

Trawlfishing Potential off Northeastern South America

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Abstract

More than 10 independent trawl fishing investigations have been conducted along the continental shelf of northeastern South America during the last 25 years. The results of these investigations are reviewed.

The government of Surinam has operated the trawler *COQUETTE* for exploratory and production fishing programs along its coast for over 10 years. Fishing logs of the *COQUETTE* for the years 1962 to 1965, comprising a total of 2,717 drags, were examined.

The UNDP/FAO Caribbean Fishery Development Project vessel *CALAMAR* conducted trawl fishing explorations from off the coast of French Guiana to Venezuela. During 1967 and 1968, more than 400 trawl drags were completed by the *CALAMAR*.

The data collected by the *COQUETTE* and *CALAMAR* were analysed for catch per unit effort to determine differences by area, year, season, depth and time of day. Differences in species composition of the catch with the above variables also were noted. The results of the *COQUETTE* and *CALAMAR* operations are compared.

With the trawl fishing explorations conducted to date as a background, the fisheries potential of the northeastern coast of South America is discussed.

INTRODUCTION

A NUMBER OF West Indian governments requested the U.N. Technical Assistance Board to evaluate the area's potential for fisheries development and opportunities for assistance. Suggested approaches to developing a Caribbean fisheries project were made by Kasahara and Idyll, 1962. A plan of operations was circulated to the countries concerned in 1965, and late in August the Caribbean Fishery Development Project* became operational. The project includes activities in exploratory fishing, marketing and training.

The West Indies are characterized by many small self-governing entities representing dense populations. Consumption of fish by West Indians is high by world standards. In many countries, food supplies of fish and shellfish are not adequately available in their contiguous waters. Evidence gathered over the years indicated a trawlfish resource off the coast of northeastern South America. Since this was in the Project area of operations, exploratory fishing and production cruises were scheduled with the objectives of: (1) confirming available information on trawlfish resources, (2) expanding coverage and

*Member countries—Barbados; Guyana; Dominican Republic; France in respect to French Guiana, Guadeloupe, Martinique; Jamaica; Antigua; Montserrat; St. Christopher, Nevis, Anguilla; Netherlands Antilles; Surinam; Trinidad and Tobago; United States of America on behalf of Puerto Rico; Grenada; St. Lucia and St. Vincent.

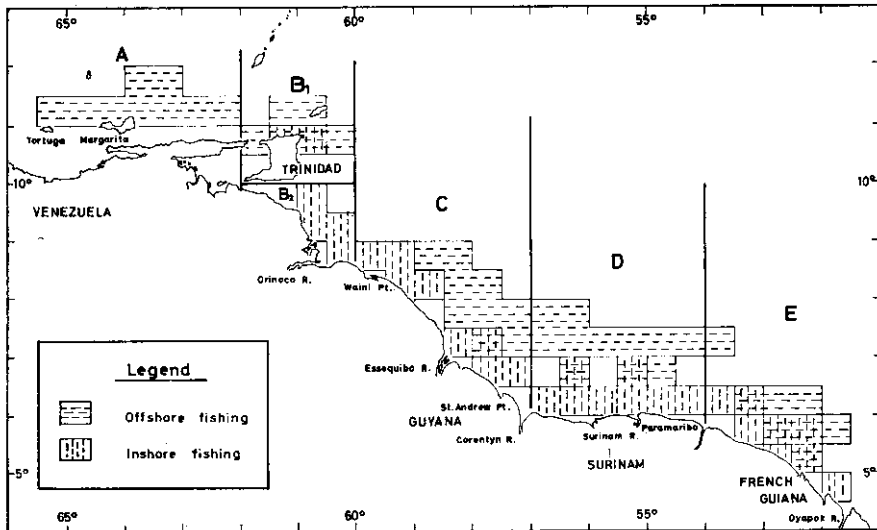


FIG. 1. Area of trawl operations 1967 - 1968, CALAMAR.

establishing catch rates, (3) providing fish for experimental marketing demonstrations and (4) providing training in the use of trawl gear to West Indian trainees.

The area examined during the trawl fishing operations extends from the northern border of Brazil to the waters adjacent to Margarita and Tortuga Islands, Venezuela (Fig. 1). The area east of Trinidad has a broad, regular continental shelf, averaging about 50 miles in width between the shoreline and depths of 50-60 fathoms. The bathymetry of the Guiana shelf is regular and differs markedly from the shelf around and west of Trinidad where there is extreme irregularity of the bottom.

The coastal Guiana area is strongly influenced by continental fresh water run-off, including waters from the Amazon, Orinoco and at least 10 lesser but significant rivers. The inshore area (out to about 15 fathoms) is characterized by soft, sticky mud which shifts in the strong currents. Sand becomes mixed with mud at approximately 15 fathoms; this continues offshore where sand completely replaces the mud. The sandy bottom is transected by patches of fossil reef composed of calcareous shell. Near the shelf edge, the bottom is very calcareous and interrupted by steep-sided limestone outcroppings. (Nota, 1958; 1967.)

The local fisheries of the Guiana shelf are concentrated on inshore estuarine species. Since the early 1960's, an extensive shrimp industry worked between the deltas of the Amazon and Orinoco Rivers. In 1965, over 15 million pounds of shrimp, mostly for export, were produced from these grounds (Crocker, 1967). Other important fisheries include a handline and trap fishery for snapper (Lutjanidae), particularly off French Guiana and the Amazon delta (Fourmanoir, 1968). In offshore waters, a tuna longline fishery operates intermittently (Wise, 1968).

HISTORICAL REVIEW

Strong interest in the development of the trawlfish resources off north-eastern South America is evidenced by the numerous documented accounts of investigations conducted to assess this potential over the 25-year period from 1943 to 1968. Additional significant efforts have been made by various commercial interests. These ventures have been notable in Guyana, Trinidad and Curacao (fishing off central Venezuela). In western Venezuela, considerable amounts of demersal species are taken by trawl and other means. The most important species is "curbina" (*Cynoscion* sp.). An annual catch of more than 7,000 tons is reported by Simpson and Griffiths (1967).

The documented investigations commenced with Whiteleather and Brown (1945). They reported on fisheries surveys conducted in waters contiguous to Trinidad and off the coast of Guyana. Trawlfishing operations were mainly limited to shallow water areas. The results were sufficiently productive for the authors to recommend the use of trawls by local fishermen. These early explorations were followed in the Trinidad area by the ASSAULT in 1951 and 1952. Good catches were consistently taken by the ASSAULT off the northeast coast of Trinidad, and the results were analyzed with particular regard to the economic parameters (Richards, 1955). The conclusions suggested that a small trawler could profitably exploit these grounds pending improvement of local marketing conditions. Encouraged by the results of the ASSAULT, the BONNIE ETHEL started commercial trawling off Trinidad in 1957. Good catches, particularly of moonshine, were made (Salmon, 1958), but difficulties in marketing terminated operations. Earlier, in 1949, additional trawling was conducted off Guyana by the ketch ARTHUR ROGERS. This work is unpublished and reportedly covered only "inshore" waters. In 1954, trawling was conducted off French Guiana by the ORSOM II (Durand, 1959). This faunal survey developed a comprehensive picture of the shelf fauna but did not attempt to evaluate catch rates. The results gave detailed accounts of the distribution of invertebrates (including commercial shrimps) and fishes.

In 1953, surveys were initiated by the Surinam government directed toward shrimp resource development (U.S. Fish and Wildlife Service, 1954). The Government sponsored additional trawl surveys using the vessel VD-3 in 1955 (Smith, 1959). This was followed by the charter of a Florida-style shrimp vessel, the COQUETTE in 1957 to extend the scope of fishery explorations off the Surinam coast (Higman, 1959). Also in 1957, the U.S. Fish and Wildlife Service vessel OREGON made the first of several exploratory trawl cruises to the area to investigate fishery potentials (Bullis and Thompson, 1959). Although work in 1957 by the COQUETTE and OREGON was particularly oriented toward the evaluation of available shrimp resources, both surveys noted the presence of large amounts of commercially desirable fish particularly in shallow waters (less than 15 fathoms).

