

Lionfish Invasion off the Northern Coast of the Yucatan Peninsula, Mexico, Southern Gulf of Mexico: What Do we Know?

La Invasión del Pez León en el Golfo de México y Mar Caribe Mexicano: ¿Qué Sabemos?

L'invasion de'l Lionfish Sur la Cote Nord du Yucatan, Mexique, Sud du Golfe du Mexique: Que Savons-Nous?

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ABSTRACT

In 2009, the first lionfish (*Pterois volitans/miles*) was found in the Parque Nacional Arrecifes de Cozumel, in Quintana Roo, in the Mexican Caribbean; however, no official record was published about this finding but just anecdotic evidence. Early in 2010, we organized workshops to lobster diver-fishermen from the northern Yucatan Peninsula on lionfish biology and potential threat of invasion, and invited them to safely collect lionfish and record basic information. In late 2010, a fisherman captured the first lionfish for the Gulf of Mexico 130 km off the northern Yucatan coast, and 50 km off eastern Alacranes Reef National Park (ARNP). Fishermen showed positive responses; thus, more workshops were organized. From 2010 to 2011, about 445 lionfish (90 - 274 mm TL) were voluntarily collected by fishermen: 1) along the coast: El Cuyo (N = 53; size range 110 - 195 mm TL), Las Coloradas (n = 1; 186 mm TL), Río Lagartos (n = 81; 139 - 327 mm TL), San Felipe (n = 2; 255-274 mm TL), Dzilam de Bravo (n = 9; 97 - 140 mm TL) Telchac Puerto (n = 1; 155 mm TL), Progreso (n = 3; 132 - 153 mm TL) and Sisal (n = 1; 145 mm TL) and 2) off the coast: Bajos del Norte (n = 21; 83 - 217 mm TL), ARNP (n = 269; 90 - 260 mm TL), and Cayo Arenas (n = 4; 134 - 180 mm TL). This work showed that 1) local community participation on conservation is viable and 2) the lionfish invaded the northern coast of the Yucatan Peninsula. This abundance represents a pale number of lionfish since collections were only on a voluntary basis. It is necessary finding ways of collaboration with monitoring initiatives in the Mexican Caribbean and establishing others (Campeche and Veracruz) to reach decisive actions for the lionfish invasion in Mexico.

KEY WORDS: Lionfish, Yucatan Peninsula, coral reef, *Pterois volitans*, Gulf of Mexico

INTRODUCTION

After more than 30 years of first sighted in the reefs off the Florida coast (Courtenay 1995, Ruiz-Carus et al. 2006) USA, the Indo-Pacific lionfish (*Pterois volitans* [Linnaeus, 1758] and *P. miles* [Bennett, 1828]) has expanded in the Western Atlantic and Caribbean Sea (Schofield 2010). The lionfish is not the only non-native, marine fish adapted to the coral reefs of this region. Other Indo-Pacific fishes, such as the Emperor angelfish, *Pomacanthus imperator* (Bloch, 1787) and the sailfin tang, *Zebrasoma desjardinii*, along with other 12 species that were sighted in reefs off the Florida coast (Seemans et al. 2004). However, the lionfish is the only marine fish that has invaded the region widely (Schofield 2010) and is threatening the marine ecosystem.

The potential threat of the lionfish to the marine ecosystem stems on its rapid population growth, which in turns may disrupt the ecosystem function in many ways (Albins and Hixon 2011, such as:

- i) It is a highly predator that compete for food with the native fish fauna,
- ii) It lacks a common predator (but groupers could be a predator to it, Mumby et al. 2011), and
- iii) It reproduces all year (Morris et al. 2011a).

Currently, alternatives to fight the invasion include fish removal (mainly juveniles, Morris et al. 2011b), protection of potential natural predators (such as groupers) through establishment of marine reserves (Albins and Hixon 2011, Mumby et al. 2011), and lionfish adult removal for human consumption (Morris et al. 2011c).

