



منظمة الأغذية والزراعة للأمم المتحدة

联合国粮食及农业组织

FOOD AND AGRICULTURE ORGANIZATION  
OF THE UNITED NATIONS

ORGANISATION DES NATIONS UNIES POUR  
L'ALIMENTATION ET L'AGRICULTURE

ORGANIZACION DE LAS NACIONES UNIDAS  
PARA LA AGRICULTURA Y LA ALIMENTACION

FII:ExCons-STD/86/G.C. 3

November 1986

FAO EXPERT CONSULTATION ON SELECTIVE SHRIMP TRAWL DEVELOPMENT.

Mazatlán, México, 24-28 November 1986.

GENERAL CONTRIBUTION

STATUS OF THE BRAZILIAN SHRIMP FISHING OPERATIONS AND RESULTS  
OF RELATED RESEARCH.

BY

PHILIP C. CONOLLY

FISHERIES RESEARCH CENTER OF THE SOUTHERN REGION-SUDEPE/CEPSUL

ITAJAI, S.C., BRAZIL.

## TABLE OF CONTENTS

	Page
1 - INTRODUCTION	01
2 - BACKGROUND	02
3 - CHARACTERISTICS OF THE TRAWL FISHING REGIONS	03
3.1 - North Region	03
3.2 - Northeast Region	04
3.2 - Southeast and South Region	04
4 - GEAR AND FISHING OPERATIONS	06
5 - BY-CATCH NATIONAL SITUATION	09
6 - GEAR DEVELOPMENT AND RESEARCH	11
6.1 - Experimental Fishing	12
6.2 - Materials and Methods	12
7 - RESULTS	15
7.1 - Escape Panels	15
7.2 - Net Design	16
8 - DISCUSSION AND CONCLUSION	17
9 - ACKNOWLEDGEMENTS	19
10 - REFERENCES	20

## LEGENDS TO FIGURES

	Page
1 - Map of Brazil	23
2 - Illustration of the "gerival" net	24
3 - Fyke net	25
4 - Three net rig	26
5 - Escape panels, experiment Nº 1 and Nº 2	27
6 - Square mesh escape panels, experiment Nº 3	28
7 - Flat trawl used in the experiment Nº 5	28

## LEGENDS TO ABBREVIATIONS

- SUDEPE - Superintendência do Desenvolvimento da Pesca  
"Superintendence for Fisheries Development" (Federal  
Department of Fisheries)
- CEPSUL - Centro de Pesquisa e Extensão Pesqueira das Regiões  
Sudeste Sul (Ministério da Agricultura - SUDEPE)  
"Fisheries Research Center of the Southern Region".  
(Ministry of Agriculture - SUDEPE)
- CEPENE - Centro de Pesquisa e Extensão Pesqueira da Região  
Nordeste. (Ministério da Agricultura - SUDEPE)  
"Fisheries Research Center of the Northeast Region".  
(Ministry of Agriculture - SUDEPE)
- PDP - Instituto de Pesquisa e Desenvolvimento Pesqueiro -  
SUDEPE  
Fisheries Development Programme - SUDEPE
- GPE - Grupo Permanente de Estudos do Camarão  
Permanent Study Group on Shrimp

## 1 - INTRODUCTION

Shrimp fishing in Brazil is a very important social economic activity. Prawn exports have increased about 258 percent in the last ten years, from 2.4 thousand tons in 1974 to 9.3 thousand tons in 1985. Shrimp exports represent 60 percent of the total value of all fisheries products. (SUDEPE 1986).

Brazil's coast line has an extension of 4,590 nautical miles. The shrimp trawling activities occur from latitude 5° N to 28° S. Commercial fishing is carried out on all the coast extension in small artesanal or industrial scale. The operation methods vary from oceanic double-rig trawlers to small stern trawlers, cast nets, gerival nets, fyke-nets and gill nets.

Shrimp fisheries in Brazil are been studied by a national research programme, Permenent Study Group on Shrimp, GPE. It was created by SUDEPE with the purpose to study all biological aspects and development of the fisheries operations. The members are researchers from many different fisheries departments and universities. The results of the annual meetings are submitted to SUDEPE that establishes laws and regulations for the fisheries.

Other authors as Barbosa, and Rocha, (1977), Porto, (1984), Fonteles Filho, (1984) and Rebelo Neto, (1985) have published papers about biological aspects of shrimp fisheries. Bailon (in preparation, 1980) and Damasceno (in preparation, 1985) made the first evaluation of the participation of fish by-catch in North prawn fisheries.

The present paper deals mainly with the fishing operations, methods and special attention is directed towards

the by-catch national status, its problems and the present situation of the research programmes related to this matter.

## 2 - BACKGROUND

The national shrimp fleet is composed by 1155 industrial vessels (12<sup>2</sup> - 23 meters) and 4289 small artesanal boats (5 - 9 meters). The total landings in 1985 reached 39.351 tons, that includes all major shrimp species (Penaeus subtilis, Penaeus paulensis, Penaeus brasiliensis and Xiphopenaeus kroyeri). (Sudepe. PDP, 1986).

