Relative Abundance and Distribution of Adult Flyingfish in the Eastern Caribbean

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ABSTRACT

A total of 31,264 flyingfish adults were recorded during 160 hours of visual survey, which covered 950 nautical miles along 34 straight-line transects throughout the eastern Caribbean.

Flyingfish abundance varied significantly over the survey area with low abundance (abundance index < 10 fish/0.5nmi) along the windward side of the Lesser Antilles island chain and high abundance (abundance index > 10 fish/0.5nmi) along the leeward side of the island chain and to the windward side of Barbados and Tobago. Flyingfish abundance did not decrease along the east or west boundaries of the survey area, suggesting that the resource extends beyond the survey area and well beyond the area presently fished by local flyingfish fleets.

Airborne fish were identified as to species by experienced observers on a subset of transects. The commercially important species, *Hirundichthys affinis*, comprised 46.1% of the flyingfish observed over the survey area, whilst *Parexocoetus brachypterus* and *Cypselurus cyanopterus* comprised 52.9 and 1.0%, respectively. Mean airborne school size varied with species, being 4.1 (fish/0.5 nmi) for *P. brachypterus*, 2.6 for *H. affinis*, and 1.1 for *C. cyanopterus*.

The validity of a visual survey technique for estimates of relative abundance of flyingfish was supported. Observations from port and starboard viewing windows were significantly correlated, indicating that the proportion of fish taking to the air at the approach of the survey vessel was similar on both sides of the vessel. Furthermore, there were no significant differences in numbers of flyingfish observed under different viewing conditions (determined by sun position relative to observer), different sea conditions for flyingfish take-off (determined by vessel travel direction relative to waves), and at different times of day, indicating that these variables do not affect the reliability of the method in producing an index of abundance.

INTRODUCTION

The small island states of the eastern Caribbean typically have limited agricultural land area, increasing local and tourist populations, and severe trade imbalances. Consequently, they are under pressure to increase local production of protein. As a result, attention is being focused on expansion of local fishing fleets, and inter-island conflicts are emerging over fishing rights. Fisheries resource mapping is increasing in importance as a basis for geographical expansion of fishing fleets and resolution of conflicts over fishing rights.

Flyingfish is the most important fishery resource in the eastern Caribbean, yet the geographical extent of the resource and, consequently, the feasibility of geographical expansion of the flyingfish fisheries remains unknown (Mahon *et al.*, 1986)

In this study a visual survey technique was investigated as a means of quantitatively assessing the distribution and relative abundance of flyingfish in the eastern Caribbean and commenting on the feasibility of geographical expansion of the flyingfish fisheries.

METHODS

Flyingfish adults in the eastern Caribbean were surveyed visually from the Caribbean Fisheries Training and Development Institute (CFTDI) research vessel, the 24 m RV *Provider*. The commercially important species of flyingfish, *Hirundichthys affinis*, is abundant in the eastern Caribbean only between January and June (Mahon *et al.*, 1986). The survey took place from April 10 to May 6, 1988, during the period of peak abundance. The survey track, which encompassed the known fishing areas for flyingfish, is shown in Figure 1. The survey was conducted only during daylight hours (5:00 – 19:00 hrs) at vessel speeds of 5 – 8 knots. Two viewing posts were established on top of the bridge, one looking to port, the other to starboard. Observers sat in a fixed location at each post and viewing windows were framed by the railing uprights of the vessel. Observations were made from both viewing posts by a rotating team of three observers. Each observer would view for one hour and rest for 30 minutes, such that observations were continuous and synchronised between port and starboard viewing posts along each transect. All airborne flyingfish observed through the specified viewing windows were recorded, as were the number of fish in each school and the number of schools seen every 5 minutes. School sizes of more than 15 individuals were estimated to the nearest 5 and those over 30 were estimated to the nearest 10.

Experienced observers could differentiate between three species of flyingfish and recorded them separately. *Cypselurus cyanopterus* was recognised by its large size and dark brown "wings". *Parexocoetus brachypterus* was recognized by its small size, translucent wings, and under ideal viewing conditions, by its long, spotted dorsal fin. *Hirundichthy affinis* was recognized by its medium size and translucent wings. When viewing conditions were difficult (*i.e.*, when looking into early morning or late evening sun), or when observers were inexperienced, no attempt was made to identify to species level.

Physical parameters considered to have a possible effect on the viewing efficiency of observers or on the fright response of the fish were recorded hourly. These were sun position relative to observer, direction of vessel travel relative to waves, and time of day.

