develops near the shore soon spreads out as far as 10 miles by April and probably farther by May. The higher values of phosphate on the bottom 5–10 miles offshore, shown in Fig. 1 B, are believed to be the result of upwelling to the south, possibly in the region of the Godavari Delta, and which have flowed along the shelf to Waltair.

SUMMARY

From a study of the changes in nutrient salts, currents and meteorological conditions off Waltair, it is concluded that the nutrient replenishn ent of phosphates and silicates in spring is the result of both vertical and horizontal circulation. The driving force is the wind associated with the south-west monsoon system. This causes the shelf water to flow to the north-east, with a slight offshore displacement. The latter moves some of the surface water seaward and thus causes the deeper, nutrient-rich water to upwell to the surface near shore. Here, with the aid of sunlight, a rapid and profuse planktonic vegetation develops, as was reported by Ganapati *et al.* (1954). This was followed by a zooplankton growth during March-April.

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FLYING-FISH FISHERY ALONG THE COROMANDEL COAST

By H. L. Arora and S. K. Banerji

(Central Marine Fisheries Research Station, Mandapam Camp)

Introduction

The flying-fish fishery is an important seasonal fishery on the east coast of India extending from Madras to Point Calimere along the Coromandel coast. Beyond this region there is no organised fishery for this species though they have been recorded in small numbers elsewhere along the east coast and rarely along the west coast. Along the Coromandel coast the season starts towards the end of May and lasts till the middle of July, though occasionally it extends up to the middle of August. It has been observed that the flying-fishes never appear in discoloured and muddy water. It is reported that, if the monsoons break early and discolour the sea-water with the silt from the rivers, the fishes migrate away from the shore and the season comes to an abrupt end.

The method of fishing is rather interesting and has been described in detail by Hornell (1923) and Naidu (1923). A specially built 7-log catamaran, called " Kola-catamaran," sturdy enough to reach the fishing grounds 20—40 miles out on sea where the depths vary from 30–40 fathoms, is used for fishing. The net employed for the capture of the flying-fish is a simple dip-net, consisting mainly of a rectangular piece of netting, cast between 7 feet bamboo poles. The fishermen usually carry with them bundles of screw-pine leaves (*Pandanus odoratissimus*) or leaves of some leguminous shrub (*Tephrosia purpurea*), locally known as " Kambi " to be used as lures to attract the fish. When a shoal is sighted, the lures are let down from the catamaran on ropes 15–20 fathoms in length and are held in a half-submerged position with the help of floats. The fish gather around the lures in great numbers for the purpose of spawning and become pre-occupied with egg-laying. Taking advantage of this peculiar spawning habit of the fish, the fishermen quietly draw the lure towards the catamaran and quickly scoop the fish out into it with their dip-nets.

Three species of flying-fish, *viz.*, *Cypsilurus coromandelensis*, *C. spilopterus* and *C. bahiensis*, are generally found in these waters, but more than 90% of the catch consists of *C. coromandelensis* Hornell.

The fishery, in spite of its short duration, is significant in the fisherman's economy, since he is hard hit in case of a failure of this fishery. It is, therefore, hardly necessary to emphasise the need for a study of this fishery over a large number of years and to investigate into the causes of its annual variation. As a preliminary step, therefore, in 1950, we took up the problem of estimating, by sampling method, the total catch of this fish from year to year along with a study of some of the essential biological aspects.

Design of Sampling

Just before the start of the 1950 fishery season, a complete survey was undertaken to enumerate all the fishing villages in this region and to assess the number of "Kola catamaran" available in each village. The names of all fishing villages, along with the number of Kola catamarans available in each village are given in Appendix. It will be seen that the villages have been classified into two groups. The first group of villages is situated near about Madras (*see* map), while the second group is in one continuous run from Cuddalore to Pt. Calimere. In the intervening area between these two groups are situated the then French Territories, and no village was kept under observation.

