Preliminary Tagging Results on the Four-Wing Flyingfish *Hirundichthys affinis* in the Eastern Caribbean

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ABSTRACT

A method of tagging and releasing *Hirundichthys affinis* in good condition is described. During the 1988 fishing season, a total of 3559 flyingfish were tagged and released at three locations in the eastern Caribbean: Barbados, Dominica and Tobago. Recapture rates for fish released early in the fishing season were 6.0% for fish released off Tobago, 4.3% for fish released off Barbados, and 0.5% for fish released off Dominica. The recapture rate for fish released off Tobago late in the fishing season was 1.3%. The greatest recorded displacement of a tagged fish was 200 nm, and the fastest estimated speed greater than 16 nm/day. The longest period at large before recapture was 121 days, and the mean time was 21 days. Although many fish (55%) were recaptured near their point of release, there appears to be considerable mixing between islands. Twenty-two percent of all recaptures were in territorial waters other than those in which the fish were released. Fish released off Barbados were recaptured in all of the other eastern Caribbean islands with flyingfish fisheries, but most recorded movement was northwest. The fish which moved away from Tobago travelled in a west northwesterly direction, and those from Dominica were recaptured to the south. Whether fish also moved in other directions could not be ascertained.

INTRODUCTION

The four winged flyingfish, *Hirundichthys affinis,* is an important resource in the eastern Caribbean, being the primary or secondary species landed by the commercial fisheries of all islands except St. Vincent (Mahon *et al.,* 1986). However, very little is known about the stock structure of the species and resource management is not practised although fishing fleets in the area continue to expand.

Tagging programs can be used to determine migration patterns, population size, and mortality rates (Jones, 1977; White *et al.,* 1982). For an open oceanic population which is commercially fished by several different fisheries, as is the case for flyingfish in the eastern Caribbean, such information is more difficult to obtain by tagging. However, tag returns do provide valuable information on movements of individual fish and in collaboration with other data, may allow determination of stock structure and estimates of population size. These in turn have important implications for management of the resource.

There is considerable seasonal variation in availability of flyingfish in the eastern Caribbean (Mahon *et al.,* 1986). One explanation for this is seasonal migration. In spite of the scarcity of tagging data, various migration hypotheses

have been proposed (Brown, 1942; Hall, 1955; Mahon *et al.*, 1981; Hunte and Mahon, 1982; Storey, 1983). These typically assume that eggs, larvae and juveniles are either retained in the lee of islands by eddies or drift in a general west northwesterly direction, and that adults move in an east southeasterly direction to counteract the drift. Previous attempts at tagging *H. affinis* (Mulloney, 1961; Lewis, 1964; Barroso, 1967) were small-scale. The tag returns demonstrated only that flyingfish can survive tagging and that some individuals remain in the release location for up to 50 days. The purpose of the present study is to investigate the direction and extent of movement of individual flyingfish in the eastern Caribbean by tagging and releasing flyingfish at three widely spaced locations across the region.

MATERIALS AND METHODS

Flyingfish were tagged and released off Barbados, Tobago and Dominica near the beginning of the 1988 fishing season, and off Tobago near the end of the 1988 fishing season. A total of 859 fish were tagged and released off the west coast of Barbados from January 17-24th, 806 off the north coast of Tobago from January 30th to February 2nd and 979 off the west coast of Dominica from February 8-11th. A further 915 fish were tagged and released close to the northwest coast of Tobago from May 16-20th. The release positions were determined by dead reckoning, radio direction finder or satellite navigator, depending on the distance from shore and the equipment available on the tagging vessel. The recapture positions were determined by fishermen at the time of recapture.

Flyingfish were attracted to the tagging vessel by use of FADs (coconut fronds, cane trash, bamboo or gillnetting) and by 'chumming' (release of chopped or crushed fish into the water). When fish had aggregated, the capture was initiated using fine barbless hooks baited with flyingfish flesh. As soon as fish began spawning on the FADs, they were easy to capture using handheld dipnets. Captured fish were placed with minimal or no handling into a large circular tub of fresh seawater and tagged immediately. Each fish was carefully restrained head down in the water by gently grasping the head and 'wings' with one hand and the tail with the other hand. A second person could then attach the tag using a short length of vinyl thread stitched through the dorsal musculature in front of the dorsal fin and fastened by a reef knot (Figure 1). Individually numbered, small (5 x 3 mm), brightly coloured plastic tags (Floy Tag FTF-69) were used. These tags are designed for use on fingerlings (size 100 mm) and were chosen to minimize drag and swimming/flight interference of the flyingfish (size range 190-250 mm). The tag wound was minimized by using a fine sewing needle, and scale loss was kept to a minimum (1 to 3 scales per fish) by handling the fish with cotton gloves.