Initiatives for lionfish monitoring of sightings and removals are important to determine the level of invasion in a given area. In fact, volunteer-based, community participation of people affected by the invasion (in this case fishers and divers) is an alternative currently being used for the lionfish in many countries of the region (ICRI 2010, López-Gómez et al.). This volume). Actually, the community participation for recording bioinvasions has been applied successfully for other marine organisms, such as crabs (Delaney et al. 2008).

In Mexico, the lionfish was detected in the Caribbean Sea in 2009 (Schofield 2009) in coral reefs off the Cozumel Island, Quintana Roo, in the Mexican Caribbean. Later in 2010, a lobster diver-fisherman sighted two lionfish and collected one of them off the northern coast of the Yucatan Peninsula (Aguilar-Perera and Tuz-Sulub 2010). In the Mexican Caribbean-

an, a monitoring protocol, implemented by government organizations mainly the Comisión Nacional de Áreas Naturales Protegidas in Cozumel and in Banco Chinchorro, has been used to document the invasion and foster participation of recreational divers and fishermen.

In the Southern Gulf of Mexico, off the northern coast of the Yucatan Peninsula, a volunteering-based initiative was established by initiative of the Universidad Autónoma de Yucatan. This initiative is based on the participation of local diver-fishermen who catch lobsters (*Panulirus argus*). The objective of this work is aimed to describe the progression of lionfish invasion along the northern coast of the Yucatan Peninsula as determined by volunteering-based collaborations mainly from commercial diver-fishermen. This work also addresses the management alternatives to face the invasion on this particular regional area. Additionally, this work is also aimed to build local capacity and awareness among fishermen to address threats related to the lionfish invasion.

MATERIALS AND METHODS

Volunteer-based Workshops to Diver-fishermen

Due to our past experience with a small group of local lobster, diver-fishermen, who voluntarily decided to collaborate with us as lionfish collectors (Aguilar-Perera and Tuz-Sulub 2010), we decided to implement workshops to more lobster fishermen in the northern Yucatan Peninsula. These fishermen commonly catch lobster (*Panulirus argus*) through free diving on a daily basis, from July 2010 to February 2011 (lobster fishing season). They travel to different places along and off the coast, such as the Alacranes Reef (140 km off the northern Yucatan Peninsula), Bajos del Norte, San Felipe and Rio Lagartos (eastern Yucatan coast), Dzilam and Puerto Progreso.

After briefings with the authorities in charge of the fishermen groupings (in Mexico called "Cooperativas") and the federation of fishermen and the chairs of each group, we organized and applied brief but detailed workshops especially elaborated for the local lobster diver-fishermen the communities of Puerto Progreso, Dzilam de Bravo and San Felipe, and Ria Lagartos. These workshops included information on:

- i) Morphology and appearance of lionfish,
- ii) Chronology of the invasion,
- iii) Potential threats (to the commercial fishery and human health)
- iv) Potential use of lionfish for human consumption and handcrafted material, and
- v) Instructions for collecting lionfish

For the last point (v), we invited the fishermen to record basic information along with each lionfish captured on a voluntary basis. This requested information from fishermen included:

- i) Approximate coordinates of capture,
- ii) Record bottom type,

- iii) Date,
- iv) Name of collector,
- v) Depth, and
- vi) Number of fish.

In order for them to record that information, we elaborated a logbook to fill. We also provided them with plastic-covered, color photographs of lionfish to be attached to each ship deck. The photo included contact information (cellphone numbers). Additionally, we gave them Ziploc bags and markers. Fishermen were told to keep the caught lionfish frozen.

Laboratory Analysis

Lionfish caught by local diver-fishermen were brought to the laboratory frozen. After thawing, fish were measured (to the nearest millimeter) using a wooden ictiometer and weighed (to the nearest gram) using an electronic scale. Fish were taxonomically identified following Schultz (1986) and the FAO identification keys (Carpenter and Niem 1998). Most fish were also dissected in order to remove the stomach contents and gonads to be analyzed elsewhere. Otoliths, fin-clips, and abdominal tissue were removed for age and growth and molecular studies, respectively, and were stored. These latter items (tissue, otoliths, and stomach contents) will be analyzed elsewhere. A database was elaborated containing basic information of capture and morphometrics. We measured specific body parts, such as pectoral fins, and counted spines and rays in order to eventually distinguish for the presence of the devil firefish (*P. miles*). However, tissue samples still need to be analyzed for molecular distinction in order to confirm the presence of the devil firefish.

