



11-21-2014

# Comment on “Chemically Mediated Behavior of Recruiting Corals and Fishes: A Tipping Point That May Limit Reef Recovery”

Andrew H. Baird  
*James Cook University*

Vivian R. Cumbo  
*James Cook University*

Joana Figueiredo  
*Nova Southeastern University, <<span class="elink">jfigueiredo@nova.edu*

Saki Harii  
*University of the Ryukyus - Japan*

Tom Hata  
*Stanford University*

*See next page for additional authors*

Follow this and additional works at: [http://nsuworks.nova.edu/occ\\_facarticles](http://nsuworks.nova.edu/occ_facarticles)

 Part of the [Marine Biology Commons](#), and the [Oceanography and Atmospheric Sciences and Meteorology Commons](#)

## NSUWorks Citation

Andrew H. Baird, Vivian R. Cumbo, Joana Figueiredo, Saki Harii, Tom Hata, and Joshua S. Madin. 2014. Comment on “Chemically Mediated Behavior of Recruiting Corals and Fishes: A Tipping Point That May Limit Reef Recovery” .PeerJ .  
[http://nsuworks.nova.edu/occ\\_facarticles/557](http://nsuworks.nova.edu/occ_facarticles/557).

This Article is brought to you for free and open access by the Department of Marine and Environmental Sciences at NSUWorks. It has been accepted for inclusion in Oceanography Faculty Articles by an authorized administrator of NSUWorks. For more information, please contact [nsuworks@nova.edu](mailto:nsuworks@nova.edu).

---

**Authors**

Joshua S. Madin  
*Macquarie University*

1 **Comment on “Chemically mediated behavior of recruiting corals and fishes: A tipping**  
2 **point that may limit reef recovery”**

3

4 Baird AH<sup>1\*</sup>, Cumbo VR<sup>1</sup>, Figueiredo J<sup>2</sup>, Harii S<sup>3</sup>, Hata T<sup>4</sup>, Madin JS<sup>5</sup>

5

6 <sup>1</sup>ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville,  
7 Queensland, 4811, Australia

8 <sup>2</sup>Oceanographic Center, Nova Southeastern University, 8000 N Ocean Drive, Dania Beach,  
9 FL 33004, USA

10 <sup>3</sup>Sesoko Tropical Biosphere Marine Station, University of the Ryukyus, Okinawa, Japan

11 <sup>4</sup>Hopkins Marine Station, Stanford University, Pacific Grove, CA 93950, USA

12 <sup>5</sup>Department of Biological Sciences, Macquarie University, NSW 2109, Australia

13 \*corresponding author [andrew.baird@jcu.edu.au](mailto:andrew.baird@jcu.edu.au)

14

15 **Abstract**

16 Dixon *et al.*<sup>1</sup> report that coral larvae navigate towards chemical cues associated with healthy  
17 reefs and avoid cues from degraded reefs. However, the swimming capabilities of coral  
18 larvae and well-established patterns of recruitment and reef hydrodynamics indicate that coral  
19 larvae will not be able to use these cues to recruit to healthy reefs.

20

21 **Main Text**

22 Dixon *et al.* (1) present a series of experiments suggesting that coral larvae can distinguish  
23 between chemical cues associated with healthy and degraded reefs, and subsequently imply  
24 that coral larvae will use these cues to navigate to healthy reefs. However, many of their  
25 results are contrary to our current understanding of coral larval swimming capabilities and

26 well-established patterns of recruitment in the field. In addition, the flow structure in their  
27 flume is likely to be more dynamic than suggested, making choice experiments with coral  
28 larval difficult to interpret.

29 In a first set of flume experiments, larvae of three species of *Acropora* overwhelming  
30 preferred to spend time in water collected from areas of reefs protected from fishing when  
31 compared to water collected from areas lacking protection. However, coral larvae are very  
32 slow swimmers and based on previously published work are unlikely to be able to maintain  
33 their position in the flume for the 5 min duration of the experiment. The reported flow speed  
34 of  $4.2 \text{ mms}^{-1}$  is greater than the mean of all average swimming speeds reported to date, even  
35 when larvae are assisted by gravity (i.e., swimming downwards; Fig. 1). The maximum  
36 horizontal swimming speed recorded for a coral larva is  $3.45 \text{ mms}^{-1}$  (Table 1), which is well  
37 below the minimum speed required to maintain position in the flume, let alone navigate  
38 between the two water bodies. The remarkable consistency of larval behavior in the flume  
39 (Fig. 1A; Dixon *et al.*) is highly unusual and suggests that a physical rather than behavioral  
40 mechanism is operating. Indeed, the flow structure in their flume is likely to be much more  
41 complicated than they describe due to the presence of a barrier initially separating the two  
42 water sources and the barrier's abrupt end at the beginning of the test section. It is highly  
43 unlikely that visual inspection of a dye plume would sufficiently characterize flow conditions  
44 experienced by such small larvae in this flume. Well established techniques such as particle  
45 image velocimetry, laser-Doppler velocimetry or planar laser-induced fluorescence (2) should  
46 have been used to verify that flow biases do not exist at the scale relevant to coral larvae.