The number of fish recorded in each 5 minute interval was standardized to a travel distance of 0.5 nmi (*i.e.*, the distance traveled in 5 minutes at 6 knots),

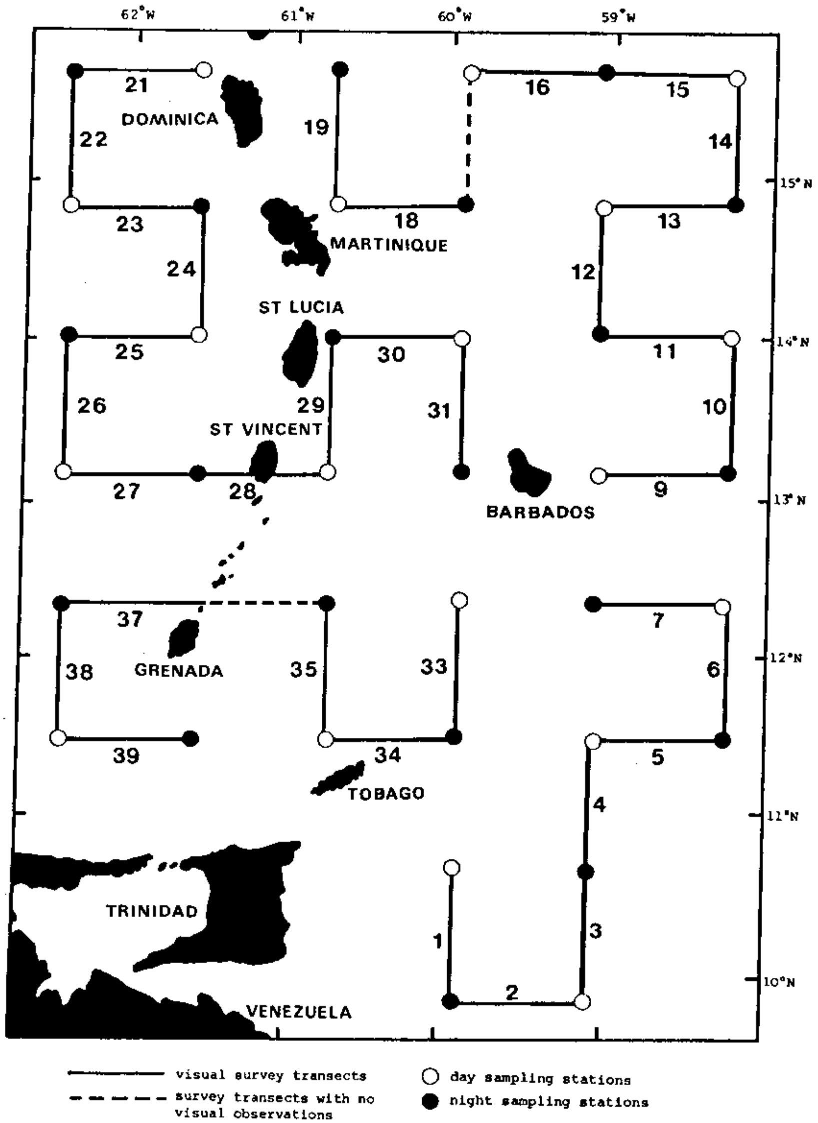

Figure 1. Cruise track for RV Provider in the eastern Caribbean showing the visual survey transects.

thus giving a standard index of flyingfish abundance. This was done by multiplying the number of fish recorded every 5 minutes by an adjustment factor (between 0.73 and 1.22) according to the actual speed of the vessel. The mean number of fish/0.5nmi was calculated for each transect, and port and starboard transect means were compared using Spearman's rank correlation. Since port and starboard means were significantly correlated, the data were combined to give a single index of abundance. Out of a total of 1,908 paired observations there were 14 missing port observations and 18 missing starboard observations. Missing port observations were filled by multiplying the starboard observation by 0.81 (the port mean/starboard mean), and missing starboard observations were filled by multiplying the port observation by 1.23 (starboard mean/port mean). The effects of physical parameters on the abundance index were examined using Kruskall Wallis tests to compare the mean number of flyingfish/0.5nmi observed under different conditions.

