# Mapping Fine-scale Dispersal of Nassau Grouper (*Epinephelus striatus*) Eggs from a Spawning Aggregation with a Novel Plankton Imaging System

# Mapeo de la Dispersión a Escala Fina de Huevos de una Agregación Reproductiva de Mero de Nassau (*Epinephelus striatus*) con una Nueva Sistema de Imágenes de Plankton

# Cartographie de la Dispersion à Petite Échelle des Oeufs Produits par une Agrégation de Mérous de Nassau (*Epinephelus striatus*) lors du Frai avec un Nouveau Système D'imagerie du Plankton

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## EXTENDED ABSTRACT

### Introduction

Nassau Grouper (*Epinephelus striatus*) are large, predatory reef fish that are ecologically, economically, and culturally valuable members of Caribbean reef communities (Sadovy and Eklund 1999). Their populations have been severely depleted throughout the Caribbean, primarily due to overfishing at fish spawning aggregations (FSAs, Sadovy et al. 2008). Since 2003, the Cayman Islands Department of the Environment (DOE) and Reef Environmental Education Foundation (REEF) have spent considerable scientific, financial, and political resources to protect the spawning aggregation of Nassau Grouper off the west end of Little Cayman—the largest known aggregation of the species. The number of spawning adults has increased under protection from fishing, but the contribution of the aggregation to recruitment (young adults entering the population) is unknown.

Recruitment is highly variable in most marine fish and is thought to be the principal driver of variability in adult abundance (Miller and Kendall 2009). Hjort (1914) first showed that egg and larval survival are key to recruitment variation. Although many researchers have since refined and expanded on Hjort's hypotheses (Houde 2008), evidence has mounted that mortality of the early life-history stages largely dictates recruitment variability and deserves research into its causal mechanisms (Cushing 1975). Three key processes govern successful recruitment — larvae must:

i) Eat enough prey,
ii) Avoid predation, and
iii) Find suitable habitat (dispersal).

These processes in turn likely depend on fine-scale and patchy distributions of eggs, prey, and predators (Bailey and Houde 1989).

Self-recruitment (Little Cayman to Little Cayman) is likely necessary for long-term viability of the population. Inter-island recruitment (Little Cayman to Grand Cayman and Cayman Brac) would aid efforts to recover Nassau Grouper populations there, as well as broaden support for protection of the Little Cayman aggregation. The frequency of successful recruitment also matters — if recruitment is only appreciable once every twelve years (as anecdotally observed), managers know protections must be in place long-term to expect any effect. Understanding the drivers of recruitment, whether early larval survival or dispersal, is important in linking changes in adult numbers to future, long-term population status. Fine-scale patterns in survival and dispersal are likely important, but have not been measured because the necessary technology has not existed until now.

### Methods

To study such fine-scale processes, we used a novel *in situ* plankton sampler to map the dispersal of Nassau Grouper eggs from the FSA following spawning on three consecutive nights: Feb 14 - 16, 2017. We collected plankton images using the Scripps Plankton Camera (SPC), an underwater microscope that images roughly 500 mL of water 7 times per second (Roberts et al. 2014, Mullen et al., *In preparation*). Standard plankton tows provide measurements of average density, integrated over the tow track. However, the SPC allows us to calculate density of eggs and other plankton at a fine spatial scale (10s of meters), in real-time, and at different depths along a tow track. We deployed the SPC attached to an Acrobat system (Sea Sciences, Inc.), an undulating tow platform that controls its depth using motorized wings (Figure 1).

In order to calculate the density of Nassau Grouper eggs from SPC plankton images, we needed to 1) classify images into plankton categories (e.g. fish eggs, copepods, etc.), and then 2) classify fish eggs as Nassau Grouper versus other fish species that spawn nearby. We found species-specific differences in egg diameter based on visual (egg size-frequency) and genetic (DNA barcoding) analysis of two collected plankton samples, and classified eggs with diameters between 0.90 - 1.10 mm as Nassau Grouper.