In April 1957, the fisheries research vessel CAPE ST. MARY commenced investigations of the potential for a trawl fishery in British Guiana. This vessel operated without major interruption for 2 years and established the feasibility of trawlfish operations off Guyana. We quote from Mitchell and McConnell (1959) concerning the major conclusions of this work. "The two year survey carried out by the CAPE ST. MARY has shown: (1) Fish are present in quantities on the grounds all the year round; over the two-year period the average catch was 339 lbs per fishing hour. Assuming a market price of 30 cents (W.I.) per pound wholesale and a suitable sized trawler with lower

operating costs than the CAPE ST. MARY, this rate of fishing should be very profitable. (2) Trawling grounds extend out to the 20 fathom line in the southeast and to 30 fathoms in the northwest, that is 30-40 miles from the coast of British Guiana. The total area covers approximately 5,000 square miles."

In addition to providing a sound basis for development of a commercial trawlfishing operation in the area, the above work also led to a series of major contributions on the biology and species distribution of Guiana fishes. These include several papers by Rosemary H. Lowe (McConnell) (1962, 1966 and others).

In 1963, the OREGON returned to the area and reported that the . . . "Largest fish catches between Georgetown, British Guiana, and Cayenne, French Guiana, were confined to waters shallower than 20 fathoms, where drags with a 65-foot-high-opening roller-rigged fish trawl, yielded from 800 to 1,500 pounds of fish per hour" (U.S. Fish and Wildlife Service, 1963). Also in 1963, the Russian vessel OBRAZTSOVO investigated the area west of Trinidad with trawling gear. This work was later supplemented by the SRTR-9075 and catches up to 5,500 pounds per hour of trawling were reported (Sal'nikov, 1965).

The NEREID made several cruises off the Orinoco Delta area in the period 1962 to 1964 (Cervigon, 1965). Particularly good fishing was experienced in depths between 13 and 25 fathoms. Although the gear was not designed for fish but for shrimp, the results suggested that up to 2 tons of "commercial fish" could be caught per day.

In 1965, the vessel AMBITION based at Cumana, Venezuela, conducted trawling operations between Blanquilla Island and Georgetown, Guyana. In an unpublished summary report, the captain reported catches of over 1,000 pounds of fish per hour off Guyana and speculated that a "profitable trawl fishery should be possible."

The modern, fully-equipped research vessel LA SALLE based at Margarita Island, Venezuela, began operations in 1967 under the auspices of the Foundation La Salle de Ciencias Naturales. Much of this work concerned the trawl resources of the Guiana shelf area (Gines and Cervigon, 1968). Conclusions suggest that trawl catches off Surinam are higher than those to the west.

The work of the COQUETTE during the years 1962 to 1965 and the CALAMAR during 1957 and 1968 is analyzed in detail in the present paper to supplement the available data on the trawlfish potential of the Guiana shelf.

FISH SPECIES

The sciaenid fishes or "drums" which include sea trouts, corvina, croaker, curbina, certain "kingfish" and others were by far the most abundant species landed by trawl from the inshore waters of the Guianas. The group is reviewed by Lowe (1966) and other discussions are provided by Cervigon (1965), Gines and Cervigon (1968), and Puyo (1949). For a general review of the fish fauna of this area see Lowe (1962). The principal species discussed in this report are listed in Table 1 with the common and scientific names. Common names are those used by Project personnel. It is not practical to attempt a definitive listing of all common names for the fish species in this area as such a list would have to include the vernacular derivatives from Portuguese, French, Dutch, English, Spanish, Indian and various intergrades of these.

"Industrial" species includes fishes which were not readily marketable. In this group, the catfishes (*Bagre* sp. and *Arius* sp.) represented the greatest volume. Some of these could be successfully marketed if specially processed.

TABLE 1
COMMON AND SCIENTIFIC NAMES OF PRINCIPAL FISH SPECIES

COMMON NAME	SCIENTIFIC NAME
DRUMS	SCIENIDAE
Sea Trout	<i>Cynoscion virescens</i>
Croaker	<i>Micropogon furnieri</i>
Surinam butterfish	<i>Nebris microps</i>
Silver perch	<i>Larimus breviceps</i>
Whiting	<i>Macrodon ancylodon</i>
JACKS	CARANGIDAE
Moonshine	<i>Selene vomer</i>
Bumper	<i>Chloroscombrus chrysurus</i>
MOJARRAS	GERRIDAE
Sea Patwas	<i>Gerres rhombus</i>
BUTTERFISHES	STROMATEIDAE
Harvestfish	<i>Pepililus paru</i>

"Industrial Fish" include primarily catfishes (*Arius* sp. and *Bagre* sp.); small sciaenids and small sharks and rays.

Small sciaenids of less than 25 cm in length and various elasmobranchs (sharks and rays) make up the remainder of this group.

ANALYSIS OF DATA

Gear, fishing methods and sampling techniques differed between the COQUETTE and CALAMAR. In some instances, therefore, the data from the two vessels were analyzed slightly differently to expedite the synthesis of catch results. The most outstanding of these are:

- (1). **CATCH RATE:** The majority of the COQUETTE drags (82%) were of 90 minute duration. The COQUETTE catch per hour was determined by multiplying the catch per drag by a factor of two-thirds. The duration of the drags by the CALAMAR were much more variable. The catch per hour was determined by dividing the total catch by the total number of fishing hours.
- (2). **SIGNIFICANCE OF TOTAL CATCH RATES:** For the most part, the COQUETTE data were summarized to give the catch rates for total catch. The CALAMAR catch rates are for marketable fish. The percentage of marketable fish compared to industrial fish and invertebrates was more constant for the COQUETTE than for the CALAMAR.
- (3). **DIEL VARIATION:** Diel variation in catch rates for the COQUETTE was calculated by grouping the drags into six 4-hour intervals. The CALAMAR fishing operations, to test for diel variation, dictated eight 3-hour intervals. Fishing results were further grouped to show diel variations in catch rates by two 12-hour intervals.

EXPLORATORY AND PRODUCTION FISHING RESULTS OF THE COQUETTE

General description

The Government of Surinam commenced a continuing exploratory and production fishing program along its coast in 1953. Since 1957, fishing cruises have been conducted by the Government vessel COQUETTE, a Gulf of Mexico-type shrimp trawler (Higman, 1959).

Catch data from the COQUETTE were made available for use to the UNDP/FAO Caribbean Fishery Development Project by Harold Lionarons of the Surinam Fisheries Division. These data included the complete fishing logs of the COQUETTE for the years 1960 through 1965. The present paper deals with only 4 years' data, 1962 through 1965, as time limited further analysis.

Most of the fishing by the COQUETTE was by 85-foot flat shrimp trawls with 2.25-inch stretched mesh webbing throughout the body of the net and 2-inch stretched mesh webbing for the codend. The net was fished without legs, that is, attached directly to the otter boards which measured 8.5 by 3.75 feet. The gear is similar to trawls used by commercial shrimp fishermen in the Gulf of Mexico and western Atlantic area (Robas, 1959).

The coast of Surinam (Fig. 2) lies in an east-westerly direction and stretches for approximately 200 miles from the eastern boundary, Maroni River, to the western boundary, Corentyn River. As the trawling survey was to be a long term project, the coast of Surinam was arbitrarily divided into seven equal statistical areas, 27 miles wide, to facilitate recording and sampling of catch statistics. These areas were designated I to VII beginning from the Maroni River to the Corentyn River.

Distribution of fishing effort and catch per unit of effort

During the 4-year interval, 1962 through 1965, 2,717 effective drags were completed by the COQUETTE. An effective drag is defined as one in which the bulk of the catch was not lost due to fouling of the gear or damage by sharks. These drags produced a grand total of 1,974,854 pounds, for an average catch rate of 485 lb/hr. Of this total, 68% (1,326,939 lb) was marketable fish, 21% (424,184 lb) was industrial fish and 11% (223,731 lb) was invertebrates. The catch rates were marketable fish, 326 lb/hr; industrial

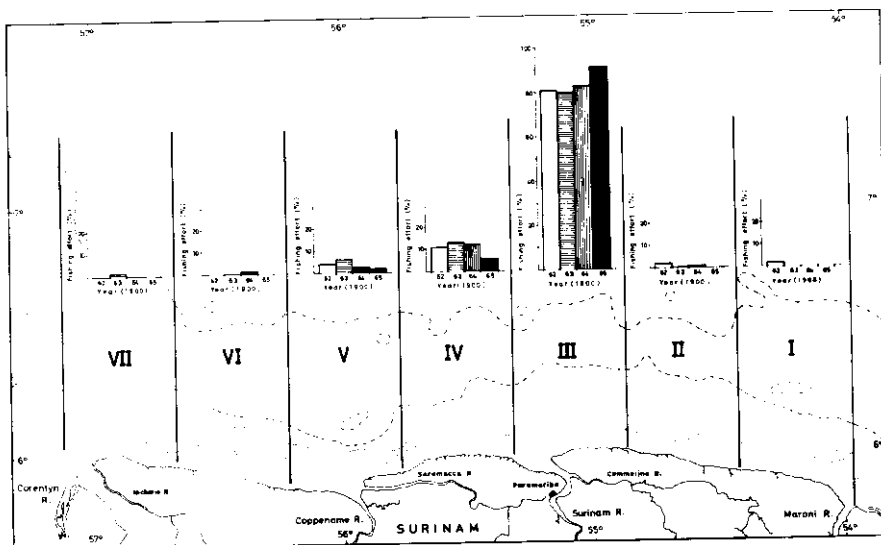


FIG. 2. Distribution of COQUETTE fishing effort by statistical area and year, Surinam.

fish, 105 lb/hr and invertebrates 55 lb/hr. Marketable species in the *total* catch were: sea trout, 24%; croakers, 6%; and various species of small size, 38%.

