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First record of the Phoenix Islands damselfish *Plectroglyphidodon phoenixensis* (Schultz, 1943) from the Northwestern Hawaiian Islands

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Abstract

Background: The coral reef fishes of Northwestern Hawaiian Islands (NWHI), encompassed by the Papahānaumokuākea Marine National Monument (PMNM), are known for high levels of endemism, as well as for strong affinities to the biota of Johnston Atoll. A novel species of pomacentrid damselfish, *Plectroglyphidodon phoenixensis*, is recorded for the first time from the NWHI.

Results: A total of nine individuals of *Plectroglyphidodon phoenixensis* were recorded at French Frigate Shoals in September 2017. All observations were made by skin divers in shallow (< 1 m), extremely surgy rocky subtidal habitats. These observations represent a significant range extension of this species into the north central Pacific. No individuals of *P. phoenixensis* were observed in similar surgy rocky subtidal habitats at the adjacent islands of Nihoa and Mokumanamana.

Conclusion: The discovery of multiple *P. phoenixensis* in an under-sampled habitat suggests that they may occur in Hawai'i more frequently than was previously thought. These observations provide valuable information on the habitat preferences and geographic range of this species. Given the absence of a reproducing population in the Hawaiian Archipelago, the closest source of propagules of this species is Johnston Atoll.

Keywords: Phoenix Islands damselfish, *Plectroglyphidodon phoenixensis*, Northwestern Hawaiian Islands, Papahānaumokuākea marine national monument, French frigate shoals

Background

The Phoenix Islands damselfish, *Plectroglyphidodon phoenixensis* (Schultz, 1943), is a coral reef associated, tropical marine fish species of the family Pomacentridae. *P. phoenixensis* is a solitary territorial herbivore (Myers 1999), feeding primarily on benthic algae (Bacchet et al. 2006). This genus exhibits paired behavior during breeding, producing demersal eggs which are guarded by the male (Breder and Rosen 1966).

First described from Enderberry Island in the Phoenix Islands by Schultz (1943), *P. phoenixensis* is widespread on tropical reefs from East Africa to French Polynesia, south to the Pitcairn Islands, and as far north as the Ryukyu Islands and Johnston Atoll (Myers 1999, Randall 2007). *P. phoenixensis* has been recorded on three occasions from the main Hawaiian Islands (Fig. 1), but is regarded as a waif without a locally reproducing population (Hoover 2007, Randall 2007). Sightings included lone individuals off Kaʻaʻawa, Oʻahu and Kailua-Kona, Hawaiʻi, and a group of multiple individuals off south Maui (Hoover 2007). *P. phoenixensis* has not been previously recorded from the Northwestern Hawaiian Islands (NWHI). This observation thus extends the known range of this species 870 km further to the northwest within the Hawaiian Archipelago.

Methods

Subtidal visual surveys were conducted adjacent to basaltic rocky intertidal shorelines of the three southernmost reefs of the Northwestern Hawaiian Islands (NWHI): Nihoa (23° 04'N, 161°55'W), Mokumanamana (23°34'N, 164°42'W),

