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Preliminary observations of flyingfish, *Hirundichthys affinis*, spawning behaviour

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Abstract: Flyingfish, *Hirundichthys affinis*, have negatively buoyant eggs with adhesive filaments for attachment to spawning substrata, and are well known to use floating substrata for attachment of eggs. However, it has been proposed that this may not be their only or typical mode of spawning. This pilot study attempts to test two hypotheses for alternative spawning behaviour. A subsurface spawning mode was tested through deployment of subsurface spawning substrata on deepwater moorings off the NW coast of Tobago. Preliminary results indicate that although surface spawning is preferred, flyingfish will spawn at least 20 m below the surface, even when surface substrata are available.

INTRODUCTION

The spawning habits of flyingfish, *Hirundichthys affinis* are often observed and utilised by eastern Caribbean fishers, but are poorly documented. Furthermore, important questions regarding aspects of *H. affinis* spawning behaviour, have arisen as a result of observations made during the Eastern Caribbean Flyingfish Project (ECFP), but remain unanswered (Oxenford *et al.* 1993). For example, it is well known that spawning *H. affinis* accumulate in large schools around a variety of floating objects on which they deposit their adhesive eggs (e.g. Hall 1955, Lewis *et al.* 1962, Monte 1965, Storey 1983, Lao 1989), and local flyingfish fishers capitalise on this habit by providing floating materials as fish attracting devices (FADs) (see Chapters 1-7 this volume, Gomes *et al.* 1998). However, the apparent scarcity of *H. affinis* eggs and of floating substrata, as recorded during a one month (April 10-May 6, 1988) flyingfish abundance survey cruise in the eastern Caribbean at the known period of peak spawning (Hunte *et al.* 1995), and during a one year (Oct 1987-Sep 1988) study of flyingfish and flotsam abundance off Barbados (Lao 1989; Lao *et al.* 2007) led to two hypotheses for alternative spawning behaviours.

It is proposed that *H affinis* may spawn on benthic or subsurface substrata when floating substrata are scarce or when located in relatively shallow coastal shelf waters. It is also proposed that *H. affinis* may continue to spawn on a floating substratum until it sinks below the surface. These hypotheses are further supported by anecdotal evidence from fishers who report finding flyingfish spawn on snapper traps set in deepwater off the northwest coast of Tobago (E. Caesar[1], pers. comm.), and by personal observations of laboratory reared *H. affinis* larvae that orient themselves vertically and swim upwards for the first few days after hatching. In an attempt to test these hypotheses, two pilot studies were undertaken.

METHODS

Spawning behaviour in *H. affinis* was investigated during two separate pilot studies conducted simultaneously off the northwest coast of Tobago, as described here.

Monitoring subsurface spawning substrata

An investigation of whether flyingfish will spawn on subsurface substrata was undertaken during a short cruise onboard M/V Meridian (May 24-June 2, 1989) off the northwest coast of Tobago (Figure 1). A total of 12 deep water moorings were deployed on the shelf between 3 and 10 km from shore in water depths from 41-160 m (Figure 1, Table 1). A maximum of 9 spawning substrata (depending on the water depth) comprising 0.6 m^2 PVC pipe frames strung with 4.1 cm

[1] Erol Caesar, Chief Fisheries Officer, Department of Marine Resources and Fisheries, Tobago

mesh nylon netting (flyingfish gillnet material) were attached to the main line of each mooring at 20 m depth intervals from the surface to the bottom (Figure 2, Table 1). Spawning substrata were checked for flyingfish eggs at 2-3 day intervals by hauling and resetting each of the moorings. Moorings were deployed on 24 May (5), 26 May (10), 29 May (7) and 31 May (7), and were hauled and checked on 26 May (5), 29 May (7), 31 May (7) and 2 June (5).

Water samples were taken each sampling day at mooring sites from the surface and from 20 m below the surface using a Van Dorn sampler and analysed for temperature, salinity and specific gravity.