Areal variations

The areal distribution of fishing effort varied considerably. Area III was the most intensively fished with over 83% of the total 4-year effort. Of the remaining effort, 11% was expended in area IV, 4% in area V, 1% in area II, 0.5% in area I, none in areas VI and VII (Fig. 2).

The most productive areas were III and IV (Fig. 3). The 4-year average catch rates were 494 and 484 lb/hr in these respective areas. The fishing grounds west of the Surinam River were in general more productive than the areas to the east. The 4-year average catch rates were 382 lb/hr in area V, 312 lb/hr in area VI, and 374 lb/hr in area VII. East of the Surinam River

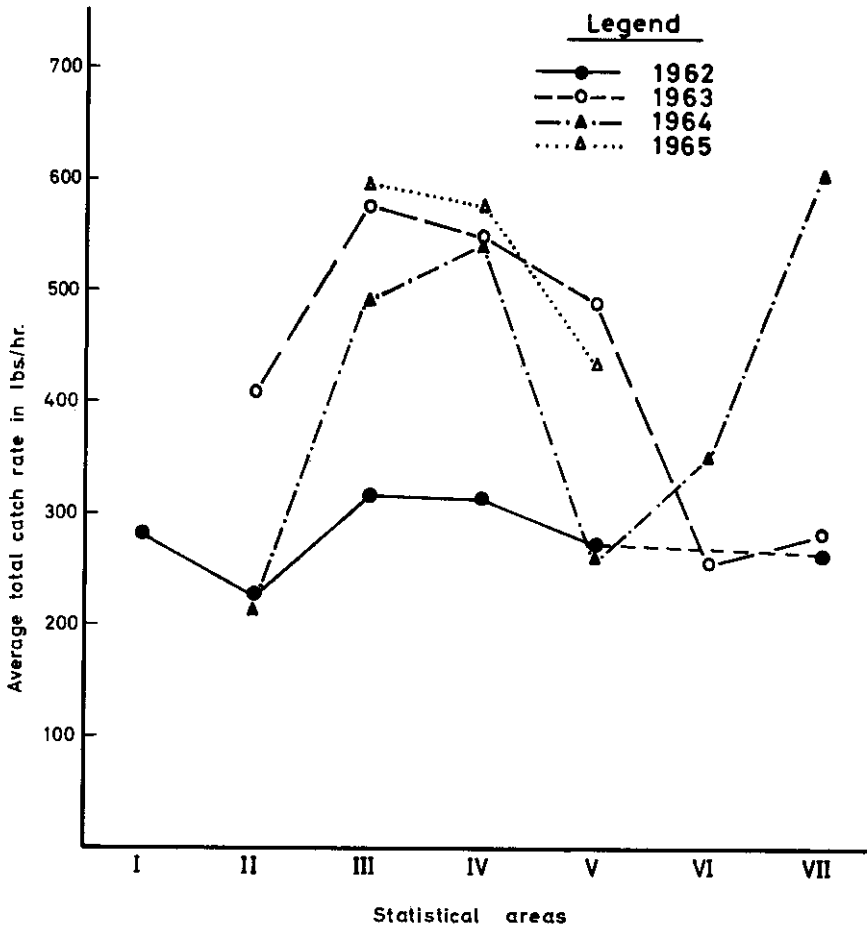


FIG. 3. Total catch rates by year and statistical area COQUETTE.

grounds, the annual catch rates averaged 281 lb/hr in area I and 257 lb/hr in area II (Fig. 3).

The following analyses of fluctuations in catch rates by year, season, depth and time of day have been limited to the data for area III as over four-fifths of the fishing effort was expended there during the 4-year interval. Though it may be presumptuous to assume that the fluctuation patterns for area III are characteristic of the entire coast of the Guianas, similar patterns probably do occur.

Annual variations

The total number of drags in area III was distributed uniformly throughout the 4-year interval, decreasing only slightly from 26% in 1962 and 1963 to 24% in 1964 and 1965. The total catch of marketable fish, industrial fish and invertebrates varied quite markedly from year to year. The total catch rate (all species) fluctuated from a low of 312 lb/hr in 1962 to 563 lb/hr in 1963. The 1964 total catch rate decreased to 489 lb/hr but increased to 590 lb/hr in 1965.

TABLE 2
SPECIES COMPOSITION OF TOTAL ANNUAL CATCHES
BY THE COQUETTE IN AREA III

	1962	1963	1964	1965
	(%)	(%)	(%)	(%)
Sea Trout	22	24	25	25
Croaker	5	5	6	5
Whiting	19	23	21	26
Surinam butterfish	5	4	5	4
Other fish	12	10	11	12
Industrial fish	23	24	21	18
Invertebrates	14	10	11	10
Number Drags	588	595	537	550
Total catch (lb)	279,336	514,129	396,114	491,242

The species composition during this 4-year interval did not change appreciably. (Table 2). The catch rates of croakers were constant, representing 5-6% of the total annual catch. Sea trout in the total annual catch ranged from 22% in 1962 to 25% in 1965. Similarly, the proportion of whiting increased from 19% in 1962 to 26% in 1965. During this interval, the percentage of industrial fish decreased from 24% in 1963 to 18% in 1965. Invertebrate catches also decreased during this period from 14% to 10% of the total annual catch.

Seasonal variations

The months of the year were arbitrarily grouped into 3-month intervals roughly corresponding to the four seasons of temperate climates. The months of March, April and May were designated as spring; June, July and August as summer; September, October and November as autumn; and December, January and February as winter.

Analyses of the drags segregated into the above categories show the seasonal fluctuations in catch rates follow a regular pattern from year to year (Fig. 4).

This pattern can be generalized by the average seasonal catch rates. Catch rates were quite low in spring (412 lb/hr). The highest rate, 649 lb/hr, occurred during summer; it decreased slightly in autumn (513 lb/hr) and poorest catches were made in winter (384 lb/hr), (Fig. 4).