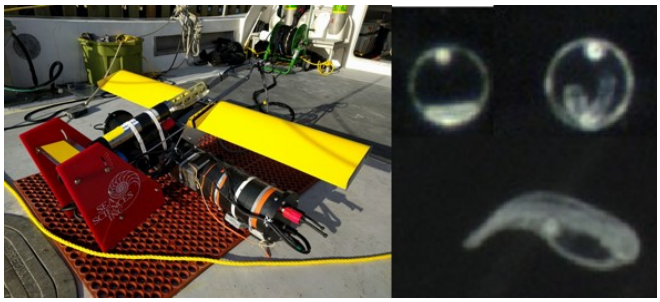

**Figure 1.** (Left) The SPC microscope on deck attached to the Acrobat. (Right) Sample images of Nassau Grouper eggs and larvae from the SPC (clockwise from top-left): egg 1 hour after spawning, egg 14 hours after spawning, yolk-sac larvae 34 hours after spawning.

## Results

We towed the SPC/Acrobat for hours 0 - 16 following spawning on Feb 14, 2017 (cohort 1), hours 0 - 23 and 30 - 36 on Feb 15,

2017 (cohort 2), and hours 0 - 6 on Feb 16, 2017 (cohort 3). Out of roughly 230,000 total images, a preliminary egg filter classified 428 eggs from cohort 1, 459 eggs from cohort 2, and 62 eggs from cohort 3. We found 47 images of yolk-sac larvae in images from cohort 2 during hours 30-36 (eggs hatch at 20 - 30 hours). Thus, we demonstrated the ability to observe fine- scale distributions of eggs as they disperse and drift away from the Nassau Grouper spawning aggregation for over 30 hours, beyond hatching (Figure 2). We anticipate that future deployments of this new tool will shed light on the fine-scale processes influencing recruitment success.

KEYWORDS: Dispersal, egg recruitment, advection, diffusion

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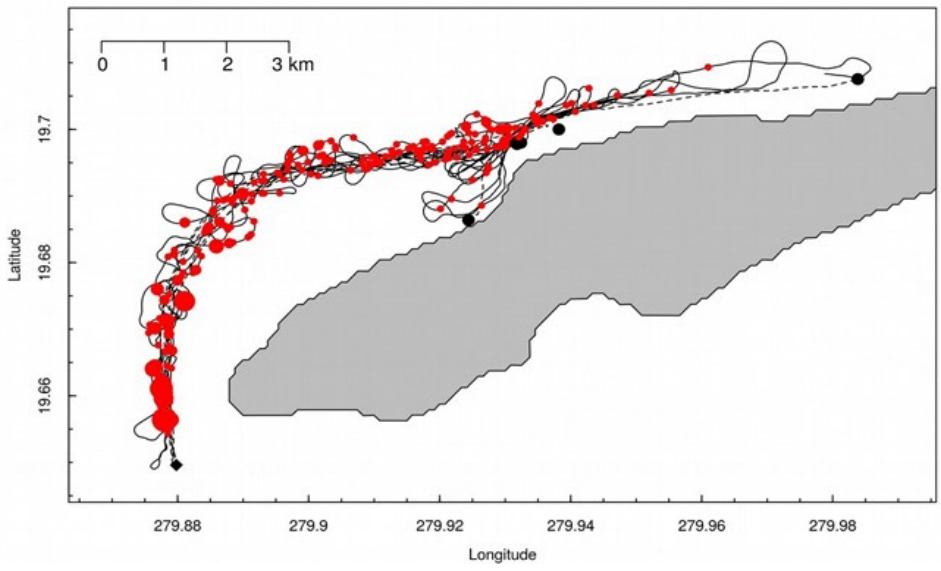


**Figure 2.** Preliminary counts of Nassau Grouper eggs along the SPC/Acrobat tow track 0-23 hours following Nassau Grouper spawning on February 15, 2017 at Little Cayman Island. Five drifters (black circles, dashed curves) deployed at the spawning site moved north and east close to Little Cayman, and three of the drifters grounded on the reef. Counts of eggs (size of red circles) from the SPC images along our tow track (solid line) show the fine-scale dispersal of the spawn cloud through time.