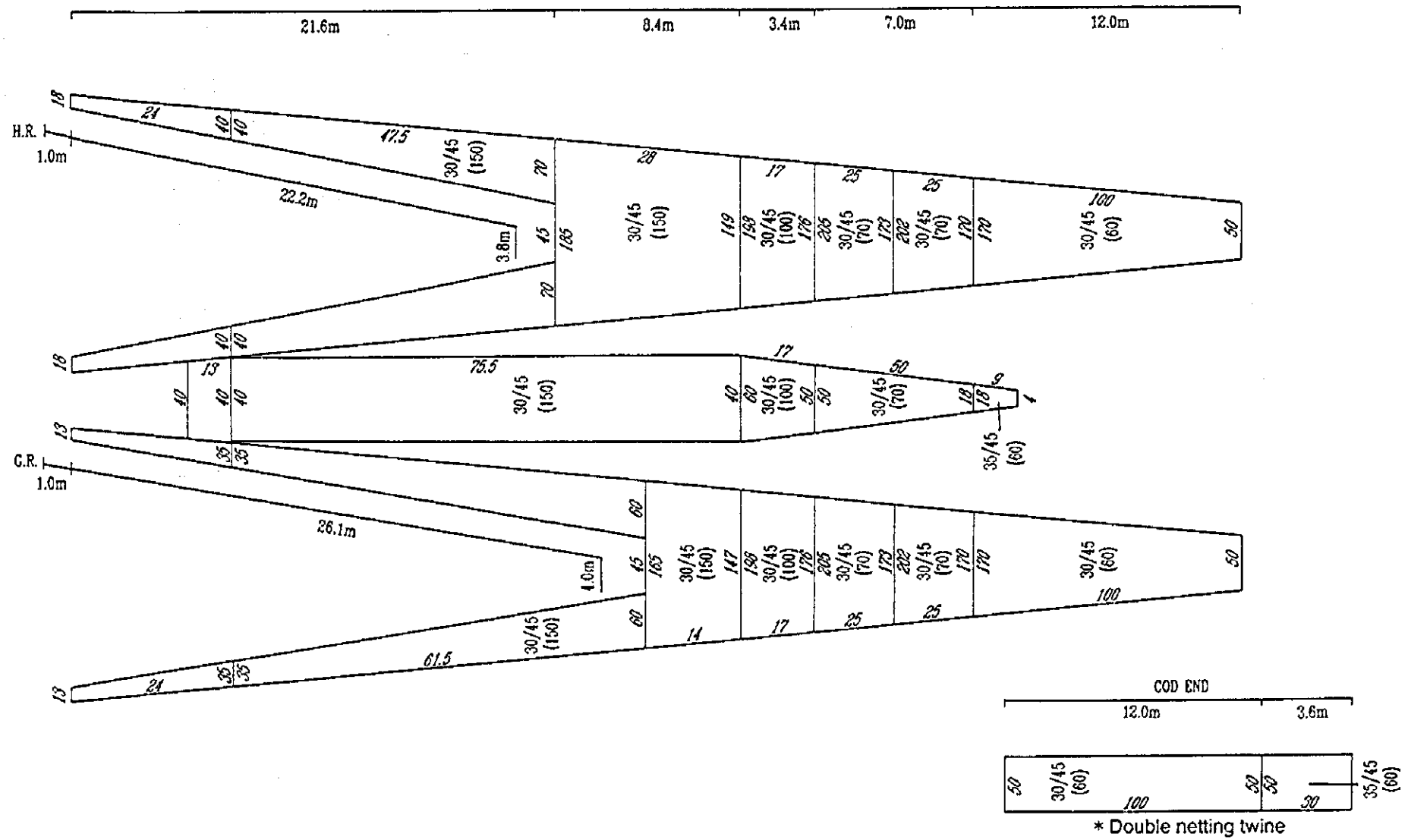
Appendix Figure 1. Analytical flow of data obtained from each survey.



Appendix Figure 2. Daily estimates of Amazon River discharge between 1970 -1983 showing the seasonal variation. Estimates are based on stage data from Obidos. (Source: MINISTERIO DAS MINAS E ENERGIA).

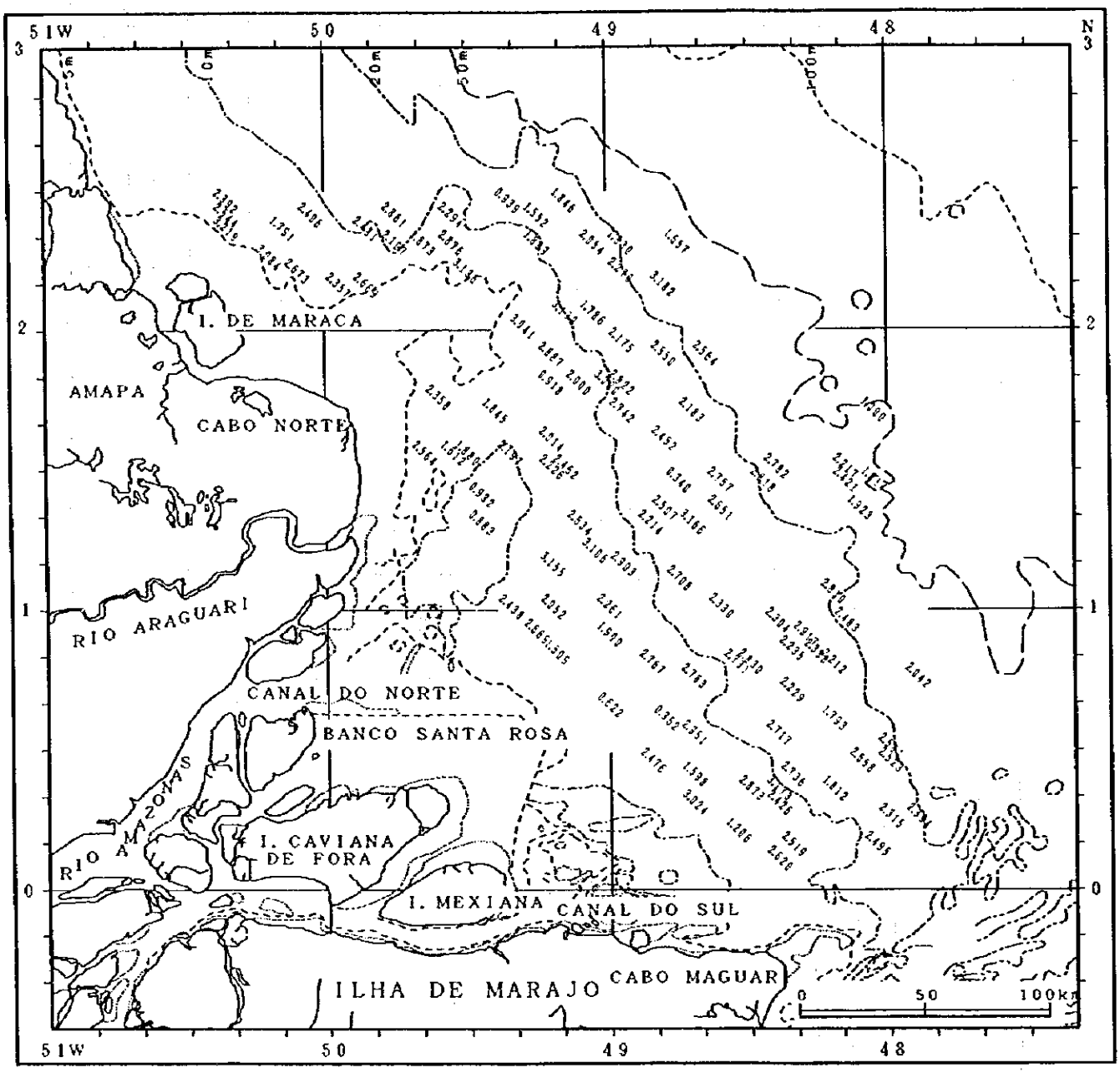


Appendix Figure 3. Annual changes in daily mean water levels of Amazon River at Obidos between 1970 and 1986. (Source: MINISTERIO DAS MINAS E ENERGIA).



Appendix Figure 4. Design of the bottom trawl net used for the Sea-Borne Survey. Roman type indicates the number of fibres and mesh size in terms of " knot to knot " in parentheses. Italic type indicates the number of meshes.