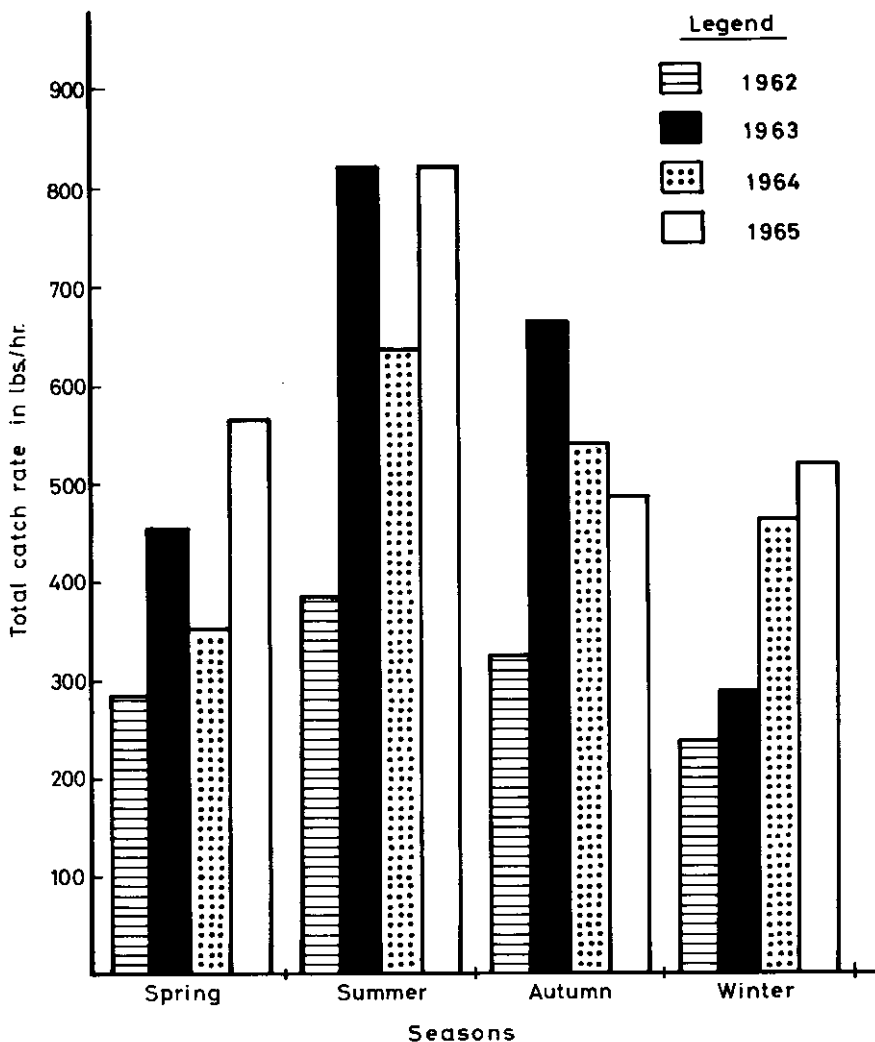


FIG. 4. Seasonal variation of total catch rates 1962-1965 in Area III, COQUETTE.

Bathymetric variations

From 1962 to 1965, the COQUETTE fished area III in depths from 5-35 fathoms. This depth range has been divided into 5-fathom intervals for analysis of bathymetric fluctuation in catch and species composition. Fishing effort

was confined almost entirely to the 5- to 20-fathom interval. Of the 2,270 drags completed, 59% was made in 5 to 10 fathoms, 34% in 10 to 15 fathoms and 6% in 15 to 20 fathoms. The remaining 1% of effort was distributed in 20 to 35 fathoms.

The average catch rates for the 4 years in the 5-fathom depth intervals decreased from a high of 527 lb/hr in 5 to 10 fathoms to 452 lb/hr in 10 to 15 fathoms. The catch rate increased to 493 lb/hr in 15 to 20 fathoms. At greater depths, the catch rate fluctuated from 73 lb/hr in 20 to 25 fathoms to 151 lb/hr in 25 to 30 fathoms, and 104 lb/hr in 30 to 35 fathoms.

The species composition of the catch changed markedly with increasing depth (Fig. 5). The 5- to 20-fathom intervals produced a high percentage of marketable species (64-69%) and a low percentage of industrial fish and invertebrates (31-36%). Drags made in 20 to 35 fathoms produced predominantly industrial fish and invertebrates (66-87%) and very little marketable species (16-34%).

The proportionate catch of sea trout, croaker and butterfish each declined from a high in 5 to 10 fathoms and they were not taken beyond 20 fathoms. On the other hand, whiting was taken in all depth intervals with the highest proportion in 20 to 25 fathoms. The relative abundance of other small species peaked in 15 to 20 fathoms (Fig. 5).

Diel variations

Most fishing was done in daytime, and limited effort was expended at night. To ascertain changes in catch rates at different times of the day, catch statistics were segregated into 4-hour intervals. For convenience, these 4-hour intervals will henceforth be referred to as early morning (0000-0400 hours);

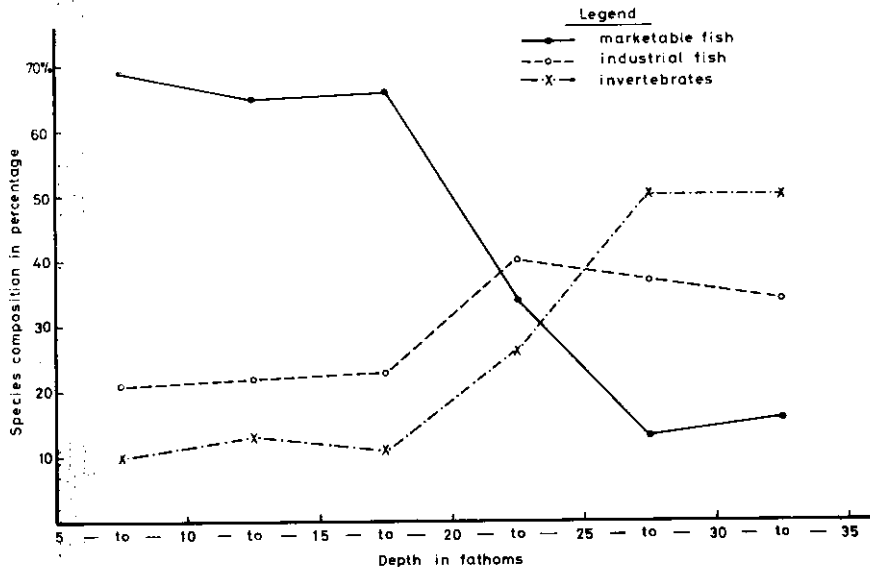


FIG. 5. Catch composition by 5-fathom interval in Area III 1962-1965, COQUETTE.

TABLE 3

DISTRIBUTION OF COQUETTE FISHING EFFORT, TOTAL CATCH, CATCH/HOUR
BY 4-HOUR INTERVALS FOR THE YEAR 1962-1965 IN AREA III

	1962		1963		1964		1965		Totals
	Time (0000)	(%)	Time (0000)	(%)	Time (0400)	(%)	Time (0800)	(%)	
No. of Drags Total Catch Catch/Hour	(0000)	46(8%) 19,650 286.20	(0400)	33(6%) 19,089 387.56	(0800)	8(0%) 2,537 212.47	(1200)	3(0%) 1,547 345.49	90(4%) 42,823 318.79
No. of Drags Total Catch Catch/Hour	(0400)	90(15%) 41,525 309.12	(0800)	89(15%) 76,421 575.30	(1200)	86(16%) 64,563 502.99	(1600)	86(16%) 79,130 616.47	351(15%) 261,639 499.42
No. of Drags Total Catch Catch/Hour	(0800)	135(23%) 71,100 352.86	(1200)	152(25%) 148,881 656.25	(1600)	150(28%) 127,092 567.68	(2000)	174(32%) 165,312 636.54	611(27%) 512,385 561.86
No. of Drags Total Catch Catch/Hour	(1200)	130(22%) 66,224 341.30	(1600)	133(22%) 123,123 620.24	(2000)	155(29%) 124,731 539.16	(2400)	153(28%) 150,337 658.34	571(25%) 464,415 544.93
No. of Drags Total Catch Catch/Hour	(1600)	111(19%) 50,618 305.53	(2000)	117(20%) 101,510 581.29	(2400)	115(21%) 67,830 395.18	Totals	116(21%) 85,985 496.64	495(20%) 305,943 446.58
No. of Drags Total Catch Catch/Hour	(2000)	76(13%) 30,215 266.37	(2400)	71(12%) 45,113 425.71		23(4%) 9,394 273.65		18(3%) 9,064 337.38	188(8%) 93,786 334.24

dawn (0400-0800 hours); late morning (0800-1200 hours); early evening (1200-1600 hours); dusk (1600-2000 hours); and late evening (2000-0000 hours). Of 2,270 drags completed in area III during 1962-1965, 52% was made during the day from 0800 to 1600 hours; only 12% during the night from 2000 to 0400 hours. The remaining effort was expended during the twilight hours, 15% at dawn and 20% at dusk (Table 3).

The highest catch rates were made during the day, the medium rates were made at twilight, and the lowest catch rates occurred at night. The average catch rate for 4 years was lowest (318 lb/hr) during early morning. At dawn, the catch rate increased to 499 lb/hr. The highest rate of 561 lb/hr was made in the late morning. The catch rate decreased slightly in the early evening to 544 lb/hr with further decline at dusk to 446 lb/hr. In late evening, the catch rate further decreased to 334 lb/hr.

Table 4 shows the diel species composition of the total 4-year catch. The relative catch of marketable species was generally higher during the day (69-70%) than during the night (61-63%). The relative catches of industrial fish and invertebrates were lower during the day (30-31%) than during the night (36-39%).

