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Short Communication

# Scuba Divers Behavior Shapes Fish Wariness and Boldness

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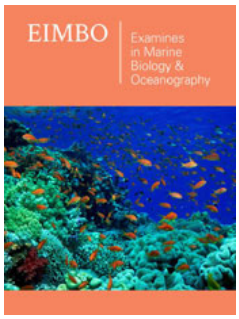
**ISSN: 2578-031X**

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**Submission:** January 24, 2023

**Published:** February 09, 2023

Volume 5 - Issue 4

**How to cite this article:** Jenny Tynyakov, Elena Kheifets, Nadav Shashar*, Assaf Pertzelan, Jonathan Belmaker. Scuba Divers Behavior Shapes Fish Wariness and Boldness. Examines Mar Biol Oceanogr. 5(4). EIMBO. 000616. 2023. DOI: 10.31031/EIMBO.2023.05.000616



## Abstract

Responses of *Chromis viridis*, a coral dwelling damselfish, to divers in sites differing by pressure of diving and by type of diving activity (recreational versus scientific) were examined. We measured variation in hiding time and the distance from a refuge of the fish as they were exposed to divers. Populations of *C. viridis* were tolerant to divers at locations of high regular exposure. Overall, younger fish were more tolerant to divers than older fish. However, where both recreational and scientific diving occurred, fish remained wary, displaying a behavior comparable to the site in which diving is banned. These results show a dynamic response of fishes to human visitation. We suggest that diving clubs and authorities should invest in divers training. Last, we warn that scientific procedures, even if targeted towards a specific fish species, may cause behavioral changes across the fish community.

**Keywords:** Coral reef fish; Diving; Human visitation; Tolerance; Wariness

## Introduction

Human activities influence wildlife on the land [1] and underwater [2,3]. Since animals can rarely predict human intentions, even non-consumptive human activities can influence animal behavior [4]. For many species of prey, the most effective method of predator avoidance is hiding in a refuge [5]. However, hiding in a refuge comes at costs such as reduced foraging [6], less opportunities for mate searching [7,8], which in turn may reduce fitness [9]. Animals living in the absence of harvesting but with frequent human disturbance often show less fear or high tolerance of humans [10,11]. In many marine touristic sites, fish must co-op with insensitive diving activities [12-16]. In protected areas large and mobile fish species are more tolerant compared to areas with harvesting behaviour [11,17-19]. However, highly mobile reef fish groups often leave areas with intensive diving [17,20-22]. Yet, studies found that territorial damselfishes hide more and miss feeding opportunities or fail in nest defense in the presence of divers [16,23]. Here we examined how activities of sites attached to reef fish change among sites that vary in diving intensity and diver's behavior.

## Methods

The Blue green damselfish *Chromis viridis* is a common coral-dwelling planktivore in indo-pacific coral reefs and is found in shoals of juveniles and adults around branching corals that serve as a refuge [24-26]. We examined four sites that differ in the number and type of diving activity. The Oil jetty (29°31'29.8"N 34°56'03.5"E) was closed to recreational divers and experienced under 20 scientific dives per year. The Eilat Coral Natural Reserve (NR) (29°30'34.9"N 34°55'21.4"E) and the Caves (29°29'51.9"N 34°54'40.7"E) each had over 25,000 recreational SCUBA dives per year [27]. The Inter University Institute for marine sciences (IUI) also had over 25000 recreational dives per year and 926 scientific dives, including collection and manipulation of non chromis fish species (2015). We tested 6-10 fish shoals per site (34

total), each composed of three fish size classes small (<2.4cm, 57% of all fishes, 80±8 individuals per shoal), medium (2.4≤x<4.9cm, 23% of the fish, 32±3 individuals), and large (≥4.9cm, 20% of the school, 28±3 individuals). Using videotaping we examined hiding time and the distance to the refuge at start of escape, when exposed to a passing diver stimulus [28,29]. All experiments were video recorded starting 5 min prior to the disturbance and until 15 min after. Videos were analyzed using the Behavioral Observation Research Interactive Software (BORIS) [30]. Our response variable included hiding time and distance to the refuge. We used two ways ANOVA with Tukey post hoc tests to determine differences among sites and size classes.