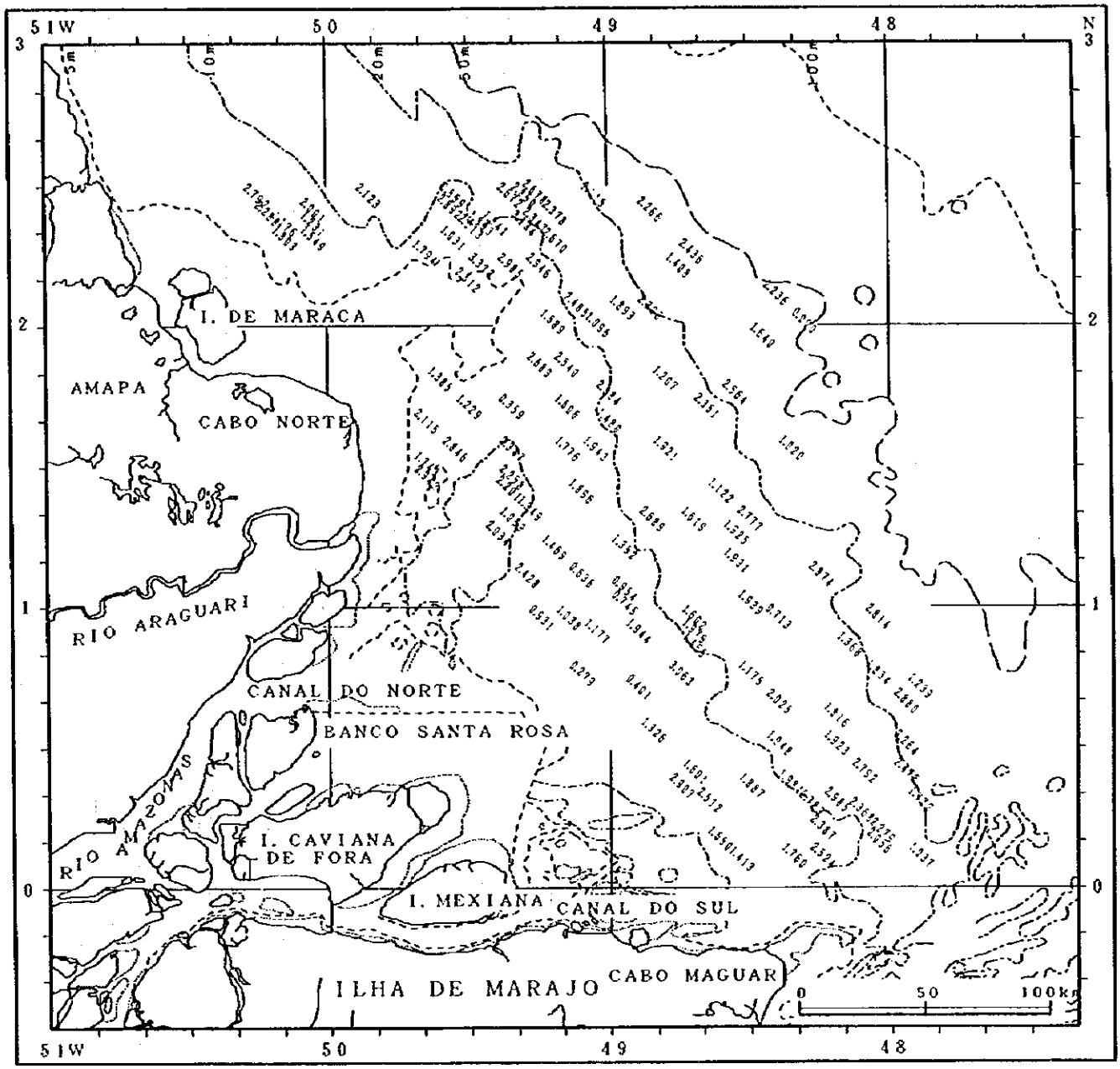
(A)



Appendix Figure 5. Horizontal distribution of diversity index *H'*. (A) Phase 1 Dry Season Survey; (B) Phase 2 Rainy Season Survey; (C) Phase 2 Dry Season Survey.

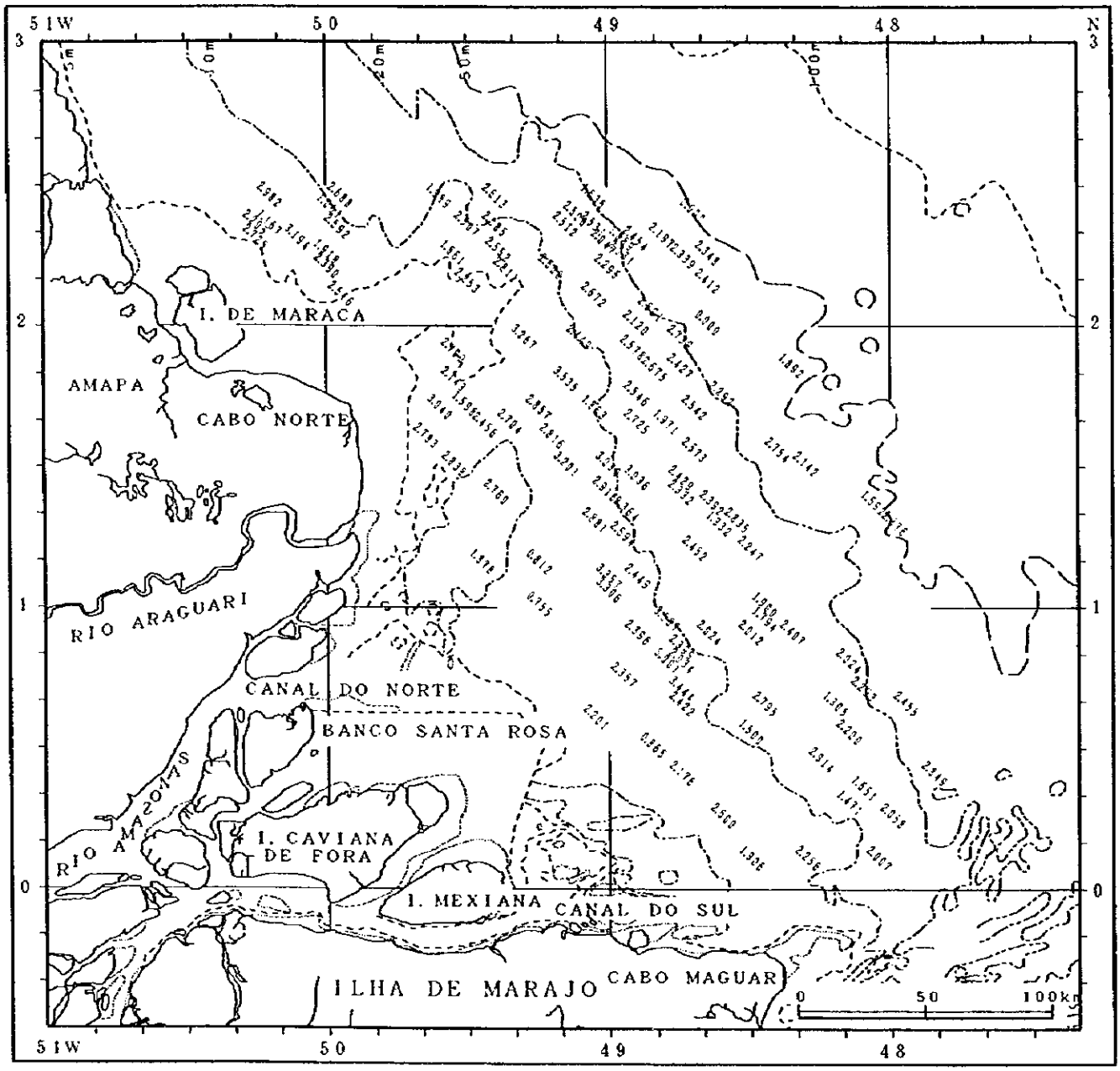
Appendix Figure 5. Continued

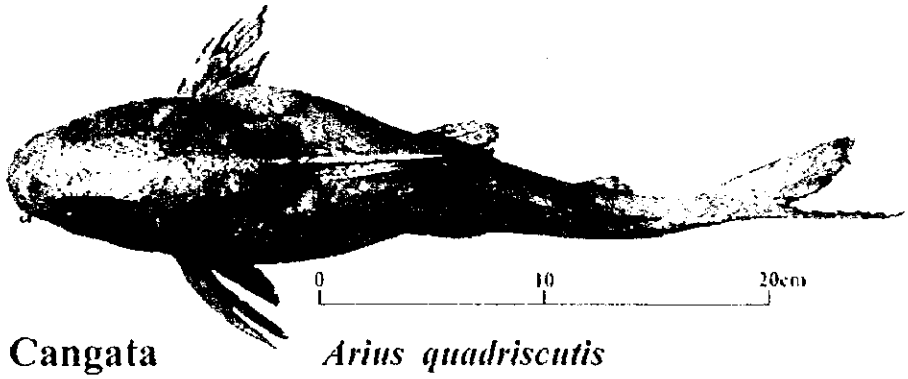
(B)



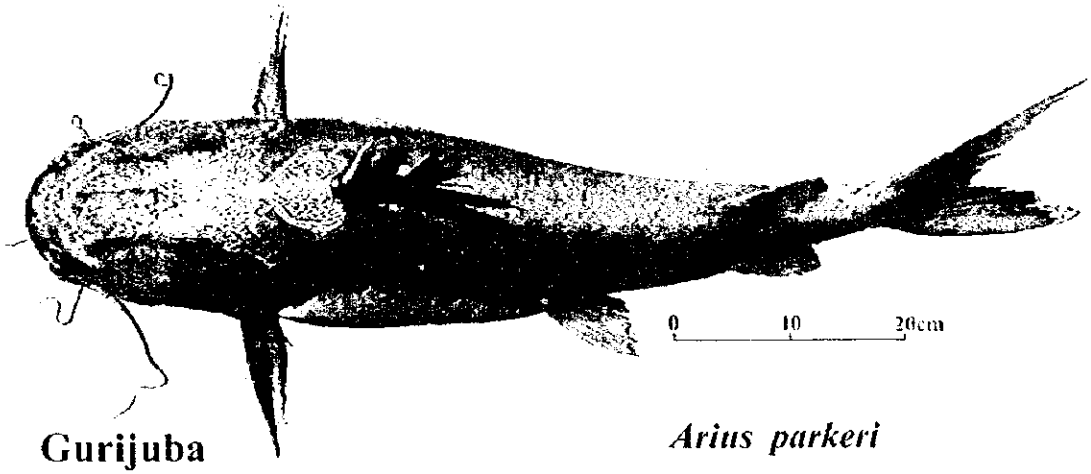
Appendix Figure 5. Continued

(C)