RESULTS

A total of 31,264 flyingfish adults were recorded during 160 hours of simultaneous port and starboard observations along 34 straight-line transects, covering 950 nmi of the eastern Caribbean. The mean number of fish observed per 0.5 nmi was taken as an index of flyingfish abundance. The overall mean abundance viewed from the port window was 7.23 fish/0.5nmi, and from the slightly larger starboard window was 8.97 fish/0.5nmi. Port and starboard transect means were very closely correlated ($r_s = 0.727$, $P < 0.0001$; Table 1) and were therefore pooled. The overall mean abundance index for pooled data was 16.25 fish/0.5nmi.

Flyingfish abundance varied significantly across the survey area (among transects: $H_c = 613.52$, $P < 0.0001$; Table 1, Figure 2). Abundance appeared to be relatively low (< 10 fish/0.5nmi) in a patch off the east coast of Venezuela, and in a band between the Lesser Antillean island chain and Barbados and Tobago. Abundance appeared to be relatively high (> 10 fish/0.5nmi) to the west of the island chain in the Caribbean, and in the Atlantic to the east of Barbados, Trinidad and Tobago (Figure 2).

The overall species composition of flyingfish observed over the eastern Caribbean was 52.9% *P. brachypterus*, 46.1% *H. affinis* and 1.0% *C. cyanopterus*.

Although the overall abundance of *H. affinis* in the eastern Caribbean appears to be less than that of the non-commercial species *P. brachypterus*, the number of *H. affinis* schools observed per transect was higher. Mean airborne school size varied significantly between species ($H_c = 53.96$, $P < 0.0001$), being 4.1 (fish/0.5 nmi) for *P. brachypterus*, 2.6 for *H. affinis*, and 1.1 for *C. cyanopterus*.

Table 1. Indices of flyingfish abundance in the eastern Caribbean by transect. Data presented separately for port and starboard observations and combined to give an overall index of abundance (see Figure 1).

Transect no.	Mean No. fish/0.5nml Port	Starboard	Overall
1	2.90	3.10	6.00
2	4.35	4.00	8.35
3	7.76	11.94	19.70
4	14.49	14.89	29.38
5	22.49	25.14	47.63
6	5.27	6.33	11.60
7	5.48	10.91	16.39
9	5.40	10.72	16.12
10	9.09	7.18	16.27
11	17.22	14.37	31.59
12	4.81	1.53	6.34
13	3.60	4.22	7.82
14	6.11	6.19	12.30
15	4.63	6.29	10.92
16	4.37	2.96	7.33
18	3.31	8.35	11.66
19	0.97	3.02	3.99
21	7.85	8.33	16.18
22	8.48	18.48	26.96
23	13.23	11.98	25.21
24	10.54	7.96	18.50
25	16.39	24.30	40.69
26	9.60	5.24	14.84
27	11.43	22.51	33.94
28	0.97	0.82	1.79
29	1.19	3.58	4.77
30	0.28	0.43	0.71
31	3.94	2.68	6.62
33	16.24	18.51	34.75
34	7.36	4.55	11.91
35	1.74	6.18	7.92
37	1.85	3.02	4.87
38	0.15	9.90	10.05
39	5.43	4.97	10.40
Mean	7.23	8.97	16.25