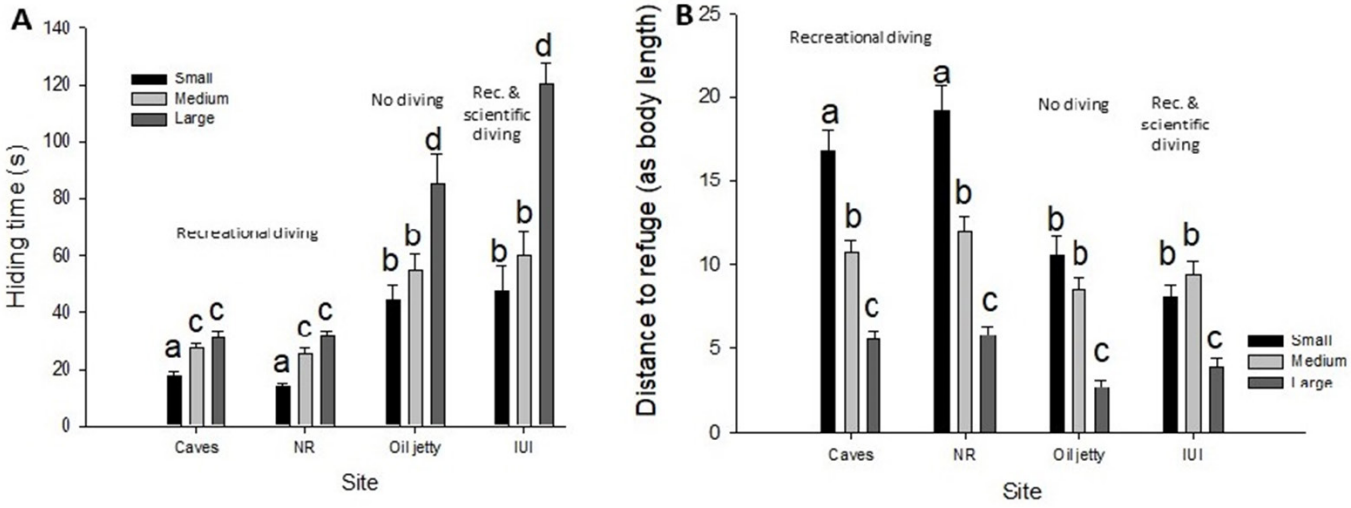


**Figure 1:** A. Smaller *C. viridis* hide less than older ones. Bar chart of time spent in the coral after a diver's passage stimulus for *C. viridis* of different size categories (Small, Medium and Large) by sites: Hiding lowest at sites where only recreation diving occurred. B. Smaller *C. viridis* keep longer relative distances from their refuge as compared to larger fish. Bar chart of distance from refuge of *C. viridis* of different size categories by site. Different letters above columns represent statistically significant differences ($p<0.05$) and error bars represent standard error (±SE).

## Results

Overall, 493 fish belonging to 34 shoals distributed over the 4 sites were examined. We found differences in fish behavior between sites associated with different human exposure levels and between fish sizes categories. Hiding time varied significantly between sites and was low for highly dived sites and high for non-visited areas as well as where scientific activities took place ($F_{3, 481}$=45.37, P<0.001) (Figure 1). Hiding duration for small individuals was significantly shorter compared to large individuals ($F_{11, 481}$=24.13, P <0.001) (Figure 1A). Small individuals kept longer distances from their refuge compared to large individuals among all the sites) distances calculated in body length per fish) ($F_{11, 481}$=33.44, P<0.001) (Figure 1B). These translate to a distance of 28 cm on average for small fish forging and 22cm for large fish.

## Discussion

We examined the effects of diving activities on fish tolerance behavior. We found that Blue green damselfish can habituate to human presence and become tolerant to diver's disturbance. This is particularly important since these fishes are known to have very small home ranges [31] and are loyal to specific coral bummie [32], thus presenting a truly site attached coral reef fish. The fish displayed tolerance to divers, manifested as shorter hiding times and longer distance to a refuge at sites where recreational diving is common (Figure 1). However, even when fish species are not targeted to fishing, their wariness stays high [33]. In our case, where scientific fish handling and collection occurred fish remained as warry as in not visited areas. Hence, promoting non-harvesting diver behavior, even for scientific diving, is pivotal for reducing the impact of divers on coral reef fishes. Small individuals showed riskier behavior, meaning hid less (Figure 1A) and kept larger distances from the coral refuge (Figure 1B) compared to larger fish. This held both in absolute (cm) distances, and in the relative value of body lengths (which is presumably relevant to fish). The above differences in fish behavior may result from different costs of hiding or different perceived risks for small versus large fish [3,34-36]. Small fish have higher metabolic cost of hiding [37] and are considered as less risk aversive [38,39]. This can be because small individuals have "less to lose" and hence are capable of taking higher risks [40,41].

## Conclusion

Anthropogenic effects on coral reefs are often examined using community and population level indices such as biomass, diversity and/or coral coverage. Here we show a fish behavioral effect which is depended on human behavior. From a reef management perspective, this study emphasis the importance of training and briefing visitors to avoid any manipulation of the reef. On the other hand, scientists should use caution in their research, as their activities may effect a wide range of species and not only the one they target.

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