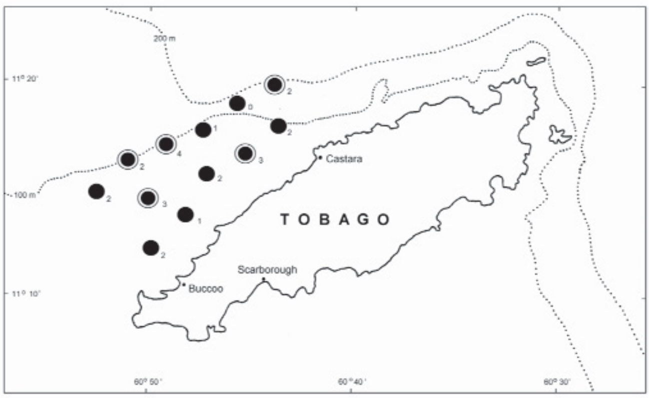

Figure 1. Map of Tobago showing the location of deep water moorings and flyingfish spawning activity. Filled circles show moorings and number of times checked for eggs. Filled circles with rings show moorings where flyingfish spawning activity occurred.

Observations of spawning behaviour on floating spawning substrata

To test whether flyingfish will continue to spawn on a floating substratum until it is so laden with eggs that it sinks, a fishing pirogue was used as the observation platform and was allowed to drift in an area 6-16 km off the northwest shore. Spawning flyingfish were attracted to the fishing vessel with fish 'chum' and three different types of spawning substratum (a bundle of seagrass, a trimmed palm frond and a square of netting) were tethered to the windward side of the vessel (Figure 3). Two observation trips were attempted on 27 May and 1 June.

RESULTS

Water Characteristics

Water temperature was consistently between 27 and 27.5 $^{\circ}$C, the salinity a constant 34.42 $^{o}/_{oo}$ with a specific gravity of 1.026 g/cm^3 at 20 $^{\circ}$C. There was no difference between surface and subsurface water characteristics.

Table 1. List of deepwater moorings showing deployment location off the northwest coast of Tobago, water depth, number of spawning substrata attached, accumulated soak times and number of times checked for flyingfish spawn.

Mooring No.	Location		Water depth (m)	Distance from shore (km)	No. substrata	No. times checked	Total soak time (hr)
	^{o}N	^{o}W					
1	11^{o} 20' 12"	60^{o} 44' 12"	160	6.4	9	2	120
2	11^{o} 18' 00"	60^{o} 43' 54"	100	3.2	7	2	122
3	11^{o} 19' 06"	60^{o} 45' 54"	70	6.4	5	0	lost
4	11^{o} 16' 54''	60^{o} 45' 37"	80	3.2	6	3	170
5	11^{o} 18' 02"	60^{o} 47' 34"	80	6.4	6	1	167
6	11^{o} 15' 46"	60^{o} 47' 22"	56	3.2	5	2	118
7	11^{o} 16' 56"	60^{o} 49' 18"	78	6.4	7	4	207
8	11^{o} 13' 43"	60^{o} 48' 26"	41	3.2	4	1	39
9	11^{o} 14' 34"	60^{o} 50' 09"	54	6.4	5	3	158
10	11^{o} 12' 10"	60^{o} 49' 48"	41	3.2	4	2	120
11	11^{o} 16' 28"	60^{o} 51' 22"	97	9.7	7	2	88
12	11^{o} 14' 48"	60^{o} 52' 18"	73	9.7	6	2	87

Preferred spawning depths

A total of 58 mooring days and 1,394 hr soak time were accumulated, and 144 spawning substrata were checked for signs of flyingfish spawning activity (Table 2). Flyingfish eggs were found on a total of nine (6.3%) substrata (Figure 1, Table 2). A clear preference for surface substrata was demonstrated with eight of the nine spawnings occurring at the surface, representing 33% of all surface set spawning substrata. Spawn was also found on one (4.2%) of the substrata set at 20 m below the surface. No spawning activity was recorded on deeper substrata.