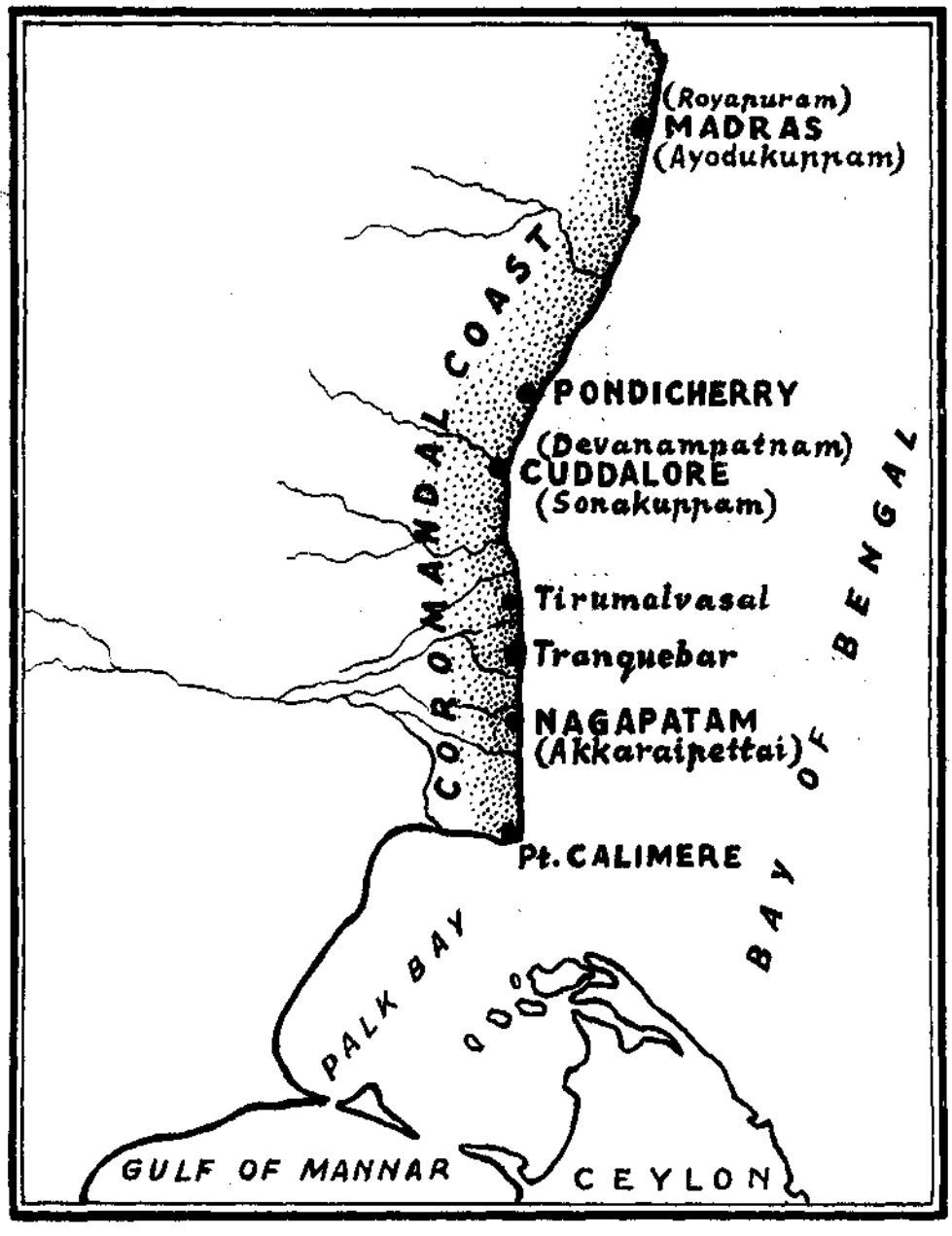
APPENDIX

Showing the names of centres where flying-fish fishery is carried out along the Coromandel coast. The number of Kola Catamarans engaged in the fishing at each centre is also shown