An interperitoneal antibiotic injection of oxytetracycline (100 mg/kg body

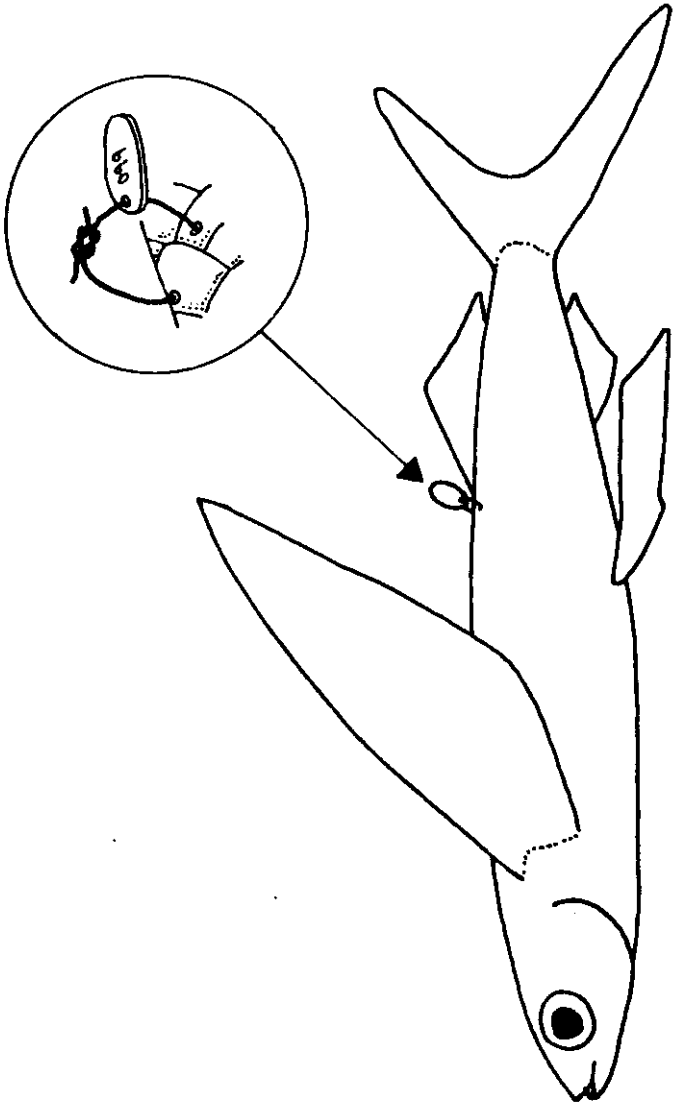

Figure 1. Diagram showing attachment and type of tag used on the flyingfish *(Hirundichthys affinis).*

weight) was administered to approximately one third of the tagged fish primarily for an aging validation study, but also to help prevent infection that might result from tagging. The tagging procedure took approximately 30 seconds per fish. Tagged fish were released immediately and were observed to rejoin the school around the vessel.

Few fish were recaptured by the tagging team, since tagged fish could be observed swimming into the dipnet and could therefore be easily rejected before raising the net from the water. Predators (particularly dolphin *Coryphaena hippurus*) which were also attracted to the FADs were a problem, since they not only scattered the flyingfish school, but were also observed to eat a few of the tagged specimens. In most cases, aided by the clarity of the water and through the use of live bait, predators were caught. Failure to catch the predators would end the day's tagging since the flyingfish school would disperse. The tagging program was widely publicized in English and French by placing tag reward posters (Figure 2) at all landing sites, markets, fishery offices and fish processing plants across the eastern Caribbean. Local newspaper articles and local and regional radio interviews in English, French and Creole were also used. A $20.00 (local currency) reward was offered for tags returned with the intact fish and $15.00 for the tag alone.