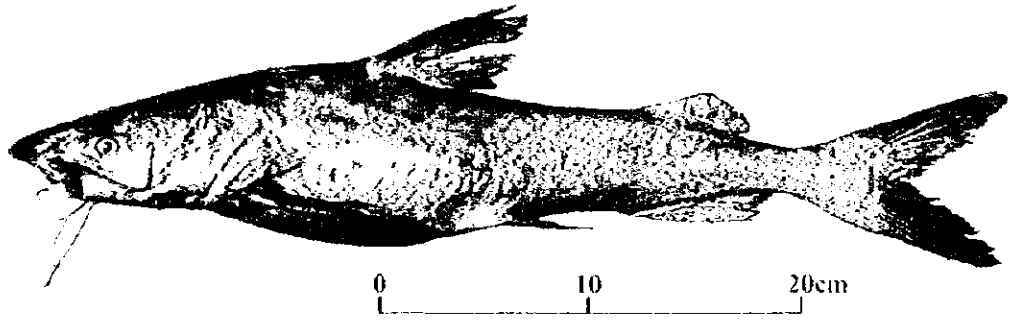




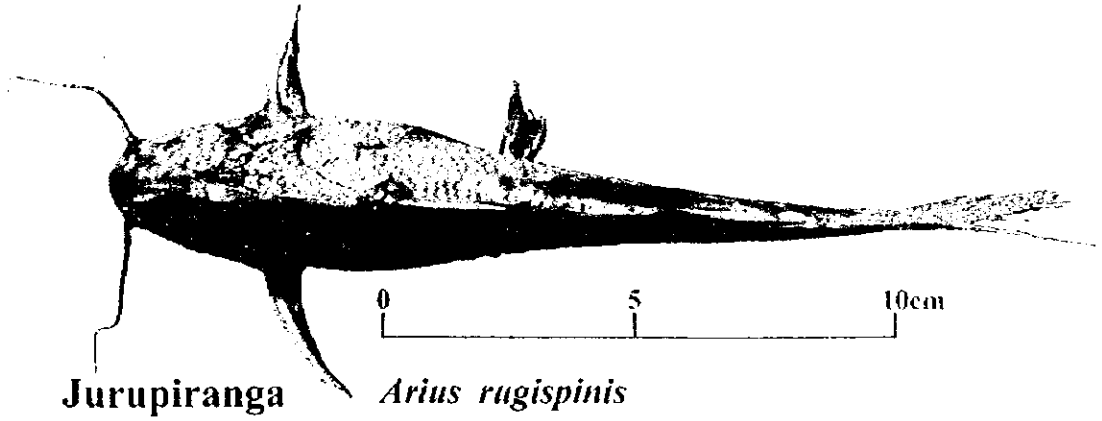
Cangata *Arius quadriscutis*



Gurijuba *Arius parkeri*



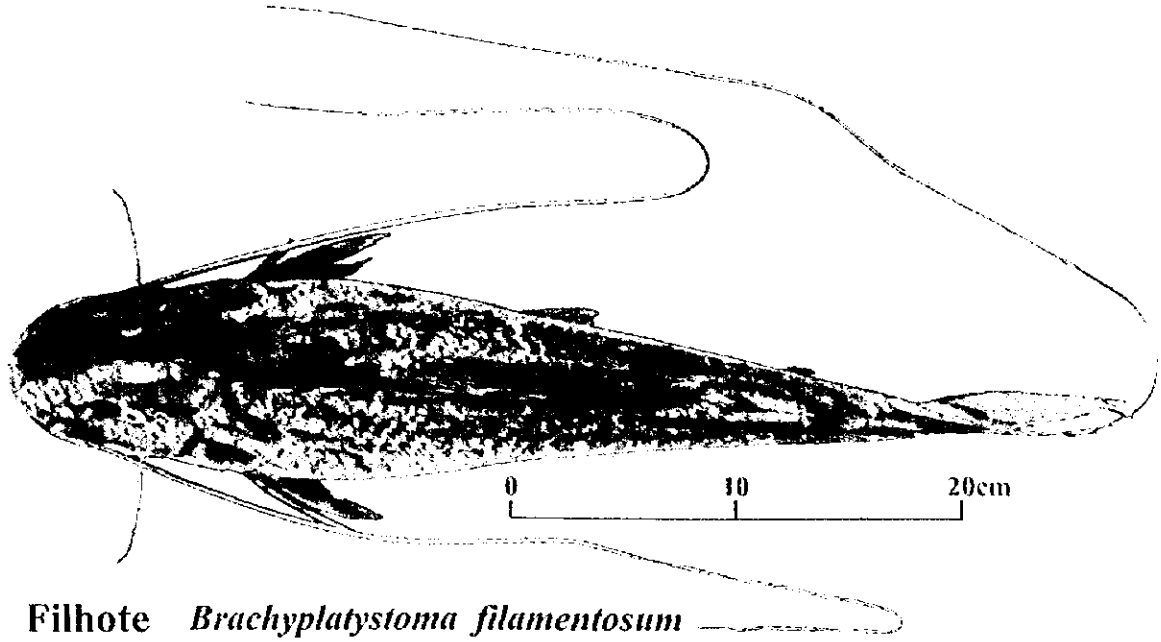
Cambeua *Arius grandicassis*



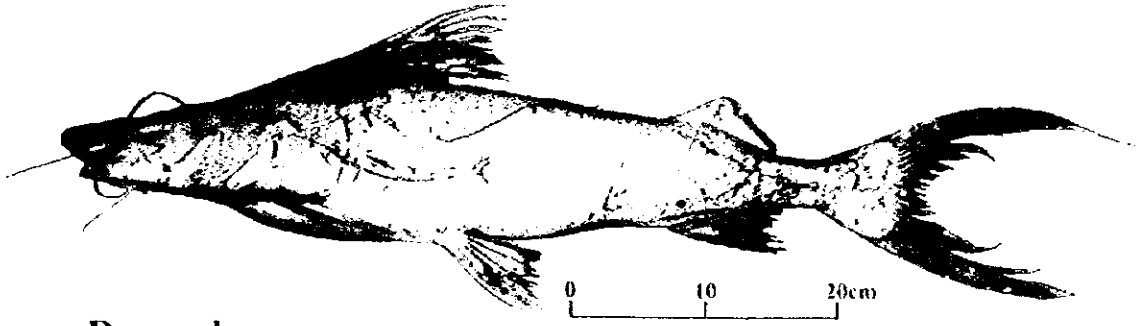
Jurupiranga *Arius rugispinis*

Plate 1. Key fish species and dominant species with respect to estimated stock size.