RESULTS

Diver-fishermen speared voluntarily a total of 445 lionfish (size range 90 - 274 mm TL) during July 2010 to July 2011. Of this total, at least 174 lionfish were juveniles and 271 adults (this allocation based 150 mm TL as mean maturation size). Fishermen provided not only captured lionfish but also information on the site of capture. We used the coordinates provided by diver-fishermen for mapping the sites where lionfish were caught off the coast (Figure 1). The vast majority of lionfish were captured in the Alacranes Reef (n = 269), compared to other sites, by at least 31 diver-fishermen, followed by Ria Lagartos (n = 81, by eight diver-fishermen) and El Cuyo (n = 53, by four diver-fishermen) (Figure 2). The lionfish captured in all the sites showed a medium size about 150 mm in TL (Figure 3). At least 73 diver-fishermen participated in the lionfish captures within about seven locations along the coast and off the coast (Figure 4). Lionfish were detected within at least two marine protected areas (MPAs): the Alacranes Reef National Park and the Ria Lagartos Biosphere Reserve. The lionfish captured within these two MPAs represent almost the 80% of the total so far.

DISCUSSION

The lionfish (*Pterois volitans/miles*) has invaded the northern coast of the Yucatan Peninsula, Mexico, including reefs and shoals. First lionfish sightings by local diver-fishermen occurred on the eastern area coast, mainly in the San Felipe and Rio Lagartos. Then, sightings progressively were reported from the west. In the Alacranes Reef, 140 km off the northern coast of the Yucatan Peninsula and in the Bajos del Norte, sightings and collections are more dramatic. The situation in the Alacranes Reef goes beyond limits (López-Gómez et al. This volume). Based on the invasion levels established by NOAA for the Florida Keys National Marine Sanctuary (Morris and Whitfield 2009), the invasion in the Alacranes could be classified at the intermediate-advanced level. In less than a year, there have been almost 300 lionfish caught in Alacranes Reef by fishermen on a voluntary basis. In the Bajos del Norte, the

situation could be similar to that of the Alacranes. However, the logistics for travelling to Bajos are demanding since this reef shoal is 200 miles offshore. Fishermen conduct a 15-days trip or longer there to catch lobster and groupers, but also some fishermen have brought us lionfish from there.

The presence of lionfish on the northern coast of the Yucatan Peninsula could be detected previously to 2009 if the lobster fishermen had been oriented and invited to participate in any lionfish initiative to detect its presence. All fishermen that participated in our workshops did not know anything about lionfish in terms of appearance. At least 10 fishermen mentioned they had never seen anything similar to lionfish in their working area before. Some fishermen mentioned that for them the lionfish is “arriving” more frequently.

The lionfish size range (90 - 274 mm TL) in the area implies that more than 60% of lionfish caught are repro-

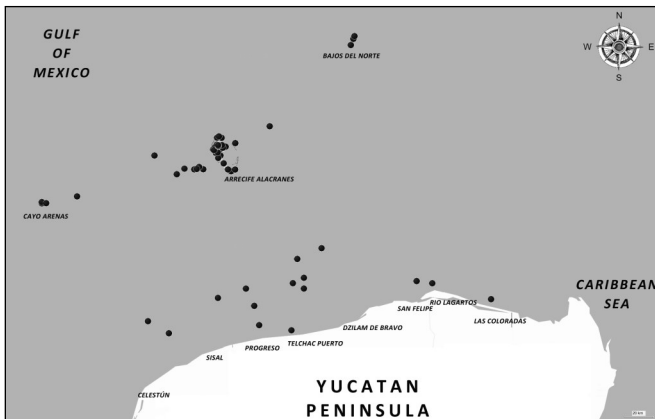


Figure 1. Map showing the location of lionfish captures (black dots) done voluntarily by diver-fishermen off the northern coast of the Yucatan Peninsula, Mexico.