The method of capture, tag number, time, place and date of release, and whether an antibiotic injection was administered was recorded for each tagged fish. Returned fish were measured for fork length, and the sex and maturity state were recorded. The otoliths were removed from all those which had received a tetracycline injection and were stored for later analysis.

RESULTS

Tag detection in commercial catches was good. Sixty-seven percent of returned tags were detected by fishermen who were able to give precise information on the date and place of capture, and 6.8% by vendors who were able to provide the date and approximate area of capture. Less information was obtained from the 1.9% that were not detected until consumer purchase and the 24.3% which were found by commercial processors. With the latter, days at large could only be estimated as being less than the number of days between tagging and tag detection, since up to two weeks could have elapsed between capture and tag detection. In most cases, processors had bought the flyingfish directly from 'ice-boats' known to be fishing in the area between Barbados, Grenada and Tobago. However, since the place of capture could not be defined any more accurately than this, it was recorded as unknown.

Infection resulting from tagging is believed to have been minimal since all but one of the returned fish were in excellent condition. Moreover, there was no apparent difference in post tagging survival of those fish which were captured at the time of tagging by barbless hook and those captured by dipnet ($X^2 = 1.9737$,

Figure 2. The tag reward poster used in the present study for flyingfish in the eastern Caribbean.

$v = 1$, $P > 0.1$), nor between fish receiving an antibiotic injection and those which did not ($X^2 = 1.8198$, $v = 1$, $P > 0.1$).

The total number of tag returns by the close of the 1988 fishing season was 103. This is an overall recapture rate of 2.9%. Recapture rates varied with time and place of release. Near the start of the season, recapture rates for fish released off Dominica were 0.5%, for Barbados 4.3%, and for Tobago 6.0%. The recapture rate for fish released near the end of the season off Tobago was 1.3%.

The area of release and recapture, and the number of days at large are presented in Table 1. The longest recorded period at large before recapture was 121 days. The mean, using only fish for which the exact date of recapture was known, was 20 days. A summary of the recapture data is given in Table 2. Many tagged fish (55%) appeared to remain in the vicinity of their release. The mean time at large for these fish was 19 days, but some were at large for up to 4 months (Table 1). The apparent small-scale movements made by the fish remaining in the vicinity of their release are shown in Figure 3.

Although 55% of the fish were recaptured in the vicinity of their release, large-scale dispersal and consequent mixing of tagged fish between islands also occurred. Twenty-two percent of all recoveries were in territorial waters other than those where the fish were released (Table 2). The greatest recorded distance travelled by a tagged fish was 200 nm (from Dominica to Grenada) and the estimated greatest speed in excess of 16nm/day (from Barbados to Martinique in less than 7 days). Some fish were observed to travel to other islands very quickly after their release, while others were recaptured in other islands up to 53 days after release. The mean time at large for fish travelling between islands was 22 days. The migrations made by fish dispersing from their place of release to other islands are shown in Figure 4.

DISCUSSION

The overall recapture rate in this study was good compared with some other studies of oceanic pelagics in the Caribbean (*e.g.* Mather *et al.*, 1972; Beardsley *et al.* , 1972; Bertolino, 1985) and especially for a small, active, short-lived species. Two common problems with tagging programs are to obtain, tag and release the fish in good condition, and to ensure that recaptured fish tags are returned with information on the date and place of capture (Jones, 1977). The capture method used in this study caused minimal stress since the fish simply swam into the handheld dipnets. Moreover, the tagging method ensured a short retention time onboard. Consequently, the fish were released in good condition. From the perspective of recovering fish tags, it is fortunate that the eastern Caribbean flyingfish fisheries are largely artisanal. As a consequence, each fish is individually handled by the fisherman either at capture (hand picked from the gillnet) or at selling (individually counted), such that the detection rate by fishermen is high, despite the small size of the tags. Tag detection by fishermen

Table 1. Release and recapture data for flyingfish (*Hirundichthys affinis*) in the eastern Caribbean. The place of release and recapture is given by direction and number of miles from shore. (BDS=Barbados, DOM=Dominica, TOB=Tobago, GND=Grenada, MART=Martinique,VIN=St. Vincent,LUC(IA)=St. Lucia).

