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Varied response of garden eels to potential predators and other large-bodied organisms

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Abstract

Garden eels live in burrows from which they protrude their bodies to feed on planktonic organisms, show courtship behavior and reproduce, and in which they seek refuge from predators. Despite universal acceptance that garden eels retract into their burrows for predator avoidance, a surprising lack of published accounts of this behaviour exists. Here, opportunist observations made during shark abundance video surveys, show reactions of garden eels during encounters with potential predators and other large-bodied organisms. Brown garden eels (*Heteroconger longissimus*) were observed during ten encounters with larger fish, and showed variable responses to five different large-bodied species. Varied responses suggested an ability to discriminate between organisms and react according to relative predation risk and proximity. The largest reactions were in response to encounters with piscivorous teleosts, the most likely predators of garden eels. Multiple encounters with two species of sharks, both improbable predators, resulted in a less pronounced reaction, consistent across encounters but variable with proximity. An encounter with a non-predator teleost resulted in the mildest response, despite very close proximity. These observations suggest that garden eels have the ability to discriminate between large-bodied organisms, and react according to relative predation risk.

Introduction

Garden eels reside in burrows from which they protrude their bodies to feed, engage in courtship behavior and spawn [1], and they use their burrows to seek refuge from predators [2]. Garden eels are well known to retract into their burrows as a method for predator avoidance [2] [3] [4], however, specific accounts are scarce in peer-reviewed literature. To date, this behaviour has largely only been described anecdotally. Very little information is available on what species are predators of garden eels. Snake eels and triggerfish are the most commonly stated predators [5], however, the origins of scientific evidence for these statements is unclear. A tarry hogfish (*Bodianus bilunulatus*) was documented to prey on a garden eel in Hawaii [6], and large stingrays (species undefined) were reported to prey on Red Sea garden eels (*Gorgasia sillneri*) [7]. In the absence of more published observations, marine predators with diets that included piscivory, and that have been documented to feed in the benthos, can be considered to pose a predation risk to garden eels.

It is not known if retraction of garden eels into their burrows is purely in response to the presence of predators, or simply a blanket behaviour in response to encounters with large-bodied marine organisms [6] [3]. Physical retraction into their burrows has been reported by many scuba divers encountering garden eel colonies, which could suggest that this reaction is a blanket response [2]. Here, opportunistic observations showing encounters between brown garden eels (*Heteroconger longissimus*) and different large-bodied marine organisms are documented. Encounters with different species, including predators and other large-bodied organisms, suggest the ability of garden eels to discriminate and adjust responses to species-specific encounters.

Objective

Describe the observed responses of brown garden eels to predators and other large-bodied organisms.

