

Lessons from the Western Atlantic lionfish invasion can inform management in the Mediterranean

Recomendaciones de política para la invasión del pez león del Mediterráneo basadas en lecciones del Atlántico occidental

Recommandations politiques pour l'invasion du poisson-lion en Méditerranée sur la base des enseignements tirés de l'Atlantique Ouest

AYLIN ULMAN^{1*}, FADILAH Z. ALI^{2*}, HOLDEN E. HARRIS^{3*}, MOHAMMAD ADEL⁴, SARA A.A. AL MABRUK⁵, MICHEL BARICHE⁶, ALLISON C. CANDELMO⁷, JENNIFER K. CHAPMAN⁸, BURAK ALI ÇIÇEK⁹, KAYLIN R. CLEMENTS¹⁰, ALEXANDER Q. FOGG¹¹, STACY FRANK¹², STEPHEN R. GITTINGS¹³, STEPHANIE J. GREEN¹⁴, JASON M. HALL-SPENCER¹⁵, JIM HART¹², SUMMER HUBER⁷, PHILIP E. KARP¹⁶, FABIAN C. KYNE⁸, DEMETRIS KLETOU¹⁷, LAURYN MAGNO⁷, SHEVY B.S. ROTHMAN¹⁸, JENNIFER N. SOLOMON¹⁰, NIR STERN¹⁹, TANER YILDIZ²⁰

¹ Mersea Marine Consulting, Fethiye, Turkey (Aylin Ulman, merseamed@gmail.com), ² Gulf and Caribbean Fisheries Institute, Florida, USA, ³ Nature Coast Biological Station, Institute of Food and Agriculture Sciences, University of Florida, Gainesville / Cedar Key, Florida, USA, ⁴ Unaffiliated, Alexandria, Egypt, ⁵ Higher Institute of Science and Technology, Cyrene, Libya, ⁶ American University in Beirut, Biology Department, Beirut 1107 2020, Lebanon, ⁷ Reef Environmental Education Foundation (REEF), Florida, USA, ⁸ Blue Ventures, Sarteneja Village, Corozal, Belize, ⁹ Department of Biological Sciences, Faculty of Arts and Sciences, Eastern Mediterranean University, Famagusta, Cyprus; Underwater Research and Imaging Center, Eastern Mediterranean University, Famagusta, Cyprus, ¹⁰ Colorado State University, Department of Human Dimensions of Natural Resources, Fort Collins, Colorado, USA ¹¹ Okaloosa County Board of County Commissioners, Destin - Fort Walton Beach, Florida, USA, ¹² Lionfish University, New York, New York and Asheville, North Carolina, USA, ¹³ National Oceanic & Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, Maryland, USA, ¹⁴ University of Alberta, Edmonton, Canada, ¹⁵ University of Plymouth, Plymouth, UK and University of Tsukuba, Japan, ¹⁶ Unaffiliated, Scottsdale, Arizona, USA, ¹⁷ Marine & Environmental Research (MER) Lab, Limassol Cyprus; Frederick University, Limassol, Cyprus, ¹⁸ Steinhardt Museum of Natural History, Tel Aviv University, Tel Aviv, Israel, ¹⁹ National Institute of Oceanography, Israel Oceanographic and Limnological Research, Haifa, Israel, ²⁰ Faculty of Aquatic Sciences, Istanbul University, Istanbul, Turkey. *Shared first authorship

