

Native grouper indirectly ameliorates the negative effects of invasive lionfish

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Table S1. Physical characteristics and treatment assignments for 16 solution holes used to test red grouper and lionfish effects on juvenile reef fish abundance and diversity. Treatment codes: “NP” neither focal predator present; “LF” lionfish alone, red grouper removed; “RG” red grouper alone, no lionfish; “BP” both a lionfish and a red grouper were present. Excavated area and maximum depth were each measured at the end of the six-week experiment in 2013. “n.a.” refers to treatments that did not include the listed predator.

| Hole # | Treatment | Area (m ²) | Max depth (cm) | Red grouper size (cm TL) | Lionfish size (cm TL) |
|--------|-----------|------------------------|----------------|--------------------------|-----------------------|
| 1 | NP | 2.18 | 33 | n.a. | n.a. |
| 2 | LF | 1.69 | 77 | n.a. | 16.1 |
| 2A | NP | 2.94 | 40 | n.a. | n.a. |
| 3 | RG | 4.06 | 46 | 50.1 | n.a. |
| 5 | LF | 6.31 | 46 | n.a. | 22.3 |
| 6 | BP | 6.08 | 50 | 49.8 | 18.6 |
| 7 | NP | 5.45 | 26 | n.a. | n.a. |
| 8 | RG | 2.52 | 47 | 56.3 | n.a. |
| 9 | BP | 6.32 | 44 | 52.0 | 19.1 |
| 11 | BP | 3.69 | 35 | 52.7 | 14.6 |
| 12 | LF | 4.73 | 49 | n.a. | 16.7 |
| 17 | NP | 5.01 | 55 | n.a. | n.a. |
| 18 | RG | 3.98 | 39 | 48.1 | n.a. |
| 23 | RG | 2.72 | 59 | 58.5 | n.a. |
| 24 | BP | 5.01 | 46 | 45.4 | 15.1 |
| 25 | LF | 4.47 | 33 | n.a. | 16.3 |

Table S2. Model selection results for linear mixed model (LMM) analysis of the effect of red grouper and lionfish on juvenile reef fish communities. Likelihood Ratio Test (LRT) results for including a treatment by time interaction term. If the interaction did not significantly improve the model based on the LRT, then treatment and week were tested independently. LMM test results for including a variance by treatment and autocorrelation structure in models were determined based on AIC scores as adding these structures caused models to be non-nested. Significant effects that improved the model fit are indicated in bold and the final “best-fit” model included all significant factors and structures.

| Response Variable | Variable | LRT Results | | | Variance Structure | Autocorrelation Structure | AIC |
|-------------------|-------------------|-------------|-----------|-------------------|--------------------|---------------------------|--------------|
| | | L-ratio | df | p-value | | | |
| N | treat*week | 31.0 | 18 | 0.029 | equal | none | 1083 |
| | treatment | -- | -- | -- | treatment | none | 994.2 |
| | week | -- | -- | -- | equal | AR(1) | 1066 |
| | | | | | treatment | AR(1) | 952.4 |
| H ₀ | treat*week | 22.8 | 18 | 0.200 | equal | none | 414.8 |
| | treatment | 17.8 | 3 | < 0.001 | treatment | none | 418.4 |
| | week | 25.6 | 6 | < 0.001 | equal | AR(1) | 402.3 |
| | | | | | treatment | AR(1) | 403.8 |
| H ₁ | treat*week | 16.8 | 18 | 0.53 | equal | none | 338.7 |
| | treatment | 15.7 | 3 | 0.001 | treatment | none | 342.5 |
| | week | 21.6 | 6 | 0.001 | equal | AR(1) | 340.5 |
| | | | | | treatment | AR(1) | 343.6 |
| H ₂ | treat*week | 18.2 | 18 | 0.44 | equal | none | 317.1 |
| | treatment | 16.1 | 3 | 0.001 | treatment | none | 320.0 |
| | week | 16.1 | 6 | 0.013 | equal | AR(1) | 318.7 |
| | | | | | treatment | AR(1) | 322.0 |
| Evenness | treat*week | 29.5 | 18 | 0.04 | equal | none | 104.4 |
| | treatment | -- | -- | -- | treatment | none | 92.1 |
| | week | -- | -- | -- | equal | AR(1) | 105.4 |
| | | | | | treatment | AR(1) | 93.1 |

Table S3. Diet composition of lionfish collected from solution holes in Florida Bay in the presence (RG+) and absence (RG-) of red grouper at the time of collection. Diet metrics listed include the total number; F = frequency of occurrence in all stomachs; % F = percent frequency of occurrence; % N = percent by number; and % W = percent by weight. "UID" = unidentified prey.

| Prey Group | Number | | F | | % F | | % N | | % W | |
|------------------|--------|-----|-----|-----|------|------|------|------|------|------|
| | RG+ | RG- | RG+ | RG- | RG+ | RG- | RG+ | RG- | RG+ | RG- |
| Total Crustacean | 26 | 8 | 9 | 7 | 56.3 | 43.8 | 56.5 | 21.6 | 12.1 | 7.62 |
| UID Crustacean | 0 | 1 | 0 | 1 | 0 | 6.25 | 0 | 2.70 | 0 | 0.95 |
| UID Shrimp | 5 | 0 | 1 | 0 | 7.69 | 0.00 | 10.9 | 0 | 2.16 | 0 |
| Hippolytidae | 3 | 2 | 2 | 2 | 15.4 | 12.5 | 6.52 | 5.41 | 1.30 | 1.90 |
| <i>Lysmata</i> | 6 | 0 | 3 | 0 | 23.1 | 0.00 | 13.0 | 0 | 3.46 | 0 |
| Palaemonidae | 12 | 5 | 8 | 5 | 61.5 | 31.3 | 26.1 | 13.5 | 5.19 | 4.76 |
| Total Teleost | 20 | 29 | 11 | 13 | 45.8 | 54.2 | 43.5 | 78.4 | 87.9 | 92.4 |
| UID Teleost | 10 | 13 | 8 | 9 | 61.5 | 56.3 | 21.7 | 35.1 | 10.0 | 29.5 |
| Lutjanidae | 1 | 0 | 1 | 0 | 7.69 | 0 | 2.17 | 0 | 59.7 | 0 |
| <i>Haemulon</i> | 2 | 0 | 2 | 0 | 15.4 | 0 | 4.35 | 0 | 8.66 | 0 |
| Gobiidae | 5 | 5 | 1 | 5 | 7.69 | 31.3 | 10.9 | 13.5 | 8.66 | 57.1 |
| UID | 2 | 11 | 2 | 6 | 15.4 | 37.5 | 4.35 | 29.7 | 0.87 | 5.71 |