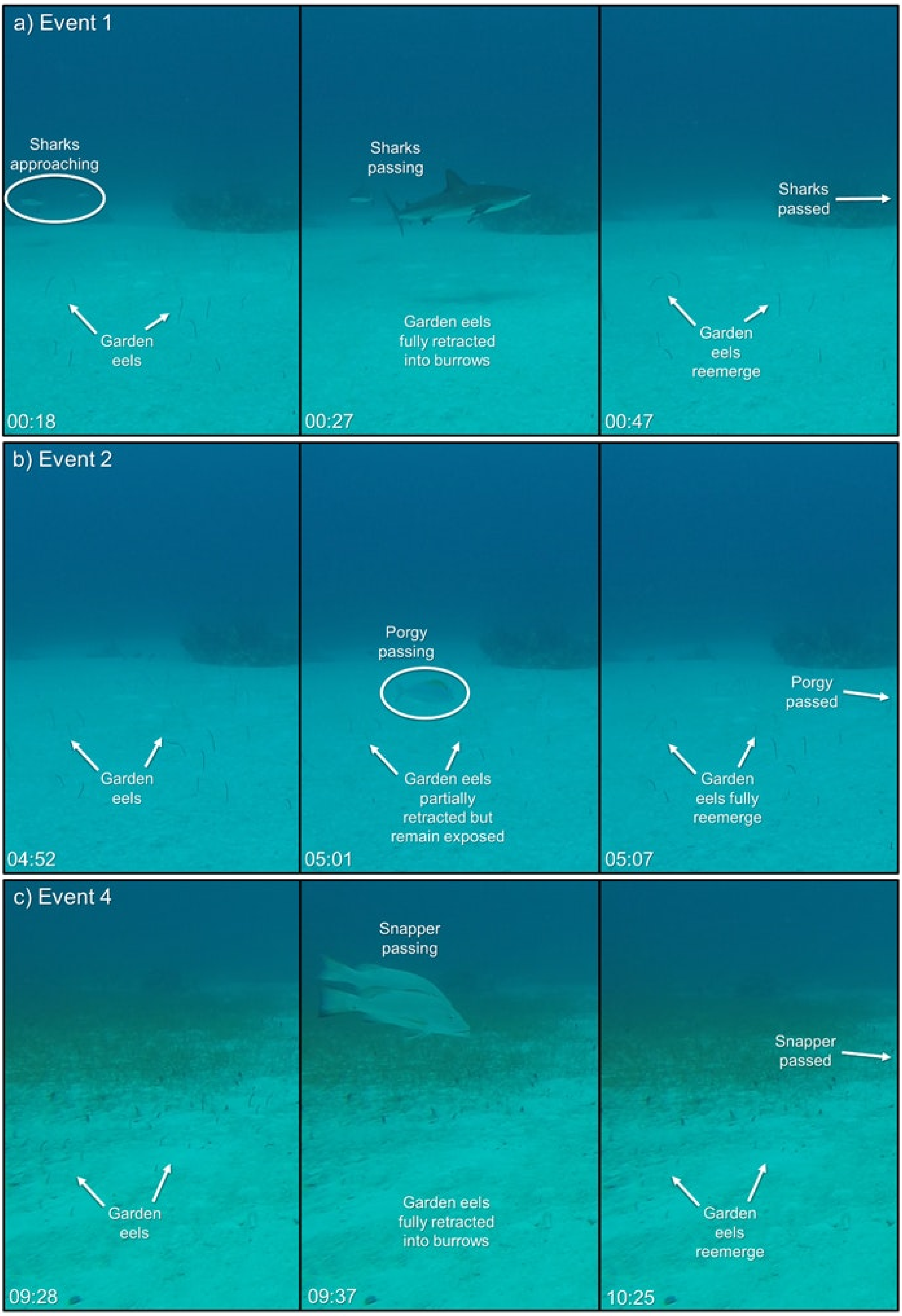

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Figure Legend

Figure 1. Varied garden eel reactions to different large-bodied species.
Annotated screenshots of garden eel reactions to encounters with (A) Caribbean reef sharks (*Carcharhinus perezi*); (B) a sourcereye porgy (*Calamus calamus*); and (C) cubera snappers (*Lutjanus cyanopterus*).
Supplementary Figure 2. Annotated screenshots of garden eel reactions to encounters with (A) a great hammerhead shark (*Sphyrna mokarran*); (B) a sand tilefish (*Malacanthus plumieri*); and (C) a queen triggerfish (*Balistes vetula*).
Supplementary Figure 3. Video survey locations (represented by stars) on the edge of the Tongue of the Ocean, on the Great Bahama Bank. Inset shows broader locations within The Bahamas.
Supplementary Table 1. Details of all observed garden eels encounters with potential predators and other large-bodied organisms, including event reference, video survey reference (from which the observation was sourced), species, number, estimated size of encounter species, estimated proximity between the garden eels and encounter species, observed reaction, and the approximate total duration of the reaction.
Supplementary Table 2. Details of video surveys from which the observations were sourced.
Supplementary Video. Available in more information.

Results & Discussion

Brown garden eels were observed during ten encounters with large-bodied fish at three reef sites (Fig. 1; Suppl. Fig. 2, Table 1, Video 1), and showed variable responses to five different species. This suggests garden eels have the ability to discriminate between organisms, and react according to relative predation risk. The most considerable and longest lasting reaction was in response to an encounter with two cubera snappers (*Lutjanus cyanopterus*), predators of garden eels. Similarly, encounters with a sand tilefish (*Malacanthus plumieri*) and queen triggerfish (*Balistes vetula*), also predators, elicited noticeable responses with a prolonged and full retraction of the eels into their burrows. Multiple encounters at two sites with two species of sharks, both improbable predators, resulted in less pronounced reactions. The reactions to sharks were consistent across encounters but varied with proximity. An encounter with a non-predator, saucereye porgy (*Calamus calamus*), resulted in the mildest response, despite very close proximity.
Five of the ten encounters were attributed to Caribbean reef sharks (*Carcharhinus perezi*; estimated size range = 150 to 180 cm total length [TL]), an improbable predator of garden eels, which passed approximately between 50 to 600 cm above the garden eels (Fig. 1A; Suppl. Video 1). On the four occasions sharks passed between 50 and 220 cm above the eels, the eels fully retracted ~2 s before the shark's arrival, and then reemerged immediately after the sharks had passed. When the shark passed over the eels at a height of ~600 cm, no response was elicited. One encounter was attributed to a great hammerhead shark (*Sphyrna mokarran*; ~300 cm TL), which passed over ~300 cm above the eels (Suppl. Fig. 2A, Video 1). In this instance, the eels partially retracted ~5 s before the shark's arrival, and then re-extended immediately after it had passed.
Large sharks that do not commonly feed in the benthos on small bony fish are improbable predators of garden eels. Other elasmobranchs, ray species that do feed regularly in the benthos, have been suggested [8] and observed [7] as predators of garden eels. As such, the observed response to the elasmobranchs in these encounters may be precautionary. Additionally, sharks of this size are often accompanied by teleosts, such as remoras and jack species, which are primarily piscivores. It is possible, therefore, that the response of the eels may be precautionary for potential commensal predator presence associated with sharks. Encounters with Caribbean reef sharks at two different sites, and multiple encounters at one site, elicited similar responses each time, suggesting that adjusted responses are consistent with probability of predation. Responses to two shark encounters, one with a Caribbean reef shark and one with a great hammerhead shark, at a large distance of separation, elicited a consistent response of partial retraction while remaining exposed throughout the encounter. The consistency between these responses, and the contrast to the Caribbean reef shark encounters at much closer proximity, suggests recognition of predation risk relative to immediate proximity.