Total weight of eggs deposited on the substrata was low, but since predation could not be ruled out, presence of eggs was taken simply as evidence of spawning activity and no attempt was made to assess spawning intensity.

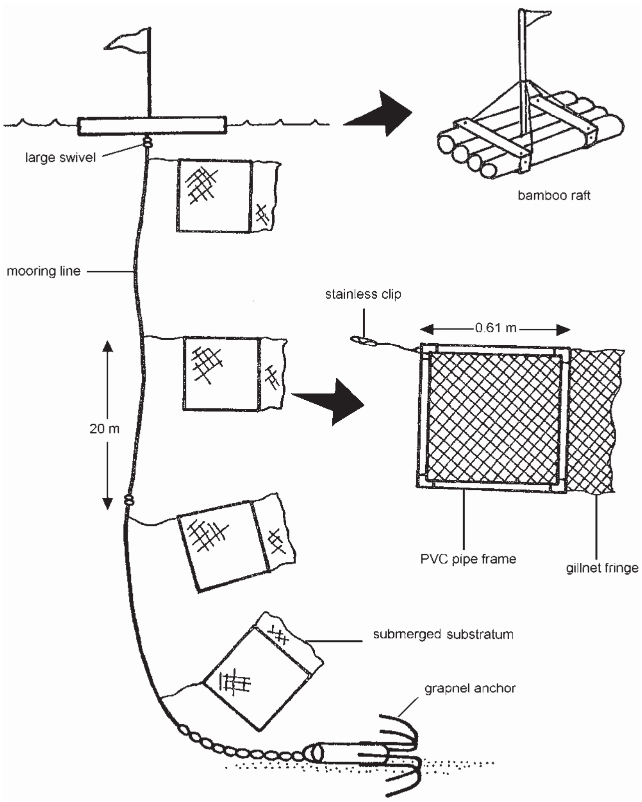

Figure 2. Design of the deepwater mooring showing the bamboo raft and arrangement of submerged flyingfish spawning substrata.

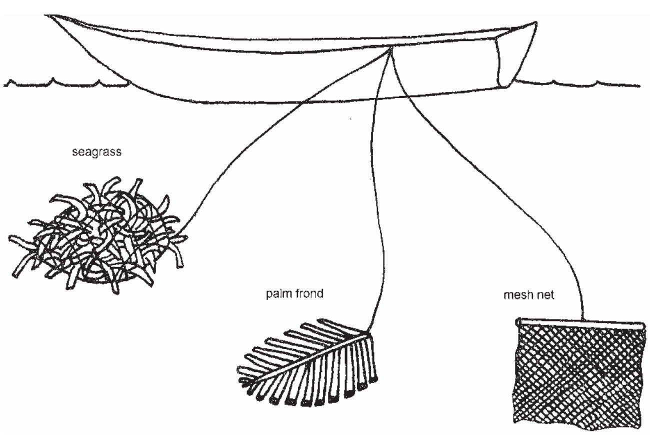

Figure 3. Types of floating substrata offered to spawning flyingfish from a drifting pirogue off Tobago.

Surface spawning behaviour

A spawning school of flyingfish began to accumulate around the pirogue after seven hours of drifting, on May 27. Spawning was observed on all three substrata, but there was insufficient time to observe the outcome of prolonged spawning, as the vessel had to return to shore before dark. On June 1 a second observational trip was attempted, but was abandoned before any spawning fish had gathered, as a result of severe weather and sea conditions.

DISCUSSION

The preliminary investigation of *H. affinis* spawning depth demonstrates that they have a clear preference for surface spawning substrata, but will spawn as deep as 20 m below the surface, even when surface substrata are available. This observation is significant in that it supports the hypothesis that *H. affinis* may spawn on subsurface substrata as an alternative to surface spawning on floating objects. Furthermore, the possibility that *H. affinis* may even use benthic substrata is not ruled out and deserves further study, particularly in shelf waters where flyingfish are reported by fishers to accumulate in large numbers. The possibility of benthic spawning grounds is of particular relevance to the management of the transboundary eastern Caribbean flyingfish resource and its critical habitats.