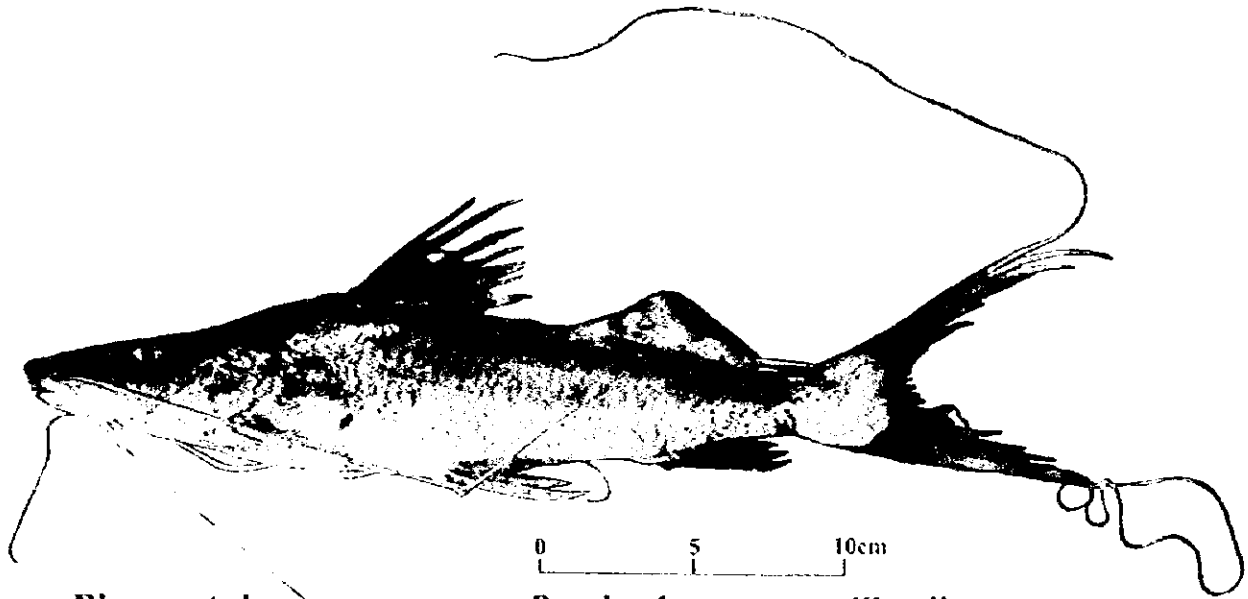
Plate 1. Continued



Filhote ***Brachyplatystoma filamentosum***

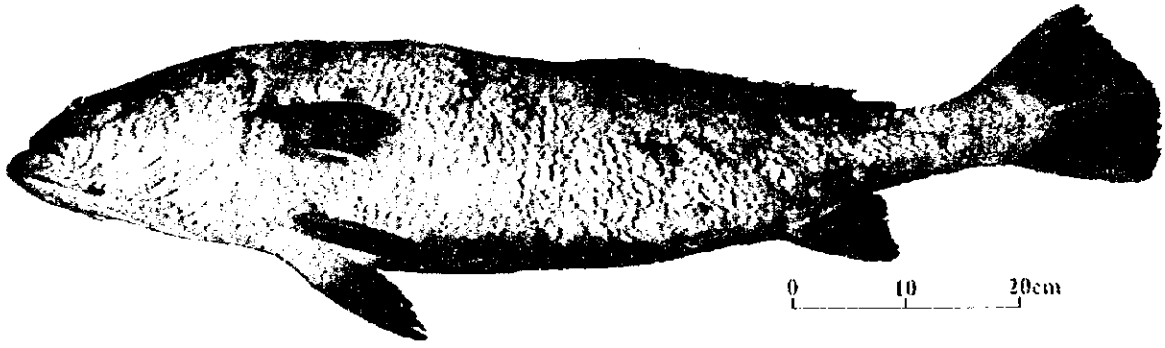


Dourada ***Brachyplatystoma flavicans***

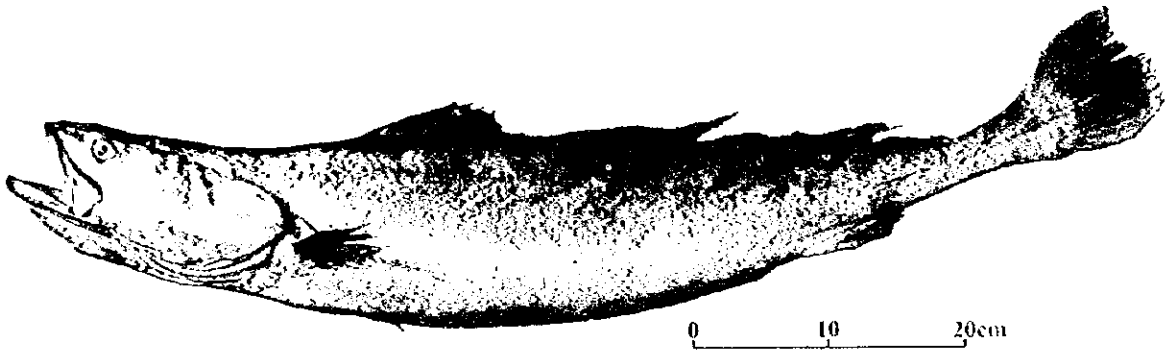


Piramutaba ***Brachyplatystoma vaillantii***

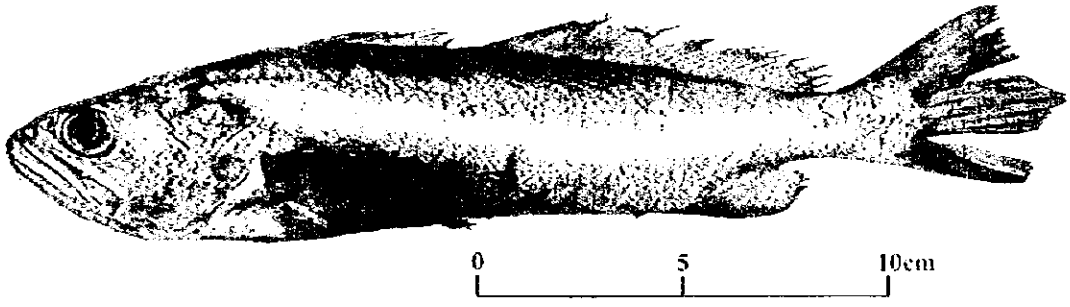
Plate 1. Continued



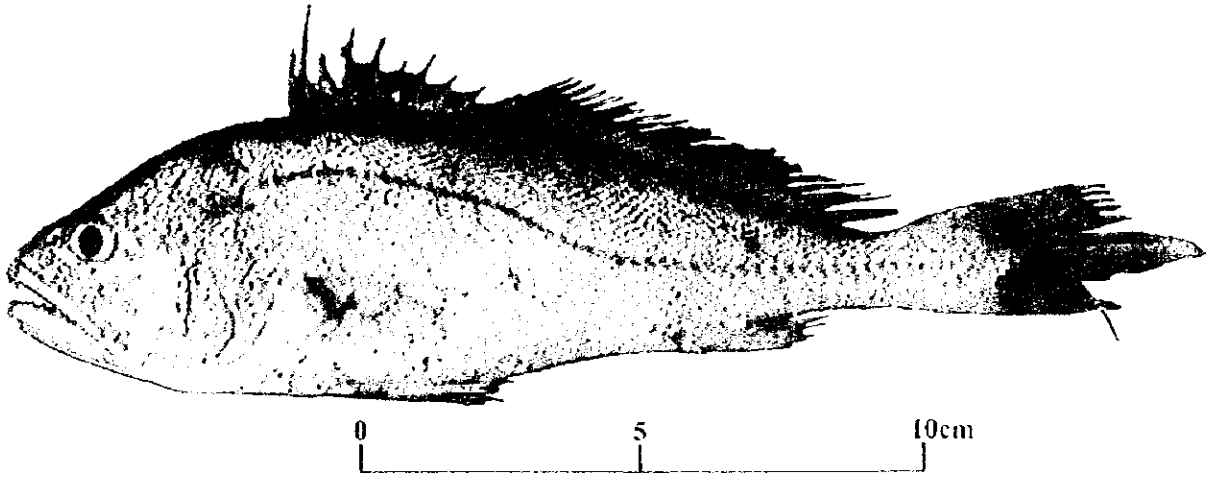
Pescada amarela *Cynoscion acoupa*



Corvina *Cynoscion virescens*



Pescadinha go *Macrodon ancylodon*



Pescada branca *Plagioscion squamosissimus*

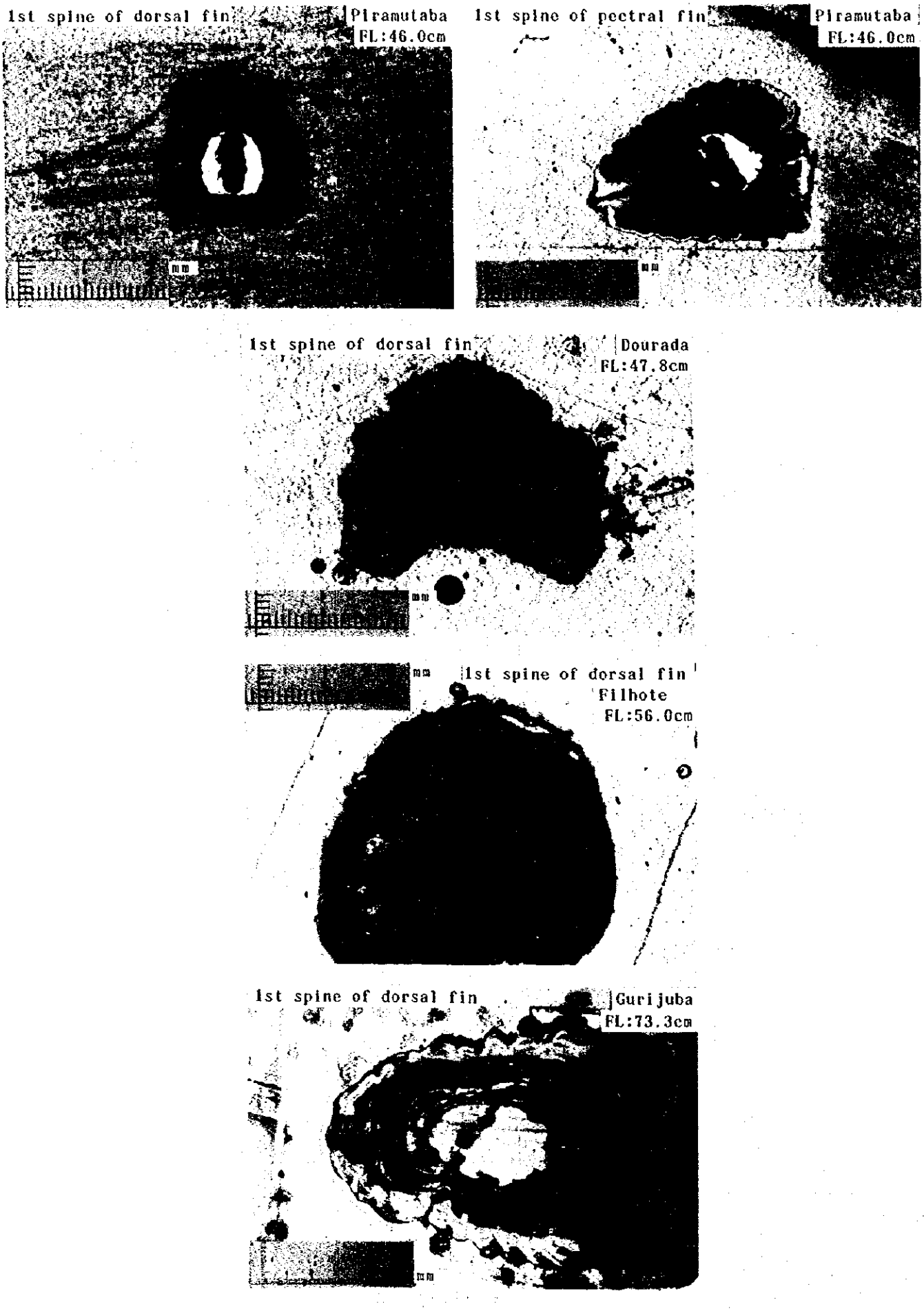


Plate 2. Spines of key fish species.