TABLE 4
CHANGES IN SPECIES COMPOSITION BY 4 HOUR INTERVALS IN AREA III
(1962 - 1965 DATA COMBINED)

	Percentages of total catch					
	0000	0400	0800	1200	1600	2000
Sea trout	18	28	27	24	20	16
Croaker	4	5	6	5	4	5
Whiting	13	22	24	26	21	12
Butterfish	12	3	3	4	6	11
Other fish	16	11	10	10	13	17
Industrial fish	23	19	20	21	24	24
Invertebrates	13	11	10	10	12	15

EXPLORATORY AND PRODUCTION FISHING RESULTS OF THE CALAMAR

General description

The UNDP/FAO Caribbean Fishery Development Project conducted cruises of exploratory and production trawl fishing off northeastern South America from June 1967 through August 1968 to evaluate the potential of the trawl fish in the region. The vessel undertaking these cruises was the project vessel CALAMAR.

The CALAMAR is a multi-purpose steel hull fishing vessel built in 1966. This vessel has an over-all length of 81.3 feet, a maximum beam of 21.8 feet and a depth of 11.5 feet. An insulated and refrigerated space holds approximately 50,000 pounds of iced fish (space capacity 46 m³). A "Freon 12" plant refrigerates the hold at temperatures of 0° to -5°C.

Accommodations are provided for 8 crew, 8 trainees and 2 scientists. Fuel and water capacities are sufficient for about 14 days continuous operation. The main engine develops 380 BHP at 1225 RPM and drives a four-blade

propeller; cruising speed is about 9.5 knots. The trawl winch on the vessel is a heavy-duty double drum hydraulic winch with a capacity of approximately 2,000 feet of $\frac{5}{8}$ -inch trawling cable in each drum. The vessel is equipped with a hydrographic winch with a capacity of 1800 meters of 4-mm diameter wire. The electronic equipment includes an auto-pilot, radio, radar, direction finder, two echo sounders and an electric water temperature recorder.

Conventional North Atlantic trawl gear was utilized for the CALAMAR fishing cruises (Knake, 1956; 1958). The otter doors were flat and rectangular, measuring 39 inches (1 m) by 78 inches (2 m) and weighing approximately 528 lb (240 kg) each. These doors were constructed of wood, heavily reinforced with steel angle and flat bars. Brackets on the doors were constructed of 1.25-inch round steel rod for the forward piece and $\frac{3}{8}$ -inch chains for the adjustable after piece. Twenty-fathom bridles were used between the doors and the wings of the trawl.

Three different types of trawl nets were fished by the CALAMAR. These included nets henceforth designated as the "70/83," "60/83" and snapper trawls. The "70/83" trawl had a groundrope of 83 feet and a headrope of 70 feet. The mesh sizes of this net were 4.5-inch for wings, square and bellies; 3-inch for extension piece and codend. The trawls were constructed throughout of polypropylene. The twine sizes were 280 yards per pound (yds/lb) for wings; 360 yds/lb for square, bellies, extension piece; and 200 yds/lb double twine for codend.

The "60/80" trawl had a groundrope of 80 feet and a headrope of 60 feet. The mesh sizes were 4.5-inch for wings and square, 4-inch for bellies and extension piece and 3-inch for codend. This net also was constructed throughout of polypropylene with twin sizes of 512 yds/lb for wings, square and bellies; 325 yds/lb for extension piece; and 200 yds/lb double twine for codend.

The "70/83" and "60/80" trawls were fished with 20 to 30, 8-inch floats on the headrope and $\frac{1}{4}$ -inch chain looped onto the groundrope. The snapper trawl measured 72 feet on the groundrope and 52 feet on the headrope. The wings, square, belly, and extension piece of this net were constructed of No. 16 braided nylon twine; the codend was constructed of 200 yds/lb polypropylene double twine. Mesh sizes of this net were 4.5-inch and 3-inch stretched mesh measures for the nylon and polypropylene webbing, respectively.

The snapper trawl was fished with 26 8-inch floats and roller gear. The rubber and wood bobbins used ranged from 14 to 20 inches in diameter and were separated by metal and wood spacers (Captiva and Rivers, 1960).

The explorations of the CALAMAR encompassed a much greater area than those of the COQUETTE. The COQUETTE investigations were limited to the continental shelf off Surinam, but the area of exploration of the CALAMAR extended from eastern Venezuela to French Guiana.

In the present analysis, the coast of South America from eastern Venezuela to French Guiana was divided into 5 zones. These are: zone A, from longitude 66°W to 62°W , off Venezuela; zone B, from longitude 62°W to 60°W ; zone C, from longitude 60°W to 57°W , off Guyana; zone D, from longitude 57°W to 54°W , off Surinam; and zone E, from longitude 54°W to 51°W , off French Guiana. Zone B was further sub-divided into B_1 and B_2 , respectively the shelf off Trinidad and Tobago, and the Orinoco delta, by latitude 10°N (Fig. 1).

The bathymetric range of fishing drags completed by the CALAMAR extended from 7 to 100 fathoms, with greatest effort in depths less than 25 fathoms. In general, the drags made in less than 25 fathoms were completed with the

"70/83" and "60/80" trawls rigged with chain loops on the groundrope. Drags in depths greater than 25 fathoms were completed with the snapper trawls rigged with roller gear on the groundrope. The drags completed with the chain groundrope trawls are summarized separately from those completed with the roller-rigged trawls. Hereafter, the groundrope trawl and roller-rigged trawl operations will be referred to as "inshore" and "offshore" fishing, respectively.

Distribution of fishing efforts in inshore waters

During part of 1967 and 1968 the CALAMAR trawled a total of 700 hours in inshore waters from Trinidad to French Guiana. (This total includes the dragging times of 330 effective drags, but not the 11 gear damaged drags). This fishing effort produced a grand total of 473,458 lb for a catch rate of 676 lb/hr. Marketable fish made up 68% (321,064 lb) of the total catch; 28% (131,024 lb) was industrial fish; and 4% (21,370 lb) was invertebrates.

Marketable fish in the total catch of the CALAMAR were 40% sea trout, 10% croaker and 18% mixed fish. Half of the total catch made by the CALAMAR was comprised of the 2 species, sea trout and croaker. Sea trout ranged from 32 to 84 cm in total length and averaged 65 cm, corresponding to a weight of about 3.5 pounds. Total length of croakers ranged from 21 to 51 cm, and the mean length was 36 cm weighing slightly over 1 pound.

The inshore fishing effort of the CALAMAR was very unevenly distributed in the 6 zones. The majority, about 80%, of the total fishing effort was expended in zone D. The zone immediately west, zone C, received the next best coverage with 10% of total effort. Zone E, B₁, B₂ and A received 6%, 3%, 1% and 0% of the total.

Catch rates of total catch and marketable fish for the CALAMAR were highest in zone D off Surinam with 735 lb/hr and 504 lb/hr respectively. In zone B₂ off the Orinoco delta, total catch rate was high (723 lb/hr), but the marketable

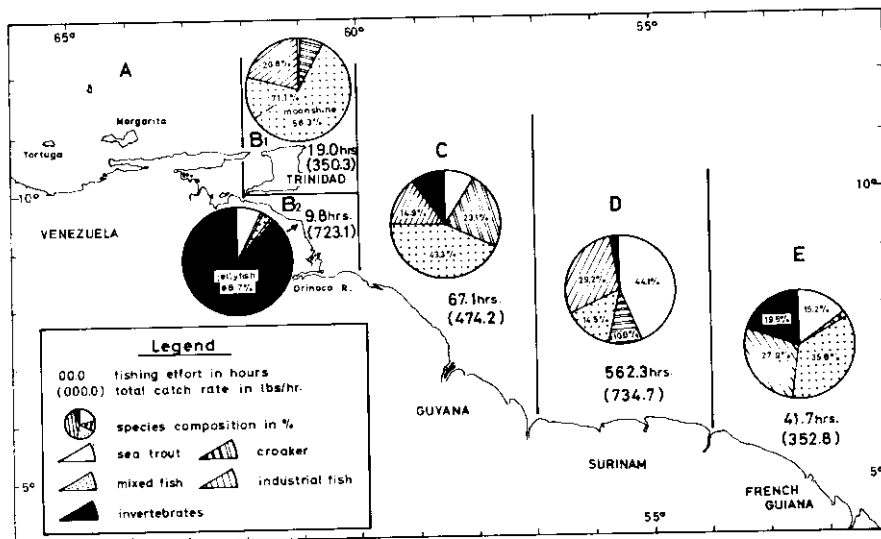


FIG. 6. CALAMAR fishing effort, total catch rate and catch composition.

fish catch rate was the lowest (73 lb/hr) of all zones. The total catch rate in zone C off Guyana decreased to 474 lb/hr, but the 357 lb/hr was the second highest marketable fish catch rate. Total catch and marketable fish catch rates in zone B₁ off Trinidad and Tobago, were low with 350 and 277 lb/hr, respectively. In zone E off French Guiana, low rates of 353 lb/hr total catch and 186 lb/hr of marketable fish were captured (Fig. 6).