The fishing gear and methods of the trawler fleet have changed very little since the introduction of the double-rig system in 1960. In 1984 SUDEPE/FAO introduced the four net rig in the north region and gradually it is spreading towards the southern regions. The split-winch has been recently developed by a national company and it is been well accepted by the fleet.

The total national by-catch is estimated in 414.883 tons, from which 32 percent of this catch is landed (133.817 tons) and 68 percent is wasted (281.066 tons). The discarded ratio varies by region because of fishing operations (number of days at sea), composition of the catch and social-economic aspects of the population. The waste ratio is 97.5 percent in the north (average), 11 percent in the north-east and 65 percent in the southern region. (Table 3)

One of the biggest problems concerning with by-catch occurs in the southern artesanal fleet that was responsible for 60 percent of the total landing in 1985 (7413 tons). The fishermen use trawls and seine nets with small meshes, 26 mm, in laggons and coastal areas where the by-catch is composed by a great percentege of juvenile fish.

In 1986 SUDEPE/CEPSUL started a research programme on selectivity of shrimp trawl nets in the south of Brazil. During the last five months experiments with escape sections for by-catch and new net designs were tested by the R.V. Diadorim.

### 3 - CHARACTERISTICS OF THE TRAWL FISHING REGIONS

There are two main (large scale) trawl fishing regions. The first is in the north and the second in the south-east and south of Brazil. A third developing area is located on the north east coast. (Figure 1).

#### 3.1 - North Region

The north Amazon region has the most productive shrimp grounds. This area is limited by the river Orinoco (Guyana) and by the state of Maranhão, covering an area of 223.000 km<sup>2</sup>.

Fishing activities started in 1960 by foreign fleets established in neighbouring countries; Guyana and Trinidad. In 1969 Brazilian fishing activity began with a national fleet of 5 boats. In 1970 the 200 miles limit was established and international agreements were signed giving permission for foreign fleets to operate in Brazilian waters. This law lasted until 1977. Since 1978 foreign vessels can only operate in the region if they are commissioned with a national firm in a joint venture contract. This law will last until 1989.

The north fleet is composed of steel double-rig trawlers of 19 to 23 m long equipped with motors of 250 to 450 HP. All boats have refrigerated holds and stay at sea for 45 days (average). (SUDEPE / PDP, 1986).

The main species caught in the Amazon area is the pink shrimp (*P. subtilis*) (Table 1).

Table 1

Number of boats and landings of, *Penaeus subtilis* from different fleets based in the north region in 1984. (Source: SUDEPE, 1986.)

FLAG	Nº BOATS	LANDINGS (KG)
Brazil	116	2.724.989
USA	35	360.398
Japan	18	854.011
Corea	36	1.056.804
Trinidad	09	109.759
TOTAL	214	5.105.961

In May 1986 the national fleet increased to 178 boats and the number of foreign vessels decreased to 75 trawlers. The total catch in 1985 was 8,005,7 tons.

### 3.2 - North East Region

The north east coast of Brazil is characterized by a typical tropical climate, warm waters and coral sea bed. However, the important São Francisco river, situated in the area at  $10^{\circ} 45'$  lat.S. provides coastal shrimp grounds that are developing gradually an important fishing industry in the region.

A small fishery started in 1974 on an artesanal scale. The fleet was composed of small coastal boats equipped with inboard diesel engines (20 - 40 HP). The boats used only one small two seam trawl operated at the stern.

The main species caught are the sea bob (X. broyeri) and the white shrimp (P. schmitti).

Since 1978 the fishing companies from the North started to invest in the region and introduced the double-rig trawling. In 1985 the fleet was composed of 36 vessels with sizes bigger than 10 m and 156 boats with sizes smaller than 9 m.

The total catch in 1985 was 248.4 tons of the white shrimp and 3,076.0 tons of sea bob. (SUDEPE / CEPENE, 1986).

### 3.3 - The South East and South Region

The south east and south region has the second major shrimp fishing grounds of Brazil. The trawling operations extend from lat  $18^{\circ} 30'$  S to lat.  $28^{\circ} 00'$  S covering an area of 17,100 NM<sup>2</sup>.

Industrial prawn fishing for P. brasiliensis and P. paulensis started in 1950 using stern trawling. In 1966 double-rig (two net-rig) was introduced and rapidly developed in all the region. In 1980 the fishing effort started to reduce the shrimp population and the productivity of the trawlers was seriously affected. In 1984 protectional measures were established during the recruitment season and fishing was prohibited for two months per year. In 1986 this period was extended to three months. These measures were taken by the permanent study Group on Shrimp (GPE/SUDEPE).

Prawn landings (P. brasiliensis) increased 103 percent from 1984 to 1985, from 6,096 tons to 12,355 tons. The artesanal lagoon fisheries was responsible for 60 percent of the total catch and the industrial fleet had an increase of 21 percent. (Table 2).