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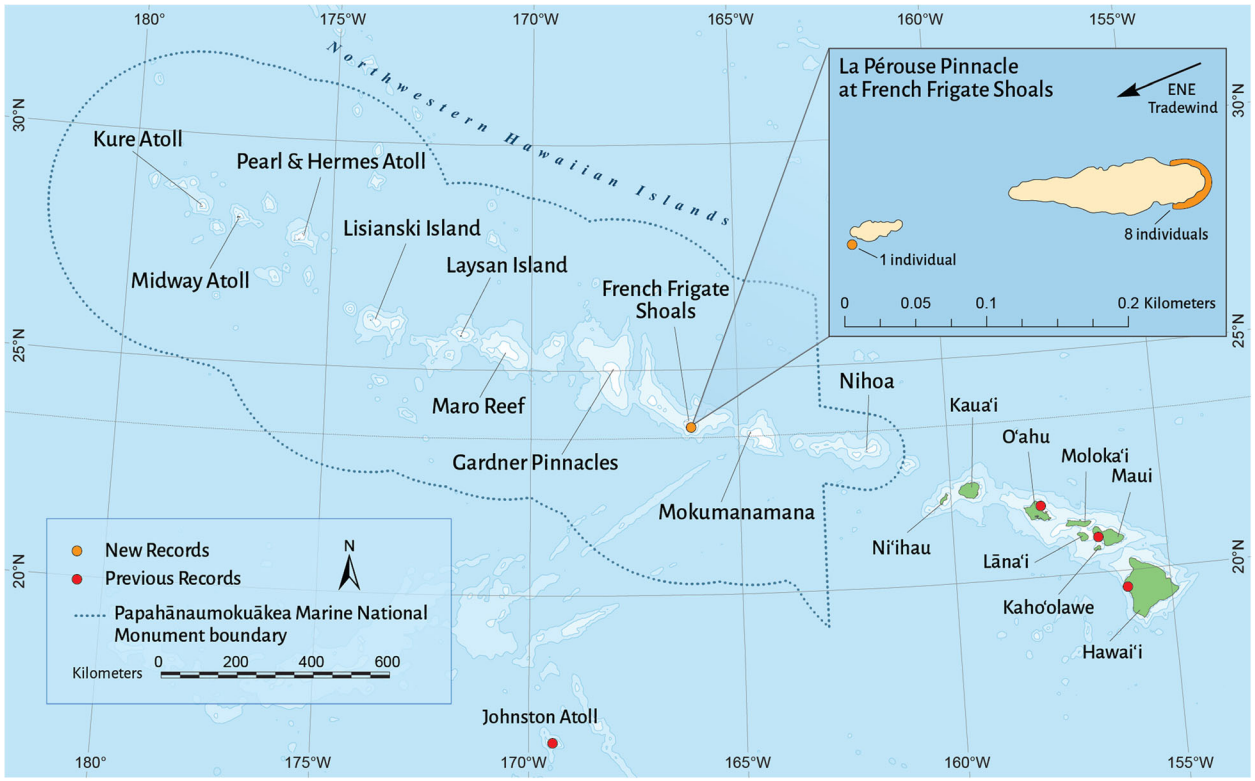

Fig. 1 Locations of current and previous reports of the Phoenix Islands damselfish, Plectroglyphidodon phoenixensis (Schultz, 1943), in the vicinity of the Hawaiian Archipelago

and French Frigate Shoals (23°52'N, 166°17'W) (Fig. 1). At French Frigate Shoals, all surveys were conducted at La Perouse Pinnacle, the last emergent remnant of a basaltic high island in the center of an otherwise completely calcareous 940 km^2 atoll. Nihoa and Mokumanamana are small, completely basaltic islands (0.69 km^2 and 0.18 km^2 respectively). Surveys completely encircled La Perouse Pinnacle, and were concentrated on the west facing shorelines of Nihoa and Mokumanamana.

25 × 2 m quantitative fish counts were conducted at depths of 1 m, 3 m, and 5 m by a breath-hold skin diver. During each survey, the diver laid out a 25 m line, and returned along the length of the line while recording numbers and sizes of all visible fishes. All fishes encountered within the transect were identified to species or lowest possible taxon, and size was estimated to the nearest centimeter. Off-transect presence/absence observations were made in the proximity of all transects at similar depths.

Results

Nine individuals of *P. phoenixensis* were observed around La Perouse Pinnacle in the center of the lagoon at French Frigate Shoals (Fig. 2). All were in less than 1 m of water on the windward exposure of the pinnacle and a small adjacent basaltic island. Wind chop from the prevailing east-northeast tradewind swell produced an extremely turbulent environment, characterized by breaking waves, poor visibility due to bubbles, and strong surge. No individuals were sighted on the leeward side of the pinnacle in much calmer, clearer conditions. 2 individuals were recorded in six 25 × 2 m transects at 1 m depth, for a mean density of 0.33 fish per 50 m^2 (± 0.33 SE). The remaining 7 individuals were sighted while conducting qualitative presence/absence surveys off-transect between 0 and 1 m depth. No individuals were recorded in transects at 3 m (n = 6) and 5 m (n = 6).

No individuals of *P. phoenixensis* were recorded on similar 25 × 2 m transects at Nihoa (1 m: n = 9; 3 m: n = 9; 5 M: n = 9) or Mokumanamana (1 m: n = 14; 3 m: n = 14; 5 M: n = 14), nor were any sighted off-transect at either island in spite of extensive searches of surgy, shallow subtidal habitats similar to those encountered at French Frigate Shoals.