The only encounter with a large-bodied bony fish that was a non-predator resulted in the smallest reaction observed. This supported the concept that garden eels can discriminate between larger fish with varying predation risk and adjust their responses accordingly. This encounter was with a saucereye porgy (estimated size ~40 cm TL), which passed approximately 30 cm above the garden eels (Fig. 1B; Suppl. Video 1). During this encounter the eels partially retracted at the point of closest proximity, but remained exposed throughout. Saucereye porgy exclusively feed on crustaceans [9], presenting no known predation risk to garden eels. The mild response observed probably constituted physical avoidance, rather than predator avoidance behaviour. Continued exposure from their burrows, despite the close proximity throughout the encounter, indicated a clear ability to discern between fish of similar size with varying associated predation risk.

The largest response elicited from all ten encounters with large-bodied organisms was in response to the greatest apparent predation risk, again indicating an ability to adjust predator-avoidance response relative to risk. In this encounter, a pair of cubera snappers (estimated size of both ~50 cm TL) passed approximately 30 cm above the eels (Fig. 1C; Suppl. Video 1). The eels responded by fully retracting ~5 s before arrival of the snappers, and then remained submerged for 28 s after they had passed. Cubera snappers are tenacious predators, with bony fish forming a large part of their diet [10]. This strong response was probably relative to the high predation risk associated with close proximity of these active redators.

The second largest response resulted from encounter with a sand tilefish (estimated size ~30 cm TL), which are considered benthically-associated predators, with bony fish as their main dietary component [11]. The tilefish passed approximately 20 cm above the eels, which reacted by fully retracting immediately before its arrival, and remained submerged for 17 s after it had passed (Suppl. Fig. 2B, Video 1). In this encounter, the tilefish moved directly over the garden eel colony and hovered in close proximity to the burrow locations, as if searching for food. It is, therefore, logical that the eels would fully retract and remain submerged for an extended period after the tilefish passed.

Close encounter with a queen triggerfish (estimated size ~30 cm TL) also resulted in an extended reaction from the garden eels. The triggerfish passed approximately 5 cm above the eels, which reacted by fully retracting ~5 s before its arrival and remained submerged for ~8 s after it had passed (Suppl. Fig. 2C, Video 1). Queen triggerfish are considered to primarily feed on sea urchins and other invertebrates, however, bony fish have been observed in their stomachs [12] [13]. Indeed, queen triggerfish are one of the few recognized predators of garden eels, having been observed chasing garden eels into their burrows, then 'dive-bombing' the substrate to dig out and consume them [5]. Prolonged retraction into their burrows for an extended period after the triggerfish left the area, again indicates recognition of direct predation risk and an adjusted response to the encounter with this species.

Conclusions

The ability of garden eels to discriminate between large-bodied organisms of varying predation risk would constitute an energetic benefit by minimizing predation risk while maximizing foraging potential. This would be particularly important on productive reef systems with a high abundance of large-bodied fish, typical of garden eel habitats in The Bahamas, Caribbean region and more broadly across the globe. The mechanism for discrimination is most probably visual, given that garden eels are visual feeders [14] [6], and the retraction response in many cases comes prior to physical arrival. Although seemingly intuitive, these observations represent an important contribution to garden eel-focused literature, due to lack of published information on this taxon.

Limitations

Results presented here are purely observational and the extent of the reactions may have been influenced by additional factors, such as environmental variables, which were not possible to retrospectively quantify.

Controlled manipulations of captive animals could be conducted to verify and quantify the factors influencing these opportunistic observations. Additionally, objects of varying sizes could be moved over garden eel colonies *in situ*, to study the influence of multiple factors.

Additional Information

Methods and Supplementary Material

Please see https://sciencematters.io/articles/201806000024.

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Ethics Statement

The accounts presented here are purely observational and no animals were manipulated.

Citations

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