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Exploring Commensalism Between Rock Wrasse (*Halichoeres semicinctus*) and Round Stingrays (*Urobatis halleri*) in Southern California

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Abstract.—Positive interactions are underrepresented in marine ecology but have a substantial impact on biodiversity and ecosystem stability. Here, we showcase a previously undescribed commensal relationship between two temperate rocky reef fishes in sandy bottom habitats: the rock wrasse (*Halichoeres semicinctus*) and round stingray (*Urobatis halleri*). Using snorkel surveys in Big Fisherman's Cove on Santa Catalina Island, we showed that rock wrasse abundances were positively associated with the presence of round stingrays and that round stingrays significantly altered rock wrasse behavior. Specifically, rock wrasse within a 1 m radius of a feeding round stingray spent approximately 40% and 35% more time feeding compared to rock wrasse in proximity of a resting round stingray or a sandy bottom control, respectively. The positive effect of feeding round stingrays on rock wrasse feeding behavior is in response to stingrays disturbing sand as they eat, uncovering small invertebrates for the wrasses to prey on. As round stingrays are one of the most common fishes in southern California, they may impact the fitness of rock wrasses.

Interspecific interactions can shape food webs, habitats, and structure marine communities (May 1972; Wootton and Emmerson 2005). Historically, ecological studies have focused primarily on antagonistic interspecific relationships such as predation, parasitism, and competition (Mathis and Bronstein 2020). Positive interactions such as commensalism (or facilitation) and mutualism, are generally overlooked (Bertness and Callaway 1994; Bruno et al. 2003). Although, studies on mutualisms, an interspecific interaction in which both species benefit, are now more prominent in the literature (Mathis and Bronstein 2020), possibly because positive interactions are favored by natural selection (Bronstein 1994; Johnson et al. 2021) or because there is evidence for positive interactions increasing habitat stability (Stachowicz 2001). Between the two types of positive interactions, commensalism—the relationship between two species in which one benefits while the other remains unaffected—is still comparatively underrepresented relative to mutualisms, especially within marine research (Mathis and Bronstein 2020). Notably, commensal relationships are more represented in terrestrial (Dickman 1992) and freshwater studies (Silknetter et al. 2020). Here, we showcase a previously unknown commensal relationship in temperate marine fishes and highlight the general importance of understanding commensal relationships in marine ecosystems.

Within the marine realm fishes are a focal point for better understanding the importance of positive interactions. In the Labridae, for example, mutualisms between the cleaner wrasse (*Labroides dimidiatus*) and other resident reef fishes are heavily researched and are shown to facilitate biodiversity (Caves 2021; Waldie et al. 2011). *Labroides dimidiatus* was recorded

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consuming up to 1200 ectoparasites in a single day, allowing them to fulfill a vital function within coral reef ecosystems, influencing the diversity, abundance, size, and recruitment of reef fish via parasite removal (Caves 2021). An 8.5 yr removal of *L. dimidiatus* revealed a significant decline in species richness on the Great Barrier Reef along with changes to resident community structure, recruitment success, and size frequency distribution of other reef fish like the damselfishes *Pomacentrus moluccensis* and *P. amboinensis* (Waldie et al. 2011). In another example, a carnivorous wrasse (*Thalassoma duperry*) formed a mutualistic relationship with the green sea turtle (*Chelonia mydas*) in which the wrasse removed ectoparasitic barnacles from the skin of the turtle (Losey et al. 1994). The sea turtles provided *T. duperry* with food while the removal of ectoparasites by the wrasse seemingly increased the health of *C. mydas* by reducing drag and lowering the chance of infection (Losey et al. 1994). While many wrasses within labrids are the focus for research on interspecific relationships in marine environments, rock wrasse (*H. semicinctus*) differ as they are predominantly foragers rather than cleaners (Hobson and Chess 1986).

Rock wrasse live in temperate rocky reefs, sandy bottoms, and kelp forests from the Gulf of California to Point Conception, California (Miller and Lea 1972). Rock wrasse are opportunistic feeders often found picking off small invertebrates from macroalgae and in disturbed sediments on sandy bottoms (Hobson and Chess 1986). The geographic range of rock wrasse also overlaps with another common temperate fish species, the round stingray (*Urobatis halleri*) (Valadez-González et al. 2001), which also feeds on invertebrates on sandy bottoms (Valadez-González et al. 2001). The round stingray utilizes its pectoral fins to disturb sediment on the sandy bottom floor to uncover prey such as stomatopods, decapods, and amphipods that compose a large portion of their diet (Valadez-González et al. 2001). This feeding practice may result in the displacement of small burrowing invertebrates such as nematodes, porifera, mollusks, echinoderms, and crustaceans from their habitats into the water column, making them readily available prey for the rock wrasse. These sand-dwelling invertebrates are common prey items for rock wrasse (Johnson et al. 1994). We hypothesized that there is a commensal relationship between round stingrays and rock wrasse, where stingrays facilitate rock wrasse by making prey easily available to them. By exploring this interspecific relationship, we plan to identify the dynamics of a potential commensal relationship between two fish species.