47 The spatial pattern in the recruitment of corals to settlement tiles are also highly  
48 unusual for a reef system that has a high number of reefs in close proximity, such as Dixon  
49 *et al.* sites in Fiji. Their results imply a strong positive correlation between adult coral cover  
50 and recruitment to settlement tiles. Indeed, not a single recruit was found on tiles placed in

51 the non-protected reef areas where coral cover was uniformly low. In contrast, in a two year  
52 study of 33 reefs spanning the length of Great Barrier Reef there was no correlation between  
53 adult abundance and coral recruitment to settlement tiles (3). Furthermore, only one of the  
54 132 sites (4 sites per reef and 8 tiles per site) had no recruits (3). The lack of an effect of algal  
55 clearance on juvenile recruitment to the substratum is also anomalous. In contrast, artificial  
56 exclusion of herbivores reduces rates of coral juvenile recruitment 3-fold, presumably due to  
57 dramatic increases in abundance of seaweeds in herbivore exclusion plots (4).

58 Even if coral larvae can distinguish between chemical cues associated with healthy  
59 and degraded reefs it is highly unlikely they will be able to use this information to navigate  
60 against ubiquitous tidal and other currents to preferred reefs for recruitment. Currents  
61 connecting reefs rarely fall below  $100 \text{ mms}^{-1}$  (5), which is almost two-orders of magnitude  
62 greater than typical coral larval swimming speeds (Table 1; Fig. 1). All existing measures  
63 indicate that coral larvae are very slow swimmers and therefore will behave as passive  
64 particles relative to inter-reef hydrodynamic regimes (6). Perfuming degraded reefs, as  
65 suggested by Dixon *et al.*, will not enhance recovery rather it will distract from the difficult  
66 task of reducing fishing effort and improving water quality.

67

68 **References**

- 69 1. D. L. Dixon, D. Abrego, M. E. Hay, Chemically mediated behavior of recruiting  
70 corals and fishes: A tipping point that may limit reef recovery. *Science* **345**, 892-897  
71 (2014).
- 72 2. M. A. R. Koehl, Mini review: Hydrodynamics of larval settlement into fouling  
73 communities. *Biofouling* **23**, 357-368 (2007).
- 74 3. T. P. Hughes, A. H. Baird, E. A. Dinsdale, N. A. Moltschaniwskyj, M. S. Pratchett, J.  
75 E. Tanner, B. L. Willis, Supply-side ecology works both ways: The link between  
76 benthic adults, fecundity, and larval recruits. *Ecology* **81**, 2241-2249 (2000).
- 77 4. T. P. Hughes, M. J. Rodrigues, D. R. Bellwood, D. Ceccarelli, O. Hoegh-Guldberg, L.  
78 McCook, N. Moltschaniwskyj, M. S. Pratchett, R. S. Steneck, B. Willis, Phase shifts,  
79 herbivory, and the resilience of coral reefs to climate change. *Curr. Biol.* **17**, 360-365  
80 (2007).
- 81 5. R. Brinkman, E. Wolanski, E. Deleersnijder, F. McAllister, W. Skirving, Oceanic  
82 inflow from the Coral Sea into the Great Barrier Reef. *Estuar. Coast Shelf Sci.* **54**,  
83 655-668 (2002).
- 84 6. E. Wolanski, M. J. Kingsford, Oceanographic and behavioural assumptions in models  
85 of the fate of coral and coral reef fish larvae. *J. Roy. Soc. Interface* **11**, 20140209  
86 (2014).
- 87 7. N. Abe, Post-larval development of the coral *Fungia actiniformis* var. *palawensis*  
88 Doderlein. *Palao Trop. Biol. Sta. Stud.* **1**, 73-93 (1937).
- 89 8. S. Harii, H. Kayanne, H. Takigawa, T. Hayashibara, M. Yamamoto, Larval  
90 survivorship, competency periods and settlement of two brooding corals, *Heliopora*  
91 *coerulea* and *Pocillopora damicornis*. *Mar. Biol.* **141**, 39-46 (2002).
- 92 9. J. Harrigan, Ph. D., University of Hawaii, Honolulu (1972).
- 93 10. S. Motoda, Observation of Period of Extrusion of Planula of *Goniastrea aspera*  
94 (Verrill.). *Kagaku Nanyo* **1**, 5-7 (1939).
- 95 11. D. F. Gleason, B. S. Danilowicz, C. J. Nolan, Reef waters stimulate substratum  
96 exploration in planulae from brooding Caribbean corals. *Coral Reefs* **28**, 549-554  
97 (2009).
- 98 12. K. Atoda, The larva and postlarval development of the reef-building corals IV  
99 *Galaxea aspera* (Quelch). *J. Morphol.* **89**, 17-36 (1951).
- 100 13. K. Atoda, The larva and postlarval development of some reef-building corals I.  
101 *Pocillopora damicornis cespitosa* (Dana). *Sci Rep Tohoku Uni 4th series (Biol)* **18**,  
102 24-47 (1947).
- 103 14. K. Atoda, The larva and postlarval development of the reef-building corals III.  
104 *Acropora brueggemanni* (Brook). *J. Morphol* **89**, 1-16 (1951).
- 105 15. K. Atoda, The larva and post-larval development of some reef-building corals V.  
106 *Seriatopora hystrix* (Dana). *Sci Rep Tohoku Uni 4th series (Biol)* **19**, 33-39 (1951).

