The International Shrimp Tagging Program off the Northeastern Coast of South America and its Current Status

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The Guianas-Brazil shrimp fishing grounds are shown in Figure 1. This multimillion dollar fishery is supported by four species of penaeids - brown shrimp (Penaeus subtilis), pink-spotted (also known as hopper) (P. brasiliensis), pink shrimp (P. duorarum) and white shrimp (P. schmitti).

The disribution and relative abundance of brown, pink-spotted, pink and white shrimp within the Guianas-Brazil shrimp fishery have been described by Dragovich (1981). The number of different stocks within this fishery and their boundaries has not as yet been identified.

The geographic distribution of the four species indicates definite patterns (Dragovich, 1981). Brown shrimp, the most abundance species, occurs throughout the fishery, being most common off Brazil and French Guiana. Pink-spotted shrimp is the second ranking species, occurring throughout the fishery but most abundant off Surinam and Guyana. Pink shrimp is third with verified records only off Guyana, Surinam, and the western part of French Guiana. The fishable populations (chiefly adult forms) of these three species are found mainly from 15 to 45 fm (27-82 m). White shrimp occur along the shallow portion (less than 37 or 20 fm) of this fishery and are the least abundant.

The published information on movement or migration, off the northeast coast of South America, of each one of the four species of shrimp prior to this report was non-existent. Since shrimp stock assessment work in the Gulf of Mexico has been based primarily on data obtained from tagging studies (Klima, 1981), it was logical to assume that a similar program in the waters of the Guianas-Brazil fishery would yield useful information toward identification of the stocks. In this report we describe the formation and objectives of the international shrimp tagging program prepared for the Guianas-Brazil shrimp fishery, and also present the results obtained during 1981 and 1982.

Brackground Information.-In the 1940s and 1950s, fishery biologists, sponsored by the Caribbean Commission, Surinam Government and U.S. Government, located aggregations of penaeid shrimp off the northeastern coast of South America (Whiteleather

and Brown, 1945; Bullis and Thompson, 1959; Higman, 1959). Based on the encouraging results of these surveys, a commercial shrimp trawling operation began in the late 1950's. The shrimp trawlers operating in this fishery represented several nations and consisted chiefly of Florida-type trawlers, fairly uniform in size, and equipped with modern fishing gear and refrigeration systems. The present shrimping fleet operates out of the ports in Brazil (Belem), French Guiana (Cayenne), Surinam (Paramaribo), and Guyana (Georgetown). The "good old days" in this restriction-free fishery ended in 1970, as Brazil declared a 200-mile economic zone. To fish in Brazilian waters, from 1972 to 1978, foreign vessels were issued licenses under bilateral agreements. The first in the series of 2- and 1-year agreements was signed on 9 May 1972 between the United States and Brazil (Allen, 1973; Jones and Dragovich, 1973). The last bilateral fishing agreement between these countries expired on 31 December 1977. The number of fishing permits was limited and seasonal and other restrictions were applied in a section of northeastern Brazil (Fig. 1)

In 1977, Guyana, Surinam and French Guiana initiated a licensing system parallel to the establishment of their extended national offshore fishing jurisdiction. Preceding the era of extended offshore fishing jurisdiction and licensing by Brazil and the Guianas, the fleets usually fished Brazilian waters at the beginning of the year (up to May), then gradually shifted to French Guiana grounds (from May to July), and later shifted to the grounds off Surinam (July-September) and Guyana (September-December). A portion of the fleet followed no fixed seasonal pattern and fished opportunistically throughout the entire area.

In 1975, a steep rise in fuel prices from about 12 cents to 48-50 cents a gallon, with associated inflationary prices of industrial products used by fishermen, altered the pattern of fishing.

Following these events, the fleets were restricted to fishing only off their respective countries, to practicing more efficient fishing with less travel, to relocating portions of their fleet within the fishery, to selling an entire fleet in some instances, to withdrawing from the fishery in other instances, and to negotiating joint ventures with Brazilians.

