

Consumption Potential of Invasive Lionfish (*Pterois volitans*) On Caribbean Coral Reefs

STEPHANIE GREEN and ISABELLE CÔTE

Department of Biological Sciences Simon Fraser University 8888 University Drive Burnaby, BC V5A1S6 Canada

EXTENDED ABSTRACT

First reported from Atlantic coral reefs in 2004, Indo-Pacific lionfish (*Pterois volitans*) have spread rapidly around the Caribbean basin (Freshwater *et al.* 2009, Morris *et al.* 2009) and are now one of the most abundant predators of their size on invaded Bahamian coral reefs (REEF 2009). Following this rapid range expansion, temporal data from the Reef Environmental Education Foundation reveal exponential increases in the local abundance of lionfish in several regions (REEF 2009). There is great concern about the ecological and economic impacts of dense lionfish populations on Caribbean coral reef systems (Green and Cote 2009). Analyses of lionfish stomach contents from the Bahamian archipelago reveal that lionfish prey on over 50 species of native Caribbean reef fish (Green Unpublished data, Morris and Akins 2009) and studies on experimental reefs reveal that a single lionfish can reduce the recruitment of native Caribbean fishes by 80% through predation (Albins and Hixon 2008). However, to understand the cumulative impact of lionfish on Caribbean coral reef fish communities, and set targets for lionfish population management, we must link the magnitude and rate of lionfish prey consumption to the production of their prey on invaded reefs.

To meet these objectives, we synthesized data on invasive lionfish population parameters, bioenergetics and diet to create a probabilistic model (Vose 2008) of lionfish prey consumption on invaded reefs and then compared these consumption rates with estimates of production of their fish prey. To parameterize our model, we collected data on prey-sized fish density, diversity and size distribution, and lionfish density, size distribution and diet collected from 13 invaded coral reef sites off the southwest coast of New Providence, Bahamas, from May through to September 2008.

Our analyses reveal that invasive lionfish populations far exceed sustainable levels on the majority of the coral reefs we studied. Using our model to quantify the density of lionfish that could be sustained by their prey populations at each site revealed that most reefs require significant reduction in lionfish abundance and that 'sustainable' lionfish densities depend not only on prey production rates, but on the size distribution of lionfish at each site.

The main tool being considered by managers to control invasive lionfish population is manual removal by divers. However, the cryptic nature of lionfish may introduce challenges in effectively detecting their presence across the reefscape. In particular, there may be a bias towards detecting and removing only the largest size classes of lionfish inhabiting a reef area. We used our model to evaluate the effect of this potential size bias on the ability of removal efforts to keep lionfish abundances at sustainable levels. Using data from a study site harbouring a high density of large lionfish (density: 344 ± 164 lionfish/ha (mean \pm SD); body mass: 296 ± 211 g/lionfish), we simulated our model for three removal scenarios. We varied the smallest size class of lionfish detected and removed from 15cm, to 20cm, and 25 cm total length, respectively. To determine how the minimum size of lionfish removed affects the sustainability of the consumption by the remaining lionfish, we simulated the difference between annual prey consumption by lionfish and the annual production of their prey base for each scenario. Results were only considered sustainable if the removal effort reduced annual prey consumption to a level equal to or less than annual prey production at the site.

We found that targeting all individuals greater than 15cm, 20cm and 25cm total length would remove 89%, 87%, and 79% of the population, respectively. However, there were substantial differences in the sustainability of each removal scenario (Figure 1). Our analyses revealed in two of the three scenarios, both targeting lionfish greater than 20cm and 25cm total length for removal, lionfish prey consumption was not reduced to sustainable levels (i.e. net annual biomass production of their prey was less than zero). However, our model revealed that removing all individuals greater than 15cm total length from the site reduced the consumption capacity of the remaining population to levels that were far surpassed by the production of their prey, and was therefore sustainable. These results indicate that potential size selectivity in removal efforts can significantly affect the success of lionfish population management efforts. Our model provides a method by which regional resource managers can assess the risk of local reef fish populations to lionfish predation, and set clear targets for control and management efforts on invaded Caribbean reefs.