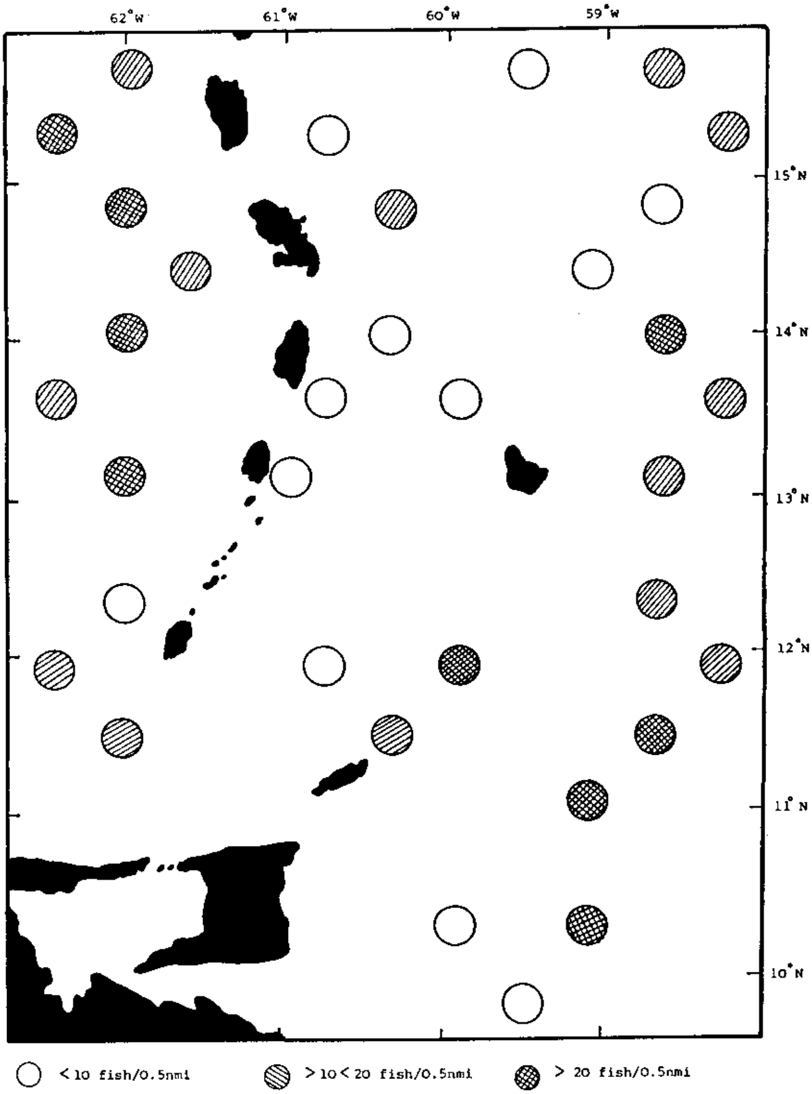

Figure 2. Relative abundance of flyingfish in the eastern Caribbean by transect.

The number of fish observed did not differ significantly under different viewing conditions (sun overhead, in front or behind; $H_c = 2.66$, $P = 0.430$), different sea conditions for flyingfish take-off (vessel traveling into, away from, or parallel to waves; $H_c = 0.09$, $P = 0.957$), or different times of day (early morning 5:00 – 9:00 hrs, midday 10:00 – 14:00 hrs, or late afternoon 15:00 – 19:00 hrs; $H_c = 0.79$, $P = 0.673$). This suggests that neither sun position, sea conditions, nor time of day have any significant effect on the abundance index.

DISCUSSION

Using the number of airborne flyingfish observed as an index of flyingfish abundance assumes that the proportion of the school taking to the air at the approach of the survey vessel is constant. This assumption underlies all previous visual surveys of flyingfish abundance (Shuntov, 1973; Nesterov and Grudtsev, 1980; Zuyev and Nikol'skiy, 1980; Khokiattiwong, 1989), but has never been adequately tested. The fact that port and starboard observations were highly correlated in the present study suggests that random variation in the proportion of the school taking to the air is not marked enough to invalidate the use of visual surveys in estimating relative abundance of flyingfish.

The proportion of the school taking to the air at the approach of a vessel will probably vary with vessel size and type (Freon, 1992) and with distance from the vessel (Zuyev and Nikolsk'skiy, 1980). However, since the same vessel was used throughout the survey and the distance from the vessel was standardized by having specified viewing windows, these factors are unlikely to affect the validity of the abundance indices obtained in this study. Similarly, effects of sun position on observer accuracy, and time of day and wave direction on flight response of fish, did not affect abundance indices in this study.

The data suggest that flyingfish are patchily distributed on several spatial scales, occurring together in schools which vary in their distribution and size. The relatively high abundance of flyingfish to the west (downcurrent) of the island chain (Figure 3) may result from eddies and turbulence downcurrent of islands (Emery, 1972; Powles, 1975). Turbulence may result in mixing of nutrients from deeper water, increased productivity of plankton, and hence increased abundance of zooplankton on which flyingfish feed. Eddies may concentrate both zooplankton and the floating material on which flyingfish spawn. However, abundance was also high in the Atlantic to the east (upcurrent) of Barbados, Trinidad, and Tobago. The influence of coastal rivers on salinity and turbidity of nearshore surface waters off the east coast of Venezuela may contribute to the low abundance of flyingfish recorded there.