Table 2

Landings and main species caught in 1985 in the south east and south region. (Source: SUDEPE, 1986)

Main Species	Landings (tons)
<u>Penaeus brasiliensis</u> & <u>Penaeus paulensis</u>	12,355
<u>Xiphopenaeus kroyeri</u> & <u>others</u>	14,719
<u>Penaeus schmitti</u>	947
TOTAL	28,021

The prawn fleet in 1985 was composed by 349 double-rig trawlers of 19 - 24 m equipped with motors of 180 to 270 HP. Most vessels have their wheel house located at the stern. This system is preferred by many skippers because it gives better steering control in bad weather.

Sea bob (X. kroyeri) fisheries started in 1962 when most of the landings were salt dried for the local market. In 1972 peeling machines were introduced and the demand of fresh shrimp increased from 8,530 tons in 1971 to 10,941 tons in 1972 (Rebelo, 1985). The biggest landing occurred in 1981 with 15,586 tons and for the last few years the increase of the fishing effort has reduced the total catch to 11,860 tons (SUDEPE/CEPSUL, 1986).

There are two classes of boats fishing the sea bob. The first is composed of 556 small wooden (9 to 12 m) double-rig trawlers equipped with 90 to 120 HP motors. This fleet works on a semi-industrial scale with each trip lasting 6 to 8 days. The catch is stored on ice.

The second class is composed by 4,133 small artesanal open deck dories equipped with inboard 9 - 36 HP diesel engines. This artesanal fleet operates on a daily trip basis using stern or small double-rig trawls. (SUDEPE - Report GPE, 1985).

#### 4 - GEAR AND FISHING OPERATIONS

The trawl nets used in the three major shrimp regions differ mostly in size and mesh dimensions. The models are basically of three types: two seam, flat, and semi-balloon trawls.

In the north region the trawlers are powered by bigger engines of 250 - 450 HP and small nets because of the very strong currents that occur in the Amazon area. Normally the trawlers operate with two 15 meters four seam trawls (model flat). The wings and belly are made of nylon (polyamid) netting, twine 210/48 and 50mm mesh (stretched length). The codend is constructed with nylon netting, 210/96 44mm mesh. The head and foot rope are of combined polypropylene wire 12mm. The trawl doors are made of wood and steel measuring 2.6m x 0.8m (average) and weighing 170 - 190 kg. Recently polyethylene braided twine netting is becoming popular.

In 1984 SUDEPE and FAO experimented and introduced in the Amazon region the twin trawl rig. The system consists of two small nets towed at the end of each outrigger. The two otter boards are 30 percent smaller than the traditional sizes. A central sledge of the same board sizes supports the inner bridles joining the two nets. This method has been used by the foreign fleet for the last four years.

The trawling operations in the north region are mainly done in 40 to 70 meters depth. The shrimp grounds consist of smooth mud bottoms in the Amazon mouth area, and rocky and mud sea beds near the Guyana border. The operation periods generally vary with the season but normally trawling is done 24 hours a day. The shrimp catch is processed on the deck, put in polyethylene netting sacks and frozen in the hold. There are no catch sorting tables or dives in the north fleet.

The fleet is equipped with the basic electronic aids such as; echosounder, radio-navigation, auto-pilot and SSB radio communication. Satellite navigation, radar and colored echosounder are becoming very popular.

The sea bob fisheries in the north east region operate with small and light gear. The most popular trawl model is 16 meters two seam net made of nylon netting 210/16 with a

36mm mesh. The codend mesh size has 28mm with 210/36 twine. The modern double-rig trawlers are using two ten meter flat model trawls made of polyethylene netting, 36mm mesh and 30/6 twine. Trawl doors are made of wood and steel measuring 1.3m x 0.6m weighing 40 kg. The larger boats are equipped with diesel engines of 90 - 170 HP and mechanical winches. The trips duration varies from one to 5 days at maximum. There are no refrigerated holds and the catch is kept on ice. The fishing grounds are very close to the coast (5 miles) and the deepest trawling is done in 20 m depths.

The south-east and south shrimp trawl fishery is divided in three classes of operations. The first is characterized by vessels of 19 - 23 m which fish exclusively P. brasiliensis and P. paulensis. These boats are equipped with engines of 180 - 270 HP and they trawl two semi-balloons or flat model nets of 16 to 20 m. The main netting is made of braided 1.5mm polyethylene twine with 50mm mesh size. The codend netting is made of polyamid 210/96 and 44mm mesh. The wooden and steel door have 2.4 - 0.8m weighing 140 kg. Normally the gear is superdimensioned to the available power. This is due to the lower shrimp abundance compared with the Amazon region, so the skippers tend to use bigger nets to increase productivity. Generally this procedure is not efficient and the engines are seriously damaged by the excess of drag. Trawling operations are done (average) 30 miles from the coast line, at 40m depth. The sea bed consists of sand and mud near the coast line and mud with shells in deeper waters. The continental shelf is in average 80 miles wide, and trawling operations are extended up to 150 meters for scampy (Metanephrops rubellus).

During the shrimp closed season, from February to April (recruitment protection), the large trawlers operate in deeper waters (90 - 150 meters) catching scampy (M. rubellus). They use the same prawn nets (50mm mesh) and riggings in this period. Other boats use two wing trawls, with 120mm mesh in the wings and 100 mm mesh in the body, for demersal fish further south (Lat. 32° 00' S).