KEYWORDS: Lionfish, invasive species, predator, fish production

Tasas de Consumo Potenciales del Pez León Invasor (*Pterois volitans*) en los Arrecifes de Coral del Caribe

Desde el año 2004 cuando se registro la primera aparición del pez león (*Pterois volitans*) especie invasiva procedente del Indo-Pacífico en los arrecifes de coral del Atlántico occidental, el pez león se ha extendido rápidamente en la cuenca del Caribe. Para entender el impacto de la depredación del pez león sobre la comunidad de peces en las Bahamas y para predecir los impactos potenciales sobre el mar del Caribe, creamos un modelo probabilístico de la tasa de consumo de presas por el pez león en 13 arrecifes invadidos en las

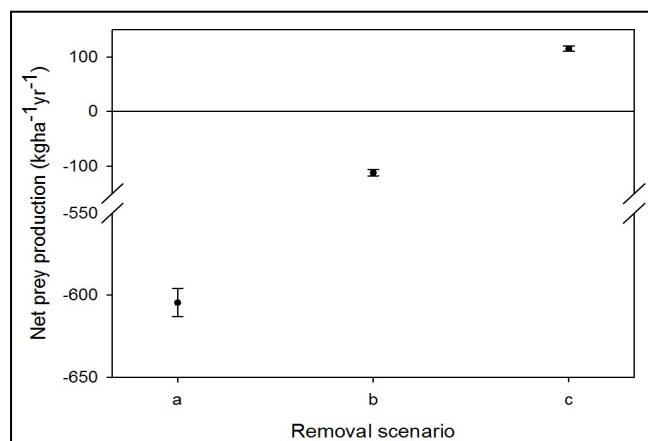
Bahamas y comparamos estos valores con las estimaciones de las tasas de producción sus peces presa. Nuestro análisis revela que el pez león tiene la capacidad de consumir presas en los arrecifes con una tasa mayor a la que las que las poblaciones de peces de arrecife pueden recuperarse. Para fijar objetivos para la gestión, usamos el modelo para cuantificar las densidades de peces león que podrían mantener las tasas de producción de peces presa disponible en cada zona. Las densidades sostenibles estimadas no dependen solo de la tasa de producción de las presas sino también del tamaño de las distribuciones de los peces león que habitan en cada zona. Nuestro modelo proporciona una herramienta a los gestores de los recursos regionales para evaluar el riesgo de los peces león sobre las poblaciones de peces de arrecife locales y para establecer objetivos de control y esfuerzos de gestión.

PALABRAS CLAVES: Especie invasiva, *Pterois volitans*, producción sus peces

Consommation Potentielle du Rascasse Envahissant (*Pterois volitans*) Sur les Récifs De Corail Antillais

D'abord annoncé des récifs de corail de l'Atlantique en 2004, le rascasse Indo-Pacifique (*Pterois volitans*) s'est étendu rapidement autour de la cuvette antillaise et est maintenant un des prédateurs les plus abondants de leur taille sur les récifs de corail envahis des Bahamas. Pour comprendre l'impact de la prédation par le rascasse sur les communautés de poisson natifs aux Bahamas et prédire leurs impacts potentiels au large des Caraïbes, nous avons synthétisé des données sur les paramètres démographiques de rascasse envahissant, la bio-énergétique et l'alimentation pour créer un modèle probabilistique de consommation de proie de rascasse sur les récifs envahis et avons comparé ces taux de consommation aux estimations de production de leur poisson de proie. Pour paramétrer notre modèle, nous avons recueilli des données sur la densité du poisson de la taille de poisson proie, la diversité et la distribution de taille et la densité rascasse, la distribution de taille et l'alimentation recueilli de 13 sites de récif de corail envahis de la côte du sud-ouest de la Nouvelle Providence, Bahamas, de mai à septembre 2008. Nos analyses révèlent que le rascasse a le potentiel d'enlever la proie de nombreux récifs à un taux bien plus élevé que les populations de poissons de récif peuvent se reconstituer. Nous avons utilisé aussi notre modèle pour quantifier la densité du rascasse qui pourrait être soutenue par la production de poissons de proie disponibles sur chaque site. Les densités de rascasse 'durable' dépend non seulement des taux de production de poisson, mais de la distribution de taille de rascasse sur chaque site. Notre modèle fournit une méthode par laquelle les directeurs de ressource régionaux peuvent évaluer le risque de la population locale de poissons de récif à la prédation du rascasse et fixent des objectifs clairs du point de vue de la densité du rascasse pour le contrôle et les efforts de gestion sur les récifs antillais envahis.

MOTS CLÉS: Rascasse, espèces envahissantes, prédateur, production de poissons



LITERATURE CITED

Figure 1. Predicted net prey production (mean ± non-parametric bootstrapped 95% confidence intervals) under three removal scenarios: Removal of all lionfish greater than 15cm TL (a), 20cm TL (b), and 25cm TL (c).

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