Release		Recapture		Release	Days at
Island	Place	Island	Place	date	large
BDS	WSW30	BDS	W15	180188	5
BDS	WSW30	BDS	W12	180188	28
BDS	WSW30	BDS	S11	180188	8
BDS	WSW30	BDS	W	180188	8
BDS	WSW30	BDS	NW	180188	16
BDS	WSW30	?	?	180188	>28<50
BDS	WSW30	BDS	W14	180188	19
BDS	WSW30	BDS	W15	180188	5
BDS	WSW30	BDS	W7	180188	10
BDS	WSW30	BDS	W15	180188	5
BDS	WSW30	BDS	?	180188	121
BDS	WSW30	LUCIA	SW	180188	22
BDS	WSW30	?	?	180188	9
BDS	WSW30	BDS	W12	180188	15
BDS	WSW30	BDS	?	180188	<42
BDS	WSW30	DOM	N	180188	53
BDS	WSW30	BDS	N	180188	31
BDS	WSW30	LUCIA	W	180188	21
BDS	WSW30	BDS	NW	180188	<56
BDS	WSW30	BDS	W	180188	7
BDS	WSW30	LUCIA	W	180188	29
BDS	WSW30	LUCIA	SW	180188	23
BDS	WSW30	LUCIA	W	180188	24
BDS	WSW30	TOB	?	180188	17
BDS	WSW30	LUCIA	NW	180188	21
BDS	WSW30	LUC/VIN		180188	17
BDS	WSW30	BDS	W	180188	7
BDS	WSW30	BDS	?	180188	20
BDS	WSW30	BDS	WSW11	180288	20
BDS	W20	GND	W	240188	21
BDS	W20	BDS	SW19	240188	6
BDS	W20	BDS	W14	240188	13
BDS	W20	BDS	W10	240188	<8

Table 1. Ctd.

Release		Recapture		Release	Days at
Island	Place	Island	Place	date	large
BDS	W20	MART	W	240188	<7
BDS	W20	BDS	W14	240188	18
BDS	W20	BDS	W9	240188	8
BDS	W20	BDS	W15	240188	<7
DOM	W10	GND	?	90288	62
DOM	W10	GND	?	90288	<85
DOM	W	DOM	NW	110288	7
DOM	W	LUCIA	?	110288	<54
DOM	W	GND	?	110288	20
TOB	NE35	?	?	300188	>16<38
TOB	NE35	GND	W12	300188	15
TOB	NE35	TOB	?	300188	<12
TOB	NE35	?	?	300188	>16<38
TOB	NE35	GND	SW	300188	14
TOB	NE35	?	?	300188	>16<38
TOB	NE35	LUCIA	SW2	300188	12
TOB	NE35	?	?	300188	>16<38
TOB	NE35	TOB	?	300188	<112
TOB	N28	TOB	NW	10288	14
TOB	N28	?	?	10288	<8
TOB	N28	TOB	?	10288	<53
TOB	N28	TOB	N	10288	13
TOB	N28	?	?	10288	>14<36
TOB	N28	?	?	10288	>14<36
TOB	N28	?	?	10288	>14<36
TOB	N28	TOB	?	10288	<85
TOB	N28	?	?	10288	>14<36
TOB	N28	GND	NW10	10288	10
TOB	N28	GND	SW	10288	14
TOB	N28	?	?	10288	>8<36
TOB	N28	GND	E	10288	<35
TOB	N28	?	?	10288	>14<36
TOB	N28	TOB	W30	10288	11
TOB	N28	?	?	10288	>14<36
TOB	N28	GND	E12	10288	<13
TOB	N28	TOB	NW	10288	7

Table 1. Ctd.