Recently, split-winches have been developed by a national company and in a near future all the fleet will gradually adopt this gear. A new 18 m trawler equipped with split-winches is using, also, with success a twin net rig (four nets).

In the south east fleet there is also no catch sorting table or devices.

The semi-industrial sea bob double-rig trawlers are more coastal and operate with two twelve meters flat model trawls, made of polyethylene twine 30/09 and 36mm mesh size. The doors are made of wood and steel measuring 1.4 x 0.6 m and weighing 60 kg (average). These vessels are equipped with echosounders and SSB radio communication.

The artisanal sea bob trawling fisheries also use the double-rig system in small open dories, equipped with central diesel engines of 09 - 36 HP. The two seam nets, with long narrow wings, measuring 10 m each are very popular. The main netting is made of polyamid 210/09 twine, 26mm or 30mm mesh size. The bunt twine is 210/36 with a 26mm mesh. Head and foot ropes are made of polypropylene 6mm rope. The trawl doors are constructed of solid wood, with no slots measuring 0.65m x 0.37m and weighing 18 kg. The two outriggers are made of wood measuring (average) 3 m.

These fisheries are very coastal and generally each boat is operated by one man. The double-rig gear is hauled by a simple mechanical winch drum driven by the engine. The trawl warps are made of 8mm polypropylene rope. The sea bob and white shrimp are sorted on deck and kept in polystyrene boxes without ice.

Other shrimp catching methods are used in the lagoons or stuarine areas, such as cast nets, fyke nets, "gerival" nets and gill nets (entangling nets). Most of these fishing gears are well known and used in many parts of the world.

The gerival net is a quite new method and probably a unique gear for catching shrimp. This net was developed in the south of Brazil and is operated by artisanal fishermen in stuarine areas where the tidal currents have strong influence. Basically the "gerival" is a cast net used in the vertical position and open by a fixed beam (wood or plastic). At the top, a metal rig is introduced and a small bunt is fixed over it. The net is operated from a small open rowing boat that drifts with the current. When the shrimp are covered by the gerival they react vertically climbing up the netting, passing

through the ring and are trapped in the bunt. (Figure 2). The net is hauled every hour and the deck operation only lasts 5 minutes.

The main advantages of the "gerival" net is that no fish is caught in the operation, but shrimp. This makes it a very selective gear and ideal for estuarine areas where the preservation of the young ictio fauna is of great importance.

The fyke nets are also used for catching shrimp in the south region in lagoon areas. These nets are operated at night combined with light attraction. One man operates 5 nets (Figure 3). The by-catch has no economic importance and is discharged alive. Some fishermen only sort the shrimp at the end of the operation, causing total mortality to the discarded fish.

Drifting tangling nets are used in some estuarine areas but there is a Federal Legislation that controls this fishing method, because of the small meshes that catch a great number of young fish.

#### 5 - BY-CATCH NATIONAL SITUATION

The large coast line, different social-economic status of each region and the operational conditions are the main reasons determining the use or waste of the by-catch. (Table 3).

In Brazil's major shrimp fishing regions there are three different percentages of by catch utilization.

In the north, fish by-catch is composed of a great number of species of commercial value. Bailon (report, 1981), estimated that 70% of the total fish biomass was weak fish (Macrodom ancylodon) that has a high market price but almost all the catch is dumped back to the sea.

The amount of commercial fish caught in relation to the shrimp catches is 4.4 : 1, and the total by-catch represents 10 : 1. (Damasceno, in prep, 1985). These

values can increase or decrease according to the season, fishing grounds, etc. Considering the 1985 landings, the total fish by-catch in the north region was 80,057 tons. From this total only 2,000 tons were landed and 78,057 tons were wasted. The main reason for this waste is the long periods that the boats stay at sea and the lack of tradition in eating marine fish in the Amazon region.

The fishing companies authorize skippers to keep a maximum of only 2 tons of fish, because a larger amount of the by-catch could put in risk the quality of the frozen shrimp. A quick storage of big hauls can cause an increase of temperature in the hold.

SUDEPE, tried to introduce a by-catch collecting programme in the north fleet. The system consisted of a collecting boat or transport vessel that would work with the trawlers. The by-catch would be selected, sacked and kept temporarily in the hold (if necessary). The bags would be tied with floats and thrown overboard and collected by the transport vessel. This system was approved by the companies but did not start operating because the boat owners were afraid that shrimp smuggling could occur.

The lack of sorting devices in the shrimp boats delay the operations and consequently all the fish are left on the hot deck. During the shrimp season, when yields are high, the classification and storage of the prawns can last two hours and only after this period the by-catch is returned to the sea. There are no survival rates.

In the north-east region the shrimp by-catch is a very important economic resource. It covers all the operational expenses of the boats. The fish is totally consumed by the local market and is sold fresh or salted dry. Only poisonous species are discarded. The amount of fish caught in relation to the shrimp yields is 8 : 1. The total by-catch landing in 1985 was 26,595 tons. The waste is estimated in 10 percent, 2,659 tons. (SUDEPE/CEPENE, 1986).