The flyingfish fishing fleets of the eastern Caribbean islands presently fish across areas of both high and low flyingfish abundance (Figure 3). This suggests that even in areas of low abundance *H. affinis* may be sufficiently abundant to maintain viable fisheries or that patches of flyingfish move around within the

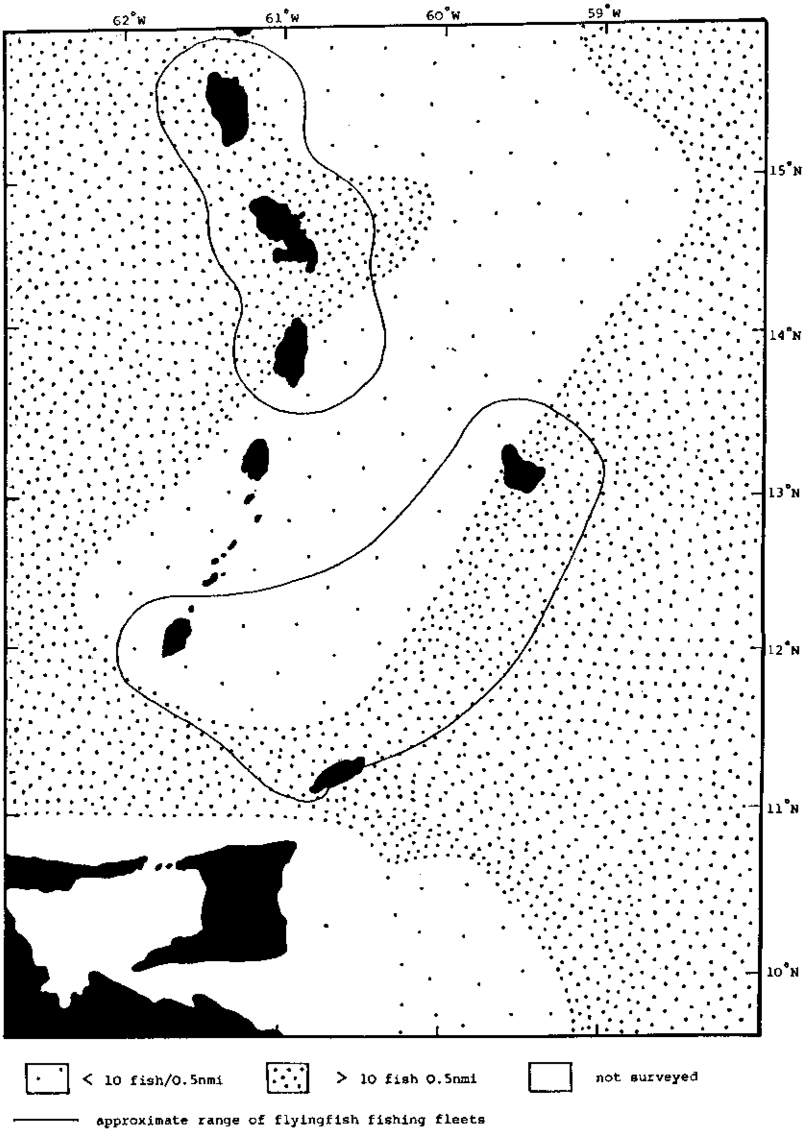

Figure 3. Approximate range of flyingfish fishing fleets and areas of relative abundance of flyingfish in the eastern Caribbean.

survey area. Since areas outside the present fishing grounds have similar flyingfish abundance as areas which are currently fished, flyingfish fleets could probably expand their range of operations and still maintain acceptable catch rates. Furthermore, flyingfish abundance did not appear to decrease towards the east and west boundaries of the survey area, suggesting that the resource extends beyond 100 nmi west of the Lesser Antilles island chain, 100 nmi east of Barbados, and 150 nmi east of Tobago. Species composition data indicated that *H. affinis* and *P. brachypterus* are relatively common and *C. cyanopterus* is relatively scarce. However, abundance indices may not be comparable between species since the proportion of fish taking to the air may vary between species. Airborne school sizes differed between species, but this again may not reflect real differences in the school sizes since the proportion of a school taking to the air may vary between species.

Estimating absolute abundance of flyingfish from visual survey techniques requires that the proportion of the school taking to the air in response to a particular vessel over a range of conditions be known. Some studies have calculated "absolute abundance" from fish observed (*e.g.*, Nesterov and Grudstev, 1980), whilst others have used apparently arbitrary correction factors (*e.g.*, Shuntov, 1973). Zuyev and Nikol'skiy (1980) were able to determine, under ideal viewing conditions that allowed fish above and below the water to be seen simultaneously, that no more than 20% of the school took to the air in an area extending 25 m from the vessel. However, it is likely that the proportion taking to the air will differ between boats and between species, such that correction factors from one study will be of little value in estimating absolute abundance from visual census data in another.

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