Release		Recapture		Release	Days at
Island	**Place**	**Island**	**Place**	**date**	**large**
TOB	N28	GND	SW	10288	9
TOB	N28	TOB	?	10288	<53
TOB	N28	TOB	?	10288	<29
TOB	N28	?	?	10288	<8
TOB	N28	TOB	?	10288	<23
TOB	N28	?	?	10288	<8
TOB	N28	TOB	?	10288	>120<135
TOB	N28	?	?	10288	<10
TOB	N28	?	?	10288	>14<36
TOB	N28	?	?	10288	>14<36
TOB	N28	?	?	10288	<8
TOB	N28	TOB	?	10288	<77
TOB	N28	TOB	?	10288	<23
TOB	N28	?	?	10288	>14<36
TOB	N28	?	?	10288	>14<36
TOB	N28	TOB	?	10288	<85
TOB	N28	?	?	10288	>14<36
TOB	N28	TOB	NW8	10288	121
TOB	N28	?	?	10288	<8
TOB	N28	TOB	?	10288	<69
TOB	N28	?	?	10288	>14<36
TOB	NW4	TOB	?	180588	<14
TOB	NW3	TOB	?	180588	<36
TOB	NW4	TOB	?	180588	8
TOB	NW3	TOB	?	180588	<12
TOB	NW3	TOB	NW8	180588	14
TOB	NW3	TOB	?	180588	<44
TOB	NW3	TOB	?	180588	2
TOB	NW4	TOB	?	180588	<27
TOB	NW3	TOB	NW	180588	21
TOB	NW4	TOB	?	180588	<13
TOB	NW4	TOB	?	200588	<41
TOB	NW4	TOB	?	200588	<13
?	?	GND	W10	?	

Table 2. Summary of recapture records for tagged flyingfish, *Hirundichthys affinis*, released in the eastern Caribbean.

Release Island / Date	BARBADOS Jan. 1988	TOBAGO Jan/Feb 1988	DOMINICA Feb. 1988	TOBAGO May 1988	TOTALS/MEANS
General Data					
Total tagged	859	806	979	915	3559
Total recaptured	37	48	5	12	103*
% total tagged	4.3	6.0	0.5	1.3	2.9
Mean days at large	20.23 (n=31,SD=21.26)	21.82 (n=11,SD=32.99)	29.67 (n=3,SD=28.75)	11.25 (n=4,SD=8.14)	20.43 (n=49,SD=23.68)
Recapture in tagging area					
No. recap. in tagging area	25	17	1	12	55
% total recaptured	67.5	35.4	20.0	100.0	53.4
Mean days at large	18.05 (n=21,SD=24.76)	33.20 (n=5,SD=49.15)	7 (n=1)	-	19.25 (n=31,SD=28.01)
Recapture dispersed fish					
No. dispersed	11	8	4	0	23
% total recaptured	29.7	16.7	80.0	-	22.3
Mean days at large	24.80 (n=10,SD=10.49)	12.33 (n=6,SD=2.42)	41.00 (n=2,SD=29.70)	-	22.44
Unknown area					
No. recap. in unknown area	1	23	0	0	25*
% total recaptured	2.7	47.9	-	-	23.3

*These totals include 1 returned tag for which information regarding the colour and number were lost.