Materials and Methods

This study consisted of a combination of behavioral and abundance surveys of rock wrasse and round stingrays during the months of October and November 2022 at Big Fisherman's Cove, Santa Catalina Island, California, USA (33° 26′ 39.1″ N, 118° 29′ 06.2″ W; Fig. 1). Big Fisherman's Cove is located within the Blue Cavern Onshore State Marine Conservation Area which is a no take zone. Rock wrasse and round stingrays are both common fishes at this site (Pondella and Allen 2000; Froeschke et al. 2006). All observations were made at depths ranging from 3 to 5 m and during daylight between the hours of 08:30 and 17:00 as rock wrasse are a diurnal species that bury themselves in the sand at night (Hobson and Chess 1986).

We tested the hypothesis that rock wrasse actively feed more in the presence of feeding round stingrays relative to resting round stingrays or a no stingray control using timed snorkel surveys. Timed snorkel surveys are a commonly used method in fish behavior studies (Lawson et al. 2011; Weaver et al. 2014). Stingray resting behavior was defined as a stingray lying motionless within or on top of the sand during the entire timed survey period. Feeding behaviors were defined as the round stingray disturbing the sand to consume prey. All control

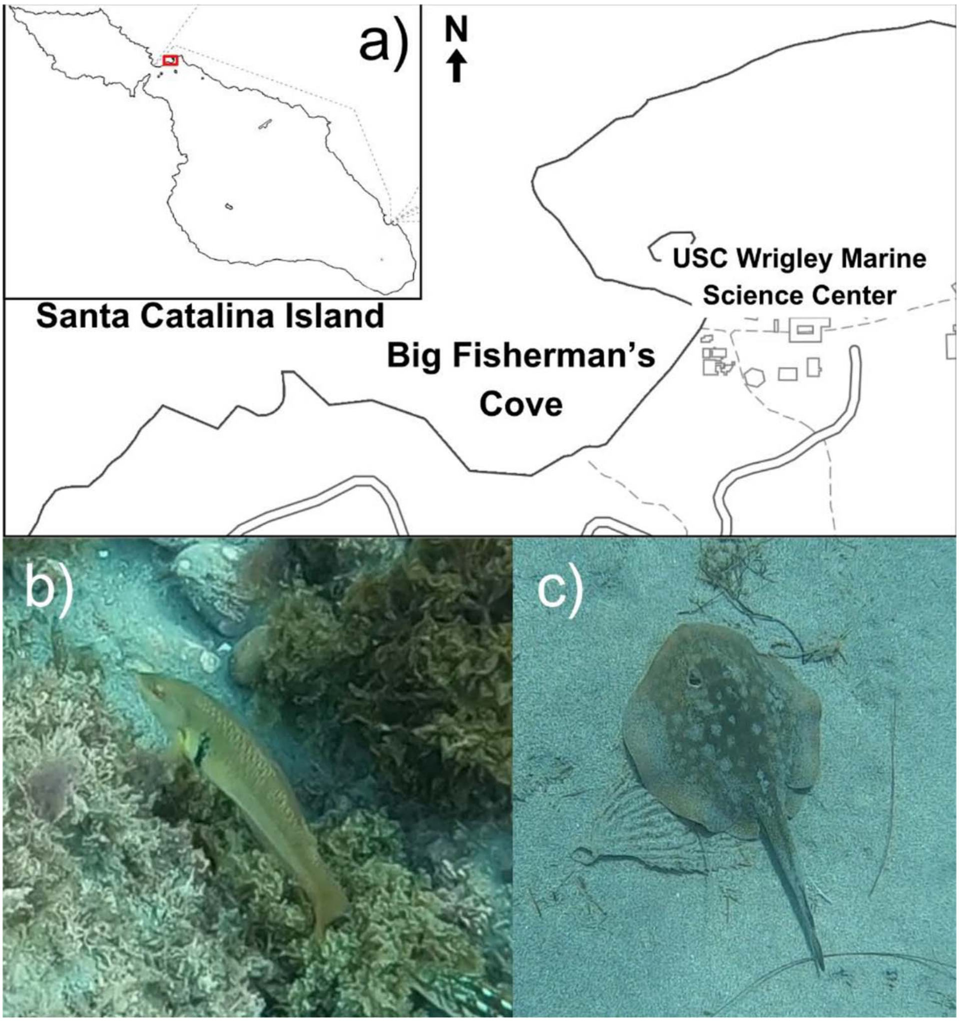

Fig. 1. (a) Geographic location of the study site at Big Fisherman's Cove, Santa Catalina Island. Insets (b) and (c) are photos of the rock wrasse and round stingray, respectively.