That *H. affinis* will spawn on subsurface or benthic substrata is not surprising given that they have evolved from demersal ancestors and still retain some demersal characteristics such as negatively buoyant eggs with adhesive tendrils adapted for attachment to substrata (Collette *et al.* 1984). Benthic spawning has been reported for other flyingfishes by Kovalevskaya (1982) who noted that *Parexocoetus* spp. typically spawn on coastal algae.

The pilot study of spawning depth preference further demonstrated that the relatively simple, lightweight moorings and spawning substrata used, could be manually hauled and would be appropriate for a longer term study (for example over a full fishing season) conducted from a local fishing vessel with a handheld GPS unit for relocation of moorings. Further technical details and suggestions are given in the research cruise report (Oxenford 1993), and include the suggestion that moorings should be set without surface substrata and should be examined for evidence of different spawning behaviour with changes in moon phase.

The pilot study of spawning intensity on a variety of floating substrates was largely unsuccessful and thereby provided lessons for further study. A larger fishing vessel capable of staying at sea with the spawning substrata for several days is clearly required to observe the final outcome of intense spawning on the

Table 2. Evidence of flyingfish (*Hirundichthys affinis*) spawning, shown by weight of eggs (g) collected from surface and subsurface substrata suspended from deepwater moorings off the northwest coast of Tobago.

Mooring No.	Date checked	Soak time (hr)	Substratum depth (m)								
			0	20	40	60	80	100	120	140	160
1	29-May-89	76.5	0	0	0	0	0	0	0	0	0
	31-May-89	43.5	0.02	0	0	0	0	0	-	-	-
2	29-May-89	78.0	0	0	0	0	0	0	0	-	-
	31-May-89	44.0	0	0	0	0	0	0	0	-	-
4	29-May-89	78.5	0.1	0	0	0	0	0	-	-	-
	31-May-89	44.5	0.01	0	0	0	0	0	-	-	-
	2-Jun-89	46.5	0	0	0	0	0	0	-	-	-
5	2-Jun-89	167	0	0	0	0	0	0	-	-	-
6	26-May-89	39	0	0	0	0	0	-	-	-	-
	29-May-89	79	0	0	0	0	0	-	-	-	-
7	26-May-89	41	0	0	0	0	0	0	0	-	-
	29-May-89	74	25.6	17.9	0	0	0	0	0	-	-
	31-May-89	44	0.04	0	0	0	0	0	0	-	-
	2-Jun-89	47.5	0	0	0	0	0	0	0	-	-
8	26-May-89	39	0	0	0	0	-	-	-	-	-
9	26-May-89	41	0	0	0	0	0	-	-	-	-
	29-May-89	73	15.3	0	0	0	0	-	-	-	-
	31-May-89	43.5	0	0	0	0	0	-	-	-	-
10	26-May-89	39	0	0	0	0	-	-	-	-	-
	29-May-89	81	0	0	0	0	-	-	-	-	-
11	31-May-89	40	70.08	0	0	0	0	0	0	-	-
	2-Jun-89	47.5	9.0	0	0	0	0	0	0	-	-
12	31-May-89	39	0	0	0	0	0	0	-	-	-
	2-Jun-89	47.5	0	0	0	0	0	0	-	-	-
Totals	-	1,393.2	24	24	24	24	21	16	9	1	1

spawning substrata.

The existence of a consistent high salinity layer (> 37 $^{o}/_{oo}$) at depths ranging from 80-180 m throughout the eastern Caribbean (Fanning 2006) indicates a possible mechanism for retention of egg laden substrata that sink through the lower salinity surface water and become trapped by this high density layer. Horizontal subsurface currents at this depth, which frequently differ in strength and direction from those at the surface (Warner and Cowen 2002, Paris and Cowen 2004), may also act to retain *H. affinis* larvae in a particular geographical area critical for their survival. Again this deserves further study to increase our understanding of spawning areas for this species.

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