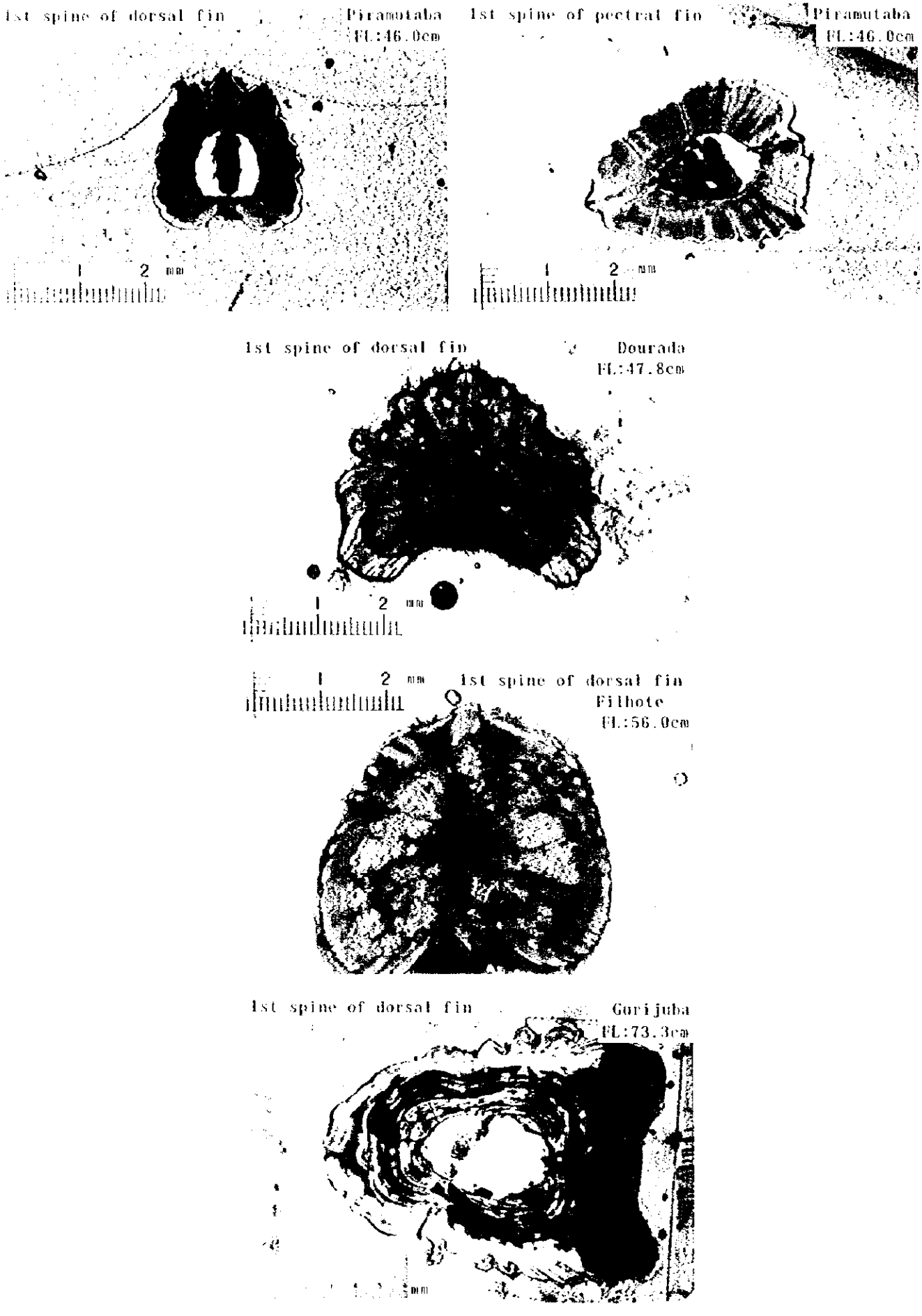


Plate 2. Spines of key fish species.

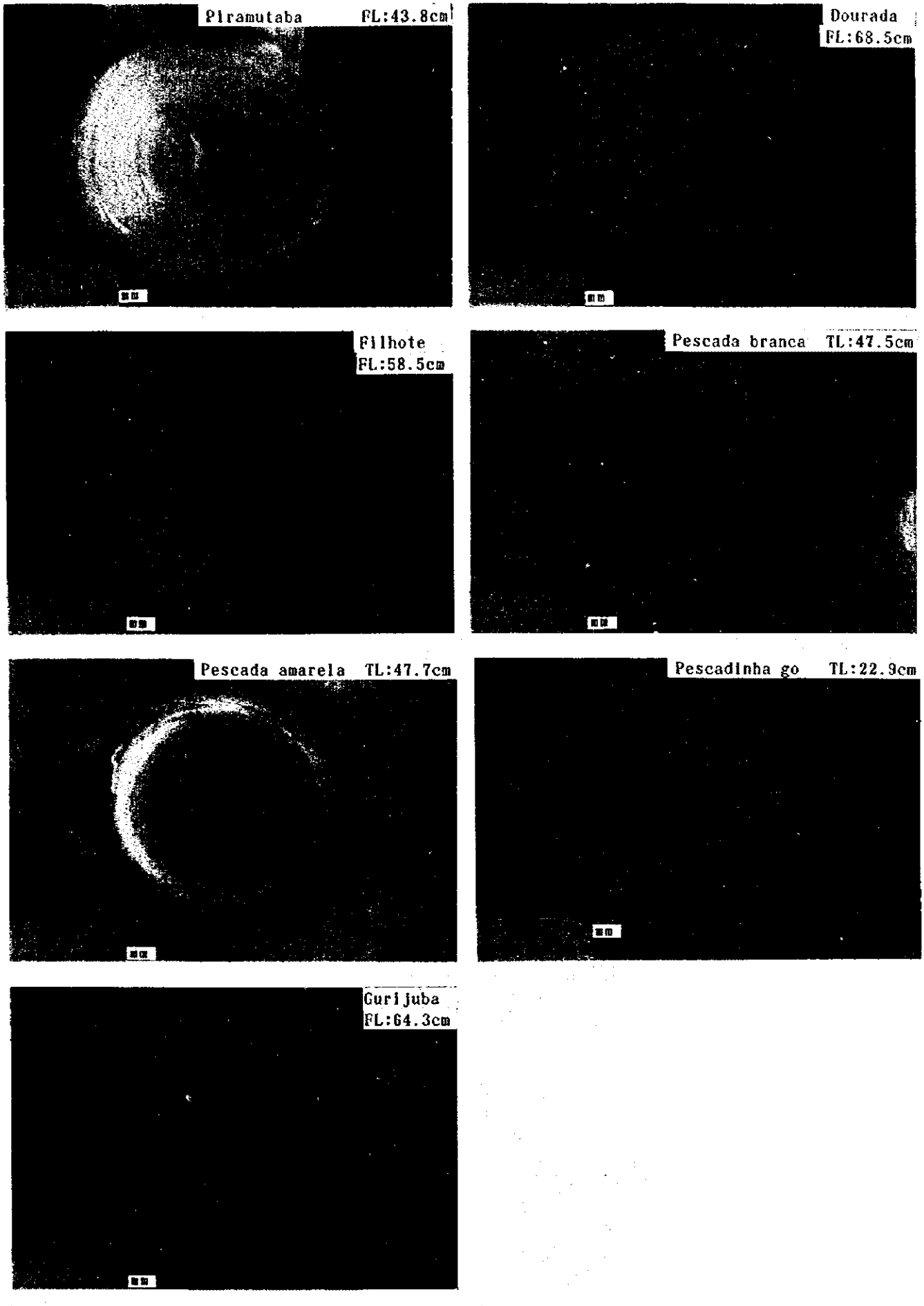


Plate 3. Centra of key fish species.

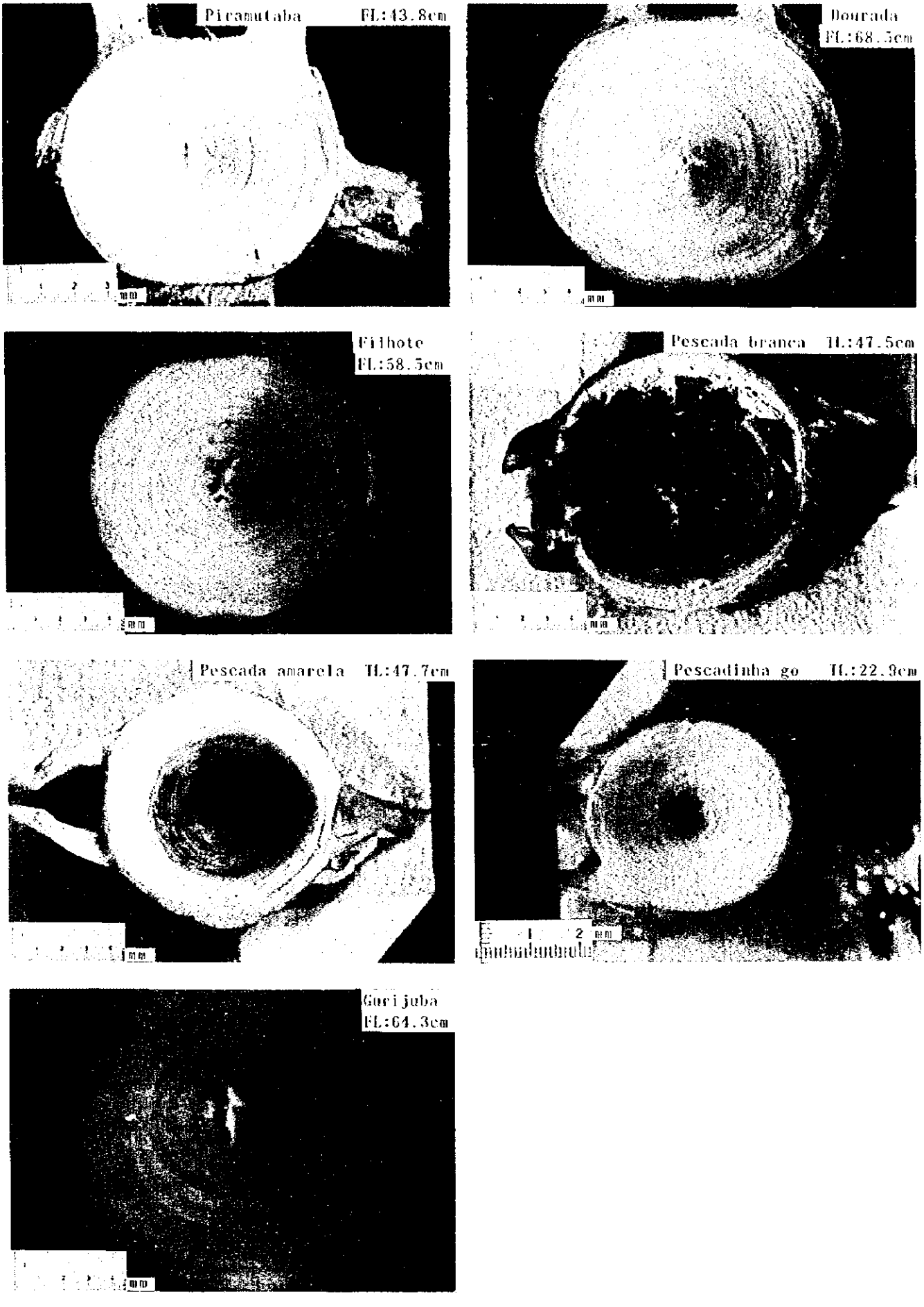
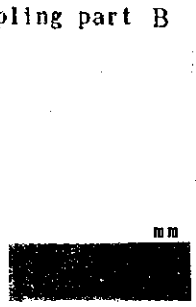