Names of centres from North to South	No. of Kola Catamarans
Group 1	
1. Tondiarpet	29
2. Royapuram	20
3. Triplicane	1
4. Ayodhakuppam	10
5. Nochikuppam	10
6. Mullikuppam	15
Total ..	85

APPENDIX (*Contd.*)

Name of centres from North and South		No. of Kola Catamarans
	GROUP 2	
1.	Devanampatnam	30
2.	Sonnakuppam	25
3.	Chinoor	20
4.	Tirumalavasal	10
5.	Melamookarai	15
6.	Kilamookarai	25
7.	Chavadikuppam	20
8.	Naikarkuppam	15
9.	Kadiakadu	8
10.	Pudukuppam	7
11.	Kaveripatnam	50
12.	Vengari	50
13.	Sinnavanagiri	5
14.	Sinnangudi	50
15.	Thalampettai	16
16.	Pudupettai	16
17.	Perumalpettai	18
18.	Pommianpettai	19
19.	Kuttiyandiwe	12
20.	Tranquebar	34
21.	Chan	18
22.	Chinoorpettai	1
23.	Nagorepatnacherry	35
24.	Samthanpettai	20
25.	Nambiarkuppam	50
26.	Negapatnam	2
27.	Keechamkuppam	25
28.	Akkaraipettai	66
29.	Kallarkuppam	11
30.	Velangani	10
31.	Seruthoor	20
32.	Tiruppoondi	5
33.	Vilundamavadi	6
34.	Vanamadevi	8
35.	Vellapallam	12
36.	Arcotthurai	5
	TOTAL ..	739
	GRAND TOTAL ..	824



Map showing the Region of Survey of Flying-Fish Fishery

Since the design of sampling from year to year was basically the same, the one adopted in the current year is described here. From the first group, two villages, *viz.*, Royapuram and Ayodhakuppam, were selected, and from the second group, five villages, *viz.*, Devanampatnam, Sonnakuppam, Tirumalavasal, Tranquebar and Akkaraipettai were selected. The selection of these villages was not made at random, but was such as to represent the region as faithfully as possible. Each of the villages was visited by a survey assistant for three consecutive days every week during the fishery season. During each day of his visit he observed 20% of the operating catamaran for examining the catch. He also enumerated the total number of operating catamaran and ascertained the total number of fishing days during the week.

In 1954 the fishery started from the last week of May and lasted till the third week of July. The above plan of sampling was carried out during the period.

Besides this programme of work, samples of fish were taken at different places of observations for length measurements, sex determination and for study of maturity and stomach contents.

Method of Estimate

The average catch per "Kola catamaran" was first determined from the samples of each group of villages. Since the total number of "Kola catamarans" available in each of the two groups of villages is known, the number of operating catamarans per day in each of the two groups was then determined by methods of ratio estimate from the knowledge of existing catamarans in the sampled villages and the observed number operating in those villages. From these the total estimated landings at each group of villages were obtained and are shown in Table I.

Table I

Group of villages	Average catch per catamaran per day in lb. ($\bar{y}$)	Average No. of catamaran operating per day (N')	No. of fishing days	Total estimated catch in tons
I	491·18	39·66	10	87
II	236·73	300·71	55	1,748
			Total	1,835

Percentage Error

The error in the estimate of landings would involve a combination of the error in the average catch per catamaran and the error in the estimate of working catamarans. Before proceeding to estimate the error, it must be mentioned that since the sampled villages were not chosen at random, it is not strictly possible to estimate the errors involved in the estimate. However, to get an idea of the nature of the magnitude of the error at different stages of sampling, we may proceed with the assumption that the villages were chosen at random. The analysis of variance of catamaran-catch figure in the second group of villages is presented below:

Analysis of variance of catamaran-catch

Source of variation	D.F.	S. of sq.	M. sq.
Between villages	4	2710,562	677,640
Between weeks within villages	23	7248,006	315,131
Between days within weeks	38	4337,408	114,142
Between observations within days ..	189	5432,651	28,744

It is seen that variations between villages, weeks within villages and days within weeks are all significant. For the second group of villages the multi-stage variance of the average catch per boat ($\bar{y}$) was found to be 1,410, *i.e.*, the percentage error of $\bar{y}$ is about 16. In a similar way, the variance of the number of operating catamarans N′ was found to be 51·60, *i.e.*, the percentage error of N′ is about 17. Combining these two, we find, that the error in the estimation of landings for the second group of villages comes to be 2%.

The data in the first group of villages are not sufficient to permit an estimate of error. Since the total estimate in the first group is very small, it follows that even a large error in this estimate would not affect the error of the overall estimate, which we may take as 23%.

From the above results, it is seen that to obtain a sufficiently accurate estimate, it will be necessary to stratify the villages in groups in geographical order and to take observations in each group in all weeks.

Landings

The estimated landings of flying-fish for the five years from 1950–54 are as follows:—

Total landings of flying-fish

		Tons
1950	..	1,478
1951	..	1,184
1952	..	581
1953	..	325
1954	..	1,835

It will be observed that the catch during the 1950 season was quite good. The landings in 1951 were also fair, but that in 1952 and 1953 were very poor. In 1954 there was a recovery of the fishery.*

It will be seen from Table I that in 1954 the average catch per catamaran in the first group of villages, *i.e.*, the villages in the neighbourhood of Madras was much higher than that in the southern group of villages. However, the fishery was very short-lived in the northern group of villages. In the 1953 season also, the average catch per catamaran in the northern group of villages was higher than that in the southern where the catch was exceptionally poor, but unlike in 1954 the duration of the fishery was longer in the north than in the south. The same trend was noticed in 1952 and 1951.

Length-Frequency

From the year 1953, samples of *Cypsilurus coromandelensis* were taken from the commercial fish catches and the total length of each fish in the sample was measured. The length-frequency distributions of these measurements are given in Tables II and III.

It will be seen from the tables that the length of the fish in the commercial catch varies from 170–260 mm. About 95% of the fish, however, have their total lengths confined within the range of 190–230 mm. In 1954, the modal size of the fish at the four places was within the interval of 200–209 mm. In 1953, the modal size at Akkaraipettai was again in the interval 200–209 mm., but at the other two places of observations it was a little higher and was in the interval 210–219 mm. Combining data for all the centres for each year (*see* Fig. 1), the fish attained a modal size of 215 mm.

* The fishery further improved in 1955. The figure of catch of flying-fish in 1955, which was obtained subsequent to the writing of this paper, was estimated at 3,177 tons.