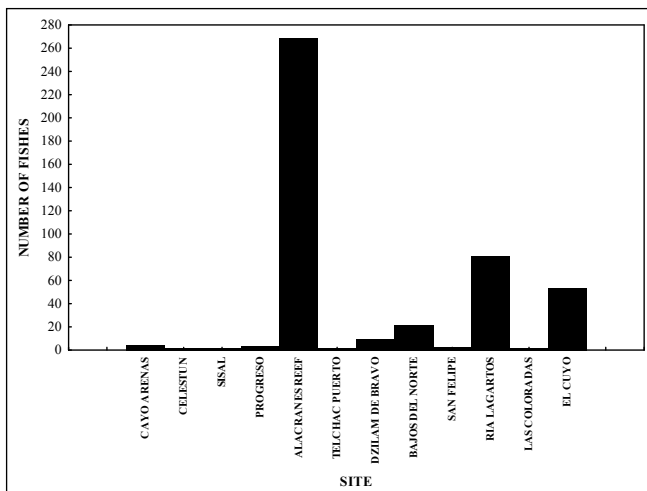


Figure 2. Lionfish captures based on location along and off the northern coast of the Yucatan Peninsula, Mexico.

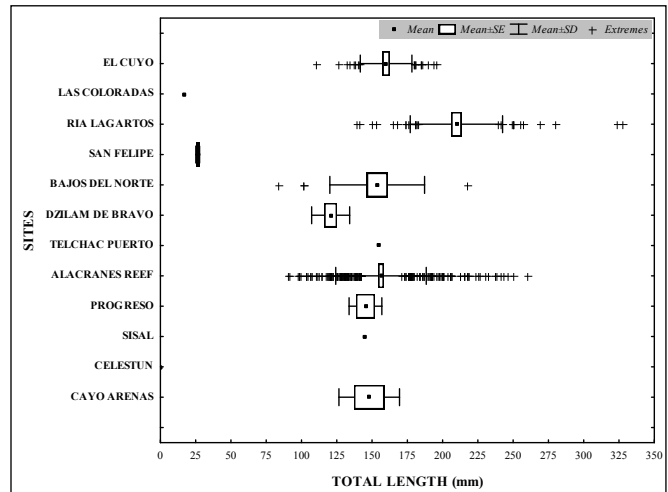


Figure 3. Mean size of 445 lionfish (\pm Mean Standard) captured by 73 diver-fishermen off the northern Yucatan Peninsula, Mexico.

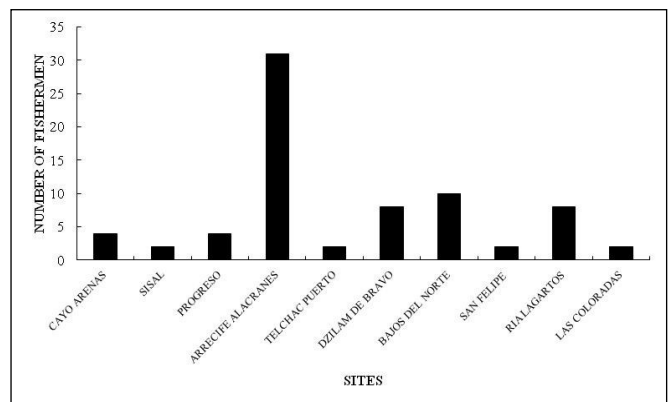


Figure 4. Number of 73 diver-fishermen who participated in collecting lionfish off the northern Yucatan Peninsula, Mexico.

ductive active fish, so it would be possible they could be spreading further by reproducing on the area. However, in our samples, we only found 5% of ripe individuals.

