

1 **Suspected spawning-associated colouration**
2 **and behaviour in black grouper (*Mycteroperca***
3 ***bonaci*)**

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5 Spawning behaviour in black grouper

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15 A probable spawning-associated aggregation of black grouper *Mycteroperca*
16 *bonaci* was observed on the leeward side of the Old Providence atoll, Seaflower
17 Biosphere Reserve, Colombia. Courtship behaviours previously reported for other
18 grouper species, including males pursuing females, nuzzling and bumping of the
19 anal area, and “burst rise”, were observed and described, as was a “white-head”
20 spawning colour phase. These results help fill the gap in published information on
21 black grouper reproductive behaviour, providing information that can aid in the
22 identification of spawning sites and the subsequent development of improved
23 management and conservation strategies for this species.

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25 Keywords: spawning behaviour; grouper; aggregation; courtship; colouration

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27 Groupers (family Serranidae, subfamily Epinephelinae) are widely distributed in
28 the world’s oceans and on tropical coral reefs (Heemstra and Randall, 1993),
29 where they are targeted by commercial, recreational, and artisanal fisheries.
30 Groupers are particularly vulnerable to overfishing partially because of their slow

31 maturation, typical hermaphroditism, and tendency to form predictable, ephemeral
32 and spatially discrete fish spawning aggregations (FSAs) (Coleman et al., 1999;
33 Huntsman et al., 1999), defined as “a grouping of a single species of reef fish that
34 has gathered together in greater densities than normal with the specific purpose of
35 reproducing” (Domeier and Colin, 1997). Fishing pressure on FSAs resulting in
36 the depletion of aggregations and the overfishing of stocks has been documented
37 for multiple coral reef-associated grouper species (Sala et al. 2001; Rhodes and
38 Sadovy, 2002; Matos-Caraballo et al., 2006a and b; Aguilar-Perera, 2007),
39 resulting in increasing efforts by management agencies to protect spawning
40 aggregations through temporal or spatial closures (e.g. Nemeth, 2005; Semmens et
41 al., 2005; Matos-Caraballo et al., 2006a). For species whose FSA locations are
42 unknown to managers, the identification of FSA sites, which can be facilitated by
43 the identification of spawning-associated colouration and behaviour, is a critical
44 first step for improved management capability. Effective management and
45 conservation of groupers therefore requires understanding their spawning
46 strategies and behaviour (Morris et al., 2000; White et al., 2002).

47

48 In the tropical Atlantic Ocean, spawning aggregations and behaviours (including
49 multiple distinct spawning colourations) have been described for large grouper
50 species such as the Nassau grouper *Epinephelus striatus* and the tiger grouper
51 *Mycteroperca tigris* (Colin, 1992; Sadovy et al., 1994). Little is known about the
52 reproductive behaviour of the black grouper *Mycteroperca bonaci*, a large
53 (maximum size 150 cm total length (L_T)), normally solitary, fishery targeted, reef-
54 associated species that ranges from Bermuda and Massachusetts, USA to southern
55 Brazil, including the southern Gulf of Mexico and the Caribbean (Froese and

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56 Pauly, 2008). Black groupers are protogynous hermaphrodites (Crabtree and
57 Bullock, 1998) that spawn primarily in the winter and spring (Crabtree and
58 Bullock, 1998; Brulé et al., 2003), most likely via FSAs associated with full
59 moons (Fine, 1990; Eklund et al., 1999). However, there are only two published
60 observations of spawning or likely spawning aggregations of black groupers
61 (Eklund et al., 1999 for one site in the Florida Keys, USA; and Paz and Sedberry,
62 in press for multiple sites in Belize), and only one containing detailed
63 observations of aggregation characteristics and courtship and spawning
64 behaviours (Paz and Sedberry, in press). The purpose of this communication is to
65 describe a suspected black grouper FSA near a West Caribbean remote atoll, as
66 well as associated courtship behaviours and colouration.

67

68 Exploratory dives were conducted on 28 February 2005, four days after the full
69 moon, on the leeward side of the Old Providence atoll, Seaflower Biosphere
70 Reserve, Colombia (Figure 1). A team of four scuba divers took photographs and
71 video and recorded descriptive and behavioural observations associated with a
72 small aggregation of black grouper.

73

74 A small aggregation of groupers (15 total, ~ 7.5 per 100m^2) was observed at a
75 shelf edge site (depth 40 m) characterised by strong upwelling and a current (0.25
76 kts) pushing seaward from the shelf. Bottom water temperature was 20.5°C .