Discussion

All observations were made in a habitat that is extraordinarily difficult to safely access by divers. Extremely shallow (< 1 m) rocky subtidal habitats exposed to breaking surf and extreme surge are greatly undersampled compared to calmer, more user-friendly coral reef habitats at greater depths. It is therefore possible that *P.*

Fig. 2 Phoenix Islands damselfish, *Plectroglyphidodon phoenixensis* (Schultz, 1043), 1 m depth, La Perouse Pinnacle, French Frigate Shoals, Hawai'i

phoenixensis occurs in Hawaiian waters more frequently than is currently thought, but goes unobserved due to the challenges associated with accessing their preferred habitat. However, the fact that significant sampling effort in comparable habitats at the adjacent islands of Nihoa and Mokumanamana failed to identify any additional *P. phoenixensis* suggests that an unusual pulse of recruitment produced the population observed at French Frigate Shoals, and a lack of sampling effort is not to blame for this species' apparent absence on neighboring reefs.

It is unlikely that *P. phoenixensis* is found in deeper waters in the NWHI. Annual Reef Assessment and Monitoring Program (RAMP) cruises deploy divers to conduct visual fish surveys throughout the NWHI. Between 2000 and 2016, 1325 unique sites were surveyed between 7 and 30 m (RAMP fish dataset described by Heenan et al. 2017). *P. phoenixensis* was not recorded in any of these surveys.

Myers (1999) described *P. phoenixensis* as living in close association with live corals, particularly *Acropora* spp. and *Pocillopora* spp. In this study, however, *P. phoenixensis* was not observed in close proximity to either genus of coral, although several species of *Acropora* and *Pocillopora meandrina* were abundant within a few meters of *all P. phoenixensis* sightings. Sightings in this study were consistent with the observations of Randall (2005, 2007), who described the habitat of this species as rocky substrate in the surge zone at depths of less than 2 m. The red alga *Asparagopsis taxiformis* and the brown alga *Turbinaria ornata* were very abundant in the home ranges of *P. phoenixensis* at French Frigate Shoals.

Competition has the potential to limit the establishment and abundance of ecologically similar fishes (Jones 1991). Other herbivorous, territorial species recorded in the transect surveys included *Plectroglyphidodon johnstonianus*, *P. imparipennis*, *Stegastes marginatus*, and *Abudefduf sordidus*. None were abundant, and no behavioral interactions with *P. phoenixensis* were observed.

Johnston Atoll, 750 km south of French Frigate Shoals (the closest reef of the 2400 km long Hawaiian archipelago), is considered to be an outlier of the Hawaiian faunal region (Fig. 1). Johnston's fish fauna is largely a subset of the Hawaiian fauna. However, some central and south Pacific species, including *P. phoenixensis*, are abundant as far north as Johnston but are rare or absent in Hawai'i (Gosline 1955; Randall et al., 1985; Kosaki et al. 1991). French Frigate Shoals, by virtue of geographic proximity and oceanographic connectivity to Johnston, has been proposed as a portal that allows tropical Pacific species to enter the Hawaiian archipelago (Gosline 1955, Grigg 1981; Randall et al. 1985, Kosaki et al. 1991; Kobayashi 2006). In a study of genetic connectivity in damselfishes between Johnston and the Hawaiian archipelago, Ramon et al. (2008) found lower stock structure and a greater number of migrants per generation between Johnston and the NWHI (especially French Frigate Shoals) compared to the main Hawaiian Islands. This supports the hypothesis that the Johnston-French Frigate Shoals corridor is important in maintaining connectivity between Johnston and the Hawaiian archipelago. Given the absence of a reproducing population in the Hawaiian Archipelago, Johnston Atoll is the most likely source of *P. phoenixensis* at French Frigate Shoals.

The Phoenix Islands Protected Area shares a sister-site relationship with PMNM (NOAA 2009). The two marine protected areas now share the distribution of a species named after the former location.

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Authors' contributions
RKK and JMH conducted the field observations. Both authors read and approved of the final manuscript.

Ethics approval and consent to participate
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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