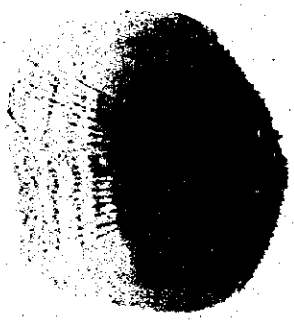
Plate 3. Centra of key fish species.

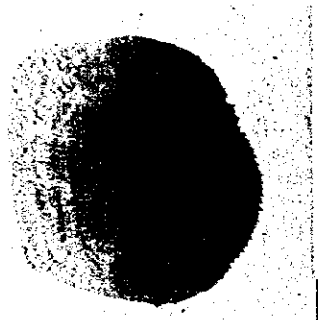
Pescada branca TL:47.5cm
Scale sampling part B



Pescada branca TL:47.5cm
Scale sampling part D

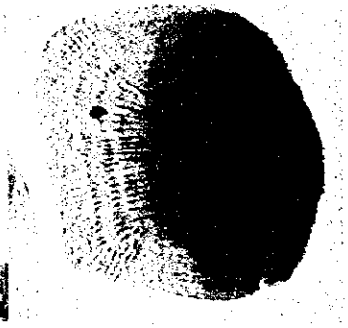
Pescada amarela TL:47.7cm
Scale sampling part A



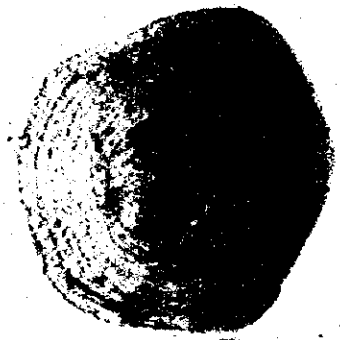


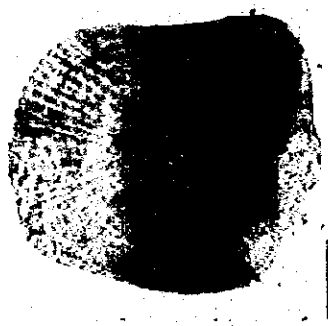
Pescada amarela TL:47.7cm
Scale sampling part B

Pescada amarela TL:47.7cm
Scale sampling part C



Pescadinha go TL:31.0cm
Scale sampling part A





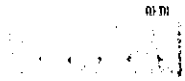
Pescadinha go TL:29.0cm
Scale sampling part E

Pescadinha go TL:28.4cm
Scale sampling part B

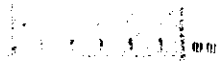
Pescadinha go TL:29.0cm
Scale sampling part F

Plate 4. Scales of key fish species.

Pescada branca TL:47.5cm
Scale sampling part B



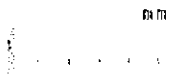
Pescada branca TL:47.5cm
Scale sampling part D



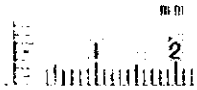
Pescada amarela TL:47.7cm
Scale sampling part A

Pescada amarela TL:47.7cm
Scale sampling part B

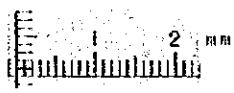
Pescada amarela TL:47.7cm
Scale sampling part C



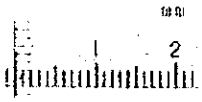
Pescadinha go TL:31.0cm
Scale sampling part A



Pescadinha go TL:29.0cm
Scale sampling part E



Pescadinha go TL:28.1cm
Scale sampling part B



Pescadinha go TL:29.0cm
Scale sampling part F

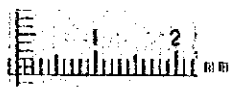


Plate 4. Scales of key fish species.

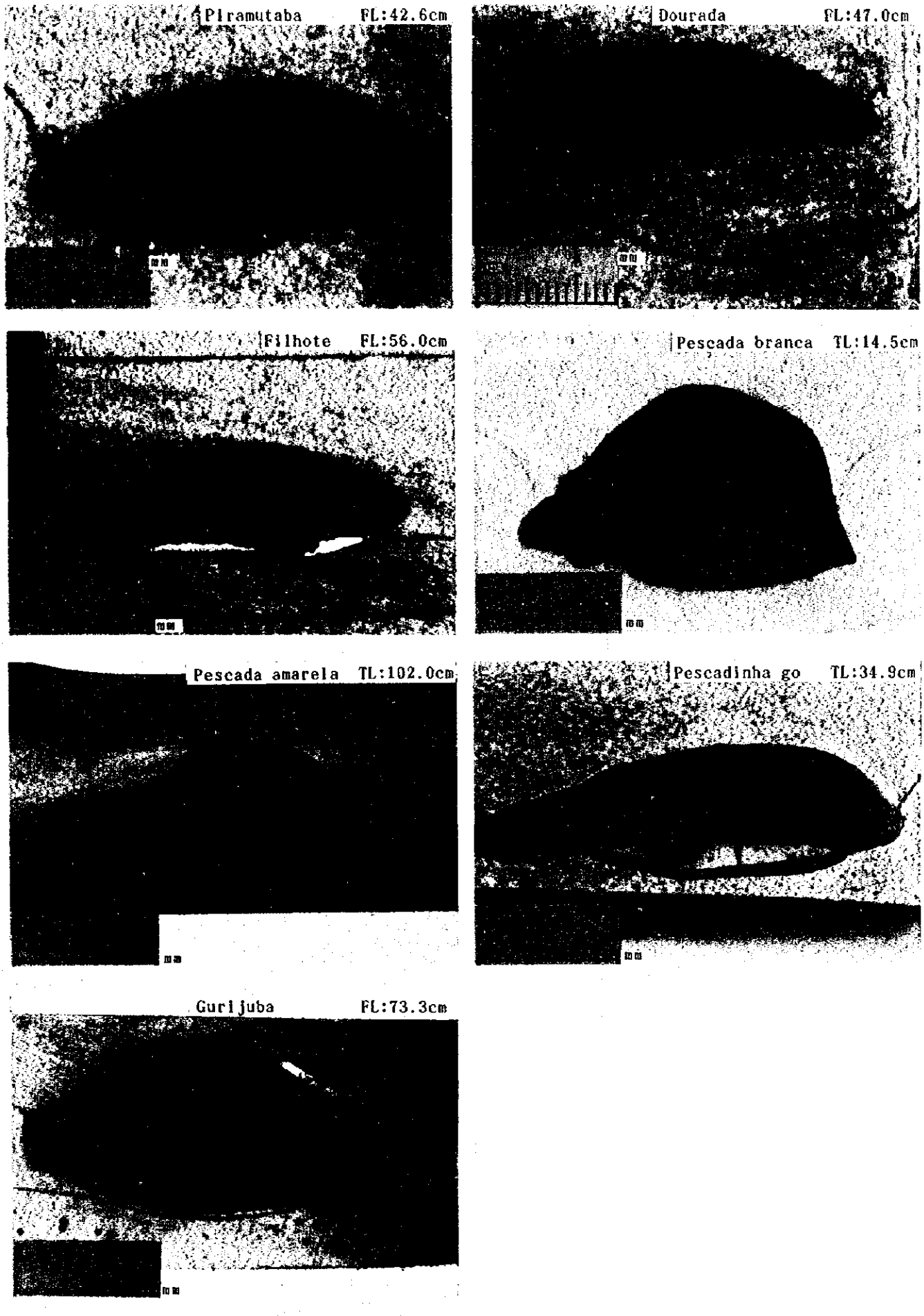


Plate 5. Otoliths of key fish species.