TABLE II

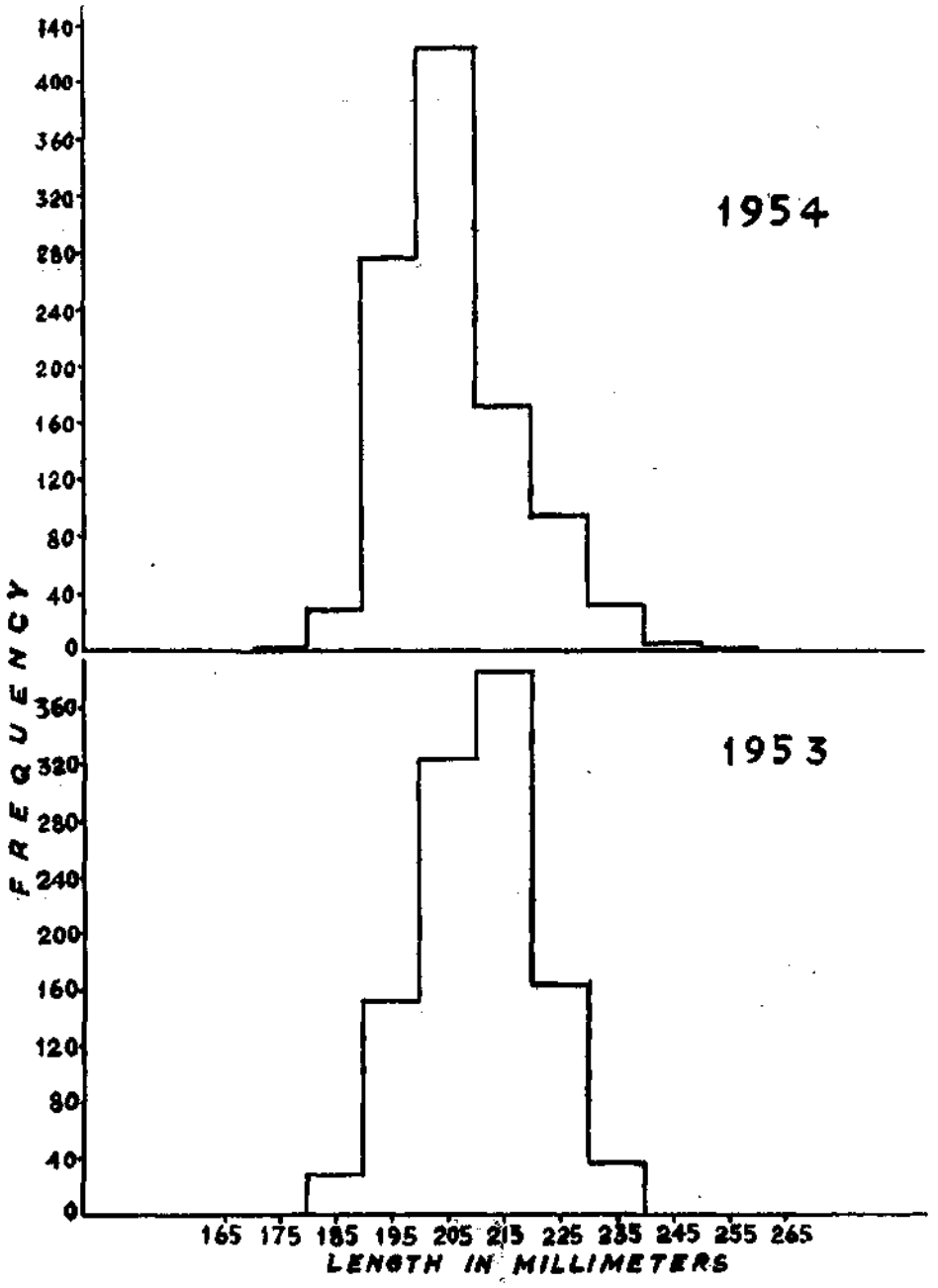
Length-frequency table of 1954

Size in mm.	Name of place				Total
	Akkarai-pettai	Tranque-bar	Tirumala-vasal	Sonna-kuppam	
170–179	..	..	..	1	1
180–189	3	1	12	12	28
190–199	27	31	137	80	275
200–209	120	37	143	125	425
210–219	57	11	42	70	180
220–229	25	4	7	59	95
230–239	7	..	..	29	36
240–249	1	..	..	3	4
250–259	..	..	..	1	1

TABLE III

Length-frequency table of 1953

Size in mm.	Name of place			Total
	Akkarai-pettai	Sonna-kuppam	Roya-puram	
180–189	..	20	8	28
190–199	22	92	39	153
200–209	99	165	58	322
210–219	85	210	91	386
220–229	39	87	38	164
230–239	7	22	6	35



Cypsilurus Coromandelensis

in 1953 and 205 mm. in 1954. This slight variation in the modal length may be due to inadequate sampling or may be real. From the data at hand,

we have no evidence of either geographical or annual variation in the size of the fish in the commercial catch.