No fisherman has ever detected any lionfish preyed by a large grouper or snapper, yet. During our talks, we mentioned the possibility that large groupers in the area, such as the Black grouper, *Mycteroperca bonci* or others, are potential predators of lionfish. Now, the lobster fishermen are aware of this, and they are carefully checking the grouper stomachs when gutting.

The environmental authorities in Mexico (SEMARNAT) still do not officially recognize the lionfish as an invasive species within their policy initiatives. Consequently, it is necessary to implement a formal policy development in order to label the lionfish as an invader and as a potential threat to the marine ecosystem of the Southern Gulf of Mexico and Mexican Caribbean. The environmental government agency, known as Comisión Nacional de Áreas Marinas Protegidas (CONANP), has been conducting a formidable work by organizing outreach initiatives among recreational divers in locations such as Cozumel, Cancun, Isla Mujeres, Playa del Carmen, and Banco Chincorro. Also, CONANP co-organized the first regional (Wider Caribbean) lionfish workshop in Cancun, Quintana Roo, Mexico in August 2010.

CONANP is only advocated to work on the Mexican Caribbean, mostly in the Cozumel National Park and the Banco Chincorro Biosphere Reserve, while the Gulf of Mexico remains relatively unattended. However, the CONANP recently addressed some initiatives to work on the Gulf of Mexico in response to proposals from the Universidad Autónoma de Yucatán (UADY). In 2010, we proposed to the Arrecife Alacranes National Park (from CONANP) an approach based on considering the diver-fishermen community and inviting them to voluntarily catch lionfish during their fishing incursions. Fishermen responded positively to this invitation and they provided all lionfish samples used on this work. Fishermen are continuously bringing lionfish after each 15-day trip to Alacranes Reef. In 2011, we received an invitation from the Ría Lagartos Biosphere Reserve (RLBR) (from CONANP) to collaborate in the scientific validation of lionfish and handling of collected specimens during the first lionfish fishing tournament with the participation of lobster fishermen only from San Felipe, el Cuyo, and Las Coloradas.

Lionfish would never be eradicated from the zone. This is due to a combination of biological and ecological factors related to its reproductive strategies and adaptations to live in deep waters (Morris and Whitfield 2009). Additionally, the remoteness of many areas, such as Alacranes Reef and Bajos del Norte, would keep lionfish in a safe refuge from extraction.

There is a remarkable difference between environmental and cultural conditions from the Mexican Caribbean and the northern Yucatan Peninsula. Water transparency

makes the Caribbean an easier medium for recreational divers to participate in the lionfish extraction on a daily basis. By contrast, in the Gulf of Mexico the water is not that transparent compared to the Mexican Caribbean, so recreational divers are scarce. However, the community of diver-fishermen dedicated to catch lobster in northern Yucatan (the Gulf of Mexico) is larger compared to the number of recreational divers.

We have made some reflections about the participation of fishermen as lionfish collectors. The participation of diver-fishermen on lionfish extraction could be relatively costly for them; consequently, their participation could be limited due to a set of factors. These factors are related to take decisive actions related to decide when, where and how lionfish could ultimately be removed from reefs based on:

- i) Availability of ice to keep lionfish frozen vs. ice used for lobster,
- ii) Time and effort employed to catch lionfish with speargun through diving when no lobster is available,
- iii) The special care needed for avoiding any accident by lionfish spine puncture,
- iv) Any incentives fishermen may receive to take care of lionfish caught when arriving to port, and
- v) Fishermens' willingness to call a scientist to pick up lionfish from their ships once arriving in port.

There is a possibility that fishermen would only be interested to catch lionfish when some small cash incentive is offered. If this would be a real case, then, who would be paying any money for lionfish samples? It is clear that it would not be possible to be paying endlessly without any positive outcome. An alternative to cope with this problematic situation is to sell lionfish like any other consumable, native fish. However, another problem emerges. Who is going to pay for lionfish on a regular basis so that fishermen will bring more lionfish to port? Here, it would be necessary to find a commercial marketing niche for lionfish in the international market. The solution could not only be related with turning the lionfish into a consumable delicacy but also into a handcrafted item.

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