The composition of the total catch varied markedly from zone to zone (Fig. 6). Zone B₁ had the highest percentage of mixed fish with 71%, of which moonshine was the dominant species. In zone B₂, invertebrates, specifically jellyfish, dominated with 89% of the total catch. Mixed fish 43%, 23% croakers and 9% sea trout constituted three quarters of the total catch in zone C. Marketable fish also constituted the bulk of the total catch in zone D with sea trout accounting for 44%, mixed fish for 15% and croaker for 10%. The proportion of industrial fish (29%) was the highest of all zones. In zone E, 36% mixed fish, 15% sea trout and 2% croaker catches accounted for slightly over half of the total catch (Fig. 6).

Seasonal variations

Comparisons of seasonal variations in the catches by the CALAMAR were limited to the drags completed in a very restricted area (roughly corresponding to area III of the COQUETTE data) northeast of the Surinam River. About 71% of the total fishing effort was expended by the CALAMAR in this area for production fishing and diel test fishing. Drags completed during the night were not included in the seasonal variations analysis.

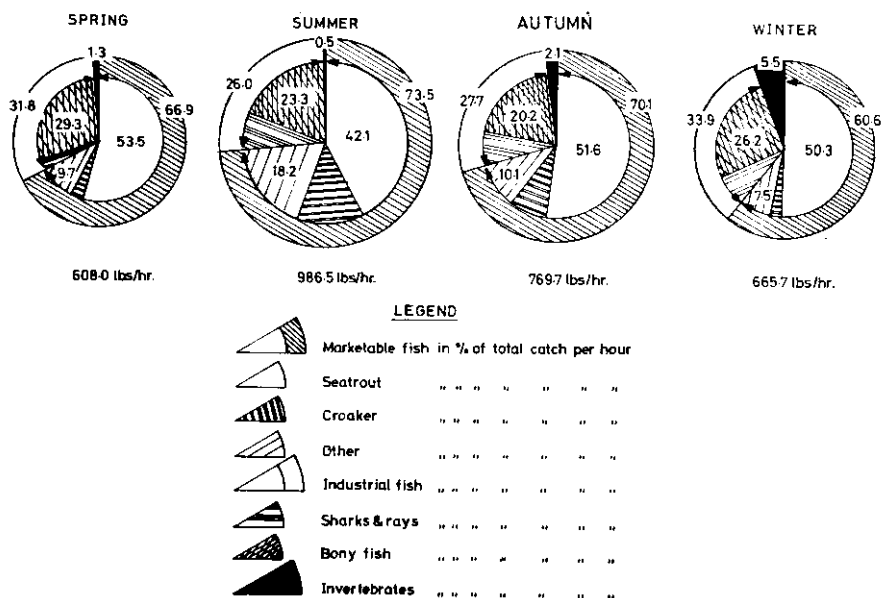


FIG. 7. Seasonal catch rate and catch composition northeast of Surinam River, CALAMAR.

The arbitrary grouping of months used in analyzing the seasonal variation in catches by the COQUETTE was used in the CALAMAR analysis. Figure 7 summarizes the catch rates and percentage composition of catches by season. The highest catch rates of both total catch and marketable fish of 986 and 725 lb/hr, respectively, were made in summer. Second highest catch rates of 770 lb/hr of total catch and 540 lb/hr of marketable fish were made in the autumn months. Catch rates further declined to 666 lb/hr for total catch and 403 lb/hr for marketable fish during the winter. In spring, the catch rates of total catch and marketable fish were low at 608 and 407 lb/hr, respectively.

There were no marked changes in composition of the catches by seasons, though the percentage of marketable fish during the summer and autumn of

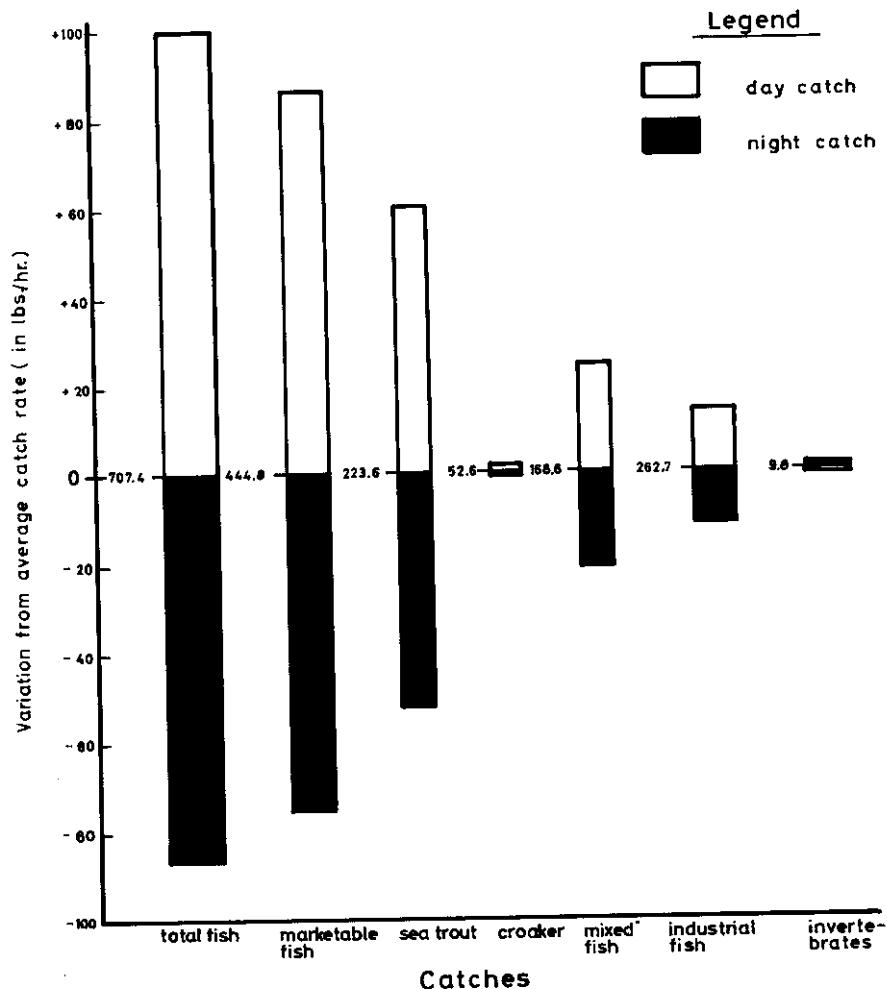


FIG. 8. Variation from average catch rate, day versus night catch rate.

74%, respectively, was slightly higher than for spring (67%) and winter (61%). Of marketable fish, sea trout accounted for slightly over 50% of the total catch during spring, autumn and winter, but decreased to 42% during summer. The catches of croakers were high during summer (13%) and autumn (8%), but low in winter (3%) and spring (4%). Mixed fish catches varied from 10%, 18%, 10% and 8% of total catch, during spring, summer, autumn and winter, respectively. (Fig. 7).

Diel variations

Day versus night fishing tests were conducted during 2 cruises by the CALAMAR in the area northeast of the Surinam River. During the first cruise in April 1968, 55 drags were completed, but due to the high catch rate only 22 drags were made during the second cruise in August 1968.

A schedule of fishing operations was designed so that all 8, 3-hour periods beginning at midnight would be fished. A total of 77, 2-hour drags were completed during these tests, of which 36 were day drags and 41 were night drags.

For the combined data of the 2 cruises, the total catch rate of 807 lb/hr during the day was 30% higher than the rate of 620 lb/hr during the night. The catch rate of marketable fish was 44% higher during the day (531 lb/hr) than during the night (369 lb/hr), (Fig. 8).