The main reasons for the utilization of the by-catch in the NE region are the coastal shrimp fishing grounds that permit daily or short trips and the lack of animal protein at low prices for the poor population.

The fish by-catch in the southern region of Brazil represents an average ratio of 5.8 kg of commercial fish to 1 kg of shrimp 5.8 : 1 and 16.2 : 1 considering the total by-catch. These proportions show that only 35% is utilized for human consumption and 65% is discharged back to the sea. These values may change according to the weather, season of the year and fishing grounds. (SUDEPE/CEPSUL, 1986). The by-catch is an important economic support for the trawling operations in the region. The boats depend on the fish yields to cover part of the fuel expenses. There is a gradual tendency to utilize greater proportions of small fish because of the increasing demand of protein and the decreasing stocks of big demersal species.

The by-catch in the sea bob trawl fisheries is composed of a great number of juvenile fish especially in the artisanal sector. The small trawlers operate very close to the beaches and in lagoons. In this case, by-catch waste can assume proportions of 95% to 100%. The lack of deck sorting devices reduces the survival rates in the by-catch close to zero.

Considering the total annual shrimp catch of 28,021 tons in 1985 (SUDEPE, 1986), the total by-catch in the south-east and southern region can be estimated in 308,231 tons using an average proportion of 11:1 (by-catch: shrimp) with a waste of 200,350 tons. These numbers can be even greater considering that the waste ratio can increase to even 25:1 in the sea bob fishery.

The national shrimp by-catch in the past, was always considered as an inconvenience or waste. With the increasing demand of fish and the decreasing stocks of demersal species, the by-catch has become an important economic resource and a danger for over fished populations, in some regions.

## 6 - GEAR DEVELOPMENT AND RESEARCH

Shrimp trawling fisheries have expanded rapidly in

the last 10 years. High export prices keep attracting more investments and consequently more vessels are being built. However, the gear and fishing operations have developed very little since the introduction of double-rig system. Only in 1984, SUDEPE/FAO, introduced the four net rig in the northern region. This method is gradually been adopted by the southern fleet. The net models are still the traditional semi-balloon, flat and two seam nets, made of polyamid or polyethylene netting.

### 6.1 - Experimental Fishing

In 1986, SUDEPE/CEPSUL started an experimental gear project in the south of Brazil with the objective to develop new fishing methods, nets and escape devices to avoid or select by-catch. The first stage of these experiments will be concluded in December 1987.

Three different research objectives were identified:

1 - Develop escape panels for juvenile species for the south east and southern region, where the by-catch has economic importance.

2 - Develop new selective nets that avoid or reduces fish catches for the north region and for the artesanal fisheries in the south of Brazil.

3 - Test and develop the three net rig for the Brazilian shrimp fleet.

### 6.2 - Materials and Methods

To perform this project SUDEPE engaged the technical staff and the R.V Diadorim based at the CEPSUL in the state of Santa Catarina, south of Brazil.

Characteristics of the R.V Diadorim:

Length O a	.23.75m
Beam	6,55m
Depth	3,60m
N.G.T	95,14 Tons
Construction material	steel
Engine	1 x Caterpillar D-353 (380HP)

The R.V Diadorim originally was an American commercial shrimp trawler that was bought by SUDEPE in 1972 and altered to a multipurpose research boat. Since 1981 it is working in the south of Brazil with pelagic and demersal gear.

To develop the selective gear and experimental fishing programme the R.V Diadorim was equipped with a three trawl system for shrimp and scampy, operated from the double-rig booms. (Figure 4).

The three net rig was chosen because of the advantages in trawling more than two nets of different sizes with escape devices, at the same time. This method uses smaller trawl boards that requires less power and consequently less fuel. The system was rigged with two small semi-balloon nets (11 m head rope) and one big wing or semi-balloon trawl (20 m head rope). The nets were made of braided polyethylene twine and 50 mm mesh size in the small units and 70 mm in the big nets. The codends were made of polyamyd netting 210/96 with a mesh size of 44 mm.

The two otter boards were made of wood and steel measuring 2.0m x 0.75m weighing 120 kg each. The steel skids measured 2,0m x 0.7m and weighed 150 kg.

The general operations with the three nets were carried out using the same methods of the traditional double-rig system. The big center net however was hauled using the existing purse seine power block.

#### SCAPE PANELS:

The first test for selecting by-catch during trawling was done with escape panels for juvenile fish in one small semi-balloon trawl. This system consisted of a section of square meshes (70mm stretched) that joined the belly of the net to the codend. The utilization of square meshes was first tested in codends for selectivity experiments on whiting (Merlangius merlangus L.) and haddock (Melanogrammus aeglefinus L.) with great success by Robertson, (1983). The under water observations done by Marine Laboratory, Scotland, proved that the square meshes keep open and do not deform during trawling.

### Experiment 1

The first escape section had a 50mm netting funnel joined at the end of the belly and extended up to the beginning square mesh area into the codend. In this way, the shrimp is kept at the end of the bunt by the water pressure and the small fish that keep swimming ahead can return to the square meshes and escape (Figure 5). The selectivity results were obtained by comparing the by-catch quantities in nets equipped with the escape section with the ones from the normal small semi-balloon trawl nets.

### Experiment 2

The second test consisted of 5 hauls using a shorter funnel that leads the catch into the square section just before the codend (Figure 5). This modification gave more escape area to the device.

### Experiment 3

The third experiment was tested with only the square 70mm mesh in the upper section and diamond 50mm mesh in the lower section. The inner funnel was excluded (Figure 6).

### NET DESIGNS (RESEARCH IN DEVELOPMENT)

#### Experiment 4

Other experiments and modifications of net designs and riggings started in September 1986. The main objective was to study the influences of different net lengths (belly lengths) versus by-catch. Total number of hauls were 10.

It is very common that net makers use the same tapering IN2B or IN4B in all shrimp trawl sizes. This means that big nets tend to have longer bellies and consequently there is a tendency to increase fish by-catch yields. Normally, smaller trawls or twin gear systems catch more shrimp and less fish than traditional big trawls.

Tapering a net belly with an AB (all bar) cut, the trawl becomes very short and works high off the bottom. The

netting rises from the foot rope to the codend in a steep angle that is generally avoided by fish. Normally fish trawls have long bodies, with gradual tapering to decrease twine resistance and turbulences that are sensed by fish.

Shrimp react moving mostly vertically to approaching gear. This behavior is observed very well in the "gerival" net (Figure 2) where the prawns reach a height up to 2.5m from bottom to enter the top bunt. This all happens at low speeds of 1 to 2 knots and no fish are caught.

Based on these facts, two 11m semi-ballon net were made. One had 1N2B tapering in the belly and the other AB cut. The longer net had 200 meshes deep, from the foot rope to the codend and the smaller net 100 meshes (50mm). (Figure 4).

### Experiment 5

A last experiment was done with the short 11m, semi-ballon trawl. The net mouth (bosum) was closed by 25 pices of twine, 2mm PA braided, spaced in 20cm intervals along the head rope and joined to the foot rope. The length of each twine was  $2 \times 0,8$  (vertical opening of the net) = 1.6m (Figure 7). This test had the objective to observe the selectivity and reaction of big and small species.

## 7 - RESULTS

### 7.1 - Escape Panels

During the last three cruises of the R.V Diadorim in the southern region of Brazil, 12 hauls were done with by-catch escape panels and 10 hauls with new net designs.

The experiment nº 1 did not achive any significant reduction of by-catch. The small fish did not escape through the square meshes and it was presumed that the long inner funnel was blocking the square meshes. Also the funnel was clogged by big fish and weeds.

The experiment nº 2 consisted of the same escape panel with a shorter funnel. Five hauls were done using this

devices and there was a decrease of 40% of small by-catch but the shrimp yield also decreased by 25%. The clogging problem of the inner funnel by rays and weeds persisted in this second test.

In experiment nº 3 the small fish by-catch was reduced by 30% and also the shrimp yield decreased by 30%. The high prawn losses did not stimulate the continuation of the tests.

## 7.2 - Net Design

The experiment (nº 4) with the short tapered net were done in September/1986. Ten hauls were accomplished during the third cruise of the R.V Diadorim.

The short net caught 14% more shrimp than the longer net and the juvenile by catch yield was also greater.

### Experiment 5

The experiment with the short 11m semi-balloon trawl equipped with twines closing the bosom and mouth did not achieve significant reduction of by-catch. The ratio of small species was the same as the other 11m trawl (long belly) but the percentage of big species was reduce in 90%. This result demonstrates that juvenile fish can not escape from a approaching trawl, even if this net has a excluding device.

The three net rig was tested at several depths (20 to 250 meters) and in 48 hauls only two problems accured. This system permitted the R.V Diadorim to trawl two 11 meters and one 20 meters net (42 meters of head line) using only two 2.0 x 0.7 meters doors. The 380 HP engine developed only 850 RPM. With the normal two 16.0 meter double-rig trawls (32 meters of head line) and four 2.6 x 0.85 meters door weighing 170 kg each, the same vessel engine need to run at 1000 RPM developing 3.0 knotts. The exact fuel saving will be established at the end of the trials in December 1986.

## 8 - DISCUSSION AND CONCLUSION

The shrimp fisheries in Brazil is gradually developing and fishing effort will soon get to the optimal limit.

The by-catch is a very important resource in the northeast and the vessel operations costs depend on the commercialization of such production. In the south east and south the number of discarded fish is slowly decreasing because of the increase of protein demand and reduction of demersal stocks. Only in the north region valuable by catch is totally wasted.

Considering the total national waste of 281,066 tons (estimated) of fish per year. The by-catch must be regarded as a major fisheries potential and a threat to fish stocks. The research of selective shrimp trawls and methods will soon become a limiting factor for the continuation of these fisheries. The closing seasons imposed by SUDEPE in the south for the last three years has, undoubtedly improved shrimp yields but the subsequent recovery of the economic rentability also attracted more vessels.

The small artesanal double-rig trawlers have a very important socio-economic activity but the inshore trawling with small meshes is putting in risk the whole ecosystem of the region.

The research in selective shrimp trawls has just started in Brazil and no effective results have been obtained up to the present.

The square escape panels using 70mm meshes, proved to be selective for small fish but the loss in shrimp yields unviablized this experiment for commercial operations. Tests with escape panels made of 60mm square meshes are recommended.

The short tapered net was only tested in eight hauls and the results were suprising, the higher fish catch rates were not expected. It is possible that the high trawling speed, (3.0 - 3.5 knotts) imposed in shrimp fisheries very quickly tire small demersal species that are swallowed by the net.

The experiment nº 5, with the closed net (Figure 7)

demonstrated that it is easier to avoid or select big fish than juvenile species. Adult fish can swim faster and get clear from the advancing trawl but the small by-catch is very vulnerable.

The increase of by-catch in the shorter net can not be considered as a final result, because of the small number of hauls in the first cruise. It is possible that the three net rig has a greater influence in herding fish with its bigger sweeping area. Also this method is more vulnerable to strong currents that alters the openings and the catch. It is recommended that future experiments are done using these nets on separate riggings (double-rig system).

By-catch selectivity or avoidance are very complex matters. Once fish enter the trawl they are stressed and when they reach the codend they are very tired (Main & Sangster, 1983). The selectivity panels are generally located towards the end of the nets where fish and shrimp are closely mixed. To achieve quicker progress, direct under water observations of shrimp behavior inside trawls would be of great importance for future developments.

The design of new nets or methods that avoid fish by-catch is of great importance for the northern region. More experiments are recommended with the gerival net to understand the shrimp behaviour and the fish avoidance to the approaching net. The operational principals of this gear can probably help the design of new selective shrimp nets.

The by-catch from fyke-nets, gill nets and other artisanal gear, used in lagoon and estuarine areas, has not yet been studied but certainly has a great influence over the juvenile fish stocks. A research programme on this matter is recommended due to the increasing fishing effort.

The by-catch collector and transport boats, for the Amazon region, is probably the most viable and immediate solution to avoid the waste of 78,057 tons of fish per year.

The development of selective devices has to consider that the results will be used by the commercial fleet. This means that the gear or methods must be practical and as simple as possible. Expensive and complicated nets will not be accepted by traditional fishermen.

This paper strongly recommends that all fisheries departments in Brazil start to consider the by-catch as a very important fisheries resource and a National problem that must be controled, better utilized and avoided according to the role of each region.

#### 9 - ACKNOWLEDGEMENTS

The author wishes to thank the officers and crew of the R.V Diadorim, Mr. José Emiliano Rebelo Neto, Mr. Francisco P. da Costa, Mr. Manoel R. Gamba for the valuable help in the preparation of this paper and Mr. Engel Jan De Boer (FAO) for all the technical support.

10 - REFERENCES

- Bailon, M.A. - Considerações sobre a captura de fauna  
acompanhante, Região Norte. SUDEPE/PDP, in  
1981 preparation, Belém, 8p (Port)
- Barbosa, F.I. & Rocha, J.M. - Algumas relações biométricas para  
o camarão rosa (Penaeus aztecus) da costa norte  
1977 do Brasil. Brasília, 12p (Port)
- Damasceno, F.G. - Tentativa da avaliação da participação de  
peixes na pesca industrial de camarão no norte  
1985 do Brasil, SUDEPE/PDP, in preparation, Belém,  
(20)5p (Port)
- Main, I. & Sagster, G.I. - A study of separating fish from  
1981 Nephrops norvegicus, in a bottom trawl. Scottish  
Fisheries Research Repor. (24) 8p (Eng.)
- Porto, H.L.R. - Determinação da estrutura da população do camarão  
1984 vermelho, Penaeus (Farfante penaeus) subtilis  
Pérez Farfante, 1967 na Ilha de São Luis - MA.  
Bol. Lab. Hidrob. 5/5 8p (Port)
- \_\_\_\_\_ & Fonteles-Filho, A.A. - Caracterização biométrica  
1984 do camarão vermelho, Penaeus (Farfantepenaeus)  
subtilis, na Ilha de São Luis do Maranhão. Bol.  
Lab. Hidrob. V 5/5 6p (Port)
- Rebello Neto, J.E. - Estudo de seletividade de malhas em rede  
1985 a tipo "aviãozinho" para captura de camarão rosa  
(Penaeus brasiliensis e Penaeus paulensis),  
SUDEPE/CEPSUL, Itajaí, (27) 2p (Port)
- \_\_\_\_\_ - Considerações sobre a pescaria do lagostim  
1986 b (Metanephrops rubellus) na região sudeste/sul do  
Brasil, SUDEPE/CEPSUL, Itajaí, (34) 10p (Port)

Robertson, J.H.B. - Square mesh codend selectivity experiments  
1983 on whiting and haddock. ICES, fish committee CM  
1983, B 25 (Eng.)

SUDEPE/CEPSUL - Relatórios de cruzeiro N.Pq. Diadorim. SUDEPE,  
1986 volumes 1-3, Itajai (Port)

SUDEPE/PDP - Relatório da V Reunião do Grupo Permanente de  
1984 a Estudos sobre o camarão da Região Sudeste/Sul,  
Caiobá/Pr, (50) 23p (Port)

---

1986 b - Relatório da II Reunião do Grupo Permanente de  
Estudos (GPE) do camarão da Costa Norte do Brasil,  
Belém, (47) 20p (Port)

Table 3

Total shrimp catches per region in metric tons and estimates of by-catch and discards in the Brazilian fisheries, 1985.

Source - SUDEPE/CEPSUL/CEPENE, 1986

Region	Total Shrimp catch	Total By-catch	By-catch Landing	By-catch Waste	Discard Ratio
North	8,005.7	80,057	2,000	78,057	97.5 %
North east	3,324.4	26,595	23.936	2,659	11.0 %
South east & South	28,021.0	308,231	107.881	200,066	65.0 %
<b>Total</b>	<b>39,351.1</b>	<b>414,883</b>	<b>133,817</b>	<b>281,066</b>	

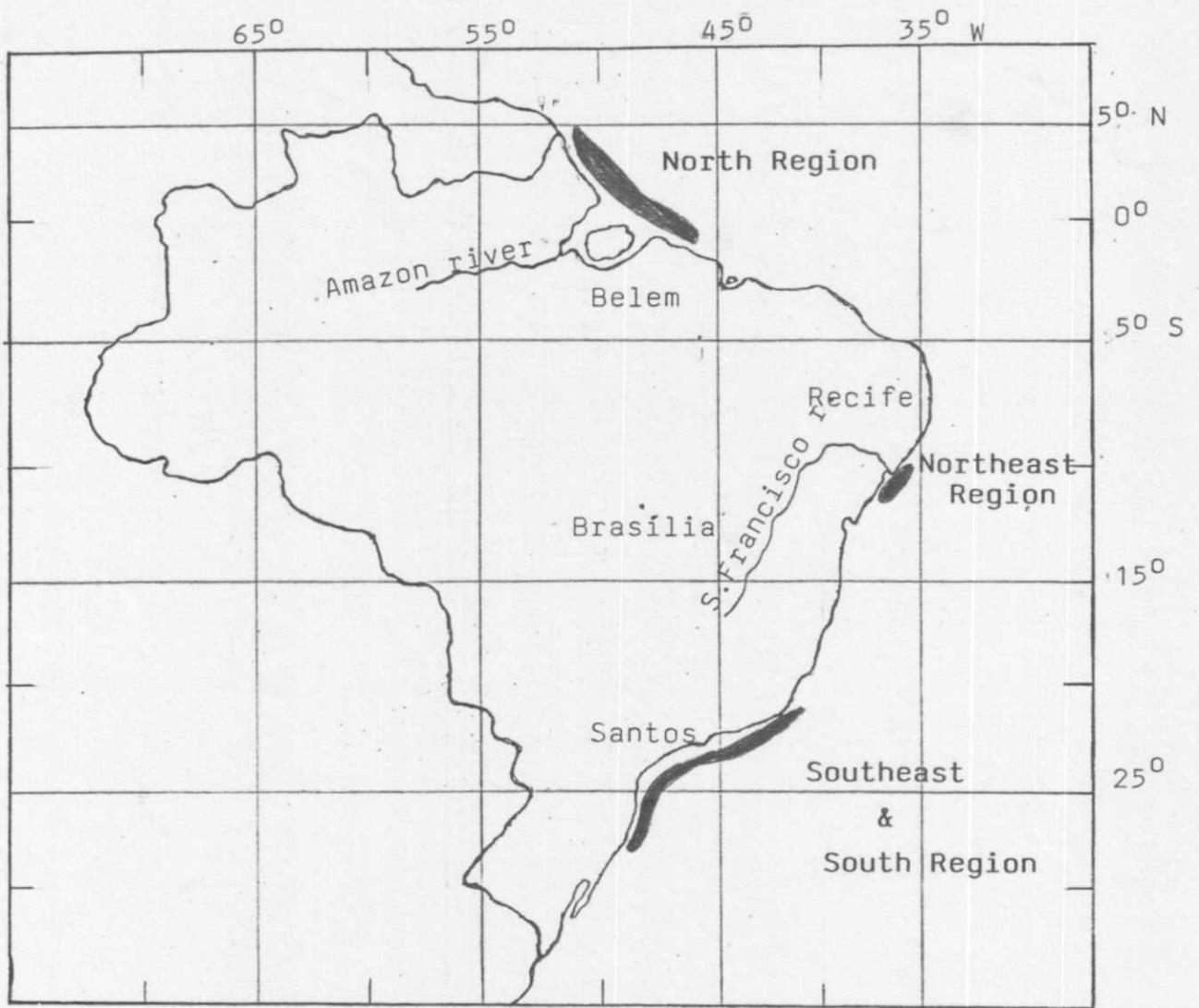


Figure 1

Map of Brasil illustrating the three main shrimp fishing regions.