Use of Low-cost Surface Drifters to Study the Dispersal Pathways of Eggs of Cubera Snapper (*Lutjanus cyanopterus*) at Gladden Spit, Belize

Influencia de las Corrientes Superficiales en las Rutas de Dispersion de Huevos de Pargo Cubera, *Lutjanus cyanopterus*, en una Agregación de Desove en Gladden Spit, Belice

Influence des Courants de Surface dans les Routes de Dispersion des Oeufs de Vivaneau Cubéra, *Lutjanus cyanopterus*, À Une Agrégation de Frai au Gladden Spit, Bélize

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EXTENDED ABSTRACT

Tropical marine conservation depends on understanding the life history of commercially exploited species. The ecology of early life stages is poorly understood for many species so assumptions have been broadly accepted without being field-tested. Such is the case of the impact of surface currents in propagule dispersal from reef fish spawning sites. Though many hypotheses have been proposed, few have actually been evaluated in the field (Pineda et al. 2007).

We used surface drifters to make repeated measurements of current movements from the time and location of a snapper spawning aggregation. We also evaluated the use of drifter tracks as a proxy for the dispersal of eggs by conducting a series of quantitative plankton tows at the location of surface drifters as they drifted away from the spawning area.

Current-following drifters measure ocean currents from a Lagrangian perspective, registering current magnitude and direction as they drift freely. Numerous designs of surface drifters have been previously used to monitor propagule dispersal in the Caribbean but no single method has been universally adopted. The drifters used in this study combine a modification of a design proposed by Heyman et al. (2004), and a tethered buoy designed to track rip currents in Florida (C. Houser, In press).

The drogue was a single 1x1.20 m cloth vane fastened on both ends to polyvinyl chloride (PVC) pipes. Buoys were constructed using 6-inch PVC sewer pipe cut into 1 m segments and capped at both ends with standard commode flanges. Through the top flange a fiberglass rod was inserted extending 50 cm above the flange and served as a stem to attach a waterproof flashlight, and in some cases, a dog-tracking collar with a built-in GPS unit (Garmin DC 40). To aid in recognition during deployment, drifters were marked with visual identifiers (Figure 1).

Cubera snappers migrate considerable distances to spawning sites where they form massive spawning aggregations. Cubera snapper is an ecologically and commercially important species. Reaching a mass of 57 kg and a total length of 160 cm, it is the largest snapper in the western Atlantic, and one of the most important food fishes in the Caribbean (Munro et al. 1973, Allen 1985). Cubera snapper spawn in massive aggregations that are predictable and space and time, making it an ideal species for the purpose of this study. Cubera snapper spawn at Gladden Spit (GS) located at 16°35′N, 88°00′W, a reef promontory along the Belize Barrier Reef (BBR). GS is adjacent to the 1,000 m isobath, and is ~46 km away from mainland Belize.

Sampling took place from May 16 to 29, 2011, encompassing the peak of the spawning period for Cubera snapper at this location (Heyman et al. 2005). The deployment scheme used to evaluate variability in surface current movements from the spawning site, consisted of releasing a set of three drifters every day one hour before sunset at the location of spawning. Deployments lasted as long as environmental factors permitted safe sampling conditions and drifters were generally retrieved one hour after initial deployment. Approximately every 15 minutes all deployed drifters were located and their position recorded using a hand held Garmin GPSMAP 76. Drifter's tracks were plotted over a bathymetric map using ArcGIS to determine the speed and direction of travel with respect to the location of the reef.

In order to determine the extent to which eggs moved along with the drifters, we measured egg density over time along tracks that started at spawning events. When spawning was observed, a single drifter was deployed at the estimated center of the spawning cloud within 1 min of its appearance at the surface, and its location was recorded. Immediately after deploying the drifter, we took plankton tows within the gamete cloud using a Hydrobio bongo net (500-µm nets, 30 cm diameter mouth x 90 cm deep) equipped with a flow meter. Collected samples were fixed in 20 ml of 100% ethanol. Four replicate 5-ml aliquots were taken from each bottle and all eggs present were counted using a stereomicroscope at 10x and a mechanical counter and used to calculate the number of eggs in each tow. The volume of water filtered in each tow was calculated from flow meter measurements. Egg counts were divided by volume to calculate egg density (eggs/L).