samples were taken at locations along the sandy bottom where no stingrays were present within 2 m of a rock wrasse. We haphazardly selected 85 rock wrasse individuals to observe for one minute each: 27 were within 1 m of a resting round stingray, 27 were in the control group with no round stingray present, and 31 were within 1 m of a feeding round stingray. The rock wrasse's behaviors were categorized as either traveling, chasing, or feeding and each behavior was measured to the nearest second using a waterproof stopwatch (Freeman and Grossman 1992). Traveling behavior consisted of the rock wrasse moving through the water column, but not feeding. Chasing behavior consisted of the observed rock wrasse either chasing another fish away or being chased by a fish. Lastly, feeding behavior consisted of foraging within macroalgae, picking through sediment, or snatching prey out of the water column. It is important to note that rock wrasse measurements in the presence of stingrays may have been near more than one stingray, as stingrays tend to feed in groups. In addition to rock wrasse behavior, we measured the instantaneous

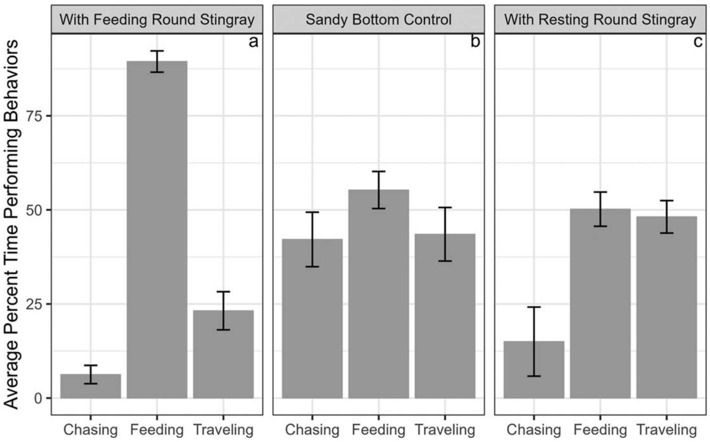

Fig. 2. Mean percent time ± standard error spent by rock wrasse chasing, feeding, and traveling when within one-meter radius of a (a) feeding round stingray (n = 31), (b) sandy bottom control (n = 27), and (c) resting round stingray (n = 27).

abundance of rock wrasse associated with 75 resting and 75 feeding round stingrays. A rock wrasse was labeled as associated with the stingray if it was within a 1m radius of the focal stingray. Rock wrasse abundance surveys were conducted using a zig-zag pattern across the sandy bottom to identify round stingrays and count the abundance of rock wrasse within 10sec of locating a stingray.

We tested the effect of stingray behavior (resting, feeding, no stingray control) on wrasse behavior (feeding, chasing, traveling) with a two-way ANOVA. The percentage of time within an activity during a one-minute sample was the response variable and stingray and wrasse behavior categories were included as interacting predictor variables. A Tukey HSD test was utilized to differentiate significant differences between the wrasse behaviors across each group. Assumptions for the two-way ANOVA were assessed by visualizing the distribution of the residuals using the *performance* package in R (Lüdecke et al. 2021). To analyze differences in rock wrasse abundance across resting versus feeding round stingrays, we used a generalized linear model with a Poisson distribution to account for non-normality within the data. All analyses were conducted using the program R (Version 4.2.1).

Results

The behavior of the round stingray significantly altered the behavior of the rock wrasse ($F_{4,155} = 17.52$, $p < 0.0001$; Fig. 2), with the greatest impact on feeding. Overall, the rock wrasse spent the majority of the time feeding when in the presence of a feeding round stingray (89.41% ± 2.82, $p < 0.0001$) and spent 39.2% and 34.1% more time feeding near a feeding round stingray compared to a resting round stingray ($p < 0.0001$) and a sandy bottom control ($p < 0.0001$), respectively. Rock wrasse near feeding round stingrays spent significantly less time on average chasing (6.25% ± 2.43) compared to rock wrasse with no round stingray present (42.14% ± 7.24; $p = 0.01$; Fig. 2). Rock wrasse associated with feeding stingrays also spent less time traveling (23.19% ± 5.06) than rock wrasse with a resting round stingray (48.15% ± 4.31; $p = 0.04$) or a sandy bottom control (43.52% ± 7.11; Fig. 2). The abundance of rock wrasse was significantly higher near feeding rays (1.07 ± 0.06, n = 75) than resting rays (0.00 ± 0.00, n = 75) during the snorkel count surveys ($X^2_{(1)} = 28.42$, $p < 0.0001$). Notably, no rock wrasse were present near resting stingrays during the instantaneous surveys whereas the highest number of wrasses documented near a feeding round stingray was three.