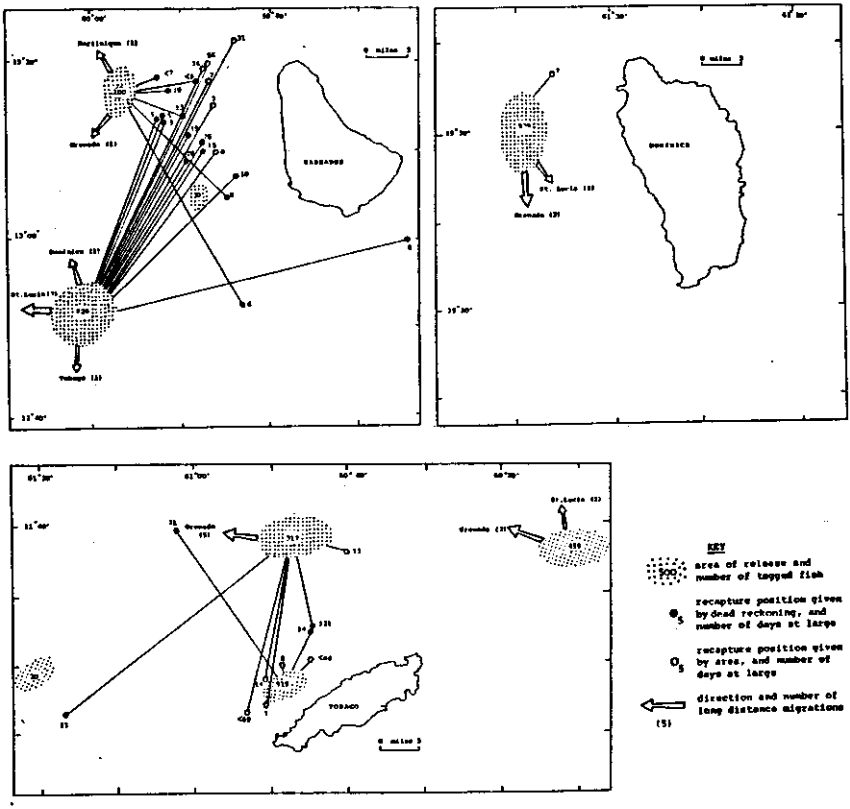

Figure 3. Maps showing approximate local migrations and dispersal of tagged flyingfish *Hirundichthys affinis* off Barbados, Dominica and Tobago. (The movements of 4 fish recaptured off Barbados and 11 off Tobago are not shown since only the country but not the position of recapture was known).

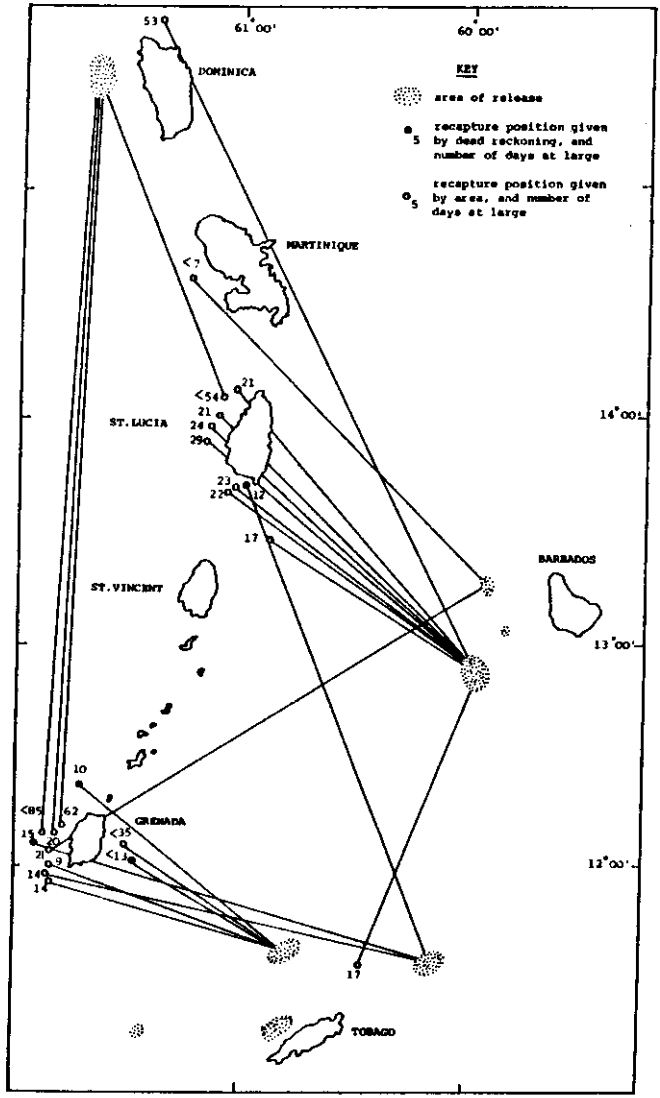

Figure 4. Map showing large scale dispersion migrations of tagged flyingfish *Hirundichthys affinis* in the eastern Caribbean.

was lowest for the Barbados 'ice-boats' which handle much greater quantities of fish than the traditional 'day-boats' and which tend to sell directly to commercial processors. However, even in this case, the fish are hand-processed (individually hand-filleted), and tag detection at this stage is highly likely.