There were marked differences in the diel catch rates between the cruises. During the April cruise, the total catch rate during the day of 597 lb/hr was 67% higher than the night rate of 357 lb/hr. Similarly, the marketable fish catch rate of 407 lb/hr during the day was 64% higher than the rate of 248 lb/hr during the night. The August cruise resulted in a total catch rate during the day of 1285 lb/hr which was 4% lower than the night rate of 1337 lb/hr. However, the marketable fish catch rate of 812 lb/hr during the day was 16% higher than the rate of 699 lb/hr during the night. The composition of total catch for the April cruise showed very little differences between day and night. During the August cruise, however, the percentage of marketable fish was higher during the day (63%) than during the night (52%). The percentage of industrial fish showed an opposite trend (Table 5).

Snapper exploration in "offshore" waters

The CALAMAR conducted exploratory fishing with roller-rigged snapper trawls during April to July 1968. The primary objectives of these cruises were to determine the ability of roller-rigged snapper trawls to fish the rough bottom frequently encountered beyond 20 fathoms on the Guiana shelf and to delineate commercial concentration of fish, particularly snapper (Lutjanidae).

Exploratory snapper fishing extended from French Guiana in the east to Tortuga Island, Venezuela, in the west (Fig. 1). A total of 114 drags were completed with roller-rigged snapper trawls. Catches were uniformly low throughout the survey area (Fig. 9). Total catch rates ranged from a low of 41 lb/hr in zone A to a high of 186 lb/hr in zone B. In zones C, D and E the total catch rates fluctuated from 50, 64 and 58 lb/hr respectively. Snappers accounted for less than 40% of the total catch in all zones. However, the proportion of snappers was higher off the coasts of Surinam and French Guiana (Fig. 9). Although a "white line" depth recorded was carefully monitored for unusually rough bottom conditions, gear damage was extensive. Of the total of 114 drags, the net "hung up" no less than 26 times; 10 times with negligible damage, 8 times with considerable damage, 3 times with severe damage and once with loss of the net with roller gear and 175 fathoms of warp.

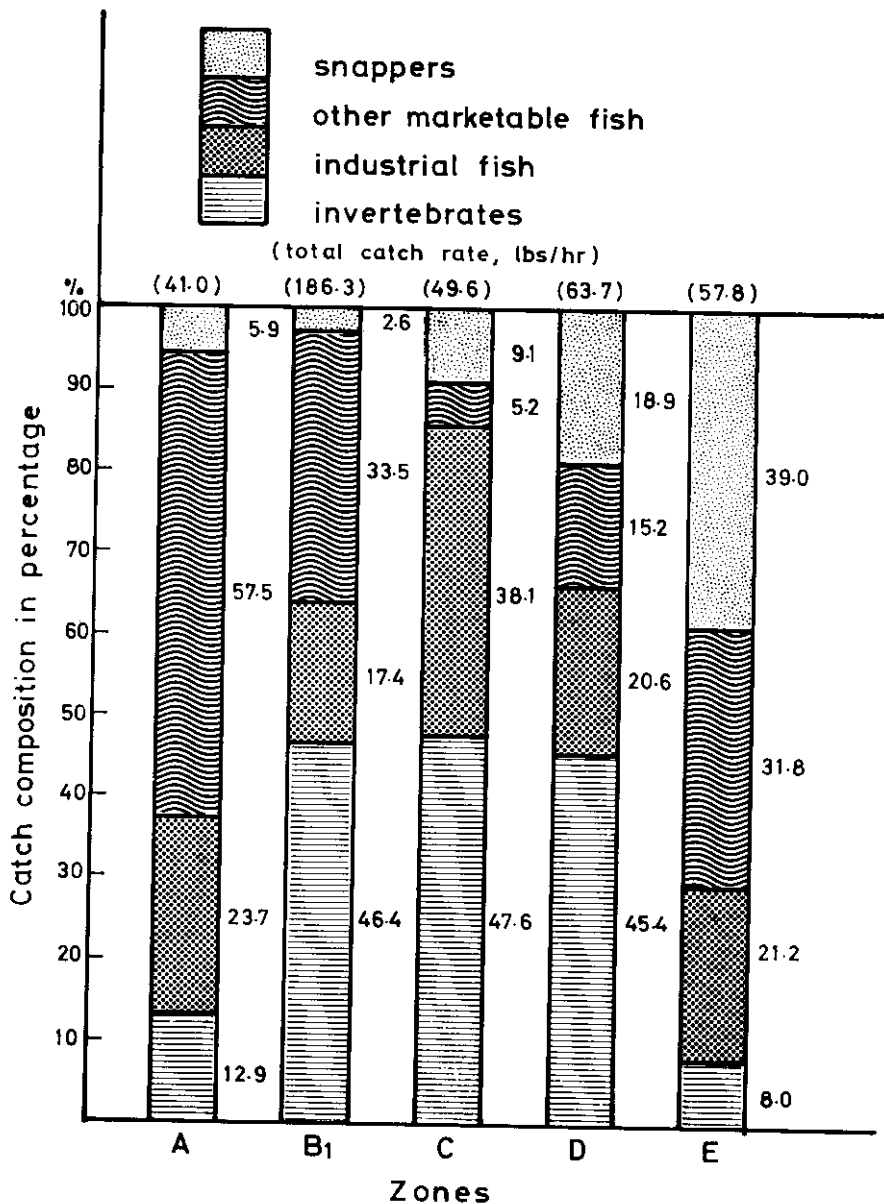


FIG. 9. Catch composition and total catch rate of roller-rigged trawl fishing by zone, CALAMAR.

DISCUSSION

The COQUETTE and CALAMAR fished the same grounds off Surinam and each completed a large number of drags in this area. The fishing results of these two vessels offer opportunity for evaluating their relative fishing capabilities. Any comparison of fishing results, however, must be evaluated with reservation as the operations of the COQUETTE and CALAMAR were conducted during different years.

From 1962 to 1965, the COQUETTE averaged 484 lb/hr total catch and 326 lb/hr of marketable fish. The total catch and marketable fish catch rates for the CALAMAR were 734 and 504 lb/hr, respectively, during a 12-month period in 1967 and 1968. The average catch rate of the COQUETTE was only 65% of the average rate of the CALAMAR for both total catch and marketable fish. The higher catch rate for the CALAMAR is attributed to the superior power of this vessel and the specialized trawls utilized during fishing operations. Analyses of the 4-year fishing operations by the COQUETTE show annual fluctuations in total catch rates from a low of 312 lb/hr to a high of 590 lb/hr. This low rate may be due in part to the unfamiliarity of the fishing grounds during the initial stages of COQUETTE fishing operations. On the basis of this analysis, annual fluctuations of the order of 90% may be expected on the Surinam fishing grounds. If these calculations are projected for the CALAMAR, the total catch rates for this vessel may be expected to range from 480 lb/hr during the poorest years to as high as 908 lb/hr during the best years.

It is interesting to note that the sea trout catches by the COQUETTE ranged from 22 to 25% of the total catch over the 4-year period, whereas sea trout catches by the CALAMAR comprised 44% of the total catch over a 12-month period. The faster towing speed of the CALAMAR and the higher opening of the fish trawls probably accounted for this difference. The proportion of mixed fish in the catches was 38% of total catch for the COQUETTE and approximately 15% for the CALAMAR. On the other hand, the relative availability of croakers did not differ appreciably between the 2 vessels. Croakers represented 6% and 10% of the total catches by the COQUETTE and CALAMAR, respectively.

Geographic variations in catch rates for the CALAMAR are in very close agreements with those of the LA SALLE (Gines and Cervigon, 1968). The total catch rates for both vessels were moderately high off Trinidad; lowest off the Orinoco delta (if the unusually large catch of jellyfish taken by the CALAMAR is not considered); moderately high off Guyana; and highest off Surinam. The coastal waters of Surinam, especially off the mouth of the Surinam River, are the most consistently productive area for trawlfish along the northeastern coast of South America from eastern Venezuela to French Guiana. Catches at other locations occasionally equal or exceed Surinam catch rates, but are not as consistent.

The composition of the total catches made by the CALAMAR varied from one geographic region to another and was in general agreement with catch composition of the LA SALLE. Off Trinidad, moonshine dominated the catches made by both vessels. The CALAMAR caught more croakers off Guyana than elsewhere, but the LA SALLE had slightly better catches of croakers off Surinam than off Guyana. The extensive fishing operations of the CAPE ST. MARY substantiate croaker as the dominant species off the coast of Guyana. Both the CALAMAR and LA SALLE produced the best catches of sea trout off Surinam. Sea trout

accounted for the greatest poundage per single species in the catches of the COQUETTE fishing operations off Surinam.