EXTENDED ABSTRACT

Two major biological invasions of Indo-Pacific lionfish (*Pterois volitans* and *P. miles*) are underway, one in the Western Atlantic Ocean and another in the Mediterranean Sea. The Western Atlantic invasion is perhaps the most robustly studied marine fish invasion to date; meanwhile the lionfish invasion in the Mediterranean is rapidly expanding. Here, we review and synthesize management successes and failures from several decades in the Western Atlantic, as well as the current state of management in the more recent Mediterranean invasion, to synthesize policy recommendations. Broadly, the most important management lessons are that (1) directed lionfish removals via spearfishing using scuba can effectively reduce their local abundances and that (2) opportunities exist to develop commercial lionfish fisheries for food and other products (e.g., jewelry, leather) that may promote long-term control. In particular, tournaments and derbies can concurrently achieve multiple objectives of promoting lionfish removals, research, and public education. Managers in the Western Atlantic often needed to adapt current conservation policies to enable lionfish removals in areas where spearfishing with scuba was otherwise prohibited for conservation purposes. The risk of abusing these policies has most commonly been mitigated through the use of gear restrictions and through direct communication with scuba divers and stakeholder organizations, via participatory approaches, in lionfish monitoring, removals, and management. Two approaches that were initially common but now advised against are (1) feeding lionfish to native fish to promote predation, which led to injurious encounters between divers and marine predators, and (2) implementing bounty programs to incentivize lionfish harvest, which need continuous financial commitments. In the more recently invaded Mediterranean Sea, our review of the current status of policies found that many of these best practice recommendations for lionfish management are not yet permitted under current regulations. Management strategies implemented in Cyprus, however, have been effective in allowing compliant removal of lionfish under the auspices of researchers and environmental agencies. We expect and fully recommend that work continues towards multinational cooperation to facilitate regional coordination of research, control, and management efforts with respect to the Mediterranean lionfish invasion. As with other major biological invasions, lionfish are unconstrained by political borders and their control will require rapid and strategic management approaches with multinational cooperation involving individuals, governments and other stakeholders.

To support this study, a data repository was built and placed online with the following reference: Candelmo, A.C., Ulman, A., Ali, F.A., Gittings, S.R., Huber, S.R., Magno, L.E., Clements, K.R., Çiçek, B.A., Chapman, J.K., Kyne, F.C., Bariche, M., Kitson-Walters, K., Tiralongo, F., Kletou, D., Yildiz, T., Stern, N., A.A. Al Mabruk, S., Adel, M., Bradai, N., Rothman, S.B.S., Minasidis, V., Green, S.J., Solomon, J.N., Harris, H.E. 2022. Information on Marine Management Policies for Invasive Lionfish in the Western Atlantic Ocean and Mediterranean Sea. Dryad Data Repository. doi:10.5061/

dryad.z08kprf7

We reviewed lionfish management policies from several decades in the Western Atlantic to suggest policy recommendations for the Mediterranean. The policy information that we collected is included in full in this data repository. For this table, information was opportunistically gathered via online searches and discussion with professional and personal contacts for the affected jurisdictions in both the Western Atlantic and Mediterranean regions. Particular attention was devoted to collecting current information on policy changes that permitted directed control efforts for lionfish, as well as management efforts to develop commercial lionfish fisheries for food and other products. Broadly, we found that managers in the Western Atlantic often needed to adapt current conservation policies to enable lionfish removals in areas where spearfishing with scuba was otherwise prohibited for conservation purposes. The risk of fishers abusing these policies was mitigated through the use of gear restrictions and engagement of scuba divers and other stakeholders in lionfish monitoring, removals, and management. Currently, many policies in the Mediterranean generally do not permit lionfish removals given current policies that prohibit take of marine fishes with the use of scuba and spearfishing, even if these fishes are designated as invasive. We note that this data table does not represent an exhaustive review, and also that its information is a static snapshot of current policies (dated early 2022), and we expect these policies to change in the future. In fact, we encourage that any missing information or discrepancies noted be sent to lionfish@reef.org. With these limitations noted, this data table contains robust information regarding policy changes and outreach efforts regarding lionfish across broad geographic regions. Our goal is that this may serve as a resource for

researchers, managers, and stakeholders. Coordinated information sharing can assist science-based decision making to better manage impacts by lionfish and the myriad of stressors on marine environments and fisheries resources.

KEYWORDS: Fisheries management, Invasive species, Marine policy, Mediterranean Sea, *Pterois* sp.

LITERATURE CITED

Candelmo, A.C., Ulman, A., Ali, F.A., Gittings, S.R., Huber, S.R., Magno, L.E., , Clements, K.R., Çiçek, B.A., Chapman, J.K., Kyne, F.C., Bariche, M., Kitson-Walters, K., Tiralongo, F., Kletou, D., Yildiz, T., Stern, N., A.A. Al Mabruk, S., Adel, M., Bradai, N., Rothman, S.B.S., Minasidis, V., Green, S.J., Solomon, J.N., Harris, H.E. 2022. Information on Marine Management Policies for Invasive Lionfish in the Western Atlantic Ocean and Mediterranean Sea. Dryad Data Repository. doi:10.5061/dryad.z08kprf7