In principal, tagging can give the clearest evidence of stock separation or mixing. Previous attempts at tagging flyingfish demonstrated only that some marked fish appeared to remain in the area of their release for up to 50 days off Barbados (Lewis, 1964) and 15 days off northeast Brazil (Barroso, 1967) (Table 3). However, these studies were limited in the number of fish tagged and in the area over which they were tagged, and the mean time at large was very small (Table 3). Based on the results of his tagging program, Lewis (1964) suggested that flyingfish were retained by eddy currents in the lee of Barbados. The present study also illustrates that some fish either remain in, or return to the vicinity of their release, since recaptures were made from the same area up to 4 months after release. However, there is evidence of considerable movement of fish between islands. Flyingfish which were tagged off Barbados were later recovered in all other territories in the eastern Caribbean, fish tagged off Tobago were recovered off Grenada and St. Lucia, and those tagged off Dominica were recovered off St. Lucia and Grenada. This suggests that there is probably one flyingfish stock in the eastern Caribbean with fish moving freely between islands. However, the possibility of several substocks remains possible. While some fish may remain in the lee of an island for considerable periods, others travel long distances, sometimes against prevailing currents (*e.g.* from Dominica to St. Lucia and Grenada; from Barbados to Grenada and Tobago, against prevailing currents travelling WNW; Figure 4). This suggests that the adult fish are not necessarily carried by prevailing currents or retained by eddies. The tendency of many to remain near their point of release may therefore reflect a choice to remain with, and spawn on floating material which is itself carried by prevailing currents or retained by eddies in the lee of islands.

Most of the flyingfish dispersing from the tagging areas, appeared to travel in a west northwesterly direction. However, an accurate picture of flyingfish movement remains masked by large differences in fishing effort for flyingfish within and beyond the eastern Caribbean. Fishing effort for flyingfish off the west coast of Barbados, and to the north of Tobago and east of Grenada is relatively high; Barbados boats fishing in these areas land close to ten times the amount of flyingfish landed by any of the other islands' fleets (Mahon *et al.*, 1986). By contrast, there is little fishing for flyingfish in areas to the east of Barbados, south of Tobago, north of Dominica, east of the Lesser Antilles Island chain, and throughout the Grenadines. Hence, any migration of flyingfish to these areas is unlikely to be detected by tag returns. A more accurate picture of flyingfish movements, allowing for variation in probability of recapture, will be modelled when the estimated total flyingfish catches for the 1987/88 fishing

Table 3. Summary of previous release and recapture data for tagged flyingfish *Hirundichthys affinis*.

Study Area	Barbados	Barbados	Barbados	NE Brazil
Date	May-June 1961	May 1962	Jan-March 1963	May-June 1965
No. of fish tagged	762	476	812	552
No. of fish recaptured	18 (2.3%)	5 (1.0%)	52 (6.4%)	14 (2.5%)
No. of fish dispersed	0	0	0	0
Mean time at large (days)	6	-	8	3
Max. time at large (days)	24	-	50	15
Max. recorded distance (mi)	33	-	50	-
Reference	Mulloney (1961)	Lewis (1964)	Lewis (1964)	Barroso (1967)

season, and the range of the fishing fleet becomes available for each island in the eastern Caribbean.

Recapture rates of fish released off Tobago near the beginning of the fishing season (6.0%) were considerably greater than those for fish released off Tobago near the end of the season (1.3%). This difference is unlikely to result from differences in mortality rates of fish due to tagging, since the same tagging team and methods were used in both cases. The differences probably reflect differences in natural mortality and/or migration patterns of flyingfish near the beginning and end of the fishing season. More information on flyingfish longevity and possible tag returns from other areas (*e.g.* the Netherlands Antilles) in the late summer and fall of 1988 could help to resolve this issue. More generally, a larger scale tagging program in the 1988/89 fishing season should produce a more complete picture of migration within the eastern Caribbean, by tagging in all territories and by allowing for effects of regional variation on the probability of recapturing tagged fish from different locales.

The tag type, tagging procedure and tag recovery method used in this study have proved to be suitable for use in future large scale tagging programs for eastern Caribbean flyingfish. The main problems remaining are:

1. The uncertainty of first capture, since many days can be spent at sea before a spawning school of flyingfish is attracted to the tagging vessel
2. The degree of lost data, particularly for fish recaptured by 'ice-boats'

In summary, the principal result of the present study is that flyingfish appear to mix freely between islands in the eastern Caribbean. This indicates that the islands share a common flyingfish stock and is an important

consideration for future management strategies for flyingfish in the area. Further work is needed to determine more precise patterns of movement and to ascertain whether there is a spawning concentration of flyingfish in the south of the eastern Caribbean.

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