107

108

109 **Table 1.** Swimming speeds in  $\text{mms}^{-1}$  for hermatypic scleractinian coral larvae. n = number of  
 110 larvae; SE = standard error; a = mean calculated as average of maximum and minimum  
 111 value; b = mean calculated from larvae aged 2 to 7 days old.

112

Species	Swim direction	Min	Max	Mean	SE	n	Larvae length (mm)	Reference
<i>Heliogungia actinoformis</i>	horizontal	1.15	1.90	1.57	0.09	8	0.50	(7)
<i>Pocillopora damicornis</i> <sup>a</sup>	horizontal	1.67	1.88	1.78	na	na	1.00	(8)
<i>Pocillopora damicornis</i> <sup>b</sup>	horizontal	0.08	3.09	2.01	0.07	82	1.18	(9)
<i>Coelastrea aspera</i> <sup>a</sup>	horizontal	2.00	3.45	2.73	na	na	0.47	(10)
<i>Heliogungia actinoformis</i>	up	0.90	2.65	1.66	0.09	18	0.50	(7)
<i>Agaricia teunifolia</i>	up	1.04	3.16	2.10	0.20	28	na	(11)
<i>Galaxea horrescens</i>	up	1.32	3.33	2.41	0.15	20	2.30	(12)
<i>Pocillopora damicornis</i>	up	1.61	4.50	2.79	0.11	30	2.00	(13)
<i>Porties asteroides</i>	up	1.26	4.34	2.80	0.20	59	0.75	(11)
<i>Isopora bruggemanni</i>	up	1.10	4.55	2.86	0.24	20	2.50	(14)
<i>Seriatopora hystrix</i>	up	na	na	3.33	na	na	1.50	(15)
<i>Heliogungia actinoformis</i>	down	1.97	3.80	2.76	0.17	9	0.50	(7)
<i>Isopora bruggemanni</i>	down	2.56	5.56	3.55	0.18	20	2.50	(14)
<i>Agaricia teunifolia</i>	down	2.01	5.19	3.60	0.30	28	na	(11)
<i>Galaxea horrescens</i>	down	3.03	5.21	3.86	0.13	20	2.30	(12)
<i>Porties asteroides</i>	down	2.76	5.84	4.30	0.30	59	0.75	(11)
<i>Seriatopora hystrix</i>	down	na	na	4.44	na	na	1.50	(15)
<i>Pocillopora damicornis</i>	down	3.68	6.49	4.79	0.13	30	2.00	(13)

113

114

115 **Figure 1.** Coral larvae are notoriously slow swimmers. The minimum swimming speed  
116 required to hold position in the experimental flume used by Dixon *et al.* ( $4.2 \text{ mms}^{-1}$ , red star)  
117 is more than twice the mean horizontal swimming speed of larvae in other studies. Mean  
118 swimming speeds were taken from 14 studies representing over 450 speed measurements (for  
119 references see Table 1. The raw data is available at coraltraits.org). An ANCOVA for log-  
120 transformed speed data against larvae size and swimming direction found only a significant  
121 effect of direction (after dropping size:  $F_{2,15} = 13.72$ ,  $p < 0.001$ ), where gravity-assisted  
122 swimming (downward) was significantly faster than other swimming directions (letters a and  
123 b denote significant differences at  $\alpha = 0.05$ , post-hoc Tukey's test).

124

125



Minimum horizontal swim speeds in Dixson et al.

\*