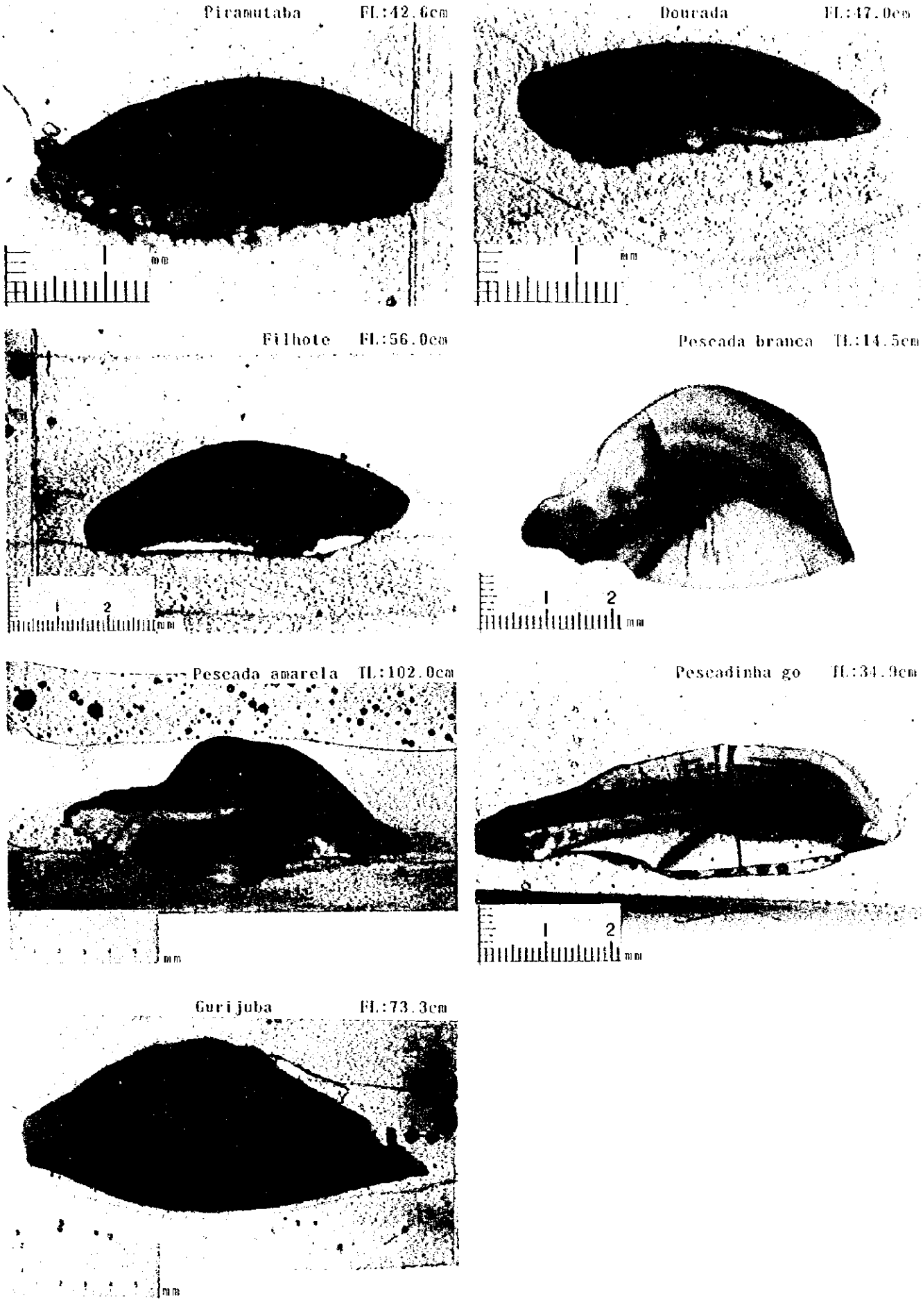


Plate 5. Otoliths of key fish species.

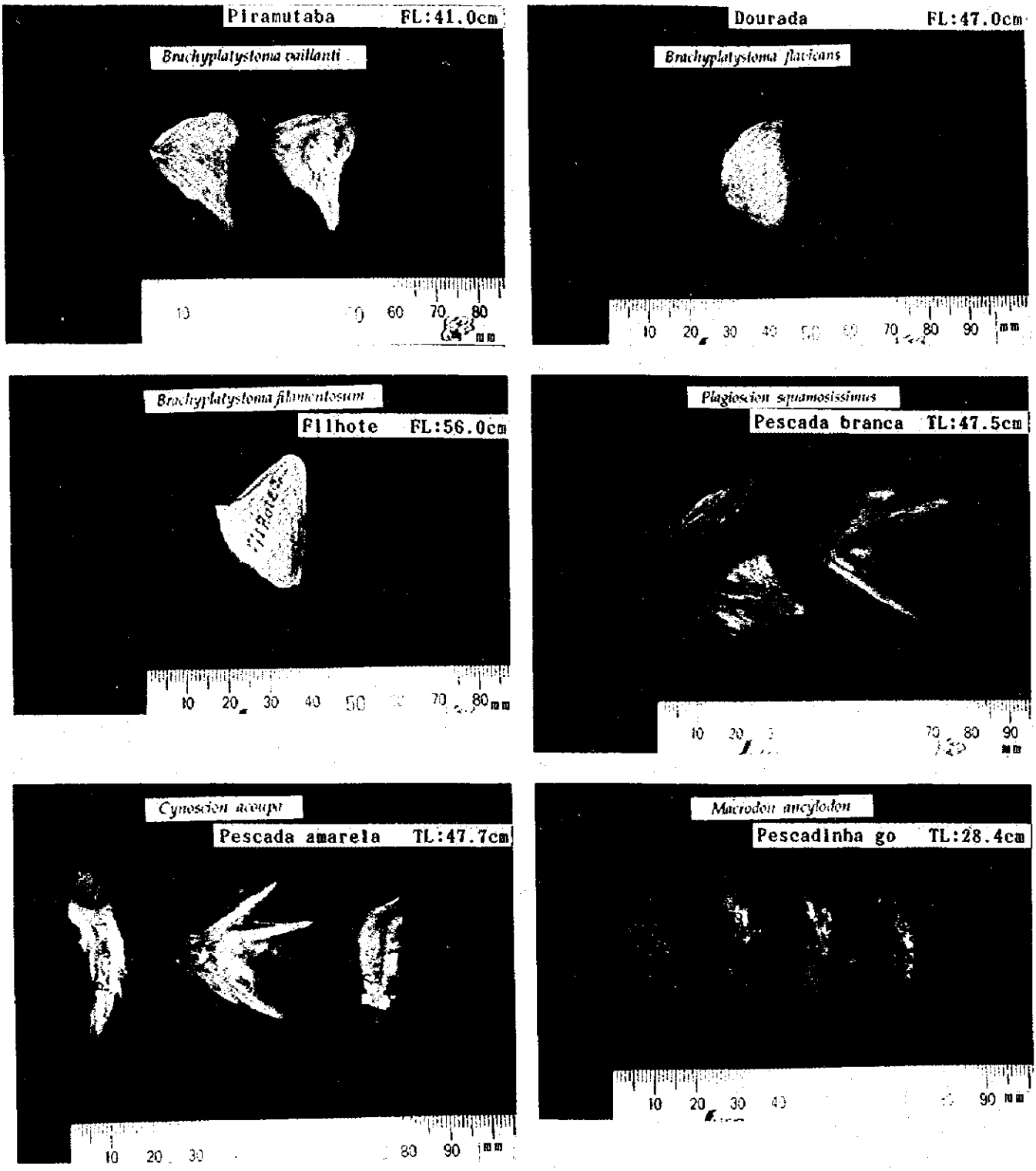


Plate 6. Opercles of key fish species.