Analysis of seasonal variations in catch rates for the COQUETTE and CALAMAR show regular fluctuations from a low rate during the spring to the highest rate during summer to a moderate rate during autumn to a low rate during the winter. The high catch rates coincide with periods of greatest discharge from the Surinam River (Fig. 10).

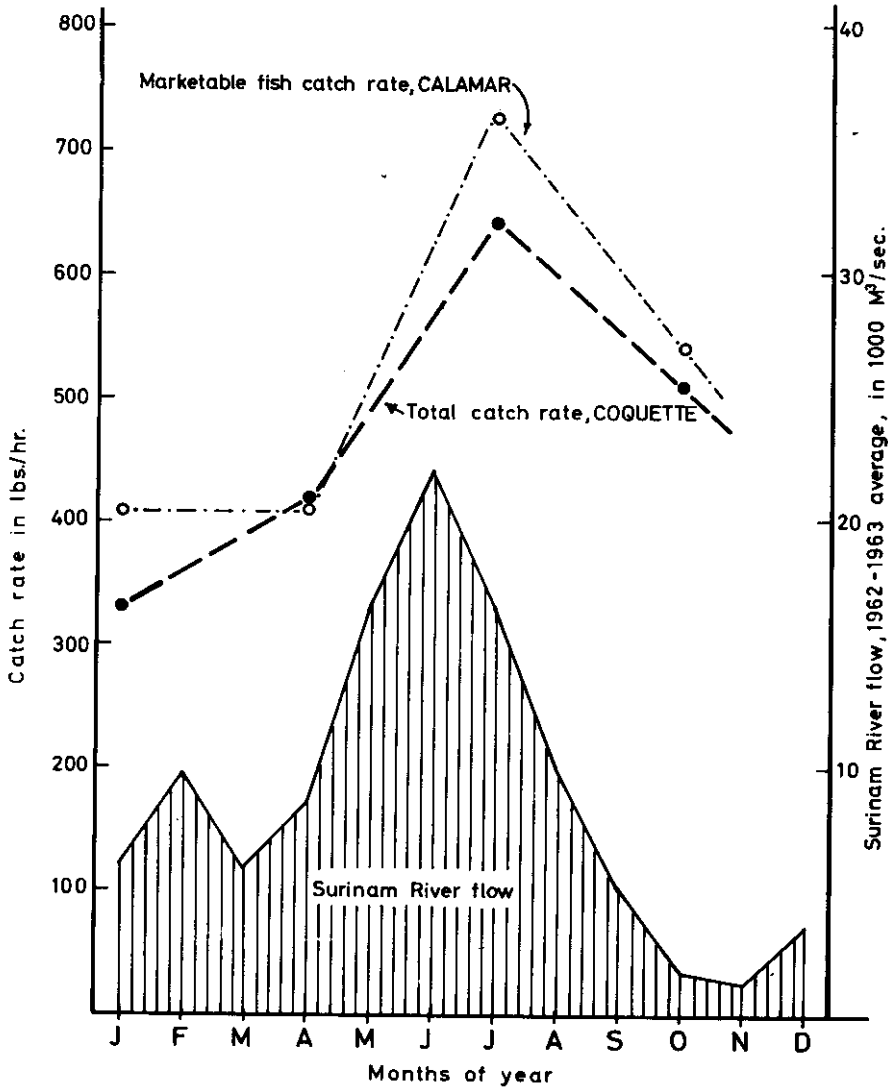


FIG. 10. Correlation between Surinam River flow and seasonal catch rates of COQUETTE and CALAMAR.

Cursory examination of both the COQUETTE and CALAMAR data shows seasonal shifts in fishing effort from 10 to 20 fathoms during the winter-spring to 5 to 15 fathoms during the summer-autumn. The best catches are generally taken at the deeper end of the 5- to 20-fathom interval during winter-spring and at the shallower end of this depth interval in summer-autumn. Although the fishing operations of the CALAMAR have been limited, the best catches during winter-spring were taken in greenish-colored water, whereas during summer-autumn, brownish-colored water yielded the best catches. These observations suggest an inshore movement into the estuaries of marketable fish during periods of greatest river run-off in summer-autumn and general dispersal into deeper water during periods of low river run-off in winter-spring.

Off Surinam the COQUETTE produced high catch rates in shallow depths of less than 20 fathoms. The CALAMAR in all areas from off eastern Venezuela to French Guiana produced high catch rates in depths shallower than 20 fathoms and low rates beyond this depth. Similar results have been observed by the LA SALLE in all areas of exploration from Trinidad to Surinam. The catch rates of other vessels, notably CAPE ST. MARY, NEREID and ORSOM II exploratory fishing off the coasts of Guyana, the Orinoco delta and French Guiana also declined markedly beyond 20 fathoms. Gines and Cervigon (1968) in a discussion of the fishing results obtained by the LA SALLE suggest that the environmental conditions at depths less than 20 fathoms on the Guiana shelf are in a continuous state of flux which they surmise provides for greater yields both in type and number of species.

Fishing results of both the COQUETTE and CALAMAR show the night catches to be lower than the catches made during the day. The total catch rates for the COQUETTE were consistently lower during the hours of darkness for all 4 years under consideration. The 4-year averages of total catch and marketable fish rates made during the night were only 59% and 53% of the day rates. However, the results of the day versus night fishing tests conducted by the CALAMAR varied quite markedly during different seasons of the year. The two fishing cruises conducted during the months of April and August produced night time rates for total catch of 60% and 104% and for marketable fish of 61% and 92% of the day time rates. At times the catch rates of marketable fish may be as high during the night as during the day. Although confirmation is necessary, night catch rates may also be influenced by the phase of the moon. There is the possibility of exploiting the bottomfish resources of the Guiana shelf on a 24-hour basis, reducing vessel turn around time and increasing the feasibility of a more economical commercial bottomfish fishery.

Resource potential

The various fisheries investigations conducted during the past 25 years have delineated a substantial trawlfish resource at depths less than 20 fathoms off the northeastern coast of South America. Table 6 lists average catch rates by five trawlers obtained during independent fishing operations conducted off the coasts of Trinidad, Guyana and Surinam. The average catch rates for these vessels ranged from 248 to 411 lb/hr off Trinidad, 205 to 357 lb/hr off Guyana and 325 to 503 lb/hr off Surinam. Variations in catch rates are attributed to the fishing abilities of the different sized vessels and to the amount of fishing effort expended at these locations. The respective overall lengths of the five vessels under consideration were: ASSAULT, 50 feet; COQUETTE, 68 feet; CALAMAR, 82 feet; CAPE ST. MARY, 117 feet; LA SALLE, 130 feet. The lower catch

rate of the COQUETTE as compared to the CALAMAR is attributed in part to the lower power of the former vessel.

The surveys conducted by the five vessels were predominantly concerned with exploratory fishing, with the exceptions of the simulated production fishing operations of the COQUETTE and CALAMAR off Surinam. Therefore, the above catch rates, excluding the production rates of COQUETTE and CALAMAR for the Surinam coast, are probably low estimates of the available trawlfish resources.

TABLE 6
AVERAGE CATCH RATES (MARKETABLE FISH) DURING VARIOUS SURVEYS

<i>Area</i>	<i>Trinidad</i>	<i>Guyana</i> (Catch in Pounds Per Hour)	<i>Surinam</i>
Assault	248	—	—
Cape St. Mary	—	325	—
La Salle	411	205	429
Coquette	—	—	325
Calamar	277	357	503

The CALAMAR conducted eight simulated trawlfish production cruises during July-October 1967 and August-October 1968. During these cruises, 57 fishing days produced a total marketed catch of 224,730 lb for an average of 4,494 lb/day. This catch per day rate was established by the CALAMAR operating with a deck crew comprised mainly of inexperienced fishermen-trainees and generally fishing a 12-hour day, from dawn to dusk, during which period an average of 3 drags were completed. It is not unreasonable to expect a commercial vessel rigged with time saving deck gear and operated by an experienced crew working 15 to 18 hours a day to increase the above catch per day rate by 25 to 50%. These projected increases for a commercial vessel would give minimum catch per day rates of the order of 5,600 to 6,700 lb of marketable fish.

Marketing experiments, in various locations throughout the West Indies, (Guyana, Trinidad, Barbados, St. Lucia, Guadeloupe, and French Guiana) with CALAMAR-caught fish have demonstrated excellent consumer acceptance. West Indian fishermen-trainees aboard the CALAMAR have adapted well to fishing techniques aboard a trawler.

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