Sex Ratio

In the 1954 survey, samples of *C. coromandelensis* were taken from four places to estimate the sex ratio in the commercial catch. The relevant figures are given in Table IV.

Table IV

Showing the sex-ratio

Name of place	No. of sample	Male	Female	% Male
Akkaraipettai	37	22	15	59·46
Tranquebar	507	357	150	70·41
Tirumalavasal	335	257	78	76·72
Sonnakuppam	1,682	1,372	310	81·57

One common feature, observed in all the four places, was the preponderance of males over the females in the commercial catch. The percentage of males at Akkaraipettai is about 60, while that in the other three places is above 70. The small sample at Akkaraipettai may account for the rather low percentage of the males.

In the 1954 survey, a sample of 421 fishes were taken at Tranquebar and they were classified according to sex and lengths to find out whether the size of the fish varied according to sex. The classified data are presented in Table V.

From the figures of percentage frequency in the table, it will be seen that there is no significant difference in the distribution of size-frequencies between males and females.

The overall percentage of males in the whole sample is 72·92. The percentages of males in the different size-classes are also shown in the last column.

The x^2 test fails to show any significant difference in sex percentages in the different size-groups.

Thus it is seen that there is neither any geographical nor any annual variation in the size of flying-fish in the commercial catch. The size-distri-

TABLE V

Size	Males		Females		% Males (= p)
	Frequency (= a)	% Frequency	Frequency (= b)	% Frequency	
180–189	10	3·26	2	1·75	83·33
190–199	122	39·74	38	33·33	76·25
200–209	133	43·32	54	47·37	71·12
210–219	36	11·73	15	13·16	70·58
220–229	6	1·95	5	4·38	54·54
TOTAL n =	307		114	$\bar{p}$ =	72·92
				$\bar{q}$ =	27·08

bution of males and females are of the same pattern. The males generally occur in greater proportion and the same sex-percentage is observed in different size-groups.

MATURITY AND STOMACH CONTENTS

Majority of the female specimens examined were found in the spent condition. A few ripe females revealed the size of the ripe ova varying from 1·7–2·1 mm. in diameter. Practically all male specimens were found fully mature and in the process of shedding milt. The number of spent males was increasingly high in July. It is probable that the spawning activity is at its height in June and gradually diminishes and comes to an end in the later part of July.

The stomach in most of the fishes examined during the season was found empty. It is likely that the fish do not eat during the spawning period.

MARKETING, PRICE-STATISTICS AND DISPOSAL

The wholesale price of the fish varies from Rs. 17–30 per thousand fish, the average price being Rs. 25 per thousand fish. In 1953 the wholesale price touched Rs. 50 per thousand fish due to very poor catch. Calculated at the rate of Rs. 25 per thousand fish, the value of the total catch in 1954 would be about Rs. 9,25,000. The earnings of a catamaran during the two-month season would come to Rs. 1,122 and the earning per fisherman per month to Rs. 112.

Merchants come to the landing place and purchase the fish as soon as they are landed. The disposal takes place by counting. The tainted fish are sun-dried on the beach. Both the fresh and sun-dried fish are sent by rail and road to inland places where this fish has a lucrative market.

Summary

Flying-fish fishery is a very important seasonal fishery along the Coromandel coast, contributing a great deal towards the economic condition of the fishermen of this region. A survey of the fisheries along the coast from 1950 to 1954 showed that the total landings of this fish vary a great deal from year to year. Investigations to associate this annual variation of catch with some simpler biological characteristics like the size of the fish, sex-ratio, etc., failed to show any correlation. Neither geographical nor annual variation in the size of the flying-fish was noticed in the commercial catch. The size-distribution of the males and females was of the same pattern. The males generally occurred in greater proportion and the same sex-proportion was observed in different size-groups.

The majority of the female specimens were found in the spent condition, but practically all male specimens were found fully mature in June and the number of spent males was increasingly high in July, indicating the probability of high spawning activity in June.

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