Discussion

This study provides evidence for a commensal relationship between the rock wrasse and the round stingray in sandy bottom habitats based on both behavioral and abundance data. The significant increase in rock wrasse time spent feeding and their abundance in the presence of a feeding round stingray indicates that rock wrasse individuals benefit from stingrays. Notably, the strength of this relationship will change seasonally as stingrays migrate to warmer waters in the winter throughout southern California (Allen et al. 2002; Hoisington and Lowe 2005; Vaudo and Lowe 2006). Further, as rock wrasse are opportunistic feeders and are not reliant on stingrays for sustenance (Hobson and Chess 1986), it is likely that the rock wrasse and round stingrays exhibit a facultative commensal relationship. Considering the seasonal variability in round stingray abundance and the dynamic nature of the rock wrasse's ecological interactions as an opportunistic feeder, more research is required to identify and understand the range of biotic relationships taking place in this system. Because many temperate fish species disturb sediment while searching for prey, rock wrasse may have many commensal relationships with other fishes and invertebrates. Specifically, we noted rock wrasse feeding around California sheephead (*Bodianus pulcher*), halfmoon (*Medialuna californiensis*), opaleye (*Girella nigricans*), garibaldi (*Hypsypops rubicundus*), sargo (*Anisotremus davidsonii*), shovelnose guitarfish (*Rhinobatos productus*), and the California two-spot octopus (*Octopus bimaculoides*) at Santa Catalina Island. The relative importance of these different bioturbators to rock wrasse should be further explored.

Rock wrasse may experience increased fitness due to the feeding behaviors of round stingrays and other bioturbators by making the rock wrasse's prey items more easily accessible. When rock wrasse feed along sandy bottoms, they use their anterior canines to meticulously search for and pick out prey items within the sand (Hobson and Chess 1986). By utilizing the feeding round stingrays, rock wrasse can single out prey in the sand clouds, which likely reduces search time and energy expenditure for finding food. Foraging fish are faced with an important risk trade-off when searching for food availability while avoiding predation (Milinski 1992). Fish, such as the bluegill sunfish (*Lepomis macrochirus*), have been shown to consciously weigh profitability of feeding against predation (Werner et al. 1983). To minimize predation risk, foraging fish often seek complex habitats for safety, decrease foraging behavior, and reduce their feeding range (Hammerschlag et al. 2010; Holbrook and Schmitt 1988; Milinski 1992; Werner et al. 1983). However, rock wrasse in this study are utilizing a high-risk feeding area due to the openness of the sandy bottom habitat in which round stingrays are feeding. This increased predation risk of foraging in an open area may be counteracted by the reduction in foraging time as a result of the round stingray increasing food availability. Increased food availability has been shown to not only affect growth rate and survival in fishes (Werner et al. 1983), but also improve reproductive success in coral reef damselfish (*Acanthochromis polyacanthus*) (Donelson et al. 2010). Further research is needed to expand our understanding of the individual and ecological impacts this species interaction may have on rock wrasse fitness.

While we did not specifically test the effect of rock wrasse on round stingrays, the round stingrays appeared indifferent to the presence of rock wrasse hovering above them, further suggesting that this is a commensal relationship as only one species benefitted from the interaction (Mathis and Bronstein 2020). Two types of commensal relationships have been identified with respect to the non-benefiting species: no-effects commensalism or balanced-cost-and-benefits commensalism (Mathis and Bronstein 2020). No-effects commensalism occurs when one of the species is completely unaffected from the interaction, while balanced-cost-and-benefits commensalism occurs when the cost and benefit of the interaction equal each other resulting in a net null effect. We propose that rock wrasse and round stingrays exhibit a no-effects commensalism as we never saw any behavioral changes in the stingray while in the presence of a rock wrasse, though this should be explicitly tested in the future. No effects commensalisms have been shown in other marine fishes such as the Carapini fish (*Carapus boraborensis* and *C. homei*) with their holothurian host (*Bohadschia argus*) during metamorphosis (Parmentier and Das 2004; Mathis and Bronstein 2020) and the juvenile jack mackerel (*Trachurus japonicus*) observed utilizing the bell cavity and tentacles of moon jellyfish (*Aurelia aurita*) for food collection and predator avoidance (Masuda et al. 2008).

Commensalism has been generally overlooked in marine ecology despite playing a major role in community dynamics (Mougi 2016; Bertness and Callaway 1994). For example, in Costa Rica, commensalism between large marine predators and fish-eating birds resulted in an enriched biodiversity at the lagoon where the commensalism was present compared to a lagoon that the interaction was absent (Deffebach et al. 2012). Indeed, further investigation into species interactions has changed our understanding of "textbook" examples of symbiotic relationships. It remains crucial to gain a better understanding of commensalisms as this species interaction has been shown to increases ecosystem stability and can positively influence recruitment, species distribution, and succession (Bertness and Callaway 1994; Mougi 2016).

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