Out of all these events, instead of development of a strong national isolationism, the need for international cooperation in research grew stronger. It was realized more and more that the Guianas-Brazil shrimp fisheries should be managed by the various countries using a regional perspective rather than in isolation by each nation separately. The biologists of coastal countries agreed that an international research effort on this fishery off the Guianas and Brazil should be carried out and that it should be aimed at providing assistance to shrimp industries in the form of guidelines for proper management of the entire fishery.

One of the first signs of international cooperation was under the terms of the United States-Brazil Bilateral Fishery Agreement when the United States began to collect catch and effort statistics (1972) from vessels that fished off northeastern Brazil. The data were submitted each month to the

SUDEPE, Programa de Pesquisa e Desevolvimento Pesqueiro do Brasil, the national Brazilian fishery agency. The United States also collected catch and effort statistics from its fishing fleet off the three Guianas. Catch and effort data collected from 13 statistical zones (Fig. 1) were recorded by boat captains on a logbook specially designed for this purpose. This logbook found wide acceptance in Surinam, French Guiana and Guyana.

As a part of this international cooperation and to learn more about the species distribution of shrimp, their biology associated fauna and ecology of the area, the United States conducted, from 1972 to 1978, six research surveys in the area with the NMFS fishery research vessel OREGON II (Dragovich, Jones and Boucher, 1980).

In 1976, the United States also initiated and funded a port sampling program of shrimp landings to obtain detailed biological data which were not available from captains' logbook forms and landings statistics (Dragovich and Tashiro, 1980).

The liaison between the scientists was chiefly in the form of periodic scientific conferences between the researchers of participating countries and members of the shrimp industry. Perhaps the most significant conference on this fishery was held in April 1979 in Panama City, Panama (Jones and Villegas, 1980a; 1980b). Under the WECAF[1] umbrella, a Working Group representing seven countries met in Panama (April 1979) to assess the state of exploitation of the shrimp fisheries off Guianas-Brazil, to determine suitable management measures and to define research needs and priorities. The Working Party agreed that there were reasons for adoption of a common management scheme on a regional basis by coastal countries concerned. The Working Party recommended that coastal countries consider the adoption of common management measures and regulations to protect small shrimp (limited fishing in nursery grounds) and control the amount of fishing effort by regulating the numbers and types of trawlers allowed to fish.

In terms of research needs and priorities, the Working Party agreed that future research programs should include collection of fishery statistics and shrimp tagging. A tagging program was considered for providing much of the missing information on growth rates, mortalities and species distribution to be used in a better assessment of the state of exploitation of the resource.

The Working Party recommended that countries participatig in the fishery carry out a cooperative tagging program with the assistance and coordiation of the WECAF Commission. The Party also requested that the WECAF Project establish (before October 1979) a small working group to prepare a proposal and a plan for

[1] WECAF is the abbreviation for the International Project for the Development of Fisheries in the Western Atlantic funded by the U.N. Development Program. The WECAF operated out of Panama until it was dissolved in December, 1981. WECAF was administered by WECAFC (Western Central Atlantic Fisheries Commission) under the FAO of the United Nations.

this tagging program.

To obtain the best results from this tagging program, a short survey of nursery grounds and artisanal fisheries in the area had to be made. The Party obtained the assistance of the Southeast Fisheries Center, NMFS, Miami, Florida (U.S.A.) to perform the survey and WECAF project.

Provisional commitments to participate in the tagging program were obtained from Brazil, French Guiana and the U.S.A. French Guiana was to start offshore tagging in late 1980 and Brazil's participation in an inshore program was proposed for 1981. The United States offered to provide expertise in shrimp tagging, training for tagging personnel and processing of tag recovery data.

Before the actual tagging program started, several noteworthy events took place. A survey of Guianas-Brazilian estuarine areas was carried out in September of 1979 (Dragovich and Villegas, 1983). The results of this survey helped in planning the shrimp tagging program and particularly in selecting the suitable places for the tagging of juvenile shrimp.

In November 1979, a preparatory meeting on the shrimp tagging was held in Belem, Brazil, and was attended by Brazil, United States and a WECAF representative. It was decided that the cost of tagging operations would be shared by all participating countries. It was also decided that the analysis of the information would be done by a Working Group to be established later by the WECAF Project.

