BUOYANCY OF ATLANTIC BLUEFIN TUNA *Thunnus thynnus* EGGS OBTAINED FROM CAPTIVE BROODSTOCK SPONTANEOUS SPAWNING EVENTS

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Introduction

One way to alleviate the pressure on the wild fishery of the Atlantic bluefin tuna (BFT) and aid in its conservation could be its domestication and the development of a self-sustained industry to rear the larvae and produce fingerlings in captive conditions for further grow-out. The Spanish Institute of Oceanography (IEO) is carrying out several research projects on this target for the last 12 years.

No one has yet measured the vertical distribution and the in situ buoyancy of bluefin tuna eggs in any of its spawning areas in the world (Mac Kenzie and Mariani, 2012). In the present study the density of bluefin tuna eggs has been measured, comparing it with those of other fish species, particularly Atlantic bonito. We have estimated the speed by which BFT eggs rise to the surface to get a better idea of the potential loss of spawned eggs dragged by the currents out of the cage.

Materials and methods

Fertilized bluefin tuna eggs were collected from spontaneous spawning, following the technique described by de la Gándara et al. (2011), in the broodstock cages placed at the concession of the company Caladeros del Mediterráneo S.L., in El Gorguel Bay (Cartagena, SE Spain). Throughout the spawning period (between 2nd and 18th July 2013) eleven daily spawning events were analyzed. The buoyancy of the eggs was estimated around 10:00a.m., 7 hours after fertilization, in the early gastrula stage. The density of BFT eggs was measured placing them in water of different densities, mixing sea water and distilled water, at which point egg buoyancy is zero and the eggs neither rise nor sink. In this point, the water density was measured with a densitometer AquaMedic©. The water temperature was maintained constant close to 25ºC. In order to compare with other species, also the density of Atlantic bonito (*Sarda sarda*) was estimated using the same method. Five bonito daily spawning events were collected from the broodstock held in the IEO facilities in Mazarrón (SE Spain). The mean diameter of the eggs was measured using a binocular microscope Leika©.

Results

The mean zero buoyancy, therefore the eggs density (ed) of the eleven BFT egg samples, was observed at 1.017mg mm^{-3} ± 0.001 ES (salinity 26ppt) being 1.027mg mm^{-3} (37ppt) the sea water density (wd) at the same temperature. The mean measured BFT egg diameter was 1.064 mm, the BFT egg volume ($4/3\ \pi r^3$) = 0.630mm^3, so the BFT egg weight would be volume * density = 0.640mg. No correlation was observed between the egg buoyancy and the egg diameter.

The Stokes Law describes the resistance of a spherical body to the movement inside a viscous fluid to be directly proportional to the radius of the body, to its velocity and to the viscosity of the surrounding fluid. The difference of the density between the egg and the seawater, makes the egg rise from the spawning point to the water surface in an accelerated movement. Nevertheless, and due to the Stokes Law, this movement raises a constant velocity because of the seawater viscosity. Given that the sea water viscosity (n) at salinity of 37ppt and temperature 25ºC is 0.01g cm^{-1} s^{-1}, r is the egg radius, g is the gravity acceleration (980cm s^{-1}), and ed and wd are respectively the egg and the sea water density, according to the Stokes law and assuming a laminar regime the constant velocity is estimated as:

$$V = [2r^2 g (ed - wd)] / 9n = 0.616 cm\ s^{-1}$$

Therefore, in these conditions and in the absence of a current, it would take 27min for BFT eggs spawned at 10m depth to arrive to the surface.

On the other hand, the mean zero buoyancy of the five bonito egg samples was estimated in 1.023mg mm^{-3} ± 0.001 ES.

Discussion and conclusion

The density of the BFT eggs estimated in the present study is in agreement with the preliminary measurements obtained during the SEFDOTT project (Anon, 2010). The value of 1.017mg mm^{-3} obtained in our study is a little below of the buoyancy range described by Masuma (2008) in Pacific bluefin tuna (*Thunnus orientalis*) (1.018mg mm^{-3} in early gastrula eggs). In comparison to other Scombrids, the BFT eggs have higher buoyancy. Coombs (2013) estimated the egg density of mackerel (*Scomber scombrus*) around 1.026mg mm^{-3}. This is a little higher than the density observed in bonito (*Sarda sarda*) in the present study (1.023mg mm^{-3}), but much higher than the BFT egg density (1.017mg mm^{-3}).

Our calculations suggest that BFT eggs spawned at a depth of 10m have a high probability of being swept out of the cage below the egg collector (6 m in our case) in the presence of a current.

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