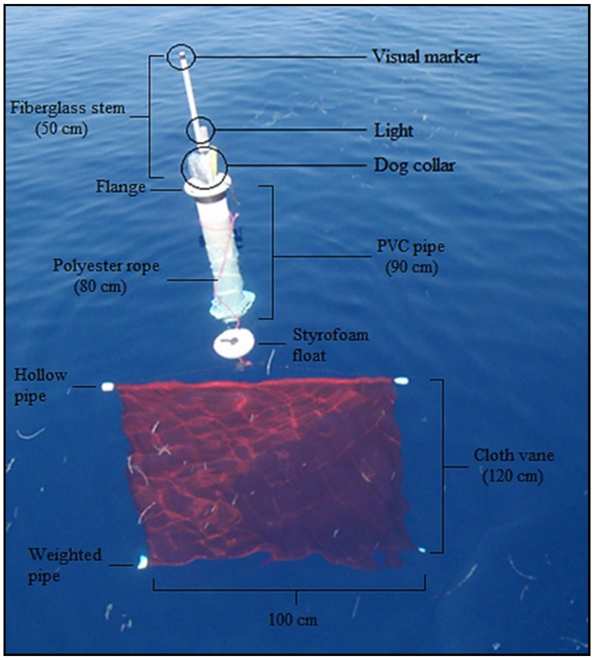

Figure 1. Drogue deployed in the water, the weighted PVC at the bottom guarantee that the cloth vane was extended during deployment, The PVC buoy granted buoyance and stability to the drifter. Unique visual markers facilitated drifter identification and data orderly data collection and the light facilitated retrieval. All parts and some dimensions are shown, picture not to scale

A total of 95 tracks were considered to determine the direction in which surface currents move around the time of spawning. During these deployments, surface drifters traveled westward towards the reef, with angles of travel ranging between 217° (SW) and 305° (NW) (Table 1).

Spawning was observed from May 19 to 25. Throughout the spawning season, egg densities increased. Egg densities recorded close to the end of the spawning period, May 23 and 24, were higher (e.g. May 23 = 41571 egg/m^3 and May 24 = 41332 egg m^{-3} for the first tow) than those registered for May 19, the first day of spawning, (1,402 egg/m^3 for the tow 1). Egg density decreased as time passed for May 19 (from 1,402 to 139 egg/m^3), 23 May (from 41,332 to 19,990 egg/m^3) and 24 May (from 41,571 to 16,275 egg/m^3). Qualitative analysis of the paths followed by the set of drifters deployed before sunset and the single drifter placed at the estimated center of the spawning cloud showed that water parcels flow in the same general direction before sunset and while spawning events were taking place.

Field-collected data do not support the hypothesis that surface currents at GS flow offshore during the peak of the spawning season for Cubera snapper. Instead, the drifter deployments examined here show that surface currents flow inshore during peak spawning time for Cubera snapper. We also found that egg densities decreased as drifters moved away from the spawning site and that the drifters likely do serve as a good proxy for freshly released eggs. These data are highly relevant for parameterizing larval connectivity models. Egg densities decrease over time as the spawning cloud disperses with the predominant surface currents; however, further research is necessary to quantify these patterns.

Table 1. Total drift time, total distance traveled, mean drift speed and angle of travel (bearing) between start and end points for all sunset drift tracks. A set of three drifters was deployed daily one hour before sunset (~18:15 local time). The location of the three drifters was recorded at ~15 minute intervals.

Date	Duration (min)	Distance (m)	Speed (cm/s)	Angle of travel (°)
16-May	91	666	12	305
17-May	210	2,260	5	002[α]
18-May	210	2,253	25	242
19-May	58	609	19	249
20-May	60	612	17	282
21-May	52	654	20	208
22-May	61	638	18	217
23-May	112	460	7	301
24-May	92	601	10	226
25-May	82	753	15	217
27-May	70	828	15	197
28-May	962	7,032	12	254

[α]This angle does not accurately represent the direction followed by the set three of drifters due to a mid-course change in direction during the drift.

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