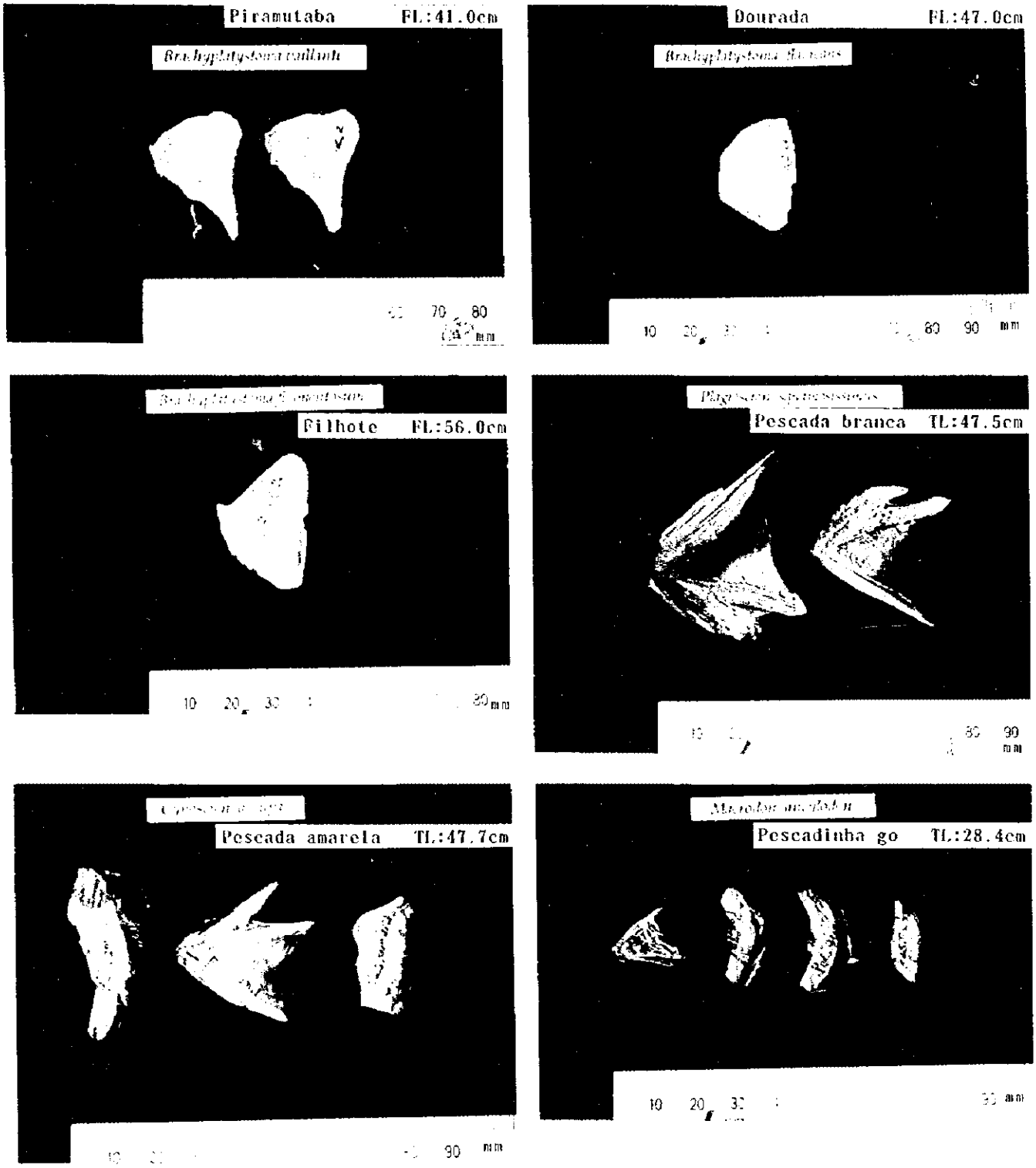


Plate 6. Opercles of key fish species.

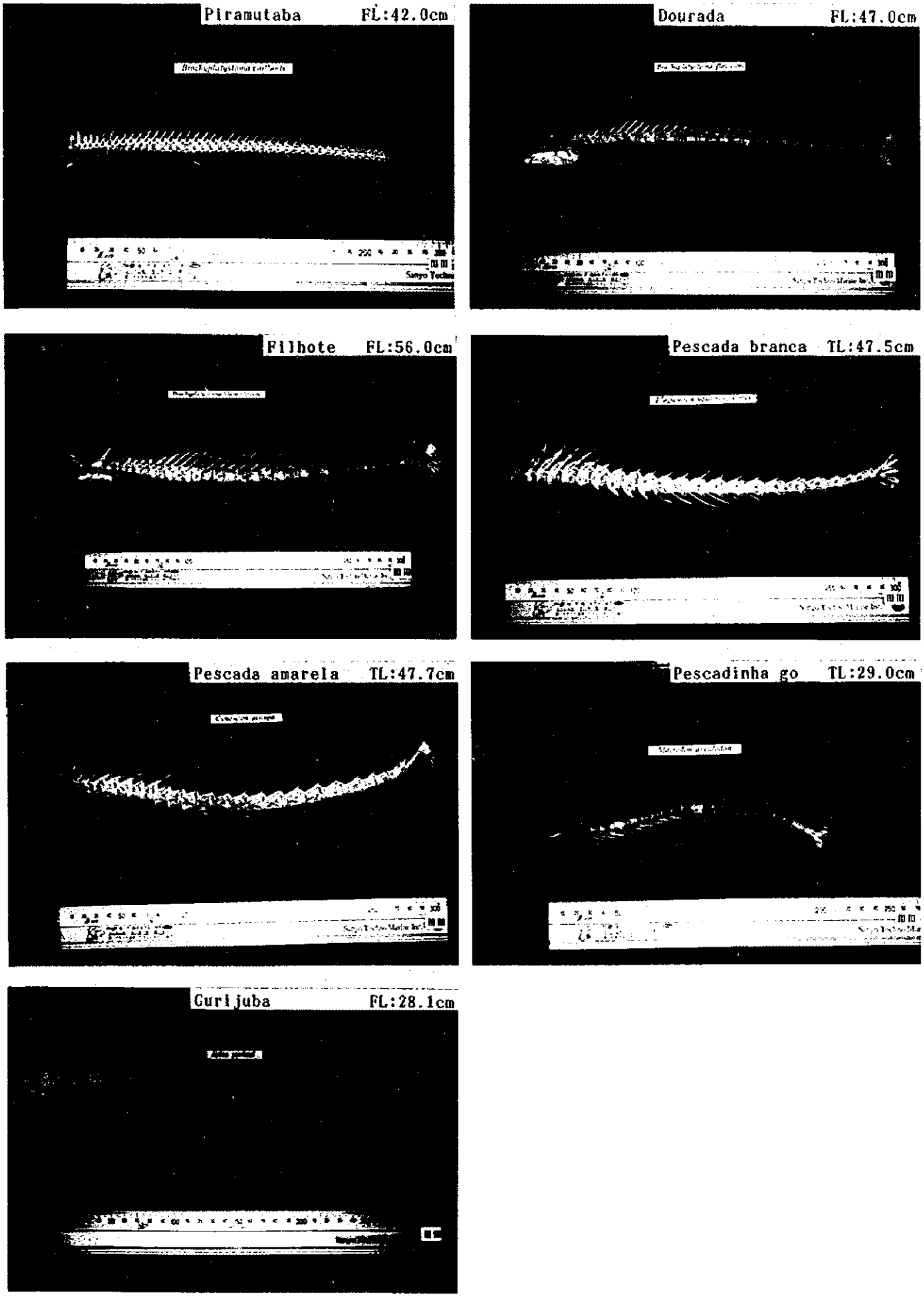


Plate 7. Skeleton samples of key fish species.

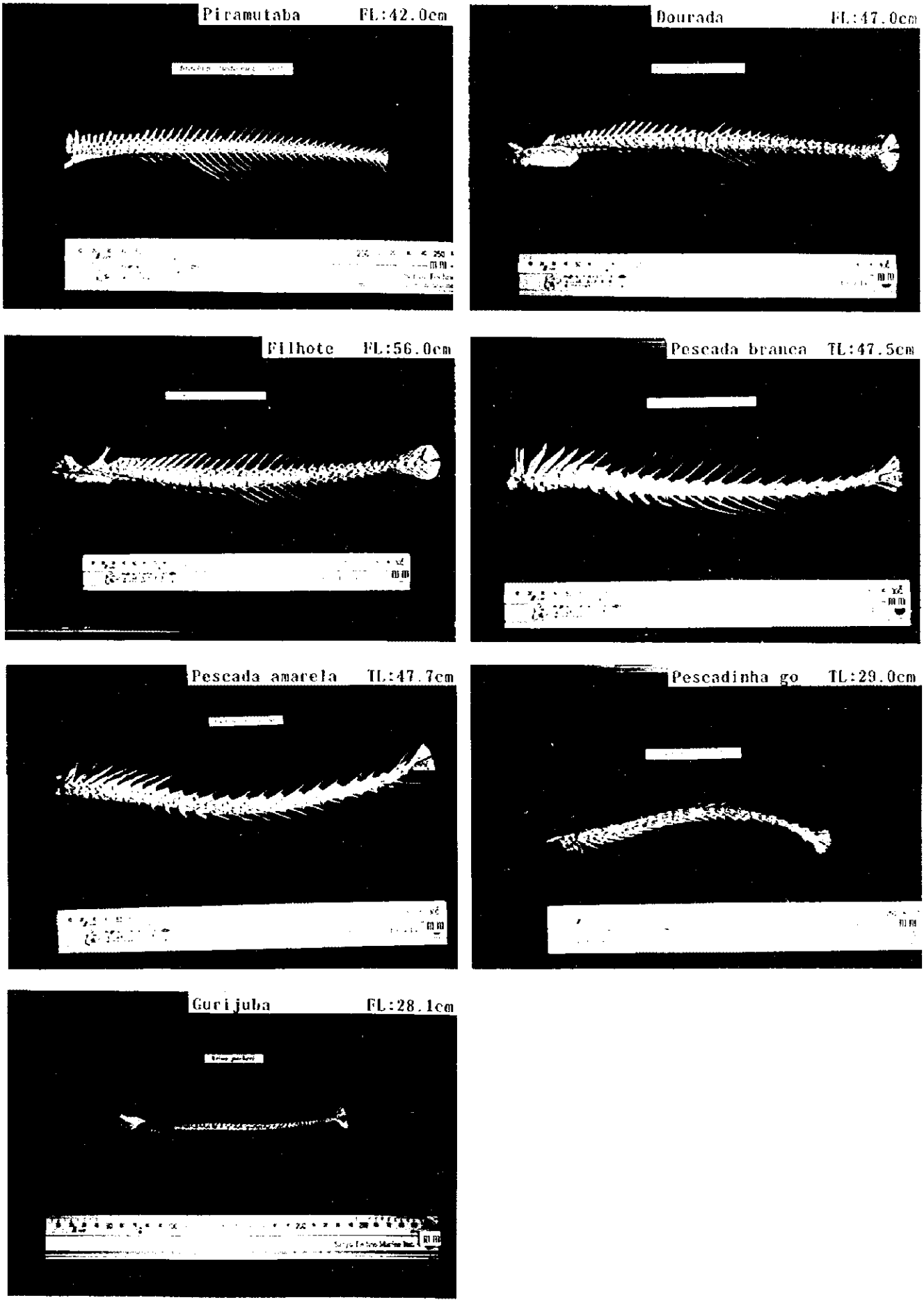


Plate 7. Skeleton samples of key fish species.