For each coastal country it was decided which species (adults and juveniles) were to be tagged and the specific areas and periods for tagging. Furthermore, the same tagging procedures would be used as those practiced in the Gulf of Mexico by U.S. scientists and each participating country would provide a project coordinator and technicians. Brazil offered their research vessel but other countries were asked to share the expenses related to the tagging cruises. Also, at least one biologist from each participating country would be trained in Galveston, Texas. Following this meeting, two Brazilian scientists and one Surinamese scientist were trained in modern taggging techniques at the NMFS Galveston Laboratory.

Aspects related to tag recoveries, such as publicity, rewards and inter-country transmission of tags, were also discussed. It was agreed that national authorities should determine the value of the rewards for returned tagged shrimp. It was also believed important to consider the advantages of establishing national tag lotteries, similar to the one used in the United States. It was suggested that preparation and distribution of attractive multilingual posters related to rewards for tagging shrimp would facilitate recoveries.

Even though many details for the tagging operation were worked out, the participants were unable to identify all funds necessary for the multitude of expenses that this program required. Thus, there was need for another meeting. The next meeting, under the auspices of WECAF, was held in San Jose, Costa Rica (6-9 November 1980). Brazil, French Guiana, Surinam, Guyana, the United States and WECAF were represented at this meeting. The purposes of this meeting were to (1) discuss and

outline the details of the shrimp tagging program for the waters of the Guianas-Brazil shrimp fishery; (2) estimate the cost of this program and (3) discuss the contribution by each country.

The participants of the Costa Rica meeting recommended that a tagging program be initiated in 1981 and continued through 1982. The proposal for 1981 was for the inshore area and consisted of two parts. As a first part of the inshore program, Brazil and Surinam agreed to carry out and finance comprehensive long-term estuarine sampling surveys of their inshore waters to determine the location of shrimp nursery areas and the peak periods of recruitment to the offshore fishery. As a second part of this proposal, Brazil also agreed to carry out an inshore mark and recapture study in the State of Para area by releasing between 30,000-60,000 blue- and green-dyed shrimp in July and August. The U.S.A. agreed to provide technical assistance in staining shrimp and Surinam and French Guiana agreed to assist in recovery of shrimp in their areas.

The proposal for 1982 was for tagging in the offshore area and included the following: (1) Tagging of brown, pink and pink-spotted shrimp off Brazil and the three Guianas; (2) Surinam agreed to purchase 50,000 tags for the study; (3) The U.S.A. agreed to provide technical assistance during a portion of the tagging study and to key punch all recovery data and provide assistance in data analysis; (4) Surinam, Guyana and French Guiana agreed to assist in tag recovery; (5) Guyana, Surinam and French Guiana agreed to obtain the permits for the vessel RIOBALDO to operate in their waters from April to August 1982; (6) International coordination of the program and of the reward system was assigned to the WECAF Project (Specifically, the project was to identify funds for the rewards and make payment).

Funding of the Tagging Program--There are many reasons why it took so much time to get this project started. The geographic distances between the working parties, preoccupation with their own ongoing projects, administrative protocols, general lack of time, lack of a continuous interest, lack of specialists and lack of materials and equipment are perhaps the most common reasons given. However, the most vital reason was lack of sufficient funds.

International projects usually require purchases and construction of special equipment, travel tickets, per diem, consultation fees and other similar expenses which involve international monetary transactions from one nation to another, and involve complicated customs regulations of each country. While a country might be very generous in financing its own projects, the same country usually does not have available funds for financing international research projects. Thus, for example, the expenses which included travel and per diem for two Brazilian and one Surinamese scientist to go to the U.S.A. to learn the current tagging techniques were provided by WECAF. Furthermore, while working out the final financial details of available funds for this project at a Western Central Atlantic Fishery Commission (WECAFC) meeting held in May 1982 in Jamaica, we discovered (1) that the available funds were insufficient to

carry out this project and (2) that the sole funding sources of each participating country were their governmental agencies and WECAF. When we examined this fishery in terms of who benefits most, it became evident that the private shrimp industry, besides providing us with catch and effort statistics, did not take part in sharing the expenses related to research which leads toward a more rational management practice in their fishery, yet they reaped the greatest benefits. Thus, after a meeting between the researchers and the members of private industry, the latter donated for this tagging project $100 per trawler. In addition to their financial donation, private industry participated in the advertising of the program and in the recovery of tags.