77 Aggregated groupers were also seen over the shelf edge beyond the depths
78 reachable by the divers (~ 40 m depth); abundances occurring below the visual
79 range of the divers are unknown. The aggregation site characteristics (e.g., depth,
80 reef substrate and relief) were consistent with those described by Eklund et al.

81 (2000) and Paz and Sedberry (in press). Several other species were also
82 aggregated at the site and were observed exhibiting apparent spawning
83 behaviours, including tiger grouper, black durgelon *Melichthys niger* and creole
84 wrasse (*Clepticus parrae*).
85
86 Black groupers within the aggregation repeatedly pursued each other closely,
87 potentially indicative of aggression or courtship (Sluka, 2001; Whalen et al., 2004;
88 Erisman and Allen, 2006; Paz and Sedberry, in press). At approximately 0800
89 hours (~1 hour 15 minutes after sunrise and 45 minutes after high tide), two
90 individuals of ~ 100 cm standard length swam as a pair in the water column, away
91 from the shelf edge, at a depth of 31m. The pair circled each other approximately
92 15 m off the bottom for ~ one minute, finally separating and swimming away
93 from each other. One of the “circling” individuals exhibited homogeneous, “dark
94 phase” colouration (Paz and Sedberry, in press), which is exhibited both during
95 and outside reproductive periods and is not specifically related to spawning (pers.
96 obs. and Paz and Sedberry, in press). The other individual had atypical
97 colouration, with white lines radiating from the head onto a much darker body, a
98 dark bar along the posterior edge of the caudal fin, and a white caudal area
99 adjacent to the dark caudal bar (Figure 2 and 3). This atypical, “white-head”
100 colouration of the second individual is courtship or spawning colouration,
101 analogous to the yellow head with radiating lines/dark body colouration of tiger
102 grouper (Sadovy et al., 1994), and has been shown to occur only in males during
103 spawning periods (Paz and Sedberry, in press). Similar colouration has also been
104 observed in suspected spawning aggregations of black groupers in the Cayman
105 Islands (P. Bush, unpublished).

106

107 Two additional instances of circling behaviour by one dark-phase and one white-
108 head individual were observed between 1640 hours and 1705 hours (sunset was at
109 1835 hours); one pair was 1-2m off the bottom; the other pair was less than 1m off
110 the bottom. In both cases the larger individual exhibited white-head colouration.
111 Another pair of black groupers was observed exhibiting circling behaviour
112 between 1745 hours and 1810 hours at the shelf edge, near a promontory at 28m
113 depth. Again, the larger grouper (110cm standard length (L_S)) exhibited white-
114 head colouration and the smaller individual (85cm L_S) exhibited dark-phase
115 colouration. The two swam directly upwards, rapidly and in tandem, from 20m to
116 5m depth and then swam back to the bottom. The larger grouper then nuzzled the
117 smaller one in the anal area, similar to courtship behaviour described by Paz and
118 Sedberry (in press) and to the pre-spawning “rubbing” and “bumping” behaviours
119 described by Erisman and Allen (2006) for the serranid kelp bass *Paralabrax*
120 *clathratus*, after which the two exhibited circling behaviour, nose to tail. The
121 larger fish then repeated the rubbing / bumping behaviour, then swam straight
122 upwards at a steady, rapid speed, head towards the surface, for 3m, akin to the
123 “burst rise” behaviour described by Sala et al. (2003) for Nassau grouper. The
124 larger fish then ceased movement, coming to a complete standstill, and slowly
125 drifted downwards, motionless.

126

127 The similarity of the behaviours and spawning colouration of the aggregating
128 groupers described here to those reported from spawning aggregations in Belize
129 (Paz and Sedberry in press) and, from a behavioural standpoint, to individuals in
130 FSAs of other grouper species elsewhere (Sala et al., 2003; Erisman and Allen,
131 2006), indicate that observance of these behaviours and white-head colouration

132 should be useful in identifying spawning locations for black grouper. Although
133 aggregated, no group-spawning behaviours were observed, adding further
134 indication that black groupers may be pair spawners as opposed to or in addition
135 to the group spawning behaviour exhibited by other grouper species (Donaldson,
136 1995; Whalen et al., 2004; Paz and Sedberry, in press).

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138 In summary, the observations reported here help fill the gap in the published
139 information on black grouper reproductive behaviour, providing information that
140 can aid in the identification of spawning sites and the subsequent development of
141 improved management and conservation strategies for this species (Morris et al.,
142 2000; Graham et al., 2007).

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249 Figure 2a and b



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