This type of participation on the part of private industry enabled us to sustain the program. This cooperation also represented a very significant step forward toward mutual collaboration between the governmental agencies, international agencies, and the private sector. It is hoped this form of joint research venture will continue and that it could be extended into other areas of fishery research.

In summary fashion, each participating country, FAO and private industry contributed as follows:

Inshore Tagging, 1981.--BRAZIL: R/V RIOBALDO and its crew, six biologists, 50,000 plastic ribbon tags, two scientists, tagging equipment.

FRENCH GUIANA: two scientists, 12,000 1 of fuel, assistance to R/V RIOBALDO during its stay within French Guiana's waters.

SURINAM: one scientist, 50,000 plastic ribbon tags, 30,000 1 of fuel, assistance to R/V RIOBALDO during its stay within Surinam's waters.

GUYANA: two scientists, assistance to R/V RIOBALDO during its stay within Guyana's waters.

FAO: advice and/or expertise during the preparation and execution of the program, and analysis of the data.

U.S.A: 10,000 plastic ribbon tags, training of scientists in tagging procedures, one scientist, coordinator of the program and serving as a liaison between the working parties.

WECAF: Travel funds for scientists from Brazil, Surinam and U.S.A.

SHRIMP INDUSTRIES: Financial assistance - donations of $100 per trawler, plus assistance in tag recoveries and advertising.

Tagging Operations.--The mark-recapture studies were extremely valuable for determining stock boundaries, migration patterns, sources of recruitment to the offshore fisheries, growth and mortality (Klima, 1981).

The cooperative shrimp marking program started in August 1981

with the release of stained and ribbon tagged shrimp in the estuarine areas of the State of Para. This operation was followed in 1982 by an offshore tagging program off the coasts of the Guianas and Brazil.

Inshore Tagging.--From 27 August to 25 October 1981, 29,039 specimens of penaeid shrimp were tagged (staining method) in the estuaries of Marapanim and Maracana, both in the State of Para. The tagged shrimp consisted of brown shrimp (91%) and white shrimp (9%). The total length of the marked shrimp varied from 40 to 110 mm; the mean length for brown shrimp was 66.2 mm and for white shrimp 79.3 mm. In Maracana, 60 brown and 37 white shrimp were recovered and in the area of Marapanim 19 brown shrimp were recovered. All shrimp were recovered in the proximity of the release area within 2 months after being tagged. The farthest distance between the release and recapture area was 4.5 km (Fig. 2). The movement of all recovered shrimp was from the nearby offshore release site to the estuarine areas.

Offshore Tagging.--The 1982 offshore tagging was conducted from 28 Septmber to 11 November. The areas covered included waters of the continental shelf, ranging in depth from 32 to 64 m and extending from off the mouth of the Amazon to the western border of Guyana. There were four legs of this cruise; one off northern Brazil and one off each of the three Guianas. The captain, engineer, deck hands, and two scientists, remained aboard RIOBALDO throughout the entire cruise, while scientists from countries other than Brazil participated in this expedition on an alternating basis.

In total, 7,067 specimens of shrimp were tagged. The tagged species were brown shrimp (Penaeus subtilis), pink-spotted or hopper (P. brasiliensis), and pink shrimp (P. notialis) (Table 1). All shrimp tagged offshore were made up of late juveniles and early adults. Up to the present, only 95 tagged shrimp have been recaptured. This represents a 1.1% recovery rate. Such a rate is low when compared to the observed recoveries from the Gulf of Mexico, which are on the average 10%. Based on our observations in the Gulf of Mexico, low return of tagged shrimp may be caused by several factors. Ribbon-tagged shrimp are better targets to the predators,they also suffer tagging mortality, and tagged shrimp are often attacked by other shrimp.

The number of recaptured shrimp was largest off French Guiana (Table 2). The recaptured shrimp off French Guiana consisted of 68 brown shrimp and 2 pink-spotted shrimp. Off Surinam, all recaptured shrimp (20) were pink-spotted. Off Guyana, four pink-spotted and one brown shrimp were recaptured. Even though only a small percentage of shrimp was recaptured, their geographic distribution corresponds to the observed distribution with browns being dominant off French Guiana and pink-spotted off Surinam (Dragovich, 1981). Because the information on recaptured shrimp from Surinam is not available and only five specimens were recovered off Guyana, we will discuss the information from French Guiana only. The recaptured tagged shrimp remained at large from 3 to 102 days. Most of the shrimp

(68%) were recaptured within 20 days after their release and 82% after 60 days at large.

Table 1. Number of tagged and recovered shrimp by species in the offshore area of the Guianas-Brazil shrimp fishery (number of recovered shrimp are given in parentheses; tagging operations conducted 28 September to 11 November 1982)

	Number of Shrimp Tagged			
Area	P. subtilis	P. brasiliensis	P. notialis	Total
Brazil	488	-	-	488
French Guiana	2,291 (68)	1,898 (2)	12	4,201
Surinam	188	1,627 (20)	61	1,876
Guyana	32	4.28 (4)	42	502
Total Tagged	2,999	3,953	115	7,067
Total Recovered	69	26		95
Percentage Recovered	1.2	1.1		1.1

The exact locations of release and recovery points of tagged shrimp and the generalized movement of tagged shrimp off French Guiana are shown in Figure 3. Even though limited in quantity, the recovery data of tagged shrimp indicate a diffusive type of movement. Most of the recovery data suggest a movement in a north-northwesterly direction paralleling the direction of the Guianas Current (Extension of the North Equatorial Current), while a few shrimp off Cayenne showed a shoreward movement and movement in a westerly direction. No relationship was observed between the days at large and distance "traveled" by a tagged shrimp. The longest distance between the release and recapture point was 85 miles - the tagged shrimp were at large 84 days; the shortest distance was 3 miles (41 days at large). It is noteworthy to mention that shrimp recovered after 4-5 days covered 24-28 miles or on the average, 6 miles per day.

In summary, the distribution of recoveries suggests existence of a generalized north-northwesterly movement by most of the shrimp while others showed movement without a pattern. Based on a very limited number of verifiable recoveries (18), the

Table 2. Environmental and biological data from the offshore shrimp tagging operation in the Guianas-Brazil shrimp fishery. For total number of tagged and recovered shrimp see Table 1.

Geographic Area	Species	Sex	Release Dates (A)	Recapture Dates (B)	Days at Large	Distance Range A to B in miles	Depth Ranges in m. Released	Depth Ranges in m. Recaptured	Growth while at large in mm
FRENCH GUIANA	Penaeus subtilis	M	Sept. 9-Oct. 3, 1982	Oct. 6, 1982-Jan. 12, 1983	3-102	13-41	40-49	27-77	7-18
	Penaeus subtilis	F	Sept. 9-Oct. 3, 1982	Oct. 6, 1982-Jan. 3, 1983	3-94	3-31	40-50	37-68	3-22
	Penaeus brasiliensis	M	Oct. 10, 1982	Nov. 23, 1982	47	not available	48	not available	4
	Penaeus brasiliensis	F	Oct. 10, 1982	Jan. 4, 1983	55	not available	40	not available	
SURINAM	Penaeus brasiliensis	M	Sept. 12-Oct. 28, 1982	Oct. 14, 1982-April 1983	not available	not available	38-50	39-48	>1
	Penaeus brasiliensis	F	Oct. 10-23, 1982	Oct. 14, 1982-Feb. 24, 1983	not available	not available	38-50	39-54	>1
GUYANA	Penaeus subtilis	M	Oct. 28, 1982	Dec. 14, 1982	48	not available	32	35	>1
	Penaeus subtilis	F							
	Penaeus brasiliensis	M							
	Penaeus brasiliensis	F	Oct. 27, 28, 1982	Dec. 2, 1982-March/April 1983 (?)	52-100(?)	not available	32-41	36-50	0.7-1.4

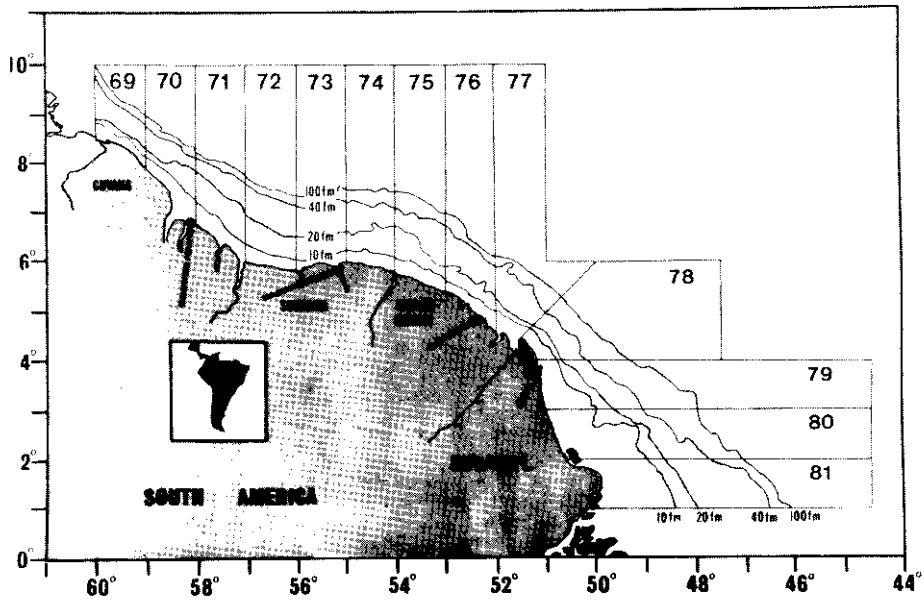

Figure 1. The Guianas-Brazil shrimping grounds with fishing zones and their common names.

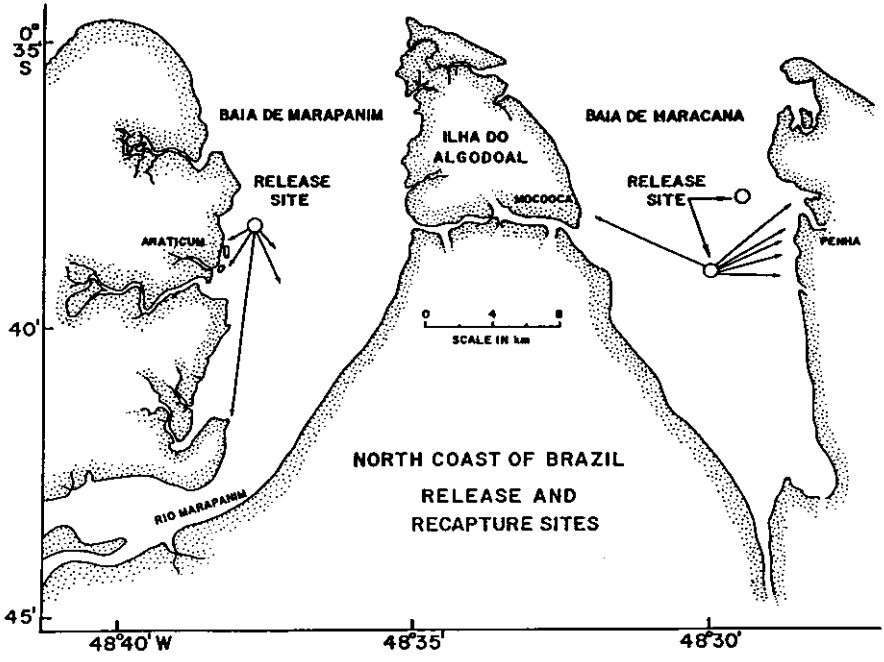

Figure 2. Locations of release and recapture sites of tagged brown and white shrimp in the inshore waters of northern Brazil.

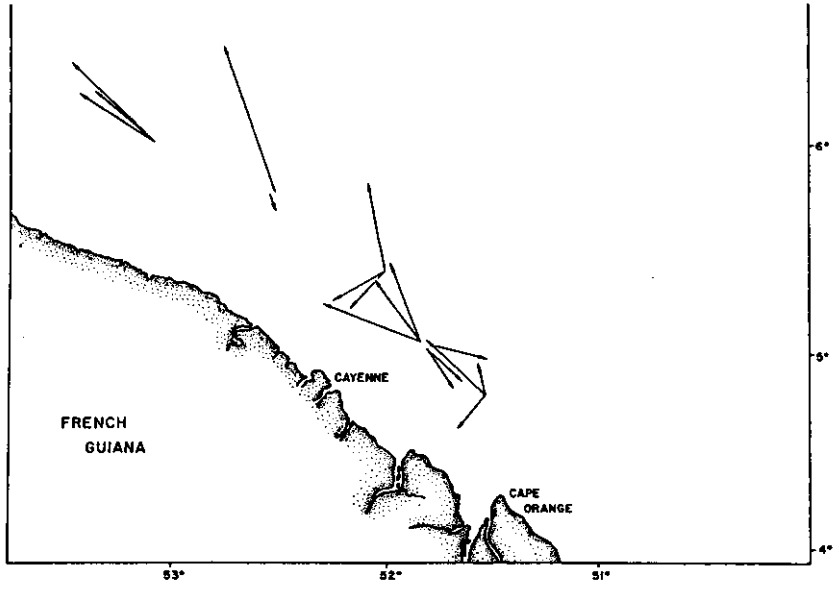

Figure 3. Locations of release and recapture sites of tagged brown shrimp off French Guiana (Septembere 1982-March 1983).

observation made here should be considered as preliminary only.

Up to the present, the data from the recovered tags are quantitatively inadequate for a study of growth patterns. The scatter diagrams of shrimp growth versus days at large showed no relationship. Qualitatively, the data on tag recoveries suggest a need for more accuracy of measurements, as we observed a few negative growth values and a few other peculiarities. In a few instances, shrimp have "grown" 15-16 mm in 3 days while in other few instances the growth was zero after 60-80 days.

CONCLUSION

Even though the Guianas-Brazil shrimp fishery is made up of coastal countries and distant countries, there is no regional body or commission with the purpose of managing this fishery and taking care of research needs. The closest to such a regional body is WECAFC (Western Central Atlantic Fish Commission), administered by FAO, a specialized agency of the United Nations with worldwide responsibilities for the conservation and rational management of the living resources of the oceans. WECAFC is therefore in a unique position to assist in meeting the needs of member countries for harmonious development and management of fisheries. But in the case of the Guianas-Brazil shrimp fishery, only Guyana, Surinam and the U.S.A. are members of WECAFC. French Guiana, a Department of France, is a member of the European Economic Community (EEC), while Brazil and the distant countries (Japan and Korea) are on their own. Thus, administratively, there is a lack of a single regional body under whose umbrella the coastal and user countries can meet to discuss problems related to research and management. The cooperative research effort between all users of the Guianas-Brazil fishery was further complicated because many countries did not have economic resources for this research and lacked specialized skills to do the job. In this connection, the WECAF Project acted as a catalyst during the entire period of cooperation, in providing financial assistance to acquire the necessary skills and in organizing meetings and other forms of communication. But the real impetus for this problem was the fishery scientists of the respective countries and, secondly, the shrimp industry.

Besides the awareness of a need for regional management of this fishery, perhaps the most significant accomplishment of this tagging program is that administratively it was possible, in spite of many obstacles, to plan, organize and implement this program and enable coastal countries to carry out their own tagging programs. Furthermore, this form of cooperation can be applied as well to other fisheries (e.g., mackerel, mullet, crabs, etc.) that need similar attention.

We consider the tagging experiments of 1981 and 1982 as the first phase of a continuing tagging effort. The results obtained from this first phase of our tagging experiments represent a positive move in the direction of comprehensive mark and recapture experiments similar too those carried out in the Gulf